ANATOMY OF THE MONOCOTYLEDONS

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BY

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FOREWORD

THE enormous and highly specialized family of Gramineae, noted for its wide diversity and complexity, has posed many problems to the taxonomist using traditional methods based on gross morphology. It has become increasingly apparent in a group where fine distinctions commonly determine differences and affinities that the evidence of histological data is of great significance. Heretofore, however, agrostologists have lacked a comprehensive treatise on grass anatomy in which a sufficiently representative range of grasses, identified in accordance with modern nomenclature, from all parts of the world has been treated.

When Dr. Metcalfe embarked on the very considerable task of presenting a treatment of the anatomy of Monocotyledons as a series of companion volumes to those on the anatomy of the Dicotyledons which he produced in collaboration with Dr. L. Chalk of the Imperial Forestry Institute at Oxford, he decided to deal first with the grasses. Primarily this arose from the pressing need for a work of reference on this economically important family. There was also the most happy circumstance that Mr. C. E. Hubbard, whose knowledge of grass classification is unsurpassed, was available throughout to advise on taxonomic questions. As a result, a specialist in plant anatomy, with the constant help of an expert on grass taxonomy, has prepared a volume that will be indispensable to those interested in grass taxonomy. Furthermore, as the emphasis on grass anatomy is not entirely with taxonomic bias, ecologists, physiologists, and others will find the book to be a most useful work of reference. It can with every justification be regarded as a dictionary of grass anatomy.

In preparing this book, Dr. Metcalfe has had the advantage of access to the extensive collection of grasses in cultivation at Kew, which includes many rare and unusual kinds. In addition, collaborating botanists in various parts of the world have collected and fixed grasses specially for this work. Dried herbarium specimens are not ideal for anatomical investigation, but nevertheless, by using a special technique for reviving the tissues, it has been possible to obtain microscope slides of good quality when no other material was available. The author's aim throughout has been to examine grasses of as many different affinities as possible, and in this way to give as complete an account as possible of the anatomy of the Gramineae. Never before has the histology of such a wide range of grasses been examined by a single author, and the uniformity of treatment thus secured adds very greatly to the value of the book as a key work for further investigations. In addition to the examination of plant material, Dr. Metcalfe has engaged in bibliographical work and this book includes summaries of many articles on grass anatomy, but this survey of the literature cannot claim to be complete.

As mentioned above, this volume is the first of a series intended to cover the anatomy of the whole of the Monocotyledons. In this very formidable effort Dr. Metcalfe has secured the co-operation of a number of anatomical

research workers of various nationalities, most of whom have been able to do at least part of their work under his personal supervision at the Jodrell Laboratory. A volume on the Palms has already been completed by Dr. P. B. Tomlinson, and much information on many of the remaining families has accumulated. The Jodrell Laboratory at Kew has enjoyed a high international reputation for the anatomical research that has been conducted there since its foundation in 1876, and it is therefore most fitting that the laboratory should still be the centre for such investigations. It is probably not too much to say that the anatomical books that have been and are being prepared there, besides adding very materially to our knowledge of the comparative histology of the angiosperms, will have a very marked influence on the future development of taxonomy by broadening the basis on which this fundamental branch of botanical science is founded.

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PREFACE

WHEN the author and Dr. L. Chalk of the Imperial Forestry Institute at Oxford had completed their two volumes entitled *Anatomy of the Dicotyledons*, Sir Edward J. Salisbury, who was then Director of the Royal Botanic Gardens, Kew, suggested that a companion work on the anatomy of Monocotyledons was sorely needed. In writing their two volumes on Dicotyledons, the authors were able to take the English translation of Solereder's *Systematic Anatomy of the Dicotyledons* as a starting-point, and this considerably simplified their task. With the Monocotyledons the work was made more difficult because there is no counterpart to Solereder's great treatise on the Dicotyledons. It is true that there is the *Systematische Anatomie der Monokotyledonen* by Solereder and Meyer, but this book, valuable as it is, is far from complete. Furthermore, Dr. Fritz Jürgen Meyer, the sole surviving author of the German work at the time when the present book was initiated, informed the author that he saw no prospects of completing his own book, and very generously cast his blessing on the present undertaking.

In embarking on the anatomy of the Monocotyledons, the author has no longer enjoyed the valued collaboration of Dr. L. Chalk. This is solely because the Monocotyledons provide no scope for the exercise of Dr. Chalk's interest in wood structure.

It was realized from the outset that it would be impossible to produce a reference book dealing with the whole of the Monocotyledons within the compass of a single volume. Because of the economic importance of the Gramineae, and because it is now generally recognized that histological details, especially of the leaf, are an essential ingredient of any satisfactory treatment of grass taxonomy, it was decided to make a start by devoting a whole volume to this one family.

The present volume is the outcome of nearly ten years' work on the Gramineae. It is based largely on the author's own researches, during which 206 genera and 413 species have been examined. In addition the literature has been sifted, summarized, and blended with the author's own results, thus bringing the total number of genera that have been treated up to 345. In order that the reader may readily distinguish original information from facts recorded in the literature, these two types of data are presented separately for each genus. The diagnostic generic characters, and the data given under the heading 'Species specially examined', are based on the author's own observations. The section for the individual genera headed 'Additional information from the literature' refers to data already published elsewhere. Many of the genera that the author has not personally examined are described from published data alone.

After most careful consideration it was decided to arrange the genera in alphabetical sequence rather than in the order adopted in any of the recognized taxonomic groupings for the Gramineae. No doubt this will appear as a matter for regret to certain of those botanists whose interest in the Gramineae is

mainly or wholly taxonomic. When, however, it comes to the question of which taxonomic system should be followed there is at present no wholly satisfying answer. No taxonomic arrangement of the Gramineae exists that conforms precisely with the anatomical evidence. On the other hand, there are still so many gaps in our anatomical knowledge that histological evidence concerning the taxonomic affinities of many genera is still lacking. Furthermore, just as a taxonomic system based solely on macroscopical, exomorphic characters is bound to be misleading or imperfect, a system of classification based solely on histological details could be still more erroneous. In addition there are few or no botanists who, so far as the Gramineae are concerned, are equally well informed concerning the exomorphic and histological approaches to the classification of the group. The author, who is an anatomist and not an agrostologist, has, therefore, attempted to present his evidence rather in the form of a dictionary of histological details, which he hopes may be of some assistance to grass taxonomists. A dictionary is normally arranged in alphabetical sequence, and, taking all of the circumstances into account, it seems reasonable that this dictionary should be arranged in the same way as others.

It will be impossible for the reader to use this book to the best advantage unless he has thoroughly understood the contents of the first two sections, dealing respectively with the morphology of the grass plant and the diagnostic microscopical characters. Apart from these two sections, the book has been designed primarily to enable the reader to answer questions of two kinds. Firstly, if he should want to know the microscopical characters of any particular genus or species, this information can be obtained by turning to the descriptions. There are, as yet, many genera and still more species for which no data are available. Nevertheless, it is hoped that, incomplete as they are, the data recorded may be sufficient to give a fair insight into the systematic anatomy of the vegetative organs of the Gramineae. The second type of question to which it is hoped that an answer will be found is that posed by a reader who wants to know in which genera and species a particular character, or combination of characters, occur. Questions of this kind can be answered, at least in part, by turning to the tables at the end of the book. It should be realized, however, that these tables are far from complete, for they are based solely on the author's own observations, and data from the literature have been omitted from them. Finally, it is to be hoped that the taxonomic clues headed 'Special notes' under the individual genera, as well as those in the third section, will be at least of some value to grass taxonomists.

Most of the grasses examined by the author were cultivated at Kew. These were all fixed and preserved in formalin acetic alcohol until required for use. In addition, grasses were collected specially for this investigation and fixed in formalin acetic alcohol by W. M. Curtis in Tasmania, by G. Jackson in Nyasaland, and by R. E. Vaughan in Mauritius. Fixed and dried specimens of *Neostapfia* and *Orcuttia* from California were collected with great difficulty, thanks to the co-operation of L. K. Mann, G. L. Stebbins, and other botanists. A number of microscope slides and preserved specimens of British grasses and of species of *Danthonia* were supplied by J. Kennedy O'Byrne of the Kew Herbarium. Besides fixed material, a considerable number of specimens from the Kew Herbarium were also examined. Here special mention must be made

of a fine collection of grasses gathered in Ceylon by the author's colleague F. Ballard of the Herbarium staff. The bamboos examined were in part cultivated at Kew and in part from the Kew Herbarium. Some large bamboo culms were supplied by N. W. Simmonds from Trinidad. The botanical identity of all this material was confirmed by the author's colleagues C. E. Hubbard and N. L. Bor.

From what has been said it must already be clear that, although the author is solely responsible for the text, for the illustrations, and the investigations on which these are based, the book could never have been produced without the collaboration of many botanical friends and colleagues. The author freely acknowledges his indebtedness to all who have assisted in any way. Amongst these he is most grateful to his colleagues, firstly to Dr. G. Taylor, the Director of the Gardens, for his encouragement and support, and also to N. L. Bor and C. E. Hubbard, without whose taxonomic aid the book would never have been written. The painstaking and devoted labours of F. Richardson and of Miss D. M. Catling, the two technicians at the Jodrell Laboratory who have prepared the microscope slides on which the original investigation rests, are beyond all praise. Thanks are also due to all those who have, with great trouble, collected specimens specially for this investigation; to Miss R. Hungerbühler (now Mrs. Beckmann) for her assistance in studying micro-hairs, and labelling drawings; to Miss E. Slatter, a former member of the staff of the Jodrell Laboratory, whose preparation of a card index to the literature has been of the greatest assistance. Finally, thanks are due to the Bentham-Moxon Trustees for providing the services of a typist.

Readers will no doubt wonder why the descriptions of the interesting genera *Neostapfia* and *Zenkeria* have been so curiously relegated to the end of the book. The author is solely responsible for this peculiarity, for he did not send the descriptions of these genera to the Press until it was too late for them to be inserted in their rightful places. He craves the indulgence of his readers and trusts that they will cast a tolerant eye on this misdemeanour.

CONTENTS

ABBREVIATIONS IN THE TEXT

I.S. Inner, usually sclerenchymatous, bundle-sheath.
O.S. Outer, usually parenchymatous, bundle-sheath.
Ph. Phloem.
Scl. Sclerenchyma.
Vb. (plural Vb's). Vascular bundle(s).
V. Very.
Xy. Xylem.

DIMENSIONS AND NUMERICAL DATA

THE dimensions for micro-hairs, &c., given in the text are based only on small samples of material. The reader should, therefore, bear in mind that the author intends these figures to serve only as rough guides concerning the sizes of the cells and structures concerned. Furthermore it should be remembered that dimensions based on herbarium specimens often tend to be low owing to contraction of the cells and tissues on drying. Similarly, the sizes of sclerenchymatous strands and girders when expressed as being so many cells wide and high, while accurate for the material which the author examined, do not necessarily represent the full range of variation that may occur in the species concerned. The same applies to the number of vascular bundles in a transverse section of a leaf, e.g. in *Festuca*. The reader should always bear in mind that, whilst these quantitative data are useful for diagnostic purposes if used with discretion, they cannot, as they stand, be relied upon for the separation of closely related taxa. The author particularly wishes to emphasize this limitation, as it would be most unfortunate for readers to draw unwarranted taxonomic conclusions based on quantitative data supported by inadequate observations.

GENERAL MORPHOLOGY OF THE GRASS PLANT

1. Introduction

It is not intended in this book to deal with the exomorphology of the vegetative organs of the grasses in any detail, nor are we concerned with the morphology of the flowers and inflorescences. Nevertheless, the micromorphology of the vegetative organs, which is our main concern, cannot be fully appreciated unless the basic morphology of the grass plant is understood.

Everybody is familiar with grass in a popular sense, and most people, especially those living in the temperate zones of the world, or who visit parts of tropical countries where grass is a dominant constituent of the vegetation, picture grasses as herbaceous plants with a habit broadly similar to that of the cereals in our arable fields. This picture is indeed an accurate one for most grasses, but it must be remembered that the botanical family Gramineae includes plants ranging in size from our humble *Poa annua* to arboreal giants such as *Dendrocalamus* amongst the bamboos. These especially large grasses of the bamboo forests, with their complex subterranean systems of thick, branched rhizomes, sometimes spread rapidly by vegetative means, and by their exceedingly rapid growth thrive successfully in competition with plants of other types and affinities. The small annual grasses, on the other hand, pass through periods unfavourable for their growth, in the form of seeds, and are thus enabled to flourish in such special habitats as on dry walls. Grasses that are herbaceous perennials can spread over large areas by creeping stolons that lie over the surface of the ground, or by wiry, underground rhizomes. Grasses with stolons or rhizomes occur both in damp as well as in dry, or even desert regions, and the stolons or rhizomes serve as a rapid means of vegetative propagation if and when they become severed by natural or artificial means. Some grasses are characteristic of damp woodlands, others of marshes, ponds, and streams, whilst others such as *Spartina townsendii*, which is so familiar a feature of maritime regions and estuaries in southern England, can exist with their roots embedded in mud that is saturated with sea-water. A few grasses, weaker than their neighbours, have developed a more or less climbing or scandent habit.

2. Morphology of the Grass Plant

What, then, are the morphological characters that are common to all of these gramineous plants of diverse habit that enable botanists to recognize them as members of a single large family? Firstly, it is evident that their individual flowers are small and relatively inconspicuous in comparison with those of flowering plants in general. The flowers, adapted for pollination by wind, are arranged in spikelets, each of which may bear one or more flowers. Each spikelet consists of an axis or rhachilla bearing in

ascending series the glumes, lemmas, and paleas, small scale-like structures that may be interpreted as bracts, the individual flowers consisting of minute lodicules which probably represent reduced perianth members, stamens, and an ovary that typically bears feathery stigmas on short styles. The spikelets are arranged either on relatively long stalks, when the inflorescence which they constitute is a panicle, or on short densely crowded stalks to form an inflorescence which is a raceme. Variations in the structure of the spikelets and in the manner in which they are arranged in the inflorescence provide characters that form the very basis of grass classification. Secondly, it may be noted that the inflorescence in the temperate grasses with which we are most familiar terminates an aerial stem, sometimes known as a haulm, but which in botanical works is generally referred to as the culm. In large grasses, however, especially some of the bamboos, the culm is branched, and, when deciduous bamboos are flowering, the whole of the branched culm resembles a gigantic inflorescence (Arber 1934). Culms vary enormously both in length and diameter in different grasses, and they may be erect, ascending, or more or less procumbent. However this may be, each culm consists of a number of nodes, which are frequently conspicuous because they are somewhat wider in diameter than the internodal portions of the culm. In most grasses the culms are hollow at the centre except at nodes where there are transverse partitions. In other grasses the centres of the culms are partly or wholly solid, although the central ground tissue is often loose or spongy. In the culms of aquatic grasses, on the other hand, there is usually a well-developed system of intercellular spaces. The foliage leaves, which are discussed in greater detail below, are attached to the culm at the nodes at the lower ends of their sheathing bases. In some of the bamboos and related grasses the blade or lamina of the leaf is separated from the basal sheath by a 'petiole' or pseudopetiole. The internodes at the base of the plant are commonly much more crowded than those in the upper parts of the culm, and the internodes immediately below the inflorescence are longer than those in the middle portion of each culm. It follows that the leaves are particularly crowded at the base of the culms and the sheaths of the basal leaves frequently overlap. The tufted habit is due to numerous leafy culms arising close together from the base of the plant, stolons, or rhizomes with long internodes not being formed. The growing points of grasses are basal, and, in tufted grasses, they are enclosed within the overlapping sheathing bases of the foliage leaves. When the growing-points give rise to fresh branches they do so either by piercing through the bases of the surrounding leaf-sheaths and so reaching the exterior, or the young shoots may grow upwards within the sheathing leaf-bases. The first of these methods of branching is described as extravaginal and the second as intravaginal.

The roots of grasses are, for the most part, adventitious, and arise from the basal nodes. The roots of tufted grasses are in consequence much more congested than those in grasses with horizontal rhizomes or stolons that spread over considerable areas of ground. It may be noted that the root-hairs of grasses are often very long and persistent. This is particularly so in grasses from dry sandy regions where the root-hairs and the adhering particles of sand are immediately obvious to the naked eye.

3. The Leaf

(*a*) *External morphology*

It has already been stated that the foliage leaf of a grass has a sheathing base. In many grasses this surrounds the bases of the next higher leaves on the culm, but the two margins of the sheath are free from one another although they may overlap, the margins of the sheath being continuous with those of the more distal part of the leaf. In other grasses the sheath completely encircles the younger leaves at least at its base and there are no free margins to the sheath, which thus has the form of a closed cylinder.

The lateral margins of the lamina in some grasses are more or less parallel to one another except at the apex, but it is common for the blade to taper more gradually to a pointed or blunt tip. In some tropical grasses the leaf-blades are much shorter in relation to their width, and thus differ somewhat in appearance from the popular conception of a grass leaf.

In a small proportion of grasses a petiolar region, cylindrical in structure, is interpolated between the distal lamina and the basal sheath.

On the adaxial surface of the leaf, where the blade joins the sheath, there is a small membranous flap of tissue known as the ligule. The membrane may bear hairs at its margin, or the ligule may be reduced to a fringe of hairs, whilst from a few grasses the ligule is absent. Also in the same region as the ligule, but at the margins of the leaf, there are sometimes tooth-like projections known as auricles.

Another important point is that the leaves are folded on either side of the midrib in the buds of some grasses, whilst in others they are rolled round one of the margins. It is possible to determine to which of these two categories a grass belongs by inspection, with a lens, of the exposed surface of a bud that has been transversely cut with a razor blade. This difference profoundly influences the structure of the blade, for in those that are conduplicate (folded) in the bud it is usual to find that the midrib projects abaxially to form a keel. Furthermore, the distribution of the bulliform cells (see p. xxx) is related to the manner in which the leaf is folded. With leaves that are rolled in the bud it is usual to find that there is no well-marked keel.

The blade of the mature leaf generally appears to be a more or less flat organ when examined with the naked eye, although the midrib may project prominently on the abaxial, or, more rarely, on the adaxial surface. In some grasses the leaves are V-shaped in transverse section because the two longitudinal halves of the lamina tend to be folded towards each other on either side of the midrib, or there may be a groove on the adaxial surface of the midrib. Then again the adaxial surface, and more rarely the abaxial surface, bears longitudinal ribs, of which the heights, transverse shapes, and spacing on the leaf surface vary from species to species. Where the ribs are prominent it is often found that the lamina has a marked capacity to become rolled up and more or less cylindrical in appearance, the adaxial surface on which the stomata are situated thus becoming protected from undue exposure in times of water shortage. The capacity for leaves with marked adaxial ribs to roll up in this way is a character that seems to have arisen as a response to ecological conditions, and for this reason leaves of this type are to be found in

grasses between which there are no close taxonomic affinities. The same considerations apply when the lamina has become acicular, or junciform, the stomata in such leaves being restricted to certain portions of, or grooves in, the adaxial side. Nevertheless, transverse sections of acicular grass leaves (Fig. X) often exhibit characters that are of taxonomic value because, in assuming the acicular form, the leaves of grasses of different affinities have not taken on precisely the same arrangements of vascular and mechanical tissue, nor are the shapes of the furrows alike in all grasses of the acicular type. In *Miscanthidium teretifolium* (p. 314) the lamina has become almost cylindrical in transverse section, and the adaxial surface can be recognized only by a minute groove on the adaxial side of the cylinder. This is an extreme example of the acicular mode of specialization in grass leaves.

Grass leaves of the predominating flat type exhibit a series of veins extending longitudinally through the lamina from its base towards its apex. Near the base of the leaf the veins are close together, but they spread farther apart and lie more or less parallel to one another throughout most of the length of the blade. In some grasses the veins diverge from one another so closely to the base of the lamina that no definite midrib or midrib bundles can be recognized. This occurs, for example, in the bamboo known as *Merostachys riedeliana* (p. 564) which thus differs from most bamboos and other grasses. It is usual to find towards the narrowing apex of the lamina of most grasses that some of the nerves become less pronounced and gradually disappear. Each vein normally contains one vascular bundle, but, in the midrib, there may be one large vascular bundle or a number of vascular bundles, according to the species concerned (Fig. XIII). In some grasses, and especially in the bamboos, the midrib contains a complex system of vascular bundles (Fig. XVII). The vascular bundles that lie longitudinally in the veins outside the midrib are not usually all of the same size, and it is customary to speak of veins of various orders depending on the sizes of the veins themselves and of the status of the vascular bundle contained in them (see also p. xxvii). The longitudinal veins are commonly interconnected by small transverse veins each containing a vascular strand which is usually very small. The number of transverse veins varies from species to species, and in many grasses, especially those with small leaves, few or no transverse veins are to be seen. In other grasses, notably in the bamboos, transverse veins are often abundant, but even in different species of bamboos the frequency of transverse veins is very variable.

(*b*) *Microscopical structure*

The microscopical characters of the lamina are more important than those of other parts of the leaf in taxonomic studies. This is indeed fortunate, for the leaf lamina is usually the most easily available part of the plant, and it can be studied irrespectively of whether or not the grass is in flower. The reason why the lamina is the most important part of the leaf for taxonomic purposes is because it is the first part to become mature, and it therefore shows a more specialized type of structure than the petiole (if there be one) and, still more than the sheath, both of which mature later. Indeed, the basal part of the sheath (and of the lamina) are the regions in which leaf elongation takes place

and so do not pass through so many developmental stages as the more distal parts of the leaf.

It may also be noted that leaves on the culm, and especially those just below the inflorescence, sometimes differ structurally in certain minor respects from those that are lower on the culm, and from basal leaves. These differences are comparatively insignificant, however, beside those that occur in leaves from different genera, or species, so that useful conclusions can be drawn even when circumstances do not permit leaves from the corresponding level on the plant to be examined for comparative purposes. It is, however, most desirable to compare leaves from corresponding positions on the plants concerned whenever circumstances permit.

The diagnostic characters of grass leaves are usually studied in preparations to show the epidermis in surface view, and in transverse sections of the lamina. It will be useful, at this stage, to review briefly the nature of the anatomical characters that are to be seen in preparations of both kinds, leaving further discussion of their taxonomic significance until the second section.

4. Epidermis in Surface View

(*a*) *Zones or strips*

In order to understand the microstructure of the epidermis of the leaf-blade in surface view, it is first necessary to remember that the lamina is divided into longitudinal zones or strips. The most obvious distinction in most grass leaves is between the intercostal zones (between the veins) and those over the veins.

The costal and intercostal zones in an individual leaf differ from one another most conspicuously in species in which sclerenchyma is abundantly developed in association with the vascular bundles. On the other hand, in a leaf in which hypodermal sclerenchyma occurs in the intercostal zones as well as over the veins, the structure of the epidermis is more uniform. There are also variations in epidermal structure over vascular bundles of different orders, and zones of the epidermis from near the leaf margins, or from over the midrib, sometimes differ from the remainder. The constituent cells of the epidermis are all comprised in the types described under (*b*) below, but, as we shall see, there are variations in the distribution, frequency, form, and sizes of the cells in the different zones.

(*b*) *Constituent cells of the epidermis*

(i) *Orientation of cells*

In order to make it as simple as possible to discuss the cellular structure of the leaf epidermis, it has been assumed, for the purpose of writing this book, that the reader will picture the epidermis as it will appear when examined under the microscope with the long axis of the leaf lying horizontally in the field of view. When the leaf surface is thus visualized it is possible to refer to zones and files of cells that lie parallel to the long axis of the leaf as being 'horizontal'. At the same time, the direction at right angles to the long axis of the leaf becomes 'vertical' for descriptive purposes.

Although all descriptions of the epidermis in this book have been drawn up with this viewpoint in mind, the reader should remember that authors of other books and articles have not necessarily done likewise. It is very important to bear this in mind, for it may otherwise appear that descriptions by other authors do not tally with those in this book. The difficulty is not lessened by the failure of some authors to take the trouble to explain just how they have pictured the epidermis to themselves when writing their descriptions. Although anybody with a knowledge of the structure of grass leaves can generally determine for himself the descriptive standpoint adopted by any particular author, the fact that no viewpoint has been adopted as a standard convention undoubtedly leaves room for misunderstanding and misinterpretation of published data. This applies particularly with reference to the proper understanding of the shapes of silica-bodies, for the shape of a silica-body cannot be accurately described unless its orientation on the surface of the leaf is clearly understood.

(ii) *Long-cells and short-cells* (see also pp. xli, xlv).

In most grasses the epidermis is made up of cells of two distinct sizes. Typically the larger of the two categories, which are commonly referred to as 'long-cells' (Fig. V), are elongated horizontally (parallel with the long axis of the leaf) and relatively narrow vertically. Cells in the smaller category, commonly known as 'short-cells' (Figs. I–IB), are much more nearly equidimensional, but in some species they are somewhat longer horizontally than they are vertically, and in other species their vertical lengths exceed their horizontal widths. Although long-cells and short-cells usually occur together in the same grass leaf, there are some grasses in which short-cells are infrequent or absent (*Bromus* spp.). There are also other grasses in which cells that from their distribution are clearly to be interpreted as homologous with long-cells, are in fact so much shortened horizontally that they could be mistaken for short-cells at first sight. Most of the epidermal cells of *Heteranthoecia guineensis* are of this type (Fig. V, 6).

Short-cells occur in horizontal rows, in pairs, or they may be solitary, according to the species. Furthermore, the short-cells in the costal and intercostal zones respectively are usually differently arranged and distributed. For convenience, short-cells are, and for many years have been, generally classified either as 'silica-cells', when each of them is more or less completely filled with a single silica-body, or as cork-cells when their cell-walls give the reactions of cork. This classification, while useful up to a point, is not always wholly satisfactory because cork-cells are commonly silicified, although usually to a lesser extent than the silica-cells by which they are accompanied. Furthermore, it is by no means unusual to find sporadically occurring long-cells filled with silica. The silica-bodies in the silica-cells assume very characteristic forms when the grass leaf is mature and are of considerable value for diagnostic and taxonomic purposes (Figs. I–IB). The long-cells (Fig. V) vary in length, and their walls vary in thickness as well as in the extent to which they are sinuous or pitted. Variations in these respects are often of specific diagnostic value.

(iii) *Stomata* (Fig. IV) (see also p. xlv)

Stomata, in grass leaves, are confined to the intercostal zones, and, in some grasses from exposed or dry localities, they are sometimes restricted to the sides or bases of furrows in the leaf surface. In most grasses they occur in well-defined horizontal bands in the intercostal zones, and each intercostal zone may include one or more stomatal bands according to the species. Furthermore, each stomatal band may include one or more rows of stomata. These facts may be made clearer by reference to the stomata shown in Figs. XXIII–XXIX.

The number of rows of stomata in each intercostal zone varies not only from one grass to another, but sometimes in different parts of a single blade or in leaves taken from different levels on the plant. Mention has already been made of grasses in which the stomata are all, or mostly, to be found on the sides or at the bases of furrows between tall adaxial ribs. This applies particularly to the leaves of grasses that tend to become inrolled when the conditions are dry, the stomata thus being in a protected position. The stomata are also well protected in grasses with acicular leaves (Fig. X), e.g. in certain species of *Festuca*, for here they are confined to grooves and furrows on the adaxial surface of the leaf. In some xerophytic grasses, e.g. *Trikeraia hookeri* (Fig. XXVIII, 6), the stomata are protected by overlying papillae, or the stomata may be in grooves protected by prickles, e.g. *Saccharum spontaneum* (Fig. VI, 4).

It is well known that in the Gramineae the two guard-cells of each stoma have a somewhat characteristic appearance, the cells having their lumina somewhat enlarged at either end and more constricted in the middle as seen in surface view. Both of the guard-cells of the stomata are accompanied on their outer, horizontal faces by a pair of subsidiary cells that stand out in marked contrast to the epidermal cells on their borders on account of their distinctive shape. It has been shown by Porterfield (1937) for certain bamboos that the subsidiary cells arise ontogenetically by divisions of adjacent epidermal cells and not from the mother-cell of the stoma itself. Indeed, the subsidiary cells can be recognized before the mother-cell of the stoma divides to give rise to the two guard-cells. Stomata arise firstly from the primary meristematic tissue of the leaf and partly at a later stage from mother-cells in the 'protoderm' which become secondarily meristematic.

Grass stomata, when fully mature, can be classified according to the shapes of their subsidiary cells (Fig. IV). The classes into which they can be divided are often sufficiently distinctive to be used for diagnostic and taxonomic purposes. It must be remembered, however, that stomata with subsidiary cells of more than one type may occur together in a single leaf, and that, as with all taxonomic characters, the shapes of the subsidiary cells tend to be somewhat intermediate in type in certain grasses.

(iv) *Interstomatal cells*

The remaining type of epidermal cell to which reference must be made is that which, in this book, has been designated 'interstomatal'. Interstomatal cells are those that lie in the same horizontal longitudinal files as the stomata, and serve to separate the individual stomata in an individual file from one

another. In grasses where the stomata in each horizontal file in which they occur are fairly or very numerous, each succeeding stoma is separated from its neighbour in the row by a single interstomatal cell of which the end-walls are concave where they fit round the stomata (Fig. V, 10–11).

5. Dermal Appendages

Appendages, of several more or less distinct but intergrading kinds, are very common on the epidermis of grass leaves, but they do not exhibit the wide range of morphological variations that is characteristic of those that are to be found in many families of Dicotyledons. In grasses the dermal appendages may conveniently be classified as (*a*) Macro-hairs, (*b*) Micro-hairs, (*c*) Prickle-hairs, and (*d*) Papillae.

(*a*) *Macro-hairs* (Figs. II–IIA) (see also p. xlii)

Macro-hairs have been so designated because they are nearly always much longer than the micro-hairs described below under (*b*). Very often they form an indumentum on a grass leaf which can easily be seen with the naked eye or simple hand-lens. Macro-hairs also nearly always differ from micro-hairs in being unicellular, although macro-hairs with fine, transverse partitions occur infrequently. Macro-hairs vary in length, in flexibility, in the thickness of the cell-walls, and in the extent to which their bases are superficial or penetrate between adjacent epidermal cells. When the bases of the hairs are sunken they are sometimes, but not invariably, surrounded by epidermal cells that are larger, more inflated, and often raised above the general level of the leaf surface than are the neighbouring cells of the epidermis. Macro-hairs of this type are often referred to as cushion hairs. In extreme examples the epidermal cells surrounding the bases of the hairs grow up around the hairs themselves, the hairs and their accompanying epidermal cells giving rise to an appearance that may be, at first sight, somewhat difficult to interpret. This occurs, for example, in *Indopoa pauperculus* (Fig. II, 5). Macro-hairs are probably homologous with prickles (see below under (*c*)), and indeed when prickles are provided with barbs of more than average length, or when macro-hairs are short, rigid, and thick walled, it is sometimes difficult to decide where the distinction between a macro-hair and a prickle should be drawn.

Macro-hairs are generally of no more than specific diagnostic value in taxonomy. They may occur in the intercostal zones, but, on the whole, are more commonly to be found over the veins or at the leaf margins. Intercostal macro-hairs are often cushion hairs, or at least have sunken bases.

(*b*) *Micro-hairs* (Figs. VII and XVI) (see also p. xliii).

These, as their name implies, are generally much smaller than macro-hairs, and they can most readily be studied with the one-sixth or one-twelfth objective. Furthermore, they are commonly two-celled, although this fact is not immediately apparent because the distal cell, which is almost invariably very thin-walled, is easily damaged, and commonly missing, especially in herbarium material. Even when micro-hairs are intact, the distal cell is often

obscure in outline because the very thin cell-wall does not readily take up stains. They can usually be observed most readily in glycerine mounts, or under a phase-contrast microscope, although, in favourable material, the distal cell has been clearly visible in permanent balsam slides. Sometimes the distal cell is very distorted even when it has not been totally destroyed, and this makes it very desirable not to rely too much on the shape of the distal cell as an indicator of taxonomic affinity. It is suspected that the hairs serve for the secretion of some undetermined substance or substances, and that the distal cell is destroyed when the secreted material is discharged. The wall of the basal cell of a micro-hair is nearly always much thicker and more durable than that of the distal cell.

It has already been mentioned that micro-hairs are very commonly two-celled, and they are usually referred to in the literature as two-celled hairs. Whilst this description is generally correct, micro-hairs that are one-celled sometimes occur, e.g. in *Sporobolus* spp. These one-celled hairs are small and of the same order of size as the two-celled hairs with which they are clearly homologous, and with which they must be classified. They cannot be regarded as macro-hairs because they are much too small. The common practice of classifying grass hairs into one-celled and two-celled categories is, therefore, unsatisfactory. The distinctions in their sizes and respective purposes appear to be much more fundamental. The term 'micro-hair' has therefore been adopted in preference to 'two-celled hair' in this book. Apart from micro-hairs that remain unicellular even when they are mature, it must also be remembered that micro-hairs that are two-celled when mature must pass through a unicellular stage during their development.

Micro-hairs commonly occur either in the stomatal bands, or in those parts of the intercostal zones that lie between the stomatal bands and the veins. They are, however, to be found elsewhere on the leaf surface in certain grasses.

(*c*) *Prickle-hairs* (Fig. VI) (see also p. xliv)

Prickle-hairs, as their name implies, are robust, sharply but shortly pointed structures, with swollen bases. They arise directly from, and their swollen bases form an integral part of, the epidermis. Their short points are usually directed towards the apex of the leaf, although exceptions to this have been noted. They are characteristically provided with thick, lignified walls. Prickle-hairs may be divided into two types which can be distinguished mainly on the basis of size, but it must be emphasized that prickle-hairs of intermediate size commonly occur. Another difference between the two types is that the smaller kind usually has a more rounded base which can best be seen when examined from above in surface preparations. The larger prickle-hairs are the 'aiguillons' of French writers on grass anatomy, whilst the smaller kind are 'crochets'. The terms 'prickle' and 'hook' are used throughout this book as the English equivalents of 'aiguillon' and 'crochet' respectively. Other English writers sometimes refer to prickle-hairs as 'asperities'.

Prickles and hooks may occur alone or together in the same grass leaf, or

they may both be absent. They are to be found above or between the veins, but it is more common to find prickles above the veins and hooks between them. Very angular, strongly pointed prickles are common at leaf margins, and frequently differ from others occurring elsewhere on the leaf. Structures that can best be interpreted as unbarbed prickles (Fig. VI, 6) have been noted in some grasses, e.g. *Arundo donax*, but are relatively uncommon. Apart from prickles that remain unbarbed when they are mature, it seems probable that those that eventually become pointed may pass through an unbarbed phase during their ontogenetic development, but this possibility needs further investigation. Usually, if not universally, one cell next to, and in the same longitudinal file of cells as, a prickle is a short-cell, so that prickles and short-cells are thus paired. It seems reasonable to suppose that prickles and short-cells are homologous.

(*d*) *Papillae* (Fig. III) (see also p. xliv)

Papillae are variously shaped protrusions from the outer walls of epidermal cells. In some species they are highly cutinized, and may indeed consist largely of cutin (Fig. III, 5). This applies particularly to grasses from dry localities, but this must not be taken to mean that grasses from dry localities necessarily have cutinized papillae. In other grasses that have them the papillae are conical or inflated in appearance (Fig. III, 6). In this book, the dome-shaped structures that occur over the veins of certain species (Fig. III, 1) have also been classified as papillae for descriptive purposes, although they differ considerably in appearance from the smaller papillae that are much more common. Papillae occur mostly on the long-cells, particularly in the intercostal zones, and there may be one or a number of them on a single cell. In some grasses there are several rows of papillae on the individual cells, and sometimes the papillae on a single cell are of two distinct sizes (Fig. III, 4). Papillae occur sporadically throughout the Gramineae, and they are especially numerous in, and characteristic of, certain taxonomic groups such as the bamboos. In this last group, as well as in some other grasses, those of the papillae which are on the epidermal cells next to the stomata often overarch and serve to protect the stomatal pores.

6. Lamina in Transverse Section

(*a*) *Distinction between midrib and the rest of the lamina* (Fig. XIII) (see also p. xlviii)

Leaves of some grasses have well-defined midribs, but in others this is not so. When a midrib is present it generally projects more prominently from the abaxial than from the adaxial surface and then constitutes a keel. In an individual leaf the midrib or keel usually becomes progressively larger towards the base of the lamina so that, in transverse sections through the lamina, the extent to which it is prominent and conspicuous depends on the precise level in the lamina at which the section is taken. The sections on which the original descriptions in this book are based were taken at a point about half-way between the leaf apex and the base of the lamina. When a midrib

or keel is described as being 'conspicuous' (Fig. XIII, 3–6), 'moderately conspicuous', or 'not conspicuous' (Fig. XIII, 1–2), it must be remembered that this refers to sections taken in the half-way position which was adopted as a standard. The vascular bundles in the midrib are discussed on p. xlviii.

The portions of the lamina on either side of the midrib are relatively thin, and the lamina frequently becomes still thinner towards the margins, although the margins themselves may again be thicker and they are frequently well supported by sclerenchyma. The two halves of the lamina are, in many grasses, arranged more or less symmetrically on either side of the midrib. This is by no means universally true, however, for, not infrequently, the portion of the lamina immediately to one side of the midrib is not symmetrical with that on the other.

(*b*) *Surface ribs and grooves* (Fig. XIV) (see also p. xlvii)

The adaxial surface of the leaf may be either flat or longitudinally ribbed, the ribs varying in height in different species. The ribs are separated from one another by wide or narrow grooves. Ribs are generally characteristic of, and more fully developed on, the adaxial than the abaxial surface, but abaxial ribs also occur, and in some grasses the abaxial ribs are taller than those on the adaxial surface. In a leaf with marked adaxial and abaxial grooves opposite each other, the leaf in transverse section has the appearance of a number of almost circular areas each enclosed by a pair of opposed ribs and having a vascular bundle at the centre, adjacent circles being connected to one another by much narrower portions of the lamina where the grooves are situated. In some grasses there are two specially prominent grooves, one on either side of the midrib, which serve to emphasize the boundary between the midrib and the rest of the lamina.

(*c*) *Epidermis*

The epidermis does not normally exhibit any particularly important diagnostic characters in transverse section, although it is often necessary to examine it in section as well as in surface view to establish the nature of papillae, the manner in which macro-hairs are attached to the epidermis, or to interpret the structure of micro-hairs.

(*d*) *Mesophyll* (Fig. XVIII) (see also p. xlix)

The term 'mesophyll' is generally applied to all of the ground tissue between the adaxial and the abaxial epidermis. It consists, for the most part, of the assimilatory tissue or chlorenchyma, but is often partly composed of translucent cells (see also under (*g*) on p. xlix), which are arranged in different patterns which appear to depend, at least in part, on the affinities of the grasses concerned. The chlorenchyma and translucent cells occupy all of the space in the leaf that is not taken up by the sclerenchyma or the vascular bundles and their surrounding sheaths.

Although the chlorenchyma of grasses, unlike that in the leaves of most

dicotyledons, only rarely exhibits a sharp differentiation into contrasting palisade and spongy portions, nevertheless, in some grasses the adaxial chlorenchyma consists of cells that are slightly more palisade-like than those towards the abaxial surface. Statements in the literature sometimes seem to imply that there is a bigger contrast between the palisade cells and the rest of the mesophyll than is justified by the facts. In most grasses from temperate regions the assimilatory tissue is more or less homogeneous and the cells not arranged in any definite pattern in relation to the vascular bundles (Fig. XVIII, 1). In many tropical grasses, on the other hand, the assimilatory cells appear, in transverse sections, to be orientated in a radiating manner around the vascular bundles, so that each bundle is at the centre of a circle, or partial circle, of chlorenchyma (Fig. XVIII, 2). These two contrasting types of chlorenchyma are commonly referred to by agrostologists as 'festucoid' and 'panicoid' respectively. This division of the grasses into those which have radiate and non-radiate chlorenchyma respectively is, as we shall see, an over-simplification, for the radiate structure is of more than one kind, and grasses with partially or incompletely radiate structure also occur. Nevertheless, the distinction between the chlorenchyma as radiate or non-radiate is useful for taxonomic purposes provided its limitations are recognized. The distribution is of more fundamental significance taxonomically than geographically. This subject is discussed further on p. liii et seq.

The chlorenchyma cells of some grasses, notably the bamboos and members of the Oryzeae, are characterized by inwardly directed projections from the cell-walls, the projections ending blindly in the lumina of the cells (Fig. XVIII, 3). It is not certain at present how these projections arise. They could be infoldings of the cell-walls, but in some grasses their appearance suggests that they arise as fine partitions that at first traverse the cells completely, but subsequently become broken as the cells become enlarged during their development. These cells are known as arm-cells.

Before leaving the structure of the mesophyll, mention must be made of the conspicuous colourless cells that are visible in transverse sections of the blade of most bamboo leaves, and which are also to be found in a few other grasses. In transverse section these cells, which have sometimes been incorrectly interpreted as intercellular spaces, usually have a somewhat fusiform or pyriform outline (Fig. XVIII, 3, F.C.). Karelstaschicoff (1868) appears to have been one of the first investigators who recognized these structures to be cells, and in his article they are figured and described quite accurately. Nevertheless, their true nature has not always been correctly understood, and, even comparatively recently, they have been referred to as if they were intercellular spaces (Jacques-Félix 1955). Brandis (1907), in his classical paper on the structure of bamboo leaves, recognized these structures as cells, although he sometimes refers to them as 'apparent cavities'. Their cellular nature was also understood by Page (1947) and this has been confirmed by the present writer (Metcalfe 1956).

Since these large, translucent cells are usually examined in transverse sections of the lamina, they may, for descriptive purposes, be referred to as 'fusoid-cells' on account of their fusiform appearance. It must be emphasized, however, that the fusoid appearance of the cells is misleading, for they

have the form of narrow plates that appear to be fusoid only when they are viewed from one side, either in macerated material (Fig. XVIII, 4*a*, *b*, *e*, *f*) or in transverse sections of the lamina (Fig. XVIII, 3, F.C.), the long axes of the cells lying at right angles to the long axis of the lamina itself. The lumina of these plate-like cells (Fig. XVIII, 6, L.) are very narrow and it is often very difficult to see them in vertical longitudinal sections of the leaf, despite the fact that these sections cut through the fusoid-cells transversely. Indeed, the cells are so thin that they could at first sight be mistaken for cell-walls. At the ends of the cells that respectively lie nearest to the adaxial and abaxial surfaces of the leaf, the lumina are slightly wider and more clearly visible (Fig. XVIII, 6, L_1 and 7, F.C.). The appearance of the cells in paradermal sections of the leaf is shown in Fig. XVIII, 4*c–d*. Vertical longitudinal sections of the leaf reveal that there are intercellular spaces (Fig. XVIII, 7, in. sp.) between adjacent fusoid-cells. Although their development has not been followed in detail, it seems reasonable to suppose that, when they are first formed, the fusoid-cells are in contact with one another, and that they become separated and assume their characteristic and unusual shapes during the ontogeny of the leaf. Fusoid-cells are especially characteristic of the mesophyll of bamboos as distinct from other grasses, although they vary considerably in size in different species and genera. In *Phyllostachys* they occur sporadically, and in some species are apparently absent. They were, however, seen by the author in some twenty other genera of bamboos that he examined and they were especially large in *Atractocarpa olyraefolia* Franch. and *Puellia ciliata* Franch. It should be noted that the author found fusoid-cells in species of *Neurolepis*, *Olyra*, *Pariana*, *Pharus*, *Streptochaeta*, and *Streptogyna*, a fact that suggests that there may be affinities between these genera and bamboos. Somewhat similar cells, which are, however, more nearly sausage-shaped, occur in *Leptaspis*. It seems very hard to believe that this very specialized and characteristic feature of bamboo leaves could have originated more than once during the evolution of the Gramineae.

(*e*) *Vascular bundles* (Fig. VIII) (see also p. xlvi)

The vascular bundles, apart from those in the midrib, are generally arranged in a single row, and they are embedded more or less in the middle of the mesophyll, although they may be closer to the abaxial or adaxial surface in different species. There are exceptions to this, however, e.g. in *Stipa tenacissima* where the bundles in the leaf are not all at the same level between the adaxial and abaxial epidermis. In acicular leaves the bundles are no longer in a straight row, but in a U-shaped series corresponding to the shape of the leaf in transverse section (Fig. X). The total number of bundles in a cross-section through a blade taken half-way between the sheath and the tip varies with the width of the leaf. Apart from this, however, the vascular bundles are much more crowded in the leaves of some grasses than in those of others.

The vascular bundles are of different sizes, and it is usual to find bundles of different sizes or orders not only in different species, but also in a single leaf. The bundles are arranged in such a way that those of different orders alternate with one another as the observer passes from the midrib towards the leaf margin or vice versa. There are many variations in the distribution pattern

of bundles of different orders in any one leaf, and these patterns are usually diagnostic for the species in which they are exemplified. It is impossible to describe in a few words the various types of distribution pattern for vascular bundles that are known to occur, but it seems to be universally true that where the bundles in a single leaf are of more than one order, there are, as the observer passes from the midrib to the leaf margin, always one or more relatively small bundles between consecutive bundles of the first order.

In should be noted that the outlines of vascular bundles as viewed in transverse sections are by no means uniform throughout the grasses. Bundles are commonly more or less circular or elliptical in outline, but very often the outlines are conspicuously angular. In this connexion it is most important for the reader to realize that the author pictures the vascular bundle as consisting solely of the xylem and phloem, the bundle-sheaths not being treated, for descriptive purposes, as if they are parts of the bundles themselves. Thus when a vascular bundle is described as being circular or angular in outline, these terms refer only to the outline of the xylem and phloem. Small bundles are more often conspicuously angular than large ones, but, from the taxonomic standpoint, the most interesting fact is that small angular bundles are especially characteristic of the panicoid grasses. Even here, however, the small bundles in an individual leaf are usually more conspicuously angular than those that are larger.

(*f*) *Bundle-sheaths* (Figs. XI–XII) (see also p. l)

Nearly every vascular bundle is surrounded, either completely or partly, by one or two bundle-sheaths, each sheath consisting of a single layer of cells. The outer sheath (contracted to O.S. in the descriptions) when two are present, or the single sheath where there is but one, generally consists of parenchymatous cells with thin, or not more than slightly thickened, walls. In transverse sections the cells are inflated and conspicuous in most grasses, the observer's eye being immediately drawn to them by the fact that they are larger than neighbouring mesophyll cells. There are, however, a few grasses in which the outer bundle-sheath is relatively inconspicuous (e.g. those of the midrib bundles in *Leptaspis*), and on the whole the sheath-cells are more inflated in the panicoid than in the festucoid grasses. The cells of the outer sheath are either translucent, or they may contain a green pigment. The green pigment is generally stated to be chlorophyll, although it is frequently in granules of larger size, and darker in colour, than the chloroplasts that occur elsewhere in the leaf. The cells of the inner sheath (I.S.) are nearly always smaller in diameter and with thicker walls than those of the outer sheaths, as viewed in transverse sections, and longitudinal sections show them generally to be elongated. In transverse sections the cells of the inner sheath are often more strongly thickened on their inner tangential and radial walls than elsewhere.

Single sheaths are generally characteristic of panicoid and double sheaths of festucoid grasses, and numerous statements to this effect are to be found in the literature. The author has found by experience, however, that, although the distinction is a valuable one, it is not absolute, and furthermore there are some grasses in which it is difficult to decide whether one or two sheaths are

present. This is because the cells of the inner sheath are not always sharply differentiated from those forming the thick-walled fibrous ground tissue of the remainder of the vascular bundle. Numerous examples are to be found in the descriptions of the individual genera and species. In view of the occurrence of sheaths that are not convincingly single or double it is, for taxonomic purposes, more profitable to recognize the existence of three categories—single, double, and intermediate—rather than of single and double alone.

(*g*) *Sclerenchyma* (Figs. IX and X) (see also p. xlvii)

A grass leaf clearly could not withstand the physical strains and stresses that are imposed upon it without mechanical support for the softer tissues. Support is provided by fibrous and other types of thick-walled cells that collectively constitute the sclerenchyma. This is in the form of subepidermal longitudinal strands or girders which follow the course of the vascular bundles. There are certain species in which the sclerenchyma lies between, rather than above or below, the vascular bundles, but this is more unusual. The strands of sclerenchyma frequently do not extend inwards from the epidermis to a sufficient depth in the mesophyll to make contact with the bundle-sheaths. Very often, however, the sclerenchyma, especially when it is opposite the large or medium-sized vascular bundles, penetrates more deeply from the epidermis into the mesophyll so that its inner face is actually in contact with, or envelopes, the bundle-sheaths. In transverse sections, sclerenchyma of the first type will appear as 'islands' of lignified tissue lying above and below, or on one side only, of each vascular bundle. Sclerenchyma of the second type will appear as girders extending from either or each epidermis to the bundle-sheath. In this book, for descriptive purposes, a distinction is drawn between sclerenchyma that does not come into contact with the bundle-sheaths and that which penetrates more deeply and does so. The first type is referred to as consisting of 'strands', and the second type as consisting of 'girders'. A vascular bundle with the more intimate, second type of mechanical support is also described as being 'girdered' by sclerenchyma. The amount of sclerenchyma that is present varies from species to species, and strands and girders often occur together in association with different bundles in a single leaf, the large bundles being more massively supported than those that are small. Sclerenchyma is especially well developed in grasses from dry or arid localities, while with many tropical grasses, on the other hand, it is common to find a high proportion of the small bundles not accompanied by sclerenchyma. The distribution of the sclerenchyma associated with the vascular bundles is thus both of ecological and taxonomic interest, but from the taxonomic standpoint it is seldom of more than specific diagnostic value (see also p. lix).

Besides the sclerenchyma that is associated with the vascular bundles, or which lies between them, strands of various sizes are common in the leaf margins, and strands or plates of sclerenchyma that are not immediately associated with vascular bundles also occur beneath the adaxial epidermis of the midrib.

It should be noted that, although the sclerenchyma is usually lignified in a broad sense, the degree of lignification and apparently the chemical nature of

the substance to which anatomists refer as lignin both vary. This has been shown, for example, in *Stipa tenacissima* (see p. 485).

(*h*) *Bulliform and colourless cells* (Fig. XV) (see also p. xlix)

Transverse sections of the lamina nearly always exhibit certain cells that stand out in marked contrast to their neighbours because they are translucent and colourless. The very specialized 'fusoid-cells' that occur particularly in the mesophyll of bamboo leaves, and also the inflated cells of the outer bundle-sheaths, have already been considered. We must now discuss the translucent, parenchymatous cells that occur elsewhere in the grass leaf.

It is only necessary to examine transverse sections of the leaves of a few common grasses before becoming familiar with groups of colourless cells that form part of the epidermis but differ from their neighbours in being larger and more inflated. These are often referred to as bulliform cells. They occur most commonly, but by no means exclusively, at the bases of the furrows in the adaxial surface of the leaf; in some grasses they form part of the abaxial epidermis as well as, or instead of, the adaxial epidermis. Bulliform cells, although appearing as variously shaped groups when viewed in transverse sections, actually form bands parallel with the long axis of the leaf. They were at one time known as 'hinge-cells' or 'motor-cells' in the belief that by inflation and deflation, due to changes of turgor, they controlled the rolling or folding of the leaves in which they occur. Without entering into a detailed discussion concerning their importance in this connexion, it may be noted that this topic is controversial. The attention of elementary students is often drawn to the bulliform cells that occur in the well-known Marram Grass (*Ammophila arenaria*), so common on coastal sand dunes, the leaves of which are known to become tightly inrolled. It is sometimes suggested that this inrolling is caused by the bulliform cells. In this connexion it may be noted that the bulliform cells of Marram Grass are less well developed than those in the leaves of many other grasses that are less liable to become infolded or inrolled. Furthermore, it should be remembered that the outer walls of bulliform cells are often quite thick, and that it is by no means unknown for their lumina to become filled with silica. It is difficult to understand how cells with these characteristics are likely to have an important 'motor' function. Because it is uncertain how far these cells are important in controlling the folding and rolling of leaves, it seems appropriate to refer to them by Duval-Jouve's purely descriptive term 'bulliform' which does no more than denote their bubble-like appearance.

Besides the cells that are here covered by the designation 'bulliform', other colourless cells occur in the mesophyll of grass leaves, where their frequency and distribution vary with the species of grass concerned. They are often immediately subjacent to the intercostal epidermal cells (Fig. XV, 10–11), or they may be more deeply seated in the mesophyll, and often appear in transverse sections as girders extending from the adaxial to the abaxial epidermis (Fig. XV, 13–14). These cells may be about the same size as, or rather larger than, the assimilatory cells, but, whatever their size or distribution may be, their universal characteristic is to be translucent. Their arrangement and

distribution amongst the other cells of the leaf are considered further on p. xlix.

(*j*) *Crystals*

It is well known that crystals (generally of calcium oxalate) of various sizes and shapes occur in many Dicotyledons and some Monocotyledons. Their forms and distribution are often of diagnostic value. It is doubtful whether true crystals ever occur in the Gramineae. On the other hand, small, generally cubical silica-bodies have sometimes been mistaken for crystals. These silica-bodies should not be confused with those that occur in the epidermis. They have been noted by the author particularly in the cells of the bundle-sheaths in a few grasses. Silica-bodies, not being crystalline, can be distinguished from true crystals by examining them with the polarizing microscope. So far the author has failed to detect the presence of genuine crystals in the Gramineae by this method. It should be noted, however, that Molisch (1918) claims to have found crystals as well as silica-bodies in *Bambusa*.

7. Culm

(*a*) *General considerations*

The culms of grasses are typically hollow cylinders interrupted at intervals by transverse partitions. The hollow units between the partitions represent the internodes and the transverse septa are at the nodes. Although this fistulose structure of the culms is characteristic of most grasses, no matter whether they be arboreal bamboos or quite small annuals, it should be remembered that the distal part of an otherwise hollow culm is often solid, and also there are some grasses, of which maize is a well-known example, in which the culms remain solid. The diameter of the hollow centre may be large or small in relation to the total diameter of the culm (Figs. XIX–XXI, H.C.). A state that is intermediate between the hollow and solid culm is presented by those grasses, e.g. *Miscanthus condensatus* (Fig. XX, 5), in which the central ground tissue becomes loose and spongy without actually breaking down sufficiently to become hollow.

The fistulose type of structure is mechanically sound, since it enables the culms to withstand bending stresses with the maximum economy of structural material. Its great weakness lies in the fact that the elongation of culms takes place at the bases of the nodes from so-called intercalary meristems. This means that the mechanical tissue is least developed in portions of the culm that must have to bear the weight of the more mature parts that lie above them. Compensation for this is provided by the sheathing bases of the leaves, each with its own mechanical tissue, which surround and protect those portions of the culm that are in most need of mechanical support.

(*b*) *Component tissue of the culm*

Transverse sections show that the culm is built up essentially of parenchymatous ground tissue, some of which contains chloroplasts and serves for

photosynthesis, whilst mechanical support is provided by fibres and other elongated cells with thickened walls, the conduction of food and sap being through the collateral vascular bundles. These components are variously arranged in relation to each other in different grasses, but similarity of culm structure is not necessarily an indication of taxonomic affinity. For this reason, and also because of differences in the appearance of sections taken at various levels in an individual culm, the author regards sections of culms as being of limited taxonomic value, although no detailed work has been undertaken to test this view. The epidermis of the culm, in surface view, is undoubtedly of greater taxonomic interest, for there, as in the leaf, the epidermis is made up of long-cells and short-cells, the latter being differentiated into silica-cells and cork-cells. Stomata are restricted to longitudinal strips overlying the assimilatory tissue. Variations in the epidermal cells provide useful taxonomic characters, but it must be remembered that the structure of, for example, the silica-bodies, is not always alike in the culm and leaf of the same species. This is a subject that would repay further investigation.

(*c*) *Mechanical tissue*

The prosenchymatous, mechanical tissues are developed to the greatest extent in the peripheral part of the culm where they provide effective support in resisting the strains and stresses to which the culm is subjected. The inner ground tissue, on the other hand, typically, but not universally, consists of large, thin-walled, parenchymatous cells. These occupy the centre of the culm in those that are solid, or surround the central cavity in those that are hollow. Small, triangular intercellular spaces are very common between the cells in these regions. The transition between this thin-walled central parenchyma and the more peripheral prosenchymatous tissue may be gradual or abrupt. An example of gradual transition is afforded by *Miscanthus condensatus* (Fig. XX, 5). Owing to the limitations imposed on the draughtsman by the necessity of having to represent tissues by conventions, a gradual transition cannot be adequately represented in a formal diagram. It would, therefore, have been misleading, in Fig. XX, 5, to represent the sclerenchyma in solid black as this does not adequately portray the gradual transition from parenchyma to sclerenchyma as it occurs in nature. In referring to Fig. XX, 5, a reader should, therefore, remember that the ground tissue consists of much narrower, thicker-walled cells where the vascular bundles are mostly concentrated as compared with other parts of the section. In other grasses, e.g. *Holcus lanatus* (Fig. XIX, 1–2), the sclerenchyma is in the form of a cylinder, and this unicylindrical type of sclerenchyma is very common. In other grasses the sclerenchyma is in two concentric cylinders separated from one another by relatively thin-walled ground tissue. An extreme example of bicylindric sclerenchyma in a grass culm is provided by *Glyceria maxima* (Fig. XXI, 4), where there is a great mass of spongy tissue (Fig. XXI, 7) between the two cylinders of sclerosed cells. In massive grasses, such as the bamboos, the whole of the ground tissue is often thick-walled and lignified, but even here the peripheral part is more highly lignified than the remainder.

Furthermore, the individual vascular bundles, even in the inner part of the culm, are accompanied by strands of thick-walled fibres.

(*d*) *Chlorenchyma*

The culms of grasses are usually green owing to the presence of chlorenchyma. In grasses where the peripheral tissues are largely fibrous it is usual to find that the chlorenchyma is in the form of longitudinal columns bounded externally by the epidermis and otherwise surrounded by, or embedded in, the peripheral sclerenchyma (Fig. XIX, 2 and 4, A.T.). In other grasses the chlorenchyma may form a continuous, or almost continuous, cylinder subjacent to the epidermis, or the cylinder may be traversed at intervals by girders of sclerenchyma, one of which often lies opposite each of the outermost vascular bundles and extends from these to the epidermis. It is a remarkable fact that thin-walled cells situated on the inner side of the peripheral sclerenchyma sometimes contain chloroplasts, thus indicating that the walls of the epidermis and subjacent sclerenchyma must be sufficiently translucent to allow enough light to penetrate for photosynthesis to take place. The intense colour generally assumed by lignified tissues after they have been stained for microscopical examination probably creates the illusion that they are less translucent than they in fact must be in the living culm.

It should be noted that the cells of the chlorenchyma are frequently irregular in shape and arrangement, and exhibit no characteristic pattern. It has been noted, however, that the radiate arrangement of the assimilatory cells, which is displayed in the leaves of panicoid grasses, is also to be seen in the culm, especially when the chlorenchyma lies next to the vascular bundles. The author has made no attempt to ascertain if species that have radiate chlorenchyma in the leaf are always the same as those that have radiate chlorenchyma in the culm, but this may well be so.

(*e*) *Intercellular cavities or canals*

It should be noted that aquatic grasses, in common with other plants that occur in water, develop intercellular air-cavities or canals. These vary in size, shape, and distribution in different species (Figs. XX–XXI, I.C.), and, in some grasses such as *Sacciolepis* (Fig. XXI, 1–2), the cavities modify the general appearance of the culm so greatly that it is hard to realize at first sight that a transverse section could be that of a grass culm. Intercellular cavities sometimes contain stellate cells (Fig. XXI, 2, S.C.).

(*f*) *Vascular bundles*

The vascular bundles in the culm of a grass, like those in other monocotyledonous stems, are usually described as being scattered. This is true if the term 'scattered' is envisaged in a broad sense. The term is most strictly correct when it is applied to solid culms of the *Zea* type in which a transverse section shows the vascular bundles to be widely distributed and irregularly scattered throughout the cross-sectional area of the culm. Even in a solid culm of this type, however, the vascular bundles are much more widely spaced towards the centre than towards the periphery of the culm. In different species of grass, all transitions are to be found between culms of the *Zea* type and those in which the vascular bundles are in a single circle or a few concentric circles.

The number of circles that are present is largely bound up with the diameter of the culm, and the proportion of its cross-sectional area that is hollow. The circles are often not well defined, and they may be sinuous or irregular. It is usual to find that the vascular bundles nearest to the centres of the culms are much larger than those that are next to the epidermis. More often than not, those of the outermost circle are embedded in the peripheral sclerenchyma.

The individual vascular bundles are usually more or less circular, or oblong to elliptical, in transverse section, but their shapes vary considerably in grasses of various affinities. Compare, for example, those of *Spartina* (Fig. XXI, 8), *Holcus* (Fig. XIX, 2), and *Phyllostachys* (Fig. XIX, 10). The bundles are collateral, with the phloem (Fig. XX, 3, Ph.) at the pole of the bundle towards the periphery of the culm, where it is usually embedded in a fibrous tissue. The phloem is made up of sieve elements and phloem parenchyma, the sieve elements in many grasses being remarkable for their large diameter. This does not apply throughout the Gramineae, however, as there are many grasses in which the diameters are much smaller.

In small vascular bundles the metaxylem vessels are not conspicuously larger in diameter than the neighbouring cells (Fig. VIII, 1–6). In most, or all, of the other vascular bundles, however, the metaxylem is usually characterized by two (or occasionally more) vessels of which the diameters are conspicuously greater than those of any of the other cells of which the vascular bundle is composed (Fig. VIII, 7–18). The metaxylem elements have simple perforations in their end-walls, and in no grass have vessel elements with scalariform perforation plates been found. The protoxylem, lying at the opposite pole of the bundle to that at which the phloem is situated, usually has a solitary vessel or a short radial row of vessels that have much shorter diameters than the other vessels, but the protoxylem elements usually break down quite early in the life of the bundle, and are replaced by longitudinal, intercellular cavities (Fig. XX, 3, A.C.) in which the annular or spiral thickenings of the original vessel elements are sometimes to be seen.

Although there are differences of detail in different grasses it is usual to find that all of the bundles in the culm are directly continuous with those in the leaf. On entering the culm at a node the bundles pass inwards and then downwards, the median bundles penetrating more deeply than those that are lateral. In maize, for example, all of the bundles pass downwards through two or more internodes without anastomosing with other bundles. Eventually, however, they unite with other leaf-traces from a lower node, and the number of anastomoses occurring in this way keeps in line with the number of leaf-traces entering the culm from the lower nodes, so that it is usual for the number of bundles to remain relatively constant throughout the length of the culm. The leaf-traces that penetrate the culm to a deep level gradually pass outwards towards the periphery of the culm as they pass downwards through the lower internodes. This accounts for the fact that the bundles tend to become concentrated towards the periphery of the culm.

The nodes of grasses, especially those with large culms, exhibit a complex system of anastomosing vascular strands, embedded in the parenchymatous tissue. The ground tissue, as we have already noted, is in the form of septa even in those grasses that have hollow internodes.

8. Rhizome

Grass rhizomes, in species where these subterranean stems are well developed, are essentially similar in structure to the culms. It is usual to find, however, that sclerenchyma is less well developed, and that the ground tissues frequently serve for the storage of starch or other food reserves.

9. Root

Although there are differences of detail both in roots of different sizes from any one species, and also in roots of similar size belonging to different species, transverse sections of grass roots show that the same general type of structure is common to them all.

It is well known that a young root, shortly behind the growing-point, is bounded externally by a piliferous layer bearing root-hairs. In some grasses, however, especially species growing in sandy regions, root-hairs are long and persistent, the roots being covered with them throughout a good part of their length.

In most grass roots, however, the outer walls of the outermost cells become thickened, or the piliferous layer may become detached, its cells drying up and withering when food supplies are cut off from below. There is often a hypodermis of thin-walled cells just beneath the outermost layer of cells, and on the inner side of the hypodermis a narrow zone of fibres develops. This type of structure is to be seen, for example, in transverse sections through a root of *Paspalum commersonii* about 1 mm in diameter (Fig. XXII, 1–2). Beneath the narrow ring of sclerenchyma (scl.) there is a broad cortex. The outer, larger part of the cortex has a very characteristic appearance owing to the fact that it consists of radiating plates of cells (C.P.) with large radiating intercellular cavities (I.C.) between them. The intercellular cavities no doubt arise as the root increases in girth and some of the cells collapse. The cells constituting the plates between the intercellular cavities themselves tend to contract and collapse, and, in a typical transverse section, cells in various stages of disorganization are to be found. This type of structure in the outer part of the root cortex is very common in grasses, but it is interesting to note in the literature that authors have repeatedly drawn attention to this type of structure as if it were a special feature in the grass or grasses in which they happened to be interested.

The inner part of the cortex consists of parenchymatous cells that are arranged in very definite radial rows with small intercellular spaces between them (Fig. XXII, 1). The innermost layer of cortical cells is in contact with an endodermis which is very conspicuous because of the U-shaped thickenings of the inner tangential, radial, and end-walls of each cell. Passage cells may frequently be recognized. The endodermis surrounds the stele in which the most conspicuous feature is a circle of metaxylem vessels. The number of metaxylem vessels varies with the diameter of the root, and, in very narrow roots, it is common to find a single, central, axile metaxylem vessel in place of the circle of vessels that are characteristic of wider roots. In the roots of many grasses protoxylem vessels, much smaller in diameter than the metaxylem

vessels, also occur. These are often twice as numerous as the metaxylem vessels and alternate with small strands of phloem. The phloem strands commonly become very inconspicuous in mature roots. The ground tissue of the stele consists of cells that are thin or thick-walled in different species and the very centre of the root is often pith-like. In the roots of some grasses a narrow pericycle can be recognized immediately on the inner side of the endodermis, but this zone is not always clearly differentiated.

A root of *Cleistachne sorghoides* 2 mm in diameter differs from the type that has just been described in having a much broader zone of peripheral sclerenchyma, a cortex that does not break down into radiating plates of parenchymatous cells, and the metaxylem vessels are more numerous. The same radiating arrangement of the inner cortical cells is to be seen, and it is interesting to note that a solitary silica-body is present in each endodermal cell.

Further descriptions of roots of other grasses are given in this book under some of the individual species. Root structure has, however, been studied in only a few of the species that have been examined, so it is not known how far the differences between them are of taxonomic value.

Adventitious roots arise in the pericyclic region.

DIAGNOSTIC MICROSCOPICAL CHARACTERS

1. General Considerations

In the preceding section the morphology and anatomy of the grass plant were considered in general terms. With this background in mind we must now ask ourselves which anatomical characters can most usefully be employed to aid in the identification and classification of grasses. The taxonomic conclusions that have been reached are not mentioned in this section, except in passing, and this topic is discussed more fully on pp. li–lix.

No microscopical characters can be used successfully for diagnostic or taxonomic purposes unless they can be made clearly visible by the use of simple, rapid techniques. Furthermore, the characters must be capable of precise definition, and it is useless to rely on any that cannot be unambiguously recognized. Where it is not possible to decide easily whether a particular specimen or species of grass exhibits diagnostic character *a* or its alternative *b* it is much wiser to face up to this fact at once and to seek to establish its identity or affinity on other grounds. It must always be remembered that living organisms do not always consist of taxa with clearly defined boundaries between them. This is inevitable from the very fact that evolution has taken place by descent with modification, the modifications usually being slight and gradual.

Although there is a strong human urge to arrange living organisms in well-defined taxonomic compartments, the divisions between these compartments must always be somewhat arbitrary because, as any unbiased observer of nature cannot fail to recognize, living organisms constitute a continuum and not a series of discrete entities. The taxonomist will therefore be attempting the impossible unless he recognizes that the interrelationships of organisms cannot ever be wholly and completely expressed in the form of a compartmentalized system. This is far from saying that all attempts to arrange living organisms on a natural taxonomic basis are useless. All that the author wishes to do is to remind his readers that, because nature abhors distinct lines of demarcation, our present methods of recording taxonomic data can represent the interrelationships of living and extinct plants no more than imperfectly. We must studiously avoid the very natural temptation to distort facts, or interpretations of facts, so as to enable us to support any preconceived ideas we may have concerning the classification of the organisms in which we are interested. As we read the open book of nature we should remember that, as taxonomists, it is our duty to discover and interpret the natural, systematic order that actually exists and the course that evolution has already taken and is still following. Our task is to reveal and not to invent.

Evolution is now accepted as an historical event, and as a series of changes that have taken place with the passage of time. It is the very nature of historical events that they can and in fact do take place only in the way in which we are able to establish that they occur. Unfortunately the sequence of events

that is known to us as the course of evolution is still very imperfectly understood, but, since these events are believed to be historical facts, it is still open to us to seek for evidence of the exact manner in which they took place. It should be our aim as biologists to seek to reveal further evidence concerning this course of events as it actually took place, and this in turn must lead us further towards the one, true, natural classification of organisms.

It is not for us to substitute our own ideas of how we think organisms ought to be classified for the true natural order, the discovery of which should be our ultimate goal. We must refrain from observing nature whilst our vision is restricted by the spectacles of our own preconceived ideas.

It may seem to many readers that it is pointing to the obvious to draw attention to the difficulty of classifying living organisms, but it is the writer's experience that taxonomists so often seem to be surprised or distressed when it is not easy to distinguish between two alternatives or to decide in which taxonomic compartment an organism should be placed. No doubt we are misled from the outset by writers of textbooks who draw clear lines of demarcation between morphological characters or categories. It is easy to do so until sufficient material has been examined, and, generally speaking, outlines of, and distinctions between, characters become progressively less obvious the more one learns about the material in which they are supposedly exemplified. Readers of this book should realize that this difficulty has continually been very much in the mind of the author, and it must be remembered that variations of and transitions between the characters that are of diagnostic value are to be met with very frequently. No apology is made for this, however, for it is clearly the duty of the grass anatomist to observe his material as it occurs in nature and to draw from it such conclusions about its classification as are justified on the available evidence. It would be wrong to 'force' the genera and species into taxonomic compartments when evidence is inadequate. It is much sounder to suspend judgement in these circumstances than to assign a taxon to a dubious position. There can be no harm in admitting that we do not know everything. Furthermore if, by frankly admitting that we do not know where to place it, we draw attention to the fact that the affinities of any particular taxon are uncertain, it is probable that the taxon in question will receive special attention and so the prospects of ultimately finding the best niche for it will be greatly increased. If we leave a taxon buried in a position to which it does not really belong without drawing attention to this fact it may well remain there unnoticed by those very specialists who are most likely to be able to throw some light on its true affinities.

Although intermediate or borderline anatomical characters are frequent, and cause difficult problems wherever they occur, it is, fortunately, far more usual to find characters falling quite clearly into definite categories. Much can therefore be done by the anatomist to aid the agrostologist in classifying his material on a natural basis, provided, as has already been emphasized, that he uses characters that can be made visible by simple, rapid techniques. This may perhaps be made clearer by the following considerations. The practical taxonomic value of, for example, following the precise course of the vascular bundles in the culm of a grass is limited, not so much by the fact that information on this subject would necessarily be of no importance, but because

a busy taxonomist or anatomist would seldom, if ever, have sufficient time to follow the bundle course in more than a limited number of species. Similar considerations would apply in studying the development of the apical meristem. We must, therefore, be realists and devote our attention to collecting data that can be assembled sufficiently rapidly to be of everyday use in taxonomy.

In the vegetative organs of the Gramineae the most important diagnostic characters are to be found in the leaf. It must be remembered, however, that (i) there are minor anatomical variations within a single leaf-blade; (ii) that leaves from different levels on an individual plant exhibit structural variations; (iii) that leaves from plants belonging to a single species grown in different habitats also vary within limits. In the author's experience, however, intraspecific differences are very minor when compared with those that are interspecific, many of them being quantitative rather than qualitative.

In dealing with intraspecific variations it should be remembered that an individual leaf grows in length from a basal meristem. It follows that the apex of the leaf is mature whilst the basal part is still completing its ontogenetic development, intermediate parts of the leaf showing a gradual transition from mature to immature characters on passing downwards. It has been noted by the author, for example, that, in a single leaf of a species of *Sporobolus*, short-cells are mostly in pairs, but that they are more frequently in short rows towards the apex than towards the base of the lamina. It has also been noted that the epidermis of different parts of cauline and basal leaves of *Festuca arundinacea* exhibits only comparatively small microscopical differences (Fig. XXIV). Then again, comparison of the leaves of specimens of *Cynodon dactylon* (see p. 123) from different localities and from plants of various sizes and habits shows that there are variations in the size and frequency of the epidermal papillae. This is, however, but a small variation when it is seen against the fact that the leaf structure in this species is otherwise constant. It has been noted, from time to time, that species of Gramineae cultivated at Kew are 'softer' and less rigid in their leaf structure than are the same species grown in the wild. It might be expected that corresponding microscopical differences would be found to exist, and that these would be great enough to destroy the microscopical method as a satisfactory aid in taxonomy. It is true that the softer growth of Kew specimens is due to the fact that the sclerenchyma is much less well developed and less lignified compared with overseas specimens of the same species. Furthermore, where silica-bodies are abundant and well developed in a specimen from overseas, they are frequently less so in specimens grown at Kew. In spite of these variations we have no evidence that the form of silica-bodies or the distribution pattern of sclerenchyma differ in Kew-grown specimens as compared with wild specimens of the same species. Such differences as exist are indeed quantitative rather than qualitative. In comparing specimens of any one species from two different localities it is important to bear in mind that small variations may occur, for it is clearly undesirable to attach undue importance to quantitative distinctions provided there is good qualitative agreement in the structure.

Allowing for the limitations that have just been discussed, it has been found in practice that a list of characters of proved diagnostic value can be drawn up.

In order to see all of them it is necessary to examine the epidermis in surface view and the lamina in transverse section. Because of the small variations that are known to occur in different parts of a single leaf it has been the custom in the work at the Jodrell Laboratory to pay particular attention to the abaxial epidermis from a point half-way between the apex and the base of the lamina, whilst transverse sections of the lamina have been taken in the same position in the leaf. The abaxial rather than the adaxial epidermis has been selected as a standard for comparison because the longitudinal ridges and furrows that are characteristic of the adaxial surface of many diverse genera and species make it difficult to prepare satisfactory slides.

Many, indeed most, of the diagnostic characters that follow have been used to a greater or lesser extent by previous investigators. In comparing the work of grass anatomists in general, however, one is confronted by the difficulty that many investigators have used the same anatomical terms in slightly different senses. One agrostologist may describe the heights of the ridges and depths of the furrows on the leaf surface of a certain species as tall and deep respectively. A second agrostologist who has occasion to compare the same species with others that were not examined by the first, may see the relative heights and depths of the ridges and furrows in another light and describe them in different terms. Then again terms such as 'saddle-shaped', 'cross-shaped', &c., have not always been used in precisely the same sense by different authors. The present author has, therefore, attempted to give more precision to the meaning of the descriptive terms by illustrating many of them with line drawings (Figs. I–XV).

2. Standard Line Drawings of the Diagnostic Characters

Figs. I–XV have been drawn from epidermal preparations and transverse sections of the lamina of the species named in the legends accompanying the figures. In some of the diagrams a number of separate drawings have been made to show the range of variation in any one character that has been noted in a single species. For example, Fig. I, 9, i–vii, shows the various shapes of silica-body that have been noted in *Chloris robusta*. These can loosely be classified as 'saddle-shaped', although this term covers a considerable range of variations in shape. The four silica-bodies of *Eleusine indica* in the lower part of Fig. I, 5, can likewise be classed as 'saddle-shaped' although they are not exactly like those of *Chloris robusta*. Then again the silica-bodies of *Aristida longiflora* are, loosely speaking, dumb-bell shaped, although the body in Fig. IA, 18*c* (i) is nodular and very similar to the nodular body of *Brachiaria distichophylla* shown in Fig. IB, 22 (iii). Facts such as these show that it is quite common to find bodies of more than one kind closely associated with one another in the same leaf, and the occurrence of these combinations of types is repeatedly made clear in the descriptions of the individual species in the body of the text.

On looking through Figs. I–XV it soon becomes evident that the lines of demarcation between some of the characters that have been illustrated are not very sharp. This confirms what has been said on p. xxxviii, where attention was drawn to the occurrence of intermediate characters. In using Figs. I–XV it follows that independent investigators might well have difficulty in deciding, for example, whether the micro-hairs in a particular grass were more like those in Fig. VII, 4, or whether they more closely resembled those in Fig. VII, 5 or 6. Then again, there are transitions between stomata with triangular subsidiary cells (Fig. IV, 1) and those with low, dome-shaped subsidiary cells (Fig. IV, 3). This kind of difficulty arises all the way through, and the reader must regard the figures as guides rather than as providing absolute standards for comparison. We are not dealing with a problem comparable with classifying postage stamps which conform to specific designs drawn up in agreement with a printing firm. We have before us biological material that does not conform exactly to immutable designs. In using the figures it is therefore very often necessary to indicate that the appearance of a diagnostic character in a particular species varies from that shown in one figure to that shown in another.

3. The Diagnostic Characters

A. *Characters of the epidermis*

(*a*) *Short-cells and silica-bodies* (Figs. I–IB) (see also p. xx)

It should be noted that, in a grass leaf, it is usual to find that the short-cells above the veins (i.e. in the costal zones) are not necessarily of the same types, or arranged in the same way, as the short-cells of the intercostal zones. In comparing two grasses it is therefore important to ensure that no confusion arises through mistakenly comparing an intercostal zone with one from above the veins. On the whole the morphology of the short-cells above the veins appears to be rather more important taxonomically than is that of the intercostal short-cells, but both can usefully be taken into account.

First of all the distribution and relative frequencies of the short-cells should be considered. Observing the short-cells in a single file, i.e. longitudinal or horizontal row of epidermal cells, it will be seen that they may be solitary, in pairs, in rows of 3–5 cells, or in rows of more than 5 cells. As we have already noted (p. xx), where the short-cells are in pairs, each pair usually consists of a so-called cork-cell and a silica-cell. Where they are in rows it is usual to find cork-cells and silica-cells alternating with one another in each row. It would no doubt be ideal to record their frequency as the number per unit area of leaf surface, but, when making a broad survey of a considerable number of grasses, it is seldom possible to spare enough time to do this. It is, however, useful to classify them loosely as 'abundant', 'common', or 'infrequent or absent'. It is also important to note whether there is a marked difference in the frequency of short-cells in the intercostal as compared with the costal zones, for they are often by no means equally frequent in both. It is quite common for them to be 'abundant over, and infrequent or absent between, the veins'.

Apart from the frequency and distribution of short-cells, the shapes of the silica-bodies in the silica-cells are very important for taxonomic purposes. Furthermore, it cannot be too strongly emphasized that the shapes of the silica-cells are not necessarily the same as those of the silica-bodies contained

in them. Therefore it is important, for descriptive purposes, to state quite clearly whether a silica-cell or a silica-body is being described. Agrostologists are not always too careful about this point, and it is not always clearly evident in published articles whether an author is speaking about a cell or the body contained therein.

The descriptive terms that have been adopted were chosen partly because they conform as far as possible with existing usage, and partly in the hope of describing the shapes of the bodies in words that are familiar or self-explanatory. The introduction of an entirely new terminology would have made for brevity, but against this is the onus that would be placed on readers if they had to memorize the new terms.

The types of silica-bodies recognized for descriptive purposes are as follows:

Tall and narrow (Fig. I, 4).
Cubical, i.e. of cubic form.
Cuboid, i.e. more or less cubical but with rounded edges.
Round (Fig. I, 6*a* or 7*a*).
Elliptical (Fig. I, 6*c*, S.B., or 8*a*).
Crescent-shaped (Fig. I, 9, (i) or (iii)).
Oblong (Fig. I, 8*b*, and the right-hand figure in C, or 10, the more horizontally elongated bodies in the series labelled C).
Fitting into a concavity in a cork-cell (Fig. I, 6–7).
Saddle-shaped (Fig. I, 9, (iv)–(viii)).
Acutely angled (Fig. I, 11).
Horizontally elongated with rounded ends and smooth outlines (Fig. IA, 12, or the more elongated bodies in 13*a* and *c*). For brevity these could be described as 'elongated-smooth'.
Horizontally elongated with sinuous outlines (Fig. IA, 14–15); for brevity these could be termed 'elongated-sinuous'.
Cross-shaped (Fig. IA, 16).
Intermediate between cross and dumb-bell shaped (Fig. IA, 17).
Dumb-bell shaped: (i) with narrow middle portions (Fig. IA, 18, (ii)–(v)); (ii) with wide middle portions (Fig. IB, 19).
Shortly dumb-bell shaped (Fig. IB, 20, especially the first two figures in series *b*).
Dumb-bell shaped, but varying in appearance with the focus (Fig. IB, 21).
Nodular (Fig. IA, 18 (i) or IB, 22 (iii)).
Oryza type (Fig. IB, 23).
Tall, narrow, and crenate (Fig. IB, 24). For brevity these could be termed 'crenate-vertical'.

(*b*) *Macro-hairs* (Figs. II and IIA) (see also p. xxii)

We have already noted that macro-hairs vary in length, frequency, thickness of cell-wall, in the extent to which they are rigid and straight, or flexible and bent. Variations in these respects are, however, of restricted diagnostic value except as confirmatory characters for the identification of species. The density of hairs, in particular, is often very unreliable for taxonomic purposes. It is far more important to note whether the attachment of the hairs to the

epidermis is superficial (Fig. II, 1) or whether the bases of the hairs are sunken between, or below, the general level of the adjacent epidermal cells (Fig. II, 2, 3, 4, &c.). With these sunken hairs it will also be found that the structure of the hair bases falls into a series of more or less distinct types. Hairs with deeply sunken bases appear, on the whole, to be characteristic of grasses from warm countries, and the more superficial types are more common in temperate grasses. Similar hairs occur in many genera between which there are not believed to be any close affinities, which indicates that each of the common kinds has probably appeared more than once in the course of evolution. This makes it all the more interesting to note the occasional genera that are characterized by hairs of a really distinctive type. Examples are the crozier hairs (Fig. IIA, 7), and the mushroom-like, shortly stalked glands (Fig. IIA, 9) of *Neostapfia colusana*; the tall, slender, glands with a unicellular head (Fig. IIA, 8) that have been seen only in *Enneapogon*.

The types of hairs recognized for descriptive purposes are as follows:

Superficial, with swollen bases (Fig. II, 1).
Slender, with sunken bases and bulbous proximal endings (Fig. II, 2).
Stiff, with sunken, constricted bases (Fig. II, 3).
Short, stiff, superficial (Fig. II, 4).
Specialized hairs, partly surrounded by raised epidermal cells (Fig. II, 5). (Seen only in *Indopoa*.)
Stiff, with sunken bases surrounded by specialized epidermal cells (Fig. IIA, 5).
Slender, with thick-walled bases (Fig. IIA, 6).
Crozier hairs (Fig. IIA, 7).
Long-stalked, glandular (Fig. IIA, 8).
Short, rigid, thick-walled (Fig. IIA, 10).
Sinuous, with sunken bases (Fig. IIA, 11).
Short, rigid, thick-walled, with sunken bases (Fig. IIA, 12).
Shortly stalked, two-celled, sunken glands; more appropriately classified as micro-hairs (Fig. IIA, 13).

(*c*) *Micro-hairs* (Figs. IIA, 13, VII, and XVI) (see also p. xxii)

As already stated, these hairs, besides differing from the macro-hairs in being very much smaller, are mostly two-celled, but one-celled types (Fig. VII, 1) occur in certain genera such as *Sporobolus*. Many of the examples illustrated in the figures tend to merge into one another, e.g. Fig. VII, 4–6. The diagnostic value of the shapes of the distal cells is limited because the cells are readily distorted, as is illustrated, for example, in Fig. VII, 6*c*, 7*a*, and 8*a*. Very frequently the distal cell is missing, when the persistent basal cell could readily be mistaken for a 'unicellular hair', e.g. in Fig. VII, 5*b*. The total length of the hairs, their diameters, and the relative lengths of their proximal and distal cells appear to be the most reliable characteristics for taxonomic purposes. Micro-hairs are not always easy to examine, but it is generally rewarding to persevere with them because they are valuable indicators of the affinities of the grasses in which they occur. The mere fact of

whether micro-hairs are present or not is, in itself, important because there are so many genera of temperate grasses in which they do not occur at all.

The various types of micro-hair that have proved to be of diagnostic value include the following:

Unicellular, rounded to dome-shaped—the *Sporobolus* type (Fig. VII, 1).
Two-celled, with rounded to dome-shaped distal cells—the *Chloris* type (Fig. VII, 2). (Bent and sunken forms of the *Chloris* type also occur (Fig. IIA, 13).)
With a short basal cell and usually much longer distal cell having a broadly rounded apex—the balanoform or *Zea* type (Fig. VII, 3).
With a short basal cell and a longer distal cell tapering to a pointed apex—the panicoid type (Fig. VII, 4–6).
With distal and basal cells about equal in length, the distal cell usually having a broadly rounded apex unless distorted—the *Echinochloa* type (Fig. VII, 7).
With basal and distal cells long and narrow, and both uniform in diameter throughout their lengths unless distorted—the *Loudetia* type (Fig. VII, 8).
With the basal cell usually longer than the apically tapered distal cell—the *Arundo* type (Fig. VII, 9–10).
With the basal and distal cells both short and about equal in length, the distal cell being apically tapered—the *Zizania* type (Fig. VII, 11).
With the basal cell very much longer than the dome-shaped distal cell—the *Eragrostis* type (Fig. VII, 12).
Bambusoid micro-hairs of various types (Fig. XVI).

(*d*) *Prickle-hairs* (Fig. VI) (see also p. xxiii)

The types recognized for descriptive purposes are as follows:

Prickles, which may be small (Fig. VI, 1) or large (Fig. VI, 2). They also vary in the shape and degree of inflation of the base and in the length of the barb.
Angular prickles (Fig. VI, 3) found chiefly at leaf margins.
Interlocking prickles overlying stomata in a groove (Fig. VI, 4).
Hooks (Fig. VI, 5); these are smaller than prickles and their bases more rounded. Intermediates between prickles and hooks also occur.
Unbarbed or unpointed prickles (Fig. VI, 6).

(*e*) *Papillae* (Fig. III) (see also p. xxiv)

The types recognized for descriptive purposes are as follows:

Globose papillae in chains overlying the veins (Fig. III, 1).
Oblique, with thickened distal ends (Fig. III, 2).
Unthickened, globose, and often somewhat oblique (Fig. III, 3).
Combination of small cuticular and larger inflated papillae on the same cell; all papillae rounded (Fig. III, 4).
Small, variously shaped, thickened, cuticular papillae (Fig. III, 5).
Large, thin papillae (Fig. III, 6).

(*f*) *Stomata* (Fig. IV) (see also p. xxi)

The types recognized for descriptive purposes, based on the shapes of the subsidiary cells in surface view, are as follows:

Triangular (Fig. IV, 1); *a–b* are variants of this type.
Parallel-sided (Fig. IV, 2); *a–d* are variants of this type.
Low dome-shaped (Fig. IV, 3); *a–c* are variants of this type.
Tall dome-shaped (Fig. IV, 4); *a–b* are variants of this type.
Variable type (Fig. IV, 5).

The triangular and low dome-shaped types, frequently, but not invariably, occur together in the same leaf. The triangular type occurs most commonly in the panicoid grasses.

(*g*) *Long-cells* (Fig. V) (see also p. xx)

Fig. V represents, in surface view, the various types of intercostal long-cells that have proved to be of diagnostic value.

Walls thick, and pitted or sinuous. (Pits not represented in the drawing.) (Fig. V, 1*a–b*.)
Walls thin; not sinuous (Fig. V, 2*a–c*).
Walls thin; sinuous (Fig. V, 3*a–c*).
Cells relatively short, with thin, non-sinuous walls (Fig. V, 4*a–b*).
Inflated cells, varying in appearance with the focus (Fig. V, 5). (Bulliform cells (Fig. XV) often appear like those in Fig. V, 5 in surface view.)
Cells relatively short, with thin, markedly sinuous walls (Fig. V, 6).
Cells almost cubical, with slightly to moderately sinuous walls (Fig. V, 7*a–b*).
Cells almost cubical with walls not sinuous (Fig. V, 8).
Cells with overlapping end walls (Fig. V, 9).
Interstomatal cells relatively short, with concave ends (Fig. V, 10*a–b*).
Interstomatal cells relatively long, with concave ends (Fig. V, 11).

The types of long-cells mentioned above have proved to be very useful when making a broad survey of the grasses. The author fully recognizes, however, that they are not adequate for all purposes, since there are many variants and intermediates. An investigator who is making a detailed study of a limited number of species may, therefore, find it necessary to introduce some additional types for descriptive purposes.

B. *Characters of the lamina in transverse section*

(*a*) *Outline of the lamina* (Fig. X) (see also pp. xxiv–xxv).

The lamina of most grass leaves in transverse section is flattened, and it may or may not have a conspicuous keel or midrib. The leaves of certain grasses also exhibit various types of inrolling and infolding, but these are not always of much value as taxonomic characters because the degree of inrolling or infolding varies with the environmental conditions. Where the lamina is so strongly infolded that the leaf has become permanently acicular or setaceous the position is rather different, and the outline of the lamina in transverse section is then often of specific diagnostic value. Apart from the outline of the section, the number of vascular bundles and of adaxial ribs and the distribution of sclerenchyma are of taxonomic interest. This applies particularly to certain genera such as *Festuca* (p. 209) and *Triodia* (p. 506).

(*b*) *Vascular bundles* (Fig. VIII) (see also p. xxvii)

In grass leaves at least a few, and sometimes a high proportion, of the vascular bundles resemble one or other of the types in Fig. VIII, 7–15. The xylem in each bundle of this type is usually characterized by a single, conspicuously large metaxylem vessel to the right and left of the protoxylem. Sometimes these large metaxylem vessels appear to be paired, but the apparent pairs are often no more than the overlapping ends of otherwise solitary vessels. This being so the number of large metaxylem vessels in an individual bundle is unreliable as a diagnostic character, for it will vary with the level at which the section is taken. In the literature, vascular bundles with conspicuous metaxylem vessels are commonly termed first-order bundles. Since at least a few of them are present in the leaves of nearly all grasses they are referred to in this book as vascular bundles of the basic type. All of the vascular bundles in Fig. VIII, 7–15 are of the basic type, the individual diagrams representing variants of this basic pattern. It is sometimes difficult to refer the basic type vascular bundles to any particular one of these diagrams, and individual investigators might not always come to the same conclusion when attempting to do so. It is desirable to bear this in mind when reading the descriptions of the individual species in this book. Differences between the bundles in Fig. VIII, 7–15 are, therefore, unreliable for diagnostic purposes.

Basic type vascular bundles that differ from the normal in exhibiting varying degrees of sclerosis of the phloem are to be seen in Fig. VIII, 12 and 16–18. Sclerosis is most common in specially large bundles, usually in grasses from dry localities.

At the other end of the scale we have the smaller vascular bundles from which conspicuously large metaxylem vessels are lacking (Fig. VIII, 1–6). In the smallest of these bundles the xylem and phloem are not easily distinguishable from one another in transverse sections (Fig. VIII, 1). They can also be classified on the basis of whether they are angular (Fig. VIII, 4–5), inconspicuously angular (Fig. VIII, 6), or not angular (Fig. VIII, 2) in outline. Vascular bundles with conspicuously angular outlines are, on the whole, characteristic of the panicoid, and non-angular bundles of the festucoid, grasses. *Leptaspis*, and one or two allied genera, are characterized by narrow, somewhat angular bundles with the vertical sides of the bundle-sheath remarkably straight and parallel to one another (Fig. VIII, 3).

The relative proportion of small to basic type vascular bundles in individual leaves from any one species of grass is remarkably constant. There may, however, be some variations in this respect in leaves taken from different levels on a single plant, the variations being bound up with differences in the width of the lamina. On the other hand, there are very marked variations in the total number of vascular bundles per leaf, and in the proportions that are of the basic and smaller types respectively in grasses belonging to different genera and species.

The above statement may be summarized by saying that the following types of vascular bundle are recognized for diagnostic purposes:

Bundles small; containing no conspicuously large metaxylem vessels; xylem and phloem not easy to distinguish from one another in transverse section (Fig. VIII, 1).

Bundles relatively small; xylem and phloem easy to distinguish but no conspicuously large vessels present; xylem and phloem not angular in outline (Fig. VIII, 2).

Bundles tall, narrow, and somewhat angular in outline; no conspicuously large vessels present; vertical sides of the bundle-sheath straight and parallel to one another—the *Leptaspis* type (Fig. VIII, 3).

Bundles small, and usually pentagonal to hexagonal in outline; no conspicuously large vessels present (Fig. VIII, 4).

Bundles small, angular, usually at least octagonal; no conspicuously large vessels present (Fig. VIII, 5).

Bundles not more than inconspicuously angular in outline; no conspicuously large vessels present (Fig. VIII, 6).

Bundles of basic type, i.e. with at least one, and sometimes two, metaxylem vessels (M.V.) to the right and left of the protoxylem (Fig. VIII, 7–15).

Large, basic type bundles exhibiting varying degrees of sclerosis of the phloem (Fig. VIII, 12 and 16–18).

(*c*) *Ribs and furrows on the adaxial surface* (Fig. XIV) (see also p. xxv)

Fig. XIV, 1–8 should be self-explanatory except that it must be pointed out that the specially massive rib in Fig. XIV, 8 occurs over the midrib of *Cortaderia conspicua*. In describing the ribs and furrows of the various species dealt with in the main body of the text of this book the figures have been used to indicate the height of the ribs rather than the distances between them. If, for example, a particular species is described as having ribs of the type in Fig. XIV, 4, this means that the ribs are of the height and appearance shown in the figure, but they could be much more widely separated from one another. Furthermore, ribs in a single grass leaf may be of two distinct sizes and it has sometimes been necessary to draw attention to this by referring to more than one figure.

(*d*) *Sclerenchyma* (Figs. IX and X) (see also p. xxix)

Some idea of the range of variation in the distribution patterns of sclerenchyma in relation to the vascular bundles can be gained from Figs. IX and X, where the sclerenchyma is represented in solid black. The distribution patterns of the sclerenchyma in Fig. X are special types, to be found in grasses with acicular leaves.

In using these diagrams it should be remembered that the large or first-order vascular bundles are generally more massively supported by sclerenchyma than those that are smaller. Furthermore, it is important to bear in mind the distinction, to which reference has already been made on p. xxix, between sclerenchyma that is in the form of girders and that which is in the form of strands. The term girder is used, for descriptive purposes, when the sclerenchyma extends from the epidermis on its outer surface to the bundle-sheath on its inner surface, e.g. in Fig. IX, 3–9. The term strand, on the other hand, is applied to sclerenchyma of which the outer surface rests against the epidermis but does not penetrate sufficiently deeply to make contact with the bundle-sheath on its inner surface (Fig. IX, 2).

All the distribution patterns for sclerenchyma shown in Figs. IX, 2–8 can occur as either strands or girders. For example, the sclerenchyma in Fig. IX, 2 as drawn is an adaxial strand, but if it were in contact, on its inner face, with the bundle-sheath it would constitute an adaxial girder. Similarly, the adaxial and abaxial girders in Fig. IX, 4 would be termed strands if they were not in contact with the bundle-sheath. In order to reduce the number of diagrams, all of these variations have not been shown separately, and the author has assumed that when the reader is told that a vascular bundle is accompanied by 'small adaxial and abaxial strands', and is then referred to Fig. IX, 4 to illustrate this point, it will be understood that the sclerenchyma is like that shown in Fig. IX, 4 except for the fact that it is not in contact with the bundle-sheath. Similarly, when a vascular bundle is described as 'with an adaxial girder only' it means that the sclerenchyma is like that in Fig. IX, 2 except that it is in contact with the bundle-sheath on its inner face. This point has been specially emphasized because, if the reader fails to grasp the author's intention, he may find difficulty in interpreting the descriptions of the sclerenchyma given under the genera and species.

The various types of sclerenchyma used for descriptive purposes are as follows:

Vascular bundle not accompanied by sclerenchyma (Fig. IX, 1).
Vascular bundle accompanied by an adaxial strand only (Fig. IX, 2).
Vascular bundle with a well-developed abaxial girder only (Fig. IX, 3).
Vascular bundle accompanied by small adaxial and abaxial girders (Fig. IX, 4).
Vascular bundle accompanied by low, wide, adaxial, and abaxial girders (Fig. IX, 5).
Combined adaxial and abaxial girders anchor-shaped (Fig. IX, 6).
Vascular bundle with tall, narrow, adaxial and abaxial girders (Fig. IX, 7).
Vascular bundle with adaxial T- and abaxial I-girders (Fig. IX, 8).
Specialized types of sclerenchyma (Fig. IX, 9–11).
Types of sclerenchyma in acicular leaves (Fig. X).

(*e*) *Midrib, keel, and keel bundles* (Fig. XIII) (see also p. xxiv)

As indicated on p. xxiv, midribs have always been examined, for purposes of comparison, in sections taken about midway between the apex and base of the lamina, and the diagrams in Fig. XIII represent sections from this position in the leaf. Where the midrib projects prominently on the abaxial side of the lamina it constitutes a 'keel'.

Fig. XIII shows that the number of vascular bundles is, in a general way, roughly proportional to the size of the midrib or keel. The various types that have been recognized are fairly easily distinguished, although the type in Fig. XIII, 1 merges into that in Fig. XIII, 2. Prominent, rounded keels, as in Fig. XIII, 3 but with vascular bundles of more uniform size, sometimes occur in addition to the types shown in Fig. XIII, and various distinctive kinds are mentioned, where appropriate, under the descriptions of the individual species in which they are to be found.

The following types of keel and arrangements of keel bundles have proved to be valuable for diagnostic purposes:

Keel inconspicuous; containing a solitary vb (Fig. XIII, 1).
Keel inconspicuous; containing three vb's (Fig. XIII, 2).
Keel conspicuous, rounded; containing numerous vb's of equal or unequal size (Fig. XIII, 3).
Keel more or less triangular; containing numerous vb's of equal or unequal size (Fig. XIII, 4).
Keel very conspicuous, rounded; containing very numerous vb's of unequal sizes (Fig. XIII, 5).
Keel of specialized, *Zizania* type (Fig. XIII, 6).

(*f*) *Mesophyll and chlorenchyma* (Fig. XVIII) (see also p. xxv)

The types of chlorenchyma that have proved to be valuable for diagnostic purposes are as follows:

Chlorenchyma not radiate (Fig. XVIII, 1).
Chlorenchyma radiate (Fig. XVIII, 2).
Chlorenchyma indistinctly or incompletely radiate. (Intermediate between Fig. XVIII, 1 and 2.)
Chlorenchyma radiate, but radiating cells long and narrow—the *Isachne* type (Fig. XVIII, 5).
Chlorenchyma composed of arm-cells, i.e. with inwardly directed projections from the cell-walls (Fig. XVIII, 3).
Mesophyll containing fusoid-cells—the bamboo type (Fig. XVIII, 3, 6, and 7).

(*g*) *Bulliform and colourless cells* (Fig. XV) (see also p. xxx)

The various types of bulliform and colourless cells in the mesophyll that have proved to be useful for diagnostic purposes are as follows:

Bulliform cells in irregular groups (Fig. XV, 1).
Bulliform cells in well-defined, regular groups, but cells not very much larger than the remaining epidermal cells (Fig. XV, 2).
Bulliform cells specially large, in regular groups—the *Zea* type (Fig. XV, 3).
Bulliform cells in fan-shaped groups; outer walls of cells sometimes thickened (Fig. XV, 4; a variant of the type in Fig. XV, 6).
Bulliform cells of variable size, but none of them specially large; usually in deep furrows—the *Ammophila* or *Elymus* type (Fig. XV, 5).
Bulliform cells in fan-shaped groups at the bases of furrows (Fig. XV, 6; a variant of the type in Fig. XV, 4).
Bulliform and associated colourless cells in narrow groups penetrating deeply into the mesophyll—the *Arundo* type (Fig. XV, 7).
Bulliform and associated colourless cells in fan-shaped groups penetrating deeply into the mesophyll—the *Sporobolus* type (Fig. XV, 8–9).
Bulliform and associated colourless cells forming arches over the small vb's (Fig. XV, 10).

Adaxial half of the mesophyll consisting of colourless cells—the *Chloris* type (Fig. XV, 11).

Colourless cells forming a broad girder extending inwards from the base of an adaxial furrow towards a vb—a specialized type found in certain xerophytes (Fig. XV, 12).

Bulliform cells in groups resembling those of the *Sporobolus* type, but each group connected to the abaxial surface by a narrow girder of colourless cells (Fig. XV, 13).

Colourless cells forming a girder from the adaxial to the abaxial surface (Fig. XV, 14).

(*h*) *Bundle-sheaths* (Figs. VIII, 2–6 and XI–XII) (see also p. xxviii)

In using structural variations in the bundle-sheaths for diagnostic purposes, it is first of all necessary to determine whether the sheaths are single or double, and, secondly, to note how far, and in what position, the individual sheaths are 'interrupted' by sclerenchyma. The presence of 'girder-like extensions' (Fig. XII, 1, 4, 6, and 7) from the outer (or single) bundle-sheath is also frequently of diagnostic value. The 'extensions' usually consist of translucent cells, which in transverse section resemble the sheath-cells themselves. Sometimes there is a gradual transition from the translucent cells to the sclerenchymatous cells with which they are in contact, the change from the large translucent cells to the narrow, thick-walled, fibrous cells of the sclerenchyma often being more gradual than is implied in the diagrams.

Variations in the bundle-sheath that have proved to be of diagnostic value are as follows:

Sheaths absent (Fig. XI, 1).

Sheaths single:

Sheath complete (Fig. XI, 2*a–b* or VIII, 5).

Sheath with vertical sides—parallel to one another—the *Leptaspis* type (Fig. VIII, 3).

Sheath with slight abaxial and adaxial interruptions (Fig. XI, 3).

Sheath with wide adaxial and abaxial interruptions (Fig. XI, 4).

Sheath reduced to two lateral strips at the phloem end of the vb (Fig. XI, 5).

Sheath with an abaxial interruption only (Fig. XI, 6).

Sheath with an adaxial extension of colourless cells (Fig. VIII, 4).

Sheaths double:

Sheaths complete (with slight adaxial and abaxial extensions of colourless cells) (Figs. VIII, 2 or XII, 1).

I.S. complete; O.S. not quite complete abaxially (Fig. XII, 2).

I.S. complete; O.S. interrupted adaxially and abaxially (Fig. XII, 3*a–b*).

I.S. complete; O.S. interrupted abaxially and connected to the adaxial scl. by a girder-like extension of colourless cells (Fig. XII, 4).

I.S. and O.S. interrupted abaxially (Fig. XII, 5).

I.S. complete (but frequently obscure); O.S. complete, with an extension of colourless cells towards the adaxial surface (Fig. XII, 6).

I.S. and O.S. complete; O.S. with a broad adaxial extension of colourless cells (Fig. XII, 7).

LEAF STRUCTURE AND TAXONOMY OF THE GRASSES

1. Phylogenetic Status and Relationship of the Gramineae to other Families

At the end of a period of years devoted to studying the anatomy and histology of the vegetative organs of the Gramineae, one may ask oneself what taxonomic conclusions may be drawn. In this connexion the author makes no claim to be an expert on the taxonomy of the Gramineae, and his knowledge of exomorphic and other characters that must be taken into consideration is very limited. In such circumstances it is impossible to do more than draw attention to certain broad conclusions to which the anatomical evidence appears to point. It must then be left to agrostologists to make such use as they may think fit of the factual information that has been brought together and of the taxonomic conclusions for which there appears to be anatomical evidence.

First, then, let it be said that the Gramineae constitute a group of Monocotyledons exhibiting specialized anatomical characters. That this is so is shown by the fact that, as far as is known, the tracheal elements in all parts of the grass plant consist of vessels and not of tracheids. Cheadle, who, for some years, has been interested in the morphology of the tracheal elements in Monocotyledons, has repeatedly drawn attention to the fact that the replacement of tracheids by vessels represents a phylogenetic advance. Cheadle (1955) has assigned the Gramineae to a very advanced phylogenetic level amongst the Monocotyledons on the evidence of their vessel structure. Subsequent work at Kew has confirmed Cheadle's views, and the significance of these investigations will become more apparent as work on other groups of Monocotyledons proceeds. Further evidence of specialization in the Gramineae is provided by the very elaborate and distinctive structure of the leaf epidermis, with its long-cells and short-cells, and with the varied types of silica-bodies that are so valuable for diagnostic purposes. Amongst the Monocotyledons the epidermal structure of the Gramineae appears to be unique. It is true that silica-bodies occur in the epidermal cells of other families such as the Cyperaceae, but here the silica deposits are simpler and very much less variable in form.

It might be expected that an extension of these lines of argument will throw some light on the phylogenetic status of the tribes and genera within the Gramineae. This, however, is not so. Firstly, as Cheadle has pointed out, no convincing evidence of the existence of a phylogenetic sequence of genera within the Gramineae is provided by the tracheal elements. Secondly, the evidence from the structure of the epidermis is no more helpful, for there is nothing to indicate that grasses in which the leaf epidermis is especially complex are more advanced than those in which the epidermis is relatively simple. On this basis we should have to argue that *Bromus* is less advanced than the bamboos, for the leaf epidermis of the bamboos is more complex

than that of *Bromus*. On other grounds, however, there is reason to believe that the bamboos are relatively primitive grasses, their flower structure in particular pointing to this conclusion. But how, turning to another line of evidence, can the supposedly primitive flower structure be reconciled with the highly specialized and distinctive systems of fusoid-cells that occur in the bamboo leaf? It is hard to understand why this very curious type of structure should have been evolved and retained in the bamboos if they are indeed to be regarded as primitive grasses, when the mesophyll in other, supposedly more advanced grasses is much simpler in construction. In the face of such conflicting evidence no argument concerning the relative phylogenetic status of different groups or genera of grasses appears to carry much weight. We must content ourselves by recognizing that the grasses as a whole appear to represent an advanced group of Monocotyledons, but that we can say little or nothing about lines of phylogenetic advance within the family.

Before leaving the general question of the relationships of the Gramineae, as a whole, to other families of Monocotyledons, it should be noted that in the Gramineae each stoma in the mature leaf is accompanied on either side by a subsidiary cell with its long axis parallel to that of the stomatal pore. Although this arrangement of the subsidiary cells occurs in a number of monocotyledonous families it is by no means characteristic of the Monocotyledons as a whole. In the Scitamineae and certain genera of Haemodoraceae, Hypoxidaceae, &c., it is usual to find each stoma accompanied by four subsidiary cells, two having their long axes parallel to that of the stomatal pore, the two others being at the narrow ends of the stomata, where they are at right angles to the long axis of the stomatal pore. It is impossible, at present, fully to assess the value of these two types of stoma as a taxonomic character in the Monocotyledons as a whole, owing to the incompleteness of the available data. It is interesting to note, however, that preliminary investigations indicate that the subsidiary cells in the Gramineae are similar to those, for example, in the Liliaceae, as well as in *Flagellaria* and *Joinvillea* of the Flagellariaceae. Smithson (1956), working at Kew, has shown that *Hanguana*, also commonly treated as a member of the Flagellariaceae, differs from *Flagellaria* and *Joinvillea* in having stomata accompanied by four subsidiary cells. This and other evidence, including that provided by the morphology of the pollen grains, indicates that *Flagellaria* and *Joinvillea* may well have affinities with the Gramineae, and that *Hanguana* has not. This last genus should probably be excluded from the Flagellariaceae.

2. Basic Taxonomic Groups within the Gramineae

(*a*) *General considerations*

Turning to taxonomic groupings within the Gramineae, the evidence of leaf anatomy indicates the existence of a number of major groups that are easy, or fairly easy, to recognize so far as most of the genera of which they are composed is concerned. As with most taxonomic groups, however, the outlines of these taxa are somewhat nebulous and they tend to merge with one another.

The anatomical characters that provide the evidence for the existence of these major taxonomic groups have already been discussed (pp. xli–l). Using these characters as taxonomic criteria, it may first be noted that the Bambuseae, together with a few genera that are almost certainly allied to the bamboos, stand apart from all other grasses. Further discussion of the Bambuseae is, therefore, deferred until after the other groups of grasses have been considered (see pp. 540 et seq.).

Apart from a comparatively small number of grasses with mixed characters, all others not included in the Bambuseae may, on the basis of leaf structure, be divided into a festucoid and a panicoid group. Furthermore, these two groups may be divided into a number of tribes, but the tribes in the festucoid are much less well defined than those in the panicoid group. The festucoid and panicoid types of leaf structure are, however, so fundamental that it is most desirable not to include any of the tribes or genera with *wholly* panicoid structure in the same alliance as those grasses in which the leaf structure is *wholly* festucoid. As we shall see later, many of the comparatively small number of grasses with mixed panicoid and festucoid characters are more closely allied to the panicoid than to the festucoid group.

It will be noted that the subdivisions of the panicoid and festucoid groups have been referred to as tribes. Opinions will probably differ as to whether all of the tribes are of equal status. On the anatomical side, however, there are no criteria that indicate conclusively whether we are dealing with groups of equal taxonomic rank, or whether it is desirable to introduce other units such as subfamilies or subtribes into the picture as well. It seems reasonable, from the practical standpoint, to treat these anatomically homogeneous but reasonably distinct taxa within the panicoid group as tribes of equivalent status, at least until such time as this conception is shown conclusively to be wrong. The so-called tribes amongst the festucoid grasses, on the other hand, are less homogeneous anatomically than are the panicoid tribes, and this suggests that the concept of what is meant by a tribe may not be strictly equivalent in the festucoid and panicoid groups respectively. It seems to the author that too much has sometimes been attempted in drawing up some of the systems of grass classification. Taxa of various ranks between the family and the genus have been employed more for convenient compartmentalizing than because there is clear evidence that they accurately portray the interrelationships of the grasses concerned. This in turn creates an illusion of the existence of a phylogenetic hierarchy that may in fact be wide of the mark. Pilger's (1954) authoritative system, excellent as it is in many ways, seems, in the light of anatomical evidence, to be unduly complex. Further, some parts of it, especially in the subfamily Festucoideae, appear anatomically unsatisfying because certain grasses with panicoid leaf structure have been included in the festucoid alliance.

(*b*) *Festucoid leaf characters*

The festucoid leaf characters are as follows. Short-cells, over the veins, usually solitary or paired and seldom, if ever, in long rows. Silica-bodies of one or more of the following types: (1) tall and narrow (Fig. I, 4); (2) round, elliptical, or crescent-shaped, bodies of these types sometimes overlapping or fitting into concavities in adjacent cork-cells (Fig. I, 6–7); (3) oblong

(Fig. I, 8); (4) elongated, with sinuous or smooth outlines (Fig. IA, 12–15). Macro-hairs, when present, usually with broad, superficial bases. Micro-hairs absent. Stomata usually with dome-shaped (Fig. IV, 3), or parallel-sided (Fig. IV, 2), subsidiary cells. Outline of the xylem and phloem in the vascular bundles not angular, the bundles themselves usually being widely spaced. Midrib or keel, when prominent, not containing more than a limited number of vascular bundles (Fig. XIII, 1–2) and never with a complex system such as that of the bamboos. Mesophyll with chlorenchyma not radiate (Fig. XVIII, 1). Bundle-sheaths double, the inner sheath usually consisting of relatively elongated cells often with the walls, especially the inner tangential and radial walls, thickened. Outer sheath composed of relatively thin-walled cells, with or without chloroplasts.[1]

(*c*) *Panicoid leaf characters*

The panicoid leaf characters are as follows. Short-cells, over the veins, seldom solitary or paired, but usually in rows that are typically more than five cells long. Silica-bodies, over the veins, saddle-shaped (Fig. I, 5 and 9), cross-shaped (Fig. IA, 16), dumb-bell shaped (Fig. IA, 18, IB, 19–20), oryzoid (Fig. IB, 23), or nodular (Fig. IA, 18 (i) and IB, 22 (iii)), intermediate types also occurring. Macro-hairs, when present, usually with sunken bases, and commonly situated in the intercostal zones. Micro-hairs nearly always present, varying from sparse or local in some species to abundant in others; usually two-celled, but one-celled types also occurring in Chlorideae, Eragrosteae, and Sporoboleae. Micro-hairs exhibiting a considerable range of variation in shape (Fig. VII).[2] Stomata commonly with subsidiary cells triangular (Fig. IV, 1), or dome-shaped (Fig. IV, 3), both types frequently occurring together in the same leaf. Outlines of the xylem and phloem, especially in the small vascular bundles, markedly angular (Fig. VIII, 4–5), the bundles generally being much more numerous and closely crowded than in the festucoid grasses, but exceptions to this generalization sometimes occur. Midrib or keel, when prominent, containing a number of vascular bundles, usually arranged in an abaxial arc, the bundles themselves generally being of unequal sizes (Fig. XIII, 3 and 5). Mesophyll with chlorenchyma nearly always conspicuously to inconspicuously radiate (Fig. XVIII, 2). Arm-cells not present except in the Oryzeae. Bundle-sheaths generally single, the inner or mestome sheath being absent or inconspicuous; certain of the vascular bundles, especially the large ones, sometimes with an inner sheath. (Double bundle-sheaths have been noted even in some species of *Panicum* itself.)

[1] Brown (1958) claims that *Aristida* differs from all other grasses in having each vascular bundle surrounded by two parenchymatous sheaths, the thick-walled or mestome sheath being absent. This type of structure has been noted in *Aristida* by the present author, but it sometimes appears as if three sheaths are present, the innermost being the mestome sheath. Furthermore, the two parenchymatous sheaths have not been seen in all species of *Aristida* examined by the author. The bundle-sheaths in *Stipa* do not appear to be wholly unlike those of *Aristida* as stated by Brown.

[2] Variation in the shapes of distal cells are often artefacts, and these should be ignored for diagnostic purposes. The distal cells of two-celled micro-hairs are often missing, especially in herbarium specimens. The persistent basal cell of the previously two-celled micro-hairs should not be mistaken for micro-hairs that are truly unicellular.

(*d*) *Subdivisions of the festucoid and panicoid groups*

It has already been noted that the festucoid and panicoid grasses can be divided into groups which are described as tribes. Leaf structure appears, however, to be of limited value as an index to the tribes of festucoid grasses. This does not mean that the leaf structure is uniform throughout the festucoid group. On the contrary, there is a considerable range of patterns in the arrangement of the epidermal cells, in the shapes of the silica-bodies, and in other characters. The difficulty is rather that if the genera and species are placed in groups based on similarity of leaf structure, the groups do not coincide very well with the taxonomists' concepts of the tribes into which the festucoid grasses are divided on exomorphic characters. It would, therefore, seem that the usual taxonomic concepts of tribes amongst the festucoid grasses cannot be quite equivalent to the tribes amongst those with panicoid leaf structure. It is outside the scope of this book to deal with this problem, for it is clearly evident that it cannot be solved on anatomical evidence alone. On the other hand, the panicoid grasses fall much more easily into groups that appear to be natural. Although there is much still to be learned, and it will require long and profound consideration by taxonomists and anatomists before finality can be reached, the following notes on the subdivisions of the panicoid grasses are given for what they are worth, and in the hope that they may provide clues to experts in grass taxonomy.

ANDROPOGONEAE AND PANICEAE

The genera that are generally placed in the Andropogoneae and Paniceae have many characters in common, and, from the anatomical standpoint, they appear to form a natural alliance. They are characterized by cross to dumb-bell shaped silica-bodies over the veins; by relatively long micro-hairs of which the distal cell tapers towards the apex (Fig. VII, 4–6); by conspicuously to inconspicuously radiate chlorenchyma; generally by single bundle-sheaths, double sheaths being uncommon, and, when present, often restricted to the large vascular bundles.

MAYDEAE

Similar in structure to and merging with the Andropogoneae, but tendency for the silica-bodies over the veins to be more frequently cross-shaped and for the micro-hairs to be balanoform (Fig. VII, 3).

ORYZEAE

Characterized by silica-bodies of the oryzoid type (Fig. IB, 23) over the veins; by a complex system of vascular bundles in the midrib or keel (Fig. XIII, 6); by the fact that the chlorenchyma consists of arm-cells.

ISACHNEAE

Genera in this group stand out from the other panicoid grasses because the mesophyll, in addition to being radiate, usually consists of narrow, elongated

cells with well-developed intercellular spaces between them, the mesophyll thus tending to be spongy, especially in the neighbourhood of the veins (Fig. XVIII, 5). Other common, characteristic features in this tribe are the rectangular, often acutely angular silica-bodies (Fig. I, 11), the stomata with variable subsidiary cells (Fig. IV, 5), and the cubical intercostal long-cells (Fig. V, 8).

PAPPOPHOREAE

Enneapogon stands out from other grasses on account of its glandular hairs, each consisting of a long, narrow stalk-cell bearing a spherical, unicellular, glandular head (Fig. IIA, 8). It is not known if, or to what extent, similar glandular hairs occur in other genera of the Pappophoreae.

CHLORIDEAE, ERAGROSTEAE, SPOROBOLEAE

Members of these tribes combine festucoid and panicoid characters. Many, but not all, members of the Chlorideae are characterized by saddle-shaped silica-bodies over the veins, the short-cells being in long rows. The Chlorideae also exhibit small, spherical micro-hairs (Fig. VII, 1–2) that are often partly sunken. Quite frequently, especially in *Chloris* itself, the adaxial part of the mesophyll consists of translucent cells (Fig. XV, 11).

Members of the Eragrosteae are frequently very similar to the Chlorideae in leaf structure. They often have similar, spherical micro-hairs, but, in *Eragrostis* itself, the proximal cell of each micro-hair is much longer, although the distal cell is short and hemispherical (Fig. VII, 12). Taxonomists who are interested in the dividing lines between the Chlorideae and Eragrosteae might well consider whether this distinction between typical chloridoid and eragrostoid hairs would be a useful diagnostic character in separating the two tribes. This difference is not wholly satisfactory for this purpose with the tribes constituted as they are at present, but the subject appears to merit closer investigation.

The Sporoboleae, like the Chlorideae, have short, spherical micro-hairs, but more often than not they are one-celled rather than two-celled. *Sporobolus wrightii* appears to be unusual in having typical chloridoid micro-hairs. Unlike the Chlorideae, the Sporoboleae have paired short-cells over the veins, or they may occasionally be in short rows of not more than a few cells. Other characters of the Sporoboleae are the groups of bulliform cells of the *Sporobolus* type (Fig. XV, 8–9) (groups of this type are not restricted to the Sporoboleae), and the triangular parenchymatous bundle-sheaths, especially around the small vascular bundles, the apices of the triangles being directed towards the adaxial surface of the leaf.

DANTHONIEAE

The genus *Danthonia* itself, as at present constituted, is not anatomically homogeneous, for in some species the structure is wholly festucoid and in others the epidermis is panicoid. It seems not improbable that the festucoid species should be placed in one of the festucoid tribes and thus separated from the remainder.

NEOSTAPFIA AND ORCUTTIA

Reference to the descriptions of these two genera on pp. 651 and 336 shows that they have many points in common, and they appear to stand out clearly from other genera. It seems that they might form the basis of a tribe.

BAMBUSEAE

It has already been noted that the Bambuseae have leaves that do not fall into the panicoid or festucoid types. Indeed, like some of the genera that we have just been discussing, they combine the characters of both groups, but, in addition, they have distinctive characters of their own. For these reasons the Bambuseae have been treated separately in this book. The characters of bamboo leaves that distinguish them from those of most other grasses are also to be seen in a few genera such as *Anomochloa*, *Neurolepis*, *Pariana*, *Streptochaeta*, *Streptogyna*, and *Thysanolaena*, and to a lesser extent in such genera as *Leptaspis*, *Pharus*, and *Olyra*.

The leaf characters of the Bambuseae are as follows: Short-cells, over the veins, paired or in rows. Silica-bodies, over the veins, cross to dumb-bell shaped, saddle-shaped, or sometimes tending to be of the oryzoid type. Micro-hairs generally present, usually with both cells of more or less equal lengths, the distal cell generally having a rounded apex; variants of this basic type occur in different species (Fig. XVI). Papillae on the long-cells very common, but varying in frequency from species to species, often overarching the stomata and thus obscuring the outlines of the subsidiary cells. (Similar papillae occur in certain other grasses, such as the Oryzeae, besides the bamboos, but are much less common.) Midrib or keel generally well developed and exhibiting a complex vascular system, the vascular bundles being strongly supported by sclerenchyma (Fig. XVII). Mesophyll with the chlorenchyma always consisting of arm-cells, and nearly always including characteristic fusoid-cells between the veins (Fig. XVIII, 3, 4, 5, and 7), although the fusoid-cells tend to be reduced, or are sometimes absent, in certain species of *Phyllostachys*. Bundle-sheaths always double.

Although the Bambuseae constitute a well-defined, natural group, they resemble the Oryzeae in having arm-cells in the mesophyll, and this affinity is also supported by the occurrence of oryzoid silica-bodies in certain species. On the whole, however, the Bambuseae tend to resemble the Olyreae rather than any other tribe.

(*e*) *General conclusions*

It seems unwise, at this stage, to proceed any further in discussing the use of histological details in elucidating the boundaries between the tribes. The subject is clearly one that needs the closest collaboration between anatomists and grass taxonomists. It is felt, however, that provided this collaboration can be achieved, and that none of the collaborators wishes to carry his own point of view at all costs, and to the exclusion of all others, we have here a tool that may well give us some deeper insight into the basic classification of the Gramineae. It seems as if it will be more profitable, at this stage, to concentrate on discovering natural taxonomic groups rather than to speculate concerning the phylogeny of the grass genera as we know them today. We

know remarkably little concerning the ancestors of the Gramineae, and we must recognize that the present-day grasses may have evolved along independent lines from remote geological times. In such circumstances it seems to serve no useful purpose to speak as if there is necessarily any direct phylogenetic connexion between the present-day species, genera, and tribes of grasses. As we know nothing of the ancestors of the Gramineae it is a matter of sheer speculation to speak of this, that, or the other character as being primitive or advanced. On the other hand, the attempt to arrange the grasses in natural taxonomic units is a line of inquiry that can be pursued along scientific lines, and without having to resort unduly to speculation. It is, however, a line of inquiry that calls for a very high order of intellectual honesty and capacity if it is to lead to the discovery of taxonomic units that have real significance, and are not just compartmentalized conveniences based on guesswork or superficial investigation. The systematic anatomist can at least take courage from the fact that inquiries made along independent lines are leading to conclusions not unlike his own. For example, Reeder (1957) has put forward suggestions concerning the basic groups of the Gramineae following his investigation into the morphology and structure of grass embryos. His basic groups are the true festucoids, the true panicoids, the chloridoid-eragrostoid, the bambusoid, the oryzoid-olyroid, and the arundoid-danthonioid groups. With the exception of the arundoid-danthonioid group, concerning which the present author has expressed no views, the remaining five groups seem to have much in common with the main divisions that appear to exist in the light of the anatomical evidence. It is also interesting to note that the embryological evidence, like the evidence of leaf anatomy, indicates that the tribes of the festucoid grasses are more heterogeneous than the panicoid tribes.

Before finally leaving the primary taxonomic divisions of the Gramineae, it must be emphasized once again that taxonomic conclusions based on anatomical evidence that is too narrow can be misleading. Thus, for example, the interesting investigations by Brown (1958) into the nature of the bundle-sheaths have led to his classifying a considerable number of genera in bambusoid, arundoid, panicoid, aristoid, and chloridoid groups. On the whole these groups appear to be natural in the light of other evidence, but his bambusoid group seems unsatisfactory when other anatomical evidence is taken into account.

3. Anatomical Evidence concerning Genera and Species

During the course of his investigations the author recorded the diagnostic microscopical characters for a great many species on perforated index cards similar to those devised by Clarke (1938) as an aid to the identification of timbers. When data have been recorded in this way it is quite easy, by placing the appropriate cards together in a pack, to see at a glance how far the individual genera are clearly distinguishable from one another. If the genera are truly distinct, this should immediately be made evident by the fact that the slots in the cards representing the diagnostic characters for the genera do not correspond. In practice this mode of investigation makes it abundantly

clear that there is a marked overlap in the characters of those genera that are generally accepted as being closely related to one another. This seems to indicate that differences between closely related genera, based on leaf characters alone, would be of little taxonomic value. On the other hand, differences clearly exist between genera that are not closely related to one another, but these differences are often the same as those that serve to separate the tribes as well as the genera themselves. The lack of intergeneric differences in leaf structure is particularly marked in the Bambuseae. On leaf characters alone the Bambuseae fall into not more than a very few genera, and even the differences between these are not very clear cut. Interspecific differences, on the other hand, are often quite marked in the Bambuseae. (See also p. 584.)

In writing this book the emphasis has been on basic divisions rather than on interspecific differences. The author can, therefore, speak on the differences between the minor taxa with comparatively little authority because there are but few genera of which he has made a detailed survey. Furthermore, quite inadequate attention has been devoted to studying the range of variation in leaf structure within a species. Nevertheless, the reader will find that some genera have been treated quite fully. Examples are *Festuca*, *Danthonia*, *Chloris*, and *Sporobolus*, whilst some idea of the range of leaf variation that can occur within a species will be found, for example, under *Cynodon dactylon*. From the information that is available it seems evident that much can be done in the way of distinguishing between species by studying their leaf anatomy, but the characters that are valuable for this purpose are entirely different from those that serve for the basic division of the Gramineae into tribes. Interspecific differences are to be seen, for example, in the distribution of short-cells, silica-bodies, and prickle-hairs; in the number of vascular bundles in a transverse section of a leaf taken at a standard position in the leaf, the leaf being taken from a standard position on the plant; in the height and shape of the surface ridges and furrows; in the distribution, sizes, and shapes of sclerenchyma strands or girders associated with the vascular bundles. There are, however, some genera such as *Danthonia* which, as already discussed on p. lvi, are composed of species that differ in respects that are much more fundamental. The taxonomist should be on his guard when dealing with genera that exhibit such a wide range of structure, for it may well be that the genus does not represent a natural group.

To elaborate this discussion of the relationship of leaf structure to taxonomy would involve repetition of much of the information that is given in the 'Special notes' at the ends of the descriptions of the individual genera, and the reader should turn to these notes for further details. In conclusion the author would, once again, emphasize the lack of wisdom in basing taxonomic opinions on evidence that is incomplete or on a basis that is too narrow. The evidence of leaf anatomy, besides being correlated with that based on exomorphology, must be considered alongside the findings of cytologists, embryologists, and other specialist investigators. It is only by a synthesis of these specialized approaches that any real advance in the taxonomic treatment of the Gramineae is to be expected. If this present contribution can be incorporated in this synthetic approach the author will rest content.

SELECTION AND PREPARATION OF MATERIAL

WHENEVER possible material that had been fixed and preserved in formalin acetic alcohol (F.A.A.) was used.

Transverse sections of grass leaves are cut on a sledge microtome. The material is not embedded in wax, but held between pieces of pith in the clamp of the microtome. The exact procedure, devised by F. Richardson, is as follows. Freshly gathered material is placed in F.A.A. for a minimum of 48 hours, but it can remain in this mixture indefinitely until required for use. After removal from the fixative the material is washed in water, and selected pieces are then transferred to 5–10 per cent commercial hydrofluoric acid for 16–24 hours, an operation designed to remove silica. It is then washed in water for 6 hours and transferred to 70 per cent alcohol. Sections are then cut on a sledge microtome between pieces of pith. The sections are next cleared in a hypochlorite solution of the Eau de Javelle type. In practice the best results were obtained with a domestic bleaching solution such as 'Parozone', which can readily be obtained from a store that deals in household goods. The clearing requires 10–30 minutes depending on the nature of the material. After being washed in water for a few minutes, the sections are transferred to 70 per cent alcohol in a watchglass or excavated glass block. They are next stained in a mixture of 94 parts of 1 per cent safranin in 70 per cent alcohol and 6 parts of Delafield's haematoxylin, the safranin and haematoxylin thus being applied simultaneously. The staining solution is most satisfactory when freshly mixed and it should not be used if it is more than a week old. The sections should be stained for 16–24 hours, after which they are washed in 50 per cent alcohol. In order to obtain a satisfactory differentiation between the lignified and non-lignified cells the sections are placed in 50 per cent alcohol acidified with a few drops of concentrated hydrochloric acid. When the stain has been suitably differentiated, the sections are washed in 50 per cent alcohol, dehydrated by transferring them successively to 70 per cent, 95 per cent, and absolute alcohol, before being cleared in xylol and mounted in Canada balsam.

If it is necessary to use herbarium specimens rather than fixed material it is worth while to select portions of leaf that are as green as possible and free from cracks and abrasions. The selected material is boiled in water until the leaf has been restored as nearly as possible to its original shape. It is then placed in F.A.A. for 24 hours, after which sections can be prepared in the same way as for fixed material. Remarkably good results are often obtained by this technique, but its success largely depends on the state of preservation of the tissues in the herbarium material.

Surface view preparations of the leaf epidermis are made in the following way. A portion of the leaf to be examined is placed on a smooth, hard surface, with the epidermis to be investigated facing downwards. This can be done on a sheet of plate glass or on a microscope slide, but it is often more convenient

to do it directly on the surface of a laboratory bench, provided it is covered with 'Formica' or a similar material. The leaf specimen to be examined is irrigated with a hypochlorite solution or a bleaching agent such as 'Parozone', and the cells and tissues above the epidermis that is to be examined are gradually scraped away, starting with a sharp knife and finishing off with a safety razor blade. The 'Parozone' acts as a lubricant, and at the same time softens the tissues. When most of the unwanted cells and tissues have been removed the epidermis itself is cleared in 'Parozone', and washed in water, any cells that still adhere to it being carefully removed with a camel hair or similar brush. The epidermis can then be stained and mounted as described above for the leaf sections. This technique has been found to give better results than any other that has been tried, and it is usually possible to obtain very elegant preparations in which all of the diagnostic characters are clearly displayed. Patience and the skill derived from constant practice are both necessary if the best possible results are to be obtained. It is scarcely necessary to point out that it is essential to make sure that the epidermis is eventually mounted with its outer surface next to the coverslip.

Owing to difficulties arising through the refractive index of Canada balsam it is sometimes desirable to make supplementary preparations in other mounting media such as dilute glycerine. Phenol is an excellent mountant for demonstrating silica-bodies.

DESCRIPTIONS OF THE GENERA AND SPECIES IN ALPHABETICAL SEQUENCE

I. GENERA NOT IN THE BAMBUSEAE

ACIACHNE

For comments on the relationship of this genus to the Stipeae see under *Stipa* on p. 486. Parodi and Freier (1945) consider that *A. pulvinata* Benth. does not agree very closely, either in its anatomy or floral characters, with other genera belonging to the Stipeae, such as *Aristida*, *Nassella*, *Oryzopsis*, *Piptochaetium*, and *Stipa*.

Lamina very short, with 3 vb's, and with well-developed scl. forming a continuous layer at the periphery. Vb's more or less circular, each with a single bundle-sheath. Cells of the adaxial epidermis small and highly cutinized, bearing characteristic papillose hairs.

LITERATURE

Parodi and Freier 1945 (leaf)

ACROCERAS

DIAGNOSTIC GENERIC CHARACTERS

Short-cells, over the veins, in rows. Silica-bodies, over the veins, cross or dumb-bell shaped. Micro-hairs present: balanoform, or with the distal cell tapering towards the apex. Stomata with triangular subsidiary cells. Vascular bundles angular in outline. Mesophyll: chlorenchyma radiate, or tending to be so. Bundle-sheaths single and double.

SPECIES SPECIALLY EXAMINED

***Acroceras tonkinense* (Balansa) C. E. Hubbard**

LEAF

Abaxial epidermis

Short-cells in rows of 3–5 or rather more cells over the large veins; apparently absent between the veins. **Silica-bodies** dumb-bell shaped (Fig. IA, 18 (ii–iv), sometimes varying in appearance with the focus. **Macro-hairs:** fairly long hairs, with swollen constricted bases (Fig. II, 3), numerous in the intercostal zones. **Micro-hairs:** length 38–84 (mostly 72–84) μ; basal cell 18–58 (mostly 40–45) μ; distal cell 21–38 (mostly 30–36) μ; hairs exceptionally long and usually tapering to a pointed apex (Fig. VII, 9), the basal cell being longer than the distal cell. **Prickle-hairs:** prickles rather infrequent over, and hooks (Fig. VI, 5) between, the veins. **Stomata** with triangular subsidiary cells (Fig.

IV, 1). **Long-cells:** those between the veins nearly or quite cubical, with slightly to moderately sinuous walls (Fig. V, 7*a–b*); interstomatal cells with concave ends (Fig. V, 10*a–b*).

T.S. lamina

Vascular bundles: most vb's small, angular (Fig. VIII, 5); large vb's of basic type (Fig. VIII, 10). **Adaxial surface** with slight, rather widely spaced, rounded ribs, separated from one another by wide, shallow furrows (Fig. XIV, 2). **Sclerenchyma:** most vb's with v. small adaxial and abaxial girders (Fig. IX, 4); large vb's with wider adaxial and abaxial girders (Fig. IX, 5). **Midrib** conspicuous owing to adaxial and abaxial projections; abaxial projection strongly supported by a subepidermal layer of scl.; containing a large median vb. accompanied on either side by a smaller lateral vb (Fig. XIII, 2). **Mesophyll** with chlorenchyma distinctly radiate around the vb's; radiating cells very long as in *Isachne*. **Bulliform cells** in well-defined groups as Fig. XV, 2. **Bundle-sheaths** single and double; all small vb's with single complete sheaths (Fig. XI, 2A), the sheaths being provided with adaxial uniseriate or unicellular extensions to the adjacent scl. Large vb's with 2 complete sheaths (Fig. XII, 1). Median keel bundle with an O.S. connected to the adaxial scl. by a multiseriate extension of colourless cells.

MATERIAL EXAMINED: R. H. Foster F.81. North Borneo.

Acroceras zizanioides (H. B. K.) Dandy

LEAF

Abaxial epidermis

Short-cells, over the veins, in rows of more than 5, those between the veins mostly paired; abundant both over and between the veins. **Silica-bodies,** over the veins, cross-shaped (Fig. IA, 16); those between the veins tall and narrow (Fig. I, 4). **Macro-hairs:** long, narrow, slender (Fig. II, 1); infrequent. **Micro-hairs**: length 36–45 (mostly 40–45) μ; basal cell 12–22 (mostly 14–18) μ; distal cell 24–31 (mostly 26–30) μ; hairs mostly balanoform (Fig. VII, 3), the distal cells being inflated and usually having rounded, or only slightly pointed, apices; hairs very much shorter than those of *A. tonkinense*. **Papillae** and **prickle-hairs:** none observed. **Stomata** with triangular (Fig. IV, 1), but not very tall, subsidiary cells. **Long-cells:** of 2 types, some with thin, sinuous walls (Fig. V, 3*a–c*), others more inflated (Fig. V, 5); interstomatal cells with concave ends (Fig. V, 10*a–b*).

T.S. lamina

Vascular bundles mostly small, polygonal (Fig. VIII, 5). **Adaxial surface** smooth, or with very slight ribs and furrows (Fig. XIV, 1–2). **Sclerenchyma:** all small vb's with small adaxial and abaxial girders (Fig. IX, 4), with extensions to the epidermis; keel bundle with an anchor-shaped girder (Fig. IX, 6). **Keel** fairly prominent, projecting slightly from the abaxial surface; containing a solitary vb (Fig. XIII, 1). **Mesophyll** with chlorenchyma tending to be radiate around the vb's; not radiate opposite the furrows. **Bulliform cells** sometimes tending to be in groups of specially large cells—*Zea* type (Fig. XV, 3), the cells projecting well above the level of the epidermis, at least in dried material; most bulliform cells in fan-shaped groups (Fig. XV, 4). **Bundle-sheaths:** small vb's with single complete sheaths of v. large cells (Fig. XI, 2A); with short, generally unicellular extensions to the adaxial epidermis. A few large vb's with 2 complete sheaths (Fig. XII, 1), with pluriseriate extensions to the adaxial epidermis.

CULM

Culm examined about 4 mm in diameter. Epidermis subtended by 4 layers of unlignified cells, followed by a band of fibrous ground tissue about 5 cells wide with a single circle of vb's embedded in it; 3 concentric circles of vb's between the zone of fibrous ground tissue and the hollow centre of the culm.

MATERIAL EXAMINED: Meikle 552; Nigeria.

SPECIAL NOTE

The leaf structure is panicoid.

AEGILOPS

DIAGNOSTIC GENERIC CHARACTERS

Silica-bodies, over the veins, mostly horizontally elongated and with smooth or sinuous outlines (Fig. IA, 13–14), but other types also occur. Stomata with subsidiary cells parallel-sided or tending to be so. Mesophyll: chlorenchyma not radiate. Bundle-sheaths double.

Aegilops crassa Boiss.

LEAF

Abaxial epidermis

Short-cells: those over the veins mostly solitary and in rows of 3–5 cells; a few paired; infrequent between the veins. **Silica-bodies** horizontally elongated with rounded ends and smooth (Fig. IA, 12), or sinuous (Fig. IA, 14), outlines. **Macro-hairs** long, superficial, with swollen bases (Fig. II, 1). **Micro-hairs** absent. **Prickle-hairs:** angular prickles (Fig. VI, 3), at the leaf margins. **Stomata** with parallel-sided subsidiary cells (Fig. IV, 2). **Long-cells** with thin, non-sinuous walls (Fig. V, 2*a–c*).

T.S. lamina

Vascular bundles: small vb's numerous and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 15). **Adaxial surface:** v. slightly ribbed (Fig. XIV, 2). **Sclerenchyma:** smallest vb's not accompanied by scl. (Fig. IX, 1); other small vb's with adaxial strands only (Fig. IX, 2), or small adaxial and abaxial strands (Fig. IX, 4); a few medium-sized vb's with 1- or partly 2-seriate adaxial and abaxial girders; largest vb's with short but wide adaxial and abaxial girders (Fig. IX, 5). **Keel** not prominent; with a solitary vb. (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform**

cells in well-defined groups as in Fig. XV, 2. **Bundle-sheaths** all double; both large and small vb's with I.S. complete and O.S. interrupted abaxially (Fig. XII, 2).

MATERIAL EXAMINED: Cultivated at Kew.

Aegilops triaristata Willd.

LEAF

Abaxial epidermis (Fig. XXIX, 1)

Short-cells, over the veins, often appearing to be solitary, but some of them appearing to be in rows when separated from one another by relatively short cells in the same files; definitely in rows at the margins of the large veins; some in pairs over the largest veins; common over, but infrequent or absent between, the veins. **Silica-bodies** horizontally elongated and mostly with sinuous outlines (Fig. IA, 14); some of those over the largest veins oblong (Fig. I, 10). **Macro-hairs** not v. frequent; moderately long; with swollen, superficial bases (Fig. II, 1). **Micro-hairs** and **prickle-hairs:** none seen. **Stomata** with subsidiary cells more or less parallel-sided (Fig. IV, 2), but sometimes tending to be low dome-shaped. **Long-cells** with thin, non-sinuous walls (Fig. V, 2*a–c*); interstomatal cells rather long, with concave ends (Fig. V, 11).

T.S. lamina

Vascular bundles: most vb's small and not conspicuously angular in outline (Fig. VIII, 2); a few large vb's of basic type (Fig. VIII, 15). **Adaxial surface** v. slightly ribbed (Fig. XIV, 2). **Sclerenchyma:** smallest vb's not accompanied by scl. (Fig. IX, 1); others with small adaxial strands only (Fig. IX, 2), or small to minute adaxial and abaxial strands (Fig. IX, 4); largest vb's occasionally girdered abaxially. **Keel** scarcely prominent; with a solitary bundle (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** in well-defined groups as in Fig. XV, 2; slight tendency to be in fan-shaped groups (Fig. XV, 4). **Bundle-sheaths** double; most small vb's with 2 complete sheaths (Fig. XII, 1); all large, and occasional small, vb's with O.S. not quite complete abaxially (Fig. XII, 2).

MATERIAL EXAMINED: Cultivated at Kew.

Aegilops ventricosa Tausch

LEAF

Abaxial epidermis

Short-cells mostly solitary over the small veins, and in pairs over some of the large ones; tending to be in rows over, or at the sides of, some of the large veins; abundant over, but infrequent between, the veins. **Silica-bodies** mostly horizontally elongated, with sinuous outlines (Fig. IA, 14); others, especially those near the leaf margins, tall and narrow (Fig. I, 4), or sometimes fitting into concavities in the cork-cells (Fig. I, 6–7). **Macro-hairs** fairly long and frequent; superficial, with swollen bases (Fig. II, 1). **Micro-hairs:** none seen. **Prickle-hairs:** angular prickles at the leaf margins (Fig. VI, 3), and prickles

over a few veins near the leaf margins. **Stomata** with parallel-sided subsidiary cells (Fig. IV, 2). **Long-cells** with thin, non-sinuous walls (Fig. V, 2*a–c*).

T.S. lamina

Vascular bundles: most vb's small, and not conspicuously angular in outline (Fig. VIII, 2); a few large vb's of basic type (Fig. VIII, 15). **Adaxial surface** slightly ribbed (Fig. XIV, 2). **Sclerenchyma:** smallest vb's not accompanied by scl. (Fig. IX, 1); others with a small abaxial girder or strand only (Fig. IX, 3); large vb's with small adaxial and abaxial girders (Fig. IX, 4), and the largest vb's with wider adaxial and abaxial girders (Fig. IX, 5). **Keel** fairly prominent; with a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** in well-defined groups as in Fig. XV, 2; also tending to be in fan-shaped groups in some of the adaxial furrows (Fig. XV, 6). **Bundle-sheaths** double; both large and small vb's with O.S. incomplete abaxially (Fig. XII, 2).

CULM

Culm examined about 3 mm in diameter and elliptical in outline. Epidermis subtended by 3–4 subjacent layers of thickened lignified cells. Outer ring of small vb's embedded in the thickened ground tissue. Inner ground tissue consisting of 3–4 layers of large, thin-walled cells, the centre of the culm being occupied by a large cavity. Only 1 ring of vb's embedded in the inner, large-celled, ground tissue.

MATERIAL EXAMINED: Cultivated at Kew.

ADDITIONAL INFORMATION FROM THE LITERATURE

Prat (1932), basing his observations on *A. ovata* L., *A. triuncialis* L., and *A. ventricosa* Tausch, refers to 'cellules à pointes courtes', sometimes known as crown-cells (Prat 1933), which appear to be rounded in surface view preparations of the epidermis, and occur as solitary cells in the rows of intercostal long-cells. They are also present on the lemmas and glumes. Cells of this type, when observed by the author, have been interpreted as prickle-hairs or macro-hairs with v. short points. Prat (1932) also indicates that hooks (Fig. VI, 5), often paired with stomata, are common on the adaxial surfaces of the leaf-sheaths. He figures the silica-bodies that are in the more distal members of pairs of short-cells as fitting into concavities in the adjacent cork-cells, the bodies being somewhat oval in outline.

Günzel (1921) indicates that the adaxial surface in *A. ovata* L. is strongly ribbed, and the abaxial surface less so; intercostal long-cells in the same species with sinuous walls, and prickles present on certain parts of the leaf.

SPECIAL NOTE

Prat (1932) stresses that *Aegilops* has many structural similarities to *Agropyron* and *Triticum* and that hybrids between these genera show the structural features common to both genera, but the distribution of these structures in any particular hybrid is partly that of one parent and partly that of the other. Leaf structure festucoid.

Literature

Günzel 1921 (leaf); Pée-Laby 1898 (leaf); Prat 1932, 1936 (leaf and taxonomy); Schröder 1931.

AEGOPOGON

The following information has been recorded by Grob (1896), based on '*A. pusillus* Beauv.', now known as *A. cenchroides* Humb. & Bonpl. ex Willd.

Sharply angular silica-cells, sometimes resembling crystals, present between the somewhat elongated bulliform cells on the adaxial surface, and in the intercostal areas on both surfaces of the leaf. Cushion hairs present. Club-shaped micro-hairs noted, especially in the intercostal regions, but a few present over the scl. as well.

Special Note

The presence of club-shaped micro-hairs suggests affinities with the panicoid grasses, possibly with Chlorideae.

Literature

Grob 1896 (leaf).

AELUROPUS

Diagnostic Generic Characters

Silica-bodies, over the veins, cross to dumb-bell shaped. Micro-hairs present as in Fig. VII, 2. Stomata with triangular or low dome-shaped subsidiary cells. Mesophyll with radiate chlorenchyma. Bundle-sheaths single round the small, and double round the large, vb's.

Species Specially Examined

***Aeluropus littoralis* (Gouan) Parl.**

Leaf

Abaxial epidermis

Short-cells, over the veins, in rows of more than 5 cells; those between the veins obscured by papillae, but present as solitary or paired cells, especially at the sides of the veins; generally common. **Silica-bodies,** over the veins, either cross-shaped (Fig. 1A, 16), or intermediate between cross-shaped and dumb-bell shaped, but with the middle piece nearly as wide as the ends (Fig. 1B, 19); short-cells between the veins devoid of conspicuous silica-bodies, the cells being tall and narrow. **Macro-hairs:** none seen. **Micro-hairs:** length 21–27 (mostly 23–25) μ; basal cell 7–12 (mostly 9–12) μ; distal cell 14–18 μ; hairs spherical, the distal cells being inflated and with rounded apices (Fig. VII, 2). **Papillae** abundant, except over the veins; oblique, with thick endings (Fig. III, 2). **Prickle-hairs:** prickles (Fig. VI, 1–2), locally frequent over the veins. **Stomata** with triangular (Fig. IV, 1) or low dome-shaped (Fig. IV, 3) subsidiary cells. **Long-cells** nearly or quite cubical, with slightly to moderately sinuous walls (Fig. V, 7*a–b*).

T.S. lamina

Vascular bundles: most vb's small and markedly angular in outline (Fig. VIII, 5); a few large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with ribs and furrows well developed (Fig. XIV, 4). **Sclerenchyma:** a v. few of the smallest vb's not accompanied by scl. (Fig. IX, 1); most vb's with small adaxial and abaxial strands or girders (Fig. IX, 4); most vb's with short but wider adaxial and abaxial girders, or, occasionally, strands (Fig. IX, 5). **Keel** not prominent; with a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma distinctly radiate around the vb's. **Bulliform** and **colourless cells** forming girders extending from the bases of the adaxial furrows to the abaxial epidermis (Fig. XV, 14). **Bundle-sheaths** single and complete around all the vb's of the polygonal type (Fig. XI, 2A); double and complete around the large vb's (Fig. XII, 1).

Material Examined: Sandwith 1046.

Additional Information from the Literature

Duval-Jouve (1875) records transverse veins in the leaf. Grob (1896) refers to highly silicified papillae, short-cells occurring sporadically in the intercostal zones of the leaf. Günzel (1921) records the leaf-sheaths as containing much mechanical tissue, as being weakly ribbed on the adaxial surface, and as having numerous abaxial papillae.

Special Note

Although *Aeluropus* has been classified in the Festuceae the leaf structure is panicoid. The micro-hairs resemble those of the Chlorideae.

Literature

Duval-Jouve 1875 (leaf); Grob 1896 (leaf epidermis); Günzel 1921 (leaf); Wille 1916.

AFRACHNERIA

Six spp. listed by de Wet (1956) under *Afrachneria* have leaves with a panicoid epidermis and festucoid anatomy. The genus is regarded as a member of the Danthonieae, closely related to *Pentaschistis*. The genus is out of place in the Aveneae.

Literature

de Wet 1956 (leaf).

AGROPOGON

A. littoralis (Sm.) C. E. Hubbard is a hybrid between *Agrostis stolonifera* (L.) and *Polypogon monspeliensis* (L.) Desf. It is sometimes known as *P.*

littoralis Sm. Under this name Pée-Laby (1898) says of the plant that it has stomata in equal numbers on both leaf surfaces, and that bulliform cells are present.

Literature

Duval-Jouve 1875 (leaf); Pée-Laby 1898 (leaf under *Polypogon littoralis* Sm.).

AGROPYRON

Diagnostic Generic Characters

Short-cells solitary and in pairs both over and between the veins. Silica-bodies commonly tall and narrow (Fig. I, 4), but varying proportions of other types often present as well in different species. Micro-hairs absent. Stomata with low dome-shaped subsidiary cells. Small vascular bundles not angular in outline. Mesophyll with chlorenchyma not radiate. Bundle-sheaths double.

Species Specially Examined

***Agropyron caninum* (L.) Beauv.**

Leaf

Abaxial epidermis

Short-cells mostly solitary or in pairs, both over and between the veins. **Silica-bodies** rather diverse in shape; sometimes, especially between the veins, tall and narrow (Fig. I, 4); a few tending to be saddle-shaped (Fig. I, 5); some fitting into concavities in the cork-cells (Fig. I, 6–7); a v. few of those over the veins horizontally elongated (Fig. IA, 12–13). **Macro-hairs** short, rigid, thick-walled (Fig. IIA, 10). **Micro-hairs:** none seen. **Prickle-hairs:** prickles (Fig. VI, 1–2) common over the veins; hooks (Fig. VI, 5) local between the veins. **Stomata** absent from the abaxial surface. **Long-cells** with thin non-sinuous walls (Fig. V, 2*a–c*).

T.S. lamina

Vascular bundles mostly small and not conspicuously angular in outline (Fig. VIII, 2). **Adaxial surface** smooth (Fig. XIV, 1). **Sclerenchyma:** smallest vb's not accompanied by scl. (Fig. IX, 1); most vb's with 1–2-seriate adaxial and abaxial girders (Fig. IX, 4); largest vb's with low, wide, adaxial and abaxial girders (Fig. IX, 5); keel bundle with stronger girders than the others. **Keel** fairly prominent; with 1 main vb. **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** in well-defined groups as in Fig. XV, 2, the groups being about 5–8 cells long. **Bundle-sheaths** double; all large, and some small, vb's with the O.S. interrupted adaxially and abaxially (Fig. XII, 3*a–b*); small vb's with O.S. abaxially incomplete (Fig. XII, 2).

Material Examined: Cultivated at Kew.

***Agropyron elongatum* (Host) Beauv.**

Leaf

Abaxial epidermis

Short-cells mostly solitary or in pairs, both over and between the veins; abundant. **Silica-bodies** tall and narrow (Fig. I, 4). **Macro-hairs** and **micro-hairs:** none seen. **Prickle-hairs:** angular prickles (Fig. VI, 3) local over the veins. **Stomata** with low dome-shaped subsidiary cells (Fig. IV, 3). **Long-cells** both over and between the veins, with thick, pitted or sinuous walls (Fig. V, 1*a–b*).

T.S. lamina

Vascular bundles: small vb's opposite the furrows not conspicuously angular in outline (Fig. VIII, 2); large vb's, opposite the ribs, of basic type (Fig. VIII, 15). **Adaxial surface** fairly strongly ribbed (Fig. XIV, 3). **Sclerenchyma:** a few v. small vb's not accompanied by scl. (Fig. IX, 1); those opposite the furrows with well-marked abaxial girders only (Fig. IX, 3); vb's opposite the ribs with adaxial T- and broad abaxial I-girders (Fig. IX, 8), the cells of the T-girders having wide lumina. **Keel** not prominent; with a solitary vb. (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform-cells** in fan-shaped groups (Fig. XV, 6) at the bases of the furrows. **Bundle-sheaths** double; vb's opposite the ribs with O.S. interrupted adaxially and abaxially (Fig. XII, 3*a*); vb's opposite the furrows with O.S. interrupted abaxially (Fig. XII, 2).

Culm

Culm examined about 3 mm in diameter and circular in outline. Epidermis subtended by a zone of about 6 layers of lignified, thick-walled cells, with a circle of longitudinal columns of assimilatory tissue, each column being more or less oval in T.S., embedded in the scl. A single ring of small vb's also embedded in the peripheral scl. Ground tissue between the peripheral scl. and the hollow centre of the culm, consisting of about 14 layers of thin-walled cells, with 2 circles of vb's embedded in it.

Material Examined: Cultivated at Kew.

***Agropyron laxum* (Fries) Almq. (*A. repens*×*junceiforme*)**

Leaf

Abaxial epidermis

Short-cells mostly solitary, but sometimes in pairs, both over and between the veins; abundant. **Silica-bodies** of rather diverse shapes; sometimes tall and narrow (Fig. I, 4) or saddle-shaped (Fig. I, 5), and others appearing cubical or oblong. **Macro-hairs, micro-hairs,** and **prickle-hairs:** none seen. **Stomata** with low dome-shaped subsidiary cells (Fig. IV, 3). **Long-cells** with rather thick, sinuous walls (Fig. V, 1*a–b*), especially over the veins; those between the veins sometimes with thinner walls and more as in Fig. V, 3*a–b*; interstomatal cells rather long and with concave ends (Figs. V, 11).

T.S. lamina

Vascular bundles: most vb's small and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with fairly marked ribs and wide, shallow furrows (Fig. XIV, 3). **Sclerenchyma:** occasional vb's with either an adaxial or abaxial girder only (Fig. IX, 3); most vb's with 1–4-seriate adaxial and abaxial girders (Fig. IX, 4), the adaxial girder tending to be T-shaped. **Keel** inconspicuous; containing a solitary vb. (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** in well-defined groups as in Fig. XV, 2, each group being up to about 8 cells long; some groups tending to be fan-shaped (Fig. XV, 4). **Bundle-sheaths** double; large vb's with O.S. interrupted adaxially and abaxially (Fig. XII, 3*a*); most small vb's with O.S. interrupted abaxially (Fig. XII, 2); occasional vb's with 2 complete sheaths (Fig. XII, 1).

MATERIAL EXAMINED: Cultivated at Kew.

Agropyron intermedium (Host) Beauv.

LEAF

Abaxial epidermis

Short-cells solitary and paired both over and between the veins; many of the short-cells over the veins conspicuously pitted; abundant. **Silica-bodies** rather diverse in shape; some tending to be tall and narrow (Fig. I, 4); others rounded and fitting into concavities in the cork-cells (Fig. I, 6–7). **Macro-hairs** and **micro-hairs:** none seen. **Prickle-hairs:** angular prickles at the leaf margins (Fig. VI, 3). **Stomata** with low dome-shaped subsidiary cells (Fig. IV, 3). **Long-cells** over the veins with thick, sinuous or pitted walls (Fig. V, 1*a–b*); those between the veins similar, or with thin, sinuous walls (Fig. V, 3*a–c*); interstomatal cells long, with concave ends (Fig. V, 11).

T.S. lamina

Vascular bundles: small vb's opposite the furrows and small ribs not conspicuously angular in outline (Fig. VIII, 2); vb's in the large ribs of basic type (Fig. VIII, 15). **Adaxial surface** with fairly tall ribs and deep furrows (Fig. XIV, 4); also some shorter secondary ribs. **Sclerenchyma:** occasional small vb's devoid of scl. (Fig. IX, 1); vb's opposite the furrows and small ribs with well-marked abaxial girders only (Fig. IX, 3); large vb's with the adaxial girders slightly T-shaped, the abaxial girders being short and up to about 6-seriate (Fig. IX, 8). **Keel** not prominent; with a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells:** some groups as in Fig. XV, 2; also groups in the deep furrows fan-shaped (Fig. XV, 6). **Bundle-sheaths** double; large vb's with O.S. interrupted adaxially and abaxially (Fig. XII, 3*a*), small vb's with O.S. interrupted abaxially only (Fig. XII, 2).

CULM (Fig. XIX, 4)

Culm examined about 4 mm in diameter and circular. Epidermis subtended by about 9 layers of cells with thickened, lignified walls, with a circle of small, oval, columns of assimilatory tissue embedded in the thickened ground tissue. Inner ground tissue consisting of some 12 layers of large cells, with thin walls and wide lumina, surrounding the hollow centre of the culm. A single ring of vb's present in the peripheral, thickened ground tissue; two rings of vb's embedded in the more central thin-walled ground tissue.

MATERIAL EXAMINED: Cultivated at Kew.

ADDITIONAL INFORMATION FROM THE LITERATURE

1. LEAF

Prat (1932) describes the genus as homogeneous so far as types of epidermal cells and appendages are concerned. Prickles and hooks are common, 'crown-cells' (see below) sometimes present, and hairs with club-shaped endings occur rarely.

A. repens (L.) Beauv.

Burr and Turner (1933) record macro-hairs and prickles as present or absent, the hairiness varying from leaf to leaf. Adaxial surface with unequal ribs, those on the large vb's with flattened, and the remainder with rounded, apices. Keel slightly developed. Bulliform cells present in the furrows. According to Prat (1932) the hypodermal scl. in this sp. forms a continuous layer.

A. junceiforme A. & D. Löve (as *A. junceum*).

Lewton-Brain (1904) records and figures unequal ribs.

A. glaucum Roem. & Sch.

The glaucous, rolled, junciform leaves described by Prat (1932) as having well-developed ribs and furrows on the adaxial surface; prickles and hooks over the veins; ubiquitous 'crown-cells' (see below). Prat (1932) also gives some detailed particulars concerning '*A. campestre* Godr. & Gren., *caesium* Presl., *elongatum* P. B. Host., *junceum* P. B., *orientale* L., *pycnanthum* Godr. & Gren., *rouxii* Gren. & Duval-Jouve (leaf rolled and narrow and rather distinctive from other sp.), and *savignonii* de Not.' Prat emphasizes that variations within a sp. make specific identifications very difficult.

Crown-cells, or *cellules à pointe courte*, i.e. isolated epidermal cells in the files of long-cells, and each with a protruding point, recorded by Prat (1933) on the leaves and stems of *A. campestre*, *caesium*, *elongatum*, *glaucum* Roem. & Sch., *pouzolzii* Godr. & Gren., *pycnanthum*, and *savignonii*. Crown-cells noted by Prat only on the bracts, lemmas, and glumes in *A. caninum*, *junceum*, and *repens*.

American specimens of *A. repens* and *A. trachycaulum* (Link.) Malte were found to be devoid of crown-cells on the abaxial surfaces of their leaves, but such cells were noted on the abaxial leaf surface in *A. smithii* Rydburg. Crown-cells also occur in *Aegilops* and *Triticum*.

2. CULM

Prat (1932) records the vb's as being in 2–3 circles in *A. junceum*, in one circle in the hollow culm of *A. repens*, as numerous and arranged in a single circle in the solid culm of *A. glaucum*.

3. RHIZOME

Grob (1896) records cork- and silica-cells in the epidermis of *A. repens*. Prat (1932) indicates that the cortex is narrow and that the vb's are in 3–4 circles in *A. junceum*; in *A. repens* there are 1–3 circles of bundles and a wide cortex in the solid

or hollow rhizome, and 1–2 circles of bundles and a wide cortex in the solid rhizome of *A. glaucum.*

4. ROOT

Holm (1908), discussing the structure of the roots of certain grasses from the ecological standpoint, figures a T.S. of the root of *A. violaceum* (Hornem.) Lge., and records that the roots of this sp., and of *A. scribneri* Vas., from dry, stony soil, have the outer cortex sclerosed.

5. STEM APEX

Sharman (1945, 1947) indicates that the rhizomes and early aerial shoots have relatively short apices with only a few primordia. Later in the season the apex of the main aerial shoot becomes longer and bears more numerous primordia. After still further elongation spikelet primordia arise in the axils of the primordia.

SPECIAL NOTE

Leaf structure festucoid.

LITERATURE

Burr and Turner 1933 (leaf); Duval-Jouve 1870, 1875 (leaf); Grob 1896 (leaf); Holm 1908 (root), 1929 (rhizome); Lewton-Brain 1904 (leaf); Pée-Laby 1898 (leaf); Prat 1932, 1933, 1934, 1936 (leaf); Sharman 1945, 1947 (shoot apex); Strecker 1913 (leaf); Wiemann 1954 (ecological anatomy); Zufall 1919 (comparison with *Cynodon dactylon*).

AGROPYROPSIS

The short description of the leaf structure of *A. lolium* (Bal.) A. Camus by Hansen and Potztal (1954) includes the following particulars.

Silica-bodies rounded or somewhat oblong. Prickles infrequent. Scl. forming well-developed adaxial and abaxial girders to the vb's. Mesophyll with chlorenchyma not radiate. Bundle-sheaths single; the single sheath corresponding to the I.S., a parenchymatous sheath being absent. Starch compound.

SPECIAL NOTE

Hansen and Potztal treat *Agropyropsis* as a member of the Leptureae.

LITERATURE

Hansen and Potztal 1954 (leaf).

AGROSTIS

DIAGNOSTIC GENERIC CHARACTERS

Silica-bodies, over the veins, usually including some that are horizontally elongated and sinuous in outline (Fig. 1A, 14), but other types also occur. Stomata with parallel-sided, or low dome-shaped, subsidiary cells. Small vb's seldom conspicuously angular in outline. Mesophyll: chlorenchyma not

radiate. Micro-hairs: none seen. Bundle-sheaths usually double, but I.S. sometimes inconspicuous or apparently absent round the small vb's.

SPECIES SPECIALLY EXAMINED

***Agrostis semiverticillata* (Forsk.) C. Christ**

LEAF

Abaxial epidermis

Short-cells, over the veins, solitary and in rows of 3–5 cells; infrequent over, and absent between, the veins. **Silica-bodies** horizontally elongated with sinuous outlines (Fig. 1A, 14). **Macro-hairs** and **micro-hairs:** none seen. **Prickle-hairs:** small prickles (Fig. VI, 1) frequent over and between the veins; small intercostal prickles tending to resemble hooks. **Stomata** with parallel-sided subsidiary cells (Fig. IV, 2). **Long-cells** with thin, non-sinuous walls (Fig. V, 2*a–c*), each cell narrower at the ends than in the middle.

T.S. lamina

Vascular bundles: most vb's small and not conspicuously angular in outline (Fig. VIII, 2), although sometimes rather angular (tending towards Fig. VIII, 5); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with moderate ribs and furrows (Fig. XIV, 3). **Sclerenchyma:** most vb's not accompanied by scl. (Fig. IX, 1), or at most with minute adaxial and abaxial strands, each strand consisting of only about 2 cells (Fig. IX, 4); large vb's accompanied by rather larger adaxial and abaxial strands; no girders noted. **Keel** not prominent; with a single vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells:** fairly well-defined groups as in Fig. XV, 2, in the furrows. **Bundle-sheaths:** small vb's each apparently with a single complete sheath (Fig. XI, 2*a*), no distinct I.S. being visible, possibly because of the small size of the cells. Large vb's infrequent, each with 2 complete sheaths (Fig. XII, 1).

MATERIAL EXAMINED: Collected by J. K. O'Byrne.

***Agrostis stolonifera* L. var. *palustris* (Huds.) Farw.**

LEAF

Abaxial epidermis

Short-cells, over the veins, sometimes appearing solitary because paired with prickles, but mostly paired with other short-cells, and a few in short rows of 3–5 cells; infrequent, especially between the veins. **Silica-bodies:** those between the veins sometimes horizontally elongated with sinuous outlines (Fig. IA, 14); others less sinuous (Fig. 1A, 12–13); a few, probably a short form of the type in Fig. 1A, 14, appearing almost cross-shaped. Some silica-bodies between the veins tall and narrow (Fig. I, 4), or tending to be rounded and to fit into concavities in the cork-cells (Fig. I, 6–7); rather a wide range of types for one species. **Macro-hairs** and **micro-hairs:** none seen. **Prickle-hairs:** numerous prickles (Fig. VI, 1–2) over and between the veins, with transitions to hooks (Fig. VI, 5) between the veins. **Stomata** with parallel-sided (Fig. IV, 2) or low dome-shaped (Fig. IV, 3) subsidiary cells.

T.S. lamina

Vascular bundles: most vb's small and not conspicuously angular in outline as in Fig. VIII, 2; a few large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with slight to moderate ribs and wide, shallow furrows (Fig. XIV, 2–3). **Sclerenchyma:** small vb's accompanied by minute adaxial and abaxial strands (Fig. IX, 4); large vb's with adaxial and abaxial girders mostly 3–4-seriate and not v. tall. **Keel** fairly prominent; with a solitary bundle (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** in well-defined groups as in Fig. XV, 2; slight tendency to form fan-shaped groups (Fig. XV, 4). **Bundle-sheaths** double, with 2 complete sheaths round all vb's (Fig. XII, 1), but adaxial part of the O.S. less conspicuous than the remainder in the small vb's.

CULM

Culm examined 2 mm in diameter. Epidermis and about 8 subjacent layers consisting of cells of small diameter with much thickened walls; no very definite columns of assimilatory tissue in the peripheral mechanical tissue, but a few cells here and there with thinner walls possibly serving this purpose. Inner ground tissue about 12 cells wide, consisting of larger cells with thinner walls; hollow centre of the culm narrow in diameter. A ring of small, inconspicuous vb's embedded in the peripheral mechanical tissue, and 2 rings of vb's in the outer part of the inner thin-walled ground tissue.

MATERIAL EXAMINED: Collected by J. K. O'Byrne at Flatford Mill.

ADDITIONAL INFORMATION FROM THE LITERATURE

1. LEAF

Burr and Turner (1933), amongst many others, have recorded the following facts.

A. canina L.

Leaves narrow, lower ones often setaceous. Adaxial surface with prominent, rounded ribs. Lower surface with slight ribs. Keel present. Prickle-hairs rare. Scl. present at the leaf margins, on the keel and below and/or above each vb, and frequently between the vb's. Bulliform cells well developed.

A. gigantea Roth (as *A. stolonifera* L. var. *gigantea* Koch)

Characters similar to those of *A. stolonifera* var. *palustris* described above, but prickles stated to be rare. Scl. present above and below the vb's and rarely between them. Bulliform cells not well developed.

A. stolonifera L. var. *stolonifera*

Said to have finer leaves than the var. *gigantea*, and the adaxial surface acutely ribbed; prickles rare. Scl. scanty, present above and below the veins and rarely between them. Bulliform cells well developed.

A. tenuis Sibth.

Adaxial surface with numerous rounded ribs; prickles frequent. Scl. present above and below, and frequently between, the veins. Bulliform cells not well developed.

Philipson (1937) found characters of the T.S. leaf to be unreliable for the separation of British spp. other than *A. setacea* Curt., with its bristle-like leaves.

Goosens (1945), referring to S. African spp. of *Agrostis*, records that, on the whole, their leaf anatomy is remarkably uniform. *Epidermis.* Short-cells round or elliptical, the oval cells often bearing prickles; those between the veins solitary or paired. Intercostal long-cells thin-walled, often inflated. *T.S. lamina.* Usually flat or open, but *A. eriantha* Hack. has rigid folded leaves that are ellipsoidal or V-shaped. Keel seldom well developed. Adaxial surface always with prominent, flat-topped or rounded, adaxial ribs. Abaxial surface usually slightly undulating or flat. Chlorenchyma not radiate. Lacunae tending to form in the mesophyll of *A. barbuligera* Stapf. Bulliform cells in groups of 3–5 cells between the ribs, not always clearly distinguished from other epidermal cells.

2. CULM

Philipson (1937) in 8 varieties of 5 British spp. records the following facts, with special reference to sections above the insertion of the uppermost leaf. Surface of the culm with ridges and furrows, with a small vb opposite each ridge, and a large vb deeper in the ground tissue opposite each furrow. Culm encircled by fibrous tissue, extending to the epidermis opposite each vb, but separated from it by a strand of assimilatory tissue between each consecutive pair of vb's. Centre of the culm becoming hollow. Larger culms containing more numerous vb's, and when the peripheral vb's are crowded the patches of assimilatory tissue between them may be reduced or absent. Culm structure not of specific diagnostic value.

Culm described briefly and illustrated by Holm (1908) for *A. canina* L. Vb's figured as being in a single circle, embedded in scl. which extends to the epidermis opposite each bundle. Separate strands of subepidermal chlorenchyma alternating with the vb's.

3. STOLON

Structure similar to that of the culm. Ground tissue between the epidermis and vascular tissue wide or narrow. Fibres in which the vb's are embedded forming a continuous ring or confined to the neighbourhood of the vb's. Stolons solid in young internodes, but generally becoming hollow. For further details see Philipson (1937).

4. RHIZOME

Rhizome, when present, similar to the stolon, but differences include the following: cuticle thinner; starch commonly abundant in cortex and pith; pith frequently solid; circle of fibrous tissue not extending to the epidermis. For further details see Philipson (1937).

5. ROOT

Philipson (1937) records the following details in 8 varieties of 5 British spp. Cortex in 3 zones, the outer and inner being compact, and the middle zone including intercellular cavities. Endodermis with cells thickened on inner tangential and radial walls surrounding a fibrous stele. Centre of root occupied by a large 'duct' (metaxylem vessel C. R. M.), or by 4 or more such 'ducts', *A. setacea* Curt. being distinctive with 17 'ducts' in its larger roots. Earliest roots and fine branches monarch or diarch; larger roots with 6–8, or rarely more, protoxylem strands, *A. setacea* being exceptional with more than 12 strands. Roots of spp. other than *A. setacea* cannot be distinguished microscopically.

6. Abnormal Anatomy

Watson (1950) records that 28 day-old seedlings of *A. canina* var. Velvet Bent. treated with the sodium salt of 2,4-D selective herbicide exhibited a reduction in the root system, nodule-like growths on the roots, and a swelling at the base of the plant containing numerous root initials.

Special Note

Philipson (1937) in revising the British spp. of *Agrostis* records that the genus is closely allied to *Apera*, *Calamagrostis*, *Deyeuxia*, and *Polypogon*, from which it cannot be readily distinguished. Leaf structure festucoid.

Literature

Altenkirch 1894; Burr and Turner 1933 (leaf); Canfield 1934; Chauveaud 1897 (ph. in 1 sp.); Duval-Jouve 1875 (leaf); Friedenfelt 1904 (root); Goosens 1945 (leaf of S. African spp.); Grob 1896 (leaf); Holm 1908 (root), 1929 (rhizome); Lewton-Brain 1904 (leaf of British spp.); Paunero 1947 (figures of T.S. leaves of 15 spp. occurring in Spain); Pée-Laby 1898 (leaf); Philipson 1937 (revision of British spp. with morphological and anatomical details); Prat 1932, 1936 (leaf); Schumann 1891 (thickness of culms); Sharman 1947 (stem apex); Strecker 1913 (leaf); Watson 1950 (structure modified by chemical treatment).

AIRA

Much of the information in the literature concerning *Aira* refers to spp. now included in *Deschampsia*. The following information about *A. caryophyllea* L. and *A. praecox* L. has been recorded by Burr and Turner (1933) and by Lewton-Brain (1904).

A. caryophyllea has a few thick, inrolled leaves, each with a prominent abaxial keel. Adaxial surface with a prominent rib over the midrib, a less pronounced rib also being present on either half of the lamina. Abaxial surface somewhat angular in outline as seen in T.S. Vascular bundles: about 7 present. Scl. not strongly developed, but present at the leaf margins and in the apices of the adaxial ribs; small abaxial strands also present opposite the vb's. Prickles present on both leaf surfaces; those that are adaxial being on the ribs. Bundle-sheaths double. The leaf of *A. praecox* is v. similar but smaller and with only about 5 vb's.

Special Note

Prat (1936) rightly notes that the leaf structure of *Aira* is festucoid.

Literature

Burr and Turner 1933 (leaf); Lewton-Brain 1904 (leaf); Prat 1936 (leaf); Zeman 1906, 1907 (leaf, but mainly refers to *Deschampsia*).

AIROPSIS

Pée-Laby (1898) records adaxial ribs and furrows and well-developed bulliform cells, in '*A. agrostidea* DC.' = *Antinoria agrostidea* (DC.) Parl. (see p. 33). Stomata are more numerous on the adaxial than on the abaxial surface.

Literature

Grob 1896; Pée-Laby 1898.

ALLOEOCHAETE

Hubbard (1950*a*) founded the genus *Alloeochaete* on *A. andongensis* (Rendle) C. E. Hubbard, a sp. previously known as *Danthonia andongensis* Rendle.

Special Note

According to de Wet (1956) *Alloeochaete* has panicoid epidermis and chlorenchyma. The relationship of the genus to other members of the Danthonieae is discussed by the same author.

Literature

Hubbard 1950*a* (taxonomy); de Wet 1956 (leaf and taxonomy).

ALLOTEROPSIS

Diagnostic Generic Characters

Short-cells, over the veins, in rows. Silica-bodies, over the veins, mostly cross or dumb-bell shaped, but sometimes nodular. Micro-hairs present, mostly with the distal longer than the proximal cell and tapering to the apex. Stomata with triangular subsidiary cells. Vascular bundles: small vb's angular in outline. Mesophyll with radiate chlorenchyma. Bundle-sheaths single.

Species Specially Examined

***Alloteropsis cimicina* (L.) Stapf**

Leaf

Abaxial epidermis

Short-cells in rows of more than 5 cells with a silica-body in nearly every cell; abundant over the veins, but infrequent or absent between them. **Silica-bodies** commonly dumb-bell shaped, but varying in appearance with the focus (Fig. Ib, 21), or sometimes more nearly cross-shaped (Fig. Ia, 16); others nodular (Fig. Ib, 22 (iii)). **Macro-hairs** rather infrequent; short and stiff, with swollen bases surrounded by cushions of tall epidermal cells; similar hairs at the leaf margins. **Micro-hairs:** length 48–60 (mostly 50–55) μ; basal cell 18–30 (mostly 24–26) μ; distal cell 30–36 (mostly 30–34) μ; distal cells usually tapering to rounded apices (Fig. VII, 4–5). **Stomata** with triangular subsidiary cells (Fig. IV, 1). **Long-cells** between the veins, relatively short, with thin, or only slightly sinuous walls (Fig. V, 4*a–b* or 7*a–b*); cells over the veins apparently thick-walled, but obscured by the silica-bodies.

T.S. lamina

Vascular bundles: nearly all vb's polygonal (Fig. VIII, 5). A few large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with slight ribs and furrows (Fig. XIV, 2). **Sclerenchyma:** a few vb's, especially towards the leaf margins, not accompanied by scl. (Fig. IX, 1); other vb's with minute adaxial strands only (Fig. IX, 2); most vb's accompanied by small abaxial and adaxial strands

(Fig. IX, 4); with the largest vb's the strands form minute adaxial and abaxial girders extending from the v. inflated sheath cells to the epidermis; leaf margins also supported by scl. **Keel** not conspicuous; containing a single vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma distinctly radiate. **Bulliform cells** in fan-shaped groups (Fig. XV, 4), and groups of the *Sporobolus* type (Fig. XV, 8). **Bundle-sheaths** single; complete round all vb's (Fig. XI, 2*a–b*).

MATERIAL EXAMINED: F. Ballard 1469; Ceylon.

***Alloteropsis* sp. nov.**

The structure of this sp. resembles that of *A. cimicina* (Ballard 1469) in all essential characters, but the following differences were noted. **Short-cells** mostly in rows, but a few at the vein margins solitary. **Silica-bodies** more commonly cross-shaped. **Macro-hairs** on the abaxial surface more frequent. **Midrib** more conspicuous, being delimited on either side by a constriction in the thickness of the lamina; with a single median vb very strongly supported by massive adaxial and abaxial girders of scl. Elsewhere both surfaces of the lamina have v. low ribs and shallow furrows, the apices of the adaxial ribs being occupied by strands, and those opposite the large vb's by girders, of scl. Abaxial strands and girders of scl. also present at the bases of the shallow furrows. **Bulliform cells** in fan-shaped groups (Fig. XV, 4), or in groups of the *Sporobolus* type (Fig. XV, 8), the groups being connected to the abaxial epidermis by girders of colourless cells traversing the mesophyll between the veins. **Mesophyll** with markedly radiate chlorenchyma.

MATERIAL EXAMINED: Milne-Redhead and Taylor 7393; Tanganyika.

SPECIAL NOTE

Leaf structure typically panicoid.

ALOPECURUS

DIAGNOSTIC GENERIC CHARACTERS

Short-cells not more than common, and often infrequent, especially between the veins. Silica-bodies, over the veins, horizontally elongated with smooth to sinuous outlines; infrequent. Micro-hairs absent. Prickle-hairs common over the veins. Stomata with parallel-sided subsidiary cells. Vascular bundles: small vb's not angular in outline. Adaxial surface with poor to well-developed ribs. Mesophyll with chlorenchyma not radiate. Bundle-sheaths double.

SPECIES SPECIALLY EXAMINED

***Alopecurus geniculatus* L.**

LEAF

Abaxial epidermis (Fig. XXV, 1)

Short-cells only locally visible over the veins, most of the available space being occupied by papillae; short-cells also rare between the veins. Occasional short-cells over the veins each containing a narrow, horizontally elongated

silica-body with a slightly sinuous outline, as Fig. IA, 14, but more elongated. **Macro-hairs** and **micro-hairs:** none seen. **Papillae:** chains of oblique, globose papillae overlying the veins (Fig. III, 1). **Prickle-hairs:** a few angular prickles at the leaf margins (Fig. VI, 3). **Stomata** rather obscure in the available material, but subsidiary cells parallel-sided (Fig. IV, 2). **Long-cells** with thin, non-sinuous walls (Fig. V, 2*a–c*).

T.S. lamina

Vascular bundles: most vb's small and not conspicuously angular in outline as in Fig. VIII, 2; large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with well-marked ribs and furrows (Fig. XIV, 5), the ribs being acutely triangular. **Sclerenchyma:** most vb's probably with minute abaxial strands, and other strands in the apices of the triangular ribs (Fig. IX, 4), but scl. inconspicuous in the material examined. **Keel** not prominent; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** in well-defined groups as in Fig. XV, 2, at the bases of the furrows, or tending to be in fan-shaped groups (Fig. XV, 6). **Bundle-sheaths** double; 2 complete sheaths surrounding most, if not all, vb's (Fig. XII, 1), but abaxial part of the O.S. obscured by chloroplasts; small chloroplasts present in all of the O.S. cells.

CULM

Culm examined 2 mm in diameter. Epidermis subtended almost entirely by assimilatory tissue except where interrupted at intervals by a ring of vb's each embedded in a little scl. ground tissue extending from the epidermis to the large-celled ground tissue between the assimilatory tissue and the hollow centre of the culm. Inner ground tissue about 12 cells wide, with 2 rings of vb's embedded in it.

MATERIAL EXAMINED: Cultivated at Kew.

***Alopecurus myosuroides* Huds.**

LEAF

Abaxial epidermis

Short-cells solitary, in pairs, and in rows of 3–5 cells; infrequent over, and absent between, the veins. **Silica-bodies** horizontally elongated, with rounded ends and smooth (Fig. 1A, 13) or sinuous (Fig. 1A, 14) outlines. **Macro-hairs** and **micro-hairs:** none seen. **Prickle-hairs:** prickles (Fig. VI, 1–2) numerous over the veins. **Stomata** with parallel-sided subsidiary cells (Fig. IV, 2). **Long-cells** with thin, v. slightly sinuous walls (Fig. V, 3*a–b*), or even smooth (Fig. V, 2*a–c*); interstomatal cells with concave ends (Fig. V, 11).

T.S. lamina

Vascular bundles: as in *A. geniculatus*. **Adaxial surface** with slight ribs and furrows (Fig. XIV, 2). Ribs and furrows present on the abaxial surface also. **Sclerenchyma:** most vb's accompanied by minute adaxial and abaxial strands (Fig. IX, 4); large vb's accompanied by wider adaxial strands or girders. **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:**

chlorenchyma not radiate. **Bulliform cells** in groups as in Fig. XV, 2, or tending to be in fan-shaped groups in a few furrows (Fig. XV, 6). **Bundle-sheaths** double; 2 complete sheaths surrounding most vb's (Fig. XII, 1), but O.S. obscure on the abaxial side of some vb's (Fig. XII, 2).

MATERIAL EXAMINED: (i) J. K. O'Byrne 155. (ii) Cultivated at Kew.

***Alopecurus pratensis* L.**

LEAF

Abaxial epidermis

Short-cells: those over the veins mostly solitary, but occasionally in pairs or short rows; common over, but infrequent between, the veins. **Silica-bodies** over the veins, horizontally elongated with rounded ends and smooth (Fig. 1A, 12) or sinuous (Fig. 1A, 14) outlines. **Macro-hairs** and **micro-hairs:** none seen. **Prickle-hairs:** prickles (Fig. VI, 1–2), and structures transitional between these and hooks (Fig. VI, 5), fairly frequent over the veins. **Stomata** with parallel-sided subsidiary cells (Fig. IV, 2). **Long-cells,** in the intercostal zones, mostly with thin, non-sinuous walls (Fig. V, 2*a–c*), the cells frequently being narrower at their ends than in the middle; cells beside the veins with sinuous walls (Fig. V, 3*a–c*).

T.S. lamina

Vascular bundles: as in *A. geniculatus*. **Adaxial surface** with fairly well-developed, wide, rounded, ribs and relatively narrow furrows (Fig. XIV, 3). **Sclerenchyma:** a very few, small, marginal vb's with small adaxial and abaxial strands (Fig. IX, 4); other vb's with tall, narrow, 1–3-seriate girders (Fig. IX, 7), and transitions between these and girders as in Fig. IX, 4; largest vb's with adaxial and abaxial girders up to about 6 cells wide. **Keel** not prominent; vascular strand solitary (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells:** some in groups as in Fig. XV, 2; mostly tending to be in fan-shaped groups at the bases of the furrows (Fig. XV, 6). **Bundle-sheaths** double; small vb's with 2 complete sheaths (Fig. XII, 1), the O.S. sometimes being extended towards the adaxial and abaxial epidermis; other vb's with the O.S. not quite complete abaxially (Fig. XII, 2); some of the largest vb's with the O.S. interrupted both adaxially and abaxially (Fig. XII, 3*a*).

CULM

Culm examined 2 mm in diameter. Epidermis thick-walled, subtended by assimilatory tissue, but vb's of the outer ring connected to the epidermis by scl. girders. Assimilatory tissue bounded on the inner side by a ring of about 6 layers of sclerosed cells. Inner ground tissue about 12 cells wide, with 2 rings of vb's embedded in it, surrounding the hollow centre of the culm.

MATERIAL EXAMINED: J. K. O'Byrne 127 and 129.

ADDITIONAL INFORMATION FROM THE LITERATURE

1. LEAF

Lewton-Brain (1904) figures *A. alpinus* Sm. as having v. marked adaxial ribs and furrows, the apices of the ribs being rounded or flattened. Scl. as small adaxial and abaxial strands opposite the vb's, and small abaxial strands opposite some of the adaxial furrows.

Figures of the leaf of 6 *Alopecurus* spp. that occur in Spain have been published by Paunero (1951, 1952).

2. ROOT

Root of *A. myosuroides* Huds. (as *A. agrestis* L.) reported by Freidenfelt (1904) to exhibit the following characters. Roots of first order each with a thin-walled piliferous layer, but surface becoming covered with a brown crust (exodermis) when older. Cortex of 6–7 cell layers with small intercellular spaces in the outer part, and large intercellular spaces in the middle region. Endodermis of uniformly thickened, quadrangular cells. Centre of root occupied by 1 tracheal element (metaxylem vessel C. R. M.) about 50 μ wide, and by 8–9 peripheral groups of vessels. Ground tissue within the endodermis strongly lignified and thickened.

Root of *A. geniculatus* L. similar, but with sparse root-hairs. Exodermis not clearly differentiated, but large-celled in subsidiary roots; outer part of the inner cortex becoming disorganized; central tracheal element 28 μ in diameter; only 4 peripheral xy. groups.

The origin and physiological function of the root nodules of *A. pratensis* have been discussed by Nogtev (1938).

SPECIAL NOTE

Leaf structure typically festucoid.

LITERATURE

Burr and Turner 1933 (leaf of British spp.); Chauveaud 1897 (root); Duval-Jouve 1875; Freidenfelt 1904 (root); Frohnmeyer 1914 (mode of silicification); Grob 1896; Lewton-Brain 1904 (leaf of British spp.); Nogtev 1938 (root nodules); Paunero 1951 (1952) (leaf of spp. growing in Spain); Pée-Laby 1898; Prat 1936; Roelants 1921 (mechanical tissue in culm); Strecker 1913; Ziegenspeck 1926 (structure of stigma).

AMMOPHILA

DIAGNOSTIC GENERIC CHARACTERS

The following generic diagnosis is based solely on *A. arenaria* (L.) Link. Short-cells solitary. Silica-bodies inconspicuous within the short-cells. Micro-hairs absent. Vascular bundles: small vb's not angular in outline. Mesophyll with chlorenchyma not radiate. Bundle-sheaths double.

SPECIES SPECIALLY EXAMINED

***Ammophila arenaria* (L.) Link**

LEAF

Abaxial epidermis

Short-cells mostly solitary; abundant; cubical, or slightly longer horizontally than vertically (Fig. I, 1). **Silica-bodies** inconspicuous within the short-cells. **Macro-hairs** short, rigid, thick walled (Fig. IIA, 10); hairs especially numerous in the grooves on the adaxial leaf surface. **Micro-hairs** and **prickle-**

hairs: none seen. **Stomata** absent from the abaxial surface. **Long-cells** with thick, pitted, or sinuous walls (Fig. V, 1*a–b*).

T.S. lamina

Vascular bundles: small vb's not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 15); largest vb's of the *Elymus* type (Fig. VIII, 18) with the ph. partly sclerosed; ph. well developed. **Adaxial surface** with marked ribs of 2 distinct sizes (Fig. XIV, 7) and deep, v. narrow furrows between them. **Sclerenchyma:** small vb's with adaxial T- and abaxial I-girders (Fig. IX, 8). A few layers of strongly thickened cells present beneath the whole of the abaxial epidermis, and, at the very blunt leaf margins, extending to the 2 most marginal of the adaxial furrows. **Keel** not prominent; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate, and confined to strips on either side of each rib. **Bulliform cells** present in the U-shaped furrows, the cells being variable in size and none of them specially large—*Ammophila* type (Fig. XV, 5). **Bundle-sheaths** double; most vb's with the O.S. interrupted abaxially and adaxially (Fig. XII, 3*a–b*); cells of the O.S. small, and those of the I.S. with very marked U-shaped thickenings.

Rhizome

Rhizome examined 3 mm in diameter. Epidermis subtended by about 6 layers of thin-walled parenchymatous cells, bounded on the inner side by about 3–4 layers of cells with v. thick walls, the thickenings being U-shaped, and the v. small lumina facing towards the exterior of the rhizome. Inner ground tissue fairly thick walled, with 2–3 irregular circles of vb's embedded in it. Centre to the rhizome hollow.

Material Examined: Herbarium specimen; reference No. unknown.

Additional Information from the Literature

1. Leaf

Prat (1932) points out that although the mature leaves of *A. arenaria* are v. unlike those of *Mibora minima* (L.) Desv., the first leaves of a seedling of *Ammophila* differ from those of a mature plant of the same sp., and are not unlike those of *Mibora*.

Tschirch (1882) points to the small size of the bulliform cells in *A. arenaria* as supporting his view that these cells are to be interpreted as hinge-cells rather than as motor-cells in relation to the unrolling of the leaves. This subject has also been discussed by Vrede (1930).

2. Root

Freidenfelt (1904) and Purer (1942) have recorded the following information concerning the root of *A. arenaria*. Roots of first order 1·03 mm in diameter exhibiting a conspicuous exodermis; intercellular spaces in the inner cortex; inner 3 layers of the cortex thick-walled and persisting when the remainder of the tissue decays; endodermis thick-walled; vessels 75–83 μ in diameter. Roots of second order 0·36 mm in diameter have a cortex consisting of about 5 layers of thin-walled cells, intercellular spaces being absent.

Special Note

Leaf structure festucoid.

Literature

Burr and Turner 1933 (leaf); Duval-Jouve 1870 (rhizome), 1875 (leaf); Freidenfelt 1904 (root); Grob 1896 (epidermis); Harshberger 1909 (ecological anatomy of leaf); Lewton-Brain 1904 (leaf); Molliard 1904 (bulliform cells); Paratore 1899 (leaf); Pée-Laby 1898 (leaf); Prat 1932, 1936; Purer 1942 (root); Starr 1912 (ecological anatomy of leaf); Steinbrinck 1908 (leaf rolling); Tschirch 1882 (leaf rolling); Vrede 1930 (leaf rolling); Warncke 1911 (stomata from the ecological standpoint).

AMPELODESMOS

Diagnostic Generic Characters

Short-cells paired. Silica-bodies mostly elliptical and fitting into concavities in adjacent cork-cells. Micro-hairs absent. Vascular-bundles: small vb's not angular in outline. Adaxial surface with pronounced ribs of 2 distinct sizes. Mesophyll with chlorenchyma not radiate. Bundle-sheaths double.

Species Specially Examined

***Ampelodesmos mauritanica* (Poir.) Dur. & Schinz. (*A. tenax* Link.)**

Leaf

Abaxial epidermis

Intercostal zones not clearly demarcated from the zones over veins owing to the subepidermal scl. being continuous over the whole leaf surface. **Short-cells** mostly paired; abundant. **Silica-bodies** fitting into the concavities in the cork-cells (Fig. I, 6–7), mostly elliptical. **Macro-hairs** and **micro-hairs:** none seen. **Prickle-hairs:** prickles present (Fig. VI, 1–2), but rather sparse; large prickles at the leaf margins. **Stomata** absent from the abaxial surface. **Long-cells** with fairly thin, v. sinuous walls (Fig. V, 3*a–c*), or tending to be as in Fig. V, 6.

T.S. lamina

Vascular bundles: numerous small vb's not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with tall ribs and furrows (Fig. XIV, 6), the ribs being of 2 distinct sizes, the small ones rounded and the large ones flattened; furrows W-shaped towards the midrib and V-shaped towards the leaf margins. **Sclerenchyma:** a very few, small, marginal vb's with well-marked abaxial girders only (Fig. IX, 3); nearly all vb's with adaxial T- and abaxial I-girders of a special type (Fig. IX, 9); the stems of the T-girders, especially in the small vb's, being tall, narrow, often 1–3-seriate, and less wide than the abaxial I-girders which are often about 8-seriate; stems of the adaxial T-girders of the largest vb's up to about 9-seriate at the base. A continuous band of fibres below the whole abaxial surface. **Keel** not prominent; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate, occupying not only the sides of the furrows, but also filling the space between the bases of the furrows and the subepidermal abaxial scl., each mass of chlorenchyma thus being U-shaped (cf. different arrangement in *Ammophila*). **Bulliform cells** of variable size, none of them specially large, and all of them situated in the W- and V-shaped furrows—

the *Ammophila* type (Fig. XV, 5). **Bundle-sheaths** double; some of the smaller vb's with I.S. complete and O.S. not quite complete abaxially (Fig. XII, 2); most vb's with O.S. interrupted abaxially and adaxially (Fig. XII, 3*a–b*).

MATERIAL EXAMINED: J. Bornmuller 492; Sicily.

SPECIAL NOTE

The structure is not unlike that of *Stipa*. *A. mauritanica* is sometimes used as a substitute for Esparto Grass (*Stipa tenacissima*, see p. 485).

LITERATURE

Duval-Jouve 1875 (leaf); Grob 1896 (leaf); Lohauss 1905 (leaf); Paratore 1899 (leaf); Pée-Laby 1899 (leaf).

AMPHICARPUM

Amphicarpum is a genus from SE. U.S.A. consisting of 2 spp., the stoloniferous *A. muhlenbergianum* (Schult.) Hitchcock and the caespitose *A. purshii* Kunth. Both spp. have subterranean fruits. The leaf anatomy of both spp. has been described by Holm (1896) and the leaf epidermis of *A. purshii* has also received attention from Grob (1896). The following information has been taken from these 2 sources.

A. muhlenbergianum (referred to by Holm as *A. floridanum* Chapm.)

Epidermis

Adaxial epidermis figured as having rows of short-cells. Silica-bodies not illustrated or mentioned in the text, but presumably dumb-bell shaped judging from the illustration of the cells in which they occur. Nodular short-cells also shown in the same files, but no clear evidence of whether they contain silica-bodies. Small prickles and micro-hairs with distal cells tapering towards their apices also present. Long-cells: those in the middle of each intercostal zone mostly bulliform; those next to and on either side of the veins with thin, coarsely sinuous walls. Abaxial epidermis similar, but no typical bulliform cells present.

T.S. lamina

Slight ribs and furrows on both surfaces. Vascular bundles of 2 distinct sizes, the smaller ones being angular in outline. Sclerenchyma present as adaxial and abaxial strands associated with all vb's, but abaxial strands sometimes extending inwards to the bundle-sheaths and so forming girders; exceptionally large strands also present in the leaf margins. Mesophyll with radiate chlorenchyma. Bulliform cells in fan-shaped groups between the vb's. Bundle-sheaths double; O.S. with girder-like extensions of colourless cells connecting them to the adaxial scl. strands.

A. purshii Kunth

Epidermis

Short-cells, over the veins, in rows. Silica-bodies, over the veins, figured as dumb-bell shaped. Silica-cells, at leaf margins, of a rather different type. Macro-hairs: cushion hairs present on both surfaces and at the leaf margins. Micro-hairs present, mostly in the intercostal zones, sporadically over the veins, and exceptionally in the stomatal strips; each with the distal cell tapering to a pointed apex (Fig. VII, 4–6). In other respects resembling *A. muhlenbergianum*, but bulliform cells present on both surfaces.

T.S. lamina

Similar to *A. muhlenbergianum*, but bulliform cells present on both surfaces.

SPECIAL NOTE

The microscopical characters of the leaf are, for the most part, panicoid, but it should be noted that the bundle-sheaths are double, which is a festucoid character. Double bundle-sheaths are, however, not unknown even in *Panicum* itself.

LITERATURE

Grob 1896 (leaf); Holm 1896*b* (leaf).

AMPHILOPHIS (a synonym of *Bothriochloa*, p. 57)

This genus has not been examined by the author, but the following characters have been recorded by Vickery (1935).

'*A. affinis* A. Camus' = *Dichanthium affine* (R. Br.) A. Camus

Leaf thin. Both surfaces flat. Sclerenchyma as small girders to the large vb's, but less well developed in association with the small vb's. Papillae present on the abaxial surface. Stomata present on both surfaces, but most numerous on the abaxial side. Mesophyll: chlorenchyma radiate. Midrib scarcely conspicuous. Bulliform cells in the adaxial epidermis interrupted over every second, third, or fourth vb. Bundle-sheaths single and circular in outline.

'*A. intermedia* Stapf' = *Bothriochloa intermedia* (R. Br.) A. Camus

Similar to *A. affinis*, but the following points are noteworthy. Cells of the abaxial epidermis with moderately thick outer walls and arched or prominently papillose. Bulliform cells interrupted only over every fourth vb, the central cells in each group being slightly larger than the remainder and occupying nearly half the thickness of the leaf. A few colourless cells present below the bulliform cells. Midrib conspicuous with a group of colourless cells above the midvein.

SPECIAL NOTE

Vickery notes that *A. affinis* is v. similar to *Bothriochloa decipiens* (Hackel) C. E. Hubbard and *Dichanthium sericeum* (R. Br.) A. Camus, and *A. intermedia* resembles *B. decipiens* in type. *Amphilophis* is treated by Vickery as a member of the Andropogoneae.

LITERATURE

Breakwell 1914 (as *Andropogon*); Vickery 1935 (leaf structure).

ANDROPOGON

DIAGNOSTIC GENERIC CHARACTERS

The following generic diagnosis refers particularly to the species examined by the author and described below. Short-cells, over the veins, commonly in rows. Silica-bodies, over the veins, dumb-bell or crescent shaped. Micro-

hairs present, with distal cells tapered towards their apices. Stomata commonly with triangular subsidiary cells. Vascular bundles: small vb's angular in outline. Mesophyll with chlorenchyma distinctly radiate. Bundle-sheaths single.

Species Specially Examined

Andropogon amplectens Nees

Leaf

Abaxial epidermis

Short-cells, over the scl. towards the leaf margin, mostly paired; also solitary and paired in the intercostal zones; those over the small veins mostly in short or long rows; alternate short-cells in each row usually containing a silica-body. **Silica-bodies,** over the veins, cross-shaped (Fig. 1A, 16); infrequent and variable in shape between the veins. **Macro-hairs:** a few stiff hairs with swollen, sunken bases; each surrounded by specialized epidermal cells (Fig. IIA, 5). **Micro-hairs:** length 40–55 (mostly 48–55) μ; basal cell 18–24 (mostly 20–22) μ; distal cell 21–34 (mostly 24–30) μ; with the relatively long distal cells tapering to pointed apices (Fig. VII, 4–6), situated in the interstomatal bands of the intercostal zones. **Prickle-hairs:** prickles (Fig. VI, 1–2), hooks (Fig. VI, 5), and bodies of an intermediate character, abundant over and between the veins. **Stomata** with triangular subsidiary cells (Fig. IV, 1). **Long-cells** relatively short, with thin, non-sinuous or only slightly sinuous, walls (Fig. V, 4*a–b*); interstomatal cells fairly short, with concave ends (Fig. V, 10*a–b*).

T.S. lamina

Vascular bundles: numerous small vb's with the xy. and ph. v. similar in appearance (Fig. VIII, 1); most vb's polygonal (Fig. VIII, 5); largest vb's of basic type (Fig. VIII, 15). **Adaxial surface** smooth (Fig. XIV, 1). **Sclerenchyma:** many small vb's not accompanied by scl. (Fig. IX, 1); some vb's with small abaxial or adaxial (Fig. IX, 2) strands, or both (Fig. IX, 4); large vb's with short but broad girders, often up to about 6-seriate (Fig. IX, 5). **Midrib** prominent but not projecting much from the abaxial surface; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma distinctly radiate. **Bulliform cells** sometimes in irregular groups (Fig. XV, 1); also some columns of small, colourless cells traversing the mesophyll from the adaxial to the abaxial epidermis between many, but not all, of the vb's. **Bundle-sheaths** single; most vb's with complete sheaths (Fig. XI, 2*a–b*); sheaths of the large vb's with abaxial interruptions (Fig. XI, 6).

Culm

Culm examined 4 mm in diameter. Epidermis subtended by a single hypodermal layer of thin-walled cells. Ground tissue, on passing inwards from the hypoderm, exhibiting progressively larger cells with thinner walls. Vb's consisting of an outer circle of small vb's and 2 inner circles of larger vb's; those towards the spongy centre of the culm more scattered.

Material Examined: Collected by G. Jackson in Nyasaland.

Andropogon schirensis Hochst.

Leaf

Abaxial epidermis

Short-cells, over the veins, in rows of more than 5 cells; alternate cells in each row containing silica-bodies; abundant; short-cells infrequent or absent between the veins. **Silica-bodies:** dumb-bell shaped, but differing in appearance with the focus (Fig. IB, 21). **Macro-hairs:** a few stiff hairs with deeply sunken, bulbous bases (Fig. II, 3), sometimes surrounded by specialized cells (Fig. IIA, 5). **Micro-hairs:** length 30–40 (mostly 34–40) μ; basal cell 14–21 (mostly 15–18) μ; distal cell 14–18 (mostly 16–18) μ; the basal cells wider than the distal cells which taper to rather acutely pointed apices. **Prickle-hairs:** a few small prickles (Fig. VI, 1), or structures intermediate between these and hooks (Fig. VI, 5), present between the veins. **Stomata** with triangular subsidiary cells (Fig. IV, 1); some tending to have low, dome-shaped subsidiary cells (Fig. IV, 3). **Long-cells** relatively short, with thin, non-sinuous, or only slightly sinuous, walls (Fig. V, 4*a–b*); cells beside the veins more like those in Fig. V, 3*a–c*, with thin, sinuous walls; interstomatal cells with concave ends (Fig. V, 10*a–b*).

T.S. lamina

Vascular bundles: a few small bundles with the xy. and ph. not v. clearly distinguishable (Fig. VIII, 1); most of the larger vb's as in Fig. VIII, 2 or 6; a few large vb's of basic type (Fig. VIII, 15). **Adaxial surface** smooth (Fig. XIV, 1). **Sclerenchyma:** most vb's in the keel with well-marked abaxial girders only (Fig. IX, 3); many small vb's with small adaxial and abaxial strands or girders (Fig. IX, 4), the adaxial girder being 1–2-seriate and only about 2 cells tall; some vb's, especially those opposite the largest bulliform cells, each with a small abaxial strand only; large vb's with inversely anchor-shaped girders, but with the I-girder rather short. **Keel** prominent, rounded; containing a number of vb's (Fig. XIII, 3). **Mesophyll:** chlorenchyma distinctly radiate. **Bulliform cells:** some in irregular groups (Fig. XV, 1); adaxial half of the mesophyll elsewhere consisting of colourless cells (Fig. XV, 11), sometimes united to the abaxial epidermis by uniseriate, or partly biseriate, columns of colourless cells traversing the mesophyll. **Bundle-sheaths** single; small vb's with a single complete sheath (Fig. XI, 2*a*); others with the sheath interrupted abaxially (Fig. XI, 6).

Culm

Culm examined 2 mm in diameter; solid. Epidermis, of thickened cells, subtended by a zone of scl. about 6 cells wide, the individual cells being v. thick-walled and polygonal in outline. A few assimilatory cells and a single circle of vb's embedded in the scl. ring. Ground tissue on the inner side of the scl. ring consisting of large rounded cells, with 2 rings of vb's embedded in the peripheral part, the ground tissue at the centre of the culm being pith-like.

Material Examined: Collected by G. Jackson in Nyasaland.

Additional Information from the Literature

Prat (1937) records that the leaf of *A. pseudapricus* Stapf exhibits a large midrib; 7–10 small vb's between each pair of large vb's; bulliform cells above the smallest vb's; long cushion hairs above the veins on the adaxial surface.

Starr (1913), writing about the leaf structure of '*A. scoparius* Michx.' from the ecological standpoint, gives the following details. Ratio of large to small vb's 1:3; scl. supporting the large vb's adaxially and abaxially, and the small vb's on the abaxial side only; occasional epidermal cells prolonged into 'sharp hairs'. Hayden (1919), writing about the leaf of the same sp., also from the ecological standpoint, refers to ribs and furrows on both surfaces; mesophyll with radiate chlorenchyma; bulliform cells and subjacent colourless cells forming girders. This sp. is now known as *Schizachyrium scoparium* (Michx.) Nash.

Special Note

Prat (1936) rightly states that the leaf structure is panicoid. The genus belongs to the Andropogoneae.

Literature

Most of the remarks about *Andropogon* in the older literature refer to spp. that have since been transferred to other genera. Breakwell 1914 (leaf of Australian spp.; many of the spp. mentioned are now in other genera); Duval-Jouve 1875 (leaf; distribution of bulliform and colourless cells; some of the spp. mentioned are now in other genera); Hayden 1919 (leaf, ecological anatomy of 1 sp.); Prat 1936 (leaf), 1937 (distribution of bulliform cells, cushion hairs, and vb's; all spp. mentioned not now in *Andropogon*); Starr 1912 (leaf; ecological anatomy of 1 sp.).

ANOMOCHLOA

Diagnostic Generic Characters

Short-cells, over and between the veins, mostly in pairs; some of those over the veins in short rows. Silica-bodies, over the veins, fitting into concavities in adjacent cork-cells, some of them being oblong (Fig. I, 10). Micro-hairs present. Stomata mostly with triangular subsidiary cells. Vascular bundles angular in outline and tending to resemble those of *Leptaspis*. Mesophyll: chlorenchyma not radiate, composed of arm-cells; fusoid-cells present. Bundle-sheaths double.

Species Specially Examined

***Anomochloa marantoidea* Brongn.**

Leaf

Abaxial epidermis

Some **short-cells** over the veins, and the infrequent short-cells between the veins, paired; others over the large veins in rows of 3–5 cells; common. **Silica-bodies:** some of those over the veins fitting into concavities in adjacent cork-cells (Fig. I, 6–7); others oblong (Fig. I, 10); infrequent silica-bodies between the veins tall and narrow (Fig. I, 4). **Macro-hairs:** none seen. **Micro-hairs** very difficult to interpret in the available material, many of them appearing to be unicellular and spherical with slightly pointed apices (Fig. VII, 1), but careful

search also revealed 2-celled hairs. Length of 2-celled hairs 74–102 (mostly 80–90) μ; basal cell 30–42 (mostly 30–36) μ; distal cell 45–63 (mostly 48–60) μ; distal cells sometimes tapering towards the pointed apices, but others more uniform in diameter throughout their lengths and with more rounded apices (Fig. VII, 5). The apparently unicellular micro-hairs may represent the basal cell only, or be immature 2-celled hairs. **Prickle-hairs:** hooks (Fig. VI, 5) frequent between the veins. **Stomata** mostly with triangular (Fig. IV, 1), and a few with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells** relatively short with v. marked sinuations (Fig. V, 6); interstomatal cells also v. sinuous in outline, with concave ends (Fig. V, 10*a–b*).

T.S. lamina

Vascular bundles: most vb's fairly small and more or less of the *Leptaspis* type (Fig. VIII, 3), but some more as in Fig. VIII, 4–5; large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with slight ribs and furrows (Fig. XIV, 2). **Sclerenchyma:** most vb's with small adaxial and slightly wider abaxial girders (Fig. IX, 4); the adaxial strands or girders sometimes not more than uniseriate, and only a few cells high; a few of the largest vb's, including the keel vb, with incompletely anchor-shaped girders (Fig. IX, 6). **Midrib** prominent, owing to a very marked projecting rib on the adaxial side, with a layer of scl. about 4 cells wide in the flattened apical end of the rib; containing 1 large abaxial vb. and 2 smaller vb's in the ground tissue of the midrib in a line directly above the abaxial bundle. **Mesophyll:** chlorenchyma not radiate, and composed of **arm-cells. Fusoid-cells** also present in the mesophyll. **Bulliform cells** in irregular groups (Fig. XV, 1). **Bundle-sheaths** double; small vb's with 2 complete sheaths (Fig. XII, 1); a few large vb's with O.S. not complete abaxially (Fig. XII, 2).

Special Notes

This grass has obvious points in common with the bamboos, notable resemblances including the fusoid-cells and arm-cells in the mesophyll, the nature of the long epidermal cells, as well as of the vb's, their enveloping sheaths and accompanying scl. The similarity to the bamboos has been noted by Page (1947).

Literature

Page 1947 (leaf).

ANTHAENANTIA

The following information concerning '*A. lanata* Benth.', now known as *Leptocoryphium lanatum* (H. B. K.) Nees, has been recorded by Grob (1896).

Short-cells between the veins mostly paired, but sometimes in short rows. Silica-bodies cross-shaped and almost quadratic. Numerous vb's said to be unaccompanied by supporting scl., but Grob also refers to vb's supported by T-girders.

ANTHEPHORA

This genus has not received much attention from anatomists, but the following particulars have been recorded by Grob (1896) and Günzel (1912). Günzel, whose account refers especially to '*A. pubescens* Nees', records the following characters.

Silica-bodies dumb-bell shaped, but sometimes rather flattened; cylindrical micro-hairs present, particularly at the sides of the veins; prickle-hairs, flexible hairs, and cushion hairs also occur. Surface of the leaf with abaxial ribs, scl. associated with the vb's occupying the ribs; adaxial scl. present only above the larger vb's. Mesophyll with chlorenchyma apparently radiate. Bundle-sheaths single. Midrib well developed.

Structure of '*A. hochstetteri* Nees' similar, but flexible hairs absent, and scl. more abundantly developed in association with the vb's.

Grob (1896), with reference to '*A. elegans* Schreb.' = *A. hermaphrodita* (L.) O. Kuntze, describes the short-cells as paired, the silica-bodies being mostly dumb-bell shaped, but sometimes cross-shaped or nodular. Micro-hairs and cushion hairs present in the same sp.

Special Note

The leaf structure is panicoid.

Literature

Grob 1896 (leaf); Günzel 1912.

ANTHISTIRIA

'*A. membranacea* Lindl.' has been described under *Iseilema membranaceum* Domin., and *A. ciliata* Benth. (non Linn.) and *A. imberbis* Retz. under *Themeda australis* Stapf. These descriptions are by Vickery (1935). (See pp. 266 and 492.)

Literature

Vickery 1935.

ANTHOCHLOA

Diagnostic Generic Characters

Short-cells, over the veins, solitary, paired, and in rows. Silica-bodies horizontally elongated, and with smooth outlines. Micro-hairs: none seen. Stomata with parallel-sided or dome-shaped subsidiary cells. Vascular bundles; small vb's not angular in outline. Mesophyll with chlorenchyma not radiate. Bundle-sheaths mostly double.

Species Specially Examined

***Anthochloa lepidula* Nees et Meyen**

Leaf

Abaxial epidermis

Short-cells, over the veins, solitary and in pairs, as well as in short, or perhaps occasionally long, rows; abundant over but infrequent between, the veins. **Silica-bodies** horizontally elongated, with smooth outlines (Fig. IA, 13); each member of a pair of short-cells equally silicified. **Macro-hairs, micro-hairs,** and **prickle-hairs:** none seen. **Stomata** mostly with parallel-sided (Fig. IV, 2), and others with low dome-shaped, subsidiary cells (Fig. IV, 3). **Long-cells** with thin, non-sinuous walls (Fig. V, 2*a–c*); cells narrowing at the ends.

T.S. lamina

Vascular bundles: most vb's small and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** smooth (Fig. XIV, 1). **Sclerenchyma:** a very few small vb's, especially at the leaf margins, not accompanied by scl. (Fig. IX, 1); most vb's with small adaxial and abaxial strands or girders (Fig. IX, 4); a few vb's with adaxial (Fig. IX, 2) or abaxial scl. only. **Midrib** fairly conspicuous; marked chiefly by a large solitary vb (Fig. XIII, 1). **Mesophyll** with chlorenchyma not radiate. **Bundle-sheaths:** a few of the smallest vb's with no distinct I.S.; some vb's with I.S. complete and O.S. interrupted abaxially (Fig. XII, 2); a few vb's with I.S. and O.S. incomplete abaxially (Fig. XII, 5).

Material Examined: D. Stafford 702; Peru.

Special Note

Leaf structure festucoid.

ANTHOXANTHUM

Diagnostic Generic Characters

Short-cells, over the veins, solitary and paired. Silica-bodies, over the veins, horizontally elongated, with smooth or sinuous outlines. Micro-hairs absent. Stomata with parallel-sided subsidiary cells. Vascular bundles: small vb's not angular in outline. Mesophyll with chlorenchyma not radiate. Bundle-sheaths: double.

Species Specially Examined

***Anthoxanthum odoratum* L.**

Leaf

Abaxial epidermis

Short-cells, over the veins, mostly solitary, or occasionally in pairs; infrequent over, and absent between, the veins. **Silica-bodies,** over the veins, horizontally elongated with smooth (Fig. IA, 12) or sinuous outlines (Fig. IA,

14). **Macro-hairs:** a few, fairly long, superficial hairs with swollen bases (Fig. II, 1). **Micro-hairs:** none seen. **Prickle-hairs:** prickles fairly frequent over the veins (Fig. VI, 1–2), and angular prickles (Fig. VI, 3) at the leaf margins. **Stomata** with parallel-sided subsidiary cells (Fig. IV, 2). **Long-cells** between the veins, with thin, non-sinuous (Fig. V, 2*a–c*) or sinuous walls (Fig. V, 3*a–c*); some of the cells tapering to narrow ends.

T.S. lamina

Vascular bundles: most vb's small and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 10). **Adaxial surface** with slight ribs and furrows (Fig. XIV, 2). **Sclerenchyma:** a very few small vb's with adaxial scl. only (Fig. IX, 2); most vb's with adaxial and abaxial strands (Fig. IX, 4), sometimes, especially with the larger bundles, extending to the O.S. to form girders. **Keel** fairly conspicuous, rounded; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells:** those towards the leaf margins in well-developed groups of the type in Fig. XV, 2; also in fan-shaped groups (Fig. XV, 4 and 6). **Bundle-sheaths** double; most vb's with 2 complete sheaths (Fig. XII, 1); some vb's with slight adaxial interruptions to the O.S. (Fig. XII, 2); O.S. to some large vb's, especially that in the keel, with an adaxial extension to the scl. (Fig. XII, 7).

CULM (Fig. XIX, 3)

Culm examined 2 mm in diameter, with a large central cavity. Epidermis subtended by about 3 layers of cells with strongly thickened walls, with a few small columns of thin-walled assimilatory tissue embedded amongst them. Ground tissue on the inner side of the mechnical ring consisting of only about 4 layers of cells. Vascular bundles in only 2 circles, some of the smaller ones in the outer circle being embedded in the peripheral mechanical tissue.

MATERIAL EXAMINED: (i) J. K. O'Byrne 126. (ii) Cultivated at Kew.

ADDITIONAL INFORMATION FROM THE LITERATURE

ROOT

Wilkens (1928) has recorded the following information concerning the structure of roots 0·5 mm in diameter. Surface with a piliferous layer bounding a thin-walled cortex 5–6 cells wide; endodermis well developed, with marked thickening of the inner tangential and radial walls; stele polyarch, consisting mainly of thick-walled ground tissue, the ph. being much reduced. With 2–3 large vessels near the centre of the root, or up to 8 or 9 such vessels distributed throughout the stele. Centre of the stele consisting of fibrous elements.

SPECIAL NOTE

Leaf structure festucoid.

LITERATURE

Altenkirch 1894 (ecological anatomy); Burr and Turner 1934 (leaf); Grob 1896 (epidermis); Lewton-Brain 1904 (leaf); Paunero 1953 (Spanish spp., v. little histology); Pée-Laby 1898 (leaf); Prat 1932, 1936 (leaf); Roelants 1921 (mechanical tissue in culm); Rozanova 1926 (variability in *A. odoratum*); Sharman 1947 (shoot apex); Strecker 1913 (leaf); Wilkens 1928 (root, culm, and leaf).

ANTINORIA

The epidermis of the lemma of *A. agrostidea* (DC.) Parl. has been figured by Paunero (1955). See also *Airopsis* on p. 16.

LITERATURE

Paunero 1955 (epidermis of lemma).

APERA

This genus has received little attention from anatomists.

Lewton-Brain (1904) records that *A. spica-venti* (L.) Beauv. exhibits ribs on both surfaces of the leaf, the adaxial rib over the midrib being the least prominent. Macro-hairs frequent on the apices of the ribs on both surfaces. Scl. figured as small adaxial and abaxial strands in the apices of the ribs opposite most of the vb's, the leaf margin also being supported by fibres.

SPECIAL NOTE

Prat (1936) records that the leaf structure is festucoid.

LITERATURE

Grob 1896 (epidermis); Lewton-Brain 1909 (leaf structure; under *Agrostis*); Prat 1936 (leaf and cytology).

APLUDA

DIAGNOSTIC GENERIC CHARACTERS

Short-cells, over the veins, in rows. Silica-bodies, over the veins, mostly nodular, but sometimes dumb-bell shaped. Micro-hairs present, each with the distal cell tapering to a pointed apex. Vascular bundles: small vb's somewhat angular in outline. Mesophyll with chlorenchyma probably radiate. Bundle-sheaths single.

SPECIES SPECIALLY EXAMINED

***Apluda mutica* L. var. *aristata* (L.) Pilger.**

LEAF

Abaxial epidermis

Short-cells, over veins, in rows of more than 5 cells; sometimes solitary at the margins of the leaves or between the veins; abundant over the veins, but not very numerous between them, apart from those at the vein margins. **Silica-bodies,** between the veins, intermediate between cross and dumb-bell shaped (Fig. IA, 17), or sometimes nodular (Fig. IB, 22 (iii)), but rather short; a few of those over the veins more definitely dumb-bell shaped, but varying in appearance with the focus (Fig. IB, 21); most of those over the veins nodular (Fig. IB, 22 (iii)), rather long. **Macro-hairs:** none seen. **Micro-hairs** difficult to

observe in the available material; length 38–45 (mostly 42–45) μ; basal cell 24–30 μ; distal cell 14–20 (mostly 14–18) μ; distal cell tapering to an acutely pointed, or only very slightly rounded, apex (Fig. VII, 9–10). **Prickle-hairs:** prickles (Fig. VI, 1–2) v. numerous over the veins. **Stomata** probably with triangular subsidiary cells (Fig. IV, 1), but material rather distorted. **Long-cells:** too contracted to be interpreted.

T.S. lamina

Vascular bundles: most vb's small, somewhat angular in outline and rather taller than wide (Fig. VIII, 4); a few large vb's of basic type (Fig. VIII, 15). **Adaxial surface** smooth (Fig. XIV, 1). **Sclerenchyma:** a few small vb's not accompanied by scl. (Fig. IX, 1); most vb's accompanied by small adaxial and abaxial strands (Fig. IX, 4) and not girdered; large vb's practically girdered by small strands; large keel vb's girdered abaxially only (Fig. IX, 3). **Midrib** conspicuous; triangular, projecting strongly from the abaxial, and slightly from the adaxial, surface; containing 3 large, and about 6 small, vb's (Fig. XIII, 4). **Mesophyll:** chlorenchyma probably radiate, but badly preserved in the available material. **Bulliform cells** in irregular groups (Fig. XV, 1), but groups rather shorter than usual for this type. **Bundle-sheaths** single; all small vb's with a complete sheath (Fig. XI, 2*a–b*); sheaths of the large vb's interrupted abaxially (Fig. XI, 6).

MATERIAL EXAMINED: Ballard 1099; Ceylon.

SPECIAL NOTE

Leaf structure panicoid.

LITERATURE

Grob 1896 (epidermis).

ARISTIDA

DIAGNOSTIC GENERIC CHARACTERS

Short-cells, over the veins, solitary, paired, and in rows, the proportion in each category varying in different spp. Silica-bodies, over the veins, oblong to elliptical in some spp.; dumb-bell shaped, sometimes with the middle part of each body elongated and tending to be lobed, in other spp. Micro-hairs: none present in some spp., but present in others, commonly with the distal cell of each hair tapering to the apex. Stomata with triangular or low dome-shaped subsidiary cells. Vascular bundles: small vb's not angular in outline. Mesophyll with chlorenchyma varying from radiate to non-radiate in different spp.; assimilatory tissue confined to the sides of the adaxial ribs in spp. where these are tall. Bundle-sheaths double or single in different spp.[1] The leaves of many spp. from dry localities strongly inrolled.

[1] According to Brown (1958), *Aristida* is peculiar in having a double parenchyma sheath and no mestome sheath. This appears to be true of some spp. but the present author is doubtful whether it applies throughout the genus.

SPECIES SPECIALLY EXAMINED

***Aristida ciliata* Desf. var. *capensis* Trin. & Rupr.**

LEAF

Abaxial surface

Short-cells, both over and between the veins, occasionally solitary, but mostly in pairs; abundant. **Silica-bodies,** over the veins oblong (Fig. I, 10) to elliptical, sometimes with slight concavities in the ends; the accompanying short-cell of each pair rather tall and narrow; silica-bodies between the veins less elongated horizontally. **Macro-hairs:** numerous slightly sinuous hairs with their bases sunken in the epidermis (Fig. IIA, 11), present only in the adaxial furrows. **Micro-hairs:** none seen. **Prickle-hairs:** a few unpointed prickles (Fig. VI, 6) over the veins. **Stomata** mostly with triangular (Fig. IV, 1), but others with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells,** both over and between the veins, with rather thick, sinuous walls as in Fig. V, 6, but with thicker walls; interstomatal cells also with v. sinuous walls and concave ends (Fig. V, 10*a–b*).

T.S. lamina

Vascular bundles: fairly numerous vb's not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 15), but with a v. small part of the ph. sclerosed (Fig. VIII, 16); ph. in all vb's consisting of elements of small diameter; outline of the ph. in the large vb's pear-shaped. **Adaxial surface** with fairly tall ribs and deep, W-shaped furrows (Fig. XIV, 4), the ribs being of 2 distinct sizes. **Sclerenchyma:** vb's opposite the low ribs with well-marked abaxial strands only (Fig. IX, 3); large vb's with short-stemmed adaxial T- and wide abaxial I-girders (Fig. IX, 8). **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll** very obscure in the available material, but chlorenchyma apparently not radiate. **Bulliform cells** in the form of girders extending from the bases of the W-shaped furrows to the abaxial epidermis, passing on either side of the small vb's (Fig. XV, 14). **Bundle-sheaths** double; a few of the smallest vb's with 2 complete sheaths (Fig. XII, 1); most small vb's, and a few large ones, with O.S. interrupted abaxially (Fig. XII, 2); some large vb's with I.S. and O.S. incomplete abaxially (Fig. XII, 5); others with I.S. interrupted abaxially and O.S. interrupted adaxially and abaxially.

MATERIAL EXAMINED: Supplied by B. de Winter; S. Africa.

***Aristida longiflora* Schumach.**

LEAF

Abaxial epidermis

Short-cells, over the veins, in rows of more than 5 cells; abundant; a few between the veins, solitary, and in pairs. **Silica-bodies,** over the veins, dumb-bell shaped (Fig. IA, 18 (ii–iv)), with the narrow part of each body v. elongated and sometimes tending to be lobed; alternating cells nodular (Fig. IB, 22 (iii)); silica-bodies between the veins v. infrequent, and rather variable in shape. **Macro-hairs:** short, rigid, thick-walled hairs (Fig. IIA, 10) on and near

the apices of the adaxial ribs. **Micro-hairs** sparse; length 48–66 μ; basal cell 24–30 μ; distal cell 24–44 (mostly 32–36) μ; distal cell usually tapering to a pointed apex. **Prickle-hairs:** pointed, angular prickles (Fig. VI, 3) locally abundant. **Stomata** with low dome-shaped subsidiary cells (Fig. IV, 3); generally a single row of stomata between each pair of veins. **Long-cells** with thick, pitted or sinuous walls (Fig. V, 1*a–b*).

T.S. lamina

Vascular bundles: many vb's small and not conspicuously angular in outline (Fig. VIII, 2); some larger vb's of basic type (Fig. VIII, 13), but rather taller and narrower than usual; ph. strands in all vb's rather large, and consisting of cells with small diameters. **Adaxial surface** with deep furrows and tall ribs (Fig. XIV, 7), the ribs being of 2 more or less distinct sizes; some furrows V- and others W-shaped. **Sclerenchyma:** vb's opposite the small ribs with well-marked abaxial girders only (Fig. IX, 3); large vb's opposite the tall ribs with short-stemmed adaxial T- and broad abaxial I-girders (Fig. IX, 8). **Keel** not prominent; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** difficult to observe the cells in the material available; chlorenchyma confined to strips on either side of the large vb's, and to U-shaped masses surrounding the vb's in the small ribs. **Bulliform** and subjacent **colourless cells** forming girders extending from the bases of the adaxial furrows to the abaxial epidermis (Fig. XV, 14). **Bundle-sheaths** double; a few of the small vb's with 2 complete sheaths (Fig. XII, 1); others with the O.S. interrupted abaxially (Fig. XII, 2); largest vb's with I.S. and O.S. interrupted abaxially (Fig. XII, 5).

CULM

Culm examined 1 mm in diameter. Epidermis subtended by a ring of well-defined columns of cells with unlignified walls, each column being opposite a vb of the outer circle. Columns of unlignified tissue separated from one another by girders of scl. cells of smaller diameter; each column also separated from a subjacent vb by a well-defined single layer of oval cells with fairly thin walls, followed by an inner layer of cells, also well defined, but cells conspicuously larger and with thicker walls. Ground tissue at the centre of the culm solid, but somewhat spongy, 2 circles of vb's being embedded in the peripheral part of it. Culm differing from those of many other grasses in having the girders of scl. extending from the epidermis to the thin-walled ground tissue, alternate with, and not opposite to, the vb's of the outer ring. Ph. elements in the vb's of the outer ring of the same small type as those in the ph. in the leaf bundles. Phloem of the bundles in the inner part of the culm consisting of elements of appreciably wider diameter.

MATERIAL EXAMINED: Meikle 809; Nigeria.

***Aristida pungens* Desf.**

LEAF

T.S. lamina

Vascular bundles of same types as those of *A. longifolia*. **Adaxial surface** with deep furrows and tall ribs (Fig. XIV, 7), the ribs being somewhat variable

in height, but not of 2 distinct sizes; furrows nearly all narrowly V-shaped. **Sclerenchyma:** small vb's with well-marked abaxial girders only (Fig. IX, 3); large vb's with adaxial T-girders and very wide abaxial I-girders (Fig. IX, 8). **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll** not radiate; chlorenchyma mainly confined to narrow strips at the sides of the principal ribs; also as U-shaped groups round the small vb's. **Bulliform** and subjacent **colourless cells** forming girders extending inwards from the bases of the adaxial furrows, and reaching nearly to the outer bundle-sheaths of the small vb's opposite the furrows (Fig. XV, 12). **Bundle-sheaths** double; I.S. and O.S. round all vb's v. incomplete abaxially (Fig. XII, 5).

MATERIAL EXAMINED: Chipp 54; Central Sahara.

***Aristida setacea* Retz.**

LEAF

Abaxial surface

Short-cells, over the veins, in rows of more than 5 cells; abundant; those between the veins infrequent, solitary, and in pairs. **Silica-bodies,** over the veins, mostly dumb-bell shaped (Fig. IA, 18 (ii–iv)), the intervening short-cells in the same files being cross-shaped or nodular; silica-bodies between the veins rather variable, some tall and narrow (Fig. I, 4), others tending to be saddle-shaped (Fig. I, 9), or occasionally obscurely cross-shaped. **Macro-hairs:** none seen. **Micro-hairs:** length 48–60 (mostly 54–60) μ; basal cell 24–26 μ; distal cell 24–34 (mostly 24–30) μ; distal cell often tapering to a pointed apex, or sometimes with a rounded apex and more uniform in diameter throughout its length (Fig. VII, 4–5). **Prickle-hairs:** prickles (Fig. VI, 1–2) rather infrequent over the veins. **Stomata** mostly with triangular (Fig. IV, 1), and a few with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells:** some with thick, pitted or sinuous walls (Fig. V, 1*a–b*); others with thin, sinuous walls (Fig. V, 3*a–b*).

T.S. lamina

Vascular bundles: most vb's small and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 10), but rather narrow. **Adaxial surface** with well-developed ribs and furrows (Fig. XIV, 6), most of the ribs being of about equal height and flat-topped; a few ribs appreciably smaller and with rounded apices; furrows mostly widely V-shaped, but occasionally W-shaped where rounded ribs occur. **Sclerenchyma:** small vb's with small adaxial and abaxial girders (Fig. IX, 4); larger vb's with similar but wider girders (Fig. IX, 5); largest vb's with girders of the inverted anchor-shaped type. **Keel** not prominent; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma somewhat radiate, but cells rather short. **Bulliform** and subjacent **colourless cells** in the form of girders extending from the adaxial furrows to the abaxial epidermis (Fig. XV, 14). **Bundle-sheaths** double; most vb's with 2 complete sheaths (Fig. XII, 1), but O.S. tending to be interrupted abaxially round the large vb's (Fig. XII, 2).

CULM

Culm examined 2–3 mm in diameter. Epidermis subtended by about 3 layers of cells not strongly lignified, followed by a zone of scl. with 2 circles of vb's embedded in it. Inner ground tissue, extending almost to the centre of the culm, thin-walled, with a few vb's embedded in it. Vb's tending to be pyriform in T.S.

MATERIAL EXAMINED: Ballard 1478; Ceylon.

***Aristida* sp.**

LEAF

Abaxial epidermis

Short-cells, over the veins, in rows of more than 5 cells; those between the veins solitary or in pairs; abundant over, but very infrequent between, the veins. A few of the **silica-bodies** over the veins intermediate between cross and dumb-bell shaped (Fig. IA, 17); mostly dumb-bell shaped (Fig. IA, 18 (ii–iv)), and sometimes varying in appearance with the focus (Fig. IB, 21); silica-bodies between the veins rare and rather variable in shape, sometimes tending to be cross-shaped. **Macro-hairs :** none seen. **Micro-hairs :** length 45–60 (mostly 48–54) μ; basal cell 18–24 μ; distal cell 26–36 (mostly 26–30) μ; distal cell frequently tapering to a pointed, but usually somewhat rounded, apex (Fig. VII, 4), or relatively narrow and of more uniform diameter throughout its length (Fig. VII, 7). **Prickle-hairs :** rather large, elongated prickles (Fig. VI, 2) present over most of the veins; angular prickles (Fig. VI, 3) at the leaf margins. **Papillae :** tendency for the development of small, variously shaped, thickened, cuticular warts (Fig. III, 5) on the long-cells. **Stomata** with triangular subsidiary cells (Fig. IV, 1). **Long-cells** with thin, or fairly thick, sinuous walls (Fig. V, 3*a–c*).

T.S. lamina

Vascular bundles : all vb's, except those in the largest ribs, as in Fig. VIII, 2; keel bundle, and bundles in a few of the large ribs at or near the leaf margins, of basic type (Fig. VIII, 15). **Adaxial surface** with deep furrows and tall ribs (Fig. XIV, 4); ribs mostly of uniform height, and with rounded apices, but the marginal ribs, and one other near the margin on either side of the lamina, conspicuously taller; furrows V-shaped. **Sclerenchyma :** small marginal vb's not accompanied by scl. (Fig. IX, 1); vb's in the large ribs at or near the leaf margins, as well as the keel bundle, with wide adaxial and abaxial girders (Fig. IX, 5); most ribs apart from those just mentioned, each with a shallow, arc-shaped strand at the apex, a small, inconspicuous abaxial strand also being present opposite each vb. **Keel** fairly prominent; containing a solitary bundle (Fig. XIII, 1). **Mesophyll :** chlorenchyma distinctly radiate. **Bulliform** and subjacent **colourless cells** in the form of groups resembling the *Sporobolus* type (Fig. XV, 8), each group having an abaxial girder-like extension (Fig. XV, 13). **Bundle-sheaths** double; nearly all vb's with 2 complete sheaths (Fig. XII, 1), the cells in both sheaths being of about equal size and similar in appearance in T.S.; vb's in the large ribs near the leaf margin with O.S. interrupted abaxially and adaxially (Fig. XII, 3*a*).

CULM

Culm examined 2 mm in diameter; centre solid, occupied by spongy tissue. Vb's in 3 circles, only those of the outer circle being embedded in scl. ground tissue. Each vb. of the outer circle subtended, on the side towards the epidermis, by an arc of assimilatory tissue, the ground tissue between these arcs being thickened but not strongly lignified.

MATERIAL EXAMINED: Collected by R. E. Vaughan in Mauritius.

ADDITIONAL INFORMATION FROM THE LITERATURE

1. LEAF

Holm (1901–2) studied the leaf structure of 32 spp. of *Aristida* belonging to the section *Chaetaria*. Special attention was devoted to *A. adscensionis* Linn. (as *A. fasciculata*), with particular reference to the occurrence of vb's with three bundle-sheaths, not only in the leaf but also in the culm. Other characters noted for the section *Chaetaria* include a deeply furrowed adaxial surface; thick, smooth cuticle; infrequent papillae; pointed unicellular hairs on the ribs, the hairs often overlying the furrows; mesophyll with radiate chlorenchyma; bulliform cells at the bases of the furrows with girders of colourless cells extending from them to the abaxial surface; scl. as adaxial and abaxial girders of v. thick-walled fibres associated with the vb's; scl. also present on the abaxial side of the leaf between the vb's and sometimes continuous over the whole abaxial surface. Specific diagnostic characters for the spp. in the section *Chaetaria* include variations in the proportion and distribution of papillae and macro-hairs, in the sizes of the bulliform cells, and in the thickness of the fibre-walls. *A. dichotoma* Michx., *A. ternipes* Cav. (as *A. divergens* Vas.), and *A. orcuttiana* Vas. (as *A. schiediana* Trin.) are similar in structure to spp. belonging to the section *Chaetaria*. This applies also to *A. californica* Thurb. ex. Boland., *A. desmantha* Trin. & Rupr., and *A. tuberculosa* Nutt. of the section *Arthratherum*. Most spp. belonging to the section *Arthratherum* exhibit a mesophyll with radiate chlorenchyma, a large-celled parenchymatous sheath, and an I.S. of thick-walled parenchyma surrounding each vb, a third bundle-sheath being present. Other characters for spp. such as *A. plumosa* Linn. belonging to this same group include furrows on both surfaces almost covered by overlapping, long, pointed hairs and by papillae with globular heads, very much resembling glandular hairs; absence of bulliform cells; adaxial and abaxial girders of scl., associated with the vb's, more fully developed than in the section *Chaetaria*. Similar structure was noted by Holm in a few spp. from N. Africa and Russia. Vb's between the ribs noted in a few spp.

Turning now to African spp., it may be noted that Günzel (1912, 1921) published detailed descriptions of the leaf in 6 spp. The reader must consult Günzel's papers for specific diagnostic details.

Theron (1936) has published a v. detailed description of the leaf anatomy of nearly 50 spp. of *Aristida* from S. Africa. It should be noted that he always worked with sections cut transversely in the lower half of the leaf, about 1 cm above the ligule, so as to secure uniform treatment. It is impossible here to summarize all the details that Theron gives, but, in a general way, the facts which he records agree with those given under the first two sections above. The leaves are strongly xerophytic and become so strongly inrolled that the abaxial surface of T.S.s is always convex. This marked rolling occurs in spite of the small size of the bulliform cells. The adaxial surface may be flat, furrowed, or provided with deep grooves, and the spp. can be grouped taxonomically on the basis of these characters. The adaxial surface is provided with well-marked, usually hairy ribs separated from one another by furrows, the heights of the ribs and the depths of the furrows being of specific diagnostic value. Theron,

however, does not agree with Henrard (1929) that the sections *Stipagrostis* and *Schistachne* can be distinguished from the rest of the genus by having only one sheath around each vb. The I.S. is also lacking from certain spp. belonging to the sections *Chaetaria* and *Arthratherum*. Other characters of specific diagnostic value include the arrangement of the scl., the number and arrangement of the bulliform cells, the type of hair, the proportion of large to small vb's, and the outline of the cross-section of the leaf.

More recently, Jelenc (1950) examined the epidermis and T.S. of the leaves of about 25 spp. and varieties of *Aristida* from Morocco. Jelenc's treatment of the epidermis is on the same lines as that adopted by Prat for the grasses in general. Here again it is impossible, in this book, to summarize the details for each sp. examined by Jelenc. It may be noted, however, that the sections *Schistachne* and *Stipagrostis*, in the sense used by Henrard, were found to be characterized by 'globular' silica-bodies and vb's with single bundle-sheaths. In the sections *Arthratherum*, *Chaetaria*, and *Pseudarthratherum*, on the other hand, the silica-bodies are dumb-bell shaped, and the vb's always possess double parenchymatous sheaths. Jelenc concluded that the sections *Stipagrostis* and *Schistachne* are related to the Stipeae, and that the sections *Arthratherum*, *Chaetaria*, and *Pseudarthratherum*, and perhaps *Pseudochaetaria* and *Streptachne*, are more like the Paniceae.

Sabnis (1921) has recorded that in *A. hirtigluma* Steud. the adaxial grooves are not deep; the hairs are spiny; the mesophyll includes radiate chlorenchyma round the small vb's and arcs of chlorenchyma on either side of each of the large vb's. In *A. funiculata* Trin. et Rupr. the adaxial grooves are deeper.

2. Culm

Canfield (1934) has recorded that 8 *Aristida* spp. he examined have solid culms.

3. Root

Price (1911) has described the root of *A. pungens* Desf. and gives the following particulars. Roots spreading over great distances a few inches below the soil; thin and cord-like, uniform in diameter and sheathed by agglutinated sand; root-hairs persistent, each cell of the piliferous layer near the root tip secreting mucilage; exodermis present; outer cortex compact, but inner part containing large intercellular spaces; endodermis well defined; stele polyarch, sometimes with as many as 40 protoxylem strands; centre of the mature root occupied by a scl. pith. Root-hairs reaching their maximum development 1½–2 inches behind the apex, the hairs being v. long. Roots of *A. obtusa* Delile shorter but more or less resembling those of *A. pungens* in structure.

Special Notes

Parodi and Freier (1945) note that *Aristida* is a member of the Stipeae, forming a natural group with *Piptochaetium*, *Nassella*, *Oryzopsis*, and *Stipa*. See also the section above for taxonomic views expressed by Theron and Jelenc respectively. This genus, like *Danthonia*, exhibits a wide range of leaf structure. Brown (1958) regards *Aristida* as a distinct type on the grounds that the 2 bundle-sheaths are both parenchymatous. To the present author the relationship to *Stipa* seems more certain.

Literature

Canfield 1934 (solid culms in 8 spp.); Goosens 1935 (root); Grob 1896 (epidermis); Günzel 1912, 1921 (leaf of African spp.); Henrard 1929 (monograph of the genus); Holm 1901–2 (leaf of American spp.); Jelenc 1950 (leaf of African spp.); Prat 1932, 1934, 1936 (leaf); Price 1911 (root); Sabnis 1921 (ecological anatomy); Zemke 1938 (ecological anatomy of 1 sp.).

ARRHENATHERUM

Diagnostic Generic Characters

Short-cells, over the veins, solitary and paired. Silica-bodies, over the veins, mostly horizontally elongated, with rounded ends and smooth outlines. Micro-hairs absent. Stomata with parallel-sided subsidiary cells. Vascular bundles: small vb's not angular in outline. Mesophyll with chlorenchyma not radiate. Bundle-sheaths double.

Species Specially Examined

Arrhenatherum elatius (L.) J. & C. Presl

Leaf

Abaxial epidermis

Short-cells, over the veins, mostly solitary or in pairs; common over, but v. infrequent or absent between, the veins. A few **silica-bodies** fitting into concavities in the adjacent cork-cells (Fig. I, 6–7); mostly horizontally elongated, with rounded ends and smooth outlines (Fig. Ia, 13). **Macro-hairs** and **micro-hairs:** none seen in the material examined, but macro-hairs commonly present. **Prickle-hairs:** prickles common both over and between the veins (Fig. VI, 1–2). **Stomata** with parallel-sided subsidiary cells (Fig. IV, 2). **Long-cells** with thin, non-sinuous walls (Fig. V, 2*a–c*).

T.S. lamina

Vascular bundles: small vb's not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 7 and 15). **Adaxial surface** practically smooth (Fig. XIV, 1), or with low, rounded ribs (Fig. XIV, 2). **Sclerenchyma:** a few small vb's not accompanied by scl. (Fig. IX, 1); occasional vb's with abaxial girders only, others with small adaxial and abaxial girders 1–2 cells wide, and 2–3 cells high (Fig. IX, 4); large vb's with adaxial and abaxial girders up to about 4 cells wide. **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells:** groups occasionally irregular (Fig. XV, 1), but mostly as shown in Fig. XV, 2. **Bundle-sheaths** double; large vb's with I.S. complete, and O.S. interrupted abaxially and adaxially (Fig. XII, 3*a*); some small vb's with 2 complete sheaths (Fig. XII, 1).

Culm

Culm examined 2 mm in diameter. Epidermis, and 5–6 subjacent layers of cells, highly lignified; vb's in 2 circles only, the outer circle being embedded in the highly lignified scl. and the inner circle in the inner ground tissue con-

sisting of much larger cells with thinner walls; centre of the culm hollow, the cavity being large.

MATERIAL EXAMINED: Cultivated at Kew.

ADDITIONAL INFORMATION FROM THE LITERATURE

1. RHIZOME OF ONION-COUCH

The so-called onion-couch, a form of *A. elatius* with tuberous internodes to the rhizome, has been described by Seignette (1889) and Mondino (1919). In the tuberous portion of the rhizome the central cavity is replaced by parenchyma; the vb's, which are less numerous and more simplified in structure than usual, are arranged in radial groups separated from one another by rows of parenchyma. The nodes are composed of thickened parenchyma containing scattered bundles as in a normal rhizome. In the tuberous rhizome the cuticle is thickened, and the mechanical tissue reduced. Food is reserved in the form of a carbohydrate related to inulin.

2. Burr and Turner (1933) record that the root of *A. elatius* is a pronounced yellow colour.

SPECIAL NOTES

The leaf structure is typically festucoid. Potztal (1951) has discussed the relationship of *Arrhenatherum* to other genera such as *Helictotrichon* and *Avena*, and has made considerable use of leaf anatomy in reaching her conclusions. She has made a considerable number of new combinations which involve transferring certain spp. of *Trisetum*, *Helictotrichon*, *Avena*, *Avenastrum*, *Danthonia*, and *Bromus* to *Arrhenatherum*. It is not within the province of this book to include a discussion of the merits of these new combinations, but attention is drawn to them for the convenience of readers who are interested. It is clearly evident, however, that the anatomical characters of leaves are, in themselves, generally insufficient to provide criteria for the delimitation of genera, not only in *Arrhenatherum* and its allies, but throughout the Gramineae.

LITERATURE

Burr and Turner 1933 (leaf); Grob 1896 (epidermis); Lewton-Brain 1904 (leaf); Mondino 1919 (bulbous internodes of onion-couch); Pée-Laby 1898 (leaf); Potztal 1951 (relationship to *Helictotrichon*, &c.); Prat 1936 (leaf and chromosomes); Seignette 1889 (morphology of tubers of *Arrhenatherum elatius* (L.) J. & C. Presl var. *bulbosum* (Willd.) Spen. under *Avena*); Strecker 1913 (leaf).

ARTHRAXON

DIAGNOSTIC GENERIC CHARACTERS

Short-cells, over the veins, in rows. Silica-bodies more or less dumb-bell shaped. Micro-hairs present; each with the distal cell tapering to its apex. Stomata with triangular or dome-shaped subsidiary cells. Vascular bundles: small vb's angular in outline. Mesophyll with chlorenchyma not more than inconspicuously radiate. Bundle-sheaths single.

SPECIES SPECIALLY EXAMINED

***Arthraxon quartinianus* (Rich.) Nash**

LEAF

Abaxial epidermis

Short-cells, over the veins, in rows of more than 5 cells; common over the veins, only a single row being present over each vein in the material examined; infrequent or absent between the veins. **Silica-bodies** tending to be dumb-bell shaped (Fig. IA, 18 (ii–iv)), but with the middle part of each body not much narrower than the ends; sometimes as in Fig. IA, 17, but rather longer. **Macro-hairs:** rather infrequent, short, stiff hairs, with swollen, sunken, constricted bases, present in the intercostal zones (Fig. II, 3). **Micro-hairs:** length 18–24 (mostly 22–24) μ; basal cell 7–10 μ; distal cell 10–18 μ; distal cell tapering to a pointed apex (Fig. VII, 6); hairs rather short for this type. **Prickle-hairs:** none seen. **Papillae:** a large unthickened type (Fig. III, 6) present on the long-cells between the veins. **Stomata:** some tending to have triangular (Fig. IV, 1), and others low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells** with thin, sinuous walls (Fig. V, 3*a–c*).

T.S. lamina

Vascular bundles: nearly all vb's small, polygonal (Fig. VIII, 5); a few large vb's of basic type (Fig. VIII, 11). **Adaxial surface** smooth (Fig. XIV, 1). **Sclerenchyma:** numerous small vb's not accompanied by scl. (Fig. IX, 1); a few large vb's with small, or slightly widened, adaxial and abaxial strands (Fig. IX, 4); keel bundle with an anchor-shaped strand of scl. (Fig. IX, 6). **Keel** conspicuous, containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not, or only inconspicuously, radiate. **Bulliform cells** in irregular groups (Fig. XV, 1). **Bundle-sheaths:** all vb's with single, complete sheaths (Fig. XI, 2*a–b*).

CULM

Culm examined 1 mm in diameter. Epidermis, and some 5–6 subjacent cell-layers, relatively small and lignified; vb's in 3 distinct circles, the bundles of the outermost circle being smaller than the others, and embedded in thick-walled ground tissue. Two additional vb's much nearer the centre of the culm. Central cavity relatively small and irregular in outline.

MATERIAL EXAMINED: Cultivated at Kew.

ADDITIONAL INFORMATION FROM THE LITERATURE

LEAF

Prat (1937) records a v. thin lamina, v. long cushion hairs over the veins, numerous papillae on the abaxial epidermis, radiate chlorenchyma, and an epidermis composed largely of bulliform cells, in *A. lancifolius* Hochst. (as *A. microphyllus* Hochst.). Prat also noted similar characters in *A. quartinianus* (Rich.) Nash.

V. large bulliform cells, occupying half the thickness of the leaf, also noted by Vickery (1935) on the adaxial side of the leaf in *A. ciliaris* Beauv. var. *australe* Benth. Other characters recorded for this same sp. by Vickery similar to those of *A. lancifolius* as described by Prat.

Special Note

Leaf structure panicoid.

Literature

Grob 1896; Prat 1936, 1937; Vickery 1935 (all referring to leaf structure).

ARUNDINELLA

Diagnostic Generic Characters

Short-cells, both over and between the veins, mostly solitary or paired; those over the veins locally in rows. Silica-bodies, over the veins, cross to dumb-bell shaped. Micro-hairs present; each with the distal cell tapering to a pointed apex. Stomata with triangular subsidiary cells. Vascular bundles: small vb's not more than slightly angular in outline. Mesophyll with chlorenchyma indistinctly radiate; interrupted horizontal rows of circular cells, larger in diameter than their neighbours, visible in the mesophyll between the veins in T.S. of the lamina. Bundle-sheaths mostly single, but complete or incomplete I.S. noted by Conert (1957).

Species Specially Examined

***Arundinella metzii* Hochst. ex Miq. (*A. lawii* Hook. f.)**

Leaf

Abaxial epidermis

Short-cells mostly solitary and in pairs, both over and between the veins; also locally in rows of 3–5 or more cells over the veins; abundant. **Silica-bodies,** between the veins, tall and narrow (Fig. I, 4); those over the veins intermediate between cross and dumb-bell shaped (Fig. IA, 17), or dumb-bell shaped (Fig. IA, 18 (ii–iv)). **Macro-hairs:** rather infrequent, short, stiff hairs, with swollen, sunken bases (Fig. II, 3), each surrounded by a group of specialized epidermal cells, present in the intercostal zones. **Micro-hairs:** length 36–48 (mostly 38–42) μ; basal cell 18–20 μ; distal cell 18–28 (mostly 21–24) μ; distal cell tapering to a pointed apex (Fig. VII, 5). **Prickle-hairs:** none seen. **Stomata** with triangular subsidiary cells (Fig. IV, 1). **Long-cells:** those between the veins with thin sinuous walls (Fig. V, 3*a–c*).

T.S. lamina

Vascular bundles: numerous small vb's somewhat angular in outline as in Fig. VIII, 6; large vb's of basic type (Fig. VIII, 10 and 15). **Adaxial surface** with slight ridges and rather wide, shallow furrows (Fig. XIV, 2). Abaxial surface also slightly ribbed. **Sclerenchyma:** a few of the smallest vb's, especially those towards the leaf margins, not accompanied by scl. (Fig. IX, 1); most small vb's with small adaxial and abaxial strands, or, more frequently, girders (Fig. IX, 4); large vb's with broader adaxial and abaxial girders (Fig. IX, 5). **Keel** prominent; containing a number of vb's (Fig. XIV, 3). **Mesophyll:**[1]

[1] Mesophyll: each small vb is accompanied on either side by a colourless mesophyll cell, slightly larger than its neighbours. It seems possible that these cells may be the homologues of the 'fusoid-cells' in the mesophyll of bamboo leaves. In T.S. the mesophyll also shows, between each consecutive pair of vb's, an interrupted horizontal row of rather large circular cells, which appear to be filled with translucent contents, and the cell-walls tend to be more deeply stained than those of the neighbouring cells. These cells are mostly solitary in T.S., but occasionally in horizontal pairs.

chlorenchyma not radiate, or small vb's tending to be accompanied by somewhat radiate chlorenchyma. **Bulliform cells:** those towards the leaf margins in well-defined groups, as in Fig. XV, 2; groups elsewhere tending to be fan-shaped (Fig. XV, 4). **Bundle-sheaths:**[1] single; small vb's with complete sheaths (Fig. XI, 2*a*); most keel bundles, and large vb's of the lamina, with abaxial interruptions only (Fig. XI, 6).

Culm

Culm examined 2 mm in diameter, exhibiting the following characters. Flattened columns of assimilatory tissue present beneath the epidermis, the peripheral ground tissue otherwise consisting of thick-walled cells with highly lignified walls. Vb's in 3 distinct circles, those of the outermost circle wholly embedded in scl.; those of the second circle situated at the inner periphery of the thick-walled ground tissue; inner vb's embedded in thin-walled ground tissue. Central cavity of the culm large.

Material Examined: Cultivated at Kew.

***Arundinella villosa* Arn. ex Steud.** **(see also p. 46)**

Leaf

Abaxial epidermis

Short-cells, both over and between the veins, mostly paired; locally over the veins in rows of more than 5 cells; abundant. **Silica-bodies,** between the veins, tall and narrow (Fig. I, 4), or sometimes slightly crescent-shaped; those over the veins mostly cross-shaped, or tending to be intermediate between cross and dumb-bell shaped (Fig. IA, 17). **Macro-hairs:** none seen. **Micro-hairs:** length 50–62 (mostly 57–60) μ; basal cell 18–22 μ; distal cell 36–44 (mostly 36–42) μ; distal cell tapering to a pointed apex (Fig. VII, 5–6). **Prickle-hairs:** none seen. **Stomata** with triangular subsidiary cells (Fig. IV, 1). **Long-cells** with thick sinuous walls, each long-cell in a file of cells being separated from the next long-cell in the same file by a pair of short-cells very markedly at right angles to the horizontal walls of the long-cells; interstomatal cells long, with concave ends (Fig. V, 10–11).

T.S. lamina

Vascular bundles: smallest vb's, opposite the surface furrows, with xy. and ph. scarcely distinguishable (Fig. VIII, 1); medium-sized vb's opposite the ribs not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 10). **Adaxial surface** with slight rounded ribs, and shallow, fairly narrow, furrows (Fig. XIV, 2), but ribs and furrows rather more pronounced towards the leaf margins (Fig. XIV, 3). Abaxial surface also slightly ribbed. **Sclerenchyma:** small vb's, opposite the furrows, not accompanied by

[1] Where single complete sheaths are present, the cells are not all equally inflated, those towards the abaxial surface being appreciably smaller than the others.

scl. (Fig. IX, 1); medium-sized vb's, opposite the ribs, with small adaxial and abaxial girders, the abaxial being up to about 8, and the adaxial up to about 6, cells wide (Fig. IX, 4); large vb's with wider adaxial and abaxial girders (Fig. IX, 5). **Keel** fairly conspicuous; containing a solitary vb (Fig. XIII, 1), but with a small vb on either side, each being opposite one of the furrows nearest to the midrib. **Mesophyll:** chlorenchyma indistinctly radiate. **Bulliform cells** in fan-shaped groups (Fig. XV, 6). **Bundle-sheaths** single; all small vb's each with a complete sheath (Fig. XI, 2*a*); large vb's with their sheaths interrupted adaxially and abaxially, but with a biseriate extension to the adaxial scl.

Culm

Culm examined 2 mm in diameter, exhibiting the following characters. About 12 of the outermost cell-layers v. thick-walled, and constituting a scl. ring interrupted by well-marked columns of assimilatory cells, the assimilatory tissue appearing to have been partly decomposed by fungal attack in the material examined. Vb's in 3 distinct circles, those of the outermost circle being the smallest, their outlines merging with the thickened ground tissue. Vb's of the second circle situated at the inner margin of the peripheral scl., only the vb's of the innermost circle being embedded in ground tissue with thinner walls. Centre of the culm occupied by a fairly large cavity.

Material Examined: Ballard 1404; Ceylon.

Additional Information from the Literature

Conert (1957) deals with 23 *Arundinella* spp., and gives notes concerning the anatomy of some of them. On the whole the 2 spp. described above appear to be typical of the genus. Additional characters noted by Conert in most spp. include the occurrence of prickles and papillae on the ribs, and of cushion-hairs between them; slightly inrolled, rounded leaf margins; midrib usually well developed.

Conert also mentions the following characters that appear to be diagnostic for the spp. in which they occur.

A. intricata Hughes

Leaf inrolled. Adaxial surface strongly ribbed. Leaf margins pointed.

A. laxiflora Hook. f.

Adaxial epidermis, between the vb's, appearing small-celled in T.S. (Typical bulliform cells apparently absent.) Vb's nearest the leaf margins strongly supported by abaxial girders of scl.

A. pumila (Hochst.) Steud.

Midrib not conspicuous. Leaf margins thickened.

A. villosa Arn. ex Steud. (see also p. 45)

Leaf margins somewhat inrolled and broadly rounded in outline. Cushion hairs v. infrequent between the veins on both surfaces.

The particulars recorded by Vickery (1935) for *A. nepalensis* Trin. are v. similar to those for the 2 spp. described in detail above. The midrib is, however, inconspicuous.

Special Notes

Arundinella is the type genus of the Arundinelleae. Jacques-Félix (1950) considers that it forms a natural group (sub-tribe) with *Loudetia* and *Tristachya.*

Literature

Conert 1957 (leaf anatomy and taxonomy); Grob 1896 (leaf epidermis); Jacques-Félix 1950 (taxonomy); tateoka 1958A (leaf); Vickery 1935 (leaf of 1 sp.).

ARUNDO

Diagnostic Generic Characters

The following characters refer particularly to *A. donax*. Short-cells, over the veins, in short or long rows. Silica-bodies, over the veins, cross-shaped or intermediate between cross and dumb-bell shaped. Micro-hairs present: each with the distal cell tapering to a pointed apex. Stomata mostly with dome-shaped subsidiary cells, but subsidiary cells sometimes tending to be triangular in outline. Mesophyll with chlorenchyma not more than slightly radiate. Bundle-sheaths usually single, but occasionally with an obscure I.S.

Species Specially Examined

***Arundo donax* L.**

Leaf (see also p. 48)

Abaxial epidermis

Short-cells, over the veins, in rows of 3–5 or more cells; abundant; pairs and short rows of short-cells abundant between the veins in some preparations, but intercostal silica-bodies infrequent. Short-cells infrequent or absent between the veins in some preparations. **Silica-bodies,** over the veins, cross-shaped (Fig. IA, 16), or intermediate between cross and dumb-bell shaped (Fig. IA, 16–17). Intercostal silica-bodies, when present, rather variable in shape, but generally taller than wide, sometimes tending to be of the *Oryza* type (Fig. IB, 23), slightly lobed, or narrowly saddle-shaped or even cross-shaped. **Macro-hairs:** none seen. **Micro-hairs:** 54–78 (mostly 60–78) μ; basal cell 36–48 μ; distal cell 18–30 μ; basal cell very long and wide; distal cell tapering to a pointed apex (Fig. VII, 10). **Prickle-hairs:** unpointed prickles (Fig. VI, 6), and ordinary prickles (Fig. VI, 1–2), present over the veins. **Stomata** with low dome-shaped subsidiary cells (Fig. IV, 3), or with a tendency for some of the subsidiary cells to be triangular (Fig. IV, 1). **Long-cells** over the veins, with thick, sinuous walls (Fig. V, 1*a–b*); those in the intercostal zones mainly with thin, sinuous walls (Fig. V, 3*a–c*).

T.S. lamina

Vascular bundles: small vb's mostly a large form of the type shown in Fig. VIII, 2; large vb's of basic type (Fig. VIII, 15), but with the ph. slightly sclerosed (Fig. VIII, 16). **Adaxial surface** practically smooth (Fig. XIV, 1).

Sclerenchyma: small vb's with adaxial and abaxial girders about 3–7 cells wide (Fig. IX, 4); large vb's with low but wider adaxial and abaxial girders (Fig. IX, 5). **Keel** prominent, with 1 (Fig. XIII, 1) or 3 (Fig. XIII, 2) vb's. **Mesophyll:** chlorenchyma not radiate, or with a slight suggestion of radiate arrangement. **Bulliform cells** in narrow groups, associated with subjacent **colourless cells** penetrating deeply into the mesophyll (*Arundo* type) (Fig. XV, 7); the colourless cells sometimes penetrate more deeply into the mesophyll than is implied in Fig. XV, 7. **Bundle-sheaths** single or obscurely double; complete round all vb's (Fig. XI, 2*b* and XV, 7), often with 1–2-seriate extensions towards the adaxial, and sometimes with less pronounced extensions towards the abaxial, scl. Extensions more conspicuous in association with the small than with the large vb's.

Sheathing Leaf Base

Sheathing leaf base characterized by v. large intercellular air-cavities; vb's much nearer to the abaxial than to the adaxial surface, the large vb's being situated in girders of colourless cells between adjacent air-cavities, and just below the abaxial surface opposite the air-cavities.

Culm (Fig. XX, 1–3)

Culm examined 1·2 cm in diameter. Epidermis subtended by about 4 layers of small, thick-walled cells, followed by a single layer of larger cells resembling an endodermis, situated around the outer contours of the vb's in the outermost circle. Vb's in about 7 circles, those of the outermost circle being appreciably smaller than the remainder. Cells of the peripheral ground tissue slightly smaller in diameter than those more deeply seated in the culm, but ground tissue wholly consisting of cells of rather small diameter. Vb's in the inner circles each accompanied by a scl. column. Culm 8 mm in diameter similar, but slightly less lignified.

Culm epidermis exhibiting abundant pairs of short-cells, the silica-bodies, unlike those of the leaf, being rounded, or sometimes oblong, and fitting into the concavities of the cork-cells (Fig. I, 6–8).

Material Examined: Cultivated at Kew.

Additional Information from the Literature

Günzel (1921) records the following characters for the lamina of *A. donax*. Both surfaces ribbed, but only slightly on the adaxial side; silica-bodies sometimes circular or oval; adaxial long-cells next to the bulliform cells provided with papillae. With reference to the leaf-sheath the same author records the presence of air-canals, and describes the adaxial long-cells as specially small. Lohauss (1905) records that the outer walls of the bulliform cells are often more thickened than the lateral walls and that the lumina are sometimes filled with silica. Prat (1936) describes the leaf as mainly panicoid, but with a tendency to be festucoid. He also records that the starch grains are compound.

Chrysler (1906), who investigated the course of the vb's in the culm, states that the leaf-traces penetrate rather deeply at the nodes, their course thus resembling the 'palm type' recognized by Von Mohl.

Special Notes

The leaf structure is, on the whole, panicoid, but exhibits some festucoid characters. The groups of bulliform cells are somewhat distinctive.

Literature

Areschoug 1878; Chrysler 1906 (culm bundles); Duval-Jouve 1870, 1875 (leaf); Frohnmeyer 1914 (silica deposition); Günzel 1921 (leaf); Lohauss 1905 (leaf); Magnus 1876; Molisch 1918 (silica-bodies); Nazario 1955 (morphology and growth of rhizomes); Ohki 1939; Paratore 1899 (leaf); Pée-Laby 1898 (leaf); Prat 1936 (leaf).

ASTHENATHERUM

De Wet (1954, 1956) has recorded that the leaf of *Asthenatherum* may exhibit a festucoid or panicoid epidermis, and that the mesophyll is panicoid. The genus is said to be related to *Danthonia*.

Literature

De Wet 1954, 1955 (leaf).

ASTREBLA

Diagnostic Generic Characters

Short-cells, over the veins, in rows. Silica-bodies, especially those over the veins, saddle-shaped. Micro-hairs present; spherical, with rounded apices. Stomata: subsidiary cells with variable outlines. Vascular bundles: small vb's not angular in outline. Mesophyll with chlorenchyma distinctly radiate. Bundle-sheaths double.

Species Specially Examined

***Astrebla squarrosa* C. E. Hubbard**

Leaf

Abaxial epidermis

Short-cells, between the veins, paired; those over the veins in rows of more than 5 cells; abundant. **Silica-bodies,** over the veins, typically saddle-shaped (Fig. I, 9); those between the veins also saddle-shaped but of a narrower type. **Macro-hairs:** none seen. **Micro-hairs:** length 24–26 μ; basal cell 12–16 μ; distal cell 12–15 μ; hairs spherical, with rounded apices (Fig. VII, 2). **Prickle-hairs:** prickles (Fig. VI, 1–2) rather sparse over the veins; angular prickles (Fig. VI, 3) present at the leaf margins. **Papillae:** an oblique type, with thickened endings (Fig. III, 2) occurring on many of the long-cells in the intercostal zones. **Stomata** rather variable, some having triangular (Fig. IV, 1) and others low dome-shaped (Fig. IV, 3) subsidiary cells; could be classified as the variable '*Heteranthoecia* type' (Fig. IV, 5). **Long-cells:** those next to the veins rather short and with thin, sinuous walls (Fig. V, 3*a–c*); others more remote from the veins tending to be more nearly cubical, with slightly to moderately sinuous

walls (Fig. V, 7); interstomatal cells sometimes with concave ends (Fig. V, 10*a–b*).

T.S. lamina

Vascular bundles: most vb's small and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with slight ribs and furrows (Fig. XIV, 2). Abaxial surface with similar ribs. **Sclerenchyma:** keel bundles with well-marked abaxial girders only (Fig. IX, 3); small vb's with low adaxial and abaxial strands (Fig. IX, 4), varying from about 3–12 cells wide; large vb's with low, but rather wider, adaxial and abaxial girders (Fig. IX, 5). **Keel** prominent; rounded; containing a number of vb's (Fig. XIII, 3). **Mesophyll:** chlorenchyma distinctly radiate. **Bulliform** and subjacent **colourless cells** in groups of the *Sporobolus* type (Fig. XV, 8), but with girder-like extensions to the abaxial surface (Fig. XV, 13). **Bundle-sheaths** double; small bundles, and also probably the large ones, with I.S. complete but O.S. interrupted abaxially, but connected to the adaxial scl. by large cells (Fig. XII, 4).

MATERIAL EXAMINED: Hubbard 7071; Queensland, Australia.

SPECIAL NOTES

Although it has been classified in the Aveneae, this genus combines panicoid and festucoid characters. Micro-hairs of *Chloridoid* type. Bulliform cells recalling those of *Sporobolus*.

LITERATURE

Breakwell 1915 (leaf of *A. pectinata* F. V. M.).

ATROPIS (see *Puccinellia*, p. 415)

AVENA

DIAGNOSTIC GENERIC CHARACTERS

Short-cells, over the veins, solitary and in pairs; often infrequent or absent between the veins. Silica-bodies, over the veins, horizontally elongated with sinuous outlines, or occasionally cubical. Micro-hairs absent. Stomata most commonly with parallel-sided, but, at least in some spp., tending to have low dome-shaped subsidiary cells. Vascular bundles: small vb's not angular in outline. Mesophyll with chlorenchyma not radiate. Bundle-sheaths double.

SPECIES SPECIALLY EXAMINED

***Avena ludoviciana* Dur.**

LEAF

Abaxial surface

Short-cells, over the veins, solitary and in pairs; infrequent over, and very rare between, the veins. **Silica-bodies** horizontally elongated, with sinuous

outlines (Fig. IA, 15), some of them having transverse striations. **Macro-hairs** and **micro-hairs:** none seen. **Prickle-hairs:** prickles, very large and with elongated bulbous bases, present over the veins. **Stomata** with parallel-sided (Fig. IV, 2), or sometimes slightly dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells:** those between the veins with thin, non-sinuous, or v. slightly sinuous, walls (Fig. V, 2*a–c*); those over the veins with thicker and more sinuous walls (Fig. V, 1*a–b*).

T.S. lamina

Vascular bundles: numerous small vb's not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with slight, but wide and rounded ribs, and narrower, shallow furrows (Fig. XIV, 2). **Sclerenchyma:** smallest vb's not accompanied by scl. (Fig. IX, 1); others with small adaxial and abaxial strands (Fig. IX, 4); large vb's with adaxial and abaxial girders up to about 6 cells wide and high (Fig. IX, 5). **Keel** not prominent; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** in rather long groups (Fig. XV, 2); also in fan-shaped groups (Fig. XV, 4). **Bundle-sheaths** double; small vb's with I.S. complete, but O.S. not quite complete abaxially (Fig. XII, 2); large vb's with O.S. interrupted adaxially and abaxially (Fig. XII, 3*a*).

CULM

Culm examined 4 mm in diameter, exhibiting the following characters. Epidermis subtended by about 5 layers of small, fairly thick-walled cells with a small amount of assimilatory tissue, not in well-defined columns, embedded in it. Vb's in 3 circles, those of the outermost circle being much smaller than the others, and embedded in the thick-walled ground tissue. Hollow centre of the culm fairly large, with some fragments of pith-like cells extending almost to the centre.

MATERIAL EXAMINED: Cultivated at Kew.

***Avena pubescens* Huds.** Now known as *Helictotrichon pubescens* (see p. 230)

LEAF

Abaxial epidermis

Short-cells, over the veins, mostly solitary; common over, but v. rare between, the veins. **Silica-bodies** varying from more or less cubical to horizontally elongated, often with sinuous outlines (Fig. IA, 14–15), but the silica-bodies less elongated than those in *A. ludoviciana*. **Macro-hairs** long and numerous, with swollen bases; superficial (Fig. II, 1). **Micro-hairs** and **prickle-hairs:** none seen. **Stomata** with parallel-sided subsidiary cells (Fig. IV, 2). **Long-cells:** those between the veins with thin, non-sinuous walls (Fig. V, 2*a–c*); cells tending to be hexagonal in outline; those over the veins much narrower and with thicker walls.

T.S. lamina

Vascular bundles: most vb's small and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with v.

slight, wide, rounded ribs, and shallow, narrow furrows (Fig. XIV, 2). **Sclerenchyma :** smallest vb's not accompanied by scl. (Fig. IX, 1); other small vb's with small adaxial and abaxial strands (Fig. IX, 4); large vb's with wider adaxial and abaxial girders, the abaxial girders being up to about 12 cells wide and 6 cells high, and the adaxial girders somewhat smaller (Fig. IX, 5). **Keel** prominent and triangular in T.S.; containing a solitary vb (Fig. XIII, 1). **Mesophyll :** chlorenchyma not radiate. **Bulliform cells** not v. obvious apart from 2 large, fan-shaped groups (Fig. XV, 6), one on either side of the mid-rib. **Bundle-sheaths** double; small vb's with 2 complete sheaths (Fig. XII, 1); large vb's with I.S. complete, but O.S. not complete abaxially (Fig. XII, 2); often connected to the adaxial scl. by broad extensions from the O.S.

MATERIAL EXAMINED: Cultivated at Kew.

Avena strigosa Schreb.

LEAF

Adaxial epidermis

Short-cells, over the veins, mostly solitary, paired, or in v. short rows; infrequent, mostly at the margins of the veins and v. rare or absent between them. Some short-cells over the veins cubical or slightly longer horizontally than vertically (Fig. I, 1); others containing horizontally elongated and somewhat nodular **silica-bodies** (Fig. IA,15). **Macro-hairs** and **micro-hairs:** none seen. **Prickle-hairs :** prickles (Fig. VI, 1–2) abundant over, and a few between, the veins; also a few hooks (Fig. VI, 5) between the veins. **Stomata** with subsidiary cells low dome-shaped (Fig. IV, 3), or tending to be parallel-sided (Fig. IV, 2). **Long-cells** with thin, non-sinuous walls (Fig. V, 2*a–c*).

T.S. lamina

Vascular bundles : numerous small vb's not conspicuously angular in outline (Fig. VIII, 2); some large vb's with the ph. slightly sclerosed in the region of the xy. **Adaxial surface** practically smooth (Fig. XIV, 1), but with a slight suggestion of ribs and furrows. **Sclerenchyma :** a few of the smallest vb's not accompanied by scl. (Fig. IX, 1); other small vb's with small adaxial and abaxial strands, or, more commonly, girders (Fig. IX, 4); large vb's with wider adaxial and abaxial girders (Fig. IX, 5). **Keel** fairly prominent; could be interpreted as containing 3 main vb's (Fig. XIII, 2), or as having a single vb (Fig. XIII, 1). **Mesophyll :** chlorenchyma not radiate. **Bulliform cells** in well-defined groups as in Fig. XV, 2; other groups tending to be fan-shaped (Fig. XV, 4). **Bundle-sheaths** double; some small vb's with 2 complete sheaths (Fig. XII, 1); some medium-sized vb's with O.S. connected to the adaxial scl. by an extension of large cells (Fig. XII, 4); large vb's with O.S. interrupted adaxially and abaxially (Fig. XII, 3*a*).

CULM

Culm examined 2 mm in diameter, exhibiting the following characters. Epidermis subtended by about 9 layers of small, fairly thick-walled cells with ill-defined areas of assimilatory tissue embedded between them. Vb's in only

2 circles, those of the outer circle being embedded in the peripheral, small-celled tissue. Central cavity of the culm large.

MATERIAL EXAMINED: Cultivated at Kew.

ADDITIONAL INFORMATION FROM THE LITERATURE

1. LEAF

Burr and Turner (1933) describe the leaf of *A. fatua* L. as having low, flattened, adaxial ribs; macro-hairs chiefly on the keel and at the leaf margins; and prickle-hairs (asperities) on both surfaces. Duval-Jouve (1875) and Pée-Laby (1898) give some details concerning the distribution and amount of scl., and of the number and sizes of the bulliform cells, in several common spp. of *Avena*. Prat (1936) has recorded that the leaf structure is festucoid.

2. CULM

Chrysler (1906), discussing the course of the vb's in the culms, has recorded the occurrence of amphivasal bundles at the nodes. Roelants (1921), with reference to the distribution of scl. in the culms of *A. sativa*, notes that, whilst the structure varies in consecutive internodes of an individual culm, the structure of the corresponding internodes of material from different localities, and in different seasons, remains constant. Goodwin (1942), who studied the development of vascular elements in the first internodes of *Avena* seedlings, reports that annular, spiral, and pitted elements are successively developed, and that transitional types also occur. The rate of formation of spiral, and still more of pitted, elements is increased by exposure to light.

SPECIAL NOTE

Leaf structure typically festucoid.

LITERATURE

Avery 1930 (embryology); Burr and Turner 1933; Chauveaud 1897 (root); Chrysler 1906 (culm bundles); Duval-Jouve 1875 (leaf); Emmerling 1898 (glumes); Frohnmeyer 1914 (silica deposition); Goodwin 1942 (development of vascular elements in seedlings); Grob 1896 (epidermis); Hamilton 1948 (apical meristem); Holm 1908; Meyer 1925 (brief notes on roots); Pée-Laby 1898 (leaf); Potztal 1951 (comparison with *Arrhenatherum* and *Helictotrichon*); Prat 1932, 1936; Raunkiaer 1934 (hairs); Roelants 1921 (culm); Saint-Yves 1929–31 (leaf structure of Mediterranean spp., many now in *Helictotrichon*); Sharman 1947 (stem apex); Trabet 1889*b* (leaf of N. African spp.); Vierhapper 1906 (leaf); Wille 1916; Zade 1918 (microscopy of floral leaves).

BALDINGERA (see *Phalaris*, p. 377)

BECKERA

Grob (1896) notes a few details for '*B. nubica* Hochst.' = *Beckeropsis nubica* (Hochst.) Fig. & De Not.

Short-cells, over the veins on the abaxial leaf surface, arranged in rows; absent between the veins on both surfaces. Cushion hairs present amongst the bulliform cells and elsewhere in the intercostal zones.

SPECIAL NOTE

The rows of short-cells indicate that the structure is panicoid.

LITERATURE

Grob 1896 (leaf).

BECKEROPSIS

DIAGNOSTIC GENERIC CHARACTERS

Short-cells, over the veins, mostly in rows. Silica-bodies, over the veins, nearly all cross to dumb-bell shaped, and occasionally nodular. Micro-hairs present; each tapering to a pointed, sometimes thickened, apex. Vascular bundles; small vb's angular in outline. Mesophyll with inconspicuously radiate chlorenchyma. Bundle-sheaths single.

SPECIES SPECIALLY EXAMINED

***Beckeropsis uniseta* (Nees) Stapf.**

LEAF

Abaxial epidermis

Short-cells, over the veins, in rows of more than 5 cells; abundant over, but infrequent between, the veins. **Silica-bodies,** over the veins, mostly intermediate between cross and dumb-bell shaped (Fig. IA, 17), dumb-bell shaped (Fig. IA, 18 (ii–iv)), or shortly dumb-bell shaped (Fig. IB, 20), occasionally nodular (Fig. IA, 18 (i)). **Macro-hairs** present; each short, stiff, and with a constricted base surrounded by a cushion of specially large epidermal cells. Macro-hairs on the adaxial surface with their bases surrounded by large bulliform cells. **Micro-hairs:** length 44–54 (mostly 44–48) μ; basal cell 14–22 (mostly 14–18) μ; distal cell 24–36 (mostly 26–34) μ; distal cell tapering to a narrowly pointed, thickened apex (Fig. VII, 4–5). **Prickle-hairs** present. **Stomata** with triangular subsidiary cells (Fig. IV, 1). **Long-cells:** those in the intercostal zones with thin, sinuous walls (Fig. V, 3*a–c*), the cells being rather short; those over the veins much longer and with thicker, almost non-sinuous walls; interstomatal cells with concave ends (Fig. V, 11).

T.S. lamina

Vascular bundles: xy. and ph. not clearly distinguishable in the smallest vb's (Fig. VIII, 1); most vb's with the xy. and ph. easily distinguishable, the vb's being pentagonal in outline (Fig. VIII, 4). **Adaxial surface** with v. slightly rounded ribs, and wide shallow furrows (Fig. XIV, 2). Abaxial surface also slightly ribbed. **Sclerenchyma:** small vb's not accompanied by scl. (Fig. IX, 1); others with small adaxial and abaxial strands, the strands sometimes consisting of as few as 1 or 2 cells in T.S. (Fig. IX, 4); a few vb's in the lamina, and most of those in the keel, with abaxial strands or girders only; a few hypodermal adaxial strands also present in the midrib. **Keel** conspicuous; rounded, containing numerous vb's of unequal size (Fig. XIII, 3). **Mesophyll:** chlorenchyma rather inconspicuously radiate. **Bulliform cells** mostly in irregular groups (Fig. XV, 1); also in groups of the type in Fig. XV, 2, but with the cells conspicuously larger than those of the remainder of the epidermis; a few groups of the *Zea* type (Fig. XV, 3). Adaxial ground tissue of the mesophyll consisting of colourless cells. **Bundle-sheaths** single; complete round all vb's (Fig. XI, 2*a–b*).

CULM

Culm examined about 8 mm in diameter exhibiting the following characters. Epidermis subtended by a zone of about 12 layers of cells with v. thick walls; cells of the inner ground tissue larger, but also thick-walled. Vb's in 3–4 more or less distinct circles, those of the outermost circle being smaller than the others and embedded in the peripheral thick-walled ground tissue. Culm with a large central cavity.

MATERIAL EXAMINED: Supplied by G. Jackson; Nyasaland.

***Beckeropsis* sp. Milne-Redhead and Taylor 9000** (a form of *B. uniseta*)

LEAF

Similar in all essential characters to that of *B. uniseta*, but **keel** very much more prominent and containing a large adaxial mass of ground tissue composed of colourless cells. **Sclerenchyma** forming larger adaxial strands in the keel. **Bulliform cells** mostly in groups of the type in Fig. XV, 2, but occasional groups of the *Zea* type (mostly round the bases of the macro-hairs) (Fig. XV, 3) also noted. Base of the leaf resembling a 'petiole', solid at the proximal end but hollow just below the lamina. Vascular system of the 'petiole' consisting of a circle of alternating large and small vb's situated just below, and connected by scl. girders to, the abaxial epidermis, the adaxial surface being slightly concave and supported by small hypodermal strands of scl. Ground tissue in the centre of the solid portion of the 'petiole' consisting of rather spongy, thin-walled parenchyma.

CULM

Structure similar to that of *B. uniseta*, but vb's less strongly supported by thick-walled fibres. A hypodermal layer of v. thick-walled fibres of small diameter present.

***Beckeropsis* sp. Milne-Redhead and Taylor 9101** (a form of *B. uniseta*)

LEAF

Leaf structure of this sp. v. similar to that of Milne-Redhead and Taylor 9000, but stiff **macro-hairs,** with constricted bases surrounded by enlarged epidermal cells, much longer and more frequent on both surfaces of the lamina and on the abaxial surface of the keel. Epidermis similar to that of *B. uniseta* and Milne-Redhead and Taylor 9000. **Silica-bodies** mostly cross to dumb-bell shaped and commonly with slight concavities in the ends of each body; nodular bodies fairly frequent.

CULM

Culm similar to that of Milne-Redhead and Taylor 9000, but centre almost solid and occupied by thin-walled ground tissue.

SPECIAL NOTE

Leaf structure typically panicoid.

BECKMANNIA

Referring to *B. erucaeformis* (L.) Host and *B. syzigachne* (Steud.) Fernald, Prat (1934, 1936) states that the leaf characters of these 2 spp. recall those of the Festaceae and Hordeae rather than of the Chlorideae. Characters of the epidermis include rounded silica-cells, 'exodermis cells' with short points. The characters of the leaf in T.S. are stated to resemble those of the Poeoideae.

Literature

Prat 1934, 1936.

BLEPHARIDACHNE

The leaf structure of *B. benthamiana* (Hackel) Hitchcock has been described and figured by Cacares (1950, 1951).

Abaxial epidermis figured as showing short-cells solitary, paired, and in short rows; silica-bodies rather variable in shape, but many tending to be slightly cross-shaped; micro-hairs with greatly inflated, spherical distal cells and short, much narrower, proximal cells; a few prickles; stomata with low dome-shaped to slightly triangular subsidiary cells; long-cells with thin, markedly sinuous walls. T.S.s exhibit fairly pronounced ribs and furrows on both surfaces; vb's in the lamina crowded, angular in outline and accompanied by abaxial and adaxial scl., mostly in the form of strands. Midrib figured as somewhat conspicuous owing to a slight abaxial projection; containing a single vb strongly supported by a massive abaxial girder of scl. Bundle-sheaths, at least those of the small vb's, single.

Special Note

Cacares emphasizes that the leaf structure is like that of the Chlorideae, and, in particular, it resembles that of *Scleropogon brevifolius*, and similar characters were noted also in spp. of *Munroa* and *Tridens*. The leaf characters suggest affinities with the Eragrosteae.

Literature

Cacares 1950, 1951.

BOISSIERA

Lohauss (1905) has recorded the following particulars concerning the leaf of *B. squarrosa* (Soland.) Nevski.

Epidermal preparations show the long-cells, both over and between the veins, to be hexagonal, those over the veins having straight, unpitted walls, and alternating with hairs. Long-cells between the veins mostly alternating with hairs, but sometimes with stomata. Outer walls of the long-cells on both surfaces described as having outwardly directed, vesicular swellings. In T.S. the leaf exhibits the following characters. Surface with slight ribs and furrows. Scl. forming I-girders with the vb's, but not abutting directly on the bundle-sheaths. Macro-hairs forming a felt on both surfaces. Midrib scarcely protruding. Mesophyll: chlorenchyma consisting of v.

large, loosely united, stellate cells; palisade and spongy parenchyma stated to be clearly differentiated. Bulliform cells of moderate size present between the vb's. Bundle-sheaths complete; each consisting of more or less uniform cells with strongly thickened inner walls; true parenchymatous sheaths stated to be absent.

Special Note

Prat (1936) emphasizes that the leaf characters are festucoid.

Literature

Lohauss 1905; Prat 1936.

BONIA

The silica-bodies in *B. tonkinensis* Balansa have been described by Grob (1896) as saddle-shaped.

Literature

Grob 1896.

BOTHRIOCHLOA

Diagnostic Generic Characters

Short-cells, over the veins, mostly in rows. Silica-bodies, over the veins, cross to dumb-bell shaped. Micro-hairs present, each with the distal cell tapering to a pointed apex. Papillae common on the intercostal long-cells. Stomata with triangular, or low dome-shaped, subsidiary cells. Vascular bundles: most vb's conspicuously angular in outline. Mesophyll with chlorenchyma markedly radiate. Bundle-sheaths single.

Species Specially Examined

***Bothriochloa caucasica* (Trin.) C. E. Hubbard**

Leaf

Abaxial epidermis

Short-cells, over the veins, mostly in rows of more than 5 cells, but sometimes in pairs; abundant over, but v. infrequent between, the veins. **Silica-bodies** cross-shaped (Fig. IA, 16), intermediate between cross and dumb-bell shaped (Fig. IA, 17), or dumb-bell shaped (Fig. IA, 18 (ii–iv)); a few nodular (Fig. IB, 22 (iii)). **Macro-hairs:** numerous, fairly short, stiff hairs, with swollen, constricted bases (Fig. II, 3–4) present over the veins; short, rigid, thick-walled hairs (Fig. IIA, 10) also fairly frequent between the veins. **Micro-hairs:** length 56–66 (mostly 58–66) μ; basal cell 30–36 (mostly 30–34) μ; distal cell 26–33 (mostly 30–32) μ; distal cell usually tapering to a narrowly or acutely pointed apex as Fig. VII, 5, but the 2 cells more nearly equal in length. **Prickle-hairs:** a few angular prickles at the leaf margins (Fig. VI, 3). **Papillae:**

small, variously shaped, thick-walled, cuticular warts (Fig. III, 5) common, but not v. numerous on each individual cell; also a single, larger, oblique papilla on one side of, and partly overlapping, each stoma. **Stomata** with triangular subsidiary cells (Fig. IV, 1). **Long-cells:** those between the veins with thin, sinuous walls (Fig. V, 3*a–c*); those over the veins longer, narrower, and with thicker walls; interstomatal cells rather long, but sometimes with concave ends (Fig. V, 11).

T.S. lamina

Vascular bundles: numerous small, angular vb's (Fig. VIII, 5); a few large vb's of basic type (Fig. VIII, 15). **Adaxial surface** smooth (Fig. XIV, 1). **Sclerenchyma:** numerous small vb's not accompanied by scl. (Fig. IX, 1); others accompanied by small adaxial and abaxial strands (Fig. IX, 4), the strands sometimes consisting of only a few cells; largest vb's with adaxial and abaxial girders, usually not more than 3–4 cells wide and high. **Keel** prominent; containing a solitary median vb (Fig. XIII, 1), but some of the adjacent small vb's could be interpreted as being in the keel. **Mesophyll:** chlorenchyma distinctly radiate. **Bulliform cells** in irregular groups (Fig. XV, 1). **Bundle-sheaths** single; most vb's with complete sheaths (Fig. XI, 2*a–b*), but a few large vb's with sheaths interrupted abaxially (Fig. XI, 6).

CULM

Culm examined about 2 mm in diameter, exhibiting the following characters. Epidermis subtended by 9 layers of cells smaller in diameter than those of the remainder of the ground tissue, but only moderately thick-walled and with wide lumina. Central ground tissue consisting of pitted cells. Vb's in 3 distinct circles, none penetrating to the centre of the culm; vb's of the outermost circle the smallest. Centre of the culm solid.

MATERIAL EXAMINED: Cultivated at Kew.

***Bothriochloa pertusa* (L.) A. Camus**

LEAF

Abaxial epidermis

Short-cells, between the veins, solitary and in pairs; those over the veins mostly in rows of more than 5 cells, but some solitary bodies and pairs also present; abundant over, but infrequent between, the veins. **Silica-bodies,** over the veins, mostly dumb-bell shaped (Fig. IA, 18 (ii–iv)), sometimes varying in appearance with the focus (Fig. IB, 21); others nodular (Fig. IA, 18 (i)), and a few cross-shaped (Fig. IA, 16); those between the veins variable, some being cross-shaped, others a tall form of cross-shaped, or tall and narrow (Fig. I, 4). **Macro-hairs:** fairly long, stiff hairs with swollen, sunken, constricted bases (Fig. II, 3) present in the intercostal zones, the bases of the hairs being surrounded by specialized epidermal cells (Fig. IIA, 5). **Micro-hairs:** length 38–48 (mostly 38–45) μ; basal cell 14–18 μ; distal cell 24–29 μ; distal cell tapering to a pointed apex (Fig. VII, 6); hairs appreciably shorter than those of *B. caucasica*. **Prickle-hairs:** hooks (Fig. VI, 5) occasional between the veins.

Papillae: large thin papillae present on the long-cells (Fig. III, 6). **Stomata:** some tending to have triangular (Fig. IV, 1), but others with low dome-shaped, subsidiary cells (Fig. IV, 3). **Long-cells:** those between the veins with thin, sinuous walls (Fig. V, 3*a–c*); those over the veins longer, narrower, but still with sinuous walls; interstomatal cells with concave ends (Fig. V, 10*a–b*).

T.S. lamina

Vascular bundles: smallest vb's with xy. and ph. scarcely distinguishable (Fig. VIII, 1); most vb's polygonal (Fig. VIII, 5); a few large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with slight, narrow ribs, and shallow, rounded furrows (Fig. XIV, 2). **Sclerenchyma:** small vb's, especially those opposite the bulliform cells, not accompanied by scl. (Fig. IX, 1); other small vb's each with an adaxial and an abaxial strand consisting of only a few cells (Fig. IX, 4); largest vb's with anchor-shaped girders (Fig. IX, 6). **Keel** prominent, rounded; containing numerous vb's (Fig. XIII, 3). **Mesophyll:** chlorenchyma distinctly radiate. **Bulliform cells:** some in irregular groups (Fig. XV, 1); others in fan-shaped groups (Fig. XV, 6). **Bundle-sheaths:** some small vb's each with a single complete sheath (Fig. XI, 2*b*); sheaths of large vb's with abaxial interruptions (Fig. XI, 6).

MATERIAL EXAMINED: Ballard 1481; Ceylon.

ADDITIONAL INFORMATION FROM THE LITERATURE

Vickery's (1935) description of *B. decipiens* (Hackel) C. E. Hubbard includes the following information. Leaf thin; both surfaces smooth. Cells of the abaxial epidermis appearing v. unequal in size in T.S., and prominently papillose. Sclerenchyma: most small vb's not accompanied by scl., but large vb's accompanied by small adaxial and abaxial girders, and a few vb's of intermediate size by small adaxial and abaxial strands. Keel well developed; containing a large median vb accompanied on either side by a few smaller vb's. Mesophyll with conspicuously radiate chlorenchyma. Bulliform cells in irregular groups, the cells being of unequal sizes and some penetrating quite deeply into the mesophyll. Ground tissue in the adaxial part of the midrib composed of colourless cells. Bundle-sheaths single, those round the small vb's consisting of cells of unequal sizes.

B. erianthoides (F. Muell.) C. E. Hubbard, also described by Vickery, differs only slightly from *B. decipiens*.

Prat (1937) has described *B. glabra* (Roxb.) A. Camus (as *Amphilophis glabra* Stapf) and *B. intermedia* (R. Br.) A. Camus (as *Amphilophis intermedia* Stapf), both of which are similar to the spp. described above. Colourless parenchyma is stated to be well developed throughout the lamina, the chlorenchyma having a restricted distribution.

Vickery (1935) treats the genus as a member of the Andropogoneae.

SPECIAL NOTE

Leaf structure typically panicoid.

LITERATURE

Prat 1937; Vickery 1935.

BOUTELOUA

Diagnostic Generic Characters

Short-cells, over the veins, mostly paired. Silica-bodies saddle-shaped. Micro-hairs present; distal cell hemispherical. Stomata tending to have triangular subsidiary cells. Vascular bundles: most vb's conspicuously angular. Mesophyll with chlorenchyma distinctly radiate. Bundle-sheaths double.

Species Specially Examined

***Bouteloua curtipendula* (Michx.) Torr.**

Leaf

Abaxial epidermis

Short-cells, over the veins, sometimes solitary, and in pairs, but mostly in rows of more than 5 cells; abundant over, but infrequent between, the veins. **Silica-bodies** saddle-shaped (Fig. I, 9). **Macro-hairs:** short rigid, thick-walled hairs abundant in the intercostal zones (Fig. IIA, 10). **Micro-hairs:** length 20–29 μ; basal cell 12–18 μ; distal cell 8–12 μ; distal cell hemispherical; basal cell tapering towards the proximal end, as Fig. VII, 2, but often more bent. **Prickle-hairs:** prickles (Fig. VI, 1–2) abundant, especially over the smaller veins and beside the large ones. **Stomata** rather obscure in the slide examined, probably tending to have triangular subsidiary cells (Fig. IV, 1). **Long-cells:** those between the veins mostly with thin, sinuous walls (Fig. V, 3*a–c*); those over the veins narrower, with thicker walls; interstomatal cells rather long, with concave ends (Fig. V, 11).

T.S. lamina

Vascular bundles: most vb's small, polygonal, and somewhat angular in outline (Fig. VIII, 5), but less markedly angular than is usual for this type, in some respects intermediate between Fig. VIII, 5 and 2; a few large vb's of basic type, as Fig. VIII, 10. **Adaxial surface** with slight, rounded ribs, separated by narrow, shallow furrows (Fig. XIV, 2). Similar abaxial ribs also present opposite those that are adaxial. **Sclerenchyma:** a few of the small vb's not accompanied by scl. (Fig. IX, 1); others with low but wide adaxial and abaxial strands (Fig. IX, 5), many of them being about 8 cells wide and only about 2 cells high; largest vb's with adaxial and abaxial girders, rather wider than the strands accompanying the smaller vb's. **Keel** not prominent; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma distinctly radiate. **Bulliform cells** in groups of the *Sporobolus* type (Fig. XV, 8), but with girders of colourless cells extending to the abaxial surface (Fig. XV, 13). **Bundle-sheaths** double; small vb's with 2 complete sheaths (Fig. XII, 1); large vb's with I.S. and O.S. interrupted abaxially (Fig. XII, 5); sometimes with the O.S. interrupted adaxially as well. Some small vb's with a v. slight adaxial projection from the O.S.

Culm

Culm examined 1–2 mm in diameter exhibiting the following characters on passing from the epidermis to the centre of the culm. Epidermis, and a single

layer of hypodermal cells, consisting of cells of small diameter, with thick, lignified walls. Next zone consisting of about 4 layers of larger cells, with moderately thick, but less lignified, walls, the cells apparently containing chloroplasts. Ground tissue for the next 7 or so layers composed of small cells with v. thick, highly lignified walls. Vb's mostly in 3 more or less distinct circles, those of the 2 outermost circles being embedded in, and their outlines merging with, the thick-walled ground tissue. Vb's of the third circle situated at the inner periphery of the cylinder of thick-walled ground tissue. Two large additional vb's embedded in the outer part of the central ground tissue. Culm not hollow, the centre being occupied by a pith-like tissue of thin-walled cells.

Material Examined: Cultivated at Kew.

Additional Information from the Literature

1. Leaf

In general the few references to the structure of *Bouteloua* in the literature tend to confirm and extend the facts recorded above. Holm (1901–2), referring to *B. gracilis* (H. B. K.) Lag. ex Steud. (under *B. oligostachya* Torr.), describes the leaf structure as being similar to that of *Buchloe*. This sp. exhibits the following characters: both surfaces ribbed; scl., besides being present in the apices of the ribs, also occurring in the abaxial furrows. Prat (1932, 1934, 1936) indicates that the leaf structure is like that of the Chlorideae, and records epidermal characters similar to those described above. He describes the intercostal silica-bodies as irregular, but sometimes tending to be cross- or cudgel-shaped, and records the occurrence of small warts on the long-cells.

2. Culm

Canfield (1934) records the occurrence of 2 annual and 5 perennial spp. of *Bouteloua* on the Jornada Experimental Range with solid culms.

3. Root

Beckel (1956) has described the mode of development of cortical intercellular spaces in the roots of *B. gracilis* (H. B. K.) Lag.

Special Note

Leaf exhibiting mixed festucoid and panicoid characters. Micro-hairs of Chloridoid type.

Literature

Beckel 1956 (root); Canfield 1934 (culm); Grob 1896 (epidermis); Hayden 1919 (ecological anatomy of leaf of *B. curtipendula*); Holm 1901–2 (leaf); Prat 1932, 1934*b*, 1936 (leaf).

BRACHIARIA

Diagnostic Generic Characters

Short-cells, over the veins, mostly in rows. Silica-bodies, over the veins, cross to dumb-bell shaped or nodular. Micro-hairs present, each with the distal cell usually tapering to a rounded or pointed apex. Stomata with

triangular or low dome-shaped subsidiary cells. Vascular bundles mostly conspicuously angular in outline. Mesophyll with inconspicuously to distinctly radiate chlorenchyma. Bundle-sheaths nearly all single; large vb's occasionally with 2 sheaths.

SPECIES SPECIALLY EXAMINED

***Brachiaria deflexa* (Schumach.) C. E. Hubbard**

LEAF

Abaxial epidermis

Short-cells, over the veins, in rows of more than 5 cells; abundant over, but v. infrequent between, the veins. **Silica-bodies** shortly dumb-bell shaped (Fig. IB, 20), or dumb-bell shaped (Fig. IA, 18 (ii–iv)); others nodular (Fig. IB, 22 (iii)). **Macro-hairs:** short, rigid, thick-walled hairs (Fig. IIA, 10), with deeply sunken bases, each surrounded by cushion-like, bulliform, epidermal cells, abundant between the veins; 2 specialized epidermal cells, one on either side of each hair base, immediately apparent in surface view. **Micro-hairs:** length 30–60 (mostly 48–58) μ; basal cell 14–24 (mostly 15–21) μ; distal cell 24–46 (mostly 33–40) μ; shape of the distal cell rather variable, but generally tapering to a pointed apex (Fig. VII, 4). **Prickle-hairs:** none seen. **Stomata** mostly with triangular (Fig. IV, 1), but some with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells:** those on either side of each vein, and in the stomatal files, with thin, sinuous walls (Fig. V, 3*a–c*); others more nearly cubical, or tending to be rounded, with slightly to moderately sinuous walls (Fig. V, 7*a–b*).

T.S. lamina

Vascular bundles: most vb's small, polygonal (Fig. VIII, 5); a few large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with low, rounded ribs, and narrow, shallow furrows (Fig. XIV, 2). **Sclerenchyma:** small vb's not accompanied by scl. (Fig. IX, 1); a few large vb's accompanied by broad but low adaxial and abaxial strands (Fig. IX, 5), the strands being 1–2 cells high. **Keel** prominent; abaxially rounded, and containing 5 vb's (Fig. XIII, 3). **Mesophyll:** chlorenchyma partly or indistinctly radiate to not radiate, rather obscure in the available material. **Bulliform cells** in fan-shaped groups (Fig. XV, 4), or groups of the **Sporobolus** type (Fig. XV, 9). **Bundle-sheaths** single; complete (Fig. XI, 2*a–b*) round all vb's, those round the large vb's tending to have extensions to the adaxial scl.

MATERIAL EXAMINED: Meikle 1303; Nigeria.

***Brachiaria distichophylla* (Trin.) Stapf**

LEAF

Abaxial epidermis

Short-cells, between the veins, paired; those over the veins in rows of more than 5 cells; abundant; both members of a pair commonly equally silicified, but the more distal cell of a pair generally containing a more recognizable silica-body. **Silica-bodies,** between the veins, usually tall and narrow (Fig. I, 4), but others irregularly cross-shaped or somewhat variable in outline; those over the veins mostly nodular (Fig. IB, 22 (iii)), but others intermediate between cross and dumb-bell shaped (Fig. IA, 17). **Macro-hairs:** locally with short, rigid, thick-walled hairs (Fig. IIA, 10), the bases of the hairs being sunken between bulliform epidermal cells, as in *B. deflexa*. **Micro-hairs:** length 51–68 (mostly 55–62) μ; basal cell 27–38 (mostly 27–34) μ; distal cell 24–42 (mostly 26–34) μ; distal cell usually tapering to an acutely pointed, sometimes thickened, apex (Fig. VII, 4). **Prickle-hairs:** none seen. **Stomata:** a few tending to have triangular (Fig. IV, 1), and others low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells:** those between the veins mostly with thin, sinuous walls, the cell outlines being more or less rectangular (Fig. V, 3*a–c*); cells over the veins very much narrower and with v. sinuous walls.

T.S. lamina

Vascular bundles: most vb's small, polygonal (Fig. VIII, 5); a few large vb's of basic type (Fig. VIII, 15). **Adaxial surface** practically smooth (Fig. XIV, 1). **Sclerenchyma:** numerous small vb's not accompanied by scl. (Fig. IX, 1); others with small abaxial strands only; large vb's with v. small adaxial and abaxial strands (Fig. IX, 4). **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma distinctly radiate. **Bulliform cells** in groups of the *Sporobolus* type (Fig. XV, 8), and transitions to small, fan-shaped groups (Fig. XV, 4). **Bundle-sheaths:** all vb's except the large ones with a single complete sheath (Fig. XI, 2*a*); large vb's with 2 complete sheaths (Fig. XII, 1).

MATERIAL EXAMINED: Meikle 1103; Nigeria.

***Brachiaria jubata* (Fig. & De Not.) Stapf**

LEAF

Abaxial epidermis

Short-cells, between the veins, paired; those over the veins in rows of more than 5 cells; abundant, both between and over the veins. **Silica-bodies** mostly cross-shaped (Fig. IA, 16); but those over the veins with very rounded ends; those between the veins more irregularly cross-shaped. **Macro-hairs:** none seen. **Micro-hairs:** length 50–66 (mostly 58–66) μ; basal cell 18–24 μ; distal cell 31–42 (mostly 36–42) μ; distal cell usually tapering to a pointed apex (Fig. VII, 4). **Prickle-hairs:** hooks occasional in the intercostal zones. (In T.S. it can be seen that there are structures resembling small prickles or hooks arising from some of the groups of bulliform cells. These structures penetrate rather deeply between the individual bulliform cells, and they thus resemble the bases of the hairs that occur in the corresponding position in other spp. of *Brachiaria*.) **Stomata:** some tending to have triangular (Fig. IV, 1), and others low dome-shaped, subsidiary cells (Fig. IV, 3). **Long-cells:** those between the veins with thick, sinuous walls, each cell being separated from the next of its kind in the same file of cells by a pair of short-cells v. markedly at right angles to the horizontal walls; interstomatal cells with concave ends (Fig. V, 11), but cells rather long. Long-cells over the veins not v. numerous, much longer and narrower than those between the veins.

T.S. lamina

Vascular bundles: most vb's small, polygonal (Fig. VIII, 5); large vb's of basic type (Fig. VIII, 10), sometimes with the ph. v. slightly sclerosed. **Adaxial surface** with v. slight, mostly flattened ribs, and v. shallow, narrow furrows (Fig. XIV, 2). **Sclerenchyma:** small vb's, especially those opposite the bulliform cells, not accompanied by scl. (Fig. IX, 1); keel vb's with well-marked abaxial girders only (Fig. IX, 3); large vb's in the lamina with wide adaxial and abaxial girders (Fig. IX, 5), the abaxial girders being up to 12 or more cells wide and the adaxial girders rather smaller. A few of the small vb's in the ribs with small adaxial and abaxial strands (Fig. IX, 4). **Keel** prominent; containing 3 main (Fig. XIII, 2), but also numerous small (Fig. XIII, 3), vb's. **Mesophyll:** chlorenchyma indistinctly radiate. **Bulliform cells** in fan-shaped groups (Fig. XV, 4) penetrating deeply into the mesophyll, with transitions to groups of the *Sporobolus* type (Fig. XV, 8). **Bundle-sheaths** single and complete round nearly all vb's (Fig. XI, 2*a–b*), the sheaths round some of the small rib bundles having incomplete extensions towards the adaxial scl. strands. Some vb's with an indistinct I.S.

MATERIAL EXAMINED: Meikle 792; Nigeria.

Brachiaria paspaloides (Presl) C. E. Hubbard

LEAF

Abaxial epidermis

Short-cells, between the veins, paired; those over the veins in rows of more than 5 cells; abundant. **Silica-bodies,** between the veins, irregularly cross-shaped; those over the veins mostly nodular (Fig. IB, 22 (iii)), and a few shortly dumb-bell shaped (Fig. IB, 20). **Macro-hairs:** moderately long, stiff hairs with swollen, sunken bases (Fig. II, 3), each surrounded at the base by cushion cells, present in the intercostal zones. **Micro-hairs:** length 60–76 (mostly 63–67) μ; basal cell 19–29 (mostly 19–27) μ; distal cell 40–48 μ; both cells usually fairly wide throughout their lengths, the distal cell sometimes slightly tapered towards the apex (Fig. VII, 4). **Prickle-hairs:** a very few, pointed, angular prickles at the leaf margins (Fig. VI, 3). **Papillae:** a few present. **Stomata:** some with triangular (Fig. IV, 1), and others with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells:** those between the veins with thin, sinuous walls (Fig. V, 3*a–c*); those over the veins much narrower and with thicker, less sinuous walls.

T.S. lamina

Vascular bundles: most vb's small, polygonal (Fig. VIII, 5); a few large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with slight ribs and shallow, narrow furrows (Fig. XIV, 2). **Sclerenchyma:** a few small vb's not accompanied by scl. (Fig. IX, 1); most vb's with minute adaxial and abaxial strands, each consisting of only a few cells (Fig. IX, 4); large vb's with abaxial and adaxial strands or girders up to 7 or 8 cells wide, and 2 or 3 cells high (Fig. IX, 5). **Keel** conspicuous; rounded, and containing 1 large median vb, accompanied on either side by 2 much smaller vb's (Fig. XIII, 5). **Mesophyll:** chlorenchyma not radiate, or only slightly so. **Bulliform cells** in groups of the *Sporobolus* type (Fig. XV, 8). **Bundle-sheaths:** all small vb's with single, complete sheaths of large, v. inflated cells (Fig. XI, 2*b*); large vb's with 2 complete sheaths (Fig. XII, 1).

MATERIAL EXAMINED: Collected specially by R. E. Vaughan in Mauritius.

Brachiaria reptans (L.) C. A. Gardner & C. E. Hubbard

LEAF

Abaxial epidermis

Short-cells, between the veins, paired; those over the veins in rows of more than 5 cells; common. **Silica-bodies,** between the veins, irregularly cross-shaped; those over the veins mostly shortly dumb-bell shaped (Fig. IB, 20), others nodular (Fig. IB, 22 (iii)). **Macro-hairs:** none seen. **Micro-hairs:** length 32–50 (mostly 40–45) μ; basal cell 13–16 μ; distal cell 18–32 (mostly 24–32) μ; distal cell often somewhat tapered towards the apex (Fig. VII, 4); hairs narrower than those of the other spp. examined. **Prickle-hairs:** angular prickles at the leaf margins (Fig. VI, 3); a few hooks (Fig. VI, 5) present between the veins. **Stomata** with triangular subsidiary cells (Fig. IV, 1). **Long-cells:** those between the veins with thin, sinuous walls (Fig. V, 3*a–c*); those in the centre of each intercostal zone inflated (Fig. V, 5).

T.S. lamina

Vascular bundles: most vb's small, polygonal (Fig. VIII, 5); a few large vb's of basic type (Fig. VIII, 15). **Adaxial surface** smooth (Fig. XIV, 1). **Sclerenchyma:** a few small vb's not accompanied by scl. (Fig. IX, 1); most vb's with minute adaxial and abaxial strands, each consisting of only a few cells (Fig. IX, 4); a few large vb's with adaxial and abaxial strands up to about 5 cells wide, but only 1 or 2 cells high. **Keel** fairly prominent; containing 1 large median vb accompanied on either side by a smaller strand (Fig. XIII, 2). **Mesophyll:** chlorenchyma inconspicuously radiate. **Bulliform cells** in groups of the *Sporobolus* type (Fig. XV, 8). **Bundle-sheaths:** all vb's except the large ones with a single complete sheath of highly inflated cells (Fig. XI, 2*a–b*); some large vb's with 2 complete sheaths (Fig. XII, 1), but a few of them with the O.S. interrupted abaxially (Fig. XII, 2).

CULM

Culm examined 1 mm in diameter exhibiting the following characters. Culm flattened to slightly concave on one side. Epidermis subtended by a zone of small, fairly thick-walled fibres on the flattened side, and, on the rounded side, by a zone of 3–4 layers of assimilatory cells, interrupted at intervals by girders of fibres extending from the vb's of the outermost circle to the epidermis. Assimilatory tissue bounded on the inner side by 1–2 layers of small lignified cells separating it from the large-celled ground tissue. Vb's consisting of (i) a circle of small strands embedded in the peripheral assimilatory tissue; (ii) a circle of rather larger strands at the inner margins of the mechanical tissue separating the assimilatory from the central ground tissue; (iii) an

arc of bundles embedded in the thin-walled ground tissue, the arc opening towards the flattened side of the culm. Centre of the culm not hollow.

MATERIAL EXAMINED: Collected specially by R. E. Vaughan in Mauritius.

ADDITIONAL INFORMATION FROM THE LITERATURE

LEAF

Grob (1896) notes the following characters for the leaf epidermis of *B. erucaeformis* (J. E. Sm.) Griseb. (under *Panicum erucaeforme*). Silica-bodies mostly dumb-bell shaped, but cross-shaped and nodular types occasional. Cushion hairs present in the zones of bulliform cells. Günzel (1912) indicates that the leaf of *B. nigropedata* (Munro) Stapf, described under *P. nigropedatum* Munro ex Hiern, is similar to that of the spp. described above.

SPECIAL NOTE

Leaf structure panicoid.

LITERATURE

Goosens 1935 (notes on root structure); Grob 1896 (under *Panicum*); Günzel 1912 (leaf).

BRACHYELYTRUM

Grob (1896), referring to *B. erectum* (Schreb.) Beauv., records short-cells over the leaf veins in rows; dumb-bell shaped silica-bodies as dominant, cross-shaped and nodular types being occasional. The leaf structure is thus panicoid.

LITERATURE

Grob 1896.

BRACHYPODIUM

DIAGNOSTIC GENERIC CHARACTERS

Short-cells, over the veins, paired or in short or long rows. Silica-bodies, over the veins, variable, ranging from tall, narrow types fitting into concavities in adjacent cork-cells, to horizontally elongated types with sinuous outlines; saddle-shaped in some species. Micro-hairs absent. Stomata commonly with parallel-sided subsidiary cells. Vascular bundles not conspicuously angular in outline. Mesophyll with chlorenchyma not radiate. Bundle-sheaths double, but O.S. inconspicuous in some spp.

SPECIES SPECIALLY EXAMINED

***Brachypodium pinnatum* (L.) Beauv.**

LEAF

Abaxial epidermis (Fig. XXV, 5)

Short-cells, both over and between the veins, mostly paired; occasionally in rows of about 3 cells over the veins; common. **Silica-bodies** rather variable;

those between the veins, and over the small veins, tall, narrow, or rounded, and each fitting into the concavity of an adjacent cork-cell (Fig. I, 6–7); others over the veins appearing to be slightly oblong (Fig. I, 8). **Macro-hairs** and **micro-hairs:** none seen. **Prickle-hairs:** hooks (Fig. VI, 5) occasional between the veins. **Stomata** absent from the abaxial surface. **Long-cells:** those between the veins with thin, non-sinuous (Fig. V, 2*a–c*) or sometimes slightly sinuous (Fig. V, 3*a–c*), walls; cells tending to be hexagonal in outline. Long-cells over the veins narrower and with thicker walls.

T.S. lamina

Vascular bundles: most vb's small and not conspicuously angular in outline (Fig. VIII, 2); a few large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with slight, rounded ribs and fairly wide, shallow furrows (Fig. XIV, 2). **Sclerenchyma:** most vb's with adaxial and abaxial girders about 1–4 cells wide and up to about 6 cells high (Fig. IX, 7); large vb's with wider adaxial and abaxial girders (Fig. IX, 5); median vb with an anchor-shaped girder (Fig. IX, 6) (see also p. 68) **Keel** fairly conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** in well-defined groups as in Fig. XV, 2, at the bases of the furrows, some of the groups tending to be fan-shaped (Fig. XV, 4). **Bundle-sheaths** double; all vb's with I.S. complete and O.S. interrupted abaxially, and sometimes connected to the adaxial scl. by large cells (Fig. XII, 2 and 4).

CULM

Culm examined 1 mm in diameter exhibiting the following characters. Epidermis subtended mainly by assimilatory tissue; lignified, small-celled ground tissue not well developed. Vb's in 3 more or less distinct, but closely placed, circles. Culm with a relatively small hollow at the centre.

MATERIAL EXAMINED: Cultivated at Kew.

***Brachypodium sylvaticum* (Huds.) Beauv.**

LEAF

Abaxial epidermis

Short-cells: those over or at the margins of the veins, in rows of more than 5 cells; those between the veins mostly solitary; common over, but infrequent between, the veins. **Silica-bodies** over, or immediately beside, the veins, horizontally elongated with sinuous outlines (Fig. IA, 14). **Macro-hairs** long, fairly numerous, superficial, and with swollen bases (Fig. II, 1); also short, rigid, thick-walled hairs (Fig. IIA, 10); both types situated above the veins. **Micro-hairs:** none seen. **Prickle-hairs:** prickles (Fig. VI, 1–2) fairly frequent over, and hooks (Fig. VI, 5) abundant between, the veins; angular prickles (Fig. VI, 3) at the leaf margins. **Stomata** mostly with parallel-sided (Fig. IV, 2) subsidiary cells. **Long-cells:** those between the veins with thin, sinuous walls (Fig. V, 3*a–c*). Transverse veins fairly numerous.

T.S. lamina

Vascular bundles: most vb's small and not conspicuously angular in outline (Fig. VIII, 2); a few large vb's of basic type (Fig. VIII, 15). **Adaxial surface** smooth (Fig. XIV, 1) (see also below). **Sclerenchyma:** small vb's with abaxial and adaxial strands up to 3 or 4 cells wide and high, the strands sometimes becoming converted to girders (Fig. IX, 4); large vb's with broader girders (Fig. IX, 5); median keel vb with an anchor-shaped girder (Fig. IX, 6). **Keel** conspicuous; containing 1 median vb, accompanied on either side by 1 smaller vb (Fig. XIII, 2). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** in well-defined groups more or less as in Fig. XV, 2. **Bundle-sheaths** double; all, or most, vb's with I.S. complete, and O.S. interrupted abaxially (Fig. XII, 2).

Culm

Culm examined 2 mm in diameter exhibiting the following characters. Circular in T.S. with a large hollow centre. Epidermis subtended by well-defined columns of assimilatory tissue, the columns being separated from one another by girders of scl. extending from the individual vb's of the outermost circle to the epidermis, as well as by intermediate girders not immediately associated with vb's. Vb's in 3 circles, those of the outermost circle being the smallest. Only a small proportion of the ground tissue composed of large thin-walled cells.

Material Examined: Cultivated at Kew.

Additional Information from the Literature

Leaf

The leaf structure of a number of spp. of *Brachypodium* has been described by Burr and Turner (1933), Duval-Jouve (1875), Günzel (1921), Lewton-Brain (1904), Lohauss (1905), Pée-Laby (1898), and Strecker (1913).

In so far as these descriptions refer to the spp. described above there is general agreement, although Burr and Turner refer to occasional macro-hairs on the adaxial surface of *B. pinnatum*, and state that the abaxial scl. extends laterally from the vb's in well-developed specimens. According to the same authors, the leaf of *B. sylvaticum* has undulating ribs. Lohauss describes the silica-bodies on the adaxial surface as saddle or dumb-bell shaped, rarely rounded.

Lohauss (1905) says that the spp. fall into 2 groups. Group 1, which includes *B. pinnatum* and *B. sylvaticum*, exhibits relatively thin leaves, with only slight adaxial ribs; bulliform cells only slightly larger than the remaining epidermal cells; a midrib that is clearly defined, but not markedly prominent. Group 2, which includes *B. mucronatum* Willk. and *B. ramosum* (L.) Roem. & Schult., exhibits leaves with marked adaxial ribs; no clearly defined midrib; scl. that forms T-girders with the vb's; fairlylarge bulliform cells. Other characters recorded by Lohauss for individual spp. include the following.

B. mucronatum Willk.

Silica-bodies, over the veins, saddle-shaped.

B. ramosum (L.) Roem & Schult.)

Scl. forming T-girders with the vb's, and extending laterally as a thick continuous layer below the abaxial surface. Bulliform cells specially large. Abaxial epidermis exhibiting no differentiation into costal and intercostal zones; consisting of rectangular long-cells with sinuous walls, kidney-shaped short-cells, and bearing prickles. Adaxial surface with bristles and soft macro-hairs.

B. distachyon (L.) Beauv. (as *Trachynia distachya* Link.)

Structure similar to that of *B. pinnatum* but midrib less conspicuous. Macro-hairs of considerable length on both surfaces.

Günzel (1921), with reference to this same sp., describes the silica-bodies over the scl. as being dumb-bell shaped, and those in the leaf sheath as elliptical.

Special Notes

Prat (1936) says that the structure, on the whole, is festucoid, but points out that the nature of the carbohydrates do not conform with this taxonomic position. The occurrence of dumb-bell and saddle-shaped silica-bodies, which has been recorded for certain spp., is another character that is not typically festucoid.

Literature

Burr and Turner 1933 (leaf); Chauveaud 1897 (root); Duval-Jouve 1875 (leaf); Grob 1896 (leaf); Günzel 1921 (leaf); Lewton-Brain 1904 (leaf); Lohauss 1905 (leaf); Pée-Laby 1898 (leaf); Prat 1932, 1936 (leaf); Roelants 1921 (culm); Strecker 1913 (leaf); Wille 1916.

BRIZA

Diagnostic Generic Characters

Short-cells, over and between the veins, paired. Silica-bodies variable in shape, fitting into concavities in cork-cells. Micro-hairs absent. Vascular bundles: small vb's not conspicuously angular in outline. Mesophyll with chlorenchyma not radiate. Bundle-sheaths double.

Species Specially Examined

***Briza erecta* Lam.**

Leaf

Abaxial epidermis

Short-cells, both over and between the veins, paired. **Silica-bodies** fitting into concavities in the contiguous cork-cells (Fig. I, 6–7); somewhat variable in shape. **Macro-hairs** and **micro-hairs:** none seen. **Prickle-hairs:** pointed, angular prickles at the leaf margins (Fig. VI, 3). **Stomata** absent from the abaxial surface. **Long-cells** with fairly thick, somewhat sinuous walls, the cells tending to be more or less hexagonal in outline.

T.S. lamina

Vascular bundles: vb's mostly not conspicuously angular in outline (Fig. VIII, 2), but rather larger than usual for this type; large vb's of basic type (Fig. VIII, 15), sometimes with slightly sclerosed ph. (Fig. VIII, 12). **Adaxial surface** with well-developed ribs, with a slight indentation in the apex of each rib; furrows rather deep, and of about the same width as the ribs (Fig. XIV, 3–4). **Sclerenchyma:** 1 or 2 small vb's at the leaf margin not accompanied

by scl. (Fig. IX, 1); a few others near the leaf margin each with a well-marked abaxial girder only (Fig. IX, 3); most small vb's with tall, narrow, adaxial and abaxial girders (Fig. IX, 7), the adaxial girders being mostly about 2 cells wide and up to about 8 cells high, and the abaxial girders somewhat wider; large vb's with wider adaxial and abaxial girders (Fig. IX, 5). **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** in fan-shaped groups (Fig. XV, 6) of v. large cells at the bases of the furrows, the cells penetrating quite deeply into the mesophyll. **Bundle-sheaths** double; small vb's with I.S. complete and O.S. interrupted abaxially (Fig. XII, 2); large vb's with O.S. interrupted adaxially and abaxially.

MATERIAL EXAMINED: Cultivated at Kew.

ADDITIONAL INFORMATION FROM THE LITERATURE

1. LEAF

Lohauss (1905), who examined *B. maxima* L., *B. media* L., *B. minor* L., and *B. triloba* Nees. var. *pumila* Hackel., has recorded that, in these spp., the leaf surface is flat or has ribs and furrows that are no more than slight. This is supported by Burr and Turner (1933), who have recorded low flattened ribs in *B. minor*. Lohauss (1905), on the other hand, refers to fairly conspicuous adaxial ribs in *B. media*, some being tall and rounded, and others shorter with flattened apices. Lohauss, in the spp. that he examined, has also recorded that the scl. is weakly developed, but forms T-girders with some of the vb's; also that the I.S.s consist of uniform cells, with the inner more strongly thickened than the outer walls, the O.S.s not being well developed. Burr and Turner record the occurrence of a slight keel in *B. media*. Lohauss does not give much information about epidermal characters, but refers to rounded silica-bodies and kidney-shaped or elliptical cork-cells on the abaxial surface.

2. CULM

Roelants (1921) records for *B. media* that the subcortical fibre-ring is separated from the epidermis by only a few layers of parenchyma.

TAXONOMIC NOTES

Lohauss (1905) states that the spp. are more easily separated on macro- than on micro-morphological characters. Prat (1936) points out that the leaf characters of the genus are festucoid. The relationship of *Briza* to *Eragrostis* has been briefly discussed by Mimeur (1951).

LITERATURE

Burr and Turner 1933 (leaf); Chauveaud 1897 (development of sieve tubes in root); Duval-Jouve 1875 (leaf); Grob 1896 (leaf); Lewton-Brain 1904 (leaf); Lohauss 1905 (leaf); Mimeur 1951 (relationship to *Eragrostis*); Pée-Laby 1898 (leaf); Prat 1936 (leaf); Roelants 1921 (culm); Wille 1916.

BROMUNIOLA

DIAGNOSTIC GENERIC CHARACTERS

Short-cells, over the veins, in long rows. Silica-bodies, over the veins, shortly dumb-bell shaped to almost cross-shaped. Micro-hairs present; partly sunken; each with the distal cell tapering to a pointed apex. Stomata with triangular subsidiary cells. Vascular bundles: most vb's small and angular in outline. Mesophyll with chlorenchyma obscurely radiate. Bundle-sheaths double.

SPECIES SPECIALLY EXAMINED

***Bromuniola gossweileri* Stapf & C. E. Hubbard**

LEAF

Abaxial epidermis

Short-cells, over the veins, in rows of more than 5 cells; abundant over, but v. infrequent between, the veins. **Silica-bodies** mostly shortly dumb-bell shaped (Fig. IB, 20), but some almost cross-shaped (Fig. IA, 16). **Macro-hairs:** none seen. **Micro-hairs:** length 33–46 (mostly 33–42) μ; basal cell 7–18 μ; distal cell 26–41 (mostly 26–30) μ; basal cell obscure because sunken in the epidermis; distal cell tapering to an acutely pointed apex; somewhat resembling Fig. VII, 6, but not typical. **Prickle-hairs:** prickles (Fig. VI, 1–2) abundant over certain veins only. **Stomata** with triangular subsidiary cells (Fig. IV, 1). **Long-cells:** those between the veins with thin, sinuous walls (Fig. V, 3*a–c*). **Transverse veins:** fairly numerous.

T.S. lamina

Vascular bundles: most vb's small, pentagonal to hexagonal (Fig. VIII, 4); others polygonal (Fig. VIII, 5); a few large vb's of basic type (Fig. VIII, 15). **Adaxial surface** practically smooth (Fig. XIV, 1). **Sclerenchyma:** 1 or 2 of the smallest vb's near the leaf margins not accompanied by scl. (Fig. IX, 1); most vb's with small adaxial and abaxial girders up to about 4 or 5 cells wide and about 4 cells high (Fig. IX, 4); median keel vb with an anchor-shaped girder (Fig. IX, 6). **Midrib** conspicuous, with a slight adaxial, and larger, rounded abaxial projection; containing 1 main median vb with a small accessory vb on either side of and almost in contact with it (Fig. XIII, 2). **Mesophyll:** chlorenchyma partially radiate; the radiate structure being confined to some of the cells immediately around the vb's. **Bulliform cells** in groups as in Fig. XV, 2, the cells in some groups penetrating rather deeply into the mesophyll. **Bundle-sheaths** double; most vb's, including the small angular ones, with 2 complete sheaths (Fig. XII, 1), one of the O.S. cells on either side of each vb being much larger than the others and projecting into the mesophyll, each sheath appearing to be winged; large vb's with O.S. not quite complete abaxially (Fig. XII, 2).

CULM

Culm examined 2 mm in diameter exhibiting the following characters. Epidermis subtended by about 5 subjacent layers of assimilatory tissue traversed by weak girders of scl. opposite some of the outermost vb's. Assimilatory tissue bounded on the inner side by 5 or 6 layers of small, thick-walled cells. Vb's of the 2 outer circles partly embedded amongst the thick-walled cells; other vb's scattered, some o f them being quite near the spongy centre of the culm.

ROOT

Root examined 1 mm in diameter exhibiting the following characters. Root bounded externally by 2 or 3 layers of v. thin-walled cells, with a subjacent hypodermis of 2–3 layers of thickened cells. Cortex consisting of more than 12 layers of thin-walled cells, the cells of the innermost 7 layers, or thereabouts, being in v. definite rows radiating from the centre of the root, this type of structure being made possible by a gradual increase in the size of the cells from the centre of the root outwards. Endodermis made conspicuous by U-shaped thickenings of the inner tangential and 2 lateral walls of the cells. Stele exhibiting a circle of 8 large metaxylem elements, embedded in homogeneous, thick-walled ground tissue, and about 18 small groups of ph.

MATERIAL EXAMINED: Cultivated at Kew, from Angola.

SPECIAL NOTES

The winged sheaths of the vb's, and the somewhat complex vascular structure of the midrib, are slightly reminiscent of the structure exhibited by bamboos. It seems incorrect to include this genus in the Festuceae.

BROMUS

DIAGNOSTIC GENERIC CHARACTERS

Short-cells, over the veins, mostly solitary or paired, but a few in short rows in certain spp. Silica-bodies, over the veins, mostly horizontally elongated with rounded ends and smooth, or occasionally sinuous, outlines; those between the veins mostly, or exclusively, tall and narrow. Micro-hairs absent. Stomata usually with parallel-sided, but sometimes with low, dome-shaped subsidiary cells. Vascular bundles: small vb's not conspicuously angular in outline. Mesophyll with chlorenchyma not radiate. Bundle-sheaths double.

SPECIES SPECIALLY EXAMINED

***Bromus carinatus* Hook. & Arn.**

LEAF

Abaxial epidermis (Fig. XXIII, 1)

Short-cells, over and immediately beside the veins, mostly solitary and in pairs; infrequent, especially between the veins. **Silica-bodies,** beside the veins, sometimes tending to be tall and narrow (Fig. I, 4); others, especially those over the veins, horizontally elongated, with rounded ends and smooth or sinuous outlines (Fig. IA, 12 and 14). **Macro-hairs** and **micro-hairs:** none seen. **Prickle-hairs:** prickles (Fig. VI, 1–2) abundant over some of the veins. **Stomata** with parallel-sided subsidiary cells (Fig. IV, 2). **Long-cells:** those between the veins with thin non-sinuous walls (Fig. V, 2*a–c*), some of the individual cells, especially those on either side of the veins, being appreciably wider in the middle than at the ends; those in the stomatal zones more nearly rectangular in outline, but with rounded corners; interstomatal cells sometimes rather long, but with concave ends (Fig. V, 11).

T.S. lamina

Vascular bundles: many vb's small, and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with slight, rounded ribs, and narrow, shallow furrows (Fig. XIV, 2); ribs and furrows more marked on some parts of the leaf surface than others. **Sclerenchyma:** a few small vb's not accompanied by scl. (Fig. IX, 1); some small vb's with adaxial scl. only (Fig. IX, 2), usually in the form of small girders; other small vb's with adaxial and abaxial girders up to about 4 cells wide and high (Fig. IX, 4); large vb's with wider adaxial and abaxial girders (Fig. IX, 5); median keel vb with an anchor-shaped girder (Fig. IX, 6). **Keel** conspicuous; containing a solitary vb (Fig. XIII, 1), or a median vb accompanied on either side by a small lateral (Fig. XIII, 2). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells:** groups as in Fig. XV, 2, or fan-shaped (Fig. XV, 4). **Bundle-sheaths** double; a few of the smallest vb's with 2 complete sheaths (Fig. XII, 1); other small vb's with O.S. interrupted abaxially (Fig. XII, 2); all large vb's with O.S. interrupted adaxially and abaxially (Fig. XII, 3*a*).

CULM

Culm examined 3–4 mm in diameter exhibiting the following characters. Bounded externally by 7–8 layers of small thick-walled cells, with small columns of thin-walled assimilatory tissue embedded amongst them, the assimilatory tissue usually being immediately on either side of the vb's in the outermost circle of bundles. Bundles consisting of an outer circle embedded amongst the peripheral scl., and 2 additional circles in the peripheral part of the thin-walled ground tissue extending nearly to the small cavity at the centre of the culm.

MATERIAL EXAMINED: Cultivated at Kew.

***Bromus coloratus* Steud.**

LEAF

Abaxial epidermis

Short-cells, over the veins, solitary, in pairs, and in rows of 3–5 cells; common over, but v. infrequent between, the veins. **Silica-bodies** mostly horizontally elongated with rounded ends and smooth or sinuous outlines (Fig. IA, 12 and 14). **Macro-hairs** and **micro-hairs:** none seen. **Prickle-hairs:** prickles (Fig. VI, 1–2) infrequent over some of the veins. **Stomata** with parallel-sided subsidiary cells (Fig. IV, 2). **Long-cells:** those between the veins more or less hexagonal with thin, non-sinuous walls (Fig. V, 2*a–c*).

T.S. lamina

Vascular bundles: many vb's small and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 10). **Adaxial surface** smooth (Fig. XIV, 1). **Sclerenchyma:** a few of the smallest vb's, especially those towards the margins of the leaf, not accompanied by scl. (Fig. IX, 1); a few vb's with adaxial strands only (Fig. IX, 2); a few fairly large vb's with abaxial

girders only (Fig. IX, 3); other vb's, both large and small, with adaxial and abaxial girders (Fig. IX, 5), ranging in width from 1–7 cells and up to about 4 cells high, the width of each girder being proportional to the size of the vb; median keel vb with an incomplete, anchor-shaped girder (Fig. IX, 6). **Keel** conspicuous; containing 1 median vb and a smaller vb on either side (Fig. XIII, 2), or a median vb only (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells:** groups as in Fig. XV, 2. **Bundle-sheaths** double; some small vb's with 2 complete sheaths (Fig. XII, 1); large vb's with O.S. interrupted adaxially and abaxially (Fig. XII, 3*a*); keel vb with the O.S. connected to the adaxial scl. by a girder of large cells (Fig. XII, 4).

CULM

Culm examined 3 mm in diameter exhibiting the following characters. Epidermis subtended by assimilatory tissue traversed by girders of scl. opposite the outer vb's. Assimilatory tissue bounded on the inner side by a zone of scl. up to about 6 cells wide. Vb's consisting of the outer circle of small strands already mentioned, and 2 circles of larger strands on the inner side of the scl. circle, embedded in thin-walled ground tissue. A fairly large cavity at the centre of the culm.

MATERIAL EXAMINED: Cultivated at Kew.

***Bromus fibrosus* Hack.**

LEAF

Abaxial epidermis (Fig. XXIII, 2)

Short-cells, both over and between the veins, paired; abundant; cork-cells conspicuously pitted. **Silica-bodies** all tall and narrow (Fig. I, 4). **Macro-hairs:** stiff hairs, with swollen, sunken, constricted bases (Fig. II, 4), locally abundant between the veins; also transitions to short, rigid, thick-walled hairs (Fig. IIA, 10). **Micro-hairs:** none seen. **Prickle-hairs:** angular prickles (Fig. VI, 3) at the leaf margins. **Stomata** with parallel-sided (Fig. IV, 2), or tending to have low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells:** those between the veins with thin, slightly sinuous walls (Fig. V, 3*a–c*).

T.S. lamina

Vascular bundles: some vb's small and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 8 and 15). **Adaxial surface** with slight but wide and rounded, or slightly flattened ribs, and narrow, V-shaped furrows (Fig. XIV, 2). **Sclerenchyma:** small vb's not accompanied by scl. (Fig. IX, 1); occasional large vb's with well-marked abaxial girders only (Fig. IX, 3); other large vb's with adaxial and abaxial girders up to about 20 cells wide and 10 cells high (Fig. IX, 5). **Keel** conspicuous; containing a single median vb (Fig. XIII, 1), or a median vb accompanied on either side by a smaller vb in an adjacent rib. **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** in fan-shaped groups at the bases of the furrows (Fig. XV, 6). **Bundle-sheaths** double; most small vb's with O.S. not quite complete abaxially (Fig. XII, 2); large vb's with O.S. interrupted adaxially and abaxially (Fig. XII, 3*a*); keel vb with O.S. interrupted abaxially, but connected to the adaxial scl. by large cells (Fig. XII, 4).

MATERIAL EXAMINED: Cultivated at Kew.

***Bromus inermis* Leyss.**

LEAF

Abaxial epidermis (Fig. XXIII, 3)

Short-cells, over the veins, mostly solitary or paired; abundant over, but infrequent or absent between, the veins; cork-cells conspicuously pitted. **Silica-bodies:** some silica-bodies, especially those immediately beside the veins, tall and narrow (Fig. I, 4); others horizontally elongated, with rounded ends and smooth or sinuous outlines (Fig. IA, 12 and 14). **Macro-hairs** and **micro-hairs:** none seen. **Prickle-hairs:** prickles (Fig. VI, 1–2) v. occasional over the veins. **Stomata** with parallel-sided subsidiary cells (Fig. IV, 2). **Long-cells** with thin, non-sinuous, or v. slightly sinuous, walls (Fig. V, 3*a–c*); others, forming a longitudinal strip down the centre of each intercostal zone, relatively short, with thin, non-sinuous walls (Fig. V, 4*a–b*).

T.S. lamina

Vascular bundles: numerous small vb's not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 10 and 15). **Adaxial surface** with slight, but fairly wide and rounded ribs, and narrow, shallow furrows (Fig. XIV, 2). **Sclerenchyma:** some small vb's not accompanied by scl. (Fig. IX, 1); others with small adaxial and abaxial strands (Fig. IX, 4); a few large vb's with adaxial and abaxial girders up to about 5 cells wide and 4 cells high, the scl. cells round these vb's having only moderately thick walls and fairly wide lumina; keel vb's with incomplete, slightly anchor-shaped girders (Fig. IX, 6). **Keel** conspicuous; containing a median vb accompanied on either side by a lateral in a separate rib. **Mesophyll:** chlorenchyma not radiate. **Bulliform cells:** groups as in Fig. XV, 2, or sometimes fan-shaped (Fig. XV, 6). **Bundle-sheaths** double; most small vb's with 2 complete sheaths (Fig. XII, 1); large vb's with O.S. interrupted adaxially and abaxially (Fig. XII, 3*a*); median keel vb with O.S. interrupted abaxially, but connected to the adaxial scl. by large cells (Fig. XII, 4).

CULM

Culm examined 3 mm in diameter exhibiting the following characters. Epidermis subtended by columns of assimilatory tissue 1–3 cells wide. Assimilatory tissue bounded on the inner side by a ring of about 6 layers of small sclerosed cells. Vb's consisting of those in an outer circle embedded in the peripheral scl., and those in 2 additional circles embedded in the thin-walled ground tissue extending inwards from the sclerosed zone to the fairly large cavity at the centre of the culm.

MATERIAL EXAMINED: Cultivated at Kew.

***Bromus japonicus* Thunb.**

LEAF

Abaxial epidermis (Fig. XXIII, 4)

Short-cells, over the veins, mostly solitary and in pairs; less frequently in rows of 3–5, or rather more, cells; fairly common over, but v. infrequent or absent between, the veins. **Silica-bodies** horizontally elongated, with rounded ends and smooth (Fig. IA, 12), or occasionally v. slightly sinuous (Fig. IA, 14), outlines. **Macro-hairs** abundant; consisting of fairly long, superficial hairs with swollen bases (Fig. II, 1), and some shorter hairs with sunken bases (Fig. IIA, 11). **Micro-hairs** and **prickle-hairs:** none seen. **Stomata** with parallel-sided subsidiary cells (Fig. IV, 2). **Long-cells,** both over and between the veins, with thin, non-sinuous walls (Fig. V, 2*a–c*).

T.S. lamina

Vascular bundles: numerous small vb's not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 10 and 15). **Adaxial surface** smooth (Fig. XIV, 1). **Sclerenchyma:** some small vb's not accompanied by scl. (Fig. IX, 1); others with wide adaxial and abaxial strands or girders (Fig. IX, 5), the girders ranging from about 1 to 10 cells wide, and from 2 to about 5 cells high; median keel vb with an anchor-shaped girder (Fig. IX, 6). **Keel** fairly conspicuous; containing a solitary vb (Fig. XIII, 1), or a median vb with a small lateral on either side (Fig. XIII, 2). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells:** groups as in Fig. XV, 2. **Bundle-sheaths** double; smallest vb's with 2 complete sheaths (Fig. XII, 1); most vb's with O.S. interrupted adaxially and abaxially (Fig. XII, 3*a–b*).

CULM

Culm examined 3 mm in diameter exhibiting the following characters. Epidermis subtended by 1–2 layers of not more than slightly lignified cells, bounded on the inner side by a ring of about 6 layers of strongly lignified cells. Vb's consisting of those in a circle embedded in the thick-walled ground tissue, and those in 2 additional circles embedded in the thinner-walled ground tissue between the ring of lignified ground tissue and the fairly large cavity at the centre of the culm.

MATERIAL EXAMINED: Cultivated at Kew.

***Bromus sterilis* L.**

LEAF

Abaxial epidermis

Short-cells, over and between the veins, solitary and paired; those over the veins sometimes in rows of 3–5 cells; common over, but rather infrequent between, the veins. **Silica-bodies,** especially those between the veins, fitting into concavities in the adjacent cork-cells (Fig. I, 6–7); others between the veins tending to be tall and narrow (Fig. I, 4); those over the veins mostly horizontally elongated with sinuous outlines (Fig. IA, 14). **Macro-hairs:** v. numerous short, rigid hairs, with enlarged superficial bases (Fig. II, 1), and

transitions to prickles (Fig. VI, 1–2), over and between the veins; sometimes paired with short-cells. **Micro-hairs:** none seen. **Prickle-hairs:** prickles (Fig. VI, 1–2), and transitions to hairs, present over and between the veins. **Stomata** mostly with low dome-shaped subsidiary cells (Fig. IV, 3). **Long-cells** with thin, non-sinuous (Fig. V, 2*a–c*) or sinuous (Fig. V, 3*a–c*) walls, the sinuations being most marked in cells adjacent to the veins; each cell in the middle of the intercostal zones tending to be hexagonal.

T.S. lamina

Vascular bundles: most vb's small and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with low, but v. wide and slightly rounded ribs, and fairly wide, shallow furrows (Fig. XIV, 2). **Sclerenchyma:** a few small vb's not accompanied by scl. (Fig. IX, 1); others with small adaxial strands or girders only (Fig. IX, 2); large vb's with adaxial and abaxial girders up to about 7 cells wide and 4 cells high (Fig. IX, 5), the scl. of the adaxial girders merging with the O.S.; median keel bundle tending to have an anchor-shaped, but incomplete, girder (Fig. IX, 6). **Keel** conspicuous, markedly triangular; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells:** groups as in Fig. XV, 2. **Bundle-sheaths** double; some small vb's with I.S. complete, but O.S. not quite complete abaxially (Fig. XII, 2); other small vb's with 2 complete sheaths (Fig. XII, 1); a few large vb's with O.S. interrupted adaxially and abaxially (Fig. XII, 3*a*).

MATERIAL EXAMINED: Cultivated at Kew.

***Bromus tectorum* L.**

LEAF

Abaxial epidermis (Fig. XXIII, 5)

Short-cells, over the veins, solitary, in pairs, and in rows of 3–5 or rather more cells; common over, but infrequent, except locally, between the veins. **Silica-bodies,** over the veins, mostly horizontally elongated with rounded ends and smooth (Fig. IA, 12), or slightly lobed outlines (Fig. IA, 14–15). **Macro-hairs** very numerous; of medium length, slender, with slightly sunken bases (Fig. IIA, 6). **Micro-hairs** and **prickle-hairs:** none seen. **Stomata** with parallel-sided (Fig. IV, 2), or sometimes tending to have low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells:** those between the veins with thin, non-sinuous walls (Fig. V, 2*a–c*), and slightly hexagonal in outline.

T.S. lamina

Vascular bundles numerous; small vb's not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 10 and 15). **Adaxial surface** smooth, apart from v. widely separated, slight ribs (Fig. XIV, 1). **Sclerenchyma:** most small vb's not accompanied by scl. (Fig. IX, 1), but a few accompanied by adaxial strands only (Fig. IX, 2); large vb's with adaxial and abaxial girders up to about 6 cells wide and 5 cells high (Fig. IX, 5); median keel bundle with a slightly anchor-shaped girder (Fig. IX, 6). **Keel**

conspicuous; containing 1 main vb (Fig. XIII, 1), but 2 small laterals could be interpreted as being included in the keel (Fig. XIII, 2). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells:** groups as in Fig. XV, 2. **Bundle-sheaths** double; large vb's with I.S. complete, but O.S. interrupted adaxially and abaxially (Fig. XII, 3*a*); small vb's with 2 complete sheaths (Fig. XII, 1), or with O.S. not quite complete abaxially (Fig. XII, 2); median keel bundle with O.S. interrupted abaxially, but connected to the adaxial scl. by large cells (Fig. XII, 4).

CULM

Culm examined 3 mm in diameter exhibiting the following characters. Ground tissue not clearly differentiated into lignified and less lignified zones, but cells of the inner ground tissue and sub-epidermal assimilatory tissue with thinner walls than the cells of the intervening region. Vb's in 3 or 4 rather irregular circles. Central cavity of the culm fairly large.

MATERIAL EXAMINED: Cultivated at Kew.

***Bromus unioloides* H. B. K.**

LEAF

Abaxial epidermis (Fig. XXIII, 6)

Short-cells, over the veins, mostly solitary, but occasionally paired, or in short rows; common over, but v. infrequent or absent between, the veins. A few **silica-bodies** tending to be tall and narrow (Fig. I, 4), but mostly horizontally elongated, with sinuous outlines (Fig. IA, 14–15), some of them being a rather short form of this last type. **Macro-hairs** slender, with swollen, superficial or only slightly sunken bases (Fig. II, 1), fairly numerous, and of medium length. **Micro-hairs:** none seen. **Prickle-hairs:** prickles fairly frequent over some of the veins (Fig. VI, 1–2); angular prickles (Fig. VI, 3) v. numerous at the leaf margins. **Stomata** with parallel-sided subsidiary cells (Fig. IV, 2). **Long-cells:** those between the veins with thin, non-sinuous walls (Fig. V, 2*a–c*), somewhat hexagonal.

T.S. lamina

Vascular bundles: numerous small vb's not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 10 and 15). **Adaxial surface** with low but wide, v. slightly rounded ribs, and v. shallow, narrow furrows (Fig. XIV, 2). **Sclerenchyma:** small vb's mostly not accompanied by scl. (Fig. IX, 1); a few small vb's with adaxial strands only (Fig. IX, 2); large vb's with adaxial and abaxial girders up to about 6 cells wide and 5 cells high (Fig. IX, 5); a few small vb's with smaller adaxial and abaxial girders (Fig. IX, 4); median keel vb with an incomplete, anchor-shaped girder (Fig. IX, 6). **Keel** conspicuous, triangular; containing 1 median, and a smaller lateral vein on either side (Fig. XIII, 4). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells:** as fan-shaped groups in the furrows (Fig. XV, 6). **Bundle-sheaths** double; small vb's with 2 complete sheaths (Fig. XII, 1), or with O.S. not quite complete, or inconspicuous, abaxially (Fig. XII, 2); most large vb's with O.S. interrupted abaxially and adaxially (Fig. XII, 3*a*); a few medium-sized

vb's with O.S. interrupted abaxially and connected to the adaxial scl. by large cells (Fig. XII, 4); median keel vb with a wide adaxial extension.

CULM

Culm examined 4 mm in diameter exhibiting the following characters. Epidermis subtended by columns of assimilatory tissue throughout most of the circumference of the culm, but columns not equally developed around the whole periphery, and separated from one another by girders of scl. extending from the outermost vb's to the epidermis. Assimilatory tissue bounded on the inner side by a circle of small, lignified cells up to about 6 cells wide. Inner ground tissue consisting of thin-walled cells. Vb's of the outermost circle small and embedded in scl.; those of the 2 inner circles situated in the thin-walled ground tissue. Centre of the culm occupied by a large cavity.

MATERIAL EXAMINED: Cultivated at Kew.

ADDITIONAL INFORMATION FROM THE LITERATURE

1. LEAF

Besides the spp. of *Bromus* mentioned above, the leaf structure of a number of others has received attention from previous authors, particularly Burr and Turner (1933), Günzel (1921), Lewton-Brain (1904), and Lohauss (1905). The following information is based mainly on the descriptions by these authors.

B. arvensis L.

Abaxial epidermis: Similar to that of *B. mollis* (see p. 80), but hairs longer and straighter. Short-cells over the veins rounded or 4-sided. Long-cells between the veins rectangular or hexagonal. *T.S. lamina.* Adaxial surface with slight ribs and furrows. Midrib protruding adaxially and abaxially. Mesophyll: chlorenchyma consisting of polygonal, often tangentially stretched cells. Bulliform cells only slightly larger than the remaining epidermal cells.

B. ciliatus L.

Abaxial epidermis: Prickles numerous over and between the veins. Long-cells, between the veins, rectangular to hexagonal. *T.S. lamina*: Adaxial surface with slight ribs and furrows. Midrib not prominent. Bulliform cells, near the midrib, not large, but those in the middle of the lamina of considerable size and frequently protruding above the leaf surface.

B. erectus Huds.

T.S. lamina: Adaxial ribs low and flattened. Macro-hairs present, especially at the leaf margins, but hairiness variable; hairs long and erect. Midrib not conspicuous according to Burr and Turner, but Lewton-Brain describes it as marked above and below.

B. laciniatus Beal (as *B. pendulinus* Sesse ex Lag.)

Abaxial epidermis: Short-cells, over the veins, elliptical. Prickles present over the veins. Long-cells: those between the veins hexagonal, with smooth walls. *T.S. lamina*: Adaxial ribs well marked. Midrib prominent. Bulliform cells of moderate size.

B. macrostachys Desf.

Abaxial epidermis: Short-cells, over the veins, rounded; those between the veins rectangular or elliptical. Bristle hairs present. Long-cells: those between the veins

hexagonal. *T.S. lamina*: Both surfaces ribbed. Midrib well defined, but projecting only slightly on the abaxial surface of the leaf; ground tissue consisting of colourless cells. Bulliform cells small.

B. maximus Desf. (now known as *B. rigidus* Roth.)

T.S. lamina: Leaf ribbed on both surfaces, but abaxial ribs low. Bristle hairs numerous on both surfaces. Structure in general similar to that of *B. macrostachys*.

B. mollis L.

Abaxial epidermis: Soft hairs and bristle hairs present. Long-cells, between the veins, hexagonal with smooth walls. *T.S. lamina*: Adaxial surface practically smooth. Midrib projecting adaxially and abaxially according to Lohauss, but Burr and Turner describe the leaf as slightly keeled below. Mesophyll: chlorenchyma consisting of tangentially stretched cells. Bulliform cells small. Günzel describes this sp. as being v. similar to *B. macrostachys*, but adaxial epidermis including more numerous oblong or nodular cells.

B. purgans L.

Abaxial epidermis: Prickles numerous over the veins. Long-cells between the veins mostly rectangular with straight walls. Short-cells, over the veins on the adaxial surface, rectangular. *T.S. lamina*: Adaxial surface with slight ribs. Midrib prominent abaxially.

B. ramosus Huds.

T.S. lamina: Adaxial ribs low and flattened. Macro-hairs on both surfaces numerous and long. Midrib prominent adaxially, the ground tissue consisting of colourless cells.

B. rubens L.

Structure described by Günzel as similar to that of *B. maximus*, but bristle hairs more numerous. (For further details see under 'Root' below.)

B. secalinus L.

Abaxial epidermis: Soft macro-hairs occasional between the veins. Prickles numerous over the veins. Long-cells, between the veins, mostly with straight walls. *T.S. lamina*: Adaxial surface with slight ribs and furrows. Midrib slightly prominent. Bulliform cells next to the midrib specially small; remainder of moderate size.

B. velutinus Schrad.

Abaxial epidermis: Short-cells, over the veins, round to elliptical, often kidney-shaped. Bristle hairs present over, and occasionally between, the veins. Long-cells between the veins rectangular or hexagonal. *T.S. lamina*: Structure generally similar to that of *B. secalinus*. Mesophyll clearly differentiated into spongy and palisade portions. Bulliform cells larger than those of *B. secalinus*.

2. Root

Price (1911) has pointed out that the root-hairs of specimens of *B. tectorum* from arid habitats are long and persistent, and that they hold the sand particles together in such a way that the roots appear at first sight to be enclosed in sandy sheaths. The root-hairs of *Aristida pungens* behave in a similar manner.

The structure of the root and leaf of *B. rubens* L. (see also under 'Leaf' above) has been described and discussed from the ecological standpoind by Killian (1942). The plant is of interest because the structure is not markedly xerophytic, although it grows in dry localities. The leaf exhibits silicified hairs on both surfaces, and hooks (crochets) near the margins. Scl. forms girders with the vb's and is most fully developed in plants from specially arid localities.

The apical portions of the roots bear long, persistent root-hairs, which secrete a pectic material in which sand particles become embedded to form sheaths round the roots. That the secreted material is pectic and not mucilaginous is shown by the fact that it does not swell on contact with water, although it stains readily in ruthenium red. The cortex and ground tissue of the stele are composed of large, irregularly arranged cells. The endodermis consists of cells with the inner tangential walls strongly thickened, and the xy. exhibits a circle of about 7 conspicuous metaxylem elements.

Special Note

Prat (1932, 1936) rightly records that the epidermal structure agrees with that of the Hordeae, and that it is festucoid in character.

Literature

Burr and Turner 1933 (leaf); Duval-Jouve 1875 (leaf); Grob 1896 (leaf); Günzel 1921 (leaf); Killian 1942 (ecological anatomy of *Bromus rubens* L.); Lewton-Brain 1904 (leaf); Lohauss 1905 (leaf); Pée-Laby 1898 (leaf); Prat 1932, 1936 (leaf); Roelants 1921 (culm); Strecker 1913 (figs. of T.S. leaves of a few European spp.); Wille 1916.

BRYLKINIA

Diagnostic Generic Characters

Short-cells solitary and paired. Silica-bodies, over the veins, horizontally elongated, with rounded ends and smooth or sinuous outlines. Micro-hairs absent. Stomata with low, or tall, dome-shaped subsidiary cells. Vascular bundles: small vb's not conspicuously angular in outline. Mesophyll with chlorenchyma not radiate. Bundle-sheaths double.

Species Specially Examined

***Brylkinia caudata* (Munro) F. Schmidt**

Leaf

Abaxial epidermis

Short-cells, both over and between the veins, mostly solitary and paired; common. **Silica-bodies,** especially those between the veins, tall and narrow (Fig. I, 4); those over the veins horizontally elongated, with rounded ends and smooth (Fig. IA, 12) or sinuous (Fig. IA, 14) outlines. **Macro-hairs, micro-hairs,** and **prickle-hairs:** none seen. **Stomata** infrequent; with low (Fig. IV, 3) or tall (Fig. IV, 4) dome-shaped subsidiary cells. **Long-cells** with thick, pitted or sinuous walls (Fig. V, 1*a–b*).

T.S. lamina

Vascular bundles: numerous small vb's not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with slight, but wide, somewhat flattened ribs, and fairly wide, shallow furrows (Fig. XIV, 2). **Sclerenchyma:** small vb's with adaxial girders about 2–5 cells wide and 2–4 cells tall, and abaxial girders slightly taller and wider, often about 8 cells high and 5 cells wide (Fig. IX, 4 and 7); large vb's with

wider adaxial and abaxial strands (Fig. IX, 5); median keel vb accompanied by a strong abaxial strand in the apex of the keel, and a much smaller adaxial strand. **Keel** conspicuous, rather narrow; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells:** groups towards the leaf margin as in Fig. XV, 2; other groups fan-shaped (Fig. XV, 4), especially those towards the midrib. **Bundle-sheaths** double; small vb's mostly with I.S. complete, and O.S. not quite complete abaxially (Fig. XII, 2); large vb's with I.S. complete, but O.S. interrupted adaxially and abaxially (Fig. XII, 3*a*). One cell of the O.S. on either side of each small vb projecting into the mesophyll, and giving the sheaths a slightly winged appearance.

MATERIAL EXAMINED: Szechuan 2731.

SPECIAL NOTE

Leaf structure festucoid rather than panicoid, but certain characters, such as the winged outer bundle-sheaths, are not typically festucoid.

BUCHLOE

DIAGNOSTIC GENERIC CHARACTERS

Short-cells, over the veins, solitary or in rows. Silica-bodies, over the veins, nearly all saddle-shaped. Micro-hairs present; each with the basal cell tapered towards the proximal end, and the distal cell hemispherical. Stomata with slightly triangular subsidiary cells. Vascular bundles: most vb's small and conspicuously angular in outline. Mesophyll with chlorenchyma distinctly radiate. Bundle-sheaths single, or with an inconspicuous I.S.

SPECIES SPECIALLY EXAMINED

***Buchloe dactyloides* (Nutt.) Engelm.**

LEAF

Abaxial epidermis

Short-cells, over and between the veins, solitary and paired; others over the veins in rows of more than 5 cells, but silica-cells in each file separated from one another by fairly long cells; abundant. **Silica-bodies** between the veins, tall and narrow (Fig. I, 4), infrequent; those over the veins nearly all saddle-shaped (Fig. I, 9) or oblong (Fig. I, 10). **Macro-hairs:** frequent, moderately long, stiff hairs, with sunken bases present (Fig. IIA, 5). **Micro-hairs:** length 34–75 (mostly 40–55) μ; basal cell 21–45 (mostly 24–36) μ; distal cell 12–29 (mostly 14–24) μ; basal cell tapering towards the proximal end; distal cell hemispherical. **Prickle-hairs:** hooks present between the veins. **Stomata** with subsidiary cells mostly slightly triangular (Fig. IV, 1). **Long-cells:** those between the veins with thin, sinuous walls (Fig. V, 3*a–c*).

T.S. lamina

Vascular bundles: most vb's small, angular (Fig. VIII, 5); large vb's of basic type (Fig. VIII, 15), but more angular than usual; some large vb's with slightly sclerosed ph. (Fig. VIII, 16). **Adaxial surface** with numerous slight ribs separated from one another by v. narrow, shallow furrows (Fig. XIV, 2). **Sclerenchyma:** some small vb's with abaxial girders only; most small vb's with adaxial and abaxial girders, seldom more than about 2 cells high, and from 2 to 6 cells wide (Fig. IX, 4); large vb's with girders up to about 14 cells wide and 5 cells high (Fig. IX, 5). **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma distinctly radiate. **Bulliform cells** in groups of the *Sporobolus* type (Fig. XV, 8), but subjacent colourless cells forming girders extending to the abaxial surface (Fig. XV, 13). **Bundle-sheaths** single and double; all small vb's with 1 complete sheath (Fig. XI, 2*a*) (sometimes with a vague I.S.); large vb's with double sheaths, the O.S. being incomplete abaxially (Fig. XII, 5).

STOLON

Stolon examined 1 mm in diameter exhibiting the following characters. Epidermis subtended by 4 layers of thin-walled cells, followed, towards the centre of the stolon, by a ring of about 6 layers of v. thick-walled fibres of small diameter. Ground tissue from the fibrous ring to the centre of the stolon consisting of large cells. Vb's consisting of a circle embedded in the fibrous zone; an irregular circle of larger strands at the inner boundary of the fibrous zone; 2 solitary strands, one on either side of the stolon, and much nearer to the centre.

MATERIAL EXAMINED: Cultivated at Kew.

SPECIAL NOTE

Prat (1936) points out that the panicoid leaf structure resembles that of the Chlorideae. The micro-hairs are similar to those in *Eragrostis*.

LITERATURE

Grob 1896 (leaf); Holm 1901–2 (ecological anatomy of leaf); Prat 1936 (leaf).

CALAMAGROSTIS

DIAGNOSTIC GENERIC CHARACTERS

Short-cells, over the veins, sometimes solitary or paired, but mostly in short rows. Silica-bodies, over the veins, horizontally elongated with sinuous outlines, or nodular. Micro-hairs absent. Stomata with parallel-sided, or low dome-shaped, subsidiary cells. Vascular bundles: none conspicuously angular in outline. Mesophyll with chlorenchyma not radiate. Bundle-sheaths double.

SPECIES SPECIALLY EXAMINED

***Calamagrostis epigejos* (L.) Roth**

LEAF

Abaxial epidermis (Fig. XXV, 2)

Short-cells, between the veins, solitary or paired, some of them being paired with hooks; those over the veins also sometimes solitary or paired, but mostly

in rows of 3–5, or occasionally more, cells. **Silica-bodies,** between the veins, tall and narrow (Fig. I, 4); those over the veins nodular (Fig. Ib, 22 (iii)). (These last silica-bodies could be interpreted as horizontally elongated with sinuous outlines (Fig. Ia, 14), but with the sinuations being more marked than usual.) **Macro-hairs** and **micro-hairs:** none seen. **Prickle-hairs:** prickles (Fig. VI, 1–2) abundant over and between the veins, those between being rather smaller than those over the veins. Some large prickles over the veins not pointed (Fig. VI, 6). **Stomata** with subsidiary cells parallel-sided (Fig. IV, 2), or tending to be low dome-shaped (Fig. IV, 3). **Long-cells:** those between the veins with thin, sinuous walls (Fig. V, 3*a–c*).

T.S. lamina

Vascular bundles: all vb's, both large and small, of basic type (Fig. VIII, 10), some having slightly sclerosed ph. (Fig. VIII, 16). **Adaxial surface** with fairly pronounced, rounded, or slightly flattened ribs, and V-shaped furrows (Fig. XIV, 3). **Sclerenchyma:** small vb's with minute abaxial and adaxial girders or, occasionally, strands (Fig. IX, 4); large vb's with wider abaxial and adaxial girders, up to about 8 cells wide and about 5 cells high (Fig. IX, 5); other vb's with narrow adaxial and abaxial girders 1–3 cells wide, and up to about 6 cells high, the adaxial generally being rather taller and narrower than the abaxial girders (Fig. IX, 7); a v. few vb's with abaxial girders only (Fig. IX, 3). **Keel** conspicuous; containing 1 large median vb accompanied on either side by a smaller lateral (Fig. XIII, 2). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** in fan-shaped groups at the bases of the furrows (Fig. XV, 6). **Bundle-sheaths** double; most small vb's with I.S. and O.S. complete (Fig. XII, 1) or, more frequently, with O.S. interrupted abaxially and connected to the adaxial scl. by large cells (Fig. XII, 4); large vb's with O.S. interrupted adaxially and abaxially.

Culm

Culm examined 2 mm in diameter exhibiting the following characters. Culm with a small groove on one side. Epidermis subtended by small peripheral columns of assimilatory tissue separated from one another by girders of scl., some, but not all, of the scl. girders being associated with the outer vb's. Assimilatory tissue bounded on the inner side by a circle of scl. about 6 cells wide and somewhat sinuous in outline. Ground tissue between the scl. and the central cavity of the culm consisting of thin-walled rounded cells. Vb's consisting of a circle embedded in the scl. ring, a second circle at the inner face of the scl. ring, and a third circle embedded in the thin-walled inner ground tissue.

Additional Information from the Literature

1. Leaf

Warncke (1911), writing about the stomata of *Calamagrostis epigejos* (L.) Roth from the ecological standpoint, notes that they occur in both surfaces of the lamina where they are not appreciably sunken. Those in the abaxial surface of the leaf-sheaths are slightly, and those in the adaxial surface more deeply, sunken. Stomata in the culm are at about the same level as those in the abaxial surface of the leaf-sheath.

2. Culm

Chrysler (1906) records amphivasal bundles in the nodes. Holm (1908), writing from the ecological standpoint, makes brief reference to the culm structure of *C. canadensis* var., and *C. purpurascens* R. Br. According to Schumann (1891), comparison of large and small stems of *C. stricta* (Timm.) Koel. shows that the greater diameter of the larger specimen is due to an increase in the amount of interfascicular ground tissue, and to the greater diameters of the cells of the ground tissue.

3. Root

Holm (1908) records the occurrence of a compact cortex, a thickened endodermis, and broad, thick-walled pith in the roots of *C. canadensis* and *C. purpurascens*.

Special Note

Prat (1932, 1936) suggests that the epidermal characters of the leaf resemble those of the Hordeeae, and that the structure is festucoid. To the author it seems, however, that similar festucoid leaf structure is not restricted to Hordeeae.

Literature

Chauveaud 1897 (root); Chrysler 1906 (culm); Duval-Jouve 1875 (leaf); Grob 1896 (leaf); Haberlandt 1882 (leaf); Holm 1908 (culm and root); Pée-Laby 1898 (leaf); Prat 1932, 1936 (leaf); Schumann 1891 (culm); Warncke 1911 (stomata of *C. epigejos* from ecological standpoint); Wille 1916.

CALAMOVILFA

Diagnostic Generic Characters

Short-cells, over the veins, solitary, paired, and in short or long rows. Silica-bodies, over the veins, mostly saddle-shaped. Micro-hairs present; each with the basal cell slightly tapering at the proximal end and the distal cell hemispherical. Stomata with triangular, or low dome-shaped, subsidiary cells. Vascular bundles: most vb's small and not conspicuously angular in outline. Mesophyll with radiate chlorenchyma. Bundle-sheaths double.

Species Specially Examined

***Calamovilfa longifolia* (Hook.) Hack.**

Leaf

Abaxial epidermis

Short-cells, both over and between the veins, solitary and paired, and, over the veins, also in rows of 3–5, or rarely more, cells. **Silica-bodies** mostly saddle-shaped (Fig. I, 5), but some tending to be tall and narrow (Fig. I, 4), especially those at the sides of the veins. **Macro-hairs:** none seen; but a few recorded by Holm (1901–2) on the adaxial surface. **Micro-hairs:** length 38–60 (mostly 38–48) μ; basal cell 33–48 (mostly 33–38) μ; distal cell 7–12 (mostly 7–10) μ; basal cell slightly tapering at the proximal end; distal cell hemispherical (Fig. VII, 12), but with no thickening of the cell-wall. **Prickle-hairs:** none seen. **Stomata:** mostly with triangular (Fig. IV, 1), but others with

low dome-shaped, subsidiary cells (Fig. IV, 3). **Long-cells:** those between the veins with thin, to fairly thick, sinuous walls (Fig. V, 3*a–c*); those over the veins with thicker walls (Fig. V, 1*a*); interstomatal cells with concave ends.

T.S. lamina

Vascular bundles: numerous small vb's not conspicuously angular, but slightly pyriform in outline, with the xy. end of each bundle appreciably narrower than the ph. end; large vb's of basic type (Fig. VIII, 15), but occasionally with the ph. slightly sclerosed. **Adaxial surface** with fairly pronounced rounded ribs, and V-shaped furrows (Fig. XIV, 4), the ribs and furrows being almost equally pronounced on both surfaces and opposite each other. **Sclerenchyma:** all vb's with wide but low adaxial and abaxial girders, sometimes up to about 20 or more cells wide, but seldom more than 4 or 5 cells high (Fig. IX, 5). **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma as a v. narrow radiate zone surrounding the large vb in each rib. **Bulliform cells** in groups of the *Sporobolus* type (Fig. XV, 8), but, with the subjacent colourless cells, forming narrow girders extending to the abaxial surface (Fig. XV, 13). **Bundle-sheaths** double; small vb's with 2 complete sheaths (Fig. XII, 1), but with an extension of the O.S. to the adjacent adaxial scl.; large vb's also with 2 complete sheaths, but adaxial extensions lacking or scarcely apparent.

MATERIAL EXAMINED: Supplied by J. K. O'Byrne at Kew.

ADDITIONAL INFORMATION FROM THE LITERATURE

CULM AND RHIZOME

The following particulars are recorded by Stover (1934). Culm structure similar to that of *Spartina*, with 2–5 circles of vb's in the stele. Culm with an evident cortex, the central ground tissue eventually breaking down to form a small cavity. Vascular portion of the stele becoming completely thick-walled in mature rhizomes, even the ph. becoming lignified. Some vb's in the nodes and short internodes amphivasal.

SPECIAL NOTES

Holm (1901–2) notes similarities between *Calamovilfa* and *Distichlis* (see p. 165). The leaf exhibits a mixture of panicoid and festucoid characters. The micro-hairs resemble those of *Eragrostis* (see p. 189). It seems incorrect to include the genus in the Agrosteae.

LITERATURE

Holm 1901–2 (leaf); Starr 1912 (leaf); Stover 1924, 1934 (vascular structure of culm and rhizome).

CAPILLIPEDIUM

DIAGNOSTIC GENERIC CHARACTERS

Short-cells solitary and in pairs. Silica-bodies tall and narrow. Micro-hairs: none seen. Mesophyll with radiate chlorenchyma. Vascular bundles: small vb's angular, or not angular, in outline. Bundle-sheaths single.

SPECIES SPECIALLY EXAMINED

***Capillipedium* sp. (*Andropogon venustus* Thw.)**

LEAF

Abaxial epidermis

Short-cells, both over and between the veins, solitary and in pairs; abundant. **Silica-bodies** tall and narrow (Fig. I, 4). **Macro-hairs** and **micro-hairs:** none seen. **Prickle-hairs:** prickles (Fig. VI, 1–2) occurring sparsely over some of the veins. **Stomata** absent from the abaxial surface. **Long-cells:** those between the veins with thick, sinuous walls, each member of a consecutive pair in a single file of cells being separated from one another by a solitary tall silica-cell, or by a pair of such cells, the short-cells being very markedly at right angles to the horizontal walls of the long-cells.

T.S. lamina

Vascular bundles: small vb's with xy. and ph. not easy to distinguish, and not conspicuously angular in outline (Fig. VIII, 1–2), large vb's of basic type (Fig. VIII, 10). **Adaxial surface** with ribs moderately pronounced, rounded, and separated from one another by fairly wide furrows (Fig. XIV, 3), these last sometimes containing small secondary ribs. **Sclerenchyma:** smallest vb's not accompanied by scl. (Fig. IX, 1); large vb's with adaxial and abaxial girders often at least 20 cells wide, and only about 4 cells high (Fig. IX, 5); medium-sized vb's with narrower adaxial and abaxial girders (Fig. IX, 4); median keel bundle with a more or less anchor-shaped girder (Fig. IX, 6). **Keel** conspicuous, rounded; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma obscure in the available material. **Bulliform cells** in fan-shaped groups in the adaxial furrows (Fig. XV, 6). **Bundle-sheaths** single; those round the small and large veins complete (Fig. XI, 2*a–b*); those round the medium-sized vb's with small extensions reaching to the adaxial scl. Medium-sized vb's sometimes with an obscure I.S.

MATERIAL EXAMINED: Ballard 1134; Ceylon.

ADDITIONAL INFORMATION FROM THE LITERATURE

LEAF

Vickery's (1935) description of *C. parviflorum* Stapf includes the following information. Leaf wide, thin, and almost flat on both surfaces. Sclerenchyma poorly developed, forming girders above and below the large vb's, but less well developed in association with the small vb's. Pointed macro-hairs sometimes present on both surfaces. Scattered prickles sometimes present. Outer walls of cells of the abaxial epidermis arched to papillose. Midrib conspicuous, the adaxial ground tissue consisting of colourless cells. Mesophyll with radiate chlorenchyma. Bulliform cells in groups of 3–6 and occupying one-third to half of the thickness of the lamina; sometimes with colourless cells below them, especially between the vb's. Bundle-sheaths single, circular.

SPECIAL NOTE

The leaf exhibits mixed panicoid and festucoid characters.

LITERATURE

Vickery 1935 (leaf).

CATABROSA

The information concerning *C. aquatica* (L.) Beauv. recorded in the literature includes the following.

Leaf

Adaxial epidermis. Cells over the scl. of a peculiar, swollen type; cells in the rows next to the scl. hexagonal with thin, unpitted walls. *Abaxial epidermis.* Structure similar to the adaxial epidermis, but cells over the scl. not swollen; bristle hairs sometimes present over the parenchyma. *T.S. lamina.* Large vb's and median keel vb supported both adaxially and abaxially by tall, narrow girders of scl. Sclerenchyma not well developed in association with the small vb's, but often present as small adaxial and abaxial strands, or as abaxial strands only. Keel conspicuous; containing a single median vb. Mesophyll: chlorenchyma not radiate; consisting of loosely arranged polygonal cells. Bulliform cells present in a single group on either side of the midrib. Bundle-sheaths double; cells of the I.S. with strongly thickened inner walls; O.S. not v. conspicuous. Irregular intercellular lacunae arise in the leaf after flowering.

Special Note

Pée-Laby (1898) indicates that *C. aquatica* does not exhibit many of the structural characters that are typical of aquatic plants, although intercellular cavities arise in the leaves after flowering. On the whole the structure resembles that of *Poa*.

Literature

Freidenfelt 1904 (root); Lewton-Brain 1904 (leaf); Lohauss 1905 (leaf); Pée-Laby 1898 (leaf); Wille 1916.

CATAPODIUM

Diagnostic Generic Characters

Short-cells, over the veins, mostly solitary, but some paired or in short rows. Silica-bodies, over the veins, sinuous in *C. rigidum* (see p. 89), but rounded bodies fitting into concavities in contiguous short-cells recorded in *C. marinum* (see p. 89). Micro-hairs absent. Stomata with parallel-sided subsidiary cells. Vascular bundles widely spaced and not conspicuously angular in outline. Mesophyll with chlorenchyma not radiate. Bundle-sheaths double, but I.S. sometimes inconspicuous.

Species Specially Examined

***Catapodium rigidum* (L.) C. E. Hubbard (*Scleropoa rigida* (L.) Griseb.)**

The following account agrees substantially with previous descriptions of the leaf of this sp. by Lewton-Brain (1904) under *Poa rigida* and by Lohauss (1905) under *S. rigida*.

Leaf

Abaxial epidermis

Short-cells, over the veins, mostly solitary, but occasionally paired or in rows of 3–5 cells; infrequent over, and v. infrequent or absent between, the veins. **Silica-bodies** horizontally elongated with sinuous outlines (Fig. Ia, 15). **Macro-hairs** and **micro-hairs:** none seen. **Prickle-hairs:** angular prickles (Fig. VI, 3) numerous at the leaf margins; prickles (Fig. VI, 1–2) common over, and occasional between, the veins. **Stomata** v. infrequent on the abaxial surface; with parallel-sided subsidiary cells (Fig. IV, 2). **Long-cells:** those between the veins with thin, non-sinuous walls (Fig. V, 2*a–c*), many of the cells tending to be hexagonal.

T.S. lamina

Vascular bundles: most vb's small, rather widely spaced, and not conspicuously angular (Fig. VIII, 2), but others rather more angular (Fig. VIII, 5); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with slight to moderate, rounded ribs, separated from one another by rather wide, moderately deep furrows (Fig. XIV, 2–3). **Sclerenchyma:** small vb's not accompanied by scl. (Fig. IX, 1), or with minute adaxial strands only (Fig. IX, 2); large vb's with v. small adaxial and abaxial strands (Fig. IX, 4). **Midrib** fairly conspicuous, projecting both adaxially and abaxially; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells:** groups more or less as in Fig. XV, 2, at the bases of the furrows. **Bundle-sheaths** double; large vb's with 2 complete sheaths (Fig. XII, 1); small vb's probably also with 2 complete sheaths, but I.S. inconspicuous.

Material Examined: J. K. O'Bryne 157; Burnham-on-Crouch.

Additional Information from the Literature

Leaf

The following notes concerning the leaf structure of *C. marinum* (L.) C. E. Hubbard have been recorded in the literature under various synonyms, particularly by Lewton-Brain (1904) and Lohauss (1905).

Adaxial epidermis

Short-cells, over the veins, consisting of rounded silica-cells, with silica-bodies fitting into concavities in adjacent cork-cells. Grob (1896) describes the silica-bodies as circular to oval, but some tending to be sinuous in outline. Short-cells, between the veins, rounded or elliptical. Long-cells: those in some of the files between the veins rectangular, with sinuous, pitted anticlinal walls; those in other files hexagonal, with flat anticlinal walls. Long-cells, over the veins, with sinuous anticlinal walls. Prickles present on the adaxial surface.

T.S. lamina

Vascular bundles: median vb larger than the others. Adaxial surface with well-developed ribs. Sclerenchyma not well developed; present as an abaxial strand in the midrib, as weak marginal strands, and as v. small strands, one in the apex of each rib. Midrib not prominent. Mesophyll: according to Lohauss (1905) the chlorenchyma in the ribs consists of larger, and between the ribs of smaller, loosely connected cells. Lewton-Brain (1904) describes the chlorenchyma as being in circles surrounding the vb's. Bulliform cells not more than moderate in size. Bundle-

sheaths: according to Lohauss (1905) the median vb alone has 2 sheaths, and even here the I.S. is poorly developed, and the O.S. stated to be not well defined. Lewton-Brain (1904), on the other hand, describes the vb's as having well-marked double sheaths.

Special Note

Leaf characters mostly festucoid.

Literature

Grob 1896 (leaf); Lewton-Brain 1904 (leaf); Lohauss 1905 (leaf); Pée-Laby 1898 (leaf).

CENCHRUS

Diagnostic Generic Characters

Short-cells, over the veins, mostly in long rows, but sometimes solitary or paired. Silica-bodies, over the veins, mostly cross to dumb-bell shaped. Micro-hairs present, but sometimes rather scarce; each with the distal cell tapering to a pointed or somewhat rounded apex. Stomata mostly with triangular, but sometimes with low dome-shaped, subsidiary cells. Vascular bundles mostly angular in outline; arranged in 2 distinct rows in the mesophyll in certain species. Mesophyll with chlorenchyma conspicuously radiate. Bundle-sheaths single.

Species Specially Examined

***Cenchrus biflorus* Roxb.**

Leaf

Abaxial epidermis

Short-cells, over the veins, in rows of more than 5 cells; abundant over, but infrequent or absent between, the veins. **Silica-bodies,** over the veins, cross-shaped (Fig. IA, 16); others intermediate between cross and dumb-bell shaped (Fig. IA, 17), or shortly dumb-bell shaped (Fig. IB, 20). **Macro-hairs:** none seen. **Micro-hairs** rather scarce, mostly at the sides of the small veins; length 42–48 μ; basal cell 12–18 μ; distal cell 30–39 μ; distal cell usually tapering to an acutely pointed, sometimes thickened, apex, but apices of other hairs more rounded (Fig. VII, 6). **Prickle-hairs:** a few prickles (Fig. VI, 1–2) present over the veins; hooks (Fig. VI, 5) infrequent at the sides of, and between, the veins. **Stomata** with markedly triangular subsidiary cells (Fig. IV, 1). **Long-cells:** those between the veins rather a short, inflated form of the type with non-sinuous walls (Fig. V, 4*a–b*); interstomatal cells with concave ends (Fig. V, 10).

T.S. lamina

Vascular bundles: most vb's angular (Fig. VIII, 5) in outline, the sheath-cells being rather smaller than usual in vb's of this type; a few large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with ribs of unequal size, but moderately pronounced (Fig. XIV, 3), and more or less triangular in T.S.; furrows mostly V-shaped and narrow, but rather variable in shape. **Sclerenchyma:** some of the small vb's, especially those near the leaf margins and opposite the furrows, not accompanied by scl. (Fig. IX, 1); a few with adaxial (Fig. IX, 2), and others with abaxial, strands only; some small, and the few large, vb's with small adaxial and abaxial strands (Fig. IX, 4); no vb's girdered in the material examined. **Midrib** fairly conspicuous, owing to a small adaxial rib and a slight abaxial projection; containing 1 large median vb (Fig. XIII, 1), generally accompanied on either side by several smaller vb's apparently belonging to the keel (as Fig. XIII, 3, but reduced). **Mesophyll:** chlorenchyma distinctly radiate. **Bulliform cells:** groups, especially near the margins of the leaf, as in Fig. XV, 2; fan-shaped groups also present in the furrows (Fig. XV, 4). **Colourless cells** in the adaxial part of the midrib. **Bundle-sheaths:** all vb's with single, complete sheaths (Fig. XI, 2*a–b*).

Culm

Culm examined 2 mm in diameter exhibiting the following characters. Culm with a shallow groove on one side; practically solid, but with a small central cavity. Epidermis subtended by a zone consisting of several layers of unlignified cells, bounded on its inner face by a scl. ring 2–3 cells wide, the constituent cells having moderately thick walls, and fairly wide lumina. Ground tissue between the scl. ring and the small central cavity in the culm composed of thin-walled cells. Vb's arranged in a single circle embedded in the scl. ring, the remaining vb's being arranged in about 3 rather irregular circles, but appearing to have a rather scattered distribution in the thin-walled ground tissue.

Material Examined: Meikle 684; Nigeria.

***Cenchrus ciliaris* L.**

Leaf

Abaxial epidermis

Short-cells, especially those immediately beside, and a few of those over, the veins, paired; most of those over the veins in rows of more than 5 cells; abundant over, but v. infrequent between, the veins. **Silica-bodies,** especially between the veins, occasionally tall and narrow (Fig. I, 4); others between the veins cross-shaped (Fig. IA, 16); most of those over the veins intermediate between cross and dumb-bell shaped (Fig. IA, 17), or shortly dumb-bell shaped (Fig. IA, 20), more rarely nodular (Fig. IA, 18 (i)). **Macro-hairs:** none seen. **Micro-hairs:** length 63–114 (mostly 72–84) μ; basal cell 21–36 (mostly 21–30) μ; distal cell 42–78 (mostly 42–54) μ; distal cells v. long and tapering to pointed apices (Fig. VII, 4–5); mostly situated close beside the veins. **Prickle-hairs:** prickles (Fig. VI, 1–2) numerous over the veins; hooks (Fig. VI, 5) numerous between the veins. **Stomata** with triangular (Fig. IV, 1), or low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells** with thin, to moderately thick, slightly sinuous walls (Fig. V, 3*a–c*).

T.S. lamina

Vascular bundles: arranged in 2 distinct rows in the mesophyll, the bundles in the 2 rows alternating with one another between the midrib and the leaf

margin. All of the numerous small vb's angular in outline (Fig. VIII, 4–5); large vb's of basic type (Fig. VIII, 10 and 15). **Adaxial surface:** practically smooth (Fig. XIV, 1), or with v. slight ribs. Similar slight ribs also on the abaxial surface (see also p. 93). **Sclerenchyma:** small vb's, especially those in the more abaxial of the 2 rows, not accompanied by scl. (Fig. IX, 1); all other vb's with small adaxial and abaxial strands (Fig. IX, 4); no girders observed. **Keel** fairly prominent; containing 1 large median vb and several smaller laterals on either side (as Fig. XIII, 3, but reduced). **Mesophyll:** chlorenchyma distinctly radiate. **Bulliform cells:** some groups irregular (Fig. XV, 1); others of the *Sporobolus* type (Fig. XV, 8), or small and fan-shaped. Adaxial half of the midrib composed of colourless cells. **Bundle-sheaths** single; complete round all vb's (Fig. XI, 2A–B).

Culm

Culm examined 3 mm in diameter flattened on one side; practically solid, but with the centre occupied by rather spongy tissue. Vb's of the outermost circle each surrounded wholly, or on its outer side, by radiate chlorenchyma. Scl. ring rather weak, and with no clearly defined inner boundary. Vb's on the inner side of the scl. ring in at least 3 rather ill-defined circles, thus presenting a somewhat scattered distribution.

Root

Root examined 2 mm in diameter exhibiting the following zones in T.S. (i) A piliferous layer with long root-hairs. (ii) An exodermis of about 5 layers of cells. (iii) A broad zone of v. spongy cortical tissue. (iv) Three layers of small cells in v. definite radial rows immediately outside the endodermis. (v) The stele, with a circle of large, and a few small, metaxylem vessels. (vi) Centre of the root occupied by a wide, pith-like tissue.

Material Examined: Supplied by G. Jackson; Nyasaland.

Cenchrus pauciflorus Benth.

Leaf

Abaxial epidermis (Fig. XXVII, 5 (Adaxial), 6 (Abaxial)

Short-cells, over the veins, in rows of more than 5 cells; occasionally solitary, or paired, over and between the veins; abundant over, and infrequent between, the veins. **Silica-bodies** cross-shaped (Fig. IA, 16); intermediate between cross and dumb-bell shaped (Fig. IA, 17), or shortly dumb-bell shaped (Fig. IB, 20). **Macro-hairs:** none seen. **Micro-hairs** mostly situated close to certain of the veins; length 48–75 (mostly 48–60) μ; basal cells 19–25 (mostly 19–22) μ; distal cells 30–50 (mostly 36–42) μ; long distal cells tapering to acutely pointed, or slightly rounded, apices (Fig. VII, 6). **Prickle-hairs:** prickles (Fig. VI, 1–2) abundant over the veins; angular prickles present at the leaf margins (Fig. VI, 3); hooks (Fig. VI, 5) frequent between the veins. **Stomata** with markedly triangular subsidiary cells (Fig. IV, 1). **Long-cells** beside the veins, with thin, v. sinuous walls (Fig. V, 3*a–c*).

T.S. lamina

Vascular bundles: vb's in 2 distinct rows in the mesophyll, the bundles in the 2 rows alternating with one another between the midrib and the margin. Numerous small and medium-sized vb's angular (Fig. VIII, 5), the sheath-cells being rather smaller than usual in vb's of this type, and the bundles themselves sometimes less angular than in Fig. VIII, 5; a few large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with slight, rounded ribs of rather variable width, and wide, shallow furrows (Fig. XIV, 2). **Sclerenchyma:** small vb's, especially those in the adaxial row, not accompanied by scl. (Fig. IX, 1); others with small adaxial or abaxial strands only (Fig. IX, 2); a few large vb's with v. small adaxial and abaxial strands. **Keel** conspicuous, rounded or slightly triangular; containing 1 main median vb with 2 or 3 smaller vb's on either side (as Fig. XIII, 3, but reduced). **Mesophyll:** chlorenchyma distinctly radiate. **Bulliform cells:** groups sometimes more or less as in Fig. XV, 2; other groups fan-shaped (Fig. XV, 4); rather variable. **Colourless cells** also present in the abaxial part of the keel. **Bundle-sheaths** single; complete round all vb's (Fig. XI, 2A-B).

Culm

Culm examined 2 mm in diameter, flattened on one side; centre not hollow. Epidermis subtended by a narrow, but more or less continuous zone of assimilatory tissue, except on the flattened side of the culm. A narrow, well-defined ring of scl. is immediately subjacent to the epidermis on the flattened side of the culm, and at the inner boundary of the assimilatory tissue elsewhere. Vb's consisting of a circle of small strands embedded in the scl. ring, and others scattered in the thin-walled ground tissue enclosed by the scl. ring.

Material Examined: Cultivated at Kew.

Additional Information from the Literature

1. Leaf

C. ciliaris L. (as *Pennisetum cenchroides* Rich.)

Günzel (1912) records ribs on both surfaces, those on opposite surfaces alternating with one another.

C. tribuloides L.

Short-cells over the fibres of the midrib reported by Grob (1896) to be paired. Sclerenchyma associated only with the large vb's (Duval-Jouve 1875). Groups of bulliform cells present between the primary vb's and opposite the tertiary vb's, thus contrasting with *C. echinatus* where groups of bulliform cells on the 2 surfaces are opposite (Duval-Jouve 1875). 'Idioblasts' recorded in the leaf by Harshberger (1909).

2. Culm

A solid culm recorded by Canfield (1934), in a sp. of *Cenchrus* from the Jornada Experimental Range.

Special Note

Prat 1936 rightly points out that the leaf structure is panicoid.

Literature

Canfield 1934 (stem); Duval-Jouve 1875 (leaf); Grob 1896 (leaf); Günzel 1912 (leaf); Harshberger 1909 (leaf); Prat 1936 (leaf); Sabnis 1921 (ecological anatomy of the leaf of *Cenchrus biflorus* Roxb. under *C. catharticus* Del.); Youngken and La Wall 1922.

CENTOTHECA

Diagnostic Generic Characters

Silica-cells, over the veins, in rows, but solitary, paired, and in short rows in some specimens. Silica-bodies, over the veins, cross to dumb-bell shaped. Micro-hairs present; rather variable, sometimes each with the distal cell tapering to a rounded apex, others balanoform; in some specimens apparently unicellular with pointed apices. Stomata with triangular subsidiary cells. Vascular bundles not conspicuously angular in outline. Mesophyll with chlorenchyma indistinctly radiate, and often clearly differentiated into palisade and spongy parts. Bundle-sheaths double.

Species Specially Examined

***Centotheca lappacea* (Linn.) Desv.**

Leaf

Abaxial epidermis

Short-cells, between the veins, mostly paired, those over the veins in rows of more than 5 cells, but also solitary and in short rows in Ballard 1400; abundant over, and common to infrequent between, the veins. **Silica-bodies,** over the veins, cross-shaped (Fig. IA, 16), or intermediate between cross and dumb-bell shaped (Fig. IA, 17); those between the veins irregularly cross-shaped. **Macro-hairs:** none seen. **Micro-hairs:** those of Ballard 1553 31–44 (mostly 31–36) μ long; basal cells 13–20 μ; distal cells 18–22 μ; distal cells inflated but sometimes tapering to rounded apices (Fig. VII, 6); others approximating more closely to the balanoform type (Fig. VII, 3). Micro-hairs of Ballard 1001 and 1400 obscure; apparently unicellular, with pointed apices; 21–30 μ long. **Prickle-hairs:** none seen. **Stomata** with triangular subsidiary cells (Fig. IV, 1). **Long-cells** with v. sinuous, thin walls (Fig. V, 6); interstomatal cells with concave ends (Fig. V, 10*a–b*), and v. sinuous outlines. Transverse veins present.

T.S. lamina

Vascular bundles: vb's rather widely spaced, mostly small and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 10). **Adaxial surface:** practically smooth (Fig. XIV, 1), apart from v. slight ribs over the vb's, and more marked ribs over, and immediately on either side of, the midrib. **Sclerenchyma:** all or most vb's with small adaxial and abaxial girders (Fig. IX, 4); median vb with a v. incompletely anchor-shaped girder (Fig. IX, 6), with a long gap between the adaxial scl. and the vb itself. **Keel** conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma indistinctly radiate round the vb's, but chiefly noteworthy for being differentiated into well-marked palisade and spongy parenchyma. **Bulliform cells:** groups irregular (Fig. XV, 1), or as in Fig. XV, 2, the groups being v. long and consisting of v. inflated cells. **Bundle-sheaths** double; most vb's with 2 complete sheaths (Fig. XII, 1); large vb's with O.S. interrupted abaxially (Fig. XII, 2); many vb's, especially the small ones, with wing-like extensions of the O.S. into the mesophyll on either side of the vb.

Material Examined: Ballard 1553, 1001, 1400; Ceylon.

Special Notes

Ballard 1001 does not agree in every detail with Ballard 1553. 1001 has many fewer silica-bodies between the veins, the silica-bodies are more obscure, and the outlines of the long-cells are more markedly sinuous. These and other small differences suggest that the 2 leaves may not be of the same age. This suggestion is also supported by the occurrence of variations in different slides from the same material.

Prat (1934, 1936) has pointed out that the genus has simple starch grains, a panicoid epidermis, and that leaf sections exhibit panicoid characters in some species, and festucoid characters in others. The epidermal characters are said (Prat 1934) to recall those of *Triraphis* and *Uniola.*

Literature

Grob 1896 (leaf); Prat 1934, 1936 (leaf).

CHAETOBROMUS

The leaf structure of *C. dregeanus* Nees., *C. involucratus* Nees., and *C. schraderi* Stapf, 3 spp. related to *Danthonia* and *Schismus*, is briefly mentioned by de Wet (1956). All 3 spp. are described as having a 'panicoid' epidermis, whilst the structure of the lamina in T.S. is 'festucoid'. It seems incorrect to include this genus in the Aveneae.

Literature

de Wet 1956 (leaf).

CHAETURUS

The leaf of this genus exhibits festucoid characters according to information in the literature.

Literature

Grob 1896 (leaf); Prat 1936 (leaf); Wille 1916.

CHAMAERAPHIS

Grob (1896) has recorded the following facts concerning '*C. spinescens* Poir.' Now known as *Pseudoraphis spinescens* (R. Br.) Vickery.

Short-cells absent between the veins on both surfaces; silica-bodies mostly dumb-bell shaped, but occasionally cross-shaped or nodular; cushion hairs present; solitary, thin, globose, often somewhat oblique papillae present in the centre of each of the long-cells on both surfaces.

Special Note

The leaf structure, although incompletely known, appears to be panicoid.

Literature

Grob 1896 (leaf).

CHASMOPODIUM

Prat (1936, 1937) has recorded the following information, with special reference to the leaf of *C. caudatum* Stapf.

Epidermis on both surfaces including files of cells containing silica-bodies shaped like dumb-bells, alternating regularly with prickles. Most vb's small and crowded. Midrib well developed; ground tissue composed of colourless parenchyma. Bulliform cells present on the adaxial surface between the vb's.

Special Note

The leaf structure is panicoid.

Literature

Prat 1936, 1937 (leaf).

CHEVALIERELLA

The abaxial epidermis of the leaf of *C. congoënsis* A. Camus has been briefly described and illustrated, under *C. dewildemanni* (Vand.) Van der Veken, by Jacques-Félix (1955), who gives the following particulars.

Short-cells, between the veins, paired; silica-cells each containing a cuboid or elliptical silica-body. (It is not clear from the illustration or description whether the short-cells and silica-bodies over the veins are similar.) Micro-hairs present between the veins, each with a relatively short proximal cell and a longer distal cell tapering to a pointed apex. Stomata with low dome-shaped subsidiary cells. Intercostal long-cells with coarsely sinuous walls.

Special Note

The leaf characters appear to be panicoid, and they have been described by Jacques-Félix (1955) as bambuso-panicoid.

Literature

Jacques-Félix 1955 (leaf).

with the leaf surface. Mesophyll with chlorenchyma consisting of irregularly arranged, isodiametric cells; colourless cells absent. Vb's sheathed by weakly thickened cells, and joined to one another by transverse veins. Leaf withering immediately on exposure to dry conditions, scl. and a protective cuticle being absent.

Culm

Scl. absent. Epidermis consisting of cells with outwardly directed, conical papillae and bounded on the inner side by 2 layers of persistent assimilatory tissue. Vb's present as an outer circle of small strands subjacent to the assimilatory tissue, and an inner circle of larger strands. Vb's simple in construction; without the large metaxylem vessels characteristic of most grasses, but air-cavities usually arising in them. Ph. strands each exhibiting 2 large sieve tubes. The culm is described as having a 'stem-joint' that arises below the rudimentary 'sheath-joint' and comes into activity at once, thereby making the 'leaf-joint' superfluous. Main axis and lateral branches of the paniculate inflorescence thread-like.

Root

Roots confined to the lowest nodes; shoots lying on the mud not rooted; long, thin, slightly branched, each with a few densely tufted root-hairs. Cortex well developed but without air-canals; outer part eventually collapsing. Endodermis composed of slightly thickened cells. Xy. characterized by a single central vessel with 4, or more rarely 3, others around it.

Special Note

The vegetative anatomy is so specialized in relation to the habitat in which the plant grows that it affords no definite evidence concerning the affinity of *Coleanthus*. The lack of silica-bodies is also unhelpful.

Literature

Grob 1896 (leaf); Kirchner, Loew, and Schröter 1908 (the whole plant).

COLPODIUM

This genus has been briefly mentioned by Grob (1896).

Literature

Grob 1896 (leaf).

CORNUCOPIAE

This genus has been briefly mentioned by Grob (1896) and Prat (1936). The leaf structure is festucoid.

Literature

Grob 1896 (leaf); Prat 1936 (leaf).

CORTADERIA

Diagnostic Generic Characters

Short-cells, both over and between the veins, mostly solitary and paired. Silica-bodies inconspicuous in some species, but tall, narrow and fitting into concavities in adjacent cork-cells in others. Micro-hairs absent. Stomata with low, dome-shaped subsidiary cells. Vascular bundles: v. few small vb's present, and none conspicuously angular in outline. Mesophyll with chlorenchyma not radiate, or only slightly so. Bundle-sheaths double.

Species Specially Examined

Cortaderia conspicua Stapf[1]

Leaf

Abaxial epidermis (Fig. XXIX, 3)

Short-cells more or less uniformly distributed over and between the veins; mostly solitary, but many paired; abundant; taller than wide, and more or less rectangular; appearing lobed or not lobed in outline according to the focus (Fig. I, 2). **Silica-bodies** inconspicuous. **Macro-hairs** and **micro-hairs**: none seen. **Prickle-hairs**: large prickles at the leaf margins. **Stomata** with low dome-shaped subsidiary cells (Fig. IV, 3). **Long-cells** with thick, pitted or sinuous walls (Fig. V, 1*a–b*).

T.S. lamina

Vascular bundles: most vb's of the basic type (Fig. VIII, 7 and 13), but a few small vb's tending to be as in Fig. VIII, 2; a few of the large vb's with the ph. slightly sclerosed (Fig. VIII, 16). **Adaxial surface** with v. pronounced flat-topped ribs separated from one another by deep, narrow, U-shaped furrows, also 1 specially large median rib (Fig. XIV, 8), and a few similar, but smaller, ribs elsewhere on the lamina. **Sclerenchyma**: a few vb's near the leaf margins each with a well-marked abaxial girder only (Fig. IX, 3); large vb's with wide adaxial and abaxial girders, often more than 40 cells wide and 25 cells high (Fig. IX, 5); most medium-sized vb's each with a narrow, tall-stemmed, T-shaped adaxial girder and an I-shaped abaxial girder (Fig. IX, 9); main keel vb accompanied by scl. of a special type (Fig. IX, 11). Large strands of scl. also present in the leaf margins. **Midrib** conspicuous, consisting of a prominent adaxial rib and rounded abaxial projection; containing 1 main vb (Fig. IX, 11). **Mesophyll**: chlorenchyma not radiate; cells lining the adaxial grooves palisade-like. **Bulliform cells** not specially large, but rather variable in size, and all situated in the adaxial furrows (Fig. XV, 5, *Elymus* type). **Bundle-sheaths** double; large vb's with I.S. complete and O.S. interrupted adaxially and abaxially (Fig. XII, 3*a*); others with I.S. complete to incomplete, O.S. with an adaxial extension usually reaching the adaxial scl.

[1] This name is used in the same sense as in Cheesman's *Manual of the Flora of New Zealand*, 2nd edition.

Culm

Culm examined about 5 mm in diameter exhibiting the following characters. Epidermis subtended by an irregular ring of scl. about 12 cells wide, the scl. being especially well developed around the outer vb's. Scl. ring interrupted at intervals by columns of assimilatory tissue of various sizes and shapes. Inner boundary of the scl. ring not v. clearly defined, but gradually changing over to the larger-celled inner ground tissue. Vb's consisting of about 4 irregular circles embedded in the inner ground tissue in addition to some much smaller strands in the peripheral scl. ring. Centre of the culm occupied by a large cavity.

Material Examined: Cultivated at Kew.

Special Note

The inconspicuous silica-bodies are of the same type as those in *Ammophila* and *Elymus*.

Cortaderia selloana (Schult.) Aschers. & Graebn.

Leaf

Abaxial epidermis (Fig. XXIX, 4)

Short-cells, both over and between the veins, mostly solitary and in pairs; a few of those over the veins in rows of 3–5 cells; abundant. **Short-cells** taller than wide and appearing lobed or not lobed in outline according to the focus (Fig. I, 2). **Silica-bodies** fitting into concavities in adjacent cork-cells (Fig. I, 6–7), some of them being of the tall narrow type (Fig. I, 4); restricted to certain of the short-cells. **Macro-hairs**: short, rigid, thick-walled hairs (Fig. IIA, 10) occasional over the veins; similar but shorter hairs abundant on the apices of the adaxial ribs and in the outer parts of the adaxial furrows. **Micro-hairs**: none seen. **Prickle-hairs**: prickles present at the leaf margins and sometimes between the veins. **Papillae**: absent from the abaxial surface, but numerous, blunt papillae lining the bases of the adaxial furrows. **Stomata** with low dome-shaped subsidiary cells (Fig. IV, 3). **Long-cells**: those over the veins with thick, pitted or sinuous walls (Fig. V, 1*a–b*); those between the veins similar, but with slightly thinner walls.

T.S. lamina

Vascular bundles: a few of the smallest vb's not conspicuously angular in outline and of the type shown in Fig. VIII, 2; most vb's of basic type (Fig. VIII, 12), some of them having the ph. slightly sclerosed (Fig. VIII, 16). **Adaxial surface** with wide, pronounced, rounded ribs of uniform height except at the leaf margins, and narrow, mostly V-shaped furrows (Fig. XIV, 4). Abaxial surface with low rounded ribs and shallow furrows opposite those on the adaxial surface. **Sclerenchyma**: in the form of inversely anchor-shaped girders of a special type (Fig. IX, 10) in most or all of the ribs, part of the stem of the T-, and the greater part of the I-girders (marked with horizontal lines in Fig. IX, 10) consisting of cells with wide lumina, as opposed to the fibrous cells of much smaller diameter represented in the same figure by the

black areas. Scl. extending laterally from the adaxial and abaxial girders in the form of thin, subepidermal plates, interrupted round the bases of the furrows in both of the leaf surfaces. **Keel** conspicuous; rounded; containing 1 large median and 2 slightly smaller lateral vb's (Fig. XIII, 2). **Mesophyll:** chlorenchyma indistinctly radiate to not radiate; cells adjacent to the O.S. tending to be palisade-like. **Bulliform cells** small, situated at the bases of the adaxial furrows (Fig. XV, 5, *Elymus* type). **Bundle-sheaths** double; O.S. with narrow adaxial, and wider abaxial, extensions to the scl., forming girders of a special type (Fig. IX, 10).

Culm

Culm examined about 8 mm in diameter exhibiting the following characters. Epidermis almost wholly subtended by thin-walled assimilatory tissue. Peripheral scl. in the form of a loose, ill-defined ring. Vb's consisting of those of the outermost circle, each strand being embedded in variously shaped masses of scl. forming parts of the loose ring of scl. just described; remaining vb's in 5–6 irregular circles embedded in thin-walled ground tissue extending from the loose scl. ring to the large cavity at the centre of the culm.

Material Examined: Cultivated at Kew.

Special Notes

C. selloana differs from *C. conspicua* in having adaxial ribs of more uniform size; rather different scl. girders; papillae in the grooves, and short rigid hairs on the adaxial ribs; in the more radiate structure of the mesophyll; and in having slight ribs on the abaxial surface.

The leaf structure is festucoid.

CORYNEPHORUS

It has been recorded, Pée-Laby (1898), with special reference to *C. canescens* (L.) Beauv. that the leaf has prominent adaxial ribs, that abaxial stomata are absent, and that bulliform cells are not well developed.

The roots have been examined by Freidenfelt (1904) whose description includes the following information. Roots of first order exhibiting (i) a mucilagenous epidermis of large cells; (ii) numerous root-hairs; (iii) a 4-layered cortex of thin-walled cells and no intercellular spaces; (iv) an endodermis of large cells with U-shaped thickenings; and (v) a relatively large stele, wholly lignified apart from the ph., and including 3–7 vessels, the largest being 18–22 μ in diameter. All tissue external to the endodermis becoming discarded from mature roots. Subsidiary roots, 0·066 mm in diameter, characterized when young by a short-lived cortex of 2–3 layers subsequently forming a crust surrounding the endodermis; central cylinder usually including 2 vessels about 5 μ in diameter and 2–3 that are smaller.

Special Note

Prat (1936) has pointed out that the leaf characters are festucoid.

Literature

Freidenfelt 1904 (root); Grob 1896 (leaf); Pée-Laby 1898 (leaf); Prat 1936 (leaf).

COTTEA

Prat (1936) has stated that this genus should be excluded from the Festuceae because its leaf anatomy is panicoid. Micro-hairs club-shaped or swollen; silica-bodies saddle-shaped. Generally included in the Pappophoreae.

Literature

Prat 1936 (leaf).

CRYPSIS

The few facts that have been recorded about this genus include the following. Leaf epidermis exhibiting swollen micro-hairs similar to those in *Chloris*. Mesophyll with radiate chlorenchyma, but, according to Pée-Laby (1898), not in all spp. Prat (1936) interprets the leaf anatomy as being panicoid. The genus resembles, and is related to, *Sporobolus*.

Literature

Duval-Jouve 1875 (leaf); Grob 1896 (leaf); Pée-Laby 1898 (leaf); Prat 1936 (leaf).

CTENIUM

It is recorded in the literature that the silica-bodies are mostly dumb-bell shaped, but occasionally cross-shaped or nodular, and that micro-hairs are present. The characters thus appear to be panicoid. It is usually placed in the Chlorideae.

Literature

Duval-Jouve 1875 (leaf); Grob 1896 (leaf); Prat 1932 (leaf).

CUTANDIA

Günzel (1921) gives the following information concerning *C. memphitica* (Spreng.) Richt., a sp. which is remarkable because the lamina is narrower than the sheath.

Silica-bodies on the lamina oblong, frequently dumb-bell shaped; those over the veins in the sheath described as small and round. Short-cells in the sheath, and presumably also in the lamina, paired. Lamina with ribs on both surfaces. Sclerenchyma present on the adaxial and abaxial sides of the vb's and at the leaf margins. Mesophyll consisting wholly of chlorenchyma except on the abaxial side of the vb's in the large ribs. Bundle-sheaths double.

Special Note

Prat (1936) regards the leaf characters as festucoid, but this is not supported by the occurrence of dumb-bell shaped silica-bodies. It is doubtful whether the genus should be included in the Festuceae.

Literature

Grob 1896 (leaf); Günzel 1921 (leaf); Prat 1936 (leaf).

CYMBOPOGON

Diagnostic Generic Characters

Short-cells, over the veins, solitary, paired, or in short or long rows, the proportion of each type varying with the sp. Silica-bodies, over the veins, mostly cross to dumb-bell shaped. Micro-hairs present; usually each with the basal cell wider than the distal cell, the latter frequently tapering to a pointed apex, or hemispherical. Stomata with subsidiary cells ranging from low or tall dome-shaped to triangular, the proportions of each type varying in different spp., and sometimes in separate preparations from a single sp. Vascular bundles: small vb's mostly angular, but less conspicuously so in some spp. than in others. Mesophyll with distinctly radiate chlorenchyma. Bundle-sheaths single.

Species Specially Examined

Cymbopogon citratus (DC.) Stapf

Leaf

Adaxial epidermis

Short-cells, over the veins, mostly solitary, sometimes paired, and occasionally in rows of 3–5 cells; rather infrequent over, and v. infrequent between, the veins. **Silica-bodies** mostly intermediate between cross and dumb-bell shaped (Fig. Ia, 17), but some of them more nearly cross-shaped (Fig. Ia, 16). **Prickle-hairs:** prickles (Fig. VI, 1–2) with rather elongated bases, frequent over the veins. **Stomata** infrequent, usually in single rows close beside the veins; mostly with low (Fig. IV, 3) to tall (Fig. IV, 4) dome-shaped, but occasionally with triangular (Fig. IV, 1), subsidiary cells. **Long-cells:** those between the veins mostly relatively short, with thin, non-sinuous or only v. slightly sinuous, walls (Fig. V, 4*a–b*); cells immediately beside the veins longer, with thin, v. slightly sinuous walls (Fig. V, 3*a–c*); interstomatal cells rather long, with slightly sinuous walls and concave ends (Fig. V, 11).

Abaxial epidermis (Fig. XXVII, 4)

Short-cells, over the veins, solitary, paired, and less frequently, in short or long rows; those between the veins mostly solitary and paired; not v. frequent over, and infrequent between, the veins. **Silica-bodies** cross-shaped, but without pronounced arms to the crosses (Fig. Ia, 16), or intermediate between cross and dumb-bell shaped, with shallow indentations (Fig. Ia, 17). **Macro-hairs:** none seen. **Micro-hairs:** length 44–54 (mostly 44–48) μ; basal cell 28–38 (mostly 28–34) μ; distal cell 15–24 (mostly 15–18) μ; basal cell somewhat inflated and much wider than the distal cell, the latter tapering to a pointed apex. (See also under 'Papillae' below.) **Prickle-hairs:** prickles (Fig. VI, 1–2) mostly with rather elongated, swollen bases, v. frequent over the veins. **Papillae:** most long-cells provided with thin-walled papillae (Fig. III, 3). Two-celled papillae, each with a spherical, probably glandular head and a short-stalk cell, visible in T.S.s of the lamina, partly sunk in the epidermis. Similar bodies possibly occurring on the adaxial surface as well. (See also under 'micro-hairs'.) **Stomata** said to be confined to the abaxial surface, abundant; mostly with low (Fig. IV, 3) to tall (Fig. IV, 4) dome-shaped, but occasionally with triangular (Fig. IV, 1), subsidiary cells. **Long-cells** mostly fairly short and more or less rectangular (Fig. V, 3*a–c*), with thin, slightly sinuous walls; interstomatal cells mostly short, with concave ends (Fig. V, 10*a–b*).

T.S. lamina

Vascular bundles: small vb's mostly angular (Fig. VIII, 5), but sometimes tending to be less angular as in Fig. VIII, 2; largest vb's of basic type (Fig. VIII, 10–11). **Adaxial surface** practically smooth (Fig. XIV, 1), apart from slight suggestions of ribs over the large veins. **Sclerenchyma:** small vb's, especially those opposite the bulliform and colourless cells, not accompanied by scl. (Fig. IX, 1); other small vb's also opposite the colourless cells, with minute abaxial strands only; medium-sized vb's with adaxial and abaxial girders about 2–3 cells wide and high (Fig. IX, 4); large vb's with adaxial and abaxial girders up to about 8 cells wide and high (Fig. IX, 5); keel vb's with well-marked abaxial girders only (Fig. IX, 3). **Keel** conspicuous, rounded; containing 1 large median vb and 2 laterals of similar size, together with about 7 smaller laterals, on either side of the median vb (Fig. XIII, 3). **Mesophyll:** chlorenchyma immediately around each vb distinctly radiate. **Bulliform** and **colourless cells:** some, especially those towards the leaf margins, in irregular groups (Fig. XV, 1); adaxial half of the mesophyll consisting of colourless cells (*Chloris* type, Fig. XV, 11) towards the midrib; midrib itself containing a massive adaxial tissue of colourless cells. **Bundle-sheaths:** all small, and some medium-sized, vb's each with a single complete sheath (Fig. XI, 2*a–b*); large vb's with single sheaths of lignified cells interrupted adaxially and abaxially (Fig. XI, 3).

Material Examined: Cultivated at Kew.

Cymbopogon giganteus (Hochst.) Chiov.

Leaf

Abaxial epidermis

Short-cells, over the veins, in rows of 3–5 or more cells; pairs of short-cells occasional over, and abundant between, the veins. **Silica-bodies,** over the veins, mostly cross-shaped (Fig. Ia, 16), and intermediate between cross and dumb-bell shaped (Fig. Ia, 17); those between the veins tall, narrow, rather variable in outline, and sometimes nodular (Fig. Ia, 18 (i)). **Macro-hairs:** none seen. **Micro-hairs:** length 36–48 (mostly 36–42) μ: basal cell 18–28 (mostly 18–24) μ; distal cell 14–18 μ; basal cell somewhat inflated and much wider than the distal cell, the latter tapering to an acutely pointed apex. **Prickle-hairs:** hooks (Fig. VI, 5), mostly rather large and with oval bases, abundant between the veins. **Stomata** with triangular subsidiary cells (Fig. IV, 1). **Long-cells:** those between the veins mostly with thin, sinuous walls (Fig. V, 3*a–c*), some of the cells being a rather short form of this type; interstomatal cells with concave ends (Fig. V, 10*a–b*).

T.S. lamina

Vascular bundles: most vb's small and pentagonal or hexagonal (Fig. VIII, 4), or polygonal (Fig. VIII, 5), in outline; some vb's less angular and resembling Fig. VIII, 2; largest vb's of basic type (Fig. VIII, 10). **Adaxial surface** practically smooth (Fig. XIV, 1), apart from slight suggestions of ribs over the large vb's. **Sclerenchyma:** numerous small vb's, especially some of those opposite the bulliform cells, not accompanied by scl. (Fig. IX, 1); others opposite the bulliform cells with minute abaxial strands only; medium-sized vb's with small adaxial and abaxial girders up to about 4 cells wide and high; largest vb's with similar girders, but up to about 12 cells wide and 4 or 5 cells high (Fig. IX, 5); median keel vb with an incomplete, anchor-shaped girder (Fig. IX, 6); other large keel vb's each with a well-marked abaxial girder only (Fig. IX, 3). **Keel** fairly conspicuous; containing 1 large median vb, accompanied on either side by about 5 much smaller laterals. **Mesophyll:** chlorenchyma round the individual small vb's distinctly radiate. **Bulliform** and **colourless cells:** groups irregular (Fig. XV, 1) throughout most of the lamina; considerable development of adaxial colourless cells towards the midrib (*Chloris* type, Fig. XV, 11); colourless cells also well developed in the midrib itself. **Bundle-sheaths** single; those surrounding all small vb's each with an abaxial interruption only (Fig. XI, 6), the sheaths consisting of cells of rather small diameters.

CULM

Culm examined about 8 mm in diameter exhibiting the following characters. No well-defined ring of scl. subjacent to the epidermis, but cells of the ground tissue gradually increasing in size and in the thinness of the walls, from the epidermis to the practically solid centre of the culm. Scattered bundles present in the ground tissue from the epidermis almost to the centre of the culm, the most peripheral of the vb's being the smallest.

MATERIAL EXAMINED: G. Jackson; Nyasaland.

Cymbopogon martinii (Roxb.) Wats.

LEAF

Abaxial epidermis

Short-cells, between the veins, sometimes solitary, but mostly paired; those over the veins in rows of more than 5 cells; abundant. **Silica-bodies,** over the veins, cross-shaped (Fig. IA, 16), shortly dumb-bell shaped (Fig. IB, 20), dumb-bell shaped, but varying in appearance with the focus (Fig. IB, 21), or occasionally, nodular (Fig. IB, 22 (iii)); those between the veins tall, narrow, crenate (Fig. IB, 24). **Macro-hairs:** none seen. **Micro-hairs:** length 38–51 (mostly 38–42) μ; basal cell 20–30 (mostly 24–30) μ; distal cell 15–24 (mostly 16–22) μ; basal cell wider and more inflated than the distal cell, the latter tapering to an acutely pointed apex. **Prickle-hairs:** none seen apart from a few large prickles over the veins in 1 specimen. **Papillae:** most long-cells with large, thin papillae (Fig. III, 6), more clearly visible in T.S. than in surface preparations, a few, in T.S., seen to be v. slightly stalked, with sunken heads. **Stomata:** a few with triangular (Fig. IV, 1), but mostly with low dome-shaped (Fig. IV, 3), subsidiary cells, the proportion of the 2 types varying in different preparations. **Long-cells** between the veins with thin sinuous walls (Fig. V, 3*a–c*).

T.S. lamina

Vascular bundles: most vb's small, crowded, angular (Fig. VIII, 5); a few large vb's of basic type (Fig. VIII, 15). **Adaxial surface** practically smooth (Fig. XIV, 1). **Sclerenchyma:** small vb's opposite the bulliform cells mostly not accompanied by scl. (Fig. IX, 1), but a few with minute abaxial strands; larger vb's with small adaxial and abaxial strands or girders (Fig. IX, 4) up to about 5 cells wide and seldom more than 2–3 cells high. **Keel** fairly conspicuous; containing 1 large solitary median vb (Fig. XIII, 1), or a reduced form of the multifasciculate type shown in Fig. XIII, 3. **Mesophyll:** chlorenchyma distinctly radiate round each of the small vb's. **Bulliform** and **colourless cells** in irregular groups (Fig. XV, 1) throughout most of the lamina; adaxial half of the mesophyll consisting of colourless cells (*Chloris* type, Fig. XV, 11) in the region of the midrib. **Bundle-sheaths** single; complete around each of the small vb's (Fig. XI, 2*a*); sheaths round the large vb's interrupted abaxially (Fig. XI, 6).

MATERIAL EXAMINED: Cultivated at Kew.

Cymbopogon nardus (L.) Rendle

LEAF

Abaxial epidermis

Short-cells, over the veins, often in rows of 3–5 cells; also solitary and in pairs, both over and between the veins; infrequent over and, except locally, between, the veins. **Silica-bodies,** over the veins, intermediate between cross and dumb-bell shaped (Fig. IA, 17); others dumb-bell shaped, but varying in appearance with the focus (Fig. IB, 21); v. few seen between the veins. **Macro-hairs:** none seen. **Micro-hairs:** length 38–51 (mostly 42–48) μ; basal cell 24–30 μ; distal cell 13–21 μ; basal cell wider and more inflated than the distal cell, the latter tapering to an acutely pointed apex. **Prickle-hairs:** large prickles (Fig. VI, 2) abundant over the veins; hooks (Fig. VI, 5), often long pointed and resembling short macro-hairs, abundant at the margins of the leaf, and between the veins. **Papillae:** large, thin-walled (Fig. III, 6); probably abundant, but rather obscure in the material examined. **Stomata** rather variable; some with triangular (Fig. IV, 1), and others with low (Fig. IV, 3) or tall (Fig. IV, 4) dome-shaped, subsidiary cells. **Long-cells:** those between the veins with thin, sinuous walls (Fig. V, 3*a–c*); interstomatal cells with concave ends (Fig. V, 10*a–b*).

T.S. lamina

Vascular bundles: small vb's numerous, crowded, angular (Fig. VIII, 5); a few large vb's of basic type (Fig. VIII, 10). **Adaxial surface** practically smooth (Fig. XIV, 1), but with slight ribs over the small vb's, and rather larger ribs

over the larger vb's (Fig. XIV, 2). **Sclerenchyma:** most small vb's, opposite the bulliform cells, with minute abaxial strands only or, more rarely, not accompanied by scl. (Fig. IX, 1); medium-sized and large vb's with small adaxial and abaxial girders (Fig. IX, 4), occasionally as much as 8 cells wide, but usually narrower, and seldom more than about 4 cells high. **Keel** scarcely conspicuous, narrow; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma probably distinctly radiate around most of the individual vb's, but rather obscure in the material available. **Bulliform** and **colourless cells** in irregular groups (Fig. XV, 1); colourless cells tending to develop in the adaxial part of the mesophyll, especially near the midrib (Fig. XV, 11). **Bundle-sheaths** single; all small vb's each with a complete sheath (Fig. XI, 2*a*), the sheaths sometimes tending to be winged by the projection into the mesophyll of 1 lateral cell on either side of the sheath; sheaths round the larger vb's interrupted adaxially and abaxially (Fig. XI, 3), and others with wider abaxial interruptions (Fig. XI, 4).

MATERIAL EXAMINED: Ballard 1163; Ceylon.

Cymbopogon validus Stapf

LEAF

Abaxial epidermis

Short-cells, over the veins, in rows of 3–5 or more cells; common over, but infrequent and generally solitary between, the veins. **Silica-bodies,** over the veins, intermediate between cross and dumb-bell shaped (Fig. IA, 17); others shortly dumb-bell shaped (Fig. IB, 20). **Macro-hairs:** none seen. **Micro-hairs:** length 26–60 (mostly 30–48) μ; basal cell 22–50 (mostly 24–36) μ; distal cell 3–10 μ; basal cell much wider and more inflated than the short distal cell, the latter tapering to an acutely pointed apex, or sometimes hemispherical. **Prickle-hairs:** large and small prickles (Fig. VI, 1–2) abundant over the veins, the sizes of the prickles varying with the sizes of the veins. **Stomata:** often with slightly triangular (Fig. IV, 1), but others with low dome-shaped, subsidiary cells (Fig. IV, 3). **Long-cells** between the veins with thin, non-sinuous walls (Fig. V, 4*a–b*); interstomatal cells with concave ends (Fig. V, 10*a–b*).

T.S. lamina

Vascular bundles: most vb's small, angular (Fig. VIII, 5); others of basic type (Fig. VIII, 10). **Adaxial surface** with v. slight ribs over the main veins (Fig. XIV, 2); ribs and furrows more pronounced and regular on the abaxial surface, a rib being present opposite each of the small, as well as of the large, veins. **Sclerenchyma:** a very few small vb's opposite the bulliform cells not accompanied by scl. (Fig. IX, 1); most small vb's opposite the bulliform cells with abaxial scl. only; medium vb's with small adaxial and abaxial girders (Fig. IX, 4) up to about 5 cells wide and high; large vb's with adaxial and abaxial girders up to about 10 cells wide and 5 cells high. **Keel** fairly conspicuous, rounded; containing 1 large median vb, accompanied, on either side, by 1 lateral vb of about the same size, together with about 7 smaller laterals (Fig. XIII, 3). **Mesophyll:** chlorenchyma distinctly radiate round each of the small vb's. **Bulliform** and **colourless cells:** adaxial half of the mesophyll consisting of colourless cells (*Chloris* type, Fig. XV, 11) throughout most of the width of the lamina; bulliform cells in irregular groups (Fig. XV, 1) towards the leaf margins. **Bundle-sheaths** single; all small vb's with 1 complete sheath (Fig. XI, 2*a*); sheaths round the large vb's interrupted abaxially (Fig. XI, 6).

MATERIAL EXAMINED: Williams 26159; S. Rhodesia.

ADDITIONAL INFORMATION FROM THE LITERATURE

Vickery's (1935) description of the leaf structure of *C. refractus* A. Camus (syn. *Andropogon refractus* R. Br.) includes the following information. Leaves 7–30 cm long, but tapering to filiform apices; scabrous downwards and at the margins; prickles occasional, especially beside the ribs on the abaxial surface. Lamina thin; adaxial surface flat; abaxial surface with low ribs over the vb's, the ribs being occupied by strands of fibres. Large vb's accompanied by adaxial and abaxial girders of scl.; small vb's accompanied only by the scl. in the abaxial ribs. Keel conspicuous, the adaxial ground tissue consisting of colourless cells; containing a large median vb, and several smaller vb's on either side. Mesophyll with radiate chlorenchyma. Bundle-sheaths single.

The leaves of *C. bombycinus* Domin. and *C. exaltatus* Domin. have also been described by Vickery, who states that they are similar to those of *C. refractus*. Other descriptions of *C. bombycinus* and *C. refractus* have been given by Breakwell (1914) under the names *Andropogon bombycinus* R. Br. and *A. refractus* R. Br. respectively. The leaves of *C. martinianus* Schult. and *C. bombycinus* are said by Prat (1937) to be similar to those of *C. citratus* (see above).

SPECIAL NOTE

The anatomy confirms Prat's (1936) opinion that the leaf structure is panicoid.

LITERATURE

Breakwell 1914 (leaf); Goosens 1935 (root); Prat 1936, 1937 (leaf); Vickery 1935 (leaf).

CYNODON

DIAGNOSTIC GENERIC CHARACTERS

Short-cells, over the veins, mostly in long rows. Silica-bodies, over the veins, saddle-shaped. Micro-hairs present, rather short, each usually with a hemispherical distal cells, but distal cell sometimes with a pointed apex. Papillae of 2 kinds also present; for details see below. Stomata with triangular, or low dome-shaped, subsidiary cells. Vascular bundles mostly small, crowded, and angular in outline. Mesophyll with distinctly radiate chlorenchyma. Bundle-sheaths double and single.

SPECIES SPECIALLY EXAMINED

As *C. dactylon* is a very widespread grass which varies considerably in habit in different localities, 3 specimens, labelled A, B, and C respectively, have been examined and are described separately below.

A. ***Cynodon dactylon*** **(L.) Pers.**

LEAF

Abaxial epidermis

Short-cells, over the veins, in rows of more than 5 cells; abundant over, but infrequent or absent between, the veins. **Silica-bodies** saddle-shaped (Fig. I, 9). **Macro-hairs:** fairly long, stiff, thick-walled hairs with constricted bases sunken in the epidermis, frequent in the intercostal zones (Fig. II, 3); sometimes with the bases surrounded by specialized epidermal cells. **Micro-hairs:** length 19–24 μ; basal cell 7–10 μ; distal cell 12–15 μ; basal cell somewhat tapering towards its proximal end; distal cell inflated and hemispherical (Fig. VII, 2). (See also under 'papillae' below.) **Prickle-hairs:** prickles (Fig. VI, 1–2) fairly numerous, but widely spaced, over the veins. **Papillae:** numerous oblique papillae with thickened endings present on most of the long-cells, one papilla usually partly overlying each stoma from one side. Also shortly stalked, 2-celled papillae in pits (Fig. IIA, 13). (See also under 'micro-hairs' above.) **Stomata** with triangular (Fig. IV, 1), or low dome-shaped, subsidiary cells (Fig. IV, 3). **Long-cells:** a fairly short form of the type shown in Fig. V, 3*a–c*, with thin, sinuous walls; interstomatal cells with concave ends (Fig. V, 10*a–b*), but with their outlines rather obscured by the papillae overlying the stomata. **Transverse veins** not observed in this specimen.

T.S. lamina

Vascular bundles: most vb's small, crowded, angular (Fig. VIII, 4–5); a few large vb's of basic type (Fig. VIII, 10). **Adaxial surface** with v. slight wide ribs over all vb's, and narrow, shallow furrows (Fig. XIV, 2). **Sclerenchyma:** all, or most, small vb's with adaxial and abaxial girders (Fig. IX, 4) up to about 4 cells wide and 1–2, or occasionally 3, cells high; large vb's with similar girders up to about 9 cells wide (Fig. IX, 5). **Keel** fairly conspicuous, rounded; containing 1 vb (Fig. XIII, 1), or a median vb accompanied on either side by a lateral strand (Fig. XIII, 2). **Mesophyll:** chlorenchyma distinctly radiate round all vb's. **Bulliform cells** in groups resembling the *Sporobolus* type (Fig. XV, 8), but with girder-like extensions to the abaxial epidermis (Fig. XV, 13). **Bundle-sheaths** double and single; large vb's with I.S. complete and O.S. interrupted adaxially and abaxially (Fig. XII, 3*a*); single complete sheaths round all of the small vb's, the sheaths tending to be slightly flattened where in contact with the abaxial scl. or epidermis.

CULM

Culm examined about 2 mm in diameter exhibiting the following characters. Epidermis subtended by a continuous zone of assimilatory tissue, about 8 cells wide, this zone being bounded on its inner side by a scl. ring about 4 cells wide, not v. much lignified. Inner ground tissue consisting of thin-walled cells not much larger than the assimilatory cells, and extending from the inner boundary of the scl. ring to the comparatively narrow cavity at the centre of the culm. Vb's in about 3 irregular circles embedded in the inner ground tissue, a single circle of smaller vb's being present at the outer boundary of the scl. ring, each vb of the outermost circle being bounded on its inner side by a semicircle of specially large thin-walled cells.

RHIZOME

Rhizome examined about 3 mm in diameter exhibiting the following characters. Epidermis and subjacent cortical zone about 8 cells wide. Scl. ring well developed. Vb's consisting of a circle of small strands embedded in, and a second circle at the inner boundary of, the scl. ring. Remaining vb's in 2 further, irregular circles embedded in the thin-walled ground tissue extending from the inner boundary of the scl. ring to the small cavity at the centre of the rhizome.

MATERIAL EXAMINED: Cultivated at Kew.

B. ***Cynodon dactylon*** **(L.) Pers.**

LEAF

Abaxial epidermis

Short-cells, between the veins, mostly solitary; those over the veins occasionally paired, but mostly in rows of more than 5 cells; abundant, both over and between the veins. **Short-cells** between the veins tall and narrow, but seldom containing conspicuous silica-bodies. **Silica-bodies,** over the veins, saddle-shaped (Fig. I, 9). Macro-hairs: none seen. **Micro-hairs:** length 15–22 μ; basal cell 6–9 μ; distal cell 9–16 μ; distal cell inflated, hemispherical, with a rounded apex (Fig. VII, 2) (see also under 'papillae' below). **Prickle-hairs:** none seen; must be v. sparse if present. **Papillae:** small, variously shaped, cuticular warts (Fig. III, 5) abundant over the long-cells. (These papillae are much smaller and unlike those in specimens A and C.) Papillae overarching the stomata absent from the slides examined. Shortly stalked, 2-celled papillae sunken in pits also present (Fig. IIA, 13). (See also under 'micro-hairs' above.) **Stomata:** as in A. **Long-cells** with thin, sinuous walls, or almost as in Fig. V, 6, the cells being shorter and with v. marked sinuations; interstomatal cells very sinuous in outline, and with concave ends (Fig. V, 10*a–b*).

T.S. lamina

Vascular bundles: as A. **Adaxial surface** practically smooth (Fig. XIV, 1), but slight, wide ribs over most veins (Fig. XIV, 2). **Sclerenchyma** as A. **Keel** as A, but rather smaller; containing a solitary vb (Fig. XIII, 1). **Mesophyll** as A. **Bulliform cells** and colourless cells in girders as in Fig. XV, 13. **Bundle-sheaths** double and single; large vb's with O.S. interrupted abaxially only (Fig. XII, 2); small vb's with single sheaths as A, but with abaxial interruptions only (Fig. XI, 6).

CULM

Culm examined about 1 mm in diameter exhibiting the following characters. Epidermis subtended by a continuous zone of scl. 1–2 cells wide, followed by a narrower zone of assimilatory tissue divided into columns by girders of scl. extending from the small outer vb's to the epidermis. Assimilatory tissue

bounded on its inner side by a weak ring of scl., about 2 cells wide. Ground tissue, between the inner boundary of the scl. ring and the very small cavity at the centre of the culm, thin-walled. Vb's consisting of those of the outer circle, each strand being bounded on its outer side by a semicircle of specially large cells; remaining vb's in 2 irregular circles embedded in the thin-walled ground tissue.

MATERIAL EXAMINED: Specially supplied from Mauritius by R. E. Vaughan.

C. *Cynodon dactylon* (L.) Pers.

LEAF

Abaxial epidermis

Short-cells, between the veins, solitary; not v. frequent, but more frequent than in A, and locally abundant; usually tall and narrow in outline, but seldom containing conspicuous silica-bodies. Short-cells over the veins in rows of more than 5 cells; abundant. **Silica-bodies,** over the veins, saddle-shaped (Fig. I, 9). **Macro-hairs:** none of the hairs of type recorded for A observed in this material. **Micro-hairs:** length 15–20 μ; basal cell 6–8 μ; distal cell 10–12 μ; distal cell inflated, hemispherical, with a rounded, or occasionally slightly pointed, apex (Fig. VII, 2). **Prickle-hairs:** prickles (Fig. VI, 1–2) fairly numerous, but widely spaced over some of the veins; angular prickles (Fig. VI, 3) also present at the leaf margins. **Papillae:** oblique papillae with thickened endings (Fig. III, 2) present on the long-cells; 1 conspicuous papilla extending over each stoma from an adjacent interstomatal cell; papillae on other long-cells less numerous and less conspicuous than those in A. (In another slide of material from Dimapur only a very few papillae overlying the stomata were to be seen.) **Stomata** as in A. **Long-cells:** a short form of the type shown in Fig. V, 3*a–c*, with thin, v. sinuous walls; interstomatal cells variable in length with concave ends (Fig. V, 10*a–b*). V. fine **transverse veins,** each consisting of only 1 or 2 files of tracheal elements, fairly frequent.

T.S. lamina

Vascular bundles and **adaxial surface** as in A. **Sclerenchyma:** some small vb's not accompanied by scl. (Fig. IX, 1); others with minute adaxial and abaxial girders as in A (Fig. IX, 4), or with adaxial girders only (Fig. IX, 2); large vb's with adaxial and abaxial girders up to 10 or more cells wide (Fig. IX, 5). **Keel,** keel bundles, and **mesophyll** as for A. **Bulliform cells** mostly in groups of the *Sporobolus* type (Fig. XV, 8), with girder-like extensions of colourless cells traversing the mesophyll, but girders less developed than in A. **Bundle-sheaths** as in A.

MATERIAL EXAMINED: Dimapur, India; per N. L. Bor.

ADDITIONAL INFORMATION FROM THE LITERATURE

The references to *C. dactylon* in the literature in the main agree with the information given above, but some of the published data are less precise. Prat (1934) points out that, when intercostal silica-bodies are present in the leaf, they are irregular in shape.

SPECIAL NOTES

The leaf exhibits mainly panicoid characters, and the short micro-hairs and saddle-shaped silica-bodies suggest affinities with the Chlorideae.

Comparison of the descriptions A–C above indicates that most of the anatomical characters are constant in material from very diverse localities, and that this is so is confirmed by published descriptions. It must be pointed out, however, that the papillae on the abaxial epidermis of the leaf vary considerably in appearance and frequency in different specimens. In some they are large, with thin walls, and well-developed lumina; in others smaller and with thicker walls. The frequency of intercostal short-cells is also very variable. Whether these are varietal, developmental, or ecological variations cannot be decided without further investigation.

LITERATURE

Cocardas 1879; Duval-Jouve 1869, 1870, 1875 (leaf); Goosens 1935 (root); Grob 1896 (leaf); Günzel 1912 (leaf); Pée-Laby 1898 (leaf); Prat 1932, 1934, 1936 (leaf); Roelants 1921 (culm); Wille 1916.

CYNOSURUS

DIAGNOSTIC GENERIC CHARACTERS

Short-cells, over the veins, mostly paired, but occasionally in short rows. Silica-bodies, over the veins, in part fitting into concavities in adjacent cork-cells, but others horizontally elongated, with sinuous outlines. Micro-hairs absent. Stomata with parallel-sided subsidiary cells. Vascular bundles; most vb's small and not conspicuously angular in outline. Mesophyll with chlorenchyma not radiate. Bundle-sheaths double.

SPECIES SPECIALLY EXAMINED

Cynosurus cristatus L.

LEAF

Abaxial epidermis

Short-cells, over the veins, mostly paired, and occasionally in short rows; common over, but infrequent or absent between, the veins. Some **silica-bodies** fitting into concavities in adjacent cork-cells (Fig. I, 6–7); others horizontally elongated, with sinuous outlines (rather a short form of the type in Fig. IA, 14–15). **Macro-hairs** and **micro-hairs:** none seen. **Prickle-hairs:** none seen on the abaxial surface, but occasional prickles recorded at the apices of the adaxial ribs. **Stomata:** subsidiary cells parallel-sided (Fig. IV, 2). **Long-cells:** cells immediately on either side of the veins with thick, pitted, or sinuous walls (Fig. V, 1*a–b*); these elsewhere between the veins with thin, non-sinuous, or slightly sinuous, walls (Fig. V, 2*a–c*); some cells hexagonal.

T.S. lamina

Vascular bundles: most vb's small, and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with moderately tall, rounded ribs separated by fairly wide, V-shaped furrows (Fig. XIV, 3); leaf margin rounded. Abaxial surface also with slight ribs over the veins. **Sclerenchyma:** occasional vb's at the leaf margins not accompanied by scl. (Fig. IX, 1); most small vb's with adaxial and abaxial strands up to about 8 cells wide and 4 cells high, the strands being confined to the apices of the ribs (Fig. IX, 4); large vb's with slightly wider and somewhat taller girders. **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** in fan-shaped groups (Fig. XV, 6) at the bases of the furrows. **Bundle-sheaths** double; small vb's with I.S. complete, and O.S. not quite complete, or at least inconspicuous, abaxially (Fig. XII, 2); a few large vb's with O.S. interrupted abaxially, and connected to the adaxial scl. by large cells (Fig. XII, 4).

Culm

Culm examined about 3 mm in diameter exhibiting the following characters. Scl. ring not very clearly demarcated from adjacent tissues. Small vb's in the outermost circle embedded in the scl. Two irregular circles of vb's embedded in the inner ground tissue extending from the scl. ring to the fairly large cavity at the centre of the culm.

Material Examined: J. K. O'Byrne 132.

Additional Information from the Literature

Information in the literature concerning *C. cristatus* agrees in all essentials with that noted above. Lewton-Brain (1904) indicates that the amount of scl. in the leaf is somewhat variable. Pée-Laby (1898) states that the structure of the basal leaves is essentially similar to that of the cauline leaves, but scl. is less well developed in those that are basal.

In *C. echinatus* L. the adaxial ribs are broad, rounded, and low; the vb's are rather widely separated, and the bundle-sheaths not conspicuous (Lewton-Brain 1904). There is a well-developed mass of colourless cells on the adaxial side of the median vb, and transverse veins occur.

Thoenes (1929) has published a very detailed description of all parts of the plant of *C. cristatus*. Small variations in the structure of the leaves from different positions on the plant are recorded, and the structure of the culm in T.S.s taken at different levels is described and illustrated.

Special Note

The anatomy confirms Prat's (1936) opinion that the leaf structure is festucoid.

Literature

Burr and Turner 1933 (leaf); Duval-Jouve 1875 (leaf); Grob 1896 (leaf); Lewton-Brain 1904 (leaf); Pée-Laby 1898 (leaf); Prat 1936 (leaf); Strecker 1913 (leaf); Thoenes 1929 (whole plant).

CHLORIS

Diagnostic Generic Characters

Short-cells, over the veins, in long rows. Silica-bodies, over the veins, saddle-shaped. Micro-hairs present; usually short and each with a hemispherical distal cell; sometimes each in a slight depression, or difficult to observe amongst adjacent papillae. Stomata mostly with triangular, but sometimes with low dome-shaped, subsidiary cells. Vascular bundles mostly small, crowded, and conspicuously angular in outline. Keel usually conspicuous, and containing 1 to numerous vb's. Mesophyll with chlorenchyma usually radiate, but often inconspicuously so. Bundle-sheaths: generally a mixture of single and double sheaths in each species.

Species Specially Examined

***Chloris barbata* Sw.**

Leaf

Abaxial epidermis

Short-cells, in the intercostal zones, especially those immediately on either side of the veins, mostly paired; those over the veins in rows of more than 5 cells; abundant over, but rather infrequent between, the veins. **Silica-bodies** saddle-shaped (Fig. I, 9); those over the veins being wider than the few in the intercostal zones. **Macro-hairs:** none seen. **Micro-hairs:** difficult to observe in surface view because surrounded by epidermal papillae; mostly spherical and consisting of 1 or 2 cells; diameter 5–10 μ (Fig. VII, 1–2); occasional small hairs as in Fig. VII, 6, with pointed apices, noted over the veins, but easily overlooked and possibly not always present. **Prickle-hairs:** none seen. **Papillae:** rather large, variously shaped, thickened, cuticular warts (Fig. III, 5) abundant on the intercostal long-cells; the number of papillae per cell always restricted, and sometimes as low as 1–2. Papillae showing a blue cross when observed in polarized light between crossed nicols. **Stomata** mostly with triangular subsidiary cells (Fig. IV, 1). **Long-cells:** those between the veins with thin, sinuous walls (Fig. V, 3*a–c*); those in the middle of each intercostal zone nearly isodiametric, with slightly sinuous walls (Fig. V, 7*a–b*); interstomatal cells tending to have concave ends (Fig. V, 10*a–b*), but this character often obscured by the papillae and sinuosities of the cell-walls.

T.S. lamina

Vascular bundles: most vb's small and closely placed, angular (Fig. VIII, 5); a few large vb's of basic type (Fig. VIII, 15). **Adaxial surface** practically smooth (Fig. XIV, 1), but a slight suggestion of ribs and furrows produced by the bulliform cells tending to project above the general level of the epidermis. **Sclerenchyma:** most vb's with small adaxial and abaxial strands (Fig. IX, 4); large vb's with adaxial and abaxial girders up to about 12, or slightly more, cells wide, and 2–4 cells high; occasional vb's with abaxial strands only (converse of Fig. IX, 2), or none (Fig. IX, 1). **Keel** conspicuous, rounded; containing 1 large median vb and about 5 smaller vb's on either

side of it (Fig. XIII, 3). **Mesophyll:** chlorenchyma partly or indistinctly radiate; rather obscure in the material available. **Bulliform cells** sometimes in groups of the *Sporobolus* type (Fig. XV, 9), with an exceptionally large cell in the centre of each group; adaxial part of the mesophyll elsewhere consisting of colourless cells (*Chloris* type, Fig. XV, 11), the alternating bulliform and other colourless cells forming a more or less continuous, colourless tissue on the adaxial side of the mesophyll and midrib. **Bundle-sheaths** single or double; small vb's each with 1 complete sheath (Fig. XI, 2*a–b*), 1 lateral sheath cell on either side of each vb extending into the mesophyll to give a wing-like appearance. Small vb's sometimes with an obscure I.S. as well. Occasional large vb's with I.S. complete and O.S. interrupted adaxially and abaxially (Fig. XII, 3*a*); other vb's with O.S. interrupted abaxially only (Fig. XII, 2).

CULM

Culm examined about 2 mm in diameter exhibiting the following characters. Practically the whole of the transverse area of the culm occupied by thin-walled ground tissue, apart from a v. narrow peripheral ring of small, v. thick-walled cells with v. narrow lumina. Flattened columns of assimilatory tissue embedded in the scl. ring. Each column of assimilatory tissue somewhat striking in appearance because surrounded, or bounded on its inner side, by a ring or arc of specially large cells. Vb's consisting of a circle of small strands embedded in the peripheral scl., and 2–3 irregular circles of larger, but still relatively small, vb's embedded in the thin-walled ground tissue. Centre of culm occupied by spongy tissue.

MATERIAL EXAMINED: Ballard 1495; Ceylon.

***Chloris filiformis* (Vahl) Poir.**

LEAF

Abaxial epidermis

Short-cells, between the veins, solitary or, more rarely, paired; those over the veins in rows of more than 5 cells; abundant over, but infrequent between, the veins. **Silica-bodies** between the veins sometimes tending to be tall and narrow (Fig. I, 4), but many of them narrowly saddle-shaped; those over the veins also saddle-shaped (Fig. I, 9), but less narrow. **Macro-hairs:** none seen. **Micro-hairs:** length 13–21 μ; basal cells 5–9 μ; distal cells 8–12 μ; distal cells hemispherical; basal cells tapering towards their proximal ends (Fig. VII, 2). **Prickle-hairs:** angular prickles at the leaf margins (Fig. VI, 3). **Stomata** sometimes with triangular (Fig. IV, 1), and others with low dome-shaped (Fig. IV, 3) subsidiary cells; outlines rather obscure in the available material. **Long-cells** between the veins, with thin, sinuous walls (Fig. V, 3*a–c*).

T.S. lamina

Vascular bundles: most vb's small, pentagonal to hexagonal (Fig. VIII, 4); a few large vb's of basic type (Fig. VIII, 15). **Adaxial surface** smooth (Fig. XIV, 1), apart from minute grooves to the right and left of the midrib. **Sclerenchyma:** nearly all vb's, apart from the large ones, with no recognizable scl. (Fig. IX, 1) (but see under 'bundle-sheaths' below). Infrequent large vb's

with adaxial and abaxial girders up to about 12 cells wide, and seldom more than about 2 cells high (Fig. IX, 5). **Keel** conspicuous, as an abaxial projection from the V-shaped transverse section; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** radiate chlorenchyma, restricted to the cells on either side of each vb. **Bulliform cells** restricted to 2 closely placed groups above the keel vb, and to 2 similar, but much smaller, groups at the bases of v. shallow furrows to the right and left of the midrib. (Small groups just described are of the *Sporobolus* type (Fig. XV, 9), but with girders of colourless cells extending to the abaxial surface (Fig. XV, 13).) **Bundle-sheaths** single and double; small vb's each with a single sheath with an abaxial interruption (Fig. XI, 6), the interruption being occupied by smaller cells, with appreciably thicker walls than those of the sheath itself. Infrequent large vb's each with the I.S. complete, and O.S. interrupted abaxially and adaxially (Fig. XII, 3*a*), the 2 lateral parts of the O.S. lying more or less vertically between the 2 leaf surfaces.

MATERIAL EXAMINED: Supplied specially from Mauritius by R. E. Vaughan.

***Chloris pycnothrix* Trin.**

LEAF

Abaxial epidermis

Short-cells, between the veins, mostly solitary and paired; those over the veins in rows of more than 5 cells; abundant. Rare **silica-bodies,** between the veins, tall and narrow (Fig. I, 4); those over the veins saddle-shaped (Fig. I, 9). **Macro-hairs:** none seen. **Micro-hairs:** rather difficult to see amongst the epidermal papillae; visible in surface preparations as spherical bodies in shallow depressions in the epidermis, the bodies being 8–11 μ in diameter; T.S.s show each hair to be in a shallow pit, and to consist of a hemispherical-head cell and a short stalk-cell. A foot-cell, embedded in the epidermis, sometimes visible in favourable preparations. **Prickle-hairs:** angular prickles frequent at the leaf margins (Fig. VI, 3). **Papillae** present in two forms; one somewhat oblique and with thickened endings (Fig. III, 2), the other inflated, thin, and somewhat globose (Fig. III, 3); both types abundant on the long-cells. **Stomata** mostly with triangular (Fig. IV, 1), but some with low dome-shaped (Fig. IV, 3) subsidiary cells. **Long-cells:** those between the veins with thin, sinuous walls (Fig. V, 3*a–c*), but rather a short form of this type.

T.S. lamina

Vascular bundles: most vb's small, closely crowded, angular (Fig. VIII, 5); a few large vb's of basic type (Fig. VIII, 15). **Adaxial surface** smooth (Fig. XIV, 1), apart from a groove over the midrib, and a few other v. minor grooves. **Sclerenchyma:** all or most small vb's with adaxial and abaxial girders (Fig. IX, 4) up to about 5 cells wide and mostly 2–3 cells high; others with similar, but slightly wider, girders (Fig. IX, 5). **Keel** conspicuous, narrow and rounded; containing a large median vb accompanied on either side by 2–3 smaller lateral vb's (Fig. XIII, 3). **Mesophyll:** chlorenchyma somewhat radiate. **Bulliform cells** mostly in groups of the *Sporobolus* type (Fig. XV, 8); a longer, somewhat irregular group present in the adaxial furrow over the

midrib. **Midrib** itself consisting chiefly of large colourless cells. **Bundle-sheaths** single and double; all small vb's with single, complete sheaths of v. inflated cells, one of the sheath-cells on either side of each vb extending into the mesophyll and so giving the vb's a winged appearance. Large vb's with I.S. complete and O.S. interrupted abaxially (Fig. XII, 2).

CULM

Culm examined about 2 mm in diameter exhibiting the following characters. Culm slightly flattened or concave on one side. Peripheral scl. ring about 8 cells wide, the cells being of small diameter, with narrow lumina and v. thick walls. Assimilatory tissue distributed rather irregularly amongst the scl., being most abundant on the flattened side of the culm; separated from the scl. by a single layer of specially large cells. Vb's consisting of a circle of v. small strands embedded in the scl. ring, and 2 or 3 irregular circles of larger vb's in the peripheral part of the thin-walled ground tissue extending from the inner side of the scl. ring to the hollow centre of the culm. Central cavity of the culm surrounded by somewhat spongy tissue.

MATERIAL EXAMINED: Collected specially by R. E. Vaughan in Mauritius.

Chloris robusta Stapf

LEAF

Lamina rather rigid, rough to the touch owing to the exceptionally large prickles.

Abaxial epidermis

Short-cells, between the veins, mostly paired; those over the veins in rows of more than 5 cells; abundant. **Silica-bodies,** between the veins, sometimes tall and narrow (Fig. I, 4), but many of them tending to be narrowly saddle-shaped; those over the veins saddle-shaped (Fig. I, 9). **Macro-hairs:** none seen. **Micro-hairs:** length 14–18 μ; basal cell 7–10 μ; distal cell 7–10 μ; hairs spherical (Fig. VII, 2), but with rather narrow bases. **Prickle-hairs:** exceptionally large prickles (Fig. VI, 2) present over the veins; hooks (Fig. VI, 5) fairly numerous in the intercostal zones. **Stomata** mostly with triangular (Fig. IV, 1), but some tending to have low dome-shaped (Fig. IV, 3) subsidiary cells. **Long-cells** mostly with thin, sinuous walls (Fig. V, 3*a–c*), some being rather a short form of this type; interstomatal cells with concave ends (Fig. V, 10*a–b*) and sinuous outlines.

T.S. lamina

Vascular bundles: most vb's fairly small and somewhat angular (Fig. VIII, 6), or resembling a large form of the type in Fig. VIII, 5, but less angular than usual; large vb's of basic type (Fig. VIII, 14–15). **Adaxial surface** with slight ribs and furrows (Fig. XIV, 2) on both surfaces, the ribs and furrows being opposite to each other, the lamina thus appearing to consist of alternating constricted and inflated portions; ribs containing the large vb's projecting slightly more than those containing the small vb's. **Sclerenchyma:** most small vb's with abaxial and adaxial girders (Fig. IX, 4) up to about 6 cells wide and

mostly 1–3 cells high; large vb's with similar, but wider, girders (Fig. IX, 5); some keel vb's with well-marked abaxial girders only (Fig. IX, 3). **Midrib** prominent, flattened adaxially, and more rounded abaxially, the flattened adaxial projection being supported by a subepidermal plate of scl. about 2 cells thick. **Keel** containing 1 large median and 2 smaller lateral vb's on either side. **Mesophyll:** chlorenchyma distinctly radiate. **Bulliform cells** in groups of the *Sporobolus* type (Fig. XV, 8), but with girders of colourless cells extending to the abaxial surface (Fig. XV, 13). **Bundle-sheaths** single and double; all small vb's with single complete sheaths; sheaths round the large vb's conspicuously double, most vb's having 2 complete sheaths (Fig. XII, 1); others with the O.S. not quite complete abaxially (Fig. XII, 2).

MATERIAL EXAMINED: Meikle 736; Nigeria.

Chloris uliginosa Hackel (now in *Eustachys*, see p. 209)

LEAF

Abaxial epidermis

Short-cells, over the veins, mostly in rows of more than 5 cells; abundant over, but infrequent between, the veins, except sometimes immediately beside the veins. **Silica-bodies** saddle-shaped (Fig. I, 9). **Macro-hairs:** none seen. **Micro-hairs** difficult to detect in surface view being obscured by adjacent papillae; length 14–18 μ; basal cells 3–6 μ; distal cells 9–13 μ; spherical (Fig. VII, 2). **Prickle-hairs:** none seen, apart from a few angular, marginal prickles (Fig. VI, 3). **Papillae:** rather large, oblique papillae with thickened endings (Fig. III, 2) abundant on the long-cells, especially in the stomatal zones. **Stomata** mostly with low dome-shaped subsidiary cells (Fig. IV, 3); outlines rather obscured by the adjacent papillae. **Long-cells:** those immediately beside the veins with thin, sinuous walls (Fig. V, 3*a–c*); those in the stomatal zones rather short, with slightly to moderately sinuous walls (Fig. V, 7*a–b*).

T.S. lamina

Vascular bundles: most vb's small, crowded, pentagonal to hexagonal (Fig. VIII, 4); a few large vb's of basic type (Fig. VIII, 14). **Adaxial surface** smooth (Fig. XIV, 1), apart from a groove over the midrib. **Sclerenchyma:** many small vb's accompanied by v. small abaxial girders, and minute adaxial strands (Fig. IX, 4); other small vb's with minute abaxial girders only; large vb's with girders up to about 12 cells wide and only up to about 3 cells high, the adaxial girders being rather remote from the vb's themselves owing to the v. large size of the cells of the bundle-sheaths (Fig. IX, 5). **Keel** made conspicuous by an adaxial groove and a narrow, but prominent, abaxial projection; containing 1 main median vb accompanied on either side by a smaller lateral (Fig. XIII, 2). **Mesophyll:** chlorenchyma indistinctly radiate. **Bulliform and colourless cells:** adaxial half of the mesophyll consisting of colourless cells (Fig. XV, 11). **Bundle-sheaths** single and double; all small vb's with a single complete sheath, the lateral cells of the sheath projecting only slightly into the

mesophyll, and forming only slight wings to the vb's; large vb's with I.S. complete, and O.S. interrupted abaxially, but connected to the adaxial scl. by large cells (Fig. XII, 4).

MATERIAL EXAMINED: Cultivated at Kew.

Chloris virgata Sw.

LEAF

Abaxial epidermis

Short-cells, over the veins, in rows of 3–5 or more cells; v. infrequent between the veins. **Silica-bodies** saddle-shaped (Fig. I, 9). **Macro-hairs:** none seen. **Micro-hairs** apparently unicellular in the material examined, the single spherical cell being 8–11 μ long (Fig. VII, 1). **Prickle-hairs:** prickles (Fig. VI, 2), many of them specially large, abundant over the veins. **Papillae:** oblique papillae with thickened endings (Fig. III, 2) on most of the long-cells. **Stomata** with triangular subsidiary cells (Fig. IV, 1). **Long-cells** with thin, sinuous walls (Fig. V, 3*a–c*); interstomatal cells with concave ends (Fig. V, 10*a–b*) and v. sinuous outlines.

T.S. lamina

Vascular bundles: some of the smallest vb's as in Fig. VIII, 1, with xy. and ph. not easily distinguishable; most small vb's angular (Fig. VIII, 5); a few large vb's of basic type (Fig. VIII, 10). **Adaxial surface** practically smooth (Fig. XIV, 1), apart from v. slight rounded ribs over the large vb's. **Sclerenchyma:** smallest vb's not accompanied by scl. (Fig. IX, 1); most small vb's with small adaxial strands and abaxial girders (Fig. IX, 4); large vb's with wider adaxial and abaxial girders (Fig. IX, 5); a few vb's with small abaxial girders only; most keel bundles with well-marked abaxial girders only (Fig. IX, 3). **Keel** conspicuous, triangular; containing 1 large median vb and numerous smaller laterals (Fig. XIII, 4); supported by an adaxial plate of fibres 1–2 cells thick. **Mesophyll:** chlorenchyma distinctly radiate. **Bulliform** and **colourless cells** in crowded groups of the *Sporobolus* type (Fig. XV, 9), the groups being connected locally to other colourless cells forming the adaxial half of the mesophyll (Fig. XV, 11); most of the midrib occupied by a V-shaped mass of large colourless cells. **Bundle-sheaths** single and double; each small vb surrounded by a single complete sheath (Fig. XI, 2*a*), 1 lateral cell on either side of each vb projecting into the mesophyll to give a winged appearance; large vb's with I.S. complete and O.S. interrupted abaxially (Fig. XII, 2).

CULM

Culm examined about 4 mm in diameter exhibiting the following characters. Culm slightly concave on one side; centre occupied by a small, ill-defined cavity, locally containing spongy tissue. Epidermis subtended by an almost continuous zone of assimilatory tissue, except where traversed by scl. girders extending from each of the vb's in the outermost circle to the epidermis. Scl. ring rather variable in width at different points around the circumference of the culm. Vb's consisting of a circle of small strands embedded in the scl. ring; vb's on the inside of the scl. ring larger and arranged in about 3 rather vague circles, the inner vb's reaching almost to the cavity at the centre of the culm.

MATERIAL EXAMINED: Supplied specially from Nyasaland by G. Jackson.

ADDITIONAL INFORMATION FROM THE LITERATURE

1. LEAF

The leaf of the following spp. of *Chloris* has been described in the literature: *acicularis* Lindl. (Breakwell 1915), *barbata* Sw. (Prat 1932), *cucullata* Bisch. (Prat 1934), *gayana* Kunth (Fisher 1939), *glauca* (Chapm.) Wood (now in *Eustachys*) (Prat 1934), *polystachya* Sw. (Prat 1934), *pycnothrix* Trin. (Fisher 1939), *radiata* Sw. (Duval-Jouve 1875), *submutica* H. B. K. (Duval-Jouve 1875), *verticillata* Nutt. (Prat 1934), *virgata* Sw. (Fisher 1939). In general these spp. exhibit the generic diagnostic characters described above, and the descriptions of the species given above agree quite well with statements in the literature. For the leaf structure of *C. petraea* Swartz see under *Eustachys* on p. 209.

2. CULM

One sp. of *Chloris* with a solid culm recorded by Canfield (1934) from the Jornada Range.

SPECIAL NOTES

The diagnostic characters for the genus, given above, are typically chloridean. In addition the high proportion of colourless cells that occur in the adaxial half of the mesophyll in certain spp. of the genus are noteworthy.

In the small, thin leaf of *C. filiformis* the mesophyll is reduced and not characteristic of the genus.

The micro-hairs of *C. pycnothrix* somewhat recall the sunken hairs of *Neostapfia* (Fig. IIA, 9) (see p. 65).

The bulliform cells of *C. barbata* are similar to those of *Dactyloctenium aegyptium* (L.) Beauv. (see p. 132).

LITERATURE

Breakwell 1915 (leaf); Canfield 1934 (culm); Duval-Jouve 1875 (leaf); Fisher 1939 (leaf and buds); Grob 1896 (leaf); Pée-Laby 1898 (leaf); Prat 1932, 1934, 1936 (leaf).

CHRYSOPOGON

DIAGNOSTIC GENERIC CHARACTERS

Short-cells, over the veins, mostly paired. Silica-bodies, over the veins, cross or dumb-bell shaped. Micro-hairs present in at least 1 sp.; each with the distal cell tapering to a pointed apex. Stomata with triangular subsidiary cells. Vascular bundles: some of the smaller vb's tending to be angular in outline. Mesophyll with radiate chlorenchyma. Bundle-sheaths single.

Species Specially Examined

***Chrysopogon zeylanicus* (Nees ex Steud.) Thw.**

Leaf

Abaxial epidermis

Short-cells mostly paired, both over and between the veins; occasionally in short rows over the veins; abundant. **Silica-bodies** cross-shaped (Fig. Ia, 16); some, especially of those between the veins, rather irregularly cross-shaped. **Macro-hairs:** numerous long hairs, with sunken bases (Fig. II, 3) situated in the intercostal zones. **Micro-hairs:** length 48–64 (mostly 50–60) μ; basal cell 24–30 μ; distal cell 25–36 (mostly 30–36) μ; distal cell tapering to a pointed apex (Fig. VII, 5); rather obscure in the available material. **Prickle-hairs:** prickles (Fig. VI, 1–2) present. **Stomata** with triangular subsidiary cells (Fig. IV, 1). **Long-cells** mostly with thick, pitted or sinuous walls (Fig. V, 1*a–b*); rather a short form of this type.

T.S. lamina

Vascular bundles: certain of the small vb's somewhat angular (Fig. VIII, 5–6), but not conspicuously so owing to the small size of the sheath-cells; large vb's of basic type (Fig. VIII, 10). **Adaxial surface** with slight, rather distant ribs over the primary vb's. **Sclerenchyma:** numerous small vb's not accompanied by scl. (Fig. IX, 1); large vb's with adaxial and abaxial girders up to about 10 cells wide and 5 cells high, keel bundles with well-developed abaxial girders only (Fig. IX, 3). **Keel** conspicuous, triangular (Fig. XIII, 4); containing 1 large median vb and about 7 laterals on either side, all appreciably smaller than the median vb but of various sizes. **Mesophyll:** chlorenchyma distinctly radiate. **Bulliform cells** in irregular groups (Fig. XV, 1) throughout most of the lamina; also 2 or 3 cushion-like groups of cells projecting well above the general level of the surface of the lamina, on either side of the mid-rib. A V-shaped mass of colourless cells forming the ground tissue of the adaxial part of the midrib. **Bundle-sheaths** single; small vb's each with a complete sheath (Fig. XI, 2*a*); sheaths of the large vb's with considerable adaxial and abaxial interruptions (Fig. XI, 4); sheaths to keel bundles with abaxial interruptions only (Fig. XI, 6).

Material Examined: Ballard 1164; Ceylon.

Additional Information from the Literature

C. gryllus Trin.

The epidermis of the European *C. gryllus* Trin. is described by Grob (1896) under *Andropogon gryllus* L. and the T.S. lamina of an Australian sp., also under the name of *C. gryllus*, by Vickery (1935). They note the following characters. *Epidermis.* Short-cells, both over and between the veins, paired. Silica-bodies, over the veins, dumb-bell shaped; those between the veins cross-shaped. Macro-hairs: cushion hairs present amongst the intercostal long-cells and bulliform cells. Papillae present on the abaxial surface. *T.S. lamina.* Surfaces of leaf flat or with slight adaxial ribs over the large vb's. Sclerenchyma weakly developed, but forming small adaxial and abaxial girders with the large vb's; small vb's mostly not accompanied by scl. Midrib often well developed; adaxial ground tissue consisting of colourless cells.

Mesophyll including 'regular' (radiate?) chlorenchyma. Bulliform cells in groups of 3–6 cells; colourless cells sometimes present below the bulliform cells and with the bulliform cells, extending to about half-way across the lamina. Bundle-sheaths single; circular in outline.

C. aciculatus (Retz.) Trin.

Prat (1937) has recorded that, in this sp., only the large vb's are girdered by scl., and that bulliform cells are not clearly developed except for a single group on either side of the midrib.

Special Note

The information now available supports Prat's (1936) opinion that the leaf structure is panicoid.

Literature

Grob 1896 (leaf); Pée-Laby 1898 (leaf); Prat 1936, 1937 (leaf); Vickery 1935 (leaf).

CINNA

This genus has not received much attention from anatomists, although Prat (1936) notes that the leaf structure is festucoid.

Literature

Grob 1896 (leaf); Prat 1936 (leaf).

CLEISTACHNE

Diagnostic Generic Characters

Short-cells, over the veins, in long rows. Silica-bodies, over the veins, mostly dumb-bell shaped, but sometimes nodular. Micro-hairs present; each with the distal cell tapering to a pointed apex. Stomata with triangular subsidiary cells. Vascular bundles: mostly small, crowded, and conspicuously angular in outline. Mesophyll with radiate chlorenchyma. Bundle-sheaths single.

Species Specially Examined

***Cleistachne sorghoides* Benth.**

Leaf

Abaxial epidermis

Short-cells, between the veins, solitary; those over the veins in rows of more than 5 cells; abundant. **Silica-bodies,** over the veins, mostly dumb-bell shaped (Fig. Ia, 18 (ii–iv)), but some nodular (Figs. Ia, 18 (i) or Ib, 22 (iii)). **Macro-hairs:** long hairs, numerous, with sunken bases (Fig. II, 3–4), some being surrounded by specialized epidermal cells (Fig. IIa, 5). **Micro-hairs:** length 45–58 (mostly 48–54) μ; basal cell 15–28 (mostly 18–22) μ; distal cell 30–36 μ; basal cell usually narrowed at the proximal end; distal cell tapering to a pointed apex (Fig. VII, 4). **Prickle-hairs:** numerous angular prickles (Fig. VI,

3) at the leaf margins. **Papillae:** oblique papillae with thickened endings (Fig. III, 2), and others more variable in shape (Fig. III, 3), present on many of the long-cells. **Stomata** with triangular subsidiary cells (Fig. IV, 1). **Long-cells** with thin, sinuous walls (Fig. V, 3*a–c*); interstomatal cells with concave ends (Fig. V, 10*a–b*).

T.S. lamina

Vascular bundles: most vb's crowded, angular (Fig. VIII, 5); large vb's of basic type (Fig. VIII, 10). **Adaxial surface** smooth (Fig. XIV, 1), apart from v. slight ribs over the large vb's, especially towards the midrib. **Sclerenchyma:** most small vb's not accompanied by scl. (Fig. IX, 1); a few vb's with small adaxial and abaxial strands (Fig. IX, 4); large vb's with adaxial and abaxial girders up to about 14 cells wide and 5 or 6 cells high (Fig. IX, 5). **Keel** conspicuous, rounded; containing 5 large, and nearly 20 small vb's (Fig. XIII, 5). **Mesophyll:** chlorenchyma distinctly radiate. **Bulliform cells** in irregular groups (Fig. XV, 1), especially towards the leaf margins; groups towards the midrib consisting of specially large cells (Fig. XV, 3, *Zea* type). A large, adaxial, U-shaped mass of colourless cells present in the midrib. **Bundle-sheaths** single; complete round most of the vb's both large and small; the sheaths round the large vb's consisting of small, relatively thick-walled cells, inflated cells being absent.

Culm

Culm examined about 0·5 cm in diameter exhibiting the following characters. Epidermis subtended by a broad ring of mechanical tissue about 12 cells wide, the cells having fairly thick walls and comparatively wide lumina. Scl. also surrounding the vb's in the outermost circle, the cells having somewhat thicker walls; girders of similar cells also extending from each of the outer vb's to the epidermis. Vb's consisting of those of the outer circle just described, the remaining vb's being widely spaced and scattered in the inner, thin-walled ground tissue. Central ground tissue spongy.

Material Examined: Supplied specially by G. Jackson from Nyasaland.

Special Note

The leaf structure is panicoid.

COELACHNE

Diagnostic Generic Characters

Short-cells, over the veins, in long rows. Silica-bodies, over the veins, cubical and acutely angular in outline. Micro-hairs present; often short, each with a hemispherical distal cell or sometimes unicellular; distal cells in some species tapering to pointed apices. Stomata with subsidiary cells very variable in shape. Vascular bundles: most vb's angular in outline, but sometimes not v. markedly so. Mesophyll with radiate chlorenchyma usually composed of long

narrow cells, i.e. the *Isachne* type. Bundle-sheaths generally single, but some vb's with obscure inner sheaths.

Species Specially Examined

***Coelachne hackelii* Merr.**

Leaf

Abaxial surface

Short-cells, over the veins, in rows of more than 5 cells; common over, but apparently absent between, the veins. **Silica-bodies,** more or less cubical, with v. acutely angled outlines (Fig. I, 11). **Macro-hairs:** none seen on the abaxial surface, but short stiff hairs present on the adaxial ribs. **Micro-hairs:** length 12–16 μ; basal cell 3–5 μ; distal cell 7–11 μ; always spherical in shape and sometimes unicellular (Fig. VII, 1–2), those that are unicellular being 10–12 μ long. **Prickle-hairs:** none seen. **Papillae:** swollen, thin, somewhat globose, oblique papillae (Fig. III, 3) present on the long-cells. Similar papillae also present on the adaxial ribs. **Stomata** v. difficult to see amongst the more or less cubical long cells; with parallel-sided subsidiary cells (Fig. IV, 2). **Long-cells** nearly or quite equi-dimensional, with non-sinuous walls (Fig. V, 8). **Transverse veins** fairly numerous.

T.S. lamina

Vascular bundles: most vb's apparently angular (Fig. VIII, 5), but badly distorted in the available material, confined to the ribs. **Adaxial surface** with pronounced, narrow, rounded ribs and v. much wider furrows (as Fig. XIV, 3 but with wider furrows), the lamina being less than half as thick between as opposite the ribs. **Sclerenchyma:** small vb's near the leaf margins not accompanied by scl. (Fig. IX, 1); most vb's with small adaxial and abaxial strands (Fig. IX, 4), or occasionally with girders, the strands or girders being no more than up to 4 cells wide and about 2 cells high. **Keel** not prominent; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma distinctly radiate, cells probably of the long, narrow, *Isachne* type (Fig. XVIII, 5), but rather distorted in the material available. **Bulliform cells** in groups as in Fig. XV, 2. **Bundle-sheaths** single; complete round all vb's (Fig. XI, 2*a–b*).

Material Examined: Merrill 4338; Philippines.

***Coelachne perpusilla* (Arn. ex Steud.) Thw.**

Leaf

Abaxial epidermis

Short-cells, over the veins, in rows of more than 5 cells; abundant over, but v. infrequent between, the veins. **Silica-bodies,** over the veins, more or less cubical and v. acutely angled (Fig. I, 11). **Macro-hairs:** short rigid hairs on the adaxial ribs, with their bases somewhat sunken and surrounded by papillae. **Micro-hairs:** length 27–42 (mostly 30–38) μ; basal cell 10–17 μ; distal cell 15–26 (mostly 21–24) μ; basal cell sometimes contracted at the proximal end; distal cell generally tapering to a pointed apex (Fig. VII, 4 and 6). **Prickle-hairs:** a few angular prickles at the leaf margins (Fig. VI, 3). **Papillae**

v. numerous on the adaxial surface, especially at the apices of the ribs. **Stomata** v. infrequent on the abaxial surface; with triangular subsidiary cells (Fig. IV, 1). **Long-cells** mostly with thin, sinuous walls, but rather a short form of this type (Fig. V, 3*a–c*); others even shorter, with moderately sinuous walls (Fig. V, 7*a–b*). **Transverse veins** fairly frequent.

T.S. lamina

Vascular bundles confined to the ribs; small vb's pentagonal to hexagonal (Fig. VIII, 4), but mostly as in Fig. VIII, 5, but less markedly angular in outline than is usual for this type; median keel vb as in Fig. VIII, 6. **Adaxial surface** with well-developed, rounded ribs separated from one another by widely V-shaped furrows (Fig. XIV, 3); width of the lamina opposite the furrows less than half the height of the ribs. A v. shallow furrow present on the abaxial surface opposite each vb. **Sclerenchyma :** a few vb's, especially towards the leaf margins, not accompanied by scl. (Fig. IX, 1); others with small adaxial and abaxial girders (Fig. IX, 4), often only 1 or 2 cells wide and high. **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll :** chlorenchyma distinctly radiate; tending to consist of long, narrow, loosely arranged cells as in the *Isachne* type (Fig. XVIII, 5). **Bulliform cells** in well-defined groups as in Fig. XV, 2, at the bases of the furrows. **Bundle-sheaths :** those round the small vb's complete (Fig. XI, 2*a*); those round the large vb's interrupted abaxially (Fig. XI, 6). Some sheaths obscurely double. Sheaths of a few vb's slightly winged by a lateral cell on either side projecting into the mesophyll.

MATERIAL EXAMINED: Ballard 1286; Ceylon.

Coelachne simpliciuscula Munro

LEAF

Abaxial epidermis

Short-cells, over the veins, in rows of more than 5 cells; abundant over, but v. infrequent between, the veins. **Silica-bodies** more or less cubical and v. acutely angled (Fig. I, 11). **Macro-hairs :** a few, short, thick-walled hairs (Fig. IIA, 10) in the intercostal zones. **Micro-hairs :** length 13–17 μ; basal cell 3–6 μ; distal cell 9–13 μ; sometimes apparently unicellular and 7–12 μ long; spherical (Fig. VII, 1–2). **Prickle-hairs :** prickles v. occasional (Fig. VI, 1–2). **Papillae :** abundant, thin, somewhat globose and often oblique papillae (Fig. III, 3) present on the long-cells and adaxial ribs. **Stomata** rather obscure amongst the long-cells; some with triangular (Fig. IV, 1), and others with low dome-shaped (Fig. IV, 3), subsidiary cells, or variable (Fig. IV, 5). **Long-cells** nearly or quite cubical; walls not sinuous (Fig. V, 8). **Transverse veins** fairly numerous.

T.S. lamina

Vascular bundles : small vb's pentagonal to hexagonal (Fig. VIII, 4); others more nearly resembling Fig. VIII, 5 or 6. **Adaxial surface :** ribs tall in relation to the total width of the leaf in T.S.; furrows wide, the thickness of the lamina between the ribs being less than half the height of the ribs (Fig. XIV, 3). **Sclerenchyma :** a few small vb's not accompanied by scl. (Fig. IX, 1); most

vb's with small adaxial and abaxial strands or girders (Fig. IX, 4). **Keel** not prominent; containing a solitary vb (Fig. XIII, 1). **Mesophyll :** chlorenchyma distinctly radiate; consisting of long, narrow cells of the *Isachne* type (Fig. XVIII, 5). **Bulliform cells :** groups as in Fig. XV, 2 in the furrows. **Bundle-sheaths** single; complete round all vb's.

MATERIAL EXAMINED: Gardner, no number; Ceylon.

ADDITIONAL INFORMATION FROM THE LITERATURE

Potztal (1952) has reported on the leaf structure of *C. africana* Pilger, *C. friesiorum* C. E. Hubbard, *C. hackelii* Merrill, and *C. pulchella* R. Br. She regards *C. friesiorum, hackelii,* and *pulchella* as differing in certain respects from *C. africana,* but the characters which she records for *C. hackelii* do not entirely agree with those that have been noted by the author and described on p. 107. For example, Potztal says micro-hairs are absent, and the silica-bodies are described as dumb-bell shaped. A few of the silica-bodies in the Kew material are, it is true, somewhat dumb-bell shaped, but most of them are more nearly cubical and acutely angular in outline. Other features recorded by Potztal for *C. friesiorum, hackelii,* and *pulchella* are (i) short, simple, and longer bristle hairs, each of these last being surrounded at its base by a sheath of specialized epidermal cells, hairs of both types being present over the veins and at the leaf margins; and (ii) small adaxial and abaxial strands of scl. associated, and sometimes forming girders, with the vb's. Other characters recorded by Potztal are similar to those noted at Kew for *C. hackelii* (see p. 107). According to Potztal *C. africana* differs from the other 3 spp. that she examined in the following respects: (i) macro-hairs never provided with basal-sheaths of specialized epidermal cells; (ii) elongated micro-hairs, 2 to several cells long, occurring singly over the vb's; (iii) silica-bodies more often cross than dumb-bell shaped; and (iv) cells of the outer bundle-sheaths thick-walled. Potztal compares *Coelachne* with *Heteranthoecia, Isachne, Limnopoa,* and *Sphaerocaryum.*

SPECIAL NOTE

The leaf structure resembles that of *Isachne* and allied genera.

LITERATURE

Potztal 1952 (leaf).

COELACHYRUM

DIAGNOSTIC GENERIC CHARACTERS

Short-cells, over the veins, in long rows. Silica-bodies, over the veins, mostly saddle shaped. Micro-hairs present; spherical and v. bent. Stomata with triangular and low dome-shaped subsidiary cells. Vascular bundles: most vb's small and angular in outline. Mesophyll: chlorenchyma indistinctly radiate. Bundle-sheaths mostly single, but those round the largest vb's double.

Coelachyrum brevifolium (Hochst.) Nees

LEAF

Abaxial epidermis

Short-cells, over the veins, in rows of more than 6 cells; abundant over, but infrequent or absent between, the veins. **Silica-bodies** mostly saddle-shaped

(Fig. I, 9); a few cross-shaped (Fig. IA, 16), or intermediate between cross and dumb-bell shaped (Fig. IA, 17). **Macro-hairs:** none seen. **Micro-hairs:** too bent in the material examined to allow the basal cell to be measured; distal cell 6–11 μ long; hairs spherical. **Prickle-hairs:** fairly numerous, angular prickles (Fig. VI, 3) at the leaf margins. **Stomata** mostly with low dome-shaped (Fig. IV, 3), and others with triangular (Fig. IV, 1), subsidiary cells. **Long-cells:** those near the veins with thin, sinuous walls (Fig. V, 3*a–c*); those in the stomatal strips relatively short, with thin, non-sinuous walls (Fig. V, 4*a–b*); some interstomatal cells with concave ends, rather long (Fig. V, 11).

T.S. lamina

Vascular bundles: most vb's small, angular (Fig. VIII, 5); large vb's of basic type (Fig. VIII, 9), but these also somewhat angular in outline. **Adaxial surface** with slight, but fairly wide, rounded ribs, and narrower, shallow furrows (Fig. XIV, 2). Abaxial surface also slightly ribbed. **Sclerenchyma:** some of the small vb's not accompanied by scl. (Fig. IX, 1); others with abaxial scl. only (converse of Fig. IX, 2); large vb's accompanied by small adaxial and abaxial strands (Fig. IX, 4). **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma indistinctly radiate; rather obscure in the material available. **Bulliform cells** in fan-shaped groups (Fig. XV, 4), the v. tall central cell in many groups penetrating to about half-way across the mesophyll; some groups more nearly of the *Sporobolus* type (Fig. XV, 8). **Bundle-sheaths:** single complete sheaths round all the bundles except the largest (Fig. XI, 2*a–b*); large vb's with 2 complete sheaths (Fig. XII, 1).

Culm

Culm examined about 1 mm in diameter exhibiting the following characters. Epidermis subtended by a ring of assimilatory tissue partially traversed at intervals by girders of scl., many of the girders being independent of the small vb's of the outer circle. Assimilatory tissue bounded on its inner face by a single layer of large cells, the cells separating the assimilatory tissue from the outer vb's being more conspicuous than the remainder. Assimilatory tissue and subjacent layer of large cells bounded on the inner side by a weak ring of scl. Vb's consisting of those of the outer circle just mentioned, the remainder being in 2–3 rather irregular circles embedded in thin-walled ground tissue between the scl. ring and the large central cavity of the culm.

Material Examined: Trott 1586; Arabia.

Special Note

The leaf exhibits mainly panicoid but some festucoid characters. The structure is, in some respects, similar to that of *Eragrostis*.

Literature

Grob 1896 (leaf).

COIX

Diagnostic Generic Characters

Short-cells, over the veins, in long rows. Silica-bodies, over the veins, intermediate between cross and dumb-bell shaped. Micro-hairs present; balanoform, each having a fairly long distal cell with a broad, rounded apex. Shortly stalked glands, each with a unicellular, spherical head, embedded singly in slight depressions amongst the bulliform cells. Stomata with triangular subsidiary cells. Vascular bundles not angular in outline, or only v. inconspicuously so. Mesophyll with chlorenchyma not radiate. Bundle-sheaths; those round the small vb's single; others doubtful.

Species Specially Examined

***Coix lacryma-jobi* L.**

Leaf

Abaxial epidermis (Fig. XXVI, 4)

Short-cells, between the veins, paired; those over the veins in rows of more than 5 cells; abundant. **Silica-bodies,** between the veins, tall and narrow (Fig. I, 4), tall, narrow, and crenate (Fig. IB, 24), or tall and irregularly cross-shaped (Fig. IA, 16); those over the veins intermediate between cross and dumb-bell shaped (Fig. IA, 17), or shortly dumb-bell shaped (Fig. IB, 20). **Macro-hairs:** none seen on the abaxial surface, but cushion hairs recorded on the adaxial surface amongst the bulliform cells. **Micro-hairs:** length 31–39 (mostly 32–37) μ; basal cell 12–18 μ; distal cell 18–28 μ; balanoform, each with an inflated, hemispherical, or somewhat elongated distal cell with a broad, rounded apex (Fig. VII, 3). **Prickle-hairs:** unpointed prickles (Fig. VI, 6) abundant over the veins. **Stalked glands:** solitary glands common in slight depressions in the epidermis, each consisting of a unicellular, spherical head, and a v. short unicellular stalk, embedded amongst, and almost completely surrounded by, bulliform epidermal cells (cf. glands of *Neostapfia* on p. 65). **Stomata** with triangular subsidiary cells (Fig. IV, 1). **Long-cells** relatively short, with thin, sinuous walls; interstomatal cells with concave ends (Fig. V, 11), but v. long.

T.S. lamina

Vascular bundles: most small vb's not conspicuously angular in outline (Fig. VIII, 2); others rather doubtfully angular (Fig. VIII, 5); a few large vb's of basic type (Fig. VIII, 9). **Adaxial surface** practically smooth, apart from a few v. slight ribs over and near the midrib. **Sclerenchyma:** numerous small vb's not accompanied by scl. (Fig. IX, 1); others with small adaxial and abaxial strands up to about 4 cells wide and 2 cells high; a few large vb's with slightly broader adaxial and abaxial girders (Fig. IX, 5); some keel bundles with well-marked abaxial girders only (Fig. IX, 3). A thin adaxial plate of scl. subjacent to the adaxial epidermis of the midrib. **Keel** conspicuous; containing 1 large median and 2 large lateral vb's, together with 8 or 9 smaller laterals on either side of the median vb. (Fig. XIII, 3). **Mesophyll:** chlorenchyma not

radiate. **Bulliform cells:** groups mostly irregular (Fig. XV, 1), but a regular group of the type in Fig. XV, 2, present on either side of the midrib. Adaxial part of the midrib consisting largely of thin-walled colourless cells. **Bundle-sheaths** single; complete round each of the small vb's (Fig. XI, 2*a*), and possibly the large ones.

Culm

Culm examined 0·5 cm in diameter exhibiting the following characters. Flattened on one side. Epidermis subtended by a single layer of fibrous cells, followed by assimilatory tissue consisting of small cells with thin walls. No scl. ring present apart from the single layer of subepidermal cells. Vb's consisting of a circle of minute strands embedded in the assimilatory tissue; all other vb's larger, and arranged in 3 more or less distinct circles embedded in thin-walled ground tissue. Centre of the culm occupied by a small cavity.

Additional Information from the Literature

Chrysler (1906) has recorded the formation, by fusion, of amphivasal bundles in the culm nodes. The shoot apex has been investigated by Sharman (1947) and a few notes on the root ph. have been recorded by Chauveaud (1897).

Special Notes

The shortly stalked glands on the leaf epidermis recall those of *Cynodon* and *Neostapfia*. The leaf anatomy confirms Prat's opinion that the structure is panicoid, and is consistent with the inclusion of the genus in the Maydeae.

Literature

Chauveaud 1897 (root ph.); Chrysler 1906 (culm); Duval-Jouve 1875 (leaf); Frohnmeyer 1914 (deposition of silica); Grob 1896 (leaf); Prat 1932, 1936 (leaf); Sharman 1947 (shoot apex).

COLEANTHUS

The description of *Coleanthus* given by Kirchner, Loew, and Schröter (1908) includes the following particulars.

C. subtilis (Tratt.) Seidel is a small annual grass that occurs on the mud of dried up ponds, and less frequently on clay river banks. It disappears when the ground becomes submerged.

Leaf

Sheaths closed at the base; those of the culm leaves inflated, the uppermost sheath partly enclosing the inflorescence which flowers and sets seed within its protection. Sheath articulation rudimentary, the sheath merging gradually into the lamina. Ligule well developed but devoid of veins. Lamina somewhat asymmetrical, with weakly developed 'articulating' (bulliform) cells in the adaxial furrows on both sides of the median vb. Epidermis consisting of bladder-like cells with outwardly directed, conical papillae. Silica-bodies and silica-cells absent. Stomata abundant, but more frequent on the adaxial than on the abaxial surface; rather small and level

CYRTOCOCCUM

Diagnostic Generic Characters

Short-cells, over the veins, in long rows. Silica-bodies, over the veins, cross-shaped, or intermediate between cross and dumb-bell shaped. Micro-hairs present; each with the distal cell tapering to a pointed apex. Stomata variable; subsidiary cells often triangular or low dome-shaped. Vascular bundles mostly small and conspicuously angular in outline. Mesophyll with radiate chlorenchyma, consisting of long, narrow cells (*Isachne* type). Bundle-sheaths difficult to determine whether single or double owing to the obscurity of the I.S.

Species Specially Examined

A. *Cyrtococcum trigonum* (Retz.) A. Camus

Leaf

Abaxial epidermis (Fig. XXVII, 2)

Short-cells, over the veins, in rows of more than 5 cells; abundant over, but infrequent between, the veins. **Silica-bodies,** over the veins, cross-shaped (Fig. IA, 16), or intermediate between cross and dumb-bell shaped (Fig. IA, 17). **Macro-hairs:** short, stiff, thick-walled hairs, with swollen, sunken bases (Fig. II, 3–4), sometimes surrounded by specialized epidermal cells, frequent in the intercostal zones. **Micro-hairs:** length 41–50 μ; basal cell 24–27 μ; distal cell 17–27 (mostly 17–22) μ; basal cell wider and more inflated than the distal cell, the latter tapering to an acutely pointed apex (Fig. VII, 9). **Prickle-hairs:** crowded, angular prickles, at the leaf margins (Fig. VI, 3). **Papillae:** typical papillae not observed, but epidermal cells themselves standing up from the surface. **Stomata** variable (Fig. IV, 5), or with slightly triangular (Fig. IV, 1), or low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells** nearly or quite cubical, with slightly to moderately sinuous walls (Fig. V, 7*a–b*). **Transverse veins** fairly frequent.

T.S. lamina

Vascular bundles: a few of the smallest vb's with xy. and ph. not easily distinguishable (Fig. VIII, 1); most vb's small, angular (Fig. VIII, 5); a few large vb's of basic type (Fig. VIII, 10). **Adaxial surface** with low, widely separated ribs over the veins, with a slight depression in the centre of each rib, the ribs being separated from one another by wide, shallow furrows (Fig. XIV, 2). **Sclerenchyma:** a few of the small vb's towards the leaf margins not accompanied by scl. (Fig. IX, 1); most vb's with adaxial and abaxial strands about 2–3 cells wide and high, the strands sometimes forming girders with the outer bundle-sheaths (Fig. IX, 4); largest vb's with rather wider girders. **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma partly radiate, the radiate cells being of the long, narrow type that occur in *Isachne*. **Bulliform cells:** groups mostly as in Fig. XV, 2, but a few tending to be more fan-shaped (Fig. XV, 4). **Bundle-sheaths** single or obscurely double; if regarded as double, both sheaths complete (Fig. XII, 1), and mostly with extensions from the O.S. to the adaxial scl.; if single, similar, but with the I.S. missing (Fig. XI, 2*a–b*).

CULM

Culm examined about 1 mm in diameter exhibiting the following characters. Epidermis subtended by about 3–4 layers of assimilatory cells divided into columns at rather wide, irregular intervals by scl. extending from certain of the vb's in the outermost circle to the epidermis. Scl. ring up to about 8 cells wide, the cells having fairly wide lumina and moderately thick walls. Inner ground tissue consisting of appreciably larger, thin-walled cells, extending from the scl. ring to the hollow centre of the culm. Vb's in 2 more or less distinct circles, and all embedded in the scl. ring itself, or in the ground tissue immediately on the inner side of the scl. ring, the more central ground tissue being mostly free from vb's.

MATERIAL EXAMINED: Cultivated at Kew.

B. *Cyrtococcum trigonum* (Retz.) A. Camus

LEAF

Abaxial epidermis

Short-cells, over the veins, in rows of 3–5 or more cells; common over, but infrequent or absent between, the veins. **Silica-bodies** as in A. **Macro-hairs:** none seen. **Micro-hairs:** length 38–46 μ; basal cell 20–25 μ; distal cell 18–21 μ; distal cell tapering to a pointed apex (Fig. VII, 9). (The differences in the hair measurements from the Kew specimen may be due to the Ceylon specimen having been dried and the cells consequently contracted.) **Prickle-hairs:** small prickles (Fig. VI, 1) present over the veins, but not v. frequent; hooks (Fig. VI, 5) also observed. **Papillae:** swollen, thin, somewhat globose, and mostly somewhat oblique (Fig. III, 3); large, thin papillae (Fig. III, 6) also observed. Whole epidermis appearing densely papillose in T.S. **Stomata** variable (Fig. IV, 5). **Long-cells:** as A, but cells more sinuous in outline (Fig. V, 7*a–b*). **Transverse veins** fairly numerous.

T.S. lamina

Vascular bundles: most vb's small, angular (Fig. VIII, 5); a few large vb's of basic type (Fig. VIII, 15). **Adaxial surface:** ribs fairly tall and wide, the apices being slightly flattened or with a slight depression in the centre of each; furrows fairly wide, but only moderately deep (Fig. XIV, 3). (The more marked contrast between the ribs and furrows in this specimen as compared with A may be partly due to contractions in the dried material.) **Sclerenchyma** as in A. **Keel** fairly conspicuous, owing to the combination of an abaxial extension and a low adaxial rib over the median vb; containing 1 large median vb accompanied immediately on either side by a small lateral (Fig. XIII, 2). **Mesophyll:** chlorenchyma distinctly radiate, the radiate cells being of the long, narrow type as in *Isachne*. **Bulliform cells** as in A. **Colourless cells** well developed in the midrib. **Bundle-sheaths** as in A.

CULM

On the whole not unlike A, but mechanical tissue more fully developed below the epidermis.

MATERIAL EXAMINED: Ballard 1427; Ceylon.

SPECIAL NOTE

The leaf structure is mainly panicoid, and some characters such as those of the mesophyll recall *Isachne* and allied genera.

DACTYLIS

1. LEAF

The following notes on the lamina in T.S. are based on information in the literature, and they all refer to *D. glomerata* L. Adaxial surface almost ribless, or with slight, wide, rounded ribs on both surfaces. Sclerenchyma forming adaxial and abaxial girders to the large vb's, and present, usually as strands, above and/or below the small vb's. Scl. also present in the leaf margins and well developed in the apex of the keel. Prickle-hairs: prickles occasional, mostly at the leaf margins. Keel conspicuous, somewhat narrow but rounded at its apex, and with a median groove in the adaxial surface; containing a single median vb. Mesophyll with chlorenchyma not radiate; colourless cells sometimes well developed between the vb's, especially in the lower leaves. Large intercellular spaces arising between the bundles at the base of the lamina, especially in the lower leaves. Bulliform cells present as a single, conspicuous group above the median vb. Bundle-sheaths double. Transverse veins present.

2. CULM

Roelants (1921) records that small girders of scl. occur opposite the small vb's.

3. ROOT

In discussing the morphology and anatomy of the root and root system of *D. glomerata*, Kokkonen (1931) distinguishes between germinal, nutrient, nutrient prop, and prop roots. The number of large metaxylem vessels in an individual root decreases from the base of the root to its apex. The diameters of the large vessels in prop roots decrease greatly from the bases of the individual roots to their apices, which the author takes to be an indication that water enters these roots from the body of the plant rather than from the soil.

INFLUENCE OF POTASSIUM SALTS ON STRUCTURE

D. glomerata was grown by Purvis (1919) on plots treated with different mineral fertilizers. The thickness of the cell-wall and the diameters of the lumina were measured, and the ratio of the lumina to the walls then determined. This was done for elements of the scl. and metaxylem respectively. During the early stages, application of potassic fertilizers caused the walls of the scl. to become thinner, but this effect gradually disappeared during the season. The application of potassium salts, without nitrogen, caused the lumina to become wider, but this effect was reversed in the presence of ammonium salts. The thickness of the walls of the xy. elements was not affected by potassic fertilizers alone. Potassium salts without nitrogen caused the lumina to become narrower, but when applied at the same time as ammonium salts the diameters increased. The addition of potassium salts increased the ratio of the lumen to wall, but the effect was not permanent. From these facts it was concluded that potassic fertilizers may cause some initial weakening of the mechanical cells. The rigidity of the plants treated with potassic fertilizers must be due to the influence of these salts on the 'physiological condition' or 'chemical composition' of the plant.

Taxonomic Note

Prat (1932, 1936) rightly indicates that the leaf anatomy is festucoid. In Prat's opinion the characters indicate affinities with the Hordeae.

Literature

Burr and Turner 1933 (leaf); Bugnon 1921 (developmental anatomy); Deinega 1898 (developmental anatomy); Duval-Jouve 1870, 1875 (leaf); Grob 1896 (leaf); Kokkonen 1931 (roots); Lewton-Brain 1904 (leaf); Pée-Laby 1898 (leaf); Prat 1932, 1936 (leaf); Purvis 1919 (influence of potassium on structure); Roelants 1921 (culm); Sharman 1947 (developmental anatomy); Strecker 1913 (leaf).

DACTYLOCTENIUM

Diagnostic Generic Characters

Short-cells, over the veins, mostly in long rows. Silica-bodies, over the veins, mostly saddle-shaped. Micro-hairs present; spherical and apparently unicellular. Stomata: outlines often obscured by overlying papillae. Vascular bundles mostly small and acutely angular in outline. Keel often conspicuous, rounded, containing 1 large median and smaller lateral vb's. Mesophyll with radiate or inconspicuously radiate chlorenchyma. Bundle-sheaths double and single.

Species Specially Examined

***Dactyloctenium aegyptium* (L.) Beauv.**

Leaf

Abaxial epidermis

Short-cells, over the veins, mostly in rows of more than 5 cells; abundant over, but v. infrequent or absent between, the veins. **Silica-bodies,** over the veins, saddle-shaped (Fig. I, 9). **Macro-hairs:** long hairs, with swollen, sunken, constricted bases (Fig. II, 3), sometimes surrounded by specialized epidermal cells, frequent in the intercostal zones (see also p. 134 below). **Micro-hairs:** spherical and apparently unicellular (Fig. VII, 1); 13–16 μ in diameter. **Prickle-hairs:** none seen. **Papillae:** v. large, oblique papillae with thickened endings (Fig. III, 2) abundant, some of them tending to overarch the stomata. **Stomata** probably mostly with low dome-shaped subsidiary cells (Fig. IV, 3), but outlines sometimes obscured by overarching papillae. **Long-cells:** relatively short, with thin, non-sinuous or v. slightly sinuous, walls; as in Fig. V, 2*a–c* and 3*a–c*, but rather short and obscured by papillae; interstomatal cells with concave ends (Fig. V, 10*a–b*). Fine **transverse veins** frequent.

T.S. lamina

Vascular bundles: most vb's small and angular (Fig. VIII, 5); a few large vb's of basic type (Fig. VIII, 10). **Adaxial surface** practically smooth (Fig. XIV, 1), apart from a v. few, low ribs towards the leaf margins (Fig. XIV, 2). **Sclerenchyma:** a few small vb's not accompanied by scl. (Fig. IX, 1); most small vb's with minute abaxial strands or girders only; large vb's with adaxial and abaxial girders up to about 12 cells wide and seldom more than about 2 cells high (Fig. IX, 4); median keel vb with an incomplete, anchor-shaped girder (Fig. IX, 6). **Keel** conspicuous, rounded; containing 1 large median vb and about 3 small laterals on either side (Fig. XIII, 3). **Mesophyll:** chlorenchyma indistinctly radiate around the small vb's, but the radiate structure probably less obscure in better-preserved material. **Bulliform** and **colourless cells:** in groups of the *Sporobolus* type (Fig. XV, 9), especially towards the leaf margins; adaxial half of the mesophyll, especially towards the midrib, consisting of colourless cells (*Chloris* type, Fig. XV, 11). Adaxial part of the midrib also made up of very large, colourless cells. **Bundle-sheaths:** large vb's probably all with 2 complete sheaths (Fig. XII, 1); most, or all, small vb's each with a single complete sheath (Fig. XI, 2*a*), the sheaths appearing to be winged, owing to 1 lateral sheath cell on either side of the vb penetrating deeply into the mesophyll.

Culm

Culm examined about 2 mm in diameter exhibiting the following characters. Flattened on 1 side. Epidermis subtended by a small, somewhat broken ring of about 1 layer of scl. cells of v. small diameter round most of the circumference of the culm. Flattened columns of assimilatory tissue, separated from one another by scl. girders, extending from each vb of the outermost circle to the epidermis. Assimilatory tissue bounded on its inner side by a circle of 1–2 layers of mechanical cells of wider diameter than those subjacent to the epidermis. Culm practically solid, the centre being occupied by v. thin-walled spongy tissue, with 2 circles of vb's embedded in it, not far from the inside of the scl. ring. No vb's towards the centre of the culm.

Material Examined: Specially supplied from Mauritius by R. E. Vaughan; Ballard 1479; Ceylon.

***Dactyloctenium giganteum* Fisher & Schweickerdt**

Leaf

Abaxial epidermis

Short-cells, over the veins, mostly in rows of more than 5 cells; abundant over, but often infrequent between, the veins; solitary short-cells with an irregular, sometimes cruciform, outline abundant in other intercostal zones. **Silica-bodies,** over the veins, mostly saddle-shaped (Fig. I, 9); others over the veins oblong (Fig. I, 10). **Macro-hairs:** none seen. **Micro-hairs** spherical and apparently unicellular (Fig. VII, 1); 13–17 μ in diameter. **Prickle-hairs:** none seen, but stated by Fisher and Schweickerdt (1941) to be occasional on both surfaces (see p. 134 below). **Papillae:** v. large, swollen, thin papillae, somewhat globose and mostly somewhat oblique (Fig. III, 6), abundant in many of the intercostal zones. Others shortly stalked, 2-celled, sunken in pits (Fig. IIA, 13) (see also 'micro-hairs' above). **Stomata** sometimes with slightly triangular (Fig. IV, 1), but others with low dome-shaped (Fig. IV, 3) subsidiary cells; outlines tending to be obscured by papillae. **Long-cells** relatively short, with thin, non-sinuous walls (Fig. V, 4*a–b*); a few cells nearly or quite cubical, with slightly to moderately sinuous walls (Fig. V, 7*a–b*).

T.S. lamina

Vascular bundles: most vb's small, crowded, angular (Fig. VIII, 5); a few large vb's of basic type (Fig. VIII, 10). **Adaxial surface** practically smooth (Fig. XIV, 1). **Sclerenchyma:** a few small vb's not accompanied by scl. (Fig. IX, 1); most small vb's with minute abaxial strands or girders only; large vb's with adaxial and abaxial girders up to about 8 cells wide and 4 cells high (Fig. IX, 5); keel vb's with well-marked abaxial girders (Fig. IX, 3); small scl. strands also present beneath the adaxial epidermis of the midrib. **Keel** conspicuous, rounded; containing 1 large median vb and about 5 smaller laterals on either side (Fig. XIII, 3). **Mesophyll:** chlorenchyma distinctly radiate round all vb's. **Bulliform** and **colourless cells** in groups of the *Sporobolus* type (Fig. XV, 9), the groups being united to one another by other colourless cells; adaxial half of the mesophyll and midrib consisting of colourless cells (Fig. XV, 11). **Bundle-sheaths** double and single; large vb's with I.S. complete, but O.S. interrupted abaxially, and connected to the adaxial scl. by large cells (Fig. XII, 4); the O.S. around some vb's complete, and with an adaxial extension. A single complete sheath (Fig. XI, 2*a*) present round each of the small vb's, the sheaths appearing to be winged owing to the development of a large lateral sheath cell on either side of the vb, these cells extending into the mesophyll.

Culm

Culm examined about 3 mm in diameter exhibiting the following characters. Slightly flattened on 1 side. Epidermis subtended by a continuous layer of scl., 1 cell wide, the cells being of small diameter. Scl. ring followed by an almost continuous layer of assimilatory cells about 2–3 cells wide, traversed very occasionally by scl. girders from the vb's of the outermost circle to the epidermis. Assimilatory tissue bounded internally by a second scl. ring about 3–4 cells wide, with the small vb's of the outermost circle embedded in it. Thin-walled ground tissue extending from the inner boundary of the inner scl. ring to the hollow cavity at the centre of the culm, with 2–3 circles of vb's embedded in it.

Material Examined: G. Jackson; Nyasaland.

Additional Information from the Literature

On the whole the statements in the literature agree with the original observations recorded above. Some investigators do not, however, appear to have noted the occurrence of micro-hairs, or they may have confused them with papillae. The most recent anatomical study of *Dactyloctenium* which has come to notice is that by Fisher and Schweickerdt (1941), who examined 4 spp. from S. Africa, *D. aegyptium* (L.) Beauv., *D. giganteum* Fisher & Schweickerdt, *D. geminatum* Hack., and *D. australe* Steud. Their descriptions of the annual spp. *D. aegyptium* and *giganteum* agree closely with the original descriptions given above, and it is stated that these 2 spp. cannot readily be distinguished from one another by anatomical characters alone. In these 2 spp. macro-hairs with bulbous bases occur particularly on the leaf margins and keel, and the leaf margin is described as tapering to an obtuse tip sometimes crowned by groups of cells arranged fanwise and forming a cushion around the base of a hair. The mesophyll in these and other spp. is described as having irregular

chlorenchyma, but, judging from Fisher and Schweickerdt's illustrations, the chlorenchyma may well be of the type that the present writer has described as indistinctly radiate. The perennial sp. *D. geminatum* is said to be characterized by (i) absence of prickle-hairs; (ii) lack of typical bulliform cells except for a group on either side of the midrib; and (iii) scl. in the keel, above the median vb, as adaxial and abaxial strands (not girders) to the large vb's, and as smaller strands associated with some of the small vb's. *D. australe* Steud., the second perennial sp. examined by Fisher and Schweickerdt, has abaxial papillae that are smaller than those of the other spp.; occasional prickle-hairs, and macro-hairs with swollen bases, occur on both leaf surfaces; scl. is present in the keel, over the median vb, as adaxial strands to the small vb's, and sometimes as girders to the large vb's. Fisher and Schweickerdt state that the starch grains in the caryopses are compound.

Fisher and Schweickerdt do not refer to earlier work on the anatomy of *Dactyloctenium*, although some of the literature mentions details that they themselves appear to have overlooked.

Sabnis (1921), referring to the leaf structure of *Dactyloctenium scindicum* Boiss. (under *Eleusine aristata* Ehrenb.) from the ecological standpoint, notes the following characters. Surface not grooved. Scl. forming adaxial and abaxial girders with the large vb's; small vb's accompanied by adaxial strands and slight abaxial girders. Macro-hairs present; short and bluntly pointed. Mesophyll with radiate chlorenchyma. Bulliform cells in groups of the *Sporobolus* type (Fig. XV, 8), each group being united to the abaxial epidermis by a girder of colourless cells (Fig. XV, 13).

Special Note

Prat (1932, 1934, 1936) has rightly emphasized that the leaf structure of *Dactyloctenium* resembles that of *Chloris* and *Cynodon*.

Literature

Fisher and Schweickerdt 1941 (leaf); Grob 1896 (leaf); Günzel 1912 (leaf); Prat 1932, 1934, 1936 (leaf); Sabnis 1921 (leaf, ecological anatomy; under *Eleusine aristata*).

DANTHONIA

Diagnostic Generic Characters

Short-cells and silica-bodies more variable than usual in a single genus. Short-cells, over the veins, commonly in short or long rows, but, in some spp., solitary and paired, at least in part. Silica-bodies, between the veins, very variable in shape; those over the veins commonly varying from cross to dumb-bell shaped, but, in some spp., saddle-shaped, cuboid, and slightly oblong types occur. Micro-hairs present in some spp., particularly those with cross-shaped to dumb-bell shaped silica-bodies over the veins; when present, each usually with a distal cell tapering to a bluntly or acutely pointed apex. Stomata absent from the abaxial surface in some spp.,[1] but, when present, with low to tall dome-shaped or triangular subsidiary cells. Vascular bundles mostly small and not conspicuously angular in outline. Mesophyll; chlorenchyma not radiate. Bundle-sheaths double.

[1] H. J. Conert (verbal communication) says all spp. of *D.* without abaxial stomata have adaxial ribs, stomata, and micro-hairs.

Species Specially Examined

***Danthonia australis* Buch.**

Leaf

Abaxial epidermis

Short-cells, over the veins, in long rows; those between the veins mostly solitary, but occasionally paired; solitary short-cells between the veins tall and narrow, silicified, but without well-defined silica-bodies. **Silica-bodies,** over the veins, mostly oblong (Fig. I, 8*b* and *c*) to circular and occasionally cubical; rare between the veins. **Micro-hairs:** none seen. **Stomata** absent from the abaxial surface.

T.S. lamina

Blade strongly infolded; with 10 adaxial ribs in addition to the midrib. Abaxial surface smooth.

Material Examined: Prof. A. Wall, May 1939; New Zealand. Slides prepared by J. K. O'Byrne.

***Danthonia bromoides* Hook. f.**

Leaf

Abaxial epidermis

Short-cells, both over and between the veins, mostly solitary, but occasionally paired. Solitary short-cells silicified, but not containing well-defined silica-bodies, mostly taller than wide, but sometimes tending to be cubical, with somewhat sinuous outlines. **Silica-bodies,** between the veins, rare, confined to the more distal members of each pair of short-cells; elliptical with the long axis vertical, crescent-shaped, rounded or oblong; fitting into concavities in contiguous cork-cells. **Micro-hairs** absent. **Stomata** infrequent; subsidiary cells mostly triangular, but sometimes low dome-shaped.

T.S. lamina

Blade not infolded. **Adaxial surface** with about 26 marked ribs of unequal sizes, separated from one another by deep, narrow furrows; furrows sometimes W-shaped, the centre of the W consisting of a short, narrow rib between 2 large ones. Adaxial surface densely papillose.

Material Examined: Type specimen: W. Stephenson 1843–4; New Zealand. Cheesman 2/74; New Zealand. Slides prepared by J. K. O'Byrne.

***Danthonia buchanani* Hook. f.**

Leaf

Abaxial epidermis

Short-cells, over the veins, mostly in long rows, but appearing to be paired, solitary, or in short rows where separated by relatively long cells in the same files; intercostal short-cells mostly paired. **Silica-bodies** abundant, both over and between the veins; those over the veins mostly dumb-bell shaped, but

with the middle portion of each body not much narrower than the rounded ends; occasionally cross-shaped, cubical, rounded, or nodular. Silica-bodies between the veins tall, narrow, and markedly crescent-shaped; fitting into concavities in contiguous cork-cells. **Micro-hairs** present in the intercostal zones, but infrequent, and structure not well preserved in the available material. **Stomata** fairly frequent; with low dome-shaped to triangular subsidiary cells.

T.S. lamina

Blade somewhat U-shaped in T.S. **Adaxial surface** with about 7 low, rounded ribs, separated from one another by shallow, V-shaped furrows. Abaxial surface practically smooth.

Material Examined: D. Petrie; New Zealand. Slides prepared by J. K. O'Byrne.

***Danthonia calycina* (Vill.) Reichb.**

Leaf

Abaxial epidermis

Short-cells, over the veins, in long rows; those between the veins mostly paired or occasionally solitary. Solitary short-cells between the veins mostly cubical and, although silicified, seldom containing well-defined silica-bodies. **Silica-bodies,** over the veins, mostly dumb-bell shaped, often with the middle portion of each body much narrower than the rounded ends; rarely nodular, or tending to be nodular. Silica-bodies in the more distal member of each pair of intercostal short-cells mostly somewhat crescent-shaped (de Thaisz 1900 and v. Degen 1887), or variable in shape and ranging from elliptical with the long axis vertical, through crescent-shaped to cross-shaped. **Micro-hairs** numerous between the veins; resembling those in Fig. VII, 5–6. **Stomata:** none seen on the abaxial surface.

T.S. lamina

Leaf not inrolled; with about 12–15 low, rounded, adaxial ribs, separated from one another by narrow, shallow furrows. Abaxial surface with less pronounced ribs, or almost smooth. **Keel** not more than moderately conspicuous.

Material Examined: A. v. Degen 1887; Hungary. L. de Thaisz 10.6.1900; Hungary. Ferd. Weber 26.6.1932; Moravia. Slides prepared by J. K. O'Byrne.

***Danthonia compressa* Austin**

Leaf

Abaxial epidermis

Short-cells between, and many of those over, the veins, solitary and paired; others, over the veins, in rows of up to 5 or more cells; abundant. **Silica-bodies** sometimes tall and narrow (Fig. I, 4); others intermediate between cross and dumb-bell shaped (Fig. Ia, 17). **Macro-hairs:** rather sparse, short, rigid, thick-walled hairs (Fig. IIa, 10) visible, in T.S., on the adaxial surface. **Micro-hairs** present; length 67–78 (mostly 70–75) μ; basal cell 36–54 (mostly 36–

42) μ; distal cell 22–42 (mostly 26–36) μ; basal cell tapering towards its proximal end; distal cell tapering to a rounded or acutely pointed apex (Fig. VII, 9 or tending to Fig. VII, 5). **Prickle-hairs:** prickles (Fig. VI, 1–2) present over some, but by no means all, of the veins. **Stomata** absent from the abaxial surface. **Long-cells** with thin, sinuous walls (Fig. V, 3*a–c*); many of them tending to be hexagonal.

T.S. lamina

Vascular bundles not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 13). **Adaxial surface** with low but wide ribs, with slightly rounded apices and a small depression in the apex of each rib, separated by shallow, V-shaped, widely spaced furrows (Fig. XIV, 2). **Sclerenchyma:** small vb's with adaxial and abaxial girders up to about 5 cells high and not more than 2 cells wide (Fig. IX, 7), but other girders up to about 6 cells wide, the abaxial girders tending to be triangular, with their bases resting on the abaxial epidermis. Large vb's with wider adaxial and abaxial girders (Fig. IX, 5). Median keel bundle with the combined girders somewhat anchor-shaped (Fig. IX, 6). Marginal vb's not accompanied by scl. (Fig. IX, 1). **Keel** fairly conspicuous, rounded; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** as fan-shaped groups at the bases of the furrows (Fig. XV, 6). **Bundle-sheaths** double; a few small vb's with 2 complete sheaths (Fig. XII, 1); all other vb's with I.S. complete, but O.S. interrupted adaxially and abaxially (Fig. XII, 3*a–b*).

MATERIAL EXAMINED: Cultivated at Kew.

***Danthonia crassiuscula* Kirk**

LEAF

Abaxial epidermis

Costal and intercostal zones not clearly distinguished from one another. **Short-cells** and **silica-bodies** v. similar to those of *D. teretifolia* (see p. 144). **Micro-hairs** and **stomata** absent.

T.S. lamina

Blade widely V-shaped in T.S. **Adaxial surface** with about 24 well-marked ribs, mostly uniform in height but varying somewhat in width, the median rib being shorter than most of the others. Ribs separated from one another by deep, narrow grooves. Apices and sides of the ribs covered with rather large papillae, almost resembling short, stiff macro-hairs.

MATERIAL EXAMINED: W. R. B. Oliver 17.1.1928; New Zealand. Slides prepared by J. K. O'Byrne.

***Danthonia cunninghamii* Hook. f.**

LEAF

Abaxial epidermis

Short-cells, both over and between the veins, solitary or paired; those over the veins occasionally in short rows; solitary short-cells between the veins

silicified, but not containing clearly defined silica-bodies, and mostly cubical or with the vertical walls slightly concave (saddle-shaped). **Silica-bodies** between the veins rare in some specimens (W. E. Evans 1937), and confined to the more distal members of paired short-cells; rounded to elliptical with the long axis vertical, or often crescent-shaped. Silica-bodies over the veins also varying from elliptical with the long axis vertical to crescent-shaped, or sometimes rounded, or rarely oblong (Stapf 1930); others tending to be cross-shaped but with v. shallow indentations between the arms (Colenso 607, 1847). **Micro-hairs:** none seen. **Stomata** infrequent on, or absent from, the abaxial surface; when present, with low dome-shaped subsidiary cells.

T.S. lamina

Blade not inrolled; with numerous (sometimes as many as 80) adaxial ribs of unequal sizes, separated from one another by narrow furrows; apices of the ribs densely papillose. Occasional, long, stiff macro-hairs, with sunken, constricted bases, noted on the apices of the ribs of certain specimens (Colenso 607). **Keel** well developed.

MATERIAL EXAMINED: Colenso 607, 1847; New Zealand. O. Stapf 1930; Cult. Ireland, Lord Headfort. W. E. Evans. Coll. 1937; Roy. Bot. Gard. Edinburgh. Slides prepared by J. K. O'Byrne.

***Danthonia decumbens* (L.) DC.**

See *Sieglingia decumbens*, on p. 450.

***Danthonia flavescens* Hook. f.**

LEAF

Abaxial epidermis

Short-cells, both over and between the veins, mostly solitary and paired; occasionally in rows of 3–5 cells; abundant. **Silica-bodies,** as distinct from short-cells, infrequent or inconspicuous, some tall and narrow (Fig. I, 4); others tending to be saddle-shaped (Fig. I, 9), oblong (Fig. I, 10), or almost cuboid but rounded at the corners. **Macro-hairs:** none seen. **Micro-hairs:** none seen on the abaxial surface. **Prickle-hairs:** prickles (Fig. VI, 1–2) present, but v. sparse. **Papillae:** none seen on the abaxial surface, but adaxial ribs and furrows densely covered with small spherical papillae. **Stomata** v. infrequent; with low (Fig. IV, 3), or tall (Fig. IV, 4), dome-shaped subsidiary cells. **Long-cells:** those between the veins with thick, sinuous walls, each pair separated by a solitary, tall silica-cell, or by a pair of short-cells, markedly at right angles to the horizontal walls; others, especially those over the veins, as in Fig. V, 1*a–b*.

T.S. lamina

Vascular bundles: most vb's small and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 13). **Adaxial surface** with marked ribs and furrows (Fig. XIV, 6); ribs of 2 distinct sizes, the small ones having rounded, and the tall ones flat, apices. Furrows deep, narrow and

V-shaped; furrows tending to be W-shaped where a small rounded rib comes between 2 taller, flat-topped ribs. **Sclerenchyma:** vb's opposite the small, rounded ribs with well-marked abaxial girders only (Fig. IX, 3); other vb's with tall, narrow, adaxial and abaxial girders (Fig. IX, 7), the adaxial girders being 2 cells wide and up to about 8 cells high, and the abaxial girders slightly shorter and wider. Large vb's with adaxial T- and abaxial I-girders (Fig. IX, 8). A continuous layer of scl. subjacent to the abaxial epidermis in the region of the midrib. **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** confined to the U-shaped furrows, variable in size, but none of them specially large (Fig. XV, 5). **Bundle-sheaths** double; some large vb's with I.S. complete, but O.S. interrupted abaxially and adaxially (Fig. XII, 3*a*); some small vb's with I.S. complete, but with O.S. connected to the adaxial scl. by wide adaxial extensions of large cells (Fig. XII, 7). (In this grass, as in others that are similar in structure, it is difficult to decide what is bundle-sheath and what is scl., since the bundle-sheaths and girders merge into one another.)

MATERIAL EXAMINED: Cultivated at Kew.

Danthonia oreophila Petrie

LEAF

Abaxial epidermis

Short-cells, over the veins, mostly in long rows, but sometimes appearing to be solitary or in pairs when separated by relatively long intervening cells in the same files; those between the veins mostly solitary, and tall and narrow in outline, the vertical walls sometimes tending to be slightly concave. Intercostal short-cells silicified, but not usually containing well-defined silica-bodies. **Silica-bodies** numerous over the veins; mostly cubical to oblong. **Micro-hairs:** none seen. **Stomata** absent from the abaxial surface.

T.S. lamina

Blade widely V-shaped in T.S. **Adaxial surface** with about 9 well-developed ribs separated from one another by V-shaped furrows, the heights of the ribs being considerably greater than the width of the lamina between the bases of the furrows and the abaxial epidermis. Apices and sides of the ribs densely papillose, but papillae short.

MATERIAL EXAMINED: Prof. A. Wall 1939; New Zealand. Slides prepared by J. K. O'Byrne.

Danthonia pilosa R. Br.

LEAF

Abaxial epidermis

Short-cells, over the veins, mostly in long rows, but a few paired or in short rows; those between the veins mostly paired. **Silica-bodies** abundant, both over and between the veins; those over the veins mostly dumb-bell shaped, but with the middle portion of each body not much narrower than the usually

rounded ends; other bodies shortly dumb-bell shaped or more or less cross-shaped, a few with very shallow indentations between the arms of the cross, appearing to be almost cubical; nodular bodies also present but rare. Intercostal silica-bodies rather variable in shape; mostly tall and narrow, sometimes elliptical, and frequently crescent-shaped. **Micro-hairs** present, but rather infrequent, in the intercostal zones; resembling those in Fig. VII, 5–6. **Stomata** rather infrequent; with low dome-shaped or triangular subsidiary cells.

T.S. lamina

Blade not inrolled. **Adaxial surface** with about 14 v. low, rounded ribs, separated from one another by shallow, narrow furrows. Abaxial surface slightly ribbed over the larger veins. **Keel** prominent.

MATERIAL EXAMINED: W. R. B. Oliver 1910; New Zealand. Slides prepared by J. K. O'Byrne.

Danthonia planifolia Petrie

LEAF

Abaxial epidermis

Short-cells, over the veins, mostly in long rows; those between the veins mostly solitary and sometimes paired. Solitary intercostal short-cells silicified, but not containing well-defined silica-bodies, the cells themselves being tall and narrow. **Silica-bodies,** between the veins, restricted to the more distal members of the rare pairs of short-cells, the bodies being tall, narrow, and elliptical or slightly concave on one side. Silica-bodies over the veins cross-shaped (Fig. IA, 16), or intermediate between cross and dumb-bell shaped (Fig. IA, 17). **Micro-hairs:** none seen. **Stomata** v. infrequent; with triangular subsidiary cells.

T.S. lamina

Blade not infolded. **Adaxial surface** with about 20 well-developed ribs separated from one another by deep, V-shaped furrows; most ribs with flattened apices, but a single rib next to and on either side of the midrib smaller and with rounded apices, another single small rib being present near each leaf margin. Apices and sides of the ribs bearing numerous papillae.

MATERIAL EXAMINED: Prof. A. Wall 1939; New Zealand. Slides prepared by J. K. O'Byrne.

Danthonia pungens Cheesman

LEAF

Abaxial epidermis

V. similar to *D. crassiuscula* (see p. 138), but a few files over the veins consisting of long rows of **short-cells. Silica-bodies:** those in rows of short-cells rounded or oblong (Fig. I, 8); those in paired short-cells ranging from round

to tall and narrow, the last type often being slightly crescent-shaped. **Stomata** and **micro-hairs** absent.

T.S. lamina

Blade somewhat V-shaped in T.S. **Adaxial surface** with about 20 well-marked ribs, mostly uniform in height, but a few ribs shorter than the others and with narrower and more rounded apices. Ribs separated from one another by V-shaped furrows. Apices and sides of ribs clothed with conspicuous papillae.

MATERIAL EXAMINED: J. Kirk 1918. Type; New Zealand. Slides prepared by J. K. O'Byrne.

Danthonia rigida Raoul

LEAF

Abaxial epidermis

Short-cells, both over and between the veins, crowded, mostly solitary, but occasionally in pairs or rows of 3 cells; silicified, but seldom containing well-defined silica-bodies; square or narrower than tall, the long sides of the narrower cells sometimes being v. slightly concave. **Silica-bodies** v. rare, and restricted to the most distal member of pairs and trios of short-cells; usually elliptical with the long axis vertical, fitting into concavities in the contiguous cork-cells. **Micro-hairs:** none seen. **Stomata** absent from the abaxial surface.

T.S. lamina

Blade half-moon shaped in T.S. **Adaxial surface** with numerous (about 17 in Travers 1865 and about 28 in Sinclair and Haast 1860–1) ribs of unequal sizes, the larger ribs having flattened apices. Papillae numerous on the sides, but less numerous on the apices, of the ribs. **Mesophyll** with chlorenchyma not radiate. **Bundle-sheaths** double.

MATERIAL EXAMINED: Travers 1865; New Zealand. Ex Herb. Hook. Sinclair and Haast 76 (1860–1); New Zealand. Ex Herb. Hook. Slides prepared by J. K. O'Byrne.

Danthonia semiannularis R. Br.

LEAF

Abaxial epidermis

Short-cells, over the veins, mostly in long rows, but sometimes appearing to be solitary or paired when separated by relatively long cells in the same files. Short-cells, between the veins, nearly all paired; abundant. **Silica-bodies** abundant, both over and between the veins, those over the veins mostly dumb-bell shaped, but with the middle portion of each body not much narrower than the rounded ends. Silica-bodies, between the veins, tall and narrow, mostly markedly crescent-shaped, and fitting into concavities in contiguous cork-cells. **Micro-hairs** present; resembling those in Fig. VII, 5–6. **Stomata** rather infrequent; mostly with triangular subsidiary cells.

T.S. lamina

Blade not infolded. **Adaxial surface** with about 14 v. slight ribs, separated from one another by shallow furrows. Abaxial surface v. slightly ribbed over the large vb's.

MATERIAL EXAMINED: Prof. A. Wall 1939; New Zealand. Slides prepared by J. K. O'Byrne.

Danthonia spicata (L.) Beauv. (including var. *typica*)

LEAF

Abaxial epidermis

Short-cells, between the veins, paired; those over the veins in rows of more than 5 cells; abundant both over and between the veins. **Silica-bodies,** between the veins, sometimes tall and narrow (Fig. I, 4), or fitting into concavities in adjacent cork-cells (Fig. I, 6–7), but v. variable in shape, some tending to be slightly cross-shaped, and others crescent-shaped or almost cubical with rounded corners. Silica-bodies, over the veins, dumb-bell shaped (Fig. IA, 18 (ii–iv)), or shortly dumb-bell shaped (Fig. IB, 20). **Macro-hairs:** occasional, fairly long, stiff hairs with sunken, swollen, constricted bases (Fig. II, 3) present in the intercostal zones, their frequency varying locally. Short, rigid, thick-walled hairs (Fig. IIA, 10), with their bases sunken between the bulliform cells, also present, but confined to the adaxial surface. **Micro-hairs** present; length 56–90 (mostly 70–86) μ; basal cell 30–57 (mostly 36–50) μ; distal cell 19–50 (mostly 24–36) μ; basal cell wider than the distal cell, but sometimes tapering towards its proximal end; distal cell tapering to an acutely pointed apex (Fig. VII, 9). **Prickle-hairs:** angular prickles (Fig. VI, 3) present at the leaf margins. **Stomata** absent from the abaxial surface. **Long-cells:** those between the veins with thin, sinuous walls (Fig. V, 3*a–c*), some of the cells tending to be hexagonal.

T.S. lamina

Vascular bundles: most vb's small and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 13). **Adaxial surface** with fairly wide ribs, with rounded apices, separated from one another by wide, shallow furrows (Fig. XIV, 2); v. slight depressions in the apices of some of the larger ribs. **Sclerenchyma:** a few small marginal vb's not accompanied by scl. (Fig. IX, 1); large vb's with adaxial and abaxial girders, up to about 10 cells wide and 5 cells high (Fig. IX, 5); most small vb's with tall, narrow, abaxial and adaxial girders, many of the girders being no more than 2 or 3 cells wide and up to about 8 cells high (Fig. IX, 7); occasional vb's with adaxial girders only (Fig. IX, 2). **Keel:** projecting v. slightly, rounded; containing a solitary vb (Fig. XIII, 1). **Mesophyll** with chlorenchyma not radiate. **Bulliform cells** mostly as fan-shaped groups (Fig. XV, 6) but a slight tendency for some of the groups to be as in Fig. XV, 2. **Bundle-sheaths** double; small vb's with I.S. complete, but O.S. interrupted, or v. inconspicuous, abaxially (Fig. XII, 2); large vb's with I.S. complete and O.S. interrupted adaxially and abaxially (Fig. XII, 3*a*).

CULM

Epidermis subtended by an almost continuous zone of assimilatory tissue about 2 cells wide, followed by a well-marked ring of scl. about 4 cells wide, separating the assimilatory tissue from the inner ground tissue, the latter being mostly highly lignified especially round the vb's, only a small central portion of the ground tissue consisting of thin-walled unlignified cells. Vb's in 2–3 ill-defined circles, all of these being embedded in lignified tissue, the outermost vb's impinging on the inner margin of the scl. ring.

RHIZOME

A broad 'cortical' region of thin-walled cells, surrounding an irregular ring of lignified ground tissue with the vb's embedded in it. Central ground tissue, enclosed by the scl. ring, and consisting of thin-walled tissue, with small intercellular spaces in it.

MATERIAL EXAMINED: Cultivated at Kew.

Danthonia teretifolia Petrie

LEAF

Abaxial epidermis

Short-cells, both over and between the veins, mostly solitary but sometimes paired; solitary short-cells silicified, but not containing clearly defined silica-bodies, often taller than wide, with the long walls slightly concave, others more nearly cubical. **Silica-bodies** often present in the more distal members of paired short-cells, the bodies being tall and narrow, rounded, or elliptical, and generally fitting into concavities in the contiguous short-cells. **Micro-hairs**; none seen. **Stomata** absent from the abaxial surface.

T.S. lamina

Blade somewhat U-shaped in T.S. **Adaxial surface** with about 12 well-marked ribs, mostly with flattened apices, the ribs on either side of the midrib being narrower than the others and with rounded apices. Ribs separated from one another by deep, narrow grooves. Grooves and apices of the ribs papillose.

MATERIAL EXAMINED: Petrie. Coll. 1914; New Zealand. Slides prepared by J. K. O'Byrne.

ADDITIONAL INFORMATION FROM THE LITERATURE

Most of the published information concerning the leaf anatomy consists of scattered notes rather than of complete descriptions, and sometimes it is not made clear to which spp. the published data refer. The genus has received attention from de Wet (1956), who records that the leaf of *Danthonia*, in the restricted sense in which he interprets the genus, is characterized by a panicoid epidermis in some species and by a festucoid epidermis in others. The leaf anatomy, as revealed in T.S.s of the blade, is less variable and exhibits festucoid characters in all spp. These facts are partly confirmed by the data given on pp. 136–44 concerning the spp. examined by the present writer, although the epidermis in certain spp. is somewhat intermediate in character (see Special Notes).

The literature references that refer to *D. procumbens* (L.) DC. have here been considered under *Sieglingia decumbens* (L.) Bernh. on p. 450.

Günzel (1921) has recorded the following information concerning the leaf of '*D. forskalii* Trin.'[1] Adaxial and abaxial surfaces both ribbed; prickles and bristle-hairs numerous; keel not conspicuous; mesophyll with chlorenchyma apparently radiate; bulliform cells present on both surfaces; bundle-sheaths double, but cells of the I.S. with unusually thin walls.

SPECIAL NOTES

Concepts of the genus *Danthonia* differ. Thus de Wet (1954, 1956) considers that the genus, as recognized by Hubbard (1934) comprises a diverse group of spp., of which some should be included in other genera. De Wet notes that *D. pumila* Nees should be in *Asthenatherum*. He also expresses his own personal view that *D. macrantha* Schrad. and *D. brachyphylla* Stapf are deserving of generic rank, basing this opinion mainly on exomorphic characters. The 2 spp. are regarded as being allied to *Danthonia* in a restricted sense, and to *Pentameris*. *D. cincta* Nees and *D. papposa* Nees also present difficulties to de Wet because the chlorenchyma is restricted to bands adjacent to the grooves in the adaxial surface (not festucoid), whilst the silica-cells are described as more or less rod-shaped. The leaf anatomy recalls that of *Triodia* as described by Burbidge (1946 *a*, *b*), but the grass resembles *Danthonia* rather than *Triodia* on exomorphic characters.

It was pointed out on p. 144 that de Wet divides spp. of *Danthonia* into 2 groups which have a panicoid or festucoid epidermis respectively. For many spp. this seems to be quite correct, but the situation appears to be rather more complex than de Wet implies because the present writer found that the spp. of *Danthonia* which he examined, and has described above, include some in which panicoid and festucoid characters are mixed. The epidermis was found to be panicoid in *D. buchanani*, *calycina*, *compressa*, *nuda*, *semiannularis*, *spicata*, and *spicata* var. *typica*. It is festucoid in *D. bromoides*, *crassiuscula*, *cunninghamii*, *flavescens*, *teretifolia*, *pungens*, and *rigida*. It is intermediate in *D. australis*, *oreophila*, and *planifolia*. It is not for the present writer to judge how these facts should be interpreted, but it does indicate that *Danthonia*, in a broad sense, is far from homogeneous in its leaf structure.

Danthonia was at one time included in the Aveneae. This affinity does not seem impossible for those spp. in which the leaf structure is wholly festucoid. It is, however, quite clearly incorrect for those spp. in which the leaf epidermis is panicoid. The difficulty has already been recognized by Prat (1936). Cacares (1956) describes the leaf structure in *Danthonia* as 'phragmatoid', i.e. intermediate between panicoid and festucoid, and he draws a comparison between *Danthonia* and *Schismus*. It is generally recognized that *Danthonia* is related to *Sieglingia*, and this affinity seems quite a likely one so far as the spp. of *Danthonia* with a panicoid leaf epidermis are concerned. Affinities with *Molinia* have also been suggested.

LITERATURE

Burbidge 1946 *a*, *b* (comparison with *Triodia*); Cacares 1956 (comparison with *Schismus*); de Wet 1954, 1956 (leaf structure and taxonomy); Duval-Jouve 1875 (leaf); Günzel 1912, 1921 (leaf); Hubbard 1934 (taxonomy); Jacques-Félix 1958 (leaf); Prat 1936 (leaf); Vickery 1956 (taxonomy).

[1] *D. forskalii* (Vahl.) R. Br. = *Asthenatherum forskalii* (Vahl.) Nevski. See p. 49.

DANTHONIOPSIS

Diagnostic Generic Characters

Conert (1957) has described the leaf anatomy of 7 spp. of *Danthoniopsis* which have the following characters in common.

Silica-bodies dumb-bell shaped, usually elongated with narrow middle portions. Cushion hairs and prickles common. Micro-hairs present; narrow, often with the basal cell longer than the distal cell. Lamina flattened; margins generally rounded. Both surfaces usually at least slightly, and in some spp. more markedly, ribbed. Sclerenchyma usually forming adaxial and abaxial strands or girders to the large vb's in the lamina; large keel bundles often supported by abaxial girders only. Strands of a few fibres generally present in the leaf margins. Midrib often well developed but not in all spp. Mesophyll with radiate chlorenchyma. Bundle-sheaths generally single.

Descriptions of Individual Species (Based on Conert 1957)

D. barbata (Nees) C. E. Hubbard

A few papillae and prickles present on the ribs, and cushion hairs on the sides of the ribs. Leaf flattened; margins rounded. Both surfaces ribbed. Scl. associated with the large vb's consisting of adaxial strands 1–2 cells tall and oval abaxial strands. Midrib not pronounced. Adaxial epidermis over the small vb's consisting of wedge-shaped groups of specially large cells (bulliform cells). Portions of the abaxial epidermis between the veins also consisting of large cells.

D. chevalieri A. Camus & C. E. Hubbard

Similar to *D. viridis*. Midrib broader and containing only tertiary vb's.

D. dinteri (Pilger) Hubbard

Long cushion hairs present on the ribs. Midrib narrow, triangular. Leaf margins thickened. Scl. present as adaxial and abaxial strands 2–4 cells high; keel vb's supported by abaxial strands 5–6 cells high; median vb supported by an abaxial girder. Adaxial surface of the midrib supported by a plate of scl. 3–4 cells tall. V. few fibres present in the leaf margins.

D. humbertii (A. Camus) Conert

Papillae and prickles present on the ribs. Midrib not pronounced. Leaf margins rounded. Scl. forming flattened adaxial girders 2 cells tall over the first- and second-order vb's, and strands to the small vb's. Abaxial scl. to vb's of orders 1–3 consisting of broadly wedge-shaped strands 12–14 cells tall. Strands of a few fibres present in the leaf margins. Bundle-sheaths; large vb's with an I.S. at the outer boundary of the ph.; all other vb's with parenchymatous sheaths only.

D. minor Stapf & C. E. Hubbard

Similar to *D. viridis* but colourless parenchyma stated to be absent between the vb's.

D. pruinosa C. E. Hubbard

Similar to *D. barbata*. Tertiary vb's confined to the leaf margins.

D. stocksii (Boiss.) C. E. Hubbard

Leaf anatomy as in *D. humbertii*, but vb's less strongly supported by scl.

D. viridis (Rendle) C. E. Hubbard

Cushion hairs present between the veins and a few prickles and papillae on the ribs. Leaf flattened, with broadly rounded margins. Both surfaces slightly ribbed. Scl. present as adaxial strands and abaxial girders 2–3 cells tall associated with the large vb's, the small vb's being accompanied by oval strands about 3 cells tall; median vb and other large keel vb's supported by abaxial girders only. Strands, each consisting of a few fibres, present in the leaf margins. Adaxial surface of the midrib supported by a wide, flattened plate of scl. Midrib well developed; ground tissue composed of large, colourless cells; containing a median vb accompanied on either side by 4 laterals, all smaller than the median vb, but themselves of unequal sizes. Bulliform cells above the small vb's in groups illustrated as resembling those in Fig. XV, 2. Bundle-sheaths single.

Special Note

Jacques-Félix (1950) refers briefly to *Danthoniopsis* which he classifies with *Trichopteryx* and *Gilgiochloa* in the Trichopteryxineae, a subtribe of the Arundinelleae. In Jacques-Félix's treatment, *Arundinella*, *Loudetia*, and *Tristachya* are placed together in a separate subtribe. Conert (1957) like previous authors treats *Danthoniopsis* as a member of the Arundinelleae, and places *D. tristachyoides* (Trin.) Jacques-Félix and *D. purpurea* (C. E. Hubbard) Jacques-Félix in *Loudetiopsis*. Brief notes on the leaf anatomy of these 2 spp. are given in this book under *Loudetiopsis* on p. 295.

Literature

Conert 1957 (leaf and taxonomy); Jacques-Félix 1950 (taxonomy).

DESCHAMPSIA

Most of the recorded information concerning this genus refers to the appearance of the leaves of *D. caespitosa* (L.) Beauv. and *D. flexuosa* (L.) Trin. in T.S. As there are notable differences between the 2 spp., their leaves are described separately below.

***Deschampsia caespitosa* (L.) Beauv.**

Leaf usually flat, but described by Pée-Laby (1898) as becoming almost acicular in appearance in certain circumstances owing to rolling, and this occurs in spite of the small size of the bulliform cells.

Adaxial surface with v. prominent, acute, triangular ribs, with well-marked transparent lines between the ribs. **Vascular bundles :** 1 principal and 1 or more secondary vb's in each rib. **Sclerenchyma** abundant; present in the leaf margins, at the apex of each rib, and forming an almost continuous abaxial band, being present as closely placed strands between and opposite the ribs; scl. not forming girders with the vb's. **Prickles** present on the ribs. **Papillae** commonly, but not invariably, present on the intercostal long-cells on the adaxial surface, their frequency and size being a plastic character according to Raunkiaer (1901).[1] **Stomata** absent from the abaxial surface. **Keel** not prominent. **Meso-**

[1] Raunkiaer (1901) found 1–2 papillae present on each intercostal long-cell on the adaxial

phyll with chlorenchyma not radiate. **Bulliform cells** present at the bases of the furrows, but not v. large. **Bundle-sheaths** double.

A few notes on the structure of the root and culm have been recorded by Holm (1908). Thick roots are stated to exhibit radial, intercellular spaces in the cortex, and up to 15 rays of xy. with 1 protoxylem group in each ray.

***Deschampsia flexuosa* (L.) Trin.**

Leaves acicular, sometimes approximately pentagonal or hexagonal in section, the adaxial surface being reduced to a W-shaped depression, the centre of the W consisting of a well-marked median rib. **Abaxial surface** v. slightly ribbed. **Vascular bundles** consisting of a large median vb accompanied on either side by about 2 smaller strands. **Sclerenchyma** well developed in the apex of the adaxial rib, and as a series of closely placed strands adjacent to the abaxial epidermis; not forming girders with the vb's. **Prickles** or short stiff hairs present on the adaxial surface. **Stomata** absent from the abaxial surface. **Mesophyll** composed of large cells, and including a well-developed palisade layer and lacunae. **Bulliform cells** not well developed. **Bundle-sheaths** double.

Martin (1955) has recorded some dimensions of the epidermal cells.

Buschmann (1950) has recorded a few particulars concerning the structure of *D. maderensis* (Hack. et Bornm.) Buschm., *D. foliosa* Hackel, and *D. argentea* (Lowe) Lowe.

Special Note

Prat (1936) has drawn attention to the fact that the leaves of *Deschampsia* are typically festucoid in structure.

Literature

Burr and Turner 1933 (leaf); Buschmann 1950 (leaf); Duval-Jouve 1875 (leaf); Grob 1896 (leaf); Holm 1908 (culm and root); Lewton-Brain 1904 (leaf); Martin 1955 (leaf); Pée-Laby 1898 (leaf); Prat 1936 (leaf); Raunkiaer 1901 (ecological anatomy); Strecker 1913 (leaf); Woodhead 1906 (leaf of *D. flexuosa* from ecological standpoint).

DESMAZERIA

For information concerning *D. loliacea* (Huds.) Nym. see under *Catapodium marinum* (L.) C. E. Hubbard.

surface of leaves of plants grown in sunny habitats in Denmark. Leaves of plants in the shade tend to have less frequent, smaller papillae or none, and it was shown experimentally that the frequency of the papillae could be modified by moving plants to and from sunny positions. Other experiments indicated, however, that the frequency of papillae is determined by atmospheric humidity as well as by light intensity, so that papillae are formed in the shade only when the atmosphere is dry. Papillae are formed on young leaves whilst still ensheathed by the bases of the leaves that precede them, so it is thought that papillae do not arise directly from the stimulus of light. Leaves of plants from the Faroes and Iceland were found by Raunkiaer to have fewer, smaller papillae than leaves from plants from sunny localities in Denmark. Other small anatomical differences were also noted. Raunkiaer also notes that the leaf of *Deschampsia alpina* (L.) Roem. & Schult. is similar in structure to that of *D. caespitosa*, but papillae were found to be more constantly present and well developed, whilst prickles were absent, and subsidiary vb's in the ribs less numerous.

DESMOSTACHYA

Diagnostic Generic Characters

Short-cells, over the veins, mostly in long rows. Silica-bodies, over the veins, saddle-shaped. Micro-hairs present; each with the distal cell tapering to a rounded or pointed apex. Stomata with triangular subsidiary cells. Vascular bundles not conspicuously angular in outline. Mesophyll with chlorenchyma partly radiate. Bundle-sheaths double.

Species Specially Examined

***Desmostachya bipinnata* (L.) Stapf**

Leaf

Abaxial epidermis

Short-cells, between the veins, and occasionally over the veins, solitary and in pairs; those over the veins mostly in rows of more than 5 cells. **Silica-bodies,** over the veins, saddle-shaped (Fig. I, 9); those between the veins rather infrequent, but also slightly saddle-shaped, although narrower than those over the veins, sometimes crescent-shaped or tall and narrow (Fig. I, 4), but silica-bodies generally rather obscure. Intervening cells in the files over the veins slightly nodular. **Macro-hairs:** none seen in the material examined, but Sabnis (1921) refers to spiny hairs. **Micro-hairs:** length 30–42 μ; basal cell 18–28 (mostly 18–22) μ; distal cell 12–16 μ; basal cell tapering towards its proximal end; distal cell tapering slightly towards a rounded, or sometimes more acutely pointed, apex. **Prickle-hairs:** none seen. **Stomata** with triangular subsidiary cells (Fig. IV, 1). **Long-cells** between the veins with thin, sinuous walls, as Fig. V, 3*a–c*, but rather short; interstomatal cells with concave ends (Fig. V, 10*a–b*) and sinuous outlines.

T.S. lamina

Vascular bundles: fairly numerous small vb's not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 15), but with the ph. highly sclerosed (Fig. VIII, 17). **Adaxial surface** with moderate, closely placed ribs with rounded apices, separated from one another by shallow furrows (Fig. XIV, 3). **Sclerenchyma:** most vb's with fairly wide adaxial and abaxial girders, those associated with the large vb's being up to about 15 cells wide and 5 cells high (Fig. IX, 5); keel vb's with well-marked abaxial girders only (Fig. IX, 3). Midrib including a plate of scl. immediately subjacent to the epidermis. **Keel** conspicuous, rounded; containing numerous vb's of unequal sizes (Fig. XIII, 3). **Mesophyll:** chlorenchyma radiate, but restricted to narrow strips lying next to the O.S. of each of the bundle-sheaths. **Bulliform cells** forming girders with other colourless cells, extending from the bases of the adaxial furrows to the abaxial epidermis (Fig. XV, 14). **Bundle-sheaths** double; a few vb's, especially in the keel, with 2 complete sheaths (Fig. XII, 1); large keel bundles with I.S. complete, but O.S. interrupted adaxially and abaxially (Fig. XII, 3*a*); most vb's each with an extension from the O.S. to the adaxial scl.

Special Note

The leaf characters are mostly panicoid, but include a few that are festucoid. The micro-hairs sometimes resemble those of *Eragrostis*.

Literature

Sabnis 1921 (leaf, ecological anatomy).

DEYEUXIA

Diagnostic Generic Characters

The following characters refer only to the single sp. examined by the author. Short-cells, over the veins, in short or long rows. Silica-bodies, over the veins, horizontally elongated, with rounded ends and smooth outlines. Micro-hairs absent. Stomata with parallel-sided, or low dome-shaped, subsidiary cells. Vascular bundles not angular in outline. Mesophyll with chlorenchyma not radiate. Bundle-sheaths double.

Species Specially Examined

***Deyeuxia quadriseta* Benth.**

Leaf

Abaxial epidermis

Short-cells, over the veins, in rows of 3–5 or more cells; common over, but v. infrequent or absent between, the veins. **Silica-bodies** horizontally elongated, with rounded ends and smooth outlines (Fig. Ia, 12). **Macro-hairs** and **micro-hairs:** none seen. **Prickle-hairs:** prickles (Fig. VI, 1–2) fairly frequent over the veins. **Stomata** mostly with parallel-sided (Fig. IV, 2), but some tending to have low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells** with thin, non-sinuous walls (Fig. V, 2*a–c*); some of the cells somewhat hexagonal.

T.S. lamina

Vascular bundles: most vb's small, widely spaced, and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with pronounced, fairly wide ribs with rounded apices, separated from one another by moderately wide, V-shaped furrows (Fig. XIV, 5). **Sclerenchyma:** a few of the small vb's not accompanied by scl. (Fig. IX, 1); most small vb's accompanied by minute adaxial and abaxial strands, the strands being separated from the bundle-sheaths by several layers of assimilatory cells (Fig. IX, 4); large vb's with tall, narrow, often partly biseriate, adaxial girders, the abaxial girders being up to about 5 cells wide. **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** of rather variable size, but none of them specially large, and situated in the furrows (Fig. XV, 5). **Bundle-sheaths** double; small vb's with I.S. complete and O.S. not quite complete, or inconspicuous, abaxially (Fig. XII, 2); large vb's with I.S. complete and O.S. interrupted abaxially and adaxially (Fig. XII, 3*a*).

Material Examined: Supplied specially by W. M. Curtis from Oyster Cove, Tasmania.

Special Note

The leaf characters are festucoid.

DIANDROLYRA

D. bicolor Stapf exhibits all the essential characters of bamboo leaves, as has been pointed out by Brandis (1907) and Page (1947).

The characters recorded by Brandis include a midrib with only one abaxial vascular bundle (cf. Bambuseae on p. 541); mesophyll in which the chlorenchyma consists of arm-cells, narrow fusoid-cells also being present; numerous bulliform cells, often occupying the entire intervals between adjacent nerves; bundle-sheaths double.

Special Note

The leaf structure indicates that *Diandrolyra* must have affinities with the bamboos.

DIARRHENA

Diagnostic Generic Characters

Description based on the one sp. examined by the author. Short-cells, over the veins, mostly in short or long rows. Silica-bodies, over the veins, mostly nodular, but others varying from cross to dumb-bell shaped. Micro-hairs v. infrequent and rarely seen; unicellular. Stomata with low dome-shaped subsidiary cells. Vascular bundles not conspicuously angular in outline. Mesophyll with chlorenchyma not radiate. Bundle-sheaths double.

Species Specially Examined

***Diarrhena americana* Beauv.**

Leaf

Abaxial epidermis

Short-cells between, and a few of those over, the veins, solitary or paired; those over the veins mostly in rows of 3–5, or occasionally more, cells; abundant. **Silica-bodies,** between the veins, mostly tall and narrow (Fig. I, 4) or occasionally slightly crescent-shaped; those over the veins mostly nodular (Fig. Ib 22 (iii)), but a few tending to be dumb-bell shaped (Fig. Ia, 18 (ii–iv)), intermediate between dumb-bell and cross-shaped (Fig. Ia, 17), or even cross-shaped (Fig. Ia, 16). **Macro-hairs:** none seen. **Micro-hairs:** small, unicellular (Fig. VII, 1) present, but not always easy to find. **Prickle-hairs:** prickles (Fig. VI, 1–2) v. frequent between and over the veins. **Stomata** with

low dome-shaped subsidiary cells (Fig. IV, 3). **Long-cells,** between the veins, with thin, slightly sinuous, walls (Fig. V, 3*a–c*).

T.S. lamina

Vascular bundles: most vb's not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with v. slight, rounded ribs and v. shallow, wide furrows (Fig. XIV, 2) throughout most of the lamina, but ribs and furrows more pronounced over and near the midrib. Ribs slightly more pronounced on the abaxial than on the adaxial surface. **Sclerenchyma:** a very few, small, marginal vb's not accompanied by scl. (Fig. IX, 1); most small vb's with adaxial and abaxial girders 1–2 cells high, the width of the girders varying with the size of the vb's with which they are associated (Fig. IX, 4); large vb's with wider adaxial and abaxial girders (Fig. IX, 5), the girders associated with some of the largest vb's tending to be inversely anchor-shaped (converse of Fig. IX, 6); keel bundles with well-marked abaxial girders only (Fig. IX, 3). **Keel** conspicuous, rounded; containing 1 large median vb accompanied on either side by 4 vb's, all distinctly smaller than the median vb, although themselves of unequal sizes (Fig. XIII, 3). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells,** groups mostly as in Fig. XV, 2, but a few of the *Zea* type (Fig. XV, 3), or fan-shaped (Fig. XV, 4). **Bundle-sheaths** double; small vb's mostly with I.S. complete and O.S. not quite complete abaxially (Fig. XII, 2); large vb's with I.S. complete, but O.S. interrupted adaxially and abaxially (Fig. XII, 3*a*).

MATERIAL EXAMINED: W. G. Dore 646.

ADDITIONAL INFORMATION FROM THE LITERATURE

Some notes on the mode of development of the ph. in the roots of *D. americana* have been recorded by Chauveaud (1897).

SPECIAL NOTE

The leaf characters are almost wholly festucoid, but the occasional unicellular micro-hairs are noteworthy.

LITERATURE

Chauveaud 1897 (root); Grob 1896 (leaf).

DICHANTHIUM

DIAGNOSTIC GENERIC CHARACTERS

Short-cells, over the veins, in long rows. Silica-bodies, over the veins, cross to dumb-bell shaped. Micro-hairs present; each with the distal cell tapering to a rounded or a pointed apex. Stomata mostly with triangular, but some with low dome-shaped, subsidiary cells. Vascular bundles mostly small, crowded, and conspicuously angular in outline. Mesophyll with distinctly radiate chlorenchyma. Bundle-sheaths single.

SPECIES SPECIALLY EXAMINED

***Dichanthium aristatum* (Poir.) C. E. Hubbard**

LEAF

Abaxial epidermis

Short-cells, between the veins, mostly paired; those over the veins usually in rows of more than 5 cells; abundant over, but only moderately frequent between, the veins. **Silica-bodies,** between the veins, narrow and crenate (Fig. IB, 24), or irregularly cross-shaped; those over the veins cross-shaped (Fig. IA, 16), dumb-bell shaped (Fig. IA, 18 (ii–iv)), and intermediate between cross and dumb-bell shaped (Fig. IA, 17). **Macro-hairs:** none seen. **Micro-hairs:** length 43–63 (mostly 43–54) μ; basal cell 21–27 μ; distal cell 22–36 (mostly 24–30) μ; distal cell tapering to a rounded or somewhat acutely pointed apex (Fig. VII, 5–6). **Prickle-hairs:** rather small prickles (Fig. VI, 1) common over the veins; also angular prickles present at the leaf margins (Fig. VI, 3). **Papillae:** present locally on the adaxial surface, and seen most readily in T.S. **Stomata** with triangular (Fig. IV, 1), or low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells** between the veins mostly with thin, sinuous walls, as Fig. V, 3*a–c*, but rather short; interstomatal cells with concave ends (Fig. V, 10*a–b*).

T.S. lamina

Vascular bundles: a few of the smallest vb's with xy. and ph. not easily distinguishable (Fig. VIII, 1); most small vb's crowded, angular (Fig. VIII, 5); a few large vb's of basic type (Fig. VIII, 10–11). **Adaxial surface** practically smooth (Fig. XIV, 1). **Sclerenchyma:** numerous small vb's not accompanied by scl. (Fig. IX, 1); a few small vb's with minute adaxial and abaxial strands (Fig. IX, 4); large vb's with adaxial and abaxial girders up to about 6 cells wide and 2–3 cells high (Fig. IX, 5); many small vb's opposite the bulliform cells with minute abaxial strands only. **Keel** conspicuous; containing 1 fairly large median vb accompanied on either side by 3 or 4 much smaller laterals (Fig. XIII, 3). **Mesophyll:** chlorenchyma distinctly radiate round all vb's including those in the keel. **Bulliform cells:** groups mostly irregular (Fig. XV, 1), but occasionally of the *Zea* type (Fig. XV, 3), or fan-shaped (Fig. XV, 4). Adaxial part of the midrib consisting of large, thin-walled, colourless cells. **Bundle-sheaths** single; complete round all small vb's (Fig. XI, 2*a*); sheaths round the large vb's with abaxial interruptions (Fig. XI, 6).

CULM

Culm examined about 2 mm in diameter exhibiting the following characters. Flattened to slightly concave on one side. Epidermis subtended by 1 or 2 layers of small cells with thick walls. No well-defined scl. ring present, but cells of the ground tissue gradually becoming larger and more thin-walled on passing inwards from the periphery to the centre of the culm. Central ground tissue spongy and tending to break down to form several cavities. Vb's in 3 more or less distinct circles.

MATERIAL EXAMINED: Supplied specially by R. E. Vaughan from Mauritius.

***Dichanthium polyptychum* (Steud.) A. Camus**

LEAF

Abaxial epidermis

Macro-hairs: long, stiff hairs with constricted bases surrounded by papilla-like cells present in the intercostal zones. **Papillae:** whole epidermis densely covered with conical papillae.

T.S. lamina

Vascular bundles: smallest vb's with xy. and ph. not easily distinguishable (Fig. VIII, 1); most small vb's angular (Fig. VIII, 5); medium-sized vb's rather less markedly angular (Fig. VIII, 6); a few large vb's of basic type (Fig. VIII, 13). **Adaxial surface** with slight ribs over the large and medium-sized vb's, separated from one another by shallow furrows (Fig. XIV, 2) over the small vb's. **Sclerenchyma:** many of the small vb's opposite the bulliform cells not accompanied by scl. (Fig. IX, 1); other small vb's accompanied by slight abaxial strands only; medium-sized vb's with small adaxial and abaxial girders (Fig. IX, 4), up to about 5 or 6 cells wide and 4 cells high; largest vb's with wider adaxial and abaxial girders (Fig. IX, 5); larger keel bundles with strong abaxial girders only (Fig. IX, 3); median keel bundle with an incomplete, anchor-shaped girder (Fig. IX, 6). **Midrib** conspicuous, with a triangular abaxial, and a low but wide adaxial, extension; containing 1 large median vb, accompanied on either side by about 4 laterals all appreciably smaller than the median vb but of unequal sizes (Fig. XIII, 4). **Mesophyll:** chlorenchyma distinctly radiate round all vb's. **Bulliform cells** in irregular groups (Fig. XV, 1), extending half-way across the mesophyll, and almost reaching the sheaths round the smallest vb's; some fan-shaped groups (Fig. XV, 6) also present. **Bundle-sheaths** single; all small vb's with complete sheaths (Fig. XI, 2*a*); sheaths round the large vb's interrupted abaxially (Fig. XI, 6).

MATERIAL EXAMINED: Ballard 1249; Ceylon.

***Dichanthium sericeum* (R. Br.) A. Camus**

LEAF

Abaxial epidermis

Short-cells, between the veins, paired; those over the veins in rows of more than 5 cells; abundant over, but rather infrequent between, the veins. The rare **silica-bodies** between, and many of those over, the veins cross-shaped (Fig. IA, 16); others over the veins dumb-bell shaped (Fig. IA, 18 (ii–iv)). **Macro-hairs:** none seen. **Micro-hairs:** length 42–60 (mostly 42–54) μ; basal cell 24–40 (mostly 30–36) μ; distal cell 12–22 (mostly 12–15) μ; basal cell usually tapering towards its proximal end; distal cell tapering to a pointed apex (Fig. VII, 9). **Prickle-hairs:** rather small prickles (Fig. VI, 1), with rounded bases, frequent over the veins. **Papillae:** large globose papillae present in the same files of cells as the stomata, one papilla arising from each interstomatal cell (Fig. III, 2); other long-cells projecting slightly from the leaf surface in a papillose manner, a character best seen in T.S. **Stomata** with triangular subsidiary cells (Fig. IV, 1), but outlines rather obscured by papillae. **Long-cells** almost cubical with slightly to moderately sinuous walls (Fig. V, 7*a–b*).

T.S. lamina

Vascular bundles: numerous, crowded, small vb's with angular outlines (Fig. VIII, 5); medium-sized vb's rather less angular (Fig. VIII, 6); a few large vb's of basic type (Fig. VIII, 10–11). **Adaxial surface** practically smooth (Fig. XIV, 1). **Sclerenchyma:** small vb's, especially those opposite the bulliform cells, not accompanied by scl. (Fig. IX, 1), or with minute abaxial strands only; medium-sized vb's, not opposite the bulliform cells, accompanied by minute adaxial and abaxial strands (Fig. IX, 4); large vb's with adaxial and abaxial girders up to about 6 cells wide, and generally not more than 2 cells high. **Keel** fairly conspicuous; containing 1 large median vb accompanied on either side by about 4 much smaller laterals (Fig. XIII, 3). **Mesophyll:** chlorenchyma distinctly radiate round all vb's. **Bulliform cells** mostly in small groups of the *Zea* type (Fig. XV, 3); also in fan-shaped groups, the apices of the cells projecting above the level of the epidermis (Fig. XV, 4). Adaxial part of the midrib consisting of thin-walled colourless cells. **Bundle-sheaths** single; small and medium-sized bundles each with a complete sheath (Fig. XI, 2*a*); sheaths round most other bundles interrupted abaxially only (Fig. XI, 6), or occasionally adaxially and abaxially (Fig. XI, 3).

CULM

Culm examined about 2 mm in diameter exhibiting the following characters. Flattened, or v. slightly concave, on 1 side. Epidermis subtended by 3–4 layers of fibres, with v. narrow lumina and thick walls, followed by a ring of about 8 cell layers, the cells being wider in diameter, thick-walled, and with comparatively large lumina. Inner ground tissue of thin-walled cells, occupying the whole centre of the solid culm. Vb's consisting of a circle of small strands embedded in the scl. ring itself, the remainder being in 3 more or less distinct circles, the outermost circle being at the inner periphery of, and partly embedded in, the scl. ring.

MATERIAL EXAMINED: Supplied specially by G. Jackson from Nyasaland.

ADDITIONAL INFORMATION FROM THE LITERATURE

Most of the literature refers to the same spp. as those dealt with above, and, in general, the published information agrees with the original descriptions given above. Günzel (1912) records the following facts about the leaf of *D. papillosum* (Hochst.) Stapf, many of which are confirmed in Prat's (1937) description. *Epidermis.* Silica-bodies, over the veins, cross to dumb-bell shaped. Long cushion hairs present in the intercostal zones. Cylindrical micro-hairs present. Prickles present between the veins. Papillae well developed, especially on the abaxial surface, many of them overarching the stomata. Long-cells, between the veins, with thin, sinuous, anticlinal walls. *T.S. lamina.* Surfaces devoid of ribs. Midrib moderately well developed, with ground tissue of colourless cells. Bulliform cells well developed on the adaxial surface but not in the midrib.

Vickery (1935) describes *D. annulatum* (Forsk.) Stapf as being similar to *D. sericeum* (see p. 154). Prat (1937) says *D. annulatum* is similar to *D. papillosum*, but records that short cushion hairs are more numerous in the adaxial surface.

Sabnis (1921), also with reference to *D. annulatum*, which he deals with under *Andropogon annulatus* Forsk., records the following characters. Adaxial surface not much grooved; macro-hairs long and bluntly pointed; scl. forming I-girders with the large vb's, abaxial strands to the small vb's, and large strands in the leaf margins. Mesophyll with radiate chlorenchyma round the small vb's, and arcs of chlorenchyma at the sides of the large vb's.

Special Note

Leaf characters panicoid; usually regarded as belonging to the Andropogoneae.

Prat (1937) considers that *Euclasta condylotricha* (Hochst. et Steud.) Stapf should have been retained in *Dichanthium*.

Literature

Breakwell 1914 (leaf; under *Andropogon*); Günzel 1912 (leaf); Prat 1937 (leaf); Sabnis 1921 (leaf of *D. annulatum*; under *Andropogon*); Vickery 1935 (leaf).

DICHELACHNE

Diagnostic Generic Characters

Short-cells, over the veins, paired, paired with prickles, or in short rows. Silica-bodies, over the veins, mostly horizontally elongated, with slightly sinuous or smooth outlines. Micro-hairs absent. Stomata with parallel-sided subsidiary cells. Vascular bundles not conspicuously angular in outline. Mesophyll with chlorenchyma not radiate. Bundle-sheaths double.

Species Specially Examined

***Dichelachne crinita* (L. f.) Hook. f.**

Leaf

Abaxial epidermis

Short-cells between, and some of those over, the veins paired; others over the veins paired with prickles or in rows of 3–5 cells; common over, but rather infrequent between, the veins. **Silica-bodies,** between the veins, rounded in outline and fitting into concavities in adjacent cork-cells (Fig. I, 6–7); most silica-bodies over the veins horizontally elongated with slightly sinuous (Fig. Ia, 14–15), or smooth (Fig. Ia, 12), outlines. **Macro-hairs** and **micro-hairs:** none seen. **Prickle-hairs:** large prickles (Fig. VI, 2) abundant over the veins; hooks (Fig. VI, 5) or small prickles frequent in the intercostal zones. **Stomata** with parallel-sided subsidiary cells (Fig. IV, 2). **Long-cells** with thin, non-sinuous walls (Fig. V, 2*a–c*); a few of the cells hexagonal.

T.S. lamina

Vascular bundles: most vb's small and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 10–11). **Adaxial surface** with moderate ribs and rounded apices, separated from one another by fairly deep, widely V-shaped furrows (Fig. XIV, 3). **Sclerenchyma:** some small vb's with

adaxial and abaxial strands up to about 6 cells wide and 1–3 cells high (Fig. IX, 4); a few vb's with uniseriate abaxial girders and small adaxial strands, or exhibiting the converse type of structure with adaxial girders and abaxial strands; large vb's with adaxial and abaxial girders about 3–7 cells wide and about 5 cells high (Fig. IX, 5). **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** in fan-shaped groups at the bases of the furrows (Fig. XV, 6). **Bundle-sheaths** double; small vb's with O.S. not quite complete, or inconspicuous, abaxially (Fig. XII, 2); large vb's with O.S. interrupted adaxially and abaxially (Fig. XII, 3*a*).

Culm

Culm examined about 3 mm in diameter exhibiting the following characters. Circular, with a large hollow centre. Epidermis subtended by a clearly defined mechanical ring, consisting of about 12 layers of thick-walled fibres, with numerous conspicuous columns of assimilatory tissue embedded in it. A circle of small vb's also embedded in the scl. ring, and a circle of much larger vb's in the thin-walled ground tissue between the inner boundary of the scl. ring and the hollow centre of the culm.

Material Examined: Supplied specially by W. M. Curtis from Tasmania.

Special Note

Leaf characters typically festucoid.

Literature

Grob 1896 (leaf).

DIECTOMIS

Prat's (1937) description of *D. fastigiata* (Sw.) Kunth. includes the following information.

Cushion hairs and prickles present on the nerves. Lamina with thick margins containing sclerosed tissue below the adaxial epidermis, the vb's in this region being depressed towards the abaxial surface. Sclerenchyma forming abaxial girders to the vb's of the second order, the vb's of the third order being accompanied by abaxial strands of only a few fibres. Mesophyll with radiate chlorenchyma. Bulliform cells present above the numerous small vb's, each group protruding above the general level of the epidermis and penetrating deeply into the mesophyll. Bulliform cells absent immediately above, but a large group developed on either side of, the median vb.

Special Note

The radiate chlorenchyma indicates the panicoid affinities of the genus.

Literature

Prat 1937 (leaf).

DIGITARIA (see also *Reimaria* on p. 418)

Diagnostic Generic Characters

Short-cells, over the veins, mostly in long rows, but solitary or paired at the vein margins in some species. Silica-bodies cross to dumb-bell shaped. Micro-hairs present; each with the distal cell tapering to a pointed, but sometimes slightly rounded or thickened, apex. Stomata with subsidiary cells varying from triangular to low or tall dome-shaped, the proportion of each type varying in different spp. Vascular bundles mostly small, crowded, and angular. Mesophyll with chlorenchyma radiate, but usually rather indistinctly so. Bundle-sheaths single.

Species Specially Examined

Digitaria borbonica Desv.

Leaf

Abaxial epidermis

Short-cells, over the veins, in rows of more than 5 cells; abundant over, but v. infrequent or absent between, the veins. Most **silica-bodies,** over the veins, intermediate between cross and dumb-bell shaped (Fig. Ia, 17); others dumb-bell shaped, but varying in appearance with the focus (Fig. Ib, 21). **Macro-hairs:** hairs slender; abundant in the interstomatal zones, with deeply sunken bulbous bases (Fig. II, 2), each accompanied on opposite sides by a pair of small epidermal cells. Similar, but shorter, hairs also present on the adaxial surface, with their bases surrounded by bulliform cells. **Micro-hairs:** length 34–54 (mostly 42–48) μ; basal cell 18–29 (mostly 22–29) μ; distal cell 17–28 (mostly 22–26) μ; basal cell commonly tapering towards its proximal end; distal cell tapering to a rounded or acutely pointed apex. **Prickle-hairs:** none seen. **Stomata** with triangular (Fig. IV, 1), or low (Fig. IV, 3) to high (Fig. IV, 4) dome-shaped, subsidiary cells. **Long-cells:** some between the veins not much longer than tall, with slightly to moderately sinuous walls (Fig. V, 7*a–b*); others, especially those beside the veins, longer, with sinuous walls (Fig. V, 3*a–c*); interstomatal cells with concave ends (Fig. V, 10*a–b*).

T.S. lamina

Vascular bundles: most vb's small, crowded, angular, often 4-sided (Fig. VIII, 5); a few large vb's of basic type (Fig. VIII, 9). **Adaxial surface** practically smooth (Fig. XIV, 1), apart from the projecting apices of the bulliform cells. Abaxial surface with low, rounded ribs and furrows. **Sclerenchyma:** many small vb's, especially those opposite the bulliform cells, not accompanied by scl. (Fig. IX, 1); other small vb's, opposite the rows of stomata in the adaxial surface, accompanied by small abaxial strands only; the few large vb's accompanied by adaxial and abaxial girders up to about 10 cells wide and 4 cells high (Fig. IX, 4). **Keel** fairly conspicuous, rounded; containing a solitary vb (Fig. XIII, 1), or with a median vb accompanied on either side by a number of laterals (Fig. XIII, 3). **Mesophyll:** chlorenchyma radiate round most vb's, but more conspicuously so round some vb's than others. **Bulliform cells** in irregular groups (Fig. XV, 1) throughout the width of the lamina. Adaxial part of the midrib consisting of a few large, thin-walled, colourless cells. **Bundle-sheaths** single; complete round all vb's, both large and small (Fig. XI, 2*a–b*).

Culm

Culm examined about 1 mm in diameter exhibiting the following characters. Epidermis subtended by a single layer of fibres of small diameter, followed by about 4 layers of thin-walled cells, bounded on the inner side by a well-marked scl. ring, not more than about 3 cells wide, with a circle of small vb's embedded in it. Ground tissue on the inside of the scl. ring consisting of thin-walled cells, with 2 more or less distinct circles of vb's embedded in it. One or 2 vb's situated much nearer to the centre of the culm. Culm with a fairly wide cavity at the centre.

Material Examined: Meikle 1316; Nigeria.

Digitaria brazzae (Franch.) Stapf

Leaf

Abaxial epidermis

Short-cells, immediately beside the veins, solitary or paired; those over the veins in rows of more than 5 cells; abundant over, but infrequent between, the veins. **Silica-bodies,** over the veins, intermediate between cross and dumb-bell shaped (Fig. Ia, 17), and not v. tall. **Macro-hairs:** long hairs, with small warts on their surfaces, and with sunken bases (as Fig. II, 2 but warty), abundant in the intercostal zones. Similar hairs, with their bases deeply sunken between the adaxial bulliform cells, also present on the adaxial surface. **Micro-hairs:** length 45–78 (mostly 54–72) μ; basal cell 22–36 μ; distal cell 24–50 (mostly 36–48) μ; distal cell tapering to a pointed apex (Fig. VII, 4). **Prickle-hairs:** hooks (Fig. VI, 5), with rather long points, abundant at the margins of the veins, and elsewhere in the intercostal zones. **Stomata** mostly with triangular (Fig. IV, 1), but sometimes with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells:** those in the middle of each of the intercostal zones relatively short, with thin, non-sinuous walls (Fig. V, 4*a–b*); intercostal long-cells immediately adjacent to the veins with thin, sinuous walls (Fig. V, 3*a–c*).

T.S. lamina

Vascular bundles: smallest vb's with xy. and ph. not easily distinguishable (Fig. VIII, 1); most vb's crowded, angular (Fig. VIII, 4–5); a few large vb's of basic type (Fig. VIII, 10). **Adaxial surface** with slight, rounded ribs, separated from one another by rather wide, shallow furrows (Fig. XIV, 2). **Sclerenchyma:** many small vb's, especially those opposite the bulliform cells, not accompanied by scl. (Fig. IX, 1); other small vb's not opposite the bulliform cells, as well as the large vb's, accompanied by adaxial and abaxial strands up to about 16 cells wide and 1–3 or 4 cells high (Fig. IX, 5). **Keel** not prominent; containing 1 large median vb accompanied on either side by 3 laterals (Fig. XIII, 3). **Mesophyll:** chlorenchyma distinctly radiate round most vb's, but

more conspicuously so round some vb's than others. **Bulliform cells** in irregular groups (Fig. XV, 1), especially towards the leaf margins; others in groups rather similar to those in Fig. XV, 2, but cells rather large and extending into the mesophyll; some of the groups tending to be of the *Zea* type (Fig. XV, 3). **Bundle-sheaths** single; complete round all vb's.

CULM

Culm examined about 3 mm in diameter exhibiting the following characters. Epidermis subtended by a continuous ring of about 5 layers of fibres, the ground tissue on the inner side of this ring consisting of much larger cells with thin walls. Vb's consisting of 1 circle of minute strands embedded in the mechanical ring, and 2 more deeply situated circles, some of the vb's of the outer of these 2 circles being at the inner boundary of the cylinder of mechanical tissue. Centre of the culm occupied by a large cavity.

MATERIAL EXAMINED: Supplied specially by G. Jackson from Nyasaland.

Digitaria horizontalis Willd.

LEAF

Abaxial epidermis

Short-cells, over the veins, in rows of more than 5 cells; abundant over, but infrequent or absent between, the veins. Some **silica-bodies** intermediate between cross and dumb-bell shaped (Fig. IA, 17); others dumb-bell shaped, but varying in appearance with the focus (Fig. IB, 21). **Macro-hairs:** long hairs with swollen, sunken, constricted bases (Fig. II, 3), each surrounded by specialized epidermal cells, occasional in the intercostal zones. **Micro-hairs:** length 52–62 (mostly 55–62) μ; basal cell 28–34 μ; distal cell 25–30 μ; basal cell tapering to the proximal end; distal cell tapering to a pointed, somewhat thickened, apex (Fig. VII, 5 and 9). **Prickle-hairs:** small prickles abundant at the sides of the veins and elsewhere in the intercostal zones. **Stomata** mostly with triangular (Fig. IV, 1), but a few with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells:** not much longer than tall, with slightly to moderately sinuous walls (Fig. V, 7*a–b*); interstomatal cells with slightly concave ends (Fig. V, 10*a–b*).

T.S. lamina

Vascular bundles: most vb's small, crowded, angular, often quadrangular (Fig. VIII, 5); a few large vb's of basic type (Fig. VIII, 9–10). **Adaxial surface** more or less smooth (Fig. XIV, 1), but with occasional slight ribs and furrows. **Sclerenchyma:** many of the small vb's, especially those opposite the bulliform cells, not accompanied by scl. (Fig. IX, 1); other small vb's with abaxial strands only; large vb's with adaxial and abaxial strands up to about 6 cells wide and seldom more than 2 or 3 cells high (Fig. IX, 4). **Keel** fairly conspicuous; containing a solitary vb (Fig. XIII, 1), or a large median vb accompanied on either side by about 3 smaller laterals (Fig. XIII, 3). **Mesophyll:** chlorenchyma rather indistinctly radiate in the available material, but probably radiate round most of the vb's when fresh. **Bulliform cells** in irregular groups (Fig. XV, 1) throughout most of the width of the lamina. Adaxial part of the midrib also composed of large, thin-walled, colourless cells. **Bundle-sheaths** single; complete round all vb's (Fig. XI, 2*a–b*).

MATERIAL EXAMINED: Meikle 1000; Nigeria.

Digitaria milanjiana (Rendle) Stapf

LEAF

Abaxial epidermis

Short-cells, at the margins of the veins, solitary or in pairs; those over the veins in rows of more than 5 cells; abundant over, and v. infrequent between, the veins. **Silica-bodies** cross-shaped (Fig. IA, 16), or intermediate between cross and dumb-bell shaped (Fig. IA, 17). **Macro-hairs:** none seen. **Micro-hairs:** length 58–63 μ; basal cell 29–34 μ; distal cell 24–34 (mostly 28–34) μ; basal cell somewhat inflated but tapering towards its proximal end; distal cell tapering to an acutely pointed, somewhat thickened apex (Fig. VII, 5, or tending towards Fig. VII, 9). **Prickle-hairs:** small prickles (Fig. VI, 1) frequent at the sides of the veins. **Stomata** mostly with triangular (Fig. IV, 1), and others with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells:** some relatively short, with thin non-sinuous walls (Fig. V, 4*a–b*); others nearly or quite cubical, with v. slightly sinuous walls (Fig. V, 7*a–b*); interstomatal cells with concave ends (Fig. V, 10*a–b*).

T.S. lamina

Vascular bundles: most vb's small, crowded, angular, often quadrangular (Fig. VIII, 5); a few large vb's of basic type (Fig. VIII, 10). **Adaxial surface** practically smooth (Fig. XIV, 1) apart from v. widely spaced slight ribs over the large vb's. Abaxial surface also with numerous low, slightly rounded ribs. **Sclerenchyma:** many small vb's opposite the bulliform cells not accompanied by scl. (Fig. IX, 1); other small vb's opposite the bulliform cells, as well as those in the midrib, with abaxial strands only; large vb's with adaxial and abaxial strands up to about 12 cells wide and only 3–4 cells high (Fig. IX, 5). **Keel** conspicuous; containing 1 large median vb, accompanied on either side by 1 lateral, almost as large, and by about 5 appreciably smaller vb's (Fig. XIII, 3). **Mesophyll:** chlorenchyma indistinctly radiate in the available material, but probably more definitely radiate when fresh. **Bulliform cells** in irregular groups (Fig. XV, 1) throughout most of the width of the lamina. Adaxial part of the midrib also composed of large, thin-walled, colourless cells. **Bundle-sheaths** single; complete round all vb's (Fig. XI, 2*a–b*).

CULM

Culm examined 4 mm in diameter exhibiting the following characters. Epidermis subtended by 2–3 layers of v. thick-walled fibres, followed by a continuous zone of about 4 layers of rounded thin-walled cells, bounded on its inner side by a well-defined ring of mechanical ground tissue about 8 cells wide, with a circle of small vb's embedded in the ring. Ground tissue on the inner side of the mechanical ring consisting of larger cells with thin walls. Vb's, apart from the small ones in the scl. ring, consisting of 2–3 irregular

circles embedded in the inner ground tissue, the vb's of the outermost of the 3 circles being near the inner margin of the mechanical tissue. Additional vb's situated in the inner part of the thin-walled ground tissue, not far from the fairly large cavity at the centre of the culm.

RHIZOME

Rhizome examined 5 mm in diameter exhibiting the following characters. Epidermis subtended by a single layer of fibrous cells followed by a thin-walled parenchymatous zone, about 16 or more cells wide, the cells being mostly oval in outline, and arranged in v. definite radial rows. Parenchymatous zone followed by a sinuous ring of mechanical tissue about 8 cells wide, consisting of v. thick-walled cells. Vb's consisting of a circle of small, densely crowded strands embedded in the scl. ring, and 3 or 4 more or less distinct circles of vb's in the thin-walled ground tissue between the scl. ring and the centre of the rhizome, the vb's in the outermost of the circles enclosed by the mechanical tissue being at the inner boundary of the mechanical ring itself. A number of irregular, intercellular cavities present at the centre of the rhizome.

MATERIAL EXAMINED: Supplied specially by G. Jackson from Nyasaland.

***Digitaria wallichiana* (Wight & Arn.) Stapf**

LEAF

Abaxial epidermis

Short-cells, over the veins, in rows of more than 5 cells; abundant over, and v. infrequent or absent between, the veins. **Silica-bodies** dumb-bell shaped (Fig. IA, 18), but with the ends not much taller than the middle part of each body, the silica-bodies appearing very narrow and horizontally elongated. **Macro-hairs:** v. narrow, slender hairs, with deeply sunken bases with bulbous endings (Fig. II, 2), fairly frequent in the intercostal zones; bases of the hairs surrounded by specialized epidermal cells. **Micro-hairs:** length 66–78 μ; basal cells 23–28 μ; distal cells 36–52 (mostly 36–44) μ; basal cell often tapering towards its proximal end; distal cell tapering to an acutely pointed apex; hairs narrower than in the other spp. of *Digitaria* examined (Fig. VII, 5). **Prickle-hairs:** none seen. **Stomata:** mostly with somewhat triangular (Fig. IV, 1), but others with low (Fig. IV, 3) or tall (Fig. IV, 4) dome-shaped, subsidiary cells. **Long-cells** relatively short, with thin, non-sinuous (Fig. V, 4*a–b*) or slightly sinuous (Fig. V, 3*a–c*), walls.

MATERIAL EXAMINED: Cultivated at Kew.

ADDITIONAL INFORMATION FROM THE LITERATURE

Grob (1896) records, for *D. sanguinalis* (L.) Scop., silica-cells mostly dumb-bell shaped, but sometimes cross-shaped and nodular; the presence of cushion hairs, and of micro-hairs on both surfaces of the leaf. According to Prat (1932), the dumb-bell shaped silica-bodies in his sp. have long middle portions, and he mentions the presence of strongly silicified prickles and hooks. Pée-Laby (1898) mentions the radiate chlorenchyma and poorly developed bulliform cells in the same species. Goosens (1935) refers briefly to the root structure.

The leaf of *D. sanguinalis* Scop. var. *ciliaris* Prain is also described briefly by Sabnis (1921). Characters recorded include the grooved abaxial surface; the scl. forming I-girders with the vb's; the mesophyll with radiate chlorenchyma; the single bundle-sheaths.

SPECIAL NOTE

Prat (1936) rightly emphasizes that the genus exhibits typical panicoid structure. Henrard (1950) found the morphology of minute hairs on the lower lemma to be important in taxonomy.

LITERATURE

Frohnmeyer 1914 (leaf; under *Panicum*); Goosens 1935 (root); Grob 1896 (leaf); Henrard 1950 (monograph of the genus); Holm 1908 (leaf; under *Panicum*); Pée-Laby 1898 (leaf); Prat 1932, 1936 (leaf); Sabnis 1921 (leaf, ecological anatomy).

DIMERIA

DIAGNOSTIC GENERIC CHARACTERS

Short-cells, over the veins, in long rows. Silica-bodies, over the veins, cross to dumb-bell shaped, occasionally nodular. Micro-hairs present in at least 1 sp.; spherical and apparently unicellular. Stomata usually with triangular subsidiary cells. Vascular bundles mostly small, crowded, angular in outline. Mesophyll with distinctly radiate chlorenchyma. Bundle-sheaths single.

SPECIES SPECIALLY EXAMINED

***Dimeria thwaitesii* Hack.**

LEAF

Abaxial epidermis

Short-cells, over the veins, in rows of more than 5 cells; abundant over, but v. infrequent or absent between, the veins. **Silica-bodies** mostly dumb-bell shaped but outline varying with the focus (Fig. IB, 21); sometimes nodular (Fig. IB, 22 (iii)). **Macro-hairs:** none seen. **Micro-hairs:** spherical, apparently unicellular; 9–14 μ long (Fig. VII, 1). **Prickle-hairs:** none seen. **Papillae:** large, thin-walled papillae (Fig. III, 6) abundant on the long-cells, generally only 1 row per cell. **Stomata** generally with triangular (Fig. IV, 1) subsidiary cells. **Long-cells** with thin, rather coarsely sinuous, walls (Fig. V, 3*a–c*).

T.S. lamina

Vascular bundles: most vb's small, often with the xy. and ph. not easily distinguishable (Fig. VIII, 1); other vb's quadrangular or polygonal in outline (Fig. VIII, 5); a few large vb's of basic type (Fig. VIII, 15). **Adaxial surface** smooth (Fig. XIV, 1), apart from a few low and v. widely spaced ribs over the large vb's. **Sclerenchyma:** many of the small vb's not accompanied by scl. (Fig. IX, 1); others with minute adaxial and abaxial strands (Fig. IX, 4), or abaxial strands only; large vb's with v. small adaxial and abaxial girders. **Keel** conspicuous; containing a solitary vb (Fig. XIII, 1), or 1 large median vb accompanied on either side by a smaller lateral (Fig. XIII, 2). **Mesophyll:**

chlorenchyma distinctly radiate round each small vb. **Bulliform cells** in irregular groups as in Fig. XV, 1, practically the whole epidermis consisting of bulliform cells; adaxial part of the midrib consisting of a V-shaped mass of large, colourless cells. **Bundle-sheaths** single; complete round each small vb (Fig. XI, 2*a*); sometimes with a lateral sheath-cell on either side of each vb projecting into the mesophyll, thus giving the sheaths a winged appearance. Large vb's with sheaths interrupted abaxially (Fig. XI, 6).

Culm

Culm examined 1 mm in diameter exhibiting the following characters. Flattened or slightly concave on one side. No well-defined ring of mechanical tissue present, but some of the cells of the peripheral ground tissue smaller in diameter, and with thicker walls, than the cells of the inner ground tissue. Vb's in 2–3 more or less distinct circles.

Material Examined: F. Ballard 1456; Ceylon.

Additional Information from the Literature

For *D. ornithopoda* Trin., Grob (1896) records mostly solitary cork-cells between the veins on the adaxial surface; cross-shaped silica-bodies with deep indentations; cushion hairs amongst the bulliform cells and at the leaf margin; papillae on the abaxial surface.

Special Note

The leaf structure is panicoid.

Literature

Grob 1896 (leaf).

DINEBRA

For *D. retroflexa* (Forsk.) Panz. (under *D. arabica*) Grob (1896) records dumb-bell shaped silica-bodies as dominant, cross-shaped and nodular types being occasional.

DIPLACHNE

Brief mention of *D. fascicularis* (Lam.) Beauv. (Prat 1934) and *D. serotina* (L.) Link. (Duval-Jouve 1875; Pée-Laby 1898) is made in the literature.[1]

Silica-bodies of *D. fascicularis* said to be saddle-shaped over, and cross-shaped, or shaped like knuckle-bones, between, the veins. Micro-hairs present, each with a small, hemispherical distal cell and a longer proximal cell. Long-cells on the abaxial surface with large papillae. *D. serotina* exhibiting mesophyll with radiate chlorenchyma; scl. forming adaxial and abaxial strands (rather than girders) to the vb's.

Special Note

Prat (1934) suggests that this genus, at one time classified in the Festuceae, should be in the Chlorideae. It is difficult to form an opinion whilst so few

[1] *Diplachne serotina* (L.) Link. = *Cleistogenes serotina* (L.) Keng.

anatomical data are available, but it may be noted that the micro-hairs resemble those of *Eragrostis*.

DISTICHLIS

Diagnostic Generic Characters

Short-cells, over and between the veins, solitary and in pairs. Silica-bodies, over the veins, cuboid, rounded or sometimes vaguely saddle-shaped. Micro-hairs present but easily overlooked and probably local; spherical and apparently unicellular. Stomata with triangular and tall dome-shaped subsidiary cells. Vascular bundles mostly small and moderately angular in outline. Mesophyll with distinctly radiate chlorenchyma. Bundle-sheaths double and single.

Species Specially Examined

***Distichlis distichophylla* (Labill.) Fassett**

Leaf

Abaxial epidermis

Short-cells, both over and between the veins, solitary, or sometimes paired, abundant. **Silica-bodies,** between the veins, v. sparse; when present tall and narrow (Fig. I, 4); those over the veins sometimes vaguely saddle-shaped (Fig. I, 5), but many of them more or less cuboid and rounded in outline. **Macro-hairs:** fairly long, stiff hairs, with sunken, swollen, constricted bases (Fig. II, 3) present here and there in the intercostal zones. Similar hairs, with their bases surrounded by large, cushion-like, cells, sometimes occurring on the adaxial surface in the furrows. **Micro-hairs** spherical, apparently unicellular (Fig. VII, 1); 12–15μ long; surrounded by groups of papillae; easily overlooked and probably local. **Prickle-hairs:** none seen. **Papillae:** none seen on the abaxial surface, but adaxial ribs and furrows densely covered with conical papillae. **Stomata** rather infrequent; some with triangular (Fig. IV, 1), and others with tall dome-shaped (Fig. IV, 4), subsidiary cells. **Long-cells:** those over the veins with thin, sinuous walls (Fig. V, 3*a–c*); those between the veins similar but shorter and broader, with v. coarse sinuations (Fig. V, 6).

T.S. lamina

Vascular bundles: most vb's small, and angular (Fig. VIII, 5); some of them less angular; large vb's of basic type (Fig. VIII, 10), sometimes with the phl. partly sclerosed. **Adaxial surface** with numerous closely placed, fairly pronounced ribs with rounded apices, separated from one another by narrow, V-shaped furrows (Fig. XIV, 4). **Sclerenchyma:** small vb's with adaxial and abaxial girders (Fig. IX, 4) up to about 8 cells wide and 4 cells high; large vb's with wider adaxial and abaxial girders (Fig. IX, 5) up to about 16 cells wide and 4 cells high. **Keel** not prominent; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma distinctly radiate, in the form of crescent-shaped strips on either side of each vb. **Bulliform cells** of variable size present in the furrows, but none of them specially large (Fig. XV, 5); some groups connected to the abaxial surface by girders of colourless cells 1–3 cells wide (Fig. XV, 14);

other groups more of the *Sporobolus* type (Fig. XV, 8) but with girders to the abaxial surface (Fig. XV, 13). **Bundle-sheaths** double and single; large vb's either with I.S. complete, and O.S. not quite complete abaxially (Fig. XII, 2), or with O.S. interrupted adaxially and abaxially (Fig. XII, 3*a*). All small vb's with a single complete sheath (Fig. XI, 2*a*), but sheaths somewhat flattened and consisting of appreciably smaller cells where in contact with the abaxial scl. I.S. of small vb's often obscure or absent.

MATERIAL EXAMINED: Supplied specially by W. M. Curtis from Tasmania.

ADDITIONAL INFORMATION FROM THE LITERATURE

Holm (1901–2) has recorded the following information concerning *D. spicata* (L.) Greene. Adaxial surface with deep furrows. Scl. as no more than small adaxial and abaxial strands, but constituent cells thick-walled; no large amount of scl. in the midrib, and only small strands in the leaf margins. Mesophyll with radiate chlorenchyma. Bulliform cells in the adaxial furrows well developed and associated with subjacent colourless cells between the vb's. Bundle-sheaths double; I.S. of strongly thickened cells and complete only around the large vb's; O.S. of large cells with slightly thickened walls. Ph. slightly sclerosed. Maritime and inland specimens of this sp. said to be identical in structure.

Canfield (1934) records the occurrence of a sp. with solid culms from the Jornada Range.

SPECIAL NOTE

Although *Distichlis* has been treated as a member of the Festuceae, it exhibits a number of panicoid characters. The paired short-cells, mostly cuboid or rounded silica-bodies, and the double bundle-sheaths are, however, festucoid rather than panicoid. The anatomical characters are, therefore, intermediate between festucoid and panicoid rather than wholly panicoid as has been implied by Prat (1936).

LITERATURE

Canfield 1934 (culm); Grob 1896 (leaf); Harshberger 1909 (ecological anatomy); Holm 1891*b*, 1901–2 (leaf); Prat 1936) (leaf).

DRAKE-BROCKMANIA

According to Hubbard (1950*c*) the silica-bodies of the leaf epidermis of *D.-B. somalensis* Stapf are dumb-bell or knot-shaped, a fact that suggests affinities with the panicoid grasses (cf. *Heterocarpha* on p. 235).

Hubbard suggests that the concept of the Eragrosteae may need to be broadened so as to include *Drake-Brockmania* rather than leave it in an unnatural position with Festuceae.

LITERATURE

Hubbard 1950*c* (leaf and taxonomy).

DUPONTIA

The following information concerning the leaf of *D. fisheri* R. Br., an Arctic sp. from Spitzbergen, has been recorded by Lohauss (1905).

Epidermis. Prickles alternating with rectangular long-cells over the veins on both surfaces. Intercostal zones of the abaxial epidermis consisting of rectangular or hexagonal long-cells with sinuous, pitted walls, alternating with irregularly rectangular to rounded short-cells with v. sinuous walls. Stomata usually absent from the abaxial surface. *T.S. lamina.* Both surfaces flat. Vascular bundles: large and small vb's present in equal numbers. Sclerenchyma forming I-girders with most vb's, but vb's towards the margins accompanied by strands only; marginal strands of scl. fairly well developed. Mesophyll with chlorenchyma consisting of large cells and clearly differentiated into palisade and spongy portions. Bulliform cells arranged in 1 large group on either side of the midrib. Bundle-sheaths double; I.S.'s to large vb's complete and composed of cells more strongly thickened on the inner than on the outer walls, those round the small vb's being incomplete and restricted to the ph. sides of the vb's; O.S.'s to some of the large vb's interrupted on 1 side by scl; O.S. to the median vb sometimes interrupted both adaxially and abaxially.

SPECIAL NOTE

The leaf structure, although incompletely known, appears to be festucoid.

LITERATURE

Lohauss 1905 (leaf).

ECHINARIA

It has been recorded for the leaf of *E. capitata* (L.) Desf. that the short-cells, both over and between the veins, are paired; that stomata occur in equal numbers on both surfaces, and that bulliform cells are well developed.

LITERATURE

Grob 1896 (leaf); Pée-Laby 1898 (leaf).

ECHINOCHLOA

DIAGNOSTIC GENERIC CHARACTERS

Short-cells, over the veins, in long rows. Silica-bodies, over the veins, variable, including cross to dumb-bell shaped and nodular types. Micro-hairs present; each rather uniform in diameter throughout its length and with a rounded apex. Stomata with triangular, or low dome-shaped, subsidiary cells. Vascular bundles mostly conspicuously angular in outline. Mesophyll with chlorenchyma distinctly radiate. Bundle-sheaths single.

Species Specially Examined

Echinochloa colonum (L.) Link

Leaf

Abaxial epidermis

Short-cells, over the veins, in rows of more than 5 cells; common over, but rare between, the veins, apart from occasional solitary or paired short-cells in the intercostal zones. **Silica-bodies,** over the veins, cross-shaped (Fig. IA, 16), intermediate between cross and dumb-bell shaped (Fig. IA, 17), or dumb-bell shaped (Fig. IA, 18 (ii–iv)); silica-bodies over the small veins more numerous and nodular (Fig. IB, 22 (iii)); intercostal silica-bodies infrequent and cross-shaped (Fig. IA, 16). **Macro-hairs:** none seen. **Micro-hairs:** length 36–48 μ; basal cell 18–25 μ; distal cell 16–25 (mostly 20–25) μ; hairs rather uniform in diameter throughout their lengths and with rounded apices (Fig. VII, 7). **Prickle-hairs:** none seen. **Papillae:** oblique papillae with thickened endings (Fig. III, 2) present on many of the long-cells, some of them tending to overarch the stomata, but only 1 papilla associated with an individual stoma. Adaxial surface also densely covered with papillae. **Stomata** with triangular (Fig. IV, 1), or low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells:** many of those between the veins nearly or quite cubical with slightly sinuous walls (Fig. V, 7*a–b*).

T.S. lamina

Vascular bundles: smallest vb's quadrangular, with the xy. and ph. not easily distinguishable (Fig. VIII, 1); other small vb's pentagonal to hexagonal (Fig. VIII, 4), or polygonal (Fig. VIII, 5); a few large vb's of basic type (Fig. VIII, 10). **Adaxial surface** smooth (Fig. XIV, 1), apart from some groups of bulliform cells extending slightly above the surface. **Sclerenchyma:** some small vb's not accompanied by scl. (Fig. IX, 1); other small vb's with minute adaxial and abaxial strands (Fig. IX, 4); large vb's with adaxial and abaxial girders up to about 6 cells wide and 2 cells high. **Keel** fairly conspicuous; containing 1 large median vb accompanied on either side by 2 or 3 much smaller laterals (Fig. XIII, 3). **Mesophyll:** chlorenchyma distinctly radiate. **Bulliform cells** in irregular groups (Fig. XV, 1). **Bundle-sheaths** single; complete round all vb's (Fig. XI, 2*a–b*).

Culm

Culm examined 3 mm in diameter exhibiting the following characters. Epidermis subtended by 1–2 incomplete layers of fibrous cells followed by a zone of assimilatory tissue, about 4 cells wide, traversed at intervals by scl. girders extending from the vb's of the outermost circle to the epidermis itself. Assimilatory tissue bounded on the inner side by a layer of scl. 1 or 2 cells wide. Ground tissue enclosed within this scl. ring consisting of large, thin-walled cells. Vb's consisting of those of the outermost circle embedded in the chlorenchyma, each vb being provided with a single bundle-sheath; the second circle of vb's on the same radius as the scl. ring at the inner boundary of the assimilatory tissue; 2 or 3 inner circles of vb's embedded in the thin-walled ground tissue. Centre of the culm occupied by a large cavity, with remnants of stellate parenchyma in it.

Material Examined: Collected specially by R. E. Vaughan in Mauritius.

Echinochloa crus-galli (L.) Beauv.

Leaf

Abaxial epidermis (Fig. XXVII, 3)

Short-cells, over the veins, in rows of more than 5 cells; abundant over, but v. infrequent or absent between, the veins. **Silica-bodies,** over the veins, nodular (Fig. IB, 22 (iii)). **Macro-hairs:** none seen. **Micro-hairs:** length 48–60 μ; basal cell 24–30 μ; distal cell 22–30 μ; hairs slightly tapered towards their bases but otherwise rather uniform in diameter throughout their lengths and with rounded apices (Fig. VII, 7). **Prickle-hairs:** none seen. **Papillae:** oblique papillae with thickened endings (Fig. III, 2) present on most of the long-cells, 1 papilla arising from each cell. **Stomata:** mostly with triangular (Fig. IV, 1), but some with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells,** between the veins, mostly relatively short, with thin, non-sinuous walls (Fig. V, 4*a–b*), but a few narrower, slightly longer, and with somewhat sinuous walls (Fig. V, 3*a–c*).

T.S. lamina

Vascular bundles: most vb's small, crowded, angular in outline (Fig. VIII, 5); smallest vb's similar but quadrangular; a few large vb's of basic type (Fig. VIII, 10). **Adaxial surface** practically smooth (Fig. XIV, 1); apart from slight suggestions of ribs over a few of the largest vb's. **Sclerenchyma:** most small vb's not accompanied by scl. (Fig. IX, 1); other small vb's with minute adaxial and abaxial strands (Fig. IX, 4), or with abaxial strands only; large vb's with adaxial and abaxial strands sometimes as much as 6 cells wide and 2 cells high. **Keel** conspicuous, triangular (Fig. XIII, 4; containing 1 large median vb accompanied on either side by 1 large, and 5 or 6 smaller, laterals. **Mesophyll:** chlorenchyma distinctly radiate. **Bulliform cells** in irregular groups (Fig. XV, 1). Adaxial part of the midrib consisting of large, thin-walled, colourless cells. **Bundle-sheaths** single; complete round all vb's (Fig. XI, 2*a–b*).

Culm

Culm examined 5 mm in diameter exhibiting the following characters. More or less oval in T.S. with a slight concave depression at one narrow end, and a shallow V-shaped furrow at the other. Epidermis subtended by about 5–6 layers of locally somewhat spongy assimilatory tissue. Assimilatory tissue bounded on the inner side by a well-defined ring of mechanical tissue, 1–2 cells wide, with fairly thick walls, and moderately wide lumina. Inner ground tissue consisting of large, thin-walled cells. Vb's consisting of an outermost circle of small strands embedded in the assimilatory tissue, the remaining vb's being arranged in about 4 circles, the outermost immediately on the inner side of the scl. ring, and the rest embedded in the thin-walled ground tissue. Centre of

the culm with a fairly large cavity with patches of stellate parenchyma in it, the latter probably representing the remains of transverse plates of this tissue.

MATERIAL EXAMINED: Cultivated at Kew.

ADDITIONAL INFORMATION FROM THE LITERATURE

Duval-Jouve (1875) records the occurrence of air-canals amongst the colourless cells in *E. crus-galli*, particularly in the basal leaves. Transverse veins occur in the leaf of the same spp.

SPECIAL NOTES

The leaf structure is panicoid, as pointed out by Prat (1936).

In the spp. examined by the author, and described above, it is interesting to note that the outermost culm bundles are embedded in chlorenchyma (not scl.). This is unusual amongst grasses as a whole. The stellate parenchyma in the central cavities of the culms is also of interest, and it may represent all that is left of transverse partitions of this tissue across the central cavity.

LITERATURE

Duval-Jouve 1875 (leaf);[1] Holm 1908 (under *Panicum*); Krishnaswami and Rangaswami 1942 (leaf); Pée-Laby 1898 (leaf);[1] Prat 1936 (leaf).

ECTOSPERMA

DIAGNOSTIC GENERIC CHARACTERS

Short-cells, over the veins, in short or long rows. Silica-bodies, over the veins, oblong or rounded. Micro-hairs: none seen. Stomata with low dome-shaped subsidiary cells. Vascular bundles not conspicuously angular in outline; of a distinctive shape (see below). Mesophyll with distinctly radiate chlorenchyma. Bundle-sheaths usually double, but I.S. often inconspicuous.

SPECIES SPECIALLY EXAMINED

***Ectosperma alexandrae* Swallen**

LEAF

Abaxial epidermis

Short-cells, over the veins, mostly in rows of 3–5 or more cells; abundant over, but only in v. infrequent pairs between, the veins. **Silica-bodies,** over the veins, mostly oblong (Fig. I, 8), but a few more nearly circular. **Macro-hairs** and **micro-hairs:** none seen. **Prickle-hairs:** interlocking prickles overlying the stomata in grooves. **Stomata:** only a few visible in the slides examined; with low dome-shaped subsidiary cells (Fig. IV, 3). **Long-cells** relatively short, with thin, non-sinuous walls (Fig. V, 4*a–b*).

T.S. lamina

Vascular bundles: most vb's not conspicuously angular in outline (as Fig. VIII, 2) but shaped rather like hour-glasses because constricted between the xy. and ph. Large vb's of basic type (Fig. VIII, 15), but with partly sclerosed ph. (Fig. VIII, 16). **Adaxial surface** with fairly tall, closely placed, rounded ribs, separated from one another by narrow V-shaped furrows (Fig. XIV, 4). Abaxial surface almost equally ribbed, the ribs on both surfaces, and likewise the furrows, being opposite each other. **Sclerenchyma:** vb's with adaxial and abaxial strands up to about 24 cells wide and 7 or 8 cells high (Fig. IX, 5), the apices of all the ribs on both surfaces being occupied by fibres. **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma distinctly radiate; restricted to circular zones surrounding the vb's. **Bulliform cells:** U-shaped furrows containing bulliform cells of various sizes, but none of them specially large (Fig. XV, 5, *Elymus* type); some groups, at the bases of the furrows, more nearly fan-shaped (Fig. XV, 6). **Bundle-sheaths** single and double; single complete sheaths (Fig. XI, 2*a*) round all small vb's; large vb's apparently with 2 complete sheaths (Fig. XII, 1). Small vb's often with a vague I.S.

[1] As *Panicum crus-galli.*

MATERIAL EXAMINED: A. Kellog 5655; California.

SPECIAL NOTE

The leaf structure is, on the whole, festucoid, but it exhibits some panicoid tendencies, such as the radiate chlorenchyma. The distinctive shape of the vb's is noteworthy.

EHRHARTA

DIAGNOSTIC GENERIC CHARACTERS

The 2 spp. examined by the author have so few characters in common that readers must refer to the species descriptions given below.

SPECIES SPECIALLY EXAMINED

***Ehrharta abyssinica* Hochst.**

LEAF

Abaxial epidermis

Short-cells, over the veins, in rows of more than 5 cells; abundant over, but v. infrequent between, the veins. **Silica-bodies:** a few slightly saddle-shaped (Fig. I, 9), or almost cubical, but with rounded corners; others intermediate between cross and dumb-bell shaped (Fig. IA, 17), shortly dumb-bell shaped (Fig. IB, 20), or dumb-bell shaped, but varying in appearance with the focus (Fig. IB, 21); rarely nodular (Fig. IB, 22 (iii)). **Macro-hairs:** none seen. **Micro-hairs:** length 46–67 (mostly 54–60) μ; basal cells 18–24 μ; distal cells 28–46 (mostly 28–42) μ; distal cell tapering to a slightly rounded or acutely pointed apex (Fig. VII, 4–5). **Prickle-hairs:** prickles (Fig. VI, 1–2) common over the veins. **Stomata** with low (Fig. IV, 3) or tall (Fig. IV, 4) dome-shaped subsidiary cells. **Long-cells,** between the veins, with thin, non-sinuous walls (Fig. V, 2*a–c*); often hexagonal; sometimes rather shorter, with thin, non-sinuous walls (Fig. V, 4*a–b*).

T.S. lamina

Vascular bundles: most vb's small, widely spaced, and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with v. slight, widely spaced, rounded ribs over the veins (Fig. XIV, 2). Abaxial surface with similar ribs opposite those on the adaxial surface. **Sclerenchyma:** small vb's with adaxial and abaxial girders up to about 6 cells wide and 3 cells high (Fig. IX, 4); large vb's with adaxial and abaxial girders up to about 8 cells wide and 3 cells high (Fig. IX, 5). **Keel** conspicuous; containing a solitary vb (Fig. XIII, 1), or 1 large median vb accompanied on either side by 1 slightly smaller lateral (Fig. XIII, 2). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** in well-defined groups as in Fig. XV, 2, especially towards the leaf margins; small groups of the *Zea* type (Fig. XV, 3), and slightly fan-shaped groups (Fig. XV, 4) also present, chiefly towards the midrib. Adaxial part of the midrib consisting of large, colourless, thin-walled cells. **Bundle-sheaths** double; large vb's with I.S. complete, but O.S. not quite complete abaxially (Fig. XII, 2); small vb's with I.S. complete, and O.S. interrupted abaxially, but connected to the adaxial scl. by short extensions consisting of large cells (Fig. XII, 4).

MATERIAL EXAMINED: G. Jackson 181; Nyasaland.

***Ehrharta villosa* Schult. var. *maxima* Stapf**

LEAF

Abaxial epidermis

Short-cells solitary and paired, both over and between the veins; abundant. **Silica-bodies** fitting into concavities in adjacent cork-cells (Fig. I, 6–7), mostly round, oval, or slightly crescent-shaped; those between generally rather taller and narrower than those over the veins. **Macro-hairs:** none seen on the abaxial surface, but fairly short, rigid hairs (Fig. IIA, 6 and 10) present on the ribs on the adaxial surface. **Micro-hairs** and **prickle-hairs:** none seen. **Stomata:** outlines of the subsidiary cells concealed by cuticular projections from the adjacent epidermal cells. **Long-cells** mostly rather short, with thick, coarsely sinuous walls.

T.S. lamina

Vascular bundles: most vb's small, and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with fairly well-developed, rounded ribs (Fig. XIV, 4), of two distinct sizes, associated with the large and small vb's respectively; furrows widely V-shaped and not v. deep. V. slight abaxial ribs over the vb's as well. **Sclerenchyma:** small vb's with tall, narrow, adaxial and abaxial girders (Fig. IX, 7), the adaxial girders being 2 cells wide but broadening at their apices, and about 6 cells high; corresponding abaxial girders mostly at least 4 cells wide and up to 10 cells high; large vb's with rather wider adaxial and abaxial girders (Fig. IX, 5). **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** in fan-shaped groups at the bases of the furrows (Fig. XV, 6). **Bundle-sheaths** double; all vb's with I.S. complete,

and O.S. interrupted abaxially but connected to, and forming girders with, the adaxial scl. (See sclerenchyma.)

MATERIAL EXAMINED: Palmer 1933; W. Australia.

ADDITIONAL INFORMATION FROM THE LITERATURE

Grob (1896) records the following particulars for *E. panicea* Sm. Short-cells, over the scl. of the midrib, paired; those over the scl. elsewhere, in rows. Silica-bodies mostly dumb-bell shaped, but cross-shaped and nodular types also occurring; silica-cells absent from the intercostal zones on both surfaces. Micro-hairs confined to the abaxial surface; mostly near the leaf margins. Bulliform cells absent from the furrows, and replaced by a strand of scl. in each furrow.

SPECIAL NOTE

Prat (1936) considers that the leaf structure is panicoid, but the facts recorded above indicate that the structure is intermediate between festucoid and panicoid.

LITERATURE

Grob 1896 (leaf); Prat 1936 (leaf).

ELEUSINE

DIAGNOSTIC GENERIC CHARACTERS

Short-cells mostly solitary, and occasionally paired, both over and between the veins. Silica-bodies, over the veins, slightly saddle-shaped, but mostly rounded, elliptical, or cross-shaped. Micro-hairs present; each with a sunken stalk and spherical unicellular head (could be classified as sunken papillae). Stomata with markedly triangular subsidiary cells. Mesophyll with distinctly radiate chlorenchyma. Bundle-sheaths double and single.

SPECIES SPECIALLY EXAMINED

***Eleusine coracana* (L.) Gaertn.**

LEAF

Short-cells solitary, both over and between the veins; abundant. **Silica-bodies** tall, narrow (Fig. I, 4), and clearly visible but infrequent in the intercostal short-cells; those over the veins slightly saddle-shaped (Fig. I, 5), but mostly rounded, oval, or tending to be crescent-shaped. **Macro-hairs:** see micro-hairs. **Micro-hairs** resembling sunken papillae or even small, sunken macro-hairs; each consisting of a sunken stalk cell and a spherical unicellular head (Fig. IIA, 13), the heads being 20–25 × 14–17 μ in diameter, as seen in surface view. **Prickle-hairs:** none seen. **Papillae:** see micro-hairs. **Stomata** with markedly triangular subsidiary cells (Fig. IV, 1). **Long-cells,** between the veins, with thin, coarsely sinuous walls (Fig. V, 3*a–c*), but rather short; interstomatal cells with concave ends (Fig. V, 10).

T.S. lamina

Vascular bundles: small and medium-sized vb's angular in outline (Fig. VIII, 5); large vb's of basic type (Fig. VIII, 10), but somewhat polygonal in outline. **Adaxial surface** with slight rounded ribs over the veins, separated from one another by shallow, fairly wide furrows (Fig. XIV, 2). **Sclerenchyma:** some keel bundles with marked abaxial girders only (Fig. IX, 3); small vb's with adaxial and abaxial strands (Fig. IX, 4) about 6 cells wide and 3 cells high, forming girders with the rather massive bundle-sheaths; large vb's with adaxial and abaxial girders up to 20 cells wide, but seldom more than about 6 cells high (Fig. IX, 5). **Keel** conspicuous, triangular; containing numerous vb's of unequal sizes (Fig. XIII, 4). **Mesophyll:** chlorenchyma distinctly radiate immediately around the individual bundles, but tissue below the adaxial furrows not radiate. **Bulliform cells:** groups mostly of the *Sporobolus* type (Fig. XV, 9), or similar, but with the subjacent colourless cells forming girders across the mesophyll to the abaxial epidermis (Fig. XV, 13). **Bundle-sheaths** double and single; large vb's with 2 complete sheaths (Fig. XII, 1); all small vb's with single complete sheaths, but some sheaths connected to the adaxial scl. by adaxial extensions of large cells, i.e. as Fig. XII, 7, but with only 1 sheath. Sheath-cells very large, inflated, and containing bodies resembling large chloroplasts.

CULM

Oval in T.S., the longer diameter of the culm examined being about 1·0 cm. Epidermis subtended by a zone of about 8 layers of thin-walled cells, followed abruptly by a broad ring of scl. about 16 cells wide, the inner part of the scl. ring gradually passing over to the thin-walled ground tissue in the inner part of the culm. Vb's consisting of occasional small strands embedded in the peripheral thin-walled tissue, the outermost regular circle of bundles being at the outer boundary of the scl. ring; remaining vb's arranged in about 5 circles embedded in the inner ground tissue, the latter extending to the few small irregular cavities at the centre of the culm.

MATERIAL EXAMINED: Cultivated at Kew. 2 collections.

***Eleusine indica* (L.) Gaertn.**

LEAF

Abaxial epidermis

Short-cells mostly solitary, but occasionally in pairs, both over and between the veins; abundant. **Silica-bodies,** in the intercostal short-cells, seldom easily visible, but where fully developed, usually tall and narrow (Fig. I, 4); those over the veins saddle-shaped (Fig. I, 5), or tending to be round, oval, or slightly crescent-shaped. **Macro-hairs:** see micro-hairs. **Micro-hairs:** each with a short stalk cell sunken in a slight depression, and a spherical head cell 12–15×7–9 μ in diameter; resembling micro-hairs as in Fig. VII, 2, sunken papillae, or v. small macro-hairs as in Fig. IIA, 13. **Prickle-hairs:** none seen. **Papillae:** see micro-hairs. **Stomata** with markedly triangular subsidiary cells (Fig. IV, 1). **Long-cells,** between the veins, with thin to moderately thick sinuous walls (Fig. V, 3*a–c*); rather short, sometimes tending to be as in Fig. V, 6.

T.S. lamina

Vascular bundles: most vb's small, crowded, angular (Fig. VIII, 5); large vb's of basic type (Fig. VIII, 9) but somewhat angular in outline. **Adaxial surface** with slight, wide, rounded ribs, separated by v. shallow, much narrower furrows (Fig. XIV, 2). **Sclerenchyma:** small vb's with adaxial and abaxial strands (Fig. IX, 4) up to about 8 cells wide and 2–3 cells high, forming girders with the v. massive bundle-sheaths; a few small vb's near the midrib with adaxial girders only (Fig. IX, 3); large vb's with similar, but wider, adaxial and abaxial strands (Fig. IX, 5). **Keel** conspicuous, forming the apex of the V-shaped cross section of the lamina; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma distinctly radiate. **Bulliform cells** in groups of the *Sporobolus* type (Fig. XV, 9), the groups sometimes united to the abaxial epidermis by girders of colourless cells (Fig. XV, 13). **Bundle-sheaths** single and double; large vb's with 2 complete sheaths (Fig. XII, 1); a single complete sheath surrounding each of the small vb's (Fig. XI, 2*a*), the sheaths sometimes having slight adaxial and abaxial extensions to the adjacent scl. strands.

CULM (Vaughan's material)

Oval in T.S.; long diameter of the culm examined 3 mm. Epidermis subtended by a circle of columns of thin-walled tissue, separated from one another by broad girders of scl. extending from the vb's of the outermost circle to the epidermis. Other scl. girders incomplete, being connected to the epidermis at one end but only partly traversing the thin-walled tissue without reaching a vb. Peripheral thin-walled tissue bounded on the inner side by a well-defined ring of fibres forming a sinuous circle of variable width around the culm. Ground tissue, between the fibre ring and the solid centre of the culm, thin-walled. Vb's, besides those of the outermost circle already mentioned, consisting of those in 2 more circles, the vb's in the outer of these 2 circles being in contact with the scl. ring at their xy. ends. Centre of culm devoid of vb's. Each vb of the outermost circle sheathed on either side by large inflated cells, similar to the sheath cells around the small vb's in the leaves.

MATERIAL EXAMINED: (i) Cultivated at Kew, 2 collections. (ii) Collected specially by R. E. Vaughan in Mauritius.

ADDITIONAL INFORMATION FROM THE LITERATURE

Portères's (1951) description of the leaf of *E. coracana* agrees, in the main, with the information given above. Portères illustrates a T.S. of the leaf sheath showing numerous air-lacunae in the mesophyll towards the adaxial surface of the leaf.

Sabnis (1921), referring to the leaf of *E. compressa* (Forsk.) Asch. & Schweinf. (under *E. flagellifera* Nees), gives the following particulars. Adaxial surface deeply grooved. Scl. forming abaxial strands to the small, and abaxial and adaxial girders to the large, vb's; also present as large strands in the blunt leaf margins. Macro-hairs spiny, with their bases embedded amongst the bulliform cells. Mesophyll with radiate chlorenchyma round the small vb's. Bulliform cells and subjacent colourless cells forming girders between the vb's.

Duval-Jouve (1875) refers to transverse veins in the leaf of *E. coracana.*

Special Note

Prat (1932, 1934, 1936) considers that the leaf structure resembles that of *Cynodon* and *Chloris*. Observations by the author confirm this view. *Eleusine* resembles *Dactyloctenium*.

Literature

Duval-Jouve 1875 (leaf); Grob 1896 (leaf); Krishnaswami and Rangaswami 1941 (adventitious roots), 1942 (leaf, ecological anatomy); Portères 1951 (leaf and stem of *E. coracana*); Prat 1932, 1934, 1936 (leaf); Sabnis 1921 (leaf, ecological anatomy).

ELYMUS

Diagnostic Generic Characters

Short-cells, over the veins, mostly solitary or paired, rarely in short rows. Silica-bodies, over the veins, rather variable, sometimes tall, narrow, and more or less rectangular, but more frequently round, elliptical, or slightly crescent-shaped; in some spp. horizontally elongated with rounded ends and smooth or slightly sinuous outlines. Micro-hairs absent. Stomata with low dome-shaped, or parallel-sided, subsidiary cells. Vascular bundles not conspicuously angular in outline. Mesophyll with chlorenchyma not radiate. Bundle-sheaths double.

Species Specially Examined

***Elymus arenarius* L.**

Leaf

Abaxial epidermis

Short-cells, over the veins, solitary and paired; abundant; costal and intercostal zones not easily distinguishable in surface preparations. **Silica-bodies** not standing out clearly in the cells in which situated; both members of a pair of short-cells often equally silicified; sometimes tall and narrow (Fig. I, 4), but mostly more or less rectangular, and appearing smooth or lobed in outline as the focus is varied (Fig. I, 2) (cf. *Cortaderia conspicua* and *Ammophila*). **Macro-hairs :** short, rigid, thick-walled hairs (Fig. IIA, 10) present, chiefly on the sides and apices of the adaxial ribs. **Micro-hairs :** none seen. **Prickle-hairs :** none seen on the abaxial surface, but present on the adaxial ribs. **Stomata** with low dome-shaped subsidiary cells (Fig. IV, 3). **Long-cells** with thick, pitted or sinuous walls (Fig. V, 1*a–b*).

T.S. lamina

Lamina rolled or expanded.

Vascular bundles : small vb's not conspicuously angular in outline (Fig. VIII, 2); large vb's as in Fig. VIII, 18, but showing v. little sclerification of the ph. **Adaxial surface** with v. marked ribs and furrows (Fig. XIV, 7), the ribs being of 2 distinct sizes, the large ones flat-topped and small ones rounded; furrows deeply V- or W-shaped. **Sclerenchyma :** small vb's with well-marked abaxial girders only (Fig. IX, 3), the girders being up to about 9 cells wide and 12 cells high; large vb's with tall-stemmed adaxial T-, and abaxial I-girders (Fig. IX, 8) (see also under bundle-sheaths). **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll :** chlorenchyma not radiate. **Bulliform cells** of variable sizes, but none of them specially large, in V-shaped adaxial furrows (Fig. XV, 5, *Elymus* type). **Bundle-sheaths** double; most vb's with I.S. complete, and O.S. interrupted adaxially and abaxially (Fig. XII, 3*a–b*); large vb's more as in Fig. XII, 7, the O.S. extending towards the adaxial surface. (It is often difficult to decide how far the adaxial girders consist of scl. and how far of bundle-sheath cells. See also under sclerenchyma.)

Rhizome

Rhizome examined about 3 mm in diameter. Epidermis subtended by small columns of fibres, often about 4 cells in diameter, at intervals around the culm, and by a zone of thin-walled, or sometimes collenchymatous, tissue about 12 cells wide, followed in turn by a ring of highly lignified fibres about 5 cells wide. Ground tissue immediately on the inner side of this ring of fibres also lignified, but cell-walls much thinner than those of the fibres in the scl. ring. Inner ground tissue gradually becoming less lignified towards the large hollow cavity at the centre of the rhizome. Vb's consisting of a v. reduced series embedded in the subepidermal fibre columns, the remainder being in about 3 rather vaguely defined circles, the outlines of all but the innermost vb's being obscured by the surrounding lignified ground tissue.

Material Examined: From the English Coast.

***Elymus canadensis* L.**

Leaf

Abaxial epidermis

Short-cells mostly in pairs, both over and between the veins; abundant. **Silica-bodies** each fitting into a concavity in an adjacent cork-cell (Fig. I, 6–7), and round, oval, or slightly crescent-shaped. Distal cell more silicified than the proximal cell of each pair (cf. *E. arenarius*). **Macro-hairs** and **micro-hairs :** none seen. **Prickle-hairs :** prickles common over the veins (Fig. VI, 1–2). **Stomata** with low dome-shaped subsidiary cells (Fig. IV, 3). **Long-cells,** between the veins, with thin sinuous walls (Fig. V, 3*a–c*).

T.S. lamina

Vascular bundles : most vb's small and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 10). **Adaxial surface** practically smooth (Fig. XIV, 1), apart from slight suggestions of ribs over the vb's. Slight abaxial ribs also present over the large vb's. **Sclerenchyma :** occasional small vb's each with a well-marked abaxial girder only (Fig. IX, 3); most small vb's with adaxial and abaxial girders up to about 6 cells wide and high (Fig. IX, 4); large vb's with adaxial and abaxial girders wider (Fig. IX, 5), but about the same height. **Keel** fairly conspicuous; containing a solitary vb (Fig. XIII, 1) or 1 large median vb accompanied on either side by a smaller lateral. **Mesophyll :** chlorenchyma not radiate. **Bulliform cells** in well-defined groups as in Fig. XV, 2; also a few fan-shaped groups (Fig. XV, 4).

Bundle-sheaths double; large vb's with I.S. complete and O.S. interrupted adaxially and abaxially (Fig. XII, 3*a*); most small vb's with I.S. complete and O.S. interrupted abaxially (Fig. XII, 2).

CULM

Culm examined 3 mm in diameter. Epidermis subtended by small columns of assimilatory tissue embedded in a ring of scl. about 10 cells wide. Girders of tissue consisting of cells of smaller diameter, and with thicker walls than those of the cells of the scl. ring just described, connect the vb's of the outermost circle to the epidermis. Ground tissue on the inner side of the scl. ring consisting of large cells with fairly thin walls, the centre of the culm being occupied by a fairly wide cavity. Vb's in 3 more or less distinct circles, those of the outermost circle being embedded in the peripheral scl.; those of the second circle having their outer boundaries in contact with the inner boundary of the scl. ring, the innermost vb's being embedded in the thin-walled ground tissue.

MATERIAL EXAMINED: Cultivated at Kew.

Elymus caput-medusae L. = *Taeniatherum caput-medusae* (L.) Nevski

LEAF

Abaxial epidermis

Short-cells, both over and between the veins, mostly paired, sometimes solitary; a few of those over the veins in rows of 3–5 cells. **Silica-bodies** each fitting into a concavity in an adjacent cork-cell (Fig. I, 6–7), many of them rounded, oval, slightly crescent-shaped, or, more rarely, oblong (Fig. I, 8). More elongated silica-bodies with sinuous outlines (Fig. IA, 14–15) observed in certain preparations. **Macro-hairs** and **micro-hairs:** none seen. **Prickle-hairs:** pointed angular prickles (Fig. VI, 3) present at the leaf margins. **Stomata** sometimes tending to have parallel-sided (Fig. IV, 2), but mostly with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells:** some of those between the veins with thin, non-sinuous or only slightly sinuous, walls (Fig. V, 2*a–c*), the cells sometimes being narrower at the ends than in the middle; others, chiefly in the stomatal strips, with thin, more coarsely sinuous walls (Fig. V, 3*a–c*).

T.S. lamina

Vascular bundles: most small vb's not conspicuously angular in outline (Fig. VIII, 2); a few large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with slight, fairly wide, rounded ribs, and narrower, shallow furrows (Fig. XIV, 2). **Sclerenchyma:** smallest vb's, especially near the leaf margins, sometimes not accompanied by scl. (Fig. IX, 1); a few vb's with minute adaxial strands only (Fig. IX, 2); other small vb's with adaxial and abaxial strands only a few cells high and wide (Fig. IX, 4), the abaxial scl. occasionally forming minute strands with the vb's; large vb's with adaxial and abaxial girders up to about 12 cells wide and 6 cells high. **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** in fan-shaped groups (Fig. XV, 6), or groups as in Fig. XV, 2. **Bundle-sheaths** double; most vb's with the I.S. complete and O.S. not quite complete, or inconspicuous, abaxially (Fig. XII, 2); large vb's with the I.S. complete and O.S. interrupted adaxially and abaxially (Fig. XII, 3*a*).

CULM

Culm examined about 1 mm in diameter. No well-defined scl. ring present, but cells of the ground tissue gradually increasing in diameter from the epidermis to the large hollow cavity at the centre of the culm. Vb's of the outermost circle united to the epidermis by scl. girders about 3 or 4 cells wide. Remaining vb's in 2 more or less distinct circles.

MATERIAL EXAMINED: Cultivated at Kew.

Elymus condensatus J. & C. Presl

LEAF

Abaxial epidermis (Fig. XXIX, 2)

Short-cells mostly paired, but sometimes solitary, both over and between the veins; abundant. **Silica-bodies:** some tall and narrow (Fig. I, 4); others, each fitting into a concavity in an adjacent cork-cell (Fig. I, 6–7), oval or circular in outline. **Macro-hairs:** a few, v. short, thick-walled hairs on the adaxial surface (Fig. IIA, 10). **Micro-hairs** and **prickle-hairs:** none seen. **Stomata** with parallel-sided (Fig. IV, 2), or low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells** between the veins with thin sinuous walls (Fig. V, 3*a–c*).

T.S. lamina

Vascular bundles: most vb's small, and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 10), some of them with partly sclerosed ph. (Fig. VIII, 16). **Adaxial surface** with slight, fairly wide, rounded to slightly triangular ribs, and wide, shallow furrows. **Sclerenchyma:** some small vb's with well-developed abaxial strands only (Fig. IX, 3); many small vb's with adaxial girders up to about 10 cells high, but only 1–3 cells wide, the abaxial girders being slightly shorter and wider (Fig. IX, 7); large vb's with adaxial and abaxial girders up to about 10 cells high and 5–10 cells wide. **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** mostly in well-defined groups as in Fig. XV, 2. **Bundle-sheaths** double; most large vb's with I.S. complete and O.S. interrupted adaxially and abaxially (Fig. XII, 3*a*); small vb's with I.S. complete and O.S. interrupted abaxially only (Fig. XII, 2).

CULM

Culm examined 0·5 cm in diameter. Epidermis subtended by large flattened columns of assimilatory tissue, separated from one another by scl. girders extending from the vb's of the outer ring to the epidermis. Scl. ring not v. well defined but represented by a zone of about 6 layers of fairly thick-walled cells at the inner boundary of the assimilatory tissue. Ground tissue on the inner side of the scl. ring consisting of cells with increasingly wide diameters and

thinner walls on passing towards the almost solid centre of the culm, containing some irregular cavities. Vb's of the outermost circle embedded in scl.; remaining vb's in 2–3 circles embedded in the outer part of the thin-walled ground tissue.

MATERIAL EXAMINED: Cultivated at Kew.

***Elymus interruptus* Buckl.**

LEAF

Abaxial epidermis

Short-cells, over the veins, mostly solitary; infrequent over, and v. infrequent or absent between, the veins. **Silica-bodies** horizontally elongated, with rounded ends and smooth (Fig. IA, 12), or slightly sinuous (Fig. IA, 14–15), outlines. **Macro-hairs** and **micro-hairs:** none seen. **Prickle-hairs:** numerous, often v. large, prickles (Fig. VI, 2) present over the veins, and hooks (Fig. VI, 5) abundant between them. **Stomata** with more or less parallel-sided (Fig. IV, 2) or low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells** with thin non-sinuous walls (Fig. V, 2*a–c*), many of the cells being somewhat hexagonal.

T.S. lamina

Vascular bundles: most vb's small and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 10). **Adaxial surface** smooth (Fig. XIV, 1), apart from slight, v. widely spaced ribs over the larger veins. **Sclerenchyma:** a few of the smallest vb's not accompanied by scl. (Fig. IX, 1); most small vb's with adaxial and abaxial girders often 3–4 cells wide and high, but sometimes rather shorter and narrower (Fig. IX, 4); large vb's with adaxial and abaxial girders rather wider but about the same height (Fig. IX, 5). **Keel** conspicuous; containing 1 large median vb accompanied on either side by a slightly smaller lateral, and 1 or 2 v. small supplementary strands (Fig. XIII, 2). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** mostly in groups as in Fig. XV, 2. **Bundle-sheaths** double; large vb's with I.S. complete, and O.S. interrupted adaxially and abaxially (Fig. XII, 3*a*); small vb's with I.S. complete and O.S. not quite complete abaxially (Fig. XII, 2); a few large vb's in and near the keel, with the O.S. connected to the adaxial scl. by extensions consisting of thin-walled cells (Fig. XII, 4).

CULM

Culm examined 3 mm in diameter. Epidermis subtended by rather small columns of assimilatory tissue mostly situated on either side of the vb's of the outermost circle, the vb's themselves being connected to the epidermis by short scl. girders. Assimilatory tissue bounded on its inner side by a scl. ring about 6 cells wide, the narrow zone of ground tissue between the scl. ring and the large, hollow cavity at the centre of the culm being of thin-walled cells. Vb's consisting of those of the outermost circle embedded in the scl. ring, and 2 circles of large vb's in the thin-walled, inner ground tissue.

MATERIAL EXAMINED: Cultivated at Kew.

***Elymus virginicus* L.**

LEAF

Abaxial epidermis

Short-cells, both over and between the veins, mostly solitary, but occasionally paired, or, over the veins, in short rows; generally common, but very infrequent or absent in some of the intercostal zones; short-cells between the veins seldom containing conspicuous silica-bodies. A few **silica-bodies** tall and narrow (Fig. I, 4), but mostly horizontally elongated, with rounded ends and smooth (Fig. IA, 12–13), or occasionally sinuous (Fig. IA, 14–15), outlines; a few fitting into concavities in the adjacent cork-cells (Fig. I, 6–7), and rounded, oval, or slightly crescent-shaped. **Macro-hairs** and **micro-hairs:** none seen. **Prickle-hairs:** prickles (Fig. VI, 1–2) abundant over, and hooks (Fig. VI, 5) between, the veins. **Stomata** mostly with parallel-sided (Fig. IV, 2), but some with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells,** immediately on either side of the veins, with thin, sinuous walls (Fig. V, 3*a–c*); those more in the middle of the intercostal zones with thin, non-sinuous walls (Fig. V, 2*a–c*).

T.S. lamina

Vascular bundles: most vb's small and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 10). **Adaxial surface** with slight, wide, rounded ribs, and rather wide, shallow furrows (Fig. XIV, 2). **Sclerenchyma:** small vb's with adaxial and abaxial girders (rarely strands), mostly 2–3 cells wide and up to 5 or 6 cells high, the adaxial often being rather narrower than the abaxial girders (Fig. IX, 4); large vb's with slightly wider adaxial and abaxial girders, some of them being up to 8 cells wide (Fig. IX, 5). **Keel** scarcely conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** in well-defined groups as in Fig. XV, 2. **Bundle-sheaths** double; some large vb's each with I.S. complete and O.S. interrupted adaxially and abaxially (Fig. XII, 3*a*); other large, and all small, vb's with the O.S. interrupted abaxially (Fig. XII, 2).

CULM

Culm examined 4 mm in diameter. Epidermis subtended by a zone of thick-walled fibres about 10 cells wide, a few v. narrow plates of thin-walled cells being embedded amongst the fibres. Inner ground tissue of larger cells with thinner unlignified walls. Vb's in 3 circles, those of the outermost circle embedded in the peripheral scl.; those of the other 2 circles embedded in the thin-walled ground tissue, a few of the outermost of these vb's being directly in contact with inner margin of the peripheral scl. ring. Centre of the culm occupied by a large cavity.

MATERIAL EXAMINED: Cultivated at Kew.

ADDITIONAL INFORMATION FROM THE LITERATURE

Rywosch (1909), who examined the roots of *E. arenarius* and other grasses, records that, in this sp., there is a continuous pericycle and indicates that the lateral roots arise in the same way as in *Zea* and *Panicum*.

Special Notes

Prat (1932) notes the similarity in epidermal structure between *E. junceus* Fischer and *Agropyron junceum* (L.) Beauv. The structural features observed by the present author confirm Prat's (1936) opinion that the leaf characters in *Elymus* are festucoid. The spp. appear to fall into groups characterized by different types of subsidiary cells.

It is noteworthy that the silica-bodies, e.g. in *E. arenarius*, are similar to those of *Cortaderia* and *Ammophila*.

Literature

Bond 1952 (leaf); Burr and Turner 1933 (leaf); Duval-Jouve 1875 (leaf); Frohnmeyer 1914 (silica deposition); Grob 1896 (leaf); Lewton-Brain 1904 (leaf); Pée-Laby 1898 (leaf); Prat 1932, 1936 (leaf); Rywosch 1909 (roots); Vrede 1930 (leaf rolling).

ELYONURUS

Diagnostic Generic Characters

Short-cells, over the veins, mostly paired, but some in short or long rows. Silica-bodies, over the veins, mostly intermediate between cross and dumb-bell shaped, more rarely dumb-bell shaped or nodular. Micro-hairs present; each with the distal cell tapering slightly to a rounded or pointed apex. Stomata with triangular or tall dome-shaped subsidiary cells. Vascular bundles mostly small, crowded, and angular in outline. Mesophyll with the chlorenchyma distinctly or indistinctly radiate. Bundle-sheaths single.

Species Specially Examined

***Elyonurus chevalieri* Stapf**

Leaf

Abaxial epidermis

Short-cells, between the veins, mostly paired, but sometimes solitary; those over the veins also mostly paired, but some in rows of 3–5, or occasionally more, cells; abundant. **Silica-bodies,** between the veins sometimes tall and narrow (Fig. I, 4), others elliptical or rounded in outline and fitting into concavities in adjacent cork-cells (Fig. I, 6–7). Silica-bodies, over the veins, mostly intermediate between cross and dumb-bell shaped (Fig. Ia, 17), but a few nodular (Fig. Ib, 22 (iii)). **Macro-hairs:** short, rigid, thick-walled hairs with deeply sunken bases (Fig. IIa, 12) present, especially over the veins on the adaxial surface, the bases of the hairs being surrounded by the bulliform cells. **Micro-hairs** very infrequent; length 45–54 μ; basal cell 22–30 μ; distal cell 22–33 (mostly 22–30) μ; hairs v. wide in relation to their length; distal cell usually tapering somewhat to a rounded apex; more or less as Fig. VII, 6, but both cells of each hair more nearly equal in length. **Prickle-hairs:** none seen. **Stomata** sometimes with triangular (Fig. IV, 1), but mostly with tall dome-shaped (Fig. IV, 4), subsidiary cells. **Long-cells,** between the veins, mostly with thin, sinuous walls (Fig. V, 3*a–c*), many of the cells tending to be hexagonal; those over the veins narrower, and with thicker, sinuous walls.

T.S. lamina

Vascular bundles: most vb's small, crowded, and angular (Fig. VIII, 5); large vb's of basic type (Fig. VIII, 11). **Adaxial surface** smooth (Fig. XIV, 1). **Sclerenchyma:** numerous small vb's not accompanied by scl. (Fig. IX, 1); large vb's with adaxial and abaxial girders (Fig. IX, 4), the adaxial girders seldom being more than about 3–4 cells wide and high, but with the individual cells of fairly wide diameter; abaxial girders generally at least 10 cells wide and about 3 cells high. **Keel** fairly conspicuous; containing 3 main vb's (Fig. XIII, 2). **Mesophyll:** chlorenchyma distinctly radiate. **Bulliform cells** in irregular groups as in Fig. XV, 1, throughout the width of the lamina; adaxial half of the mesophyll consisting of colourless cells (*Chloris* type, Fig. XV, 11). **Bundle-sheaths** single; all small vb's with complete sheaths (Fig. XI, 2*a*); sheaths round the large vb's interrupted abaxially (Fig. XI, 6); sheaths of some vb's, both large and small, connected to the adaxial scl. or epidermis by a few specially conspicuous colourless cells.

Material Examined: Meikle 1227; Nigeria.

***Elyonurus hirtifolius* Hack.**

Leaf

Abaxial epidermis

Short-cells, all between, and some over, the veins, solitary or paired; most of those over the veins in rows of more than 5 cells; abundant. Some **silica-bodies,** between the veins, tall and narrow (Fig. I, 4); others, fitting into concavities in adjacent cork-cells (Fig. I, 6–7), mostly rounded, elliptical, or slightly crescent-shaped; those in rows over the veins intermediate between cross and dumb-bell shaped (Fig. Ia, 17), or dumb-bell shaped (Fig. Ia, 18 (ii–iv)). **Macro-hairs:** long, stiff hairs, with superficial, swollen bases (Fig. II, 1), common in the intercostal zones, the hair bases being surrounded by specialized epidermal cells. **Micro-hairs:** length 58–80 (mostly 60–78) μ; basal cells 26–36 μ; distal cells 30–51 (mostly 36–48) μ; distal cells tapering slightly to pointed apices (Fig. VII, 5). **Prickle-hairs:** prickles (Fig. VI, 1–2) abundant near the leaf margins, and a few elsewhere; hooks (Fig. VI, 5) present between some of the veins; angular prickles (Fig. VI, 3) also present at the leaf margins. **Stomata** mostly with triangular subsidiary cells (Fig. IV, 1). **Long-cells,** between the veins, with fairly thin, coarsely sinuous walls (Fig. V, 3*a–c*); some cells in the middle of the intercostal zones inflated (Fig. V, 5).

T.S. lamina

Vascular bundles: most small vb's crowded, angular (Fig. VIII, 5); a few large vb's of basic type (Fig. VIII, 11). **Adaxial surface** smooth (Fig. XIV, 1). **Sclerenchyma:** most small vb's not accompanied by scl. (Fig. IX, 1); other small vb's with adaxial strands or girders only (Fig. IX, 2), each strand or girder consisting of only a few cells; large vb's usually with abaxial girders only, the girders being up to about 9 cells wide. **Keel** conspicuous, narrow; containing 1 large median vb accompanied on either side by at least 1 lateral (Fig. XIII, 2). **Mesophyll:** chlorenchyma indistinctly radiate in the material

available. **Bulliform cells** in irregular groups (Fig. XV, 1) throughout the width of the lamina; also 1 v. large, fan-shaped group (Fig. XV, 4) in a furrow in the adaxial surface of the midrib. **Bundle-sheaths** single; complete round all vb's (Fig. XI, 2*a–b*), but some vb's, both large and small, connected to the adaxial scl., or even to the epidermis, by short extensions of the sheath cells (as Fig. XII, 6 but with no I.S.).

MATERIAL EXAMINED: Meikle 1385; Nigeria.

ADDITIONAL INFORMATION FROM THE LITERATURE

Sabnis (1921), describing the leaf of *E. royleanus* Nees from the ecological standpoint, noted the following characters. Surface not grooved. Scl. forming abaxial girders to the large vb's; none associated with the small vb's; small strands in the leaf margins. Long macro-hairs on the adaxial surface only. Mesophyll with radiate chlorenchyma round the small vb's. Bulliform cells on the adaxial surface in irregular groups.

Some particulars of the leaf structure of *E. candidus* Hack. and *E. argenteus* Nees, respectively, have been recorded by Grob (1896) and Günzel (1912). The leaves of these spp. are v. similar to those of the spp. described above.

SPECIAL NOTE

The facts confirm Prat's opinion that the leaf structure in this genus is panicoid. It is often placed in the Andropogoneae.

LITERATURE

Goosens 1935 (a few notes on root structure); Grob 1896 (leaf); Günzel 1912 (leaf); Prat 1936 (leaf); Sabnis 1921.

ELYTROPHORUS

DIAGNOSTIC GENERIC CHARACTERS

Short-cells, over the veins, in rows. Silica-cells (and presumably the silica-bodies) nodular. Micro-hairs, each consisting of a relatively short basal cell and a long distal cell tapering to a rounded apex, present on the leaves and culms. Mesophyll with chlorenchyma not radiate; including air-lacunae between the veins. Bundle-sheaths; those of the large vb's inconspicuously double; those of the small vb's single.

ADDITIONAL INFORMATION FROM THE LITERATURE

The most complete description of a species of *Elytrophorus* is that published by Schweickerdt (1942) for *E. spicatus* (Willd.) A. Camus. The description was based on dried material (Dintner 7420), and Schweickerdt points out that the aerenchyma was imperfectly preserved.

(1) *E. spicatus* (Willd.) A. Camus

LEAF

(*a*) *Sheath* (*T.S.*)

Scl. present as small abaxial girders to all of the vb's, the sizes of the girders being proportional to those of the vb's. Other abaxial strands of scl. also present between

the vb's. Keel poorly developed. Mesophyll with chlorenchyma restricted to narrow strips subjacent to the abaxial epidermis, each strip being separated from the next at either end by a vb and its accompanying scl. Chlorenchyma bounded on its inner (adaxial) face by a row of well-developed air-lacunae, one lacuna being present between each pair of vb's, the lacunae themselves being interrupted at intervals by transverse plates of aerenchymatous cells.

(*b*) *Lamina*

(i) *Epidermis.* Short-cells, over the veins, in longitudinal rows of more than 5 cells, alternate cells in each longitudinal file being silica-cells and cork-cells respectively. Silica-cells figured as being nodular in outline, the silica-bodies presumably being of the same shape. No short-cells figured in the intercostal zones. Micro-hairs: each figured as consisting of a relatively short basal cell and a longer distal cell, present in the intercostal zones. Prickle-hairs: occasional prickles present over the veins, and stated to be mostly on the adaxial surface. Stomata figured as having low dome-shaped subsidiary cells. Bulliform cells, in groups of 5–7 cells, present between the vb's. Long-cells, between the veins, figured as having thin, non-sinuous walls, some of the cells narrowing towards their ends. Certain files over the veins also consisting of long-cells, but cells more sinuous in outline than those between the veins.

(ii) *T.S. lamina* (from the top of the lowest third of the blade). Both surfaces ribbed. Vascular bundles: about 5–7 large vb's alternating with 6–8 small vb's. Scl. chiefly present as small adaxial and abaxial strands opposite the vb's, the abaxial being somewhat larger than the adaxial strands, and sometimes uniting with the outer bundle-sheaths to form girders. Small strands immediately subjacent to the abaxial epidermis also present between the vb's. Similar intercostal strands not observed by Schweickerdt in material of the same sp. from Australia. Well-developed scl. strands also present in the leaf margins. Keel not pronounced. Mesophyll with non-radiate chlorenchyma lying above and below, or sometimes surrounding, the air-lacunae, the latter arranged in a single row situated in the middle of the mesophyll, there being a single lacuna between each pair of vb's. Lacunae traversed at intervals by plates of colourless aerenchymatous cells. Bundle-sheaths: those of the large vb's double, the I.S. consisting of v. slightly lignified cells; sheaths to the small vb's single; outer sheaths commonly abutting directly on to the abaxial scl. strands and united to the adaxial scl. strands by girder-like extensions consisting of colourless cells, the O.S. and the accompanying colourless cells thus forming pear-shaped groups.

CULM

Epidermis with weakly developed cuticle; subtended by small strands of scl., generally below the micro-hairs (see 'leaf'). Cortex aerenchymatous, similar to but less extensive than the aerenchyma of the root cortex. Innermost layer of cortical cells resembling an endodermis. Endodermal layer bounded on the inner side by a broad circle of fibrous ground tissue with vb's of 2 distinct sizes embedded in it, the large ones being mostly situated along the inner periphery of the scl. ground tissue. Centre of the culm occupied by a solid parenchymatous ground tissue consisting of polygonal cells with small intercellular spaces between them.

ROOT

Remains of a piliferous layer still visible. Exodermis (hypodermis) consisting of a single layer of cells with outer and inner tangential walls more thickened than the radial walls. Cortex largely aerenchymatous and consisting of radially arranged, longitudinal, intercellular cavities separated from one another by vertical plates of radially elongated cells, each plate being 1 cell wide. Similar tangential plates also present here and there, and, with the radial plates just described, forming a network,

the meshes being occupied by the intercellular spaces. Endodermis well developed, figured as consisting of cells with the inner tangential walls strongly thickened; including some passage cells. Stele stated to exhibit no special features.

(2) *E. africanus* H. G. Schweickerdt

Lamina differing from that of *E. spicatus* in the following respects. Both surfaces flat or not more than v. slightly undulating. Bulliform cells restricted to 2 groups of 9–11 cells, 1 group being situated on either side of, and immediately adjacent to, the midrib. Vb's consisting of 7–9 large, alternating with 10–18 small, vb's.

MATERIAL EXAMINED: Phillips 2288.

(3) *E. interruptus* Pilger.

Lamina differing from that of *E. spicatus* in the following respects. Both surfaces flat or somewhat undulate. Bulliform cells present as inconspicuous groups of 7–9 cells flanking the midrib and between the next few adjacent vb's. Vb's consisting of 5–7 large, alternating with 6–8 small, vb's.

MATERIAL EXAMINED: Braun 112.

(4) *E. globularis* Hack.

Structure of the lamina difficult to distinguish from that of *E. interruptus*.

MATERIAL EXAMINED: van Son in TRV 28600.

SPECIAL NOTE

There has been considerable discussion concerning whether *Elytrophorus* should be in the Festuceae or Eragrosteae. The leaf anatomy clearly indicates that there is no reason for regarding it as a member of the Festuceae, and the Eragrosteae appear to be a more likely affinity. The air-lacunae denote that the grasses are hygrophytes and give no clue to their affinities.

LITERATURE

Prat 1936 (leaf); Schweickerdt 1942 (whole plant).

ENNEAPOGON

DIAGNOSTIC GENERIC CHARACTERS

Short-cells, over the veins, mostly in long rows. Silica-bodies, over the veins, mostly cross to dumb-bell shaped, or occasionally nodular. Macro-hairs of a highly distinctive type, each consisting of a long, narrow, stalk cell, and an oval, unicellular, glandular head. Stomata with triangular or low dome-shaped subsidiary cells. Vascular bundles mostly crowded and angular in outline. Mesophyll with radiate chlorenchyma. Bundle-sheaths single and double.

SPECIES SPECIALLY EXAMINED

***Enneapogon cenchroides* (Licht. ex Roem. & Schult.) C. E. Hubbard**

LEAF

Abaxial epidermis (Fig. XXV, 3)

Short-cells, over the veins, mostly in rows of more than 5 cells, but sometimes appearing to be solitary when separated from one another in a particular file of cells by rather long intervening cells; abundant over, but infrequent, or absent, between, the veins. Some **silica-bodies** intermediate between cross and dumb-bell shaped (Fig. IA, 17); others dumb-bell shaped (Fig. IA, 18 (ii–iv)); a few nodular (Fig. IB, 22 (iii)). **Macro-hairs:** present as stalked, glandular hairs of a special type (Fig. IIA, 8), the base of each hair being accompanied on one side by a more or less oval, nucleate, epidermal cell. (These structures could be classified as micro-hairs because they are 2-celled, but they are much longer than most micro-hairs.) Also, long, v. fine, slender hairs, tapering to v. fine apices, abundant between the veins. **Micro-hairs:** none seen, but see under 'macro-hairs'. **Prickle-hairs:** prickles (Fig. VI, 1–2) v. frequent, especially over the small vb's. **Stomata** with triangular (Fig. IV, 1), or low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells,** between the veins, with thin, sinuous walls (Fig. V, 3*a–c*).

T.S. lamina

Vascular bundles: most vb's small, crowded, angular (Fig. VIII, 5); a few large vb's of basic type (Fig. VIII, 10). **Adaxial surface** practically smooth (Fig. XIV, 1), apart from v. slight, widely spaced ribs over the large vb's. **Sclerenchyma:** a few of the small vb's not accompanied by scl. (Fig. IX, 1); others with small adaxial and abaxial strands (Fig. IX, 4) up to about 5 cells wide and 2 cells high; large vb's with slightly taller and wider adaxial and abaxial girders (Fig. IX, 5). **Keel** fairly conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll** with radiate chlorenchyma. **Bulliform cells** in fan-shaped groups (Fig. XV, 4) and groups of the *Sporobolus* type (Fig. XV, 8). **Bundle-sheaths** single and double; a single complete sheath (Fig. XI, 2*a*) round each small vb; cells in the individual sheaths of rather variable diameters; large vb's with I.S. complete and O.S. interrupted adaxially and abaxially (Fig. XII, 3*a*).

CULM

Culm examined 3 mm in diameter. Epidermis bearing stalked glandular hairs, similar to those on the leaves, and subtended by a layer of assimilatory tissue, 1–2 cells wide, this layer being interrupted at intervals by scl. girders extending from each vb of the outermost circle to the epidermis. Assimilatory tissue bounded on the inner side by a ring of 5–6 layers of fibres, the inner boundary of the ring being ill defined, the cells gradually changing over to the thin-walled, inner ground tissue surrounding the large central cavity of the culm. Vb's in 3 more or less distinct circles, those of the outermost circle being much smaller than the others and embedded in the peripheral scl. ring; inner vb's embedded in the thin-walled ground tissue.

ADDITIONAL INFORMATION FROM THE LITERATURE

Günzel (1912) has recorded the following information. *E. scaber* Lehm. (as *Pappophorum scabrum* Kunth.). *T.S. lamina.* Adaxial surface with slight, and abaxial surface with more pronounced, ribs. Scl. present both above and below the vb's. Bundle-sheaths stated to be double. *Epidermis.* Macro-hairs of a special type present between the bulliform cells, each hair consisting of a long distal cell, and a club-shaped, unicellular, glandular head. Prickles v. numerous, and enlarged prickles at the leaf margins. Silica-bodies, over the veins, dumb-bell shaped.

E. mollis Lehm.[1] (as *Pappophorum molle* Kunth. *forma uberior*). Similar to *E. scaber* but glandular hairs longer and more numerous. Other differences from *E. scaber* include the absence of abaxial ribs; less scl.; the presence of v. short, reduced prickles (in addition to long prickles and bristles) giving the leaf a saw-like feeling to the touch.

E. mollis Lehm. (as *Pappophorum molle* Kunth. *forma depauperata*) is described as having less clearly defined ribs and smaller stomata.

Sabnis (1921) refers to the leaf of *E. elegans* (Nees) Stapf (under *Pappophorum elegans* Nees), and his description includes the following particulars. Surface more deeply grooved on the abaxial than on the adaxial surface; scl. forming adaxial and abaxial strands opposite the vb's, and small strands in the acute leaf margins; macro-hairs long, spiny; mesophyll with radiate chlorenchyma; bulliform cells in groups of the *Sporobolus* type.

The sp. described by Lohauss (1905) under the name *Pappophorum commune* F. v. M. is undoubtedly a sp. of *Enneapogon*. This exhibits the distinctive glandular hairs noted in other spp. of *Enneapogon*; dumb-bell shaped silica-bodies; mesophyll with radiate chlorenchyma; specially large bulliform cells, particularly near the midrib.

Special Note

Enneapogon stands out from all the other grass genera examined by the present author on account of the distinctive glandular hairs that appear to be present throughout the genus. It is generally treated as a member of the Pappophoreae.

Literature

Duval-Jouve 1875 (leaf); Günzel 1912 (leaf); Lohauss 1905 (leaf); Sabnis 1921 (leaf, ecological anatomy; under *Pappophorum elegans*).

EPICAMPES

Schwabe (1949*b*) has recorded that the leaf structure of *E. bourgaei* Fourn. and *E. stricta* Presl resembles that of *Muhlenbergia*, *Lycurus*, and *Sporobolus*. He further points out that these 3 genera are structurally quite unlike the Agrostideae, and says that they should be classified nearer to the Eragrosteae. Canfield (1934) refers to 2 spp. of *Epicampes* from the Jornada Range as having solid culms.

Literature

Canfield 1934 (culm); Schwabe 1949 (leaf).

ERAGROSTIELLA

Diagnostic Generic Characters

Short-cells, over the veins, in long rows. Silica-bodies, both over and between the veins, saddle-shaped. Micro-hairs present; short and spherical, each with the basal cell tapering towards its proximal end. Stomata with low, dome-shaped subsidiary cells. Vascular bundles mostly small and moderately

[1] *Enneapogon mollis* Lehm. = *E. cenchroides*. See p. 186.

angular in outline. Mesophyll with distinctly radiate chlorenchyma. Bundle-sheaths double.

Species Specially Examined

***Eragrostiella bifaria* (Vahl) Bor**

Leaf

Abaxial epidermis

Short-cells, between the veins, paired; those over the veins in rows of more than 5 cells; abundant. **Silica-bodies** saddle-shaped (Fig. I, 9); those between being much smaller than those over the veins. **Macro-hairs:** none seen. **Micro-hairs:** length 14–18 μ; basal cells 6–10 μ; distal cells 7–10 μ; hairs more or less spherical, but basal cells tapering towards their proximal ends (Fig. VII, 2). **Prickle-hairs:** prickles (Fig. VI, 1–2) rather sparse, but present locally over some of the veins; angular prickles (Fig. VI, 3) at the leaf margins. **Stomata** with low dome-shaped (Fig. IV, 3) subsidiary cells. **Long-cells**, between the veins, with thick, coarsely sinuous walls (Fig. V, 1*a–b*), the cells being rather short for this type; interstomatal cells with concave ends and coarsely sinuous walls, rather long.

T.S. lamina

Vascular bundles: small vb's mostly angular (Fig. VIII, 5), but some less conspicuously so (Fig. VIII, 6); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with slight, rounded, wide ribs, separated from one another by fairly shallow furrows of about the same width as the ribs, or slightly wider (Fig. XIV, 2). **Sclerenchyma:** combined girders to all vb's anchor-shaped (Fig. IX, 6), but adaxial I-girders v. short and often almost T-shaped, but with a v. short stem to the T. **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma distinctly radiate. **Bulliform cells** in groups of the *Sporobolus* type (Fig. XV, 8), connected to the abaxial surface by girders of subjacent colourless cells (Fig. XV, 13). **Bundle-sheaths** double; each with the I.S. complete, and the O.S. having a broad abaxial interruption (as Fig. XII, 5, but with the I.S. complete), the outer sheaths being U- or V-shaped and with rounded outlines.

Material Examined: F. Ballard 1460; Ceylon.

Special Note

The leaf exhibits mixed festucoid and panicoid characters. The micro-hairs are of the chloridoid type.

ERAGROSTIS

Diagnostic Generic Characters

Short-cells, between the veins, solitary or paired; those over the veins also paired, or in short or long rows, the proportion of each type varying with the sp. Silica-bodies, over the veins, rather variable in shape according to the sp., but saddle-shaped types common, sometimes tending to be rounded, cross or

dumb-bell shaped. Micro-hairs usually present, but none detected in 1 sp.; often of a rather characteristic type with the distal cell almost hemispherical, but, more rarely, tapering to a more pointed apex; rather variable in different spp. Stomata with triangular or low dome-shaped subsidiary cells. Vascular bundles mostly small, and at least somewhat angular in outline. Mesophyll usually with distinctly radiate chlorenchyma. Bundle-sheaths usually double but more rarely single.

Species Specially Examined

Eragrostis aspera (Jacq.) Nees

Leaf

Abaxial epidermis

Short-cells, both between and over the veins, mostly paired, a few of those over the veins being in short rows; abundant. **Silica-bodies** saddle-shaped (Fig. I, 5 and 9), both over and between the veins, those between being much narrower than those over the veins. **Macro-hairs:** none seen. **Micro-hairs:** length 30–40 μ; basal cell 18–25 μ; distal cell 10–17 μ; basal cell tapering gradually towards its proximal end; distal cell with a rounded apex or almost hemispherical (Fig. VII, 12). **Prickle-hairs:** prickles (Fig. VI, 1–2) locally frequent especially over the smaller veins; a few angular prickles (Fig. VI, 3) at the leaf margins. **Stomata** mostly with triangular (Fig. IV, 1), but some with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells,** between the veins, with thin, markedly sinuous walls (Fig. V, 3*a–c*), mostly rather short.

T.S. lamina

Vascular bundles: most vb's small, angular (Fig. VIII, 5); some slightly less angular (Fig. VIII, 6); a few large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with slight rounded ribs, and narrow, shallow furrows (Fig. XIV, 2); ribs over the large vb's appreciably taller than those over the small vb's. **Sclerenchyma:** most small vb's with minute adaxial and abaxial strands (Fig. IX, 4) or small girders, or sometimes with adaxial girders and abaxial strands; large vb's with short, but wider, adaxial and abaxial girders (Fig. IX, 5), some of them being as much as 14 cells wide and slightly T-shaped. **Keel** fairly conspicuous, rounded; containing 1 large median vb accompanied on either side by 2 small laterals (Fig. XIII, 3). **Mesophyll:** chlorenchyma distinctly radiate. **Bulliform cells** in groups of the *Sporobolus* type (Fig. XV, 8) throughout the width of the lamina. A broad girder of colourless cells present between the median keel vb and the adaxial scl. **Bundle-sheaths** single and double; large vb's with I.S. and O.S. interrupted abaxially (Fig. XII, 5), or similar but with only the O.S. interrupted abaxially; O.S. U-shaped in both types but rounded in outline; each small vb surrounded by a single complete sheath, but many of the sheaths triangular in outline, the apex of each triangle being an extension towards the adaxial epidermis (as Fig. XII, 6, but with no I.S.).

Culm

Culm examined about 2 mm in diameter. Epidermis, and about 7 subjacent layers of cells, highly lignified, with v. thick walls and narrow lumina. A circle

of small, flattened strands of assimilatory tissue embedded in the peripheral scl. Cells of the ground tissue immediately on the inner side of the scl. ring also thick-walled but much wider in diameter. These cells gradually passing over to the thinner-walled cells of the inner ground tissue. Vb's in 3 more or less distinct circles, those of the outermost circle being embedded in the peripheral scl., and those of the 2 inner circles in the relatively thick-walled ground tissue that abuts directly on to the inner side of the scl. ring. Centre of the culm occupied by a fairly large cavity.

Material Examined: Supplied specially by G. Jackson from Nyasaland.

Eragrostis chloromelas Steud.

Leaf

Abaxial epidermis (Fig. XXV, 4)

Short-cells, between, and some of those over, the veins, paired; others over the veins in short or long rows, the pairs becoming converted to rows when the intervening cells in the same files are themselves short. **Silica-bodies,** over the veins, saddle-shaped (Fig. I, 9); some of those between the veins also tending to be saddle-shaped but narrower, and others more nearly of the tall, or slightly crescent-shaped, narrow type (Fig. I, 3–4). **Macro-hairs:** occasional, short, or fairly long, thick-walled hairs, with sunken constricted bases, present in the intercostal zones. **Micro-hairs:** length 40–62 (mostly 40–54) μ; basal cell 24–44 (mostly 24–36) μ; distal cell 12–18 μ; basal cell tapering gradually towards its proximal end; distal cell with a rounded apex, or almost hemispherical (Fig. VII, 12). **Prickle-hairs:** prickles (Fig. VI, 1–2) occurring sporadically, mostly in the intercostal zones. **Stomata** sometimes with slightly triangular (Fig. IV, 1), but mostly with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells,** between the veins, with thin, sinuous walls (Fig. V, 3*a–c*).

T.S. lamina

Vascular bundles: most vb's angular (Fig. VIII, 5), but sometimes less angular (Fig. VIII, 6); large vb's of basic type (Fig. VIII, 10–11). **Adaxial surface** with moderate ribs, and narrow, shallow, V-shaped furrows (Fig. XIV, 3); ribs over the large vb's with flattened, and those over the small vb's with rounded, apices. **Sclerenchyma:** a few of the smallest vb's near the leaf margins not accompanied by scl. (Fig. IX, 1); most small vb's with adaxial and abaxial girders up to about 8 cells wide and 2–3 cells high, the adaxial girders occasionally replaced by strands (Fig. IX, 4); large vb's with adaxial and abaxial girders rather wider (Fig. IX, 5), but about the same height. **Keel** scarcely conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma distinctly radiate. **Bulliform cells** in groups of the *Sporobolus* type (Fig. XV, 8), sometimes connected to the abaxial surface by girders of colourless cells (Fig. XV, 13). **Bundle-sheaths** double; most vb's with I.S. complete, the O.S. having an adaxial extension (Fig. XII, 6), cells in each individual sheath unequal in size; large vb's with the I.S. complete, the U-shaped O.S. having a wide abaxial interruption (as Fig. XII, 5, but with the I.S. complete).

CULM

Culm examined 3 mm in diameter. Epidermis subtended by 1–2 layers of thick-walled cells with v. small diameters, followed by a circle of wide columns of thin-walled assimilatory tissue, the columns being separated from one another by girders of scl. with the vb's of the outermost circle embedded in them. Assimilatory tissue bounded on the inner side by 5–6 more layers of fibrous ground tissue, gradually changing over to thinner-walled tissue towards the centre of the culm. Vb's consisting of those in the outermost circle embedded in girders of scl., a second circle at the inner periphery of the scl. ring, and 2 more central circles embedded in thin-walled ground tissue. Centre of the culm occupied by a large cavity.

MATERIAL EXAMINED: Cultivated at Kew.

Eragrostis curvula Nees

LEAF

Abaxial surface

Short-cells, between the veins, mostly solitary, but some, especially at the margins of the veins, in pairs; those over the veins mostly in rows of more than 5 cells, and sometimes in shorter rows or, more rarely, paired; abundant. **Silica-bodies** rather rare between the veins but, where present, tall and narrow (Fig. I, 4), or narrowly oval, each body tending to fit into a concavity in the accompanying cork-cell (Fig. I, 6–7). Silica-bodies, over the veins, mostly oblong (Fig. I, 10), or tending to be saddle-shaped (Fig. I, 9). **Macro-hairs, micro-hairs,** and **prickle-hairs:** none seen. **Stomata** mostly with slightly triangular (Fig. IV, 1), but others with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells,** between the veins, with thin, coarsely sinuous walls (Fig. V, 3*a–c*).

T.S. lamina

Vascular bundles: most small vb's somewhat angular (as in Fig. VIII, 5), but some of them less angular (Fig. VIII, 6 and 2); large vb's of basic type (Fig. VIII, 13). **Adaxial surface** with moderate, rounded ribs, and fairly narrow, shallow furrows (Fig. XIV, 4); apices of ribs over the small vb's rounded, those over the large vb's wider, and sometimes slightly flattened. **Sclerenchyma:** most vb's with small adaxial and abaxial girders (Fig. IX, 4) up to about 5 cells wide and 2 cells high; large vb's with somewhat broader adaxial and abaxial girders (Fig. IX, 5). **Keel** scarcely conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma distinctly radiate. **Bulliform cells** in groups of the *Sporobolus* type (Fig. XV, 8). **Bundle-sheaths** double; most vb's with I.S. complete and O.S. with a narrow adaxial extension (Fig. XII, 6); large vb's with I.S. complete, but O.S. interrupted adaxially and abaxially (Fig. XII, 3*a*).

CULM

Culm examined about 3 mm in diameter. Epidermis subtended by a circle of numerous v. small strands of assimilatory tissue embedded in a peripheral scl. ring about 12 cells wide. Inner surface of the individual columns of assimilatory tissue sometimes separated from the adjacent scl. by a single row of specially large cells. Ground tissue immediately on the inner side of the scl. ring consisting of fairly thick-walled cells of wide diameter, the centre of the culm being occupied by spongy tissue with much thinner cell-walls, with irregular cavities at the centre of the culm. Vb's consisting of v. small strands in the outermost circle embedded in scl., and 3–4 circles of larger strands embedded in the fairly thick-walled ground tissue on the inner side of the scl. ring.

MATERIAL EXAMINED: Supplied specially by G. Jackson from Nyasaland.

Eragrostis diplachnoides Steud.

LEAF

Abaxial epidermis

Short-cells, both over and between the veins, mostly solitary and paired; a few of those over the veins appearing to be in rows when separated from one another by comparatively short cells in the same files; common. **Silica-bodies,** over the veins, mostly saddle-shaped (Fig. I, 5 and 9), but a v. few tending to be cross-shaped (Fig. IA, 16). Silica-bodies infrequent between the veins, where present tall and narrow (Fig. I, 4), or crescent-shaped, and each sometimes fitting into a concavity in an adjacent cork-cell (Fig. I, 6–7). **Macro-hairs:** none seen. **Micro-hairs:** length 37–50 μ; basal cells 14–22 μ; distal cell 20–30 μ; mostly balanoform, the distal cells inflated and with rounded apices (Fig. VII, 3), but distal cell occasionally tapering to a more pointed apex. **Prickle-hairs:** none seen. **Stomata** mostly with slightly triangular (Fig. IV, 1), but others with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells,** both over and between the veins, with thin, or moderately thick, sinuous walls (Fig. V, 3*a–c*).

T.S. lamina

Vascular bundles: small vb's angular (Fig. VIII, 5); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with slight to moderate rounded ribs separated from one another by shallow, fairly wide furrows (Fig. XIV, 3); ribs over the large vb's distinctly taller and wider than those over the small vb's. Similar ribs and furrows present on the abaxial surface. **Sclerenchyma:** most vb's with adaxial and abaxial girders up to about 6 cells wide and 3 cells high (Fig. IX, 4); large vb's with rather wider adaxial and abaxial girders (Fig. IX, 5). **Midrib** fairly conspicuous, projecting adaxially and abaxially; containing 1 large median vb accompanied on either side by 1 or 2 smaller laterals (Fig. XIII, 2). **Mesophyll:** chlorenchyma too disorganized to be clearly visible. **Bulliform cells** probably all in groups of the *Sporobolus* type (Fig. XV, 9), but v. disorganized in the available material. A girder of colourless cells also present between the median vb of the midrib and the overlying adaxial scl. **Bundle-sheaths** double; most vb's with I.S. complete and O.S. with an adaxial extension to the adjacent scl. in the apex of the rib (Fig. XII, 6); large vb's with I.S. complete and O.S. interrupted adaxially and abaxially (Fig. XII, 3*a*), or abaxially only (Fig. XII, 2).

MATERIAL EXAMINED: F. Ballard 1446; Ceylon.

***Eragrostis gangetica* (Roxb.) Steud.**

LEAF

Abaxial epidermis

Short-cells, between the veins, mostly solitary, but sometimes paired; those over the veins mostly in rows of 3–5 or more cells, solitary and paired types also occurring. **Silica-bodies,** at the margins of the veins, rather variable, some being saddle-shaped (Fig. I, 5 and 9), and others almost cross-shaped (Fig. IA, 16), but mostly dumb-bell shaped with wide ends and long, narrow, middle pieces, (Fig. IA, 18 (ii–iv)), some of them resembling 2 saddle-shaped bodies united by a narrow bridge of silica to produce the dumb-bell shaped appearance. Silica-bodies infrequent between the veins. **Macro-hairs:** none seen. **Micro-hairs:** length 33–44 μ; basal cell 13–18 μ; distal cell 18–25 μ; hairs mostly rather uniform in diameter throughout their lengths and with rounded apices (Fig. VII, 7), but sometimes more nearly balanoform (Fig. VII, 3) and rather narrow; distal cell occasionally tapering slightly towards the apex. **Prickle-hairs:** a few angular prickles (Fig. VI, 3) at the leaf margins. **Stomata** sometimes with slightly triangular (Fig. IV, 1), but mostly with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells,** between the veins, with thin, sinuous walls (Fig. V, 3*a–c*).

T.S. lamina

Vascular bundles: small vb's angular (Fig. VIII, 5); a few large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with moderately tall, crowded, rounded ribs, and narrower, shallow furrows (Fig. XIV, 3). **Sclerenchyma:** most vb's with well-marked abaxial girders only (Fig. IX, 3), or sometimes each with a minute adaxial strand as well as the abaxial girder; a few small vb's with well-marked abaxial girders, and much smaller adaxial girders only 2–3 cells wide and high (Fig. IX, 4); large vb's with abaxial girders up to 14 cells wide and 4 cells high, the corresponding adaxial girders being about 4 cells wide and 2 cells high (Fig. IX, 5). **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma distinctly radiate. **Bulliform cells** in groups of the *Sporobolus* type (Fig. XV, 9), some of the groups having girder-like extensions of colourless cells to the abaxial surface (Fig. XV, 13). **Bundle-sheaths** double; small vb's with I.S. rather obscure in the material available; O.S. somewhat triangular in outline, with the apex extending to the adaxial scl. or epidermis, the constituent cells of the O.S. being v. unequal in size (Fig. XII, 6); most large vb's with I.S. complete and O.S. interrupted abaxially (Fig. XII, 2); other large vb's with the I.S. complete, and the O.S. interrupted abaxially, but connected to the adaxial scl. by large cells (Fig. XII, 4).

CULM

Culm examined 1·5 mm in diameter. Remarkable for the occurrence between the epidermis and the scl. ring of a broad zone of thin-walled tissue with abundant intercellular spaces (aerenchyma),[1] the latter not visible in sections of the culm at a higher level, and apparently confined to the base of the culm. Aerenchyma disorganized in the available material, and bounded on the inner side by a scl. ring consisting of thick-walled fibres about 3–6 cells wide, the inner boundary of the ring being v. sinuous. Ground tissue on the inner side of the scl. ring consisting of unlignified, thick-walled cells. Central cavity of the culm fairly large. Vb's consisting of the small strands of the outermost circle embedded in the scl. ring, those of a second circle at the inner boundary of the scl. ring, and those of a third more central circle embedded in unlignified ground tissue.

MATERIAL EXAMINED: F. Ballard 1455; Ceylon. Culm only: La-Danso 77; Gold Coast: from waterlogged ground. Deighton 4454; Sierra Leone: from a wet place at the edge of a field. Deighton 2103; Sierra Leone: from beside a path. H. B. Johnston 34; Nigeria: from flooded ground.

[1] The material on which the above description is based was found by Mr. Ballard on a gneiss plateau growing in crevices in which water was present. The plant is an annual. Subsequent work showed that the peripheral spongy tissue in the culm is a type of aerenchyma which occurs at the bases of culms of specimens growing in damp localities. The aerenchyma appears to consist of uniseriate plates of parenchymatous cells that are circular in outline in T.S. but which collapse v. readily in dried material. The plates are arranged in a radiating manner around the circumference of the culm, and there are large intercellular cavities between them. No evidence of this tissue was found at the bases of culms from specimens obtained from dry localities.

***Eragrostis unioloides* (Retz.) Nees**

LEAF

Abaxial epidermis

Short-cells, both over and between the veins, solitary and paired; common. **Silica-bodies,** over the veins, sometimes slightly saddle-shaped (Fig. I, 5), but mostly fitting into slight concavities in the adjacent cork-cells, and round, oval, or occasionally slightly crescent-shaped in outline (Fig. I, 6–7). Silica-bodies v. infrequent between the veins, when present usually tending to be tall and narrow (Fig. I, 4). **Macro-hairs:** none seen. **Micro-hairs:** v. few observed; each with a relatively short basal cell and long distal cell tapering to a rounded point (Fig. VII, 6). **Prickle-hairs:** prickles numerous on the adaxial ribs. **Stomata:** some with slightly triangular (Fig. IV, 1), but others with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells,** between the veins, with thin, sinuous walls (Fig. V, 3*a–c*).

T.S. lamina

Vascular bundles: most vb's small and angular (Fig. VIII, 5); a few large vb's of basic type (Fig. VIII, 13). **Adaxial surface** with moderate, rounded ribs over all of the vb's, the ribs being separated from one another by fairly wide, moderately deep, V-shaped furrows (Fig. XIV, 3). Abaxial surface practically smooth. **Sclerenchyma:** most small vb's with adaxial and abaxial girders, the adaxial girders being 3 or 4 cells wide and 2 cells high, and the abaxial girders about 7 cells wide and 3 or 4 cells high (Fig. IX, 4); a few small vb's with abaxial strands only; large vb's with girders slightly wider, but sometimes shorter, than those associated with the smaller vb's. **Keel** fairly conspicuous, rounded; containing a solitary vb (Fig. XIII, 1), sometimes accompanied on either side by 1 much smaller lateral (Fig. XIII, 2). **Mesophyll:** chlorenchyma

indistinctly radiate in the available material. **Bulliform cells** in groups of the *Sporobolus* type (Fig. XV, 9); a few of the groups with girder-like extensions of colourless cells to the abaxial surface (Fig. XV, 13). **Bundle-sheaths** single and double; small vb's with I.S. rather obscure in the available material; O.S. somewhat triangular in outline, with the apex extending to the adaxial scl., the constituent cells of the O.S. being v. unequal in size (Fig. XII, 6); large vb's with O.S. interrupted abaxially (Fig. XII, 2), the I.S. being less lignified at the xy. than at the ph. end of the vb.

Culm

Culm examined about 1 mm in diameter. Epidermis subtended by flattened columns of thick-walled fibres, some of the columns extending across the assimilatory tissue to a rather sinuous scl. ring. Vb's consisting of the v. small strands of the outermost circle embedded in the scl; those of a second circle at the inner boundary of the peripheral scl. ring; those of a third circle embedded in thin-walled ground tissue extending to the centre of the culm.

Material Examined: F. Ballard 1468; Ceylon.

Additional Information from the Literature

The leaf structure of a number of spp. has been described in some detail. These have been placed in alphabetical order below, and the information about each of them summarized. The literature reference is given at the end of the description of each sp.

E. cilianensis (All.) Lutati (syn. *E. major* Host.). Dalmatia

Epidermis. Abaxial epidermis, over the veins, including short-cells consisting of rounded to elliptical cork-cells, and silica-cells containing saddle-shaped bodies. Micro-hairs present. Prickles numerous on the adaxial surface. Tuberous structures, each composed of numerous epidermal cells, recorded at the leaf margins. Long-cells between the veins with v. sinuous, irregularly pitted, anticlinal walls. *T.S. lamina*. Adaxial surface slightly ribbed. Scl. mostly as small abaxial and adaxial strands, and well developed at the leaf margins. Bulliform cells large. Bundle-sheaths double. (Lohauss 1905.)

E. curvula var. *valida* Stapf

Macro-hairs absent. Vb's all primary. (Breakwell 1915.)

E. diarrhena (Schult.) Steud. (under *E. interrupta* Beauv.)

Grooves not deep on either surface. Leaf margins pointed and supported by small scl. strands. Macro-hairs: spiny hairs present. Mesophyll with radiate chlorenchyma forming an arc on either side of each vb. Bundle-sheaths round the small vb's complete, but those to the large vb's interrupted adaxially and abaxially by scl. (Sabnis 1921.)

E. echinochloidea Stapf (as *E. auriculata* Hackel.)

Epidermis. Short-cells, over the veins, paired. Silica-bodies oval to saddle-shaped. Glands (see also Nicoria 1941 and under *S. porosa*): certain groups of cells over the scl. projecting above the epidermis and stained bright red by Sudan III, referred to as glands. Cells subjacent to the glands larger and less thickened than those of the scl., extending into the mesophyll to the neighbourhood of the bundle-sheaths. Prickles and club-shaped micro-hairs present. Long-cells, between the veins, with

sinuous lateral walls. *T.S. lamina*. Adaxial surface slightly ribbed. Scl. present at the leaf margins, and on the adaxial and abaxial sides of the vb's. Mesophyll with radiate chlorenchyma. Bulliform cells connected to the abaxial surface by colourless parenchyma. Bundle-sheaths double. (Günzel 1912.)

E. frankii C. A. Meyer ex Steud.

Epidermis. Abaxial epidermis with short-cells, over the veins, consisting of rounded to elliptical cork-cells and silica-cells containing saddle-shaped bodies; those between the veins consisting of elliptical to kidney-shaped cork-cells, and silica-cells containing rounded to 4-sided bodies. Micro-hairs present. *T.S. lamina*. Adaxial surface slightly furrowed. Scl. well developed both adaxially and abaxially to each vb. Mesophyll with indistinctly radiate chlorenchyma. Bulliform cells specially large. (Lohauss 1905.)

E. lacunaria F. Muell.

Numerous macro-hairs present, the base of each being surrounded by 5 large, somewhat fan-shaped, epidermal cells. (Breakwell suggests that each hair and its basal cells should be termed a sub-papillose protuberance.) (Breakwell 1915.)

E. laevissima Hackel.

Silica-bodies saddle-shaped. Adaxial surface more definitely ribbed than in *E. echinochloidea*, the bulliform cells being sunken and the ribs over the vb's exaggerated by bearing numerous prickle-hairs. Old leaves with a conspicuous midrib. (Günzel 1912.)

E. mexicana (Hornem.) Link.

Adaxial surface weakly ribbed. Mesophyll with chlorenchyma consisting of isodiametric cells, mainly on the abaxial side of the large bulliform cells. (Lohauss 1905.)

E. minor Host. = *E. poaeoides* Beauv.

Well-developed cushion hairs present between the veins on the abaxial surface of the leaf-sheath and lamina, the cells forming the cushion at the base of each cell being rich in pectic substances and strongly coloured by ruthenium red. (Prat 1932.)

Epidermis. Short-cells consisting of variously shaped cork and silica-cells, the silica-bodies ranging from dumb-bell shaped to elliptical, rounded, or even star-shaped. *T.S. lamina*. Scl. not well developed. Mesophyll: chlorenchyma not conspicuously radiate. (Lohauss 1905.)

E. obtusiflora (Fourn.) Scribn.

Brief notes on the leaf structure of this sp. recorded by Ogden (1897).

E. oxylepis (Torr.) Torr.

Epidermis. Short-cells, over the veins, consisting of elliptical to kidney-shaped cork-cells, and silica-cells containing saddle-shaped bodies; short-cells between the veins rectangular. Prickles present over the veins on the adaxial surface, and at the leaf margins. Micro-hairs present in the adaxial intercostal zones. *T.S. lamina*. Adaxial surface weakly ribbed. Scl. not well developed. Mesophyll: chlorenchyma consisting of polygonal cells, and, below the bulliform cells, of tangentially elongated cells. Bulliform cells large. (Lohauss 1905.)

E. pilosa (L.) Beauv.

Structure v. similar to that of *E. tef* but with less aqueous tissue in the midrib, and less scl. present. (Lohauss 1905.)

Silica-bodies in this sp. said by Prat (1932) to be saddle-shaped, and particularly numerous over the veins on the abaxial surface of the leaf-sheath.

E. porosa Nees

Silica-bodies mostly narrowly dumb-bell shaped, but sometimes saddle-shaped. Cushion hairs and club-shaped micro-hairs present; prickles numerous. Air-canals present between the vb's in the leaf sheath. Glands similar to those in *E. echinochloidea* present in some specimens. Other small differences between different specimens of this sp. also recorded. (Günzel 1912.)

E. reptans (Michx.) Nees

Epidermis. Short-cells rectangular. Bristle-hairs present. *T.S. lamina.* Adaxial surface strongly ribbed. Scl. said to be absent except at the leaf margins. Bulliform cells subtended by colourless parenchyma. Bundle-sheaths: abaxial sheath-cells much smaller, and with thicker walls, than the remainder, and abutting on the abaxial epidermis. (Lohauss 1905.)

E. tef (Zuccagni) Trotter (syn. *E. abyssinica* Link.)

Epidermis. Adaxial epidermis, over the veins, in part consisting of files composed solely of long-cells, but prickles and saddle-shaped silica-bodies present elsewhere. Some of the long-cells, over the veins, with outwardly directed, bladder-like swellings. Prickles occasional. Micro-hairs also present between the veins. On the abaxial epidermis rectangular short-cells and cylindrical micro-hairs stated to be present between the veins. *T.S. lamina.* Adaxial surface weakly ribbed. Scl. well developed, forming I-girders with the vb's, the adaxial half of each girder being more strongly developed than the abaxial half; crescent-shaped strands of scl. also present in the leaf margins. Midrib abaxially prominent, largely consisting of aqueous tissue; including 1 large median vb and 2 other smaller vb's on either side, all 5 vb's being quite close to the abaxial surface. Mesophyll consisting of radiate chlorenchyma in the ribs, the circles of chlorenchyma being interrupted by scl. above and below the vb's; chlorenchyma below the bulliform cells consisting of isodiametric cells. (Lohauss 1905 and Sabnis 1921.)

Some details also recorded by Günzel (1912) for 3 specimens of *E. denudata* Hackel. The structure of the 3 specimens varies in certain respects. In *E. trichocarpa* Coss. and Dur. the silica-bodies are mostly saddle-shaped, but occasionally dumb-bell shaped on the adaxial surface of the lamina. *E. spinosa* (L.f.) Trin. is characterized by thorns, which are metamorphized shoots resembling the culms in anatomical structure. In addition, some of the laminae have become thornlike, being shortened, rolled, and with pointed ends, the lower parts of the thorns being structurally similar to expanded laminae. Micro-hairs not recorded in this last sp., being absent or v. rare.

Nicora (1941) records the occurrence of multicellular glands (extra-floral nectaries), see also *E. echinochloidea* on p. 196, on the leaves and floral parts of certain spp. of *Eragrostis.*

Special Note

Prat's (1932, 1934) views concerning the affinities of *Eragrostis* are somewhat mixed, but he rightly regards the structure as panicoid rather than festucoid. Prat (1934) draws attention to resemblances of *Eragrostis* to *Chloris* on account of the saddle-shaped silica-bodies, to *Triraphis* because of the structure of the micro-hairs, and to *Digitaria* and *Panicum* because of the structure of the cushion hairs. In this connexion it should be noted that the micro-hairs and shapes of the silica-bodies vary somewhat in different spp. Schwabe

(1949) has drawn attention to the affinities between *Eragrostis* and *Sporobolus.* Mimeur (1951) has discussed the relationship of *Eragrostis* to *Briza. Eragrostis* is the type genus of the Eragrosteae.

Literature

Breakwell 1915 (leaf); Duval-Jouve 1875 (leaf); Grob 1896 (leaf); Günzel 1912 (leaf); Lohauss 1905 (leaf); Mimeur 1950 (taxonomy); Nicora 1941 (extra-floral nectaries); Ogden 1897 (leaf of 1 sp.); Pée-Laby 1898 (leaf); Prat 1932, 1934, 1936 (leaf); Sabnis 1921 (leaf, ecological anatomy); Schwabe 1949 (affinities).

EREMOCHLOA

Vickery's (1935) description of *E. muricata* Hack. (syn. *Ischaemum pectinatum* Trin., *Rottboellia muricata* Retz.) includes the following information.

Leaf moderately thick; folded on drying. Adaxial epidermis of moderately thin to rather thick-walled, arched or sometimes papillose cells. Cells of abaxial epidermis similar but smaller, and not strongly arched. Sclerenchyma forming small adaxial and abaxial girders to the large vb's; small vb's sometimes accompanied by small strands. Midrib small but conspicuous because of the folding of the leaf and the position of the bulliform cells above it. Mesophyll with chlorenchyma tending to be radiate. Bulliform cells as a large group above the midrib. Bundle-sheaths single.

Special Note

This incomplete information suggests that the structure is panicoid.

Literature

Vickery 1935 (leaf).

EREMOPOGON

Prat (1937) and Sabnis (1921) have recorded the following information concerning the leaf of *Eremopogon foveolatus* (Del.) Stapf, Sabnis referring to this sp. under *Andropogon foveolatus* Del.

Surfaces not more than slightly grooved. Sclerenchyma forming small adaxial and abaxial girders to the large vb's; small vb's figured by Sabnis as not accompanied by scl. Large scl. strands also present in the blunt leaf margins. Short, bluntly pointed macro-hairs present amongst the bulliform cells. Midrib not well developed. Mesophyll with radiate chlorenchyma round the small vb's, and with arcs of chlorenchyma on either side of each large vb. Bulliform cells present above the median vb, and well developed in the wings of the lamina, being present above some of the small vb's as well as between the large ones.

Special Note

Although imperfectly known the structure appears to be panicoid.

Literature

Prat 1937 (leaf); Sabnis 1921 (leaf).

ERIACHNE

Diagnostic Generic Characters

Short-cells, over the veins, in long rows. Silica-bodies, over the veins, an angular form of the *Oryza* type. Micro-hairs present; each with the distal cell tapering slightly to a rounded apex. Stomata mostly with low dome-shaped subsidiary cells. Vascular bundles, except for a few large ones, somewhat angular in outline. Mesophyll with chlorenchyma not distinctly radiate in the available material. Bundle-sheaths double.

Species Specially Examined

***Eriachne pallescens* R. Br.**

Leaf

Abaxial epidermis

Short-cells, between the veins, mostly solitary, or occasionally paired; those over the veins in rows of more than 5 cells; abundant over, but rather infrequent between, the veins. **Silica-bodies** of the *Oryza* type (as in Fig. Ib, 23, but most of them more angular in outline); v. infrequent between the veins. **Macro-hairs:** thick-walled hairs of moderate length, and with swollen, sunken bases, occasional in the intercostal zones; bases of the hairs surrounded by specialized epidermal cells (Fig. IIa, 5). **Micro-hairs:** length 60–80 μ; basal cells 30–37 μ; distal cells 31–44 μ; basal cells tapering somewhat towards their proximal ends; distal cells mostly tapering slightly towards their rounded apices (Fig. VII, 5). **Prickle-hairs:** angular prickles (Fig. VI, 3) numerous in the intercostal zones; hooks (Fig. VI, 5) occasional. **Stomata** mostly with low dome-shaped (Fig. IV, 3) subsidiary cells. **Long-cells,** between the veins, with thick, sinuous walls (Fig. V, 1*a–b*), mostly rather short.

T.S. lamina

Vascular bundles: small vb's somewhat angular in outline (Fig. VIII, 6); a few large vb's of basic type (Fig. VIII, 15), but without any specially large metaxylem vessels. **Adaxial surface** with slight, fairly wide, rounded ribs over all the vb's and narrower, shallow furrows (Fig. XIV, 2). Abaxial surface also with slight ribs over the veins. **Sclerenchyma:** a few, small, marginal vb's not accompanied by scl. (Fig. IX, 1); nearly all vb's with small adaxial and abaxial girders (Fig. IX, 4), the adaxial being smaller than the abaxial girder of each vb, the adaxial girders varying from 2 to 10 cells wide and mostly about 2 cells high; largest abaxial girders about 10 cells wide and 3–4 cells high. Many combined girders tending to be v. slightly T-shaped. Other vb's with abaxial strands only. **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not distinctly radiate, but rather obscure in the material examined. **Bulliform cells** in fan-shaped groups (Fig. XV, 6) at the bases of the furrows. **Bundle-sheaths** double; most vb's with I.S. rather obscure but complete, the O.S. being triangular, with the apex reaching the adaxial scl. (Fig. XII, 6); large vb's with O.S. interrupted abaxially. O.S. round all

vb's composed of cells with fairly thick walls, the outer walls taking up safranin and therefore distinctly lignified. Cells of the O.S. rather variable in diameter.

Material Examined: Kerr 15664; Siam.

Special Note

Although *Eriachne* is sometimes treated as a member of the Aveneae, it exhibits a mixture of festucoid and panicoid characters.

Literature

Grob 1896 (leaf); Prat 1932 (leaf).

ERIANTHUS

Diagnostic Generic Characters

Short-cells, over the veins, in short to long rows. Silica-bodies, over the veins, intermediate between cross and dumb-bell shaped. Micro-hairs present; each with the distal cell tapering to a rounded apex. Stomata with triangular subsidiary cells. Vascular bundles; all but the large ones somewhat angular in outline. Mesophyll with distinctly radiate chlorenchyma. Bundle-sheaths single.

Species Specially Examined

***Erianthus hostii* Griseb.**

Leaf

Abaxial epidermis

Short-cells, over the veins, mostly in rows of 3–5 or more cells; those between the veins usually solitary or paired; abundant over, but rather infrequent between, the veins. **Silica-bodies,** over the veins, intermediate between cross and dumb-bell shaped (Fig. Ia, 17). **Macro-hairs:** none seen. **Micro-hairs:** length 42–54 (mostly 45–54) μ; basal cells 24–36 μ; distal cells 10–25 (mostly 20–25) μ; distal cells tapering to rounded apices (Fig. VII, 9). **Prickle-hairs:** prickles with short, or fairly long, points (Fig. VI, 1–2) abundant over the veins; hooks (Fig. VI, 5) occasional at the margins of the veins. **Stomata** with triangular subsidiary cells (Fig. IV, 1). **Long-cells** with thin, sinuous walls (Fig. V, 3*a–c*); interstomatal cells with concave ends (Fig. V, 10–11).

T.S. lamina

Vascular bundles: most vb's somewhat angular (Fig. VIII, 6); large vb's of basic type (Fig. VIII, 10). **Adaxial surface** smooth (Fig. XIV, 1), apart from v. slight, widely spaced ribs over the large vb's. Abaxial surface with v. small ribs over all vb's. **Sclerenchyma:** keel vb's, and also a few small vb's opposite the groups of bulliform cells, each with a well-marked abaxial girder only (Fig. IX, 3); most vb's with small adaxial and abaxial girders (Fig. IX, 4), usually 1–5 cells wide and 1–3 cells high, the adaxial generally being slightly smaller than the abaxial girders; large vb's with somewhat wider adaxial and abaxial girders (Fig. IX, 5). A thin plate of scl., subjacent to the epidermis,

extending over the adaxial surface of the midrib. **Keel** conspicuous, rounded; containing 1 large median vb accompanied on either side by a single lateral nearly as large, together with about 7 much smaller vb's (Fig. XIII, 3). **Mesophyll:** chlorenchyma distinctly radiate. **Bulliform cells:** sometimes in groups as in Fig. XV, 2; bulliform and subjacent colourless cells elsewhere tending to form arches over the vb's (Fig. XV, 10). Adaxial part of the midrib chiefly composed of large colourless cells. **Bundle-sheaths** single; mostly complete (Fig. XI, 2*a*), but sheaths round the large vb's sometimes interrupted adaxially and abaxially (Fig. XI, 3).

Culm

Culm examined about 0·5 cm in diameter. No well-defined scl. ring present at the periphery, cells of the ground tissue showing a gradual increase in diameter towards the centre of the culm. Each vb, throughout the T.S., supported by a strand of fibres at both the xy. and ph. ends, and some of the vb's by a small amount of scl. at the sides as well. Vb's appearing scattered, but arranged in 5 or 6 more or less distinct circles; some vb's penetrating fairly deeply towards the centre of the culm, but none present in the spongy ground tissue at its very centre.

Material Examined: Cultivated at Kew.

Additional Information from the Literature

1. Leaf

E. ravennae (L.) Beauv. Adaxial surface with ribs. Scl. present as adaxial and abaxial strands to the large vb's, and in the abaxial ribs. Mesophyll with radiate chlorenchyma. Bulliform cells v. protruding, present above the small vb's as well as between the large ones. A well-developed mass of colourless cells also present above the vb's in the midrib. (Duval-Jouve 1875; Prat 1937.)

2. Root

Borissow (1925) records the occurrence of silica-bodies, similar to those which he previously noted in *Sorghum* (see p. 455), in the cells of the root endodermis of *E. ravennae* (L.) Beauv. Longitudinal sections show 5–8 bodies in each cell, and they at first sight have the appearance of bordered pits of the type to be found in the tracheids of coniferous wood.

Special Note

The facts confirm Prat's (1936) opinion that the structure is panicoid.

Literature

Borissow 1925 (silica-bodies in root endodermis); Duval-Jouve 1875 (leaf); Grob 1896 (leaf); Prat 1936, 1937 (leaf); Vickery 1935 (under 'Pollinia').

ERIOCHLOA

Grob (1896) notes for *E. procera* (Retz.) C. E. Hubbard:

short-cells, over the veins, consisting of cork-cells with sinuous outlines, and silica-cells containing mostly dumb-bell shaped, and occasional cross-shaped or

nodular, silica-bodies. Dumb-bell shaped bodies each with the middle part short and broad. Solitary cork-cells present in the intercostal zones.

Special Note

Prat (1936) regards the structure as panicoid.

Literature

Grob 1896 (leaf); Prat 1936 (leaf).

ERIOCHRYSIS

Prat's (1937) description includes the following particulars concerning the aquatic grass *E. brachypogon* (Stapf) Stapf.

A rib, composed of a mass of sclerosed colourless tissue, present on the adaxial surface above the median vb. Each wing of the lamina containing 2–3 large vb's and 5–7 smaller vb's between each pair of large ones. Adaxial epidermis bearing numerous papillae. Bulliform tissue in the wings present only on the adaxial side of the smallest vb's. Bundle-sheaths: median vb surrounded by a perfectly cylindrical, 2-layered sheath of fibres. Other vb's also with 2 sheaths, only the inner one being fibrous.

Special Note

Leaf structure insufficiently examined to indicate the affinities of the genus.

Literature

Prat 1937 (leaf).

EUCHLAENA

Diagnostic Generic Characters

Short-cells, over the veins, in long rows. Silica-bodies, over the veins, cross-shaped, with deep indentations between the arms. Micro-hairs present; balanoform. Stomata with triangular subsidiary cells. Vascular bundles mostly small and conspicuously angular in outline. Mesophyll with chlorenchyma inconspicuously radiate. Bundle-sheaths single.

Species Specially Examined

***Euchlaena perennis* Hitchcock**

Leaf

Abaxial epidermis (Fig. XXVI, 1)

Short-cells, between the veins, mostly paired; those over the veins in rows of more than 5 cells; abundant. **Silica-bodies,** between the veins, tall and narrow (Fig. I, 4), tall narrow and crenate (Fig. Ib, 24), or a tall narrow form of cross-shaped; those over the veins cross-shaped (Fig. Ia, 16), often with deep

indentations between the arms. **Macro-hairs:** none seen. **Micro-hairs:** length 60–72 μ; basal cells 18–24 μ; distal cells 36–48 μ; hairs of the balanoform type, the distal cells being highly inflated (Fig. VII, 3). **Prickle-hairs:** none seen. **Stomata** with triangular (Fig. IV, 1) subsidiary cells. **Long-cells,** between the veins, with thin, sinuous walls (Fig. V, 3*a–c*); interstomatal cells with markedly concave ends (Fig. V, 11), and rather long.

T.S. lamina

Vascular bundles: a few of the smallest vb's, especially those near the leaf margins, with the xy. and ph. not easily distinguishable (Fig. VIII, 1); most vb's small, quadrangular to hexagonal (Fig. VIII, 5); a few large vb's of basic type (Fig. VIII, 10). **Adaxial surface** practically smooth (Fig. XIV, 1) apart from slight depressions containing the bulliform cells. **Sclerenchyma:** most small vb's not accompanied by scl. (Fig. IX, 1); other small vb's with adaxial and abaxial girders about 2–5 cells wide and 2–3 cells high (Fig. IX, 4); large vb's with much wider adaxial and abaxial girders (Fig. IX, 5); most keel vb's each with a well-marked abaxial girder only (Fig. IX, 3). **Keel** conspicuous, rounded; containing 1 large median vb accompanied on either side by 1 lateral nearly as large, and by about 7 other laterals, all appreciably smaller, but of various sizes (Fig. XIII, 3). **Mesophyll:** chlorenchyma not conspicuously radiate. **Bulliform cells** in small groups of specially large cells (*Zea* type, Fig. XV, 3). Adaxial part of the midrib composed of large colourless cells. **Bundle-sheaths** single; all small vb's each with a single complete sheath (Fig. XI, 2*a*); wide adaxial and abaxial interruptions to the single sheaths surrounding the large vb's (Fig. XI, 4).

Culm

Culm examined about 4 mm in diameter. No well-defined scl. ring present, but cells of the ground tissue gradually increasing in diameter, and decreasing in wall thickness, on passing from the epidermis to the centre of the culm. Some of the vb's, especially those in the 2 outermost circles, each surrounded by a sheath of scl. Vb's scattered throughout the culm, a few penetrating to the very centre.

Material Examined: Cultivated at Kew.

Additional Information from the Literature

Grob (1896) records the occurrence of cushion hairs in *E. mexicana* Schrad.

Special Note

The leaf anatomy confirms Prat's (1936) opinion that the structure is panicoid. The genus is generally treated as a member of the Maydeae. The cross-shaped silica-bodies and balanoform micro-hairs confirm this affinity.

Literature

Grob 1896 (leaf); Prat 1936 (leaf).

EUCHLAEZEA

Diagnostic Generic Characters

Vascular bundles mostly small and conspicuously angular in outline. Mesophyll with the chlorenchyma inconspicuously radiate. Bundle-sheaths single.

Species Specially Examined

***Euchlaezea mertonensis* Janaki Ammal**

Leaf

T.S. lamina

Vascular bundles: most vb's small, angular (Fig. VIII, 5); large vb's of basic type (Fig. VIII, 10). **Adaxial surface** smooth (Fig. XIV, 1), apart from v. slight but wide ribs over the large vb's, and slight depressions with some of the groups of bulliform cells in them (Fig. XIV, 2). **Sclerenchyma:** numerous small vb's not accompanied by scl. (Fig. IX, 1); larger keel vb's with well-marked abaxial girders only (Fig. IX, 3); other vb's with adaxial and abaxial strands, or sometimes girders, up to about 3 cells wide and 4 cells high (Fig. IX, 4); large vb's with adaxial and abaxial girders up to about 10 cells wide and 6 cells high (Fig. IX, 5). **Keel** conspicuous, rounded; containing 1 large median vb accompanied on either side by 1 lateral vb of about the same size, and by 7 or 8 laterals, all appreciably smaller, but variable in size (Fig. XIII, 3). **Mesophyll:** chlorenchyma not conspicuously radiate. **Bulliform cells** in small groups of specially large cells (*Zea* type, Fig. XV, 3). **Bundle-sheaths** single; all small vb's each with a complete sheath (Fig. XI, 2*a*); sheaths round the large vb's interrupted adaxially and abaxially (Fig. XI, 4).

Culm

Culm examined 4 mm in diameter. Epidermis subtended by a zone of about 12 layers of cells which are appreciably smaller in diameter, and with the walls more highly lignified than those of the inner, solid, but somewhat spongy, ground tissue. Vb's more or less scattered throughout the culm, those in the 2 outermost circles being embedded in the peripheral, thick-walled ground tissue.

Material Examined: Cultivated at Kew.

Special Note

An intergeneric hybrid between *Euchlaena* and *Zea*.

EUCLASTA

Diagnostic Generic Characters

Short-cells, over the veins, in long rows. Silica-bodies, over the veins, mostly dumb-bell shaped, but a few nodular, or tending to be saddle-shaped. Micro-hairs present; rather narrow; each with the distal cell tapering to a rounded

apex. Stomata with subsidiary cells triangular, or tending to be so. Vascular bundles mostly small and conspicuously angular in outline. Mesophyll with distinctly radiate chlorenchyma. Bundle-sheaths single.

Species Specially Examined

***Euclasta condylotricha* (Hochst. ex Steud.) Stapf**

LEAF

Abaxial epidermis

Short-cells, over the veins, in rows of more than 5 cells; abundant over, but infrequent between, the veins. **Silica-bodies,** over the veins, dumb-bell shaped but varying in appearance with the focus (Fig. IB, 21); occasionally nodular (Fig. IB, 22 (iii)). (Some of those that are dumb-bell shaped could be interpreted as saddle-shaped (Fig. I, 9) when the thin middle portion connecting the 2 ends of the body is inconspicuous.) Occasional silica-bodies between the veins cross-shaped (Fig. IA, 16). **Macro-hairs :** stiff hairs, with swollen, sunken, constricted bases (Fig. II, 3) frequent in the intercostal zones, the bases of the hairs being surrounded by cushion cells. **Micro-hairs :** length 40–54 μ; basal cell 25–36 μ; distal cell 12–18 μ; hairs rather narrow in proportion to their lengths; distal cells tapering to pointed apices (Fig. VII, 9). **Prickle-hairs :** none seen. **Papillae :** large, oblique papillae with thickened endings, nearly always present on the interstomatal cells, each cell bearing 1 large papilla (Fig. III, 2). **Stomata** mostly with triangular (Fig. IV, 1), or slightly triangular, subsidiary cells. **Long-cells** with thin, mostly non-sinuous walls (Fig. V, 2*a–c*).

T.S. lamina

Vascular bundles : most small vb's angular (Fig. VIII, 5); a few large vb's of basic type (Fig. VIII, 10). **Adaxial surface** practically smooth (Fig. XIV, 1). Groups of cushion cells forming mound-like projections on the abaxial surface. **Sclerenchyma :** most small vb's not accompanied by scl. (Fig. IX, 1); other small vb's with adaxial and abaxial girders 2–3 cells wide and high (Fig. IX, 4); large vb's with slightly wider adaxial and abaxial girders. **Keel** conspicuous; containing 1 large median vb accompanied on either side by 2–3 much smaller laterals (Fig. XIII, 3). **Mesophyll :** chlorenchyma distinctly radiate. **Bulliform cells** in irregular groups (Fig. XV, 1). **Bundle-sheaths** single; all small vb's, and some large vb's, each with 1 complete sheath (Fig. XI, 2*a–b*); most large vb's with the sheath interrupted abaxially (Fig. XI, 6).

MATERIAL EXAMINED: Meikle 650; Nigeria.

Special Note

Leaf structure typically panicoid. Prat (1937) considers that the structure indicates that *E. condylotricha* should be in *Dichanthium* under the old name *D. condylotrichum* (Hochst. ex Steud.) Prat.

Literature

Prat 1937 (leaf).

EULALIA (see also p. 405)

Diagnostic Generic Characters

Short-cells, over the veins, in short or long rows, and sometimes in pairs. Silica-bodies, over the veins, cross to dumb-bell shaped, or occasionally nodular. Micro-hairs present; each with the distal cell tapering to a rounded or acutely pointed apex. Stomata with low to tall dome-shaped subsidiary cells. Vascular bundles mostly small and conspicuously angular in outline. Mesophyll with chlorenchyma distinctly to indistinctly radiate. Bundle-sheaths single.

Species Specially Examined

***Eulalia geniculata* Stapf**

LEAF

Abaxial epidermis

Short-cells, over the veins, in rows of more than 5 cells; common over, but infrequent or absent between, the veins. **Silica-bodies** intermediate between cross and dumb-bell shaped (Fig. IA, 17), and dumb-bell shaped (Fig. IA, 18 (ii–iv)). **Macro-hairs :** none seen. **Micro-hairs :** length 24–33 μ; basal and distal cells 12–17 μ; distal cells tapering to rounded, or sometimes acutely pointed, apices (Fig. VII, 6). **Prickle-hairs :** pointed, angular prickles (Fig. VI, 3) numerous at the leaf margins; also a few unpointed prickles (Fig. VI, 6) over some of the veins. **Papillae :** swollen, thin-walled, somewhat globose and mostly somewhat oblique papillae (Fig. III, 3) abundant over all of the long-cells between the veins, a single row of papillae usually present on each cell. Similar papillae present on the adaxial surface as well. **Stomata** mostly with low (Fig. IV, 3), or high (Fig. IV, 4), dome-shaped subsidiary cells. **Long-cells,** between the veins, with thin, slightly sinuous, walls (Fig. V, 3*a–c*); interstomatal cells with concave ends (Fig. V, 11), and rather long.

T.S. lamina

Vascular bundles : most vb's small and angular (Fig. VIII, 5); a few large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with numerous, v. slight ribs over all vb's, separated from one another by v. slight, narrow furrows (Fig. XIV, 2). **Sclerenchyma :** most small vb's not accompanied by scl. (Fig. IX, 1); other small vb's with minute adaxial and abaxial girders (Fig. IX, 4), the adaxial girders often being 1–2 cells wide and high, and the abaxial girders about 5 cells wide; large vb's with slightly wider adaxial and abaxial girders; a few small vb's with minute abaxial girders only. **Keel** fairly conspicuous, rounded; containing 1 large median vb accompanied on either side by about 3 appreciably smaller laterals (Fig. XIII, 3). **Mesophyll :** chlorenchyma distinctly radiate. **Bulliform cells** in groups of the *Sporobolus* type (Fig. XV, 8), each group being connected to the abaxial surface by a girder of colourless cells (Fig. XV, 13). Adaxial part of the midrib consisting of colourless cells. **Bundle-sheaths** single; all small vb's each with a complete sheath (Fig. XI, 2*a*); sheaths round the large vb's usually interrupted abaxially (Fig. XI, 6).

CULM

Culm examined somewhat oval in T.S., and with a slight, crescent-shaped depression on 1 side; long diameter 3 mm, short diameter 2 mm. Epidermis subtended by 2 layers of thick-walled cells, followed by about 6 layers of lignified cells of rather wider diameter, except for small cells around the vb's of the outermost circle. Inner ground tissue consisting of cells with much larger diameters, and fairly thick to thin walls. Vb's in about 4 circles, those of the outermost circle being v. small to small and embedded in the peripheral lignified ground tissue. Vb's of the second circle situated at the inner margin of the peripheral ring of lignified ground tissue. Centre of the culm occupied by a large cavity.

MATERIAL EXAMINED: Collected specially by G. Jackson in Nyasaland.

***Eulalia phaeothrix* (Hack.) O. Ktze.**

LEAF

Abaxial epidermis

Short-cells, between the veins, mostly solitary, and in pairs; some of those over the veins also solitary and in pairs, but others in short rows; infrequent between the veins. **Silica-bodies,** over the veins, variable in form, some more or less cross-shaped (Fig. IA, 16), others intermediate between cross and dumb-bell shaped (Fig. IA, 17), or dumb-bell shaped (Fig. IA, 18 (ii–iv)), this last type sometimes varying in appearance with the focus (Fig. IB, 21); a few nodular (Fig. IB, 22 (iii)). **Macro-hairs:** none seen. **Micro-hairs:** length 40–48 μ; basal cell 14–20 μ; distal cell 24–29 μ; distal cells tapering to rounded, or sometimes acutely pointed, apices (Fig. VII, 6). **Prickle-hairs:** prickles, mostly rather small, numerous between the veins (Fig. VI, 1); structures transitional between prickles and hooks (Fig. VI, 5) also present. **Stomata** mostly with low (Fig. IV, 3), or fairly tall (Fig. IV, 4), dome-shaped subsidiary cells. **Long-cells,** between the veins, with thin, coarsely sinuous walls (Fig. V, 3*a–c*).

T.S. lamina

Vascular bundles: a few of the smallest vb's with the xy. and ph. not clearly contrasted (Fig. VIII, 1); most small vb's angular (Fig. VIII, 5); a few large vb's of basic type (Fig. VIII, 15). **Adaxial surface** practically smooth (Fig. XIV, 1). V. slight ribs present on the abaxial surface. **Sclerenchyma:** a few small vb's not accompanied by scl. (Fig. IX, 1); most of the small vb's with abaxial strands only, each up to about 10 cells wide, but a few vb's with minute adaxial strands as well (Fig. IX, 4); large vb's with slightly wider adaxial and abaxial strands (Fig. IX, 5). **Keel** fairly conspicuous, rounded; containing 1 large median vb accompanied on either side by at least 1 v. much smaller lateral (Fig. XIII, 2). **Mesophyll:** chlorenchyma indistinctly radiate, but not well preserved in the material examined. **Bulliform cells** mostly in small groups of specially large cells of the *Zea* type (Fig. XV, 3); a few in somewhat fan-shaped groups (Fig. XV, 4). **Bundle-sheaths** single; small vb's each with 1 complete sheath (Fig. XI, 2*a*); sheaths round the large vb's interrupted adaxially and abaxially (Fig. XI, 3), the inner walls of some of the sheath cells being v. strongly thickened.

CULM

Culm examined about 2 mm in diameter. Epidermis subtended by a ring of about 6 layers of thick-walled ground tissue. Inner ground tissue composed of cells of much larger diameter, with less lignified walls. Vb's in about 4 circles, those of the outermost circle v. small and embedded in the peripheral scl. ring. Other vb's embedded in the unlignified ground tissue, some of them situated in a deep position near the fairly large cavity at the centre of the culm.

MATERIAL EXAMINED: F. Ballard 1218; Ceylon.

SPECIAL NOTE

Leaf structure typically panicoid.

EUSTACHYS

E. paspaloides (Vahl.) Lanza & Mattei of S. and E. Africa has been wrongly referred to *E. petraea* (Swartz) Desv. (*Chloris petraea* Swartz) of tropical America. Its leaf structure is v. similar to that of *Chloris*.

Grob (1896), with reference to the leaf epidermis, records short-cells, over the veins, in rows; silica-bodies saddle-shaped; short micro-hairs present, each with a hemispherical distal cell. The following information concerning the lamina in T.S. has mostly been taken from Fisher's (1939) description. Prickles mainly confined to the leaf margins and keel. Keel conspicuous, as an acute abaxial projection; containing 1 large median vb accompanied on either side by several smaller bundles. Median keel bundle almost encircled by scl.; other large vb's accompanied by adaxial strands and abaxial girders of scl.; small vb's with abaxial girders only. Submarginal strands of scl. said to be absent. Mesophyll: chlorenchyma described by Fisher as non-radiate, but apparently indistinctly radiate in his illustrations; adaxial part consisting of large colourless cells. An adaxial, V-shaped mass of colourless cells also present in the midrib. Bulliform cells in the form of 1 large group over the midrib. Bundle-sheaths; those of the large and medium-sized vb's double; those of the small vb's single and mostly interrupted abaxially.

LITERATURE

Fisher 1939 (leaf and vegetative buds); Duval-Jouve 1875 (leaf); Grob 1896 (leaf).

FESTUCA

DIAGNOSTIC GENERIC CHARACTERS

Leaf-blade strongly infolded or acicular in many spp. Short-cells, over the veins, solitary or paired. Silica-bodies, over the veins, round to elliptical or slightly crescent-shaped, and fitting into concavities in adjacent cork-cells. Micro-hairs absent. Stomata absent from the abaxial surface in certain spp.;

where present with low dome-shaped or parallel-sided subsidiary cells. Vascular bundles, even when small, not conspicuously angular in outline. Mesophyll with chlorenchyma not radiate. Bundle-sheaths double.

Species Specially Examined

***Festuca arundinacea* Schreb.**

Leaf

Abaxial epidermis (Figs. XXIV, 1–6 and XXVIII, 2)

Short-cells, over the veins, paired; those between the veins often solitary but sometimes paired; abundant. **Silica-bodies** each fitting into a concavity in an adjacent cork-cell (Fig. I, 6–7), the silica-bodies themselves being mostly round or elliptical. **Macro-hairs:** a few short, rigid, thick-walled hairs (Fig. IIA, 10) present on the adaxial surface. **Micro-hairs:** none seen. **Prickle-hairs:** none seen on the abaxial surface, but recorded on the adaxial surface by Burr and Turner (1933). **Stomata** mostly with low dome-shaped subsidiary cells (Fig. IV, 3).[1] **Long-cells,** between the veins, with thin sinuous walls (Fig. V, 3*a–c*).

T.S. lamina

Vascular bundles: most vb's small and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 10 and 11), fairly numerous. **Adaxial surface** with well-developed ribs of rather variable height, and mostly with rounded apices, separated from one another by fairly deep, U-shaped furrows (Fig. XIV, 3). **Sclerenchyma:** smallest vb's accompanied by minute adaxial and abaxial strands up to about 4 cells wide and 1–2 cells high; occasional vb's with well-marked abaxial girders only (Fig. IX, 3); most vb's with adaxial and abaxial girders up to about 10 cells high and 6 cells wide (Fig. IX, 4), some of the adaxial girders being slightly T-shaped (Fig. IX, 7–8); large vb's with girders of about the same height as those just described, but somewhat wider. Scl. strands also in the leaf margins. **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** in well-marked fan-shaped groups (Fig. XV, 6) at the bases of the furrows. **Bundle-sheaths** double; smallest vb's with 2 complete sheaths (Fig. XII, 1); others with I.S. complete and O.S. not quite complete abaxially (Fig. XII, 2); some with I.S. complete and O.S. interrupted abaxially and connected to the adaxial scl. by large cells (Fig. XII, 4 and 7).

Culm

Culm examined about 3 mm in diameter. Peripheral scl. ring well defined, about 6 cells wide, with small columns of assimilatory tissue embedded in it at intervals around the culm. Inner ground tissue with progressively thinner walls on passing towards the fairly large cavity at the centre of the culm. Vb's in about 3 circles, those of the outermost circle embedded in the peripheral scl., the boundaries between them and the contiguous scl. being very obscure.

Material Examined: Cultivated at Kew.

[1] Warncke (1911) says the abaxial stomata of this sp. are slightly, and the adaxial stomata more deeply, sunken. There are corresponding differences in the shapes of the guard cells.

Festuca arundinacea* × *Lolium perenne

Leaf

Abaxial epidermis (Fig. XXVIII, 1)

Short-cells, both over and between the veins, occasionally solitary, but mostly paired; a few of those over the veins in v. short rows; common. **Silica-bodies,** between the veins, mostly tall and narrow (Fig. I, 4); those over the veins oblong (Fig. I, 10), or horizontally elongated, with rounded ends and smooth walls (Fig. IA, 12–13); some of them fitting into concavities in adjacent cork-cells (Fig. I, 6–7). **Macro-hairs:** a few short, rigid, thick-walled hairs (Fig. IIA, 10) present on the adaxial ribs. **Micro-hairs:** none seen. **Prickle-hairs:** angular prickles (Fig. VI, 3) numerous at the leaf margins. **Stomata** mostly with parallel-sided subsidiary cells (Fig. IV, 2). **Long-cells,** between the veins, with thin, sinuous walls (Fig. V, 3*a–c*).

T.S. lamina

Vascular bundles: most vb's small and not conspicuously angular in outline (Fig. VIII, 2); a few large vb's of basic type (Fig. VIII, 10 and 11). **Adaxial surface** with slight to moderate, rather widely spaced ribs, separated from one another by narrower, shallow furrows (Fig. XIV, 2 and 3). **Sclerenchyma:** a few of the small vb's with adaxial strands only (Fig. IX, 2); others with small adaxial and abaxial strands or girders (Fig. IX, 4), those associated with the small vb's up to about 3 cells wide and 6 cells high, but often, especially the adaxial strands, much narrower; large vb's with rather wider adaxial and abaxial girders. **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** mostly in well-developed fan-shaped groups (Fig. XV, 6) at the bases of the furrows. **Bundle-sheaths** double; the small, and some of the medium-sized, vb's with I.S. complete and O.S. incomplete or obscure abaxially (Fig. XII, 2); large vb's with I.S. complete, and O.S. interrupted abaxially, but connected to the adaxial scl. by large cells (Fig. XII, 4).

Culm

Culm examined about 2 mm in diameter. Epidermis subtended by a peripheral scl. ring about 6 cells wide, with some flattened columns of assimilatory tissue embedded in it. Vb's in about 3 circles, those of the outermost circle being embedded in the peripheral scl. Vb's not penetrating v. deeply into the central ground tissue. Culm solid in the material examined.

Material Examined: Cultivated at Kew.

***Festuca glauca* Lam.**

Leaf

Abaxial epidermis (Fig. XXVIII, 3)

Short-cells mostly solitary, but a few paired; abundant. Some **silica-bodies** fitting into concavities in adjacent cork-cells (Fig. I, 6–7), the bodies themselves being mostly oval or slightly crescent-shaped. **Macro-hairs:** superficial

hairs with swollen bases (Fig. II, 1) occurring particularly on the adaxial surface. **Micro-hairs:** none seen. **Prickle-hairs:** angular prickles (Fig. VI, 3) local. **Stomata** absent from the abaxial surface. **Long-cells** with thick, pitted or sinuous walls (Fig. V, 1*a–b*).

T.S. lamina

Vascular bundles: most vb's small and not conspicuously angular in outline (Fig. VIII, 2); a few large vb's of basic type (Fig. VIII, 10). **Adaxial surface:** leaf of the acicular type with an adaxial groove. **Sclerenchyma** distributed as in Fig. X, 2. **Mesophyll:** chlorenchyma not radiate. **Bulliform cells:** 2 U-shaped furrows at the base of the main adaxial groove containing bulliform cells of variable size, none of them being specially large (Fig. XV, 5). **Bundle-sheaths** double; all vb's with I.S. complete and O.S. incomplete or obscure abaxially (Fig. XII, 2).

CULM

Culm examined less than 1 mm in diameter. Superficial tissue apparently thin-walled, but missing from the sections examined. Ground tissue consisting wholly of v. thick-walled cells, the cells external to the vb's having v. markedly U-shaped thickenings, and only a v. small lumen towards the adaxial side of the cells. Vb's in 2 circles, the boundaries of the vb's merging obscurely with the thick-walled ground tissue. Centre of the culm with a fairly large cavity.

MATERIAL EXAMINED: Cultivated at Kew.

***Festuca heterophylla* Lam.**

This grass has leaves of 2 kinds. Over most of the plant the leaves are relatively broad and large, compared with the small acicular leaves that occur at the base of the plant. The leaves of these 2 types are described separately below.

1. LARGE, BROAD LEAF

Abaxial epidermis

Short-cells sometimes solitary, but mostly paired; common, but less frequent between than over the veins. **Silica-bodies:** a few tall and narrow (Fig. I, 4), but most of them fitting into concavities in adjacent cork-cells (Fig. I, 6–7), the silica-bodies being round, elliptical, or slightly crescent-shaped in outline; some of those over the veins oblong (Fig. I, 8 and 10). **Macro-hairs:** none seen on the abaxial surface, but short hairs present above the veins on the adaxial surface. **Micro-hairs:** none seen. **Prickle-hairs:** prickles (Fig. VI, 1–2) fairly common over the veins; angular prickles (Fig. VI, 3) present at the leaf margins. **Stomata** mostly with parallel-sided (Fig. IV, 2), but others with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells:** those over the veins with thick, sinuous walls (Fig. V, 1*a–b*); those between the veins with thin, sinuous walls (Fig. V, 3*a–c*), the individual cells sometimes being narrower at the ends than in the middle.

T.S. lamina

Vascular bundles: most vb's small and not conspicuously angular in outline (Fig. VIII, 2); a few large vb's of basic type (Fig. VIII, 15); about 14 vb's present altogether. **Adaxial surface** with moderate, mostly rather wide, and slightly rounded, ribs, separated from one another by narrower, moderately deep furrows (Fig. XIV, 3), a few of the ribs appreciably smaller and more rounded than the remainder. **Sclerenchyma:** small vb's near the leaf margin not accompanied by scl. (Fig. IX, 1); others with adaxial girders only (Fig. IX, 2), the girders being up to about 8 cells wide and sometimes slightly T-shaped, or with adaxial strands about 5 cells wide and 2 cells high and smaller abaxial strands often only about 2 cells wide and high (Fig. IX, 4). **Keel** not conspicuous; containing a solitary vb. **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** in fan-shaped groups (Fig. XV, 6) at the bases of the furrows, the cells being rather small, resembling those in Fig. XV, 5. **Bundle-sheaths** double; some vb's with 2 complete sheaths (Fig. XII, 1); others with I.S. complete, but O.S. not quite complete abaxially (Fig. XII, 2); median vb with I.S. complete, but O.S. interrupted abaxially and connected to the adaxial scl. by large cells (Fig. XII, 4).

2. NARROW, BASAL LEAF

Abaxial epidermis

Short-cells, both over and between the veins, mostly solitary and paired; common, but less frequent between than over the veins. **Silica-bodies** as in the broad leaf. **Prickle-hairs:** prickles (Fig. VI, 1–2) and angular prickles (Fig. VI, 3) frequent over the veins. **Stomata** absent from the abaxial surface. **Long-cells,** as in the broad leaf.

T.S. lamina

Vascular bundles: acicular leaf containing 3 vb's not conspicuously angular in outline (Fig. VIII, 2). **Sclerenchyma** as in Fig. X, 1, but simplified, with small strands of scl. confined to the 2 margins and 3 angles of the leaf. **Keel** conspicuous, forming a triangular abaxial part of the acicular leaf. **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** in v. small fan-shaped groups at the bases of the 2 furrows (Fig. XV, 6). **Bundle-sheaths** double; all vb's with the O.S. incomplete abaxially (Fig. XII, 2).

(The figure of a basal leaf in T.S. given by Pée-Laby (1898) does not appear to be correctly drawn. See also Howarth 1922–4.)

MATERIAL EXAMINED: Cultivated at Kew.

'*Festuca punctoria* Sibth. & Smith'

LEAF

Abaxial epidermis

Short-cells sometimes solitary, but mostly paired, those between the veins occasionally in groups of 3–4 cells according to Grob (1896); abundant both over and between the veins. **Silica-bodies** each fitting into a concavity in an

adjacent cork-cell (Fig. I, 6–7), the bodies being mostly round or somewhat elliptical in outline. **Macro-hairs:** short, rigid, thick-walled hairs with slightly sunken bases present on the apices, and to some extent on the sides, of the adaxial ribs (Fig. II, 3). **Micro-hairs:** none seen. **Prickle-hairs:** prickles (Fig. VI, 1–2) occur locally. **Stomata** absent from the abaxial surface. **Long-cells** with thick, sinuous walls (Fig. V, 1*b*), each consecutive long-cell in each file of cells separated from the next by a solitary, tall silica-cell, or by a pair of short-cells, v. markedly at right angles to the horizontal walls.

T.S. lamina

Leaf strongly infolded and tending to be acicular. **Adaxial surface** with a median rib accompanied on either side by 2 rounded lateral ribs, and by a wide flattened marginal rib. **Vascular bundles** consisting of a median vb accompanied by 5 laterals in each half of the lamina, one lateral being about the same size as the median vb and the rest smaller. **Sclerenchyma:** a broad continuous zone of scl. subjacent to the epidermis. **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** in fan-shaped groups (Fig. XV, 6) at the bases of the furrows, the cells penetrating rather deeply into the mesophyll. **Bundle-sheaths** double; a few vb's with 2 complete sheaths (Fig. XII, 1); others with I.S. complete but O.S. not quite complete, or inconspicuous, abaxially (Fig. XII, 2); cells of the I.S. often with U-shaped thickenings.

MATERIAL EXAMINED: Cultivated at Kew.

ADDITIONAL INFORMATION FROM THE LITERATURE

1. LEAF

Festuca is a large genus in which the interspecific boundaries are by no means clear cut. The leaf structure, particularly as revealed in T.S. through the lamina, has been used by a number of taxonomists as an aid in identification, especially of those spp. of which the lamina is strongly infolded or acicular. The spp. with expanded leaf-blades have been less thoroughly examined. With the infolded and acicular leaves the shape of the outline of the blade in T.S., the number of vb's and adaxial ribs, the distribution of scl. and the presence or absence of hairs and prickles are the characters that have been most frequently used for diagnostic purposes. There is reason to suspect, however, that although these characters are reliable for diagnostic purposes up to a point, they vary within a sp. to some extent. This appears to apply particularly to the distribution of scl. The appearance of the scl. can be obscured to some extent in a section that is too thick, and this applies particularly to the question of whether the abaxial scl. is restricted to strands or girders opposite the vb's, or whether it forms a continuous hypodermal band on the abaxial side of the leaf. There are also structural variations depending on the exact level in the blade at which a T.S. is taken. For comparative diagnostic purposes it is usually most convenient to restrict attention to T.S.s taken half-way along the length of the blade.

It is impossible here to give an adequate summary of the descriptive data that have been recorded for every sp. that has been examined anatomically, particularly as it is not always certain whether the material on which descriptions have been based has been accurately identified. Some details are given below of certain spp., but for particulars of others the reader is referred to the literature.

F. eskia Ram.

Abaxial surface of cauline leaves with silica-cells and cork-cells both over and between the veins. Adaxial surface of lamina ribbed. Some particulars for floral leaves also given. (Prat 1932, under *F. varia* Haenke.) Scl. said to occur in the leaf margins and keel, and to form a continuous, abaxial, hypodermal layer. (Duval-Jouve 1875.)

F. gigantea (L.) Vill.

Leaf-blade flat. Adaxial surface with low ribs. Scl. present in the leaf margins and keel, and forming adaxial and/or abaxial strands to the small, and girders to the large, vb's. Keel well developed. Bulliform cells not conspicuous between the ribs. Colourless cells forming the ground tissue in the adaxial part of the midrib. (Burr and Turner 1933, under *Bromus giganteus*; Hartmann 1930.)

F. hookeriana F. Muell. (*Poa hookeriana*)

Vb's all primary except those next to the leaf margins. Adaxial surface slightly sinuous. Scl. forming well-marked adaxial and abaxial girders to the vb's; crescent-shaped strands also present in the leaf margins, and strands of only a few cells opposite the bulliform cells. Midrib not v. prominent. Mesophyll with chlorenchyma differentiated into palisade and spongy portions. Bulliform cells specially large. Bundle-sheaths double; I.S. consisting of cells with the inner tangential walls only slightly more thickened than the outer tangential walls; O.S. not well defined and interrupted adaxially and abaxially by scl. (Lohauss 1905.)

F. juncifolia St.-Amans

Leaf blades v. narrow, tightly inrolled, or, when unrolled, 5 mm wide. Vb's 7–11. Adaxial surface with 5–9 prominent ribs, with minute hairs at the apices of the ribs. Scl. forming a continuous, hypodermal, abaxial band of varying thickness, and sometimes forming an abaxial girder with the median vb; small strands occasionally present at the apices of the ribs. (Howarth 1922, 1924; Hubbard 1954.)

F. laevis Hack.

Leaf-blade strongly infolded; with about 7 vb's and adaxial ribs. Scl. forming a continuous, hypodermal, abaxial band. (St. Yves 1921.)

F. ovina L. (Sheep's Fescue)

The leaf structure of this sp. is variable, and the delimitation of the sp. is not clearly defined. Blades hair- or bristle-like. Vb's 5–7 or rarely 9. Scl. said by some authors to be scantily developed and restricted to small strands in the leaf margins and opposite the vb's. Other authors refer to or illustrate the scl. as forming a continuous, hypodermal, abaxial band. Prickles and/or short hairs present on the adaxial surface. Opinions appear to differ concerning the extent to which bulliform cells are developed. The culm of this sp. has been described by Hohenauer. (Altenkirch 1894; Burr and Turner 1933; Duval-Jouve 1875; Hohenauer 1893; Howarth 1925; Hubbard 1954; Lewton-Brain 1904; Pée-Laby 1898; Strecker 1913.)

F. pratensis Huds.

Leaf-blades wide and hairless; in general similar to those of *F. arundinacea*, but smaller, less coarse, and with less frequent prickles. Scl. forming well-marked adaxial girders and smaller adaxial strands to most vb's, the strands being united to the outer bundle-sheaths by girders of colourless cells. Bulliform cells in well-developed groups at the bases of the adaxial furrows. Ground tissue in the adaxial part of the midrib composed of colourless cells. Cell dimensions for the epidermis of this sp.

have been recorded by Martin. (Burr and Turner 1933; Hartmann 1930; Hubbard 1954; Lewton-Brain 1904; Martin 1954; Strecker 1913.)

F. rubra L.

Structure somewhat variable; sspp. occur. Blade closely inrolled and markedly keeled. Vb's 5–7. Adaxial ribs apparently varying in number from 1 to 7, presumably in different forms. Scl. present as abaxial strands opposite the vb's, and in the leaf margins; occasionally as small strands at the apices of the ribs as well. Pée-Laby refers to a continuous band of scl. beneath the abaxial epidermis, but this is probably incorrect. Cell dimensions for the epidermis of this sp. have been recorded by Martin. (Burr and Turner 1933; Hartmann 1930; Howarth 1922, 1924; Lewton-Brain 1904; Martin 1954; Strecker 1913.)

F. rubra L. ssp. *rubra* (Red Fescue)

Leaf-blade acutely keeled. Adaxial surface with 5–7 ribs. Scl. restricted to small abaxial strands opposite the vb's, and in the leaf margins. (Burr and Turner 1933, under *F. rubra* ssp. *genuina*.) (Fig. X, 1.)

F. rubra L. ssp. *commutata* Gaud. (Chewing's Fescue)

Leaf-blade bristle-like; basal part tightly infolded and bluntly keeled. Prickles present on the adaxial surface. V. similar to Red Fescue. (Burr and Turner 1933; Howarth 1922–4; Hubbard 1954.)

F. tenuifolia Sibth. (Fine-leaved Sheep's Fescue)

Leaf-blade hair-like, tightly infolded and similar to that of *F. ovina* and *F. rubra*. Vb's usually 5 but rarely 7. Figured as having only 1 adaxial rib. Scl. forming a continuous hypodermal abaxial band, but not girdered to the vb's. Prickles and bulliform cells well developed on the adaxial surface. (Burr and Turner 1933; Hubbard 1954.)

Other species

Ufer (1927) found small differences in the leaves of Fescues of the *F. rubra, ovina,* and *ovina-sulcata* types. The differences may not be constant, and transitional types are stated to occur.

Horanszky (1954) has published descriptions of the leaf epidermis of the following spp. of *Festuca* as found in Hungary: *F. amethystina* L., *glauca* Lam., *ovina* L., *pseudovina* Hack., *sulcata* (Hack.) Nym., *tenuifolia* Sibth. *vaginata* W. & K. Photomicrographs of the epidermis of these spp. are given and there is a key to them based on epidermal characters. Differences between the spp. are small and are shown mainly by the distribution of prickles and hairs.

Vetter (1949–50) has published figures showing T.S.s of the leaves of the following: *F. ovina* L. ssp. *frigida* Hack. var. *peristerea* J. Vetter, *F. heteroglossa* J. Vetter, and *F. pseudovaria* J. Vetter. Latin diagnoses of these spp. are given. The spp. are said to be distinguished by small differences in the outline of the leaf and in the distribution of scl.

Parodi has illustrated the leaf structure in T.S. of 16 spp. of *Festuca* from Patagonia.

Spp. from New Zealand have been dealt with by Howarth (1928).

Other spp. have been described by St. Yves (1909–21).

2. Culm

Chrysler (1906) records the occurrence of amphivasal bundles, formed by fusion, in the culm nodes of certain spp. of *Festuca*.

3. Root

F. rubra L. var. *arenaria* Fries is a form that occurs on sand-dunes and is characterized by a creeping rhizome with deep anchoring roots and finely divided absorbing roots. Freidenfelt (1904) gives the following particulars concerning the root structure.

First-order roots. Epidermis thin-walled, becoming compressed when older. Cortex of about 8 layers of cells, with small intercellular spaces in the inner part. Innermost layer of the cortex, and sometimes the next outer layer, ultimately becoming thickened, the remainder of the cortex being reduced to a dead crust. Endodermis with the inner cell walls strongly thickened. Stele including 3–4 metaxylem vessels about 45 μ wide. Second-order roots. Cortex of large roots consisting of 3 layers of cells with no intercellular spaces between them. Epidermis and cortex eventually forming a dead crust. Endodermis consisting of thin-walled cells when young, but inner walls becoming thickened when older. Stele triarch. Roots of lesser orders with the cortex still more reduced.

4. Developmental Anatomy

The shoot apex of *Festuca* is stated by Sharman (1947) to be of the type, common amongst grasses, with 5–10 primordia.

Special Note

As is only to be expected, the structure is typically festucoid.

Literature

Altenkirch 1894 (leaf of *F. ovina*); Barsos 1957 (experimental morphology); Burr and Turner 1933 (mainly leaf; British spp.); Chrysler 1906 (notes on culm structure); Duval-Jouve 1875 (leaf); Freidenfelt 1904 (root); Frohnmeyer 1914 (deposition of silica); Grob 1896 (leaf); Günzel 1921 (leaf); Hackel 1882 (early monograph of European spp.); Hartmann 1930 (leaf); Herriott 1906 (1 sp. from New Zealand); Hohenauer 1894 (culm of *F. ovina*); Holm 1908 (brief notes on root, culm, and leaf); Horanszky 1954 (leaf epidermis of Hungarian spp.); Howarth 1919, 1922–4, 1924, 1925, 1928 (mainly leaf; 1928 deals with spp. from New Zealand); Hubbard 1954 (taxonomy and leaf); Lewton-Brain 1904 (leaf); Lohauss 1905 (leaf); Martin 1955 (cell dimensions of leaf epidermis of *F. pratensis* and *F. rubra*); Parodi 1953 (leaf of 61 spp. from Patagonia); Pée-Laby 1898 (leaf); Prat 1932, 1936 (leaf); Radelkoff 1929 (microscopy of fruit wall); Saint-Yves 1909 *a, b,* 1911–13, 1913–14, 1921 (leaf); Sharman 1947 (developmental anatomy); Strecker 1913 (leaf); Stuber 1938 (leaf, ecological anatomy); Ufer 1927 (leaf); Vetter 1915, 1917, 1949 (leaf); Vischer 1915 (mechanism of leaf folding in *F. glauca*); Warncke 1911 (stomata of *F. arundinacea*).

FINGERHUTHIA

Diagnostic Generic Characters

Short-cells, over the veins, mostly paired, but sometimes solitary. Silica-bodies, over the veins, variable, ranging from saddle-shaped to cubical or crescent shaped. Micro-hairs infrequent; each with the inflated distal cell tending to be hemispherical. Stomata with markedly triangular subsidiary cells. Vascular bundles mostly small and tending to be angular in outline. Mesophyll with distinctly radiate chlorenchyma. Bundle-sheaths single.

Species Specially Examined

***Fingerhuthia africana* Lehm.**

Leaf

Abaxial epidermis

Short-cells, both over and between the veins, mostly paired, but sometimes solitary; abundant. Silica-cells appreciably larger than the cork-cells. Some **silica-bodies** tending to be saddle-shaped (Fig. I, 5); others more or less cubical but with rounded corners, or elliptical or slightly crescent-shaped. **Macro-hairs:** moderately long hairs with fairly thick walls, and somewhat sunken and constricted bases, occurring mostly on the ribs on the adaxial surface. **Micro-hairs** only seen locally and infrequently in the material available; length 55–67 μ; basal cells 36–44 μ; distal cell 18–24 μ; basal cells tapering considerably towards their proximal ends; distal cells inflated, with rounded apices, often tending to be hemispherical (Fig. VII, 12). **Prickle-hairs:** angular prickles (Fig. VI, 3) present at the leaf margins; hooks (Fig. VI, 5) or small prickles (Fig. VI, 1) present, chiefly in the intercostal zones. **Stomata** with markedly triangular (Fig. IV, 1) subsidiary cells. **Long-cells,** both over and between the veins, with markedly sinuous, fairly thick walls, somewhat resembling those in Fig. V, 3*a–c*, but not so long.

T.S. lamina

Vascular bundles: small vb's angular, although rather less so than in Fig. VIII, 5; large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with moderate ribs and furrows (Fig. XIV, 3), the ribs over the large vb's being distinctly taller, wider, and more flattened at the apices than those over the small vb's. Ribs and furrows about equally well developed on the abaxial surface. **Sclerenchyma:** marginal vb's with v. small adaxial and abaxial strands (Fig. IX, 4), or none (Fig. IX, 1); combined girders of most vb's incompletely anchor-shaped (Fig. IX, 6), the adaxial strands not being in contact with the bundle-sheath. Large vb's with double anchor-shaped girders, i.e. each with an adaxial and an abaxial girder, both slightly anchor-shaped; a v. few, small vb's opposite the groups of bulliform cells with minute abaxial strands or girders only. **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma distinctly radiate. **Bulliform cells** in groups of the *Sporobolus* type (Fig. XV, 8), but each group connected to the base of a furrow in the abaxial surface by a girder of colourless cells extending across the mesophyll (Fig. XV, 13). **Bundle-sheaths** single; most small vb's each with a complete sheath (Fig. XI, 2*a*); sheaths round other small vb's interrupted abaxially (Fig. XI, 6), and those round the large vb's interrupted adaxially and abaxially (Fig. XI, 3).

Material Examined: E. G. Bryant 654; S. Africa.

Special Note

The facts recorded above confirm Prat's (1936) opinion that the leaf structure is panicoid. The genus is sometimes wrongly regarded as one of the Festuceae. The micro-hairs recall those of *Eragrostis*.

Literature

Grob 1896 (leaf); Prat 1936 (leaf).

GARNOTIA

Diagnostic Generic Characters

Short-cells, over the veins, in short or long rows. Silica-bodies, over the veins, variable, ranging from crescent-shaped to cross or dumb-bell shaped and occasionally saddle-shaped; when crescent-shaped each tending to fit into a concavity in an adjacent cork-cell. Micro-hairs present; each with the distal cell tapering to a rounded apex. Stomata with markedly triangular subsidiary cells. Vascular bundles mostly small and angular in outline. Mesophyll with chlorenchyma not radiate. Bundle-sheaths single.

Species Specially Examined

***Garnotia courtallensis* Thwaites**

Leaf

Abaxial epidermis

Short-cells, between, and some of those over, the veins paired; others, over the veins, in rows of 3–5 or more cells; abundant over, but rather infrequent between, the veins. **Silica-bodies,** over the veins, rarely saddle-shaped (Fig. I, 5), more frequently crescent-shaped, and each tending to fit into a concavity in an adjacent cork-cell (Fig. I, 6–7); other silica-bodies intermediate between cross and dumb-bell shaped (Fig. IA, 17), or dumb-bell shaped (Fig. IA, 18 (ii–v)), and a few nodular (Fig. IA, 18 (i)). **Macro-hairs:** long, fairly thick-walled, stiff hairs with swollen, constricted bases (Fig. II, 3) v. frequent in the intercostal zones, the bases of the hairs being surrounded by specialized epidermal cells. **Micro-hairs:** length 48–60 μ; basal and distal cells 24–30 μ; basal cells tapering slightly towards their proximal ends; distal cells tapering slightly towards their rounded apices (Fig. VII, 6). **Prickle-hairs:** none seen. **Stomata** with markedly triangular (Fig. IV, 1) subsidiary cells. **Long-cells,** between the veins, with thin, sinuous walls (Fig. V, 3*a–c*), sometimes appearing to be inflated and varying in outline with the focus (Fig. V, 5).

T.S. lamina

Vascular bundles: most vb's probably angular (Fig. VIII, 5). **Adaxial surface** with slight, v. wide, rounded ribs, separated by wide, shallow furrows. **Sclerenchyma:** small vb's not accompanied by scl. (Fig. IX, 1), or with small adaxial and abaxial strands (Fig. IX, 4), a few large vb's with adaxial and abaxial girders; median keel bundle supported by a crescent-shaped abaxial girder about 5 cells tall, and a thin, subepidermal, adaxial plate. **Keel** fairly conspicuous, rounded; containing 1 large median vb accompanied on either side by a much smaller lateral (Fig. XIII, 2). **Mesophyll:** chlorenchyma not

radiate. **Bulliform cells** v. obscure in the available material, probably in groups as in Fig. XV, 2. **Bundle-sheaths** single; complete round all or most vb's (Fig. XI, 2*a–b*).

MATERIAL EXAMINED: F. Ballard 1254; Ceylon.

SPECIAL NOTE

The leaf characters are mainly panicoid.

LITERATURE

Grob 1896 (leaf).

GAUDINIA

The few following notes have been recorded in the literature concerning *G. fragilis* (L.) Beauv.

Epidermis. Silica-bodies, over the scl., oblong; those in the leaf sheath said to be irregular, circular to oblong, and not v. numerous. Large cushion hairs present on the abaxial, and prickles on the adaxial, surface. *T.S. lamina.* Adaxial and abaxial surfaces ribbed. Scl. developed above and below the vb's. Mesophyll with chlorenchyma not radiate. Bulliform cells well developed between, and never above, the vb's. Bundle-sheaths double.

SPECIAL NOTE

Although imperfectly known, the leaf structure appears to be festucoid.

LITERATURE

Duval-Jouve 1875 (leaf); Grob 1896 (leaf); Günzel 1921 (leaf); Pée-Laby 1898 (leaf).

GILGIOCHLOA

Conert (1957), in dealing with the taxonomy of *G. indurata* Pilger, gives the following notes on the leaf anatomy.

Silica-bodies dumb-bell shaped. Long bristle-hairs present between the ribs. Prickles present over and between the veins on both surfaces. Elongated micro-hairs occurring between the ribs, each hair with the basal cell longer and wider than the distal cell. Leaf flattened. Margins rounded, and scarcely inrolled. Both surfaces ribbed. Scl. forming flattened adaxial strands and abaxial girders to the large vb's; a few fibres present in the leaf margins. Midrib conspicuous. Mesophyll with radiate chlorenchyma. Bundle-sheaths mostly single; I.S. restricted to the ph. portions of the large vb's.

SPECIAL NOTE

Gilgiochloa is treated by Conert as a member of the Arundinelleae, and its leaf structure appears to agree quite well with that of other genera included in this group.

LITERATURE

Conert 1957 (leaf structure and taxonomy).

GLYCERIA

DIAGNOSTIC GENERIC CHARACTERS

Short-cells, over the veins, mostly solitary, but occasionally in pairs or short rows. Silica-bodies, over the veins, horizontally elongated with sinuous outlines. Micro-hairs absent. Stomata mostly with low dome-shaped, but sometimes with parallel-sided, subsidiary cells. Vascular bundles; none conspicuously angular in outline. Mesophyll with chlorenchyma not radiate; commonly with large air-canals, often containing stellate parenchyma, between the vb's. Bundle-sheaths double.

SPECIES SPECIALLY EXAMINED

***Glyceria fluitans* (L.) R. Br.**

LEAF

Abaxial epidermis

Short-cells, over the veins, solitary or, more rarely, paired; infrequent over, and v. infrequent between, the veins. **Silica-bodies** horizontally elongated, with sinuous outlines (Fig. IA, 14–15). **Macro-hairs, micro-hairs,** and **prickle-hairs:** none seen. **Papillae:** chains of globose papillae overlying the veins (Fig. III, 1). Oblique papillae with thickened ends (Fig. III, 2) abundant on the adaxial surface. **Stomata** mostly with parallel-sided (Fig. IV, 2), but some with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells** relatively short, with thin, non-sinuous walls (Fig. V, 4*a–b*).

T.S. lamina

Vascular bundles: small vb's not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with well-developed triangular ribs and furrows (Fig. XIV, 5). V. small ribs also present opposite the vb's on the abaxial surface, the vb's being opposite the adaxial furrows. **Sclerenchyma:** a few small vb's with minute adaxial and abaxial strands (Fig. IX, 4), but strands to most vb's becoming converted to girders through being in contact with the outer bundle-sheaths, or with extensions from the O.S. consisting of large colourless cells. Adaxial girders, even those connected with the largest vb's, often only 1–2 cells wide and high, the corresponding abaxial girders being up to about 6 cells wide and 3 cells high. Some vb's accompanied by abaxial strands only; scl. also present at the leaf margins. **Midrib** conspicuous, projecting adaxially and abaxially, the thickness of the lamina being much constricted on either side of the midrib opposite the 2 groups of bulliform cells; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. A large intercellular cavity present beneath, and about as wide as, each rib, with, here and there, evidence of spongy, somewhat stellate parenchyma in the cavities. **Bulliform cells:** no conspicuously large bulliform cells present, apart from a rather broad, fan-shaped group on either side of the midrib (Fig. XV, 6). **Bundle-sheaths** double; vb's all with 2 complete sheaths (Fig. XII, 1), but the O.S. often with a girder-like extension to both the adaxial and abaxial scl.

CULM

Culm examined about 3 mm in diameter. Central cavity 2 mm in diameter. Epidermis subtended by a single layer of fibrous cells. Remainder of the ground tissue consisting of thin-walled cells, with large intercellular spaces in the outer part, but spaces less well developed than in *G. maxima*, and no stellate cells seen in them. Vb's in 2 circles, the outer not far below the epidermis, and the second circle almost next to the large cavity at the centre of the culm. Occasional vb's present between the 2 circles.

MATERIAL EXAMINED: J. K. O'Byrne 164; Southampton.

***Glyceria maxima* (Hartm.) Holmb. (*G. aquatica* (L.) Wahl.)**

LEAF

Abaxial epidermis

Short-cells, both over and between the veins, mostly solitary, but occasionally paired; a few of those over the veins in rows of 3–5 cells; common. **Silica-bodies,** over the veins, horizontally elongated with sinuous outlines (Fig. IA, 14–15). **Macro-hairs** and **micro-hairs:** none seen. **Prickle-hairs:** prickles (Fig. VI, 1–2), with large bases and sometimes unpointed (Fig. VI, 6), fairly numerous over most of the veins. **Stomata** mostly with low dome-shaped (Fig. IV, 3) subsidiary cells. **Long-cells** mostly with thin, non-sinuous (Fig. V, 2*a–c*), and occasionally with slightly sinuous (Fig. V, 3*a–c*), walls; interstomatal cells fairly long, with slightly concave ends (Fig. V, 11).

T.S. lamina

Vascular bundles: nearly every alternate bundle not conspicuously angular in outline (Fig. VIII, 2); remaining vb's of basic type (Fig. VIII, 15). **Adaxial surface:** smooth (Fig. XIV, 1) in material examined at Kew, but Burr and Turner (1933) refer to adaxial ribs in this sp. **Sclerenchyma:** occasional small vb's with adaxial strands or girders only (Fig. IX, 2); most vb's, both large and small, with adaxial and abaxial strands (Fig. IX, 4) up to about 10 cells high and 6 cells wide. (These strands could be interpreted as girders since they are connected to the outer bundle-sheaths by large cells that may be regarded as extensions of the bundle-sheaths themselves.) Scl. also present at the leaf margins. **Keel** conspicuous in the material examined at Kew, abaxially rounded and markedly constricted in the width of the lamina opposite the groups of bulliform cells on either side of the median vb; containing a solitary vb (Fig. XIII, 1). Keel described by Burr and Turner (1933) as inconspicuous. **Mesophyll:** chlorenchyma not radiate; with large intercellular spaces between the ribs. **Bulliform cells** in 2 groups only, 1 on either side of the median vb, each group being approximately fan-shaped (Fig. XV, 4). **Bundle-sheaths** double; vb's towards the leaf margins with 2 complete sheaths (Fig. XII, 1); all others likewise, with 2 complete sheaths, but O.S. with girder-like extensions to both the adaxial and abaxial scl.

CULM (Fig. XXI, 4 and 7)

Culm examined 1·3 cm in diameter, with a hollow centre 0·9 cm in diameter. Epidermis and 3 subjacent layers of cells small in diameter and highly lignified; followed by a wide zone of aerenchyma composed of stellate cells, constituting the greater part of the ground tissue of the culm. Aerenchyma bounded on the inner side by an incomplete, sinuous, scl. ring of v. variable width, being, for the most part, 2–4 cells wide, but locally as much as 8 cells wide. Inner scl. ring separated from the large central cavity of the culm only by 2–3 layers of large, thin-walled cells. A single circle of widely spaced vb's, of somewhat complex structure, and each containing 2 ph. groups, present in the aerenchymatous ground tissue, not far below the outer scl. ring. A second, somewhat sinuous, circle of vb's associated with the inner scl. ring, vb's otherwise being absent from the aerenchyma, apart from occasional more deeply situated strands.

MATERIAL EXAMINED: Cultivated at Kew.

ADDITIONAL INFORMATION FROM THE LITERATURE

1. LEAF

Lohauss (1905) gives a few further details about the above spp. His article also includes descriptions of *G. arundinacea* (M. Bieb.) Kunth, *G. plicata* Fries, *G. lithuanica* (Gorski) Lindm., and *G. nemoralis* Uechtr. & Körn. *G. arundinacea* exhibits an abaxially prominent midrib with a large crescent-shaped strand of scl. in its apex; large intercellular cavities in the mesophyll, at first filled with stellate parenchyma, this last tissue breaking down in the mature leaf; chains of globose or blister-like papillae occurring on the epidermis over the veins. *G. plicata* is characterized by a midrib projecting adaxially, and still more abaxially, from the surface of the lamina; slight ribs and furrows occurring on both surfaces. In *G. remota* the midrib projects from the abaxial surface only. *G. nemoralis* differs considerably from other spp. examined by Lohauss in having v. pronounced ribs and furrows on both surfaces, the adaxial ribs being between the vb's, the midrib also projecting prominently both adaxially and abaxially. Scl. present as girders to the vb's, and also as an adaxial strand in each of the ribs, with a smaller opposed abaxial strand. Space between consecutive girders largely occupied by colourless parenchyma with chlorenchyma at its periphery.

2. ROOT

Freidenfelt (1904) reports as follows concerning the roots of *G. fluitans*. First-order roots with an ephemeral thin-walled epidermis, followed by an exodermis of radially elongated cells with brown walls, the outer walls being thickened. A subexodermal layer of thickened cells also present, the outer being more strongly thickened than the inner walls. Next 2 subjacent layers, each consisting of rounded cells with thickened walls, followed by 5–7 layers of cells divided into radiating plates, separated from one another by intercellular spaces. Innermost part of the cortex composed of 4–6 layers of thin-walled cells. Endodermis, in old roots, with the inner walls strongly thickened. Stele with 1 central and 9 peripheral tracheal elements, the ground tissue consisting of thickened, lignified walls. Second-order roots exhibit an exodermis consisting of unthickened cells with brown walls, and, beneath this, a persistent protective layer. Outer part of the inner cortex containing radiately arranged intercellular cavities. Cortex of third-order roots consisting of 2–3 homogeneous layers of cells, but intercellular spaces formed even here.

3. DEVELOPMENTAL ANATOMY, ETC.

The mode of development of the intercellular cavities and stellate parenchyma in the mesophyll of *G. maxima* and *G. fluitans* has been briefly described by Pée-Laby (1898).

According to Prat (1932) the blister-like papillae above the veins on submerged leaves of *G. fluitans* are often, in the upper leaves, replaced by prickles.

For development of the shoot apex see Sharman (1947).

Special Note

The leaf structure is festucoid, and the genus has points in common with *Helictotrichon*.

Literature

Burr and Turner 1933 (leaf); Chauveaud 1897 (root); Church 1949 (leaf); Duval-Jouve 1875 (leaf); Freidenfelt 1904 (root); Grob 1896 (leaf); Haberlandt 1882 (assimilatory tissue); Lewton-Brain 1904 (leaf); Lohauss 1905 (leaf); Pée-Laby 1898 (leaf); Prat 1932, 1936 (leaf); Sharman 1947 (stem apex); Strecker 1913 (leaf); Wille 1916.

GRACILEA

G. royleana H. F. see *Melanocenchris jacquementii* J. & S.

GRAPHEPHORUM

A few notes recorded by Grob (1896) and Magnus (1876).

GYMNOPOGON

Diagnostic Generic Characters

Most of the important characters given under *G. ambiguus* appear to be characteristic of the genus.

Species Specially Examined

***Gymnopogon ambiguus* (Michx.) B. S. P.**

Leaf

Abaxial epidermis

Short-cells, over the veins, mostly appearing to be solitary when separated from one another by relatively long cells in the same files, but could be interpreted as being in rows when separated from one another by shorter cells; abundant over, but v. infrequent and paired or solitary between, the veins. **Silica-bodies,** over the veins, mostly dumb-bell shaped; many, but not all of them, with long, narrow middle portions; each dumb-bell shaped body sometimes resembling 2 elliptical bodies connected to one another by a narrow middle portion at a slightly lower level of focus. **Macro-hairs** and **prickle-hairs:** none seen. **Micro-hairs** infrequent; short, spherical, conspicuously 2-celled (Fig. VII, 2). **Papillae** present on the long-cells but rather inconspicuous; rounded. **Stomata** mostly with low dome-shaped (Fig. IV, 3), but some tending to have parallel-sided (Fig. IV, 2), subsidiary cells. **Long-cells,** between the veins, thin-walled, with conspicuous, rounded, rather distant sinuations to the walls.

T.S. lamina

Vascular bundles: numerous, small, angular vb's without any conspicuously large metaxylem vessels (Fig. VIII, 4–5); a few vb's of basic type (Fig. VIII, 14). **Adaxial surface** with v. slight ribs over the vb's. **Sclerenchyma** present as small adaxial and much wider abaxial girders to all vb's, the adaxial girders being about 3–6 cells wide and 1–2 cells high, and the abaxial girders about 16 cells wide and mostly 2 cells high. **Midrib** not conspicuous. **Mesophyll:** chlorenchyma restricted to narrow arcs on either side of each vb; composed of small, thin-walled cells exhibiting an indistinctly radiate arrangement. **Bulliform cells** in somewhat fan-shaped groups (Fig. XV, 4), but some groups tending to be of the *Sporobolus* type (Fig. XV, 8), each group generally being connected to the abaxial surface by a girder of translucent cells. **Bundle-sheaths:** the median and the few other basic type vb's each with a double sheath, the O.S. being widely interrupted by scl. on the abaxial side; all other vb's each with a single sheath, widely interrupted by abaxial scl.; O.S., or the single sheath, to all vb's characteristically dome-shaped or slightly triangular, the base of the dome or triangle consisting of the abaxial scl. girders.

Material Examined: Kearney 77; Mississippi.

***Gymnopogon delicatulus* (C. B. Cl.) Bor**

Leaf structure similar, in all essentials, to that of *G. ambiguus*, but subsidiary cells to the stomata sometimes tending to be triangular. **Micro-hairs** having distal cells of rather variable shape.

Material Examined: C. B. Clarke 33855; Bengal.

***Gymnopogon foliosus* (Willd.) Nees**

Leaf structure v. similar to that of *G. ambiguus*. Adaxial scl. girders tending to be T-shaped.

Material Examined: A. Chase 661; Porto Rico.

***Gymnopogon spicatus* (Spreng.) Kuntze**

Leaf structure v. similar to that of *G. ambiguus*.

Material Examined: Dr. Finlay 27; Trinidad.

Special Notes

The leaf structure of the Indian sp. *G. delicatulus* resembles that of the New World spp. in all essential characters. It is noteworthy that the silica-bodies, the micro-hairs, and the dome-shaped bundle-sheaths of *Gymnopogon* resemble those of *Perotis*. There is, in fact, a general similarity in the leaf structure of these 2 genera.

GYNERIUM

The leaf structure of Uva Grass, *G. sagittatum* (Aubl.) Beauv. has been described by Lohauss (1905) under *G. saccharoides* Humb. & Bonpl. His description includes the following particulars.

Epidermis. Silica-bodies, over the veins, saddle-shaped, the silica-cells often being adjacent to crescent-shaped or oval cork-cells. Micro-hairs, each consisting of a long proximal and an oval distal cell, present between the veins. Prickles present on the adaxial surface above the scl. on either side of the bulliform cells. *T.S. lamina.* Adaxial surface slightly furrowed. Scl. well developed; in the lamina forming I-girders with the vb's, and also present as girders between the vb's extending from the abaxial surface to the hypodermal tissue of colourless cells; massive strands of scl. also present in the leaf margins. Scl. present in the midrib as abaxial strands not associated with the vb's, these alternating with others associated or forming girders with the vb's, some of these girders extending from the abaxial to the adaxial surface, but others shorter and with their adaxial ends embedded in the ground tissue of the midrib. More than 1 vb sometimes present in a single scl. girder towards the centre of the midrib. Midrib slightly prominent, having the form, in T.S., of an adaxially concave crescent. Mesophyll with chlorenchyma composed of small, isodiametric cells in strips extending from the adaxial to the abaxial epidermis, each strip being adjacent on one side to a vb and its associated scl. girders, and on the other to colourless tissue. Chlorenchyma in the midrib restricted to narrow strips between the abaxial scl. girders, the remaining ground tissue of the midrib consisting of colourless cells. Colourless cells of the midrib eventually breaking down to form cavities between the scl. girders. Bulliform cells small but typical in form, 1 group being present between each pair of vb's, the bulliform cells being in contact with the subjacent colourless cells. Bundle-sheaths double; I.S. completely encircling each vb and composed of cells with strongly and uniformly thickened walls, O.S. composed of large colourless cells with strongly thickened walls; the sheaths to the small vb's being closed and those to the large vb's interrupted by scl.

Special Note

Leaf exhibiting festucoid and panicoid characters.

Literature

Lohauss 1905 (leaf).

HACKELOCHLOA

Only a few observations concerning this genus have been recorded in the literature, and these refer to *H. granularis* (L.) Kuntze. Prat (1936) regards the structure as panicoid.

Literature

Grob 1896 (leaf); Prat 1936, 1937 (leaf).

HAKONECHLOA

Diagnostic Generic Characters

Short-cells, over the veins, mostly in long rows (but see p. 227). Silica-bodies, over the veins, dumb-bell shaped or occasionally nodular. Micro-hairs present; some of uniform diameter and with rounded apices, and others tapering slightly towards their apices. Stomata absent from the abaxial surface. Vascular bundles never conspicuously angular in outline. Mesophyll with chlorenchyma not radiate. Bundle-sheaths double.

Species Specially Examined

***Hakonechloa macra* (Munro) Makino**

Leaf

Abaxial epidermis

Short-cells, between the veins, mostly solitary and sometimes paired; those over the veins mostly in rows of more than 5 cells, but sometimes in pairs. Short-cells appearing at first sight to be in rows, could be regarded as solitary when separated from one another in the individual files by rather long cells. Short-cells abundant. **Silica-bodies,** over the veins, mostly shortly or typically dumb-bell shaped (Figs. IA, 18 (ii–iv) or IB, 20), and a few nodular (Fig. IB, 22 (iii)). **Macro-hairs :** none seen. **Micro-hairs :** length 44–62 (mostly 48–60) μ; basal cells 15–23 μ; distal cells 28–39 μ; hairs rather narrow; distal cells often tapering slightly towards their apices, but others more uniform in diameter throughout their lengths, and with rounded apices (Fig. VII, 6–7). **Prickle-hairs :** prickles frequent (Fig. VI, 1–2) over some of the veins; angular prickles (Fig. VI, 3) crowded at the leaf margins. **Stomata** absent from the abaxial surface. **Long-cells** with thin, sinuous walls (Fig. V, 3*a–c*).

T.S. lamina

Vascular bundles : small vb's rather widely spaced and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** almost smooth (Fig. XIV, 1), but with slight suggestions of ribs over the large vb's (Fig. XIV, 2). Abaxial surface with slight ribs over all vb's. **Sclerenchyma :** small vb's mostly with adaxial and abaxial girders (Fig. IX, 4), the adaxial girders commonly being 1–2 cells wide and 4–5 cells high, and the abaxial girders about 4 cells wide and 2–3 cells high; large vb's with adaxial and abaxial girders up to about 10 cells wide and 3–4 cells high (Fig. IX, 5). **Keel** conspicuous; containing 1 large median vb accompanied on either side by a smaller lateral in an adjacent rib. **Mesophyll :** chlorenchyma not radiate. **Bulliform cells,** towards the leaf margins, mostly in groups as in Fig. XV, 2, but fan-shaped groups (Fig. XV, 4) more common towards the midrib. **Bundle-sheaths** double; large vb's with I.S. complete, the O.S. interrupted adaxially and abaxially (Fig. XII, 3*a*); small vb's with 2 complete sheaths, the I.S. being rather obscure (Fig. XII, 1), and the O.S. tending to be slightly winged laterally.

Material Examined: A. A. Suzaki 384; Japan.

Special Note

Leaf characters mainly panicoid, but some tendency towards being festucoid.

Literature

Sataki 1931 (inverted leaf).

HAYNALDIA

A few notes about this genus have been recorded in the literature. Leaf. Silica-cells and cork-cells, both over and between the veins, in pairs (or groups). Micro-hairs absent. Structure festucoid. Prat (1932) compares *Haynaldia* with *Agropyron* and *Triticum*, with special reference to dermal appendages of the glumes.

Literature

Blaringhem 1921 (culm, physical characteristics in relation to structure); Grob 1896 (leaf); Prat 1932, 1936 (leaf and glume structure).

HELEOCHLOA

Prat (1936) has recorded that this genus, which is now known as *Crypsis* and is related to *Sporobolus*, has swollen micro-hairs.

Literature

Prat 1936.

HELICTOTRICHON

Diagnostic Generic Characters

Short-cells, over the veins, mostly solitary or paired, but sometimes in short rows. Silica-bodies, over the veins, mostly horizontally elongated and with smooth or sinuous outlines, but sometimes, especially near the leaf margins, round, elliptical, or oblong; often fitting into concavities in adjacent cork-cells. Micro-hairs absent. Stomata with parallel-sided or low dome-shaped subsidiary cells. Vascular bundles never conspicuously angular in outline. Mesophyll with chlorenchyma not radiate. Bundle-sheaths double.

Species Specially Examined

***Helictotrichon albinerve* (Boiss.) Potztal**

Leaf

Abaxial epidermis

Short-cells, over most of the veins, solitary, paired, and in short rows; those over the scl. near the leaf margins mostly paired, but sometimes solitary; rather infrequent generally, except over the marginal scl., and v. infrequent or absent between the veins. **Silica-bodies,** over the scl. at the leaf margins, fitting into concavities in adjacent cork-cells, the silica-bodies being mostly circular, but a few of them elliptical or oblong (Fig. I, 6–7); those over the veins horizontally elongated with sinuous outlines (Fig. Ia, 14–15). **Macro-hairs** and **micro-hairs:** none seen. Prickle-hairs: prickles (Fig. VI, 1–2) v. frequent over the veins; angular prickles (Fig. VI, 3) fairly crowded at the leaf margins. **Stomata** mostly with parallel-sided subsidiary cells (Fig. IV, 2). **Long-cells:** those between the veins with thin, non-sinuous (Fig. V, 2*a–c*), or

only slightly sinuous (Fig. V, 3*a–c*), walls; a few of the cells tending to be hexagonal.

T.S. lamina

Vascular bundles: small vb's mostly alternating with the large ones, and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 10 and 15). **Adaxial surface** practically smooth, but v. slight ribs present between the vb's and v. shallow furrows opposite them (Fig. XIV, 2). **Sclerenchyma:** vb's next to the leaf margins accompanied by abaxial strands only; most vb's with minute adaxial and abaxial girders (Fig. IX, 4) connected to the vb's by extensions of colourless cells from the outer bundle-sheaths. Adaxial girders, even those associated with the large vb's, often only 2 cells wide and high, and abaxial girders 4 cells wide and 2 cells high. **Midrib** conspicuous; abaxial projection strongly reinforced by a U-shaped strand of scl.; also marked by a slight, median adaxial rib, accompanied on either side by a deep, narrow furrow with bulliform cells at the base; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells:** 1 U-shaped furrow, on either side of the midrib, containing a group of bulliform cells of variable size, but none of them specially large (Fig. XV, 5). **Bundle-sheaths** double; all vb's with 2 complete sheaths (Fig. XII, 1), the O.S. being connected to the adaxial and abaxial scl. by girder-like extensions consisting of colourless cells (cf. *H. planiculme*).

Material Examined: Cultivated at Kew.

***Helictotrichon planiculme* (Schrad.) Besser**

Leaf

Abaxial epidermis

Short-cells solitary and paired, both over and between the veins; abundant. Short-cells between the veins tall and narrow, but seldom containing conspicuous silica-bodies. **Silica-bodies,** over the veins, fitting into concavities in adjacent cork-cells (Fig. I, 6–7), rounded or oblong. **Macro-hairs:** short, v. thick-walled, superficial hairs with swollen bases (Fig. II, 1) present on the leaf margins, some of them being transitional in appearance between hairs and angular prickles (Fig. VI, 3). **Micro-hairs:** none seen. **Prickle-hairs:** see under 'macro-hairs'. **Stomata:** some with a slight tendency to have parallel-sided (Fig. IV, 2), but mostly with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells,** between the veins, with thin, sinuous walls (Fig. V, 3*a–c*).

T.S. lamina

Vascular bundles: small vb's not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 10 and 11). **Adaxial surface** smooth (Fig. XIV, 1). **Sclerenchyma:** vb's with tall, narrow adaxial and abaxial girders (Fig. IX, 7), and adaxial girders of the small vb's being up to 6 or 7 cells tall and 1–3 cells wide, and the abaxial girders up to about 8 cells tall and wide; a few vb's with adaxial strands or girders only (Fig. IX, 2). **Midrib** conspicuous; abaxial projection strongly supported by a crescent-shaped strand of scl.; also marked by a slight median adaxial rib, with a marked groove on

either side occupied by bulliform cells; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** restricted to a more or less fan-shaped group (Fig. XV, 6) on either side of the median vb. **Bundle-sheaths** double; vb's with 2 complete sheaths (Fig. XII, 1), the cells of the I.S. having well-marked U-shaped thickenings. (The girders of large colourless cells joining the O.S. to the adaxial and abaxial scl., noted in *H. albinerve*, are here replaced by lignified girders.)

MATERIAL EXAMINED: Cultivated at Kew.

***Helictotrichon pubescens* (Huds.) Pilger** (see also *Avena pubescens* on p. 51)

LEAF

Abaxial epidermis

Short-cells, over the veins, solitary and paired; common over, but v. infrequent or absent between, the veins. **Silica-bodies** mostly horizontally elongated, with rounded ends and smooth (Fig. IA, 12–13), or occasionally sinuous (Fig. IA, 14–15), outlines. **Macro-hairs:** long, fairly thick-walled, superficial hairs with swollen bases (Fig. II, 1) frequent over the veins. **Micro-hairs:** none seen. **Prickle-hairs:** occasional hooks (Fig. VI, 5) noted immediately beside the veins. **Stomata** with parallel-sided (Fig. IV, 2), or low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells,** between the veins, with thin, mostly slightly sinuous (Fig. V, 3*a–c*) walls; cells somewhat hexagonal.

T.S. lamina

Vascular bundles: small vb's not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 13). **Adaxial surface** smooth (Fig. XIV, 1). **Sclerenchyma:** some small vb's not accompanied by scl. (Fig. IX, 1); occasional vb's with small adaxial strands only (Fig. IX, 2); large vb's with adaxial girders up to 10 cells wide and 5 cells high, and abaxial girders slightly wider and about the same height (Fig. IX, 5). **Midrib** conspicuous; abaxial projection supported at the apex by a well-developed strand of scl.; also marked by a pair of deep grooves in the adaxial surface, 1 on either side of the midrib; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** confined to a pair of more or less fan-shaped groups (Fig. XV, 6) in furrows, one on either side of the midrib. **Bundle-sheaths** double: some small vb's with 2 complete sheaths (Fig. XII, 1); other small vb's with I.S. complete, but O.S. not quite complete, or inconspicuous, abaxially (Fig. XII, 2); large vb's with I.S. complete, but O.S. interrupted abaxially and connected to the adaxial scl. by extensions of large colourless cells (as in Fig. XII, 7, but with O.S. often interrupted abaxially). (In this, as in other spp. of *Helictotrichon*, the cells of the I.S. have U-shaped thickenings.)

MATERIAL EXAMINED: Cultivated at Kew.

ADDITIONAL INFORMATION FROM THE LITERATURE

Burr and Turner (1933) have recorded the following information concerning the leaf of *H. pratense* (L.) Pilger under *Avena pratensis*. Adaxial surface without ribs and furrows. Scl. well developed at the leaf margins, and as adaxial and abaxial girders to the principal veins; scl. also present in the keel, but absent below the adaxial surface of the midrib. Hairs often absent, but sometimes few and scattered. Prickles present, chiefly at the leaf margins. Keel conspicuous as an abaxial projection. Mesophyll with chlorenchyma not radiate; containing a well-developed system of air-spaces between the cells. Bulliform cells conspicuous as 2 single groups, 1 on either side of the midrib. The above particulars agree, in the main, with those recorded by Lewton-Brain (1904) for the same species, but he figures small adaxial strands of scl. in the midrib.

SPECIAL NOTES

Leaf structure typically festucoid.

Potztal (1951) has pointed out that *Arrhenatherum* and *Helictotrichon* are not anatomically homogeneous in their leaf structure, and has revised the composition of both genera in the light of this fact. For details Potztal's paper must be consulted.

Helictotrichon has points in common with *Glyceria*.

LITERATURE

Burr and Turner 1933 (leaf); Lewton-Brain 1904 (leaf); Potztal 1951 (leaf and taxonomy); Saint-Yves 1929–31 (leaf structure of a number of spp. from the Mediterranean region; under *Avena*).

HEMARTHRIA

DIAGNOSTIC GENERIC CHARACTERS

Short-cells, over the veins, paired and occasionally in short rows. Silica-bodies, over the veins, cross to dumb-bell shaped. Micro-hairs present; each with the distal cell tapering slightly towards its apex. Stomata mostly with triangular subsidiary cells. Vascular bundles mostly small and conspicuously angular in outline. Mesophyll with incompletely radiate chlorenchyma. Bundle-sheaths single.

SPECIES SPECIALLY EXAMINED

***Hemarthria uncinata* R. Br.**

LEAF

Abaxial epidermis

Short-cells, both over and between the veins, paired; others, over the veins, in rows of 3–5 cells; abundant. **Silica-bodies,** over the veins, cross-shaped (Fig. IA, 16), or intermediate between cross and dumb-bell shaped (Fig. IA, 17); those between the veins also often cross-shaped, but with a distorted appearance, and frequently narrower than those over the veins; those between the veins occasionally tall, narrow, and crenate (Fig. IB, 24). **Macro-hairs:** none seen. **Micro-hairs:** length 48–60 μ; basal cells 18–24 μ; distal cells 20–30 μ; distal cells mostly tapering slightly towards their apices (Fig. VII, 6). **Prickle-hairs:** none seen. **Stomata** mostly with triangular subsidiary cells (Fig. IV, 1).

Long-cells, between the veins, with fairly thick, sinuous walls (Fig. V, 1*a–b*), or relatively thin-walled and v. acutely sinuous (Fig. V, 3*a–c*).

T.S. lamina

Vascular bundles: most vb's small, and conspicuously angular in outline (Fig. VIII, 4 and 5); large vb's of basic type (Fig. VIII, 10). **Adaxial surface** smooth (Fig. XIV, 1). **Sclerenchyma:** most small vb's not accompanied by scl. (Fig. IX, 1); large vb's in the keel with well-marked abaxial girders only (Fig. IX, 3); other large vb's with adaxial girders up to about 8 cells wide and 4 cells high, and abaxial girders slightly wider but about the same height (Fig. IX, 4). **Keel** fairly conspicuous; containing 1 large median vb accompanied on either side by 2–3 vb's, all appreciably smaller, but unequal in size (Fig. XIII, 3). **Mesophyll:** chlorenchyma radiate immediately around the vb's, but not elsewhere. **Bulliform cells:** adaxial half of the mesophyll consisting of colourless cells (*Chloris* type) (Fig. XV, 11). **Bundle-sheaths** single; all small vb's with complete sheaths (Fig. XI, 2*a*); sheaths round the large vb's interrupted abaxially (Fig. XI, 6). For a few further details see Vickery (1935).

Rhizome

Rhizome examined about 2 mm in diameter. Epidermis subtended by a layer of small, thick-walled cells followed by a cortical zone of about 10 layers of large, thin-walled, but slightly collenchymatous cells. Collenchyma bounded on the inner side by a second ring of scl. consisting of about 2–6 layers of small, v. thick-walled fibres, this ring being somewhat undulating in outline. Second scl. ring followed, on its inner side, by a narrow zone of thin-walled ground tissue, extending to the fairly large cavity at the centre of the rhizome. Vb's in 2 circles, those of the outer circle being small and embedded in the inner scl. ring, the inner vb's lying in the thin-walled ground tissue between the scl. ring and the hollow centre of the rhizome.

Additional Information from the Literature

Prat (1937) records the following information for the leaf of *H. altissima* (Poir.) Stapf & Hubbard under *H. fasciculata* Kunth. *Epidermis.* Silica-bodies figured as cross-shaped, or with a slight tendency to be dumb-bell shaped but with concave ends. (Said to be similar to those of *Vetiveria.*) *T.S. lamina.* Vascular bundles: only 2 first-order vb's in each wing of the lamina, these being separated by 6–9 lesser vb's. Adaxial epidermis composed of fairly large cells with arched outer walls. Scl. not well developed: large vb's each accompanied by an adaxial and an abaxial girder; small vb's not accompanied by scl. Keel stated to be absent, but leaf figured as having a small one containing a single vb. Bulliform cells restricted to a single group over the median vb.

Special Note

Prat (1936) notes that the leaf structure is panicoid.

Literature

Prat 1936, 1937 (leaf); Vickery 1935 (leaf).

HENRARDIA

Notes by Hansen and Potztal (1954) on the leaf structure of *H. persica* (Boiss.) C. E. Hubbard, and *H. pubescens* (Bertol.) C. E. Hubbard show that both spp. exhibit the following characters.

Silica-bodies oblong to square, with rounded corners, or more completely rounded. Stiff macro-hairs and prickles present. Scl. usually present as small adaxial and abaxial strands, but abaxial scl. more strongly developed in *H. persica* var. *erecta.* Mesophyll with chlorenchyma not radiate. Bundle-sheaths double; inner tangential walls of I.S. strongly thickened. Starch simple.

Special Note

Hansen and Potztal regard *Henrardia* as a member of the Leptureae. Hubbard (1950*b*) previously treated *Henrardia* as a subtribe Henrardiinae of the Hordeae.

Literature

Hansen and Potztal 1954 (leaf); Hubbard 1950*b* (taxonomy).

HETERANTHELIUM

Diagnostic Generic Characters

Short-cells, over the veins, mostly solitary or paired and occasionally in short rows. Silica-bodies, over the veins, horizontally elongated and with smooth or slightly sinuous outlines. Micro-hairs absent. Stomata with parallel-sided subsidiary cells. Vascular bundles never conspicuously angular in outline. Mesophyll with chlorenchyma not radiate. Bundle-sheaths double.

Species Specially Examined

***Heteranthelium piliferum* Hochst. ex Jaub. & Spach.**

Leaf

Abaxial epidermis

Short-cells, over the veins, mostly solitary, but sometimes paired, and occasionally in rows of 3–5 cells; common over, but v. infrequent or absent between, the veins. **Silica-bodies** horizontally elongated, with rounded ends and smooth (Fig. IA, 12), or slightly sinuous (Fig. IA, 14–15), outlines. **Macro-hairs:** fairly short, acutely pointed hairs, with swollen, slightly sunken bases (Fig. II, 4), the bases appearing somewhat angular in T.S. of the lamina, numerous in the intercostal zones. **Micro-hairs:** none seen. **Prickle-hairs:** angular prickles (Fig. VI, 3) abundant at the leaf margins. **Stomata** with parallel-sided subsidiary cells (Fig. IV, 2). **Long-cells,** between the veins, with thin, non-sinuous walls (Fig. V, 2*a–c*), some of the cells hexagonal.

T.S. lamina

Vascular bundles: small vb's not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with slight,

rounded ribs, separated from one another by fairly wide, shallow furrows (Fig. XIV, 2). **Sclerenchyma:** many small vb's not accompanied by scl. (Fig. IX, 1), and a few with minute adaxial and abaxial strands; large vb's with adaxial girders 2–3 cells high and wide, and abaxial girders occasionally as much as 9 cells wide and 3 cells high (Fig. IX, 4–5). **Keel** slightly conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** rather small, in groups somewhat resembling Fig. XV, 2 at the bases of the furrows. **Bundle-sheaths** double; small vb's with I.S. complete and O.S. not quite complete abaxially (Fig. XII, 2); sheaths round the large vb's probably similar, but with extensions of the O.S. connecting the vb's to the adaxial scl.

Culm

Culm examined about 1 mm in diameter. Epidermis subtended by a scl. ring about 3–6 cells wide, the thin-walled ground tissue on the inner side of the scl. ring extending to the somewhat spongy centre of the culm. A few small vb's embedded in the scl. ring and in the peripheral part of the central, thin-walled ground tissue.

Material Examined: Cultivated at Kew.

Special Note

Leaf structure typically festucoid.

Literature

Grob 1896.

HETERANTHOECIA

Diagnostic Generic Characters

Short-cells, over the veins, in long rows. Silica-bodies, over the veins, approximately cubical, with acutely angular outlines. Micro-hairs present but obscured by papillae; short, each with the distal cell tapering to a narrowly pointed apex, with a small silica inclusion in the apex. Stomata with variable subsidiary cells. Vascular bundles: small ones sometimes v. conspicuously angular in outline. Mesophyll with radiate chorenchyma, consisting of long, narrow cells. Bundle-sheaths double.

Species Specially Examined

***Heteranthoecia guineensis* (Franch.) Robyns**

Leaf

Abaxial epidermis (Fig. XXVII, 1)

Short-cells, over the veins, in rows of more than 5 cells; abundant over, but absent between, the veins. **Silica-bodies** with v. acutely angled outlines (Fig. I, 11), more or less cubical, but with slightly concave sides. **Macro-hairs:** fairly short hairs with swollen bases (Fig. IIA, 5) frequent in the intercostal zones;

hairs constricted below the basal swellings, the constricted portions being surrounded by cushion cells forming part of the epidermis. Long bristle hairs also recorded by Potztal (1952), especially on the adaxial surface. **Micro-hairs:** rather obscure amongst the papillae; length 15–22 μ; basal cells 3–9 μ; distal cells 9–16 μ; distal cell tapering to a narrowly pointed apex, often with a small silica inclusion in the apex. **Prickle-hairs:** none seen. **Papillae:** thin papillae, somewhat globose and often somewhat oblique (Fig. III, 3), present on nearly all of the long-cells, there being 1 papilla to each cell. **Stomata** with rather variable subsidiary cells (Fig. IV, 5). **Long-cells,** between the veins, nearly or quite cubical, with non-sinuous walls (Fig. V, 8). (The term 'long-cell' is rather a misnomer when applied to this sp., because the cells that are the homologues of the long-cells in most grasses are here quite short.) **Transverse veins** fairly numerous.

T.S. lamina

Vascular bundles: small vb's somewhat angular (Fig. VIII, 6), or not angular (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 11). **Adaxial surface** with moderate ribs and wide, V-shaped furrows (Fig. XIV, 3), the ribs being mostly rounded but occasionally slightly flattened at the apices. **Sclerenchyma:** vb's with small adaxial and abaxial girders (Fig. IX, 4), those of the smaller vb's being about 6 cells wide and 2 cells high, and those of the large vb's about 10 cells wide and 2 cells high. **Keel** not conspicuous: containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma radiate round the vb's, but much of the intermediate part of the mesophyll not radiate; radiate cells, for the most part, long and narrow, and arranged in 2 rows between the O.S. and the epidermis of the adaxial ribs. **Bulliform cells** tending to be in fan-shaped groups at the bases of the furrows (Fig. XV, 6); or cells in the furrows smaller and more like those in Fig. XV, 5. **Bundle-sheaths** double; I.S. complete to incomplete, O.S. with extensions to the adaxial scl. (Fig. XII, 6–7).

Material Examined: Meikle 1091; Nigeria.

Special Note

The structure of the mesophyll, the cubical intercostal long-cells, and the acutely angular silica-bodies suggest affinities with *Isachne*.

Literature

Potztal 1952 (leaf).

HETEROCARPHA

Hubbard (1950*d*) records the occurrence of silica-bodies approximating to the dumb-bell shaped type in *H. haareri* Stapf & C. E. Hubbard (cf. *Drake-Brockmania* on p. 166).

Heterocarpha should not, in Hubbard's opinion, be placed in the Eragrosteae because the silica-bodies are not saddle-shaped. In this connexion it

should be noted that, as indicated under the description of *Eragrostis* in this book (p. 189), 'the silica-bodies are rather variable in shape according to the sp.' Saddle-shaped types are, however, common in the genus.

Literature

Hubbard 1950*d* (leaf and taxonomy).

HETEROPOGON

Diagnostic Generic Characters

Short-cells, over the veins, in long rows. Silica-bodies, over the veins, mostly markedly dumb-bell shaped, with the narrow middle portions specially long; those at the margins of the veins intermediate between cross and dumb-bell shaped. Micro-hairs present; each with the distal cell tapering to a pointed apex. Stomata with triangular subsidiary cells. Vascular bundles mostly small, crowded, and angular in outline. Mesophyll with distinctly radiate chlorenchyma. Bundle-sheaths single.

Species Specially Examined

***Heteropogon contortus* (L.) P. Beauv.**

Leaf

Abaxial epidermis

Short-cells, between the veins, mostly paired, or, less frequently, solitary and, v. rarely, in short rows; those over the veins, in rows of more than 5 cells; abundant. **Silica-bodies:** a few at the edges of the veins intermediate between cross and dumb-bell shaped (Fig. IA, 17); most of those over the veins v. markedly dumb-bell shaped, and varying in appearance with the focus (Fig. IB, 21), the middle portions of these bodies being especially long; some silica-bodies over the veins nodular (Fig. IB, 22 (iii)). Silica-bodies, between the veins, infrequent, rather irregular and variable in shape. **Macro-hairs:** long, thick-walled hairs, with sunken bases surrounded by specialized epidermal cells (Fig. IIA, 5), rather infrequent in the intercostal zones. **Micro-hairs:** length 67–82 μ; basal cells 38–43 μ; distal cells 24–38 μ; distal cells tapering to pointed apices (Fig. VII, 9). **Prickle-hairs:** hooks (Fig. VI, 5) frequent between the veins; prickles (Fig. VI, 1–2), sometimes unpointed (Fig. VI, 6), occurring sparsely over the veins. **Papillae:** somewhat globose, oblique papillae (Fig. III, 3) present, particularly in the stomatal zones, 1 papilla generally being present near 1 end of each long-cell. **Stomata** with triangular subsidiary cells (Fig. IV, 1). **Long-cells,** between the veins, with fairly thin, coarsely sinuous walls (Fig. V, 3*a–c*), or with the walls thicker as in Fig. V, 1*a–b*.

T.S. lamina

Vascular bundles: smallest vb's with the xy. and ph. not conspicuously contrasted (Fig. VIII, 1); other small vb's crowded and angular (Fig. VIII, 5);

large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with v. slight ribs over the large vb's, the furrows being scarcely perceptible (Fig. XIV, 2). **Sclerenchyma:** nearly all small vb's not accompanied by scl. (Fig. IX, 1); a few medium-sized vb's with small adaxial and abaxial girders (Fig. IX, 4); large vb's with adaxial and abaxial strands about 6 cells wide and 4 cells high. **Keel** conspicuous, rounded, but fairly narrow, supported by a broad scl. girder to the median vb; containing 1 large median vb accompanied on either side by 2–3 much smaller laterals (Fig. XIII, 3). **Mesophyll:** chlorenchyma distinctly radiate. **Bulliform cells:** mostly in irregular groups (Fig. XV, 1); also 1 large fan-shaped group (Fig. XV, 6) present in the adaxial furrow over the midrib; some groups of the *Sporobolus* type (Fig. XV, 9). **Bundle-sheaths** single; all small vb's with complete sheaths (Fig. XI, 2*a*), the constituent cells being rather unequal in size; sheaths round the large vb's interrupted abaxially (Fig. XI, 6).

Culm

Oval in outline, the longer diameter of the culm examined being about 2 mm. Epidermis subtended by 1–2 layers of v. thick-walled fibres, followed by a zone of fairly thin-walled, but somewhat collenchymatous cells, bounded on the inner side by a second scl. ring about 6 cells wide, the constituent cells having thick, concentrically zoned walls. Inner ground tissue consisting of comparatively thin-walled cells, extending to the solid centre of the culm. Vb's of the outermost circle embedded in the inner scl. ring, the remaining v. densely crowded vb's lying in the peripheral part of the thin-walled ground tissue.

Material Examined: F. Ballard 1238; Ceylon.

Special Note

Leaf structure typically panicoid.

Literature

Günzel 1912 (under *Andropogon*) (leaf); Pée-Laby 1898 (leaf); Prat 1937 (leaf); Vickery 1935. All of this literature refers to the sp. described above.

HIEROCHLOE

Diagnostic Generic Characters

Short-cells, over the veins, in short or long rows, or sometimes solitary. Silica-bodies, over the veins, narrow, horizontally elongated, with smooth or sinuous outlines. Micro-hairs absent. Stomata with dome-shaped subsidiary cells; sometimes absent from the abaxial surface. Vascular bundles never conspicuously angular in outline. Mesophyll with chlorenchyma not radiate. Bundle-sheaths double.

Species Specially Examined

***Hierochloe odorata* (L.) Beauv.**

Leaf

Abaxial epidermis

Short-cells, over the veins, in rows of 3–5, or more, cells; common over, but absent between, the veins. **Silica-bodies** horizontally elongated, with sinuous outlines (Fig. Ia, 14–15); rather narrow. **Macro-hairs** and **micro-hairs:** none seen. **Prickle-hairs:** prickles (Fig. VI, 1–2), with large, oval bases, common over the veins; angular prickles (Fig. VI, 3) present at the leaf margins. **Stomata** mostly with low dome-shaped (Fig. IV, 3), but a few tending to have parallel-sided (Fig. IV, 2), subsidiary cells. **Long-cells,** between the veins, mostly with thin, sinuous walls (Fig. V, 3*a–c*), the cells sometimes tending to be hexagonal.

T.S. lamina

Vascular bundles: small vb's not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 10). **Adaxial surface**: fairly large, rounded, but widely distant ribs present over the large (Fig. XIV, 3), and v. slight ribs over some of the small, vb's; furrows mostly rather wide and shallow. **Sclerenchyma:** a few vb's, especially in the keel, with well-marked abaxial girders only (Fig. IX, 3); combined girders of the median keel vb robust, anchor-shaped (Fig. IX, 6); other small vb's with tall, narrow adaxial and abaxial girders (Fig. IX, 7), large vb's with appreciably wider adaxial and abaxial girders (Fig. IX, 5), up to about 7 cells high and 2 cells wide. **Keel** conspicuous, rounded; containing 1 large median vb accompanied on either side by a smaller lateral (Fig. XIII, 2). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** in somewhat fan-shaped groups (Fig. XV, 6) at the bases of the furrows. **Bundle-sheaths** double: large vb's with I.S. complete, but O.S. interrupted adaxially and abaxially (Fig. XII, 3*a*); small vb's with O.S. interrupted abaxially (Fig. XII, 2), or with 2 complete sheaths (Fig. XII, 1); cells of the I.S. with U-shaped thickenings.

Material Examined: Cultivated at Kew.

***Hierochloe redolens* (Vahl) Roem. & Schult.**

Leaf

Abaxial epidermis

Short-cells, between the veins, mostly solitary, but sometimes paired; those over the veins also sometimes solitary or paired, but more usually in rows of 3–5 cells. Short-cells, between the veins, cubical or slightly longer horizontally than vertically; seldom containing conspicuous silica-bodies. **Silica-bodies,** over the veins, horizontally elongated, with rounded ends and smooth outlines (Fig. Ia, 13). **Macro-hairs:** short, rigid, thick-walled hairs (Fig. IIa, 10) present on the sides and apices of the adaxial ribs, but not v. numerous in T.S. **Micro-hairs:** none seen. **Prickle-hairs:** prickles (Fig. VI, 1–2), sometimes unpointed (Fig. VI, 6), frequent over the veins. **Stomata** absent from the abaxial surface. **Long-cells,** over the veins, with thick, sinuous walls (Fig. V, 1*a–b*); some cells tending to be hexagonal.

T.S. lamina

Vascular bundles: small vb's not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 10 and 11). **Adaxial surface** with pronounced ribs and furrows (Fig. XIV, 6), most of the ribs having flat, or even slightly depressed, apices; a few of the smaller ribs rounded; furrows mostly fairly deep, V-shaped, and rather variable in width. **Sclerenchyma:** nearly all vb's with adaxial T-, and abaxial I-, girders (Fig. IX, 8), the stems of the adaxial T-girders being 1–2 cells wide over the small vb's, and up to 3 cells wide over the large vb's; the abaxial I-girders always wider and shorter than the stems of the adaxial T's. **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** of variable size, but none of them specially large (Fig. XV, 5), present in the furrows; some groups more or less fan-shaped (Fig. XV, 6). **Bundle-sheaths** double; vb's commonly with 2 complete sheaths (Fig. XII, 1); large vb's with the O.S. sometimes interrupted abaxially (Fig. XII, 2).

Rhizome

Rhizome examined about 4 mm in diameter. Epidermis subtended by a zone of scl. about 8 cells wide, with flattened columns of thin-walled assimilatory tissue embedded in it. Inner ground tissue consisting of larger cells, gradually becoming less lignified towards the central cavity. Vb's in the outermost circle v. small and embedded in the peripheral scl. Remaining vb's in 2 more or less distinct circles, those of the outer circle being at the inner margin of the scl. ring, the vb's of the innermost circle being embedded in the thin-walled ground tissue. Central cavity of the rhizome fairly large.

Material Examined: Collected specially by W. M. Curtis in Tasmania.

Additional Information from the Literature

Parodi (1941) has recorded the following information concerning the leaf structure of S. American spp. of *Hierochloe*. Three types of structure in the lamina are recognized. In the first the vb's are connected to the abaxial epidermis by scl. girders, but the scl. does not extend laterally beneath the abaxial epidermis in the intercostal zones, the abaxial epidermis thus being in direct contact with the chlorenchyma. Adaxial T-shaped girders to the vb's also present. This type occurs in *H. gunckelii* L. R. Parodi, *H. redolens* (Vahl) Roem. & Schult., and *H. spicata* L. R. Parodi. In the second type the vb's are likewise supported by adaxial and abaxial scl. girders, but the scl. extends beneath the abaxial epidermis as a thin layer which separates the epidermis from the chlorenchyma. The adaxial girders are T-shaped. This type occurs in *H. altissima* Steudel, *H. juncifolia* (Hackel) Parodi, and *H. utriculata* (R. & Pav.) Kunth. In the third type the median vb is the only one to be provided with abaxial and adaxial scl. girders, the remaining vb's being unsupported by scl., and there is no scl. beneath the abaxial epidermis. This type was observed by Parodi only in *H. pusilla* Hackel. In all of these spp. the leaves are provided with well-developed adaxial ribs and furrows. These are especially marked in *H. juncifolia*, with ribs of 2 distinct sizes alternating with one another.

The large lacunae mentioned by Pée-Laby (1898) as being present immediately

below the leaf epidermis of *H. odorata* (L.) Beauv. (under *H. borealis* R. & Sch.) were not observed in the material examined by the author (see p. 238 above).

Chauveaud (1897) has recorded a few notes on the root ph.

Special Notes

The leaf structure is rightly described by Prat (1936) as being festucoid.

Hierochloe is sometimes stated to be related to *Anthoxanthum*, but Hubbard (1934) suggests affinities with Aveneae.

Literature

Chauveaud 1897 (root ph.); Grob 1896 (leaf); Lewton-Brain 1904 (leaf); Pée-Laby 1898 (leaf); Prat 1936 (leaf); Parodi 1941 (leaf); Wille 1916.

HILARIA

Canfield (1934) has recorded that a sp. of *Hilaria* occurring in the Jornada Experimental Range has culms with solid centres.

Literature

Canfield 1934 (culm).

HOLCUS

Diagnostic Generic Characters

Short-cells, over the veins, solitary, paired, and in short rows. Silica-bodies, over the veins, horizontally elongated and with smooth or sinuous outlines. Micro-hairs absent. Stomata with parallel-sided subsidiary cells. Vascular bundles: none conspicuously angular in outline. Mesophyll with a v. slight tendency for the chlorenchyma to be radiate. Bundle-sheaths double.

Species Specially Examined

***Holcus lanatus* L.**

Leaf

Abaxial epidermis

Short-cells, over the veins, solitary, in pairs, and short rows; infrequent over and absent between, the veins. **Silica-bodies** horizontally elongated, with rounded ends and smooth outlines (Fig. Ia, 12). **Macro-hairs:** superficial hairs of various lengths, with swollen bases (Fig. II, 1), abundant over and between the veins, those between generally being shorter than those over the veins. **Micro-hairs:** none seen. **Prickle-hairs:** v. short macro-hairs in the intercostal zones sometimes resembling hooks (Fig. VI, 5). **Stomata** with parallel-sided subsidiary cells (Fig. IV, 2). **Long-cells,** between the veins, with thin, non-sinuous walls (Fig. V, 2*a–c*), many of the cells being hexagonal; v. frequently with a short macro-hair between the narrow ends of otherwise contiguous pairs of cells in each file.

T.S. lamina

Vascular bundles: small vb's not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 8 and 10). **Adaxial surface** with slight, but wide and rounded ribs, the ribs over the large being more pronounced than those over the small vb's (Fig. XIV, 2). Furrows wide and shallow. **Sclerenchyma:** small vb's with adaxial girders 1–3 cells wide and up to about 6 cells high, and abaxial girders 2–3 cells wide and up to about 4 cells high (Fig. IX, 7); a few small vb's with abaxial strands only (converse of Fig. IX, 2); large vb's with wider adaxial and abaxial girders (Fig. IX, 5); scl. also present in the leaf margins. **Keel** not more than slightly conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma practically not radiate, only a few of the cells round the smaller vb's tending to be arranged in a slightly radiating manner. **Bulliform cells** mostly in groups as in Fig. XV, 2, but some groups tending to be slightly fan-shaped (Fig. XV, 4). Colourless cells sometimes present in the adaxial part of the midrib. **Bundle-sheaths** double; large vb's with I.S. complete and O.S. interrupted abaxially, but connected to the adaxial scl. by extensions consisting of large colourless cells (Fig. XII, 4); small vb's with I.S. complete but O.S. interrupted or inconspicuous abaxially (Fig. XII, 2).

Culm (Fig. XIX, 1–2)

Culm examined 3 mm in diameter. Surface of culm covered with short, unicellular, lignified hairs. Epidermis subtended by a scl. ring about 3 cells wide with thin, flattened columns of assimilatory tissue embedded in it. Inner ground tissue of large, thin-walled cells extending from the scl. ring to the large cavity at the centre of the culm. Vb's of the outermost circle embedded in the scl. and connected to the epidermis by scl. girders separating the adjoining columns of assimilatory tissue from one another. Remaining vb's constituting a single circle, embedded in the thin-walled ground tissue. A few additional notes on the culm of this sp. have been recorded by Roelants (1921).

Material Examined: J. K. O'Byrne 125; Kew.

***Holcus mollis* L.**

Leaf

Abaxial epidermis

Short-cells, over the veins, solitary, paired, and occasionally in short rows; abundant over, but infrequent between, the veins. **Silica-bodies** horizontally elongated, with rounded ends and smooth (Fig. Ia, 13), or sinuous (Fig. Ia, 14–15), outlines. **Macro-hairs:** superficial hairs, of various lengths, some of them being v. long, and with swollen bases (Fig. II, 1), abundant over and between the veins, those between being shorter than those over the veins; some hairs short, rigid, thick-walled (Fig. IIa, 10). Forms with glabrous leaves also recorded. **Micro-hairs:** none seen. **Prickle-hairs:** angular prickles (Fig. VI, 3) at the leaf margins; some of the smallest macro-hairs in the interstomatal zones resembling hooks (Fig. VI, 5). **Stomata** with parallel-sided subsidiary cells (Fig. IV, 2). **Long-cells,** between the veins, with thin,

non-sinuous walls (Fig. V, 2*a–c*), many of the cells hexagonal; v. frequently with a short macro-hair between the narrow ends of otherwise contiguous pairs of long-cells in each file.

T.S. lamina

Vascular bundles: small vb's not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 10). **Adaxial surface** with slight, widely spaced, rounded ribs, and wide, v. shallow furrows (Fig. XIV, 2), the ribs over the largest vb's being slightly more pronounced than the others; no ribs present over the smallest vb's. **Sclerenchyma:** smallest vb's not accompanied by scl. (Fig. IX, 1); a few small vb's with adaxial girders 1–2 cells wide (Fig. IX, 2), or abaxial girders only; others with adaxial and abaxial girders 1–2 cells wide and about 3 cells high (Fig. IX, 7); large vb's with adaxial and abaxial girders up to about 4 cells wide and high; scl. also present in the leaf margins. **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1), or a large median vb accompanied by 2 smaller laterals. **Mesophyll:** chlorenchyma not truly radiate, but some mesophyll cells arranged in a slightly radiate manner around some of the vb's. **Bulliform cells** in well-defined groups as in Fig. XV, 2. **Bundle-sheaths** double; smallest vb's with I.S. complete but O.S. not quite complete, or widely incomplete, abaxially (Fig. XII, 2); large vb's with I.S. complete and O.S. interrupted adaxially and abaxially (Fig. XII, 2*a*). O.S.'s around some of the vb's with adaxial extensions towards, or reaching, the scl. or epidermis.

CULM

Culm examined 2 mm in diameter. Epidermis subtended by a zone of about 7 layers of fibrous cells with small columns of assimilatory tissue embedded in it. Cells of the inner ground tissue increasing in diameter and decreasing in the thickness of the cell-walls towards the rather small central cavity in the culm. Vb's of the outermost circle embedded in the scl. ground tissue, the vb's in this circle being of 2 more or less distinct sizes. Remaining vb's in 2 circles embedded in the thin-walled ground tissue.

MATERIAL EXAMINED: Cultivated at Kew.

ADDITIONAL INFORMATION FROM THE LITERATURE

1. LEAF

Woodhead (1906) has described differences in the structure of the leaf of *H. mollis* from sunny and shady positions respectively.

2. ROOT

Freidenfelt (1904) has recorded the following particulars concerning the root of *H. lanatus*. Epidermis thin-walled, bearing numerous root-hairs. Cortex, in the finest roots, consisting of 2 layers of cells without intercellular spaces; in first-order roots consisting of 6 layers of cells, with intercellular spaces developing in the inner cortex, where the tissue may partly collapse. Fungal hyphae present in the young root, especially in the outer part of the cortex.

SPECIAL NOTE

Prat (1936) rightly interprets the leaf structure as festucoid.

LITERATURE

Burr and Turner 1933 (leaf); Chi 1942 (histogenesis of roots); Duval-Jouve 1875 (leaf); Freidenfelt 1904 (root); Grob 1896 (leaf); Lewton-Brain 1904 (leaf); Prat 1936 (leaf); Roelants 1921 (culm); Sharman 1947 (stem apex); Strecker 1913 (leaf); Wille 1916; Woodhead 1906 (ecological anatomy of *H. mollis*).

HORDELYMUS

DIAGNOSTIC GENERIC CHARACTERS

Short-cells, over the veins, solitary, paired, and in short or long rows. Silica-bodies horizontally elongated, with smooth or sinuous outlines. Micro-hairs absent. Stomata with parallel-sided or low dome-shaped subsidiary cells. Vascular bundles; none conspicuously angular in outline. Mesophyll with chlorenchyma not radiate. Bundle-sheaths double.

SPECIES SPECIALLY EXAMINED

***Hordelymus europaeus* (L.) Harz (*Elymus europaeus* L.)**

LEAF

Abaxial epidermis

Short-cells, over the veins, mostly solitary and paired, but occasionally in short rows; infrequent over, and absent between, the veins. **Silica-bodies** horizontally elongated, with sinuous (Fig. IA, 14–15), or sometimes smooth (Fig. IA, 12–13), outlines. **Macro-hairs** and **micro-hairs:** none seen. **Prickle-hairs:** prickles (Fig. VI, 1–2) common over, and smaller ones between, the veins; some of the smallest prickles resembling hooks (Fig. VI, 5). **Stomata** rather infrequent; with parallel-sided (Fig. IV, 2), or low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells,** between the veins, with thin, non-sinuous walls (Fig. V, 2*a–c*); cells often hexagonal.

T.S. lamina

Vascular bundles: small vb's widely spaced and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 10 and 15). **Adaxial surface** with v. slight, wide, and rather distant ribs over the vb's, separated by v. wide, shallow furrows. Abaxial surface with similar ribs. **Sclerenchyma:** small vb's with abaxial girders, mostly 2 cells wide and 3–4 cells high, the corresponding adaxial girders being about 3 cells wide and 2 cells high (Fig. IX, 4); large vb's with adaxial and abaxial girders up to about 6 cells wide, their heights being the same as those of the girders to the smaller vb's (Fig. IX, 5); keel vb supported by more massive adaxial and abaxial girders. **Keel** conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** in well-defined groups as in Fig. XV, 2. **Bundle-sheaths** double; most vb's with I.S. complete but O.S. not quite complete abaxially (Fig. XII, 2); keel vb, and possibly some of the other large vb's, with O.S. interrupted abaxially and adaxially (Fig. XII, 3*a*).

CULM

Culm examined about 2·0 mm in diameter. Epidermis subtended by a scl. ring about 12 cells wide, consisting of v. thin-walled angular cells, of small diameter, with large, broad columns of assimilatory tissue embedded in the ring. Inner ground tissue consisting of large, v. thin-walled cells, extending from the scl. ring to the large cavity at the centre of the culm. Vb's, even those of the outermost circle, fairly large; those of the outermost circle embedded in the peripheral scl. and connected to the epidermis by girders of scl. Remaining vb's in 1 circle, embedded in the inner, thin-walled ground tissue. Ph. elements of rather small diameter.

MATERIAL EXAMINED: Cultivated at Kew.

SPECIAL NOTE

Leaf structure typically festucoid. Related to *Hordeum* and *Elymus*.

HORDEUM

DIAGNOSTIC GENERIC CHARACTERS

Short-cells, over the veins, solitary, paired, and sometimes in short or long rows. Silica-bodies, over the veins, usually horizontally elongated with smooth or sinuous outlines, but those in certain spp. round to elliptical and fitting into concavities in adjacent cork-cells. Micro-hairs absent. Stomata mostly with parallel-sided, but sometimes with low dome-shaped, subsidiary cells. Vascular bundles; none conspicuously angular in outline. Mesophyll with chlorenchyma not radiate. Bundle-sheaths double.

SPECIES SPECIALLY EXAMINED

Hordeum agriocrithon **Åberg**

LEAF

Abaxial epidermis

Short-cells, over the veins, paired, and in short or long rows; common over, and infrequent between, the veins. **Silica-bodies** horizontally elongated, with rounded ends and smooth (Fig. IA, 12), or sinuous (Fig. IA, 14–15), outlines. **Macro-hairs** and **micro-hairs :** none seen. **Prickle-hairs :** prickles (Fig. VI, 1–2), and unpointed prickles (Fig. VI, 6), present. **Stomata** with parallel-sided subsidiary cells (Fig. IV, 2). **Long-cells,** between the veins, with thin, non-sinuous walls (Fig. V, 2*a–c*).

MATERIAL EXAMINED: Cultivated at Kew.

Hordeum jubatum **L.**

LEAF

Abaxial epidermis

Short-cells, over the veins, mostly solitary, but sometimes paired; common over, but v. infrequent between, the veins. **Silica-bodies** horizontally elongated,

with rounded ends and smooth (Fig. IA, 12) or sinuous (Fig. IA, 14–15), outlines. **Macro-hairs :** short, thick-walled, finely pointed hairs with superficial bases (Fig. II, 1) abundant over and between the veins. **Micro-hairs :** none seen. **Prickle-hairs :** angular prickles (Fig. VI, 3) present at the leaf margins. **Stomata** mostly tending to have parallel-sided (Fig. IV, 2), but often with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells,** between the veins, with thin, non-sinuous walls (Fig. V, 2*a–c*); rather variable in length and shape, a few tending to be hexagonal.

T.S. lamina

Vascular bundles : most vb's small and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 10 and 15). **Adaxial surface** with slight, rounded ribs, and fairly wide, shallow furrows (Fig. XIV, 2), the most pronounced ribs being over the large vb's. Abaxial surface also slightly ribbed over the veins. **Sclerenchyma :** some small vb's with adaxial and abaxial strands (Fig. IX, 4) up to about 2 cells high and 3 cells wide; other small vb's with adaxial girders 1–2 cells wide and 4 cells high, and abaxial girders about 3 cells wide and high; large vb's with adaxial and abaxial girders up to about 6 cells wide and about the same height as the girders to the smaller vb's. **Keel** fairly conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll :** chlorenchyma not radiate. **Bulliform cells** in more or less fan-shaped groups (Fig. XV, 6) at the bases of the furrows. **Bundle-sheaths** double; most small vb's with I.S. complete, but O.S. not quite complete, or inconspicuous, abaxially (Fig. XII, 2), more rarely with 2 complete sheaths (Fig. XII, 1); a few large vb's with O.S. incomplete adaxially and abaxially (Fig. XII, 3*a*); other large vb's with O.S. interrupted adaxially only.

CULM

Culm examined about 1 mm in diameter. Epidermis subtended by a zone of scl. about 2 cells wide, consisting of cells with fairly thick walls. Remaining ground tissue gradually becoming thinner-walled and the cells wider in diameter, towards the fairly large cavity at the centre of the culm. Vb's in a single, more or less sinuous circle, most of the vb's being at the inner edge of the scl. ring, and others just free of the scl. ring and embedded in the outer part of the large-celled ground tissue.

MATERIAL EXAMINED: Cultivated at Kew.

Hordeum murinum **L.**

LEAF

Abaxial epidermis

Short-cells, over the veins, mostly solitary, but occasionally in pairs or short rows; common over, but v. infrequent between, the veins. **Silica-bodies** horizontally elongated, with slightly sinuous (Fig. IA, 14–15), or smooth (Fig. IA, 13), outlines. **Macro-hairs :** moderately long, fairly thick-walled, finely pointed hairs, with enlarged, superficial bases, frequent in the intercostal zones (Fig. II, 1). **Micro-hairs :** none seen. **Prickle-hairs :** prickles

(Fig. VI, 1–2) numerous over the veins, and small prickles, or hooks (Fig. VI, 5), between them. **Stomata** mostly with parallel-sided (Fig. IV, 2), but some tending to be with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells,** between the veins, with thin, non-sinuous walls (Fig. V, 2*a–c*); most of the cells v. long, and sometimes tending to be hexagonal.

T.S. lamina

Vascular bundles: small vb's rather widely spaced and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with moderately tall ribs, rather variable in width, with rounded apices, separated by fairly wide, shallow furrows (Fig. XIV, 2–3). **Sclerenchyma:** a few of the smallest vb's not accompanied by scl. (Fig. IX, 1); others with minute adaxial strands only (Fig. IX, 2), or with minute adaxial and abaxial strands (Fig. IX, 4) occasionally forming girders with the O.S.'s; large vb's with wider adaxial and abaxial girders, the abaxial girders occasionally being up to 5 cells wide. Keel vb with a well-developed abaxial girder (Fig. IX, 3). Scl. also present in the leaf margins. **Keel:** conspicuous; containing a solitary vb (Fig. XIII, 1); adaxial part of keel consisting of colourless cells. **Mesophyll:** chlorenchyma not radiate. **Bulliform cells:** sometimes in well-defined groups as in Fig. XV, 2, but other groups more nearly fan-shaped (Fig. XV, 4). **Bundle-sheaths** double; most vb's, both large and small, with 2 complete sheaths (Fig. XII, 1).

MATERIAL EXAMINED: J. K. O'Byrne 135; Kew.

***Hordeum nodosum* Auct. = *H. secalinum* Schreb.**

LEAF

Abaxial epidermis

Short-cells, both over and between the veins, solitary or paired; abundant. Most **silica-bodies,** both over and between the veins, fitting into concavities in the adjacent cork-cells (Fig. I, 6–7), the silica-bodies being mostly round or elliptical in outline; a few others, over the veins, horizontally elongated with sinuous outlines (Fig. IA, 14–15). **Macro-hairs** and **micro-hairs:** none seen. **Prickle-hairs:** angular prickles (Fig. VI, 3) occurring at and near the leaf margins, a few less angular prickles sometimes being present as well. **Stomata** mostly with parallel-sided (Fig. IV, 2), but sometimes with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells** with fairly thin, to somewhat thickened, markedly sinuous walls (Fig. V, 3*a–c*).

T.S. lamina

Vascular bundles: small vb's fairly widely spaced and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with slight, uniform, rounded ribs, and wide, shallow furrows (Fig. XIV, 2). **Sclerenchyma:** a few of the smallest vb's not accompanied by scl. (Fig. IX, 1); occasional small vb's with adaxial (Fig. IX, 2), or abaxial, strands or girders only. Most small vb's with adaxial girders 1–2 cells wide and up to 4 or 5 cells high, and abaxial girders up to 3 cells wide and about

3 cells high (Fig. IX, 7); large vb's with abaxial and adaxial girders about 3 or 4 cells wide and high (Fig. IX, 5). **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells:** those towards the leaf margins tending to be in groups as in Fig. XV, 2, but elsewhere mostly in fan-shaped groups (Fig. XV, 6). **Bundle-sheaths** double; most small, and some large, vb's with I.S. complete but O.S. not quite complete abaxially (Fig. XII, 2); other large vb's with O.S. interrupted adaxially and abaxially (Fig. XII, 3*a*), or with the O.S. connected to the adaxial scl. by large cells (Fig. XII, 4).

CULM

Culm examined about 2 mm in diameter. Epidermis subtended by a well-marked scl. ring, consisting of about 6 layers of cells with fairly thick walls and circular lumina, moderately large, flattened columns of thin-walled assimilatory tissue being embedded in the scl. Inner ground tissue consisting of cells with increasing diameters and thinner walls towards the fairly large central cavity of the culm. Vb's of the outermost circle small, embedded in the scl. ring, and connected to the epidermis by girders of scl. separating the columns of assimilatory tissue from one another. Remaining vb's in 1 more or less sinuous circle, embedded in the inner ground tissue, many of the bundles being attached to the scl. ring at their ph. ends.

MATERIAL EXAMINED: J. K. O'Byrne 168; Kew.

***Hordeum stenostachys* Godr.**

LEAF

Abaxial epidermis

Some **short-cells,** both over and between the veins, solitary, but mostly paired; abundant. **Silica-bodies** fitting into concavities in adjacent cork-cells (Fig. I, 6–7), the bodies themselves being round, elliptical, or occasionally crescent-shaped. **Macro-hairs** and **micro-hairs:** none seen. **Prickle-hairs:** prickles (Fig. VI, 1–2) occasional over the veins, and angular prickles (Fig. VI, 3) at the leaf margins; hooks (Fig. VI, 5) occasional between the veins; unpointed prickles (Fig. VI, 6) present over some of the veins. **Papillae:** structures resembling papillae present over the veins. **Stomata:** some tending to be with parallel-sided (Fig. IV, 2), but others with more nearly low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells,** between the veins, with thin, sinuous walls (Fig. V, 3*a–c*).

T.S. lamina

Vascular bundles: most vb's small and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with moderate ribs and furrows (Fig. XIV, 3), the ribs being rather unequal in width, the narrower ones rounded, and the wider ones less rounded or slightly flattened, at the apices. Slight abaxial ribs also present opposite most of the vb's. **Sclerenchyma:** most of the smallest vb's, usually situated opposite certain of the adaxial furrows, with well-marked abaxial girders only (Fig. IX, 3); other small vb's, opposite certain of the adaxial ribs, similar, each having an

abaxial girder but, in addition, an adaxial strand in the apex of the rib concerned. Most of the other vb's with adaxial T- and abaxial I-girders (Fig. IX, 8), the sizes of the girders being proportional to the sizes of the vb's, the stems of the adaxial T-girders to the smaller vb's often being 1–2 cells wide and about 6 cells high, the corresponding abaxial I-girders being 2–4 cells wide and up to about 10 cells high, the abaxial end of each girder being enlarged and situated in a slight rib. Stems of the adaxial T-girders of the large vb's about 4–7 cells wide and 7 cells high, the corresponding abaxial girders being slightly wider. **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** mostly in more or less fan-shaped groups (Fig. XV, 6) at the bases of the furrows. **Bundle-sheaths** double; small and medium-sized vb's with I.S. complete and O.S. interrupted abaxially (Fig. XII, 2); large vb's with O.S. interrupted adaxially and abaxially (Fig. XII, 3*a*).

Culm

Culm examined about 1·5 cm in diameter. Epidermis subtended by a zone of thick-walled cells about 2–3 layers wide, the ground tissue on the inner side of this zone having cells with progressively wider diameters and thinner walls on passing towards the fairly large cavity at the centre of the culm. A circle of v. widely spaced vb's present in the narrow, peripheral scl. ring, the remaining vb's being in 2 more or less distinct circles.

Material Examined: Cultivated at Kew.

Additional Information from the Literature

1. Leaf and Culm

H. marinum Huds. (under *H. maritimum* With.) is stated by Günzel (1921) to exhibit the following characters. *T.S. lamina.* Adaxial surface strongly, and abaxial surface weakly, ribbed. Scl. present above and below the vb's and at the leaf margins. Mesophyll with chlorenchyma not radiate. *Epidermis.* Silica-bodies oblong and not very characteristic. Prickles present on both surfaces, those on the abaxial surface varying in frequency. *H. vulgare* L. (under *H. sativum* Pers.) said by Günzel (1921) to exhibit a strongly ribbed adaxial surface; bristle hairs not observed; prickles less numerous than in *H. marinum.*

Concerning the basal leaf-sheath of *H. vulgare* L. (under *H. sativum* Pers.), Aufhammer and Pech (1931) state that between the time of initiation of the first 3 leaves and the end of the culm formation a downy border of 1-celled hairs is formed. All winter varieties showed greater hairiness shortly before culm initiation than in the spring. Low winter temperature in the open field interrupted plant growth and thereby retarded the formation of hairs. Favourable growth conditions promoted a strong production of hairs. The production of hairs varies in different varieties.

Kato (1933*a*) has published an illustrated account, with English summary, of spodograms (ash pictures) of the varieties of barley commonly cultivated in Japan.

Lloyd (1921) has recorded characters whereby the leaves and culms of common cereals can be distinguished from one another.

2. Root

According to Jackson (1922), the root system of a well-developed barley plant consists of (*a*) thin, branched roots, and (*b*) thick, unbranched roots with v. abundant root-hairs. The stele of a branched root consists of ground tissue of which the cell-walls are highly thickened, there being a single axile vessel and 6–8 xy. strands in the stele of each root. The stele is surrounded by an endodermis of thick-walled cells. In unbranched roots the stelar tissues and endodermis are not thickened, there are 12–16 xy. strands, and the centre of the root consists of thin-walled 'pith' cells traversed by 4–6 metaxylem vessels.

Histological differences in the roots of barley grown respectively in aerated and non-aerated culture solutions have been noted by Bryant (1934). Aeration inhibits the development of intercellular air-spaces in the cortex, makes for greater thickening of the cell-walls, and determines the exact distance from the root apex at which the xy. and pericycle become differentiated. The developmental anatomy of the roots of barley grown in culture solutions has also been described by Heimsch (1951).

Chauveaud (1897) gives the following details concerning the root of *H. murinum.* In the first root from the embryo there is a solitary axile vessel, and 7 xy. strands alternating with 7 ph. strands. In other roots there are 8 'medullary' vessels and 13 xy. strands. This indicates that the number and arrangement of 'medullary' vessels and of xy. and ph. strands is not constant for a sp. Price (1911) records that the root-hairs in the same sp. are long and persistent throughout the length of the root, in material from sand-dunes.

3. Histological Changes Induced by Chemical Treatment and P.32 Radiation

Mackie, Blume, and Hagen (1952) found that radiation from P.32 'at a constant and fairly high level' causes cell-divisions in meristems of barley to cease, and the meristems of both roots and shoots to assume an abnormal appearance. Plants grown in less active solutions exhibited damaged shoot meristems but the root tips were normal.

Gifford (1954) noted in barley seedlings that treatment with maleic hydrazide inhibits mitoses, causes cell enlargement, and induces young ph. and xy. to become obliterated, whilst more mature tracheal elements remain small.

4. Identification of Grain

Karnauhov (1940) has claimed that certain varieties of barley can be identified by the different colour reactions given when the grain is treated with reagents such as phenol, hydrochloric acid, sulphuric acid, or alkalis.

Special Note

Prat (1936) rightly states that the leaf structure is festucoid.

Literature

Aufhammer and Pech 1931 (hairiness of barley leaves); Bryant 1934 (roots); Burr and Turner 1933 (leaf); Chauveaud 1897 (root); Duval-Jouve 1875 (leaf); Emmerling 1898 (distinction between barley and oats by the structure of the glumes); Frohnmeyer 1914 (silicification); Gifford 1954 (effect of maleic anhydride on structure); Grob 1896 (leaf); Günzel 1921 (leaf); Heimsch 1951 (developmental anatomy of roots); Jackson 1922 (barley roots); Karnauhov 1940 (chemical identification of barley varieties); Kato 1933*a* (spodograms of barley leaves); Lewton-Brain 1904 (leaf); Lloyd 1905 (culm and leaf of barley), 1922 (cereal straw); Mackie, Blume, and Hagen 1952 (histological changes in barley induced by P.32 treatment); Meyer 1925 (root); Pée-Laby 1898 (leaf); Prat 1932, 1936 (leaf); Price 1911 (root-hairs); Roelants 1921 (culm); Sharman 1947 (stem apex); Strecker 1913 (leaf); Wille 1916.

HUBBARDIA

This monotypic genus is based on *H. heptaneuron* Bor, a delicate grass, growing on, and pendulous from, wet rocks where the Sharavart River tumbles over the high cliff at Jog in W. India. The leaves are so delicate that, in the dried material examined at the Jodrell Laboratory, it was difficult to conjecture how far the structure revealed under the microscope was due to distortion, and, for this reason, no formal description of the grass has been written. In the article by Bor (1950) describing the grass it is stated, concerning the leaf, that the chlorenchyma is evenly distributed between the vb's (non-radiate structure); the hairs are unicellular; the infrequent silica-bodies are more or less square, but with the 4 sides sometimes slightly concave. The starch grains are noted by Bor as being compound, but this did not appear to be irrefutably proved in material examined by the author. The affinities of the grass are stated by Bor to lie with the Isachneae, a view to which Potztal (1952) has taken exception. It is desirable to examine more perfectly preserved material before the evidence of leaf anatomy can be used to provide a solution to this taxonomic problem. It may, even then, prove difficult to interpret the evidence because the leaf structure has become modified in relation to the special habitat of the plant.

Literature

Bor 1950 (leaf); Potztal 1952 (leaf).

HYDROTHAUMA

H. manicatum C. E. Hubbard is an endemic sp. found by Mr. E. Milne-Redhead growing in about 6 inches of water in a shallow pan of concretionary limestone in the Mwinilunga District of N. Rhodesia. The lower leaves have pseudo-petioles which vary in length so as to allow the lamina to float on the surface of the water. The adaxial surface of the lamina bears longitudinal ribs in the form of thin, erect, sinuate lamellae. Air that is trapped between the lamellae helps to keep the lamina of the leaf afloat. The following information concerning the anatomy of the grass has been recorded by Hubbard (1950*f*).

Leaf

Epidermis

(*a*) *Abaxial epidermis*. Short-cells, over each scl. strand, arranged in a single row, consisting of alternating cork-cells and silica-cells. Solitary silica-cells also present over the air-lacunae. Silica-cells dumb-bell or 'knot-shaped'. Micro-hairs sometimes noted above the lacunae; slender, adpressed to the leaf surface, and each 2-celled. Stomata in part rather distant and arranged in single rows near the vb's; others near the leaf margins more numerous. Long-cells present as 1–2 files of narrow, elongated cells, with sinuous walls, flanking the rows of short-cells over the scl.; those over the lacunae with irregularly sinuous walls.

(*b*) *Adaxial epidermis*. Differing considerably from the abaxial surface owing to the presence of sinuous lamellae. Silica-cells, above the scl., resembling those on the abaxial surface. Macro-hairs; present as rigid, thick-walled, unicellular trichomes, resembling spear heads; situated at the bases of the grooves between the lamellae.

Stomata present on the sides of the lamellae, and towards the bases of the grooves. A single, apically thickened papilla generally present on each long-cell.

T.S. lamina

Abaxial surface of the fully expanded lamina smooth. Adaxial surface bearing some 14, narrowly wedge-shaped, longitudinal lamellae, 1 above each vb. Each lamella consisting of small, chlorenchymatous cells, and supported by scl. consisting of 2–3 v. slender, lateral strands and by a more robust strand at the apex. Vb's comprising 5–7 primary vb's, the remainder being of lower rank. T.S. through the lower part of the blade abaxially rounded in outline, the leaf margins being incurved and almost meeting one another. Rounded or angular air-lacunae present in the abaxial part of the mesophyll in the lower part of the blade, but less conspicuous than those in the pseudo-petiole, the lacunae near the median part of the blade being the largest and those towards each margin progressively smaller as the margin is approached. Lacunae separated from one another by uniseriate columns of thin-walled parenchyma. Bundle-sheaths double; I.S. prominent around the abaxial half of each primary vb, the constituent cells having the inner tangential and radial walls strongly thickened; O.S. consisting of large cells containing chloroplasts. T.S. through the middle of the blade exhibiting lamellae up to 4 mm tall, lacunae being absent and replaced by 1–2 layers of parenchymatous cells. Radiately arranged chlorenchyma well developed next to the O.S. of the vb's. Cells of the I.S. without prominent thickenings. T.S. through the apex of the blade more or less crescent-shaped, the lamellae decreasing in number and size towards the tip.

Leaf-sheath and Pseudo-petiole

Leaf-sheath with v. large air-lacunae. Pseudo-petiole abaxially rounded and adaxially concave as seen in T.S.; containing large air-lacunae separated from one another by narrow girders of parenchyma. About 10 vb's of unequal sizes embedded in the parenchymatous girders between the air-lacunae, nearer to the abaxial than to the adaxial surface of the petiole, there being 1 vb in each girder, the smallest bundles being nearest to the margins of the adaxial groove. A small strand of scl., subjacent to the epidermis situated opposite each vb.

Culm

Lower internodes, in T.S., each exhibiting not only a large central cavity, but also, in the tissue surrounding the central hollow, a circle of about 12 elliptical air-lacunae, each lacuna being separated from the next by a girder of parenchymatous cells extending from the central cavity of the culm to the epidermis, a vb, with a somewhat double appearance and encircled by scl., being embedded in each girder. Cells of the epidermis with thick walls and cuticle.

Special Note

Hubbard (1950*f*) points out that the radial arrangement of the chlorenchyma, the occurrence of 2-celled micro-hairs, the dumb-bell and knot-shaped silica-cells, and the well-developed O.S.s all indicate the panicoid affinities of the grass. The general structure of the spikelets points to a similar conclusion.

The leaf structure, in some respects, recalls that of *Sacciolepis* (p. 431).

Literature

Hubbard 1950*f*.

HYGRORYZA

The few following notes concerning the leaf have been recorded by Grob (1896).

Silica-bodies, over the veins, of typical *Oryza* type; those between the veins irregular in shape and with projections. Papillae present on certain epidermal cells, a number being present on each cell. Cuticular warts also occur on the epidermis.

Special Note

These few facts indicate that the genus is related to *Oryza*.

Literature

Grob 1896 (leaf).

HYPARRHENIA

Diagnostic Generic Characters

Short-cells, over the veins, in long rows. Silica-bodies, over the veins, cross to dumb-bell shaped and occasionally nodular. Micro-hairs present; each with the distal cell tapering to a pointed apex. Stomata mostly with triangular, but some tending to have low-dome shaped, subsidiary cells. Vascular bundles mostly small, crowded, and angular in outline. Mesophyll with radiate chlorenchyma. Bundle-sheaths single.

Species Specially Examined

***Hyparrhenia dissoluta* (Nees ex Steud.) C. E. Hubbard**

Leaf

Abaxial epidermis

Short-cells, over the veins, in rows of more than 5 cells; abundant over, but absent between, the veins. **Silica-bodies,** over the veins, sometimes cross-shaped (Fig. IA, 16), but more commonly intermediate between cross and dumb-bell shaped (Fig. IA, 17), and occasionally nodular (Fig. IB, 22 (iii)). **Macro-hairs:** stiff hairs of various lengths with sunken bases, or with their bases surrounded by cushion cells (sometimes silicified) (Fig. II, 3–4), abundant over and between the veins; also numerous, short, rigid, thick-walled hairs (Fig. IIA, 10). **Micro-hairs:** length 52–72 (mostly 54–66) μ; basal cells 33–43 μ; distal cells 15–30 (mostly 15–24) μ; distal cells tapering to pointed apices; basal cells occasionally somewhat inflated (Fig. VII, 9). **Prickle-hairs:** small prickles (Fig. VI, 1) or hooks (Fig. VI, 5) common between the veins; large, angular prickles (Fig. VI, 3) rather infrequent, at the leaf margins. **Papillae:** oblique papillae, with fairly thick ends (Fig. III, 2) present on the cells in the same files as the stomata, 1 papilla being present on each cell, and frequently partly overarching an adjoining stoma. **Stomata** mostly with slightly triangular (Fig. IV, 1), but sometimes tending to be with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells:** those in the intercostal zones, and in the same files of cells as the stomata, usually with thin, sinuous walls (Fig. V, 3*a–c*).

T.S. lamina

Vascular bundles: small vb's crowded, angular (Fig. VIII, 5); other small vb's less angular (Fig. VIII, 6); large vb's of basic type (Fig. VIII, 10). **Adaxial surface** practically smooth (Fig. XIV, 1), but with slight ribs and furrows (Fig. XIV, 2) near the leaf margins. **Sclerenchyma:** many small vb's, especially those opposite the bulliform cells, not accompanied by scl. (Fig. IX, 1); other small vb's with minute abaxial strands only; most large vb's with adaxial girders up to about 5 cells wide and 2 cells high, and abaxial girders sometimes slightly larger and sometimes slightly smaller (Fig. IX, 4); median keel vb with an abaxial, anchor-shaped girder. **Keel** conspicuous; containing 1 large median vb accompanied on either side by a lateral of approximately the same size, and by 5 or 6 appreciably smaller strands (Fig. XIII, 3). **Mesophyll:** chlorenchyma radiate immediately around most vb's. **Bulliform cells** mostly in irregular groups as in Fig. XV, 1, but a few in groups more like that in Fig. XV, 2, or in small groups of specially large cells (*Zea* type, Fig. XV, 3). Adaxial part of the midrib composed of thin-walled colourless cells. **Bundle-sheaths** single; small vb's usually with complete sheaths composed of cells of v. unequal sizes (Fig. XI, 2*a*); sheaths of the large vb's interrupted abaxially (Fig. XI, 6).

Material Examined: Meikle 102; Nigeria.

Additional Information from the Literature

Concerning the leaf epidermis of *H. cyanescens* Stapf, Prat (1937) records the following characters. Silica-bodies often elongated and dumb-bell shaped; oblique papillae present on the interstomatal cells, the stomata themselves being more numerous on the abaxial than on the adaxial surface. T.S. shows the bulliform cells to be particularly well developed as 2 bands one on either side of the midrib, but also present above the fourth-order vb's. Colourless parenchyma well developed in the midrib.

Vickery's (1935) description of *H. filipendula* (Hochst.) Stapf includes the following notes on the T.S. of the lamina. Both surfaces flat. Abaxial epidermis with arched or papillose outer walls, and bearing occasional prickles. Scl. as adaxial and abaxial girders to the large vb's; smaller vb's accompanied by strands only. Stomata more numerous on the abaxial than on the adaxial surface. Midrib fairly conspicuous. Mesophyll with radiate chlorenchyma. Bulliform cells present over certain vb's, the central cell in each group occupying nearly half the thickness of the lamina. Bundle-sheaths single.

Prat (1932) records the following characters for *H. hirta* (L.) Stapf under *Andropogon hirtus* L. Abaxial epidermis of the leaf-sheaths and foliaceous bracts consisting mainly of long-cells with sinuous walls, the structure of the epidermis becoming progressively more complex and heterogeneous the higher the level of the leaf on the culm. Micro-hairs present. Adaxial epidermis of the sheath homogeneous and consisting of long-cells. Adaxial surface of the lamina ribbed. Silica-bodies said to be shaped like knuckle-bones (presumably nodular C. R. M.). Long-cells in the stomatal zones each frequently with an asymmetrical papilla. Ligule long, triangular, and furnished with hairs.

Special Note

Prat (1936) rightly indicates that the leaf structure is panicoid.

Literature

Goosens 1935 (root structure briefly mentioned); Jacques-Félix 1954; Prat 1932, 1936, 1937 (leaf); Vickery 1935 (leaf).

HYPOGYNIUM

The following information concerning the T.S. of the leaf of *H. virgatum* (Desv.) Dandy has been recorded by Prat (1937) under *H. spathiflorum* Nees.

Lamina thick. Vascular bundles: 10–12 triangular first-order vb's present, with 3–6 smaller vb's between each pair of primary vb's; those of the second order being fusiform, and those of the third order ovoid, in outline. Third-order vb's inter-connected by transverse vb's. Scl. as strong adaxial and abaxial girders to the large vb's, the second-order vb's also being connected by scl. to both leaf surfaces, and those of the third order to the adaxial epidermis only. Bundles of the fourth order not accompanied by scl. Bulliform cells present as a single group in the median fold of the lamina and accompanied by subjacent colourless cells. Colourless cells in the lamina otherwise restricted to those subjacent to the abaxial epidermis.

Special Note

Prat notes that the structure recalls that of certain Zoysieae.

Literature

Prat 1937 (leaf).

ICHNANTHUS

Grob's (1896) article includes the following notes concerning the silica-cells of *I. pallens* Munro.

Silica-bodies variable in shape; those between the veins figured as irregularly cross-shaped with long arms; others mostly dumb-bell shaped, but nodular types also occurring. Silica-cells described as solitary, but those over scl. in the midrib said to be paired with cork-cells. Macro-hairs present as cushion hairs at the leaf margins.

Literature

Grob 1896 (leaf).

IMPERATA

Diagnostic Generic Characters

Short-cells, over the veins, mostly in long rows. Silica-bodies, over the veins, mostly conspicuously dumb-bell shaped, but a few nodular. Micro-hairs present; each with the distal cell usually tapering towards a pointed apex. Stomata mostly with triangular subsidiary cells. Vascular bundles: small vb's not more than inconspicuously angular in outline. Mesophyll with the chlorenchyma distinctly radiate and consisting of small cells. Bundle-sheaths double.

Species Specially Examined

***Imperata cylindrica* (L.) Beauv.**

Leaf

Abaxial epidermis

Short-cells, over the veins, mostly in rows of more than 5 cells; those between the veins mostly solitary or occasionally paired; abundant both over and between the veins. **Silica-bodies,** over the veins, markedly dumb-bell shaped (Fig. IA, 18 (ii–v)), sometimes varying in appearance with the focus, owing to the unequal deposition of silica (Fig. IB, 21); a few silica-bodies nodular (Fig. IB, 22 (iii)). Silica-bodies infrequent between the veins, rather variable in shape, and including cross-shaped (Fig. IA, 16) and somewhat saddle-shaped types. **Macro-hairs:** none seen. **Micro-hairs:** length 40–60 (mostly 40–54) μ; basal cells 19–34 μ; distal cells 20–29 μ; basal cells commonly tapering towards their proximal ends; distal cells mostly tapering to pointed apices; as Fig. VII, 9, but with the basal cell slightly shorter in relation to the distal cell. **Prickle-hairs:** none seen. **Stomata** mostly with markedly triangular subsidiary cells (Fig. IV, 1). **Long-cells,** between the veins, with thin, sinuous walls (Fig. V, 3*a–c*), but rather short; interstomatal cells with concave ends (Fig. V, 10–11).

T.S. lamina

Vascular bundles: most vb's small, not conspicuously to somewhat angular (Fig. VIII, 2 and 6); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with only v. slight ribs over most vb's (Fig. XIV, 2), but occasional, much taller ribs present over the large vb's, and especially over a large vb near each of the leaf margins (Fig. XIV, 3). Furrows between the ribs scarcely perceptible. **Sclerenchyma:** most small vb's, including those opposite the bulliform cells, with adaxial girders, 1 to about 5 cells wide and 2 to 4 cells high, and slightly wider abaxial girders (Fig. IX, 4); small keel vb's with similar scl., or with small abaxial girders only; large vb's with adaxial and abaxial girders up to about 10 cells wide and about the same height as the girders to the smaller vb's (Fig. IX, 5). A thin plate of scl. subjacent to the adaxial epidermis over the midrib. **Keel** v. conspicuous, rounded; containing 1 large median vb, accompanied on either side by 2 laterals almost as large as the median vb, and by up to 10 much smaller strands. **Mesophyll:** chlorenchyma v. distinctly radiate, but cells rather small. **Bulliform cells** mostly in groups of the *Sporobolus* type (Fig. XV, 8), but each group connected by 2 girders of colourless cells to the abaxial epidermis, each pair of girders forming an arch over a small vb (Fig. XV, 10). Adaxial part of the midrib composed of colourless cells. **Bundle-sheaths** double; medium-sized vb's with 2 complete sheaths (Fig. XII, 1), the O.S. sometimes having a slight extension of colourless cells connecting with the adaxial scl. to form girders; large vb's with O.S. interrupted abaxially only (Fig. XII, 2), or both adaxially and abaxially (Fig. XII, 3*a*).

Material Examined: Specimen from the Kew museums.

Special Note

Prat (1936) rightly indicates that the leaf structure is mainly panicoid, although it should be noted that the bundle-sheaths are double.

Literature

Chauveaud 1897 (a few notes on root structure); Duval-Jouve 1870, 1875 (leaf); Grob 1896 (leaf); Pée-Laby 1898 (leaf); Prat 1936, 1937 (leaf); Vickery 1935 (leaf). All of these citations refer to *I. cylindrica*, and, in the main, confirm the description of the leaf given above. Vickery's article refers to *I. cylindrica* var. *koenigii* Durand & Schinz.

INDOPOA

Diagnostic Generic Characters

Silica-bodies, over the veins, saddle-shaped, but rather tall and with a tendency towards the *Oryza* type. Micro-hairs present; small, apparently unicellular. Stomata with slightly triangular to low dome-shaped subsidiary cells. Mesophyll with chlorenchyma not more than inconspicuously radiate. Bundle-sheaths single and double; outer and single bundle-sheaths characteristically dome-shaped to slightly triangular.

Species Specially Examined

***Indopoa pauperculus* (Stapf) Bor (*Tripogon pauperculus* Stapf)**

Leaf

Abaxial epidermis

Short-cells, over the veins, mostly in rows of more than 5 cells, but occasionally paired; abundant over, but infrequent to absent between, the veins. **Silica-bodies** saddle-shaped (Fig. I, 9 (iv–v)), but sometimes rather tall and with a tendency to be of the *Oryza* type (Fig. Ib, 23). **Macro-hairs** and **prickle-hairs:** none seen on the abaxial surface, but macro-hairs of a special type noted on the adaxial surface (see T.S. lamina). **Micro-hairs** abundant; of the spherical, apparently unicellular type (Fig. VII, 1). **Stomata** with slightly triangular (Fig. IV, 1), to low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells,** between the veins, with thin, sinuous walls (Fig. V, 3).

T.S. lamina

Vascular bundles: median vb of basic type, but somewhat angular in outline; about 6, smaller, angular vb's present on either side of the median vb, the xy. and ph. being difficult to distinguish from one another in the available material. **Adaxial surface** with moderately tall, closely placed ribs, with somewhat narrowly rounded apices, the ribs being separated from one another by shallow, widely V-shaped furrows. Abaxial surface smooth. One to two, short, stiff, pointed **macro-hairs** present at the apex of each adaxial rib; bases of the hairs resting on the adaxial scl. girders; hairs with a distinctive appearance because partly ensheathed by epidermal cells with papillose outer surfaces, the sheath-cells being raised above the general level of the epidermis (Fig. II, 5). **Sclerenchyma:** all vb's with adaxial and abaxial girders; adaxial girders

about 2–8 cells wide and 1–2 cells high; abaxial girders about 12–18 cells wide, and mostly 1, or sometimes partly 2, cells high. **Midrib** not conspicuous. **Mesophyll:** chlorenchyma consisting of small, thin-walled cells, arranged in a not more than inconspicuously radiate manner, and restricted to comparatively small areas between the vb's. **Bulliform cells:** those between the vb's towards the leaf margins not v. conspicuous; those at the bases of the 3–4 adaxial furrows next to and on either side of the median vein much larger and in somewhat fan-shaped groups. **Bundle-sheaths** mostly single, but median vb and a few of the larger lateral vb's each with a distinct to inconspicuous I.S.; O.S. to each large vb, and the single sheath to each small vb, dome-shaped or tending to be triangular, the bases of the domes or triangles consisting of the wide, abaxial, scl. girders; cells of the O.S. somewhat thick-walled.

Material Examined: C. McCann, A.66; Khandala.

Special Note

Bor (1958), in discussing the taxonomic position of *Indopoa*, rightly quotes the present author as stating that the leaf structure is indicative of affinities with the Chlorideae. Bor, however, points out that if *Indopoa* (together with *Bouteloua* and *Eragrostiella*) were to be transferred to the Chlorideae on anatomical evidence alone 'it would introduce the completely anomalous feature of a several-flowered spikelet into the tribe . . .'. To the present author it seems that the composition of the Eragrosteae and Chlorideae needs very careful consideration from taxonomists. The unicellular micro-hairs of *Indopoa* are especially characteristic of the Chlorideae, although similar micro-hairs also occur in the Sporoboleae, and in certain genera besides *Indopoa* which are at present included in the Eragrosteae. The type of micro-hair shown in Fig. VII, 12 is characteristic of certain of the Eragrosteae, but it is clearly evident that this type of hair could be transformed to the types in Fig. VII, 1 and 2 by reduction in the length, or complete elimination, of the basal cell. Taxonomists might well give some thought to considering how far grasses with micro-hairs similar to those in Fig. VII, 1, 2, and 12 constitute a natural group, and if they do, how this group can most naturally be subdivided. See also *Tripogon* on p. 510.

ISACHNE

Diagnostic Generic Characters

Short-cells, over the veins, in long rows; in certain spp. those near the leaf margin are paired or solitary. Silica-bodies, over the veins, more or less cubical and acutely angular in outline; those in some spp. less acutely angular and approximating to the cross-shaped or *Oryza* types. Micro-hairs present; each with the distal cell tapering to a pointed apex, the hairs sometimes filled with densely staining contents. Stomata with variable subsidiary cells. Vascular bundles: most small vb's conspicuously angular in outline, but less angular in some spp. than in others. Mesophyll usually with radiate chlorenchyma consisting of long, loosely arranged cells. Bundle-sheaths mostly single, but

large vb's, and, in some spp., the small vb's, sometimes with inconspicuous inner sheaths.

Species Specially Examined

Isachne kunthiana Wight & Arn.

Leaf

Abaxial epidermis

Short-cells, over the veins, in rows of more than 5 cells; common to abundant over, but absent between, the veins. **Silica-bodies** cubical with v. acute angles (Fig. I, 11). **Macro-hairs:** short to fairly long, stiff hairs with sunken bases usually surrounded by cushion cells (Figs. II, 3 and IIA, 5), occasional to frequent between the veins. **Micro-hairs** (in material cultivated at Kew): length 36–42 μ; basal cells 20–26 μ; distal cells 16–24 (mostly 16–21) μ; hairs wide in proportion to their lengths but some of the basal cells tapering towards their proximal ends; distal cells tapering to pointed apices, the extreme tips of the hairs being filled with densely staining contents; somewhat similar to Fig. VII, 6, but wider and with the basal cells longer in proportion to the distal cells. Micro-hairs (in Ballard 1054); length 45–60 (mostly 45–54) μ; basal and distal cells 21–29 μ; distal cells tapering to pointed apices; longer and narrower than in material grown at Kew. **Prickle-hairs:** none seen. **Stomata** with rather variable subsidiary cells (Fig. IV, 5). **Long-cells:** those between the veins about equal in length and breadth, often nearly or quite cubical, but many of the cells tending to be polygonal in outline; with slightly sinuous (Fig. V, 7*a–b*) or non-sinuous (Fig. V, 8) walls.

T.S. lamina

Vascular bundles: most vb's small, angular (Fig. VIII, 4 and 5) and sometimes rather taller than wide; large vb's of basic type (Fig. VIII, 9 and 15). **Adaxial surface** with slight to moderately tall, wide, rounded ribs, and shallow to moderately deep furrows (Fig. XIV, 2 and 3). **Sclerenchyma:**[1] most vb's with minute adaxial and abaxial girders (Fig. IX, 4), the largest being 9 cells wide and about 3 cells high; large vb's in Ballard 1105 with adaxial and abaxial girders about twice as wide but about the same height as those associated with the small vb's (Fig. IX, 5); keel bundle, in the Kew material, with an abaxial strand consisting of a thin arc of scl. in the apex of the keel, and an adaxial girder about 6 cells wide and 3 or 4 cells high, both the adaxial and abaxial scl. being in contact with extensions of the bundle-sheath. **Keel** conspicuous, rounded; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma distinctly radiate, many of the radiating cells being v. long and wide. **Bulliform cells** mostly in groups as in Fig. XV, 2, in the shallow adaxial furrows; sometimes tending to be in fan-shaped groups in Ballard 1105. **Bundle-sheaths** single; complete (Fig. XI, 2*a–b*) round all vb's, the sheaths having extensions of large colourless cells reaching to, and forming girders with, the small adaxial and abaxial scl. groups. Sheath round the keel vb connected to the adaxial and abaxial scl. by larger extensions of colourless cells.

[1] The scl. girders are wider and the adaxial furrows more pronounced in the material from Ceylon than in the material cultivated at Kew.

Culm

Culm examined about 1·5 cm in diameter. Epidermis subtended by 2–3 layers of small, thin-walled cells, followed by a single layer of cells resembling an endodermis, separating the thin-walled cells just described from a ring of about 2–3 layers of v. thick-walled fibres, each with a v. narrow lumen. Ground tissue on the inner side of the scl. ring consisting of v. thin-walled cells, and extending to the fairly large cavity at the centre of the culm. Vb's of the outermost circle situated at the outer boundary of the scl. ring, some of these vb's each being supported by a scl. girder extending to the epidermis. Remaining vb's in 2 more or less distinct circles, some of the bundles being at the inner boundary of the scl. ring, and others a little deeper in the thin-walled ground tissue.

Material Examined: (1) Cultivated at Kew. (2) F. Ballard 1054, 1105, and 1117; Ceylon.

Isachne mauritiana Kunth

Leaf

Abaxial epidermis

Short-cells, over the veins, mostly in rows of more than 5 cells; common over, but absent between, the veins. **Silica-bodies** sometimes acutely angled (Fig. I, 11), but others similar in outline but less acutely angled, approximately cross-shaped (Fig. IA, 16), or, when taller than wide, strongly resembling the *Oryza* type (Fig. IB, 23). **Macro-hairs:** fairly long, thick-walled hairs with sunken bases surrounded by cushion cells (Fig. IIA, 5), frequent in the intercostal zones. **Micro-hairs** very numerous; length 53–67 μ; basal cells 24–39 μ; distal cells 27–42 μ; basal cells mostly tapering towards their proximal ends; distal cells tapering to pointed apices (Fig. VII, 5 and 6). **Prickle-hairs:** prickles (Fig. VI, 1–2), often v. large, abundant over the veins, and others, generally smaller, present between the veins. **Papillae:** most of the long-cells papillose, there being 1 conical papilla to each cell (Fig. III, 3) (see also under 'bulliform cells'). **Stomata** with rather variable subsidiary cells (Fig. IV, 5). **Long-cells** about equal in length and breadth, often nearly or quite cubical, but some of the cells tending to be polygonal in outline, with non-sinuous walls (Fig. V, 8). **Transverse veins** fairly numerous.

T.S. lamina

Vascular bundles: most vb's small and not more than inconspicuously angular in outline (Fig. VIII, 6); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with moderate, rather widely spaced ribs over the vb's, the ribs over the small vb's being less tall than those over the large vb's; most ribs rounded at their apices, but some of the largest slightly flattened. Furrows wide, with flattened or slightly convex bases, mostly lined by groups of bulliform cells. Slight ribs, consisting mostly of scl., present on the abaxial surface opposite the vb's. **Sclerenchyma:** apex of each adaxial rib occupied by a wide but short arc of scl. consisting of fibres of small diameter, with v. thick walls and narrow lumina. Each corresponding abaxial rib occupied by a strand of

similar fibres about 10 cells wide and 3–4 cells high. Adaxial arc and abaxial strand united with the O.S. to form an inverted, anchor-shaped girder. Large vb's supported by similar girders, but with wider abaxial strands. Median keel vb supported by an inversely anchor-shaped girder more or less as in Fig. IX, 10, but not quite so tall. **Keel** conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma distinctly radiate, the radiating cells being v. long and wide. **Bulliform cells** mostly in groups as in Fig. XV, 2, but not quite typical; papillose. **Bundle-sheaths:** small vb's each with a single complete sheath (Fig. XI, 2*a*), but often with an inconspicuous I.S. as well (Fig. XII, 1); O.S. usually extended adaxially, and to a lesser extent abaxially, to connect with the adaxial and abaxial scl., i.e. as in Fig. XII, 6, but definitely connected with the scl. Large vb's with I.S. complete, but O.S. interrupted abaxially and connected to the adaxial scl. by a narrow extension of colourless cells (Fig. XII, 4).

CULM

Culm examined about 2 mm in diameter. Epidermis subtended by a ring consisting of 2 layers of thin-walled tissue followed by a layer of cells resembling an endodermis, separating the thin-walled tissue from a scl. ring of rather variable width, the ring consisting of about 6 layers of v. thick-walled fibres in its narrowest parts. Ground tissue on the inner side of the scl. ring consisting of large, thin-walled cells and extending to the large cavity at the centre of the culm. Outermost vb's arranged in a circle at the outer boundary of the scl. ring, some of them being connected to the epidermis by girders of scl. Some of the remaining vb's situated at the inner boundary of the scl. ring, and others more deeply in the inner, thin-walled ground tissue.

MATERIAL EXAMINED: Collected specially by R. E. Vaughan in Mauritius.

Isachne walkeri (Arn. ex Steud.) Wight & Arn.

LEAF

Abaxial epidermis

Short-cells, over the veins, in rows of more than 5 cells, but a zone including numerous solitary and occasional paired short-cells sometimes present near the leaf margin; common over, but generally infrequent or absent between, the veins. **Silica-bodies,** over the veins, mostly v. acutely angled (Fig. I, 11), but sometimes with the corners more rounded, and then appearing to be cross-shaped (Fig. IA, 16). **Macro-hairs:** fairly long hairs, with only slightly thickened walls, and sunken bases surrounded by cushion cells, or by cells containing silica (Fig. IIA, 5), common in the intercostal zones. Walls of the bases of these hairs appreciably thicker than those of the more distal parts. **Micro-hairs:** length 53–67 μ; basal cells 24–39 μ; distal cells 27–42 μ; distal cells commonly tapering towards their pointed apices (Fig. VII, 6). **Prickle-hairs:** prickles (Fig. VI, 1–2) present at the leaf margins, and sometimes elsewhere. **Stomata:** some with triangular (Fig. IV, 1), but, on the whole, with rather variable (Fig. IV, 5), subsidiary cells. **Long-cells,** between the veins, not appreciably longer than wide, and often nearly or quite cubical, but some of the

cells polygonal in outline, with slightly sinuous (Fig. V, 7*a–b*), or non-sinuous (Fig. V, 8), walls.

T.S. lamina

Vascular bundles: most vb's small, sometimes angular (Fig. VIII, 4 and 5), but others less definitely so (Fig. VIII, 6); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with slight rounded ribs, and wide shallow furrows (Fig. XIV, 2) with flattened or slightly convex bases. **Sclerenchyma:** most vb's with adaxial and abaxial girders up to about 5 cells high and wide (Fig. IX, 4), the adaxial girders often being rather smaller and slightly anchor-shaped compared with the abaxial girders; large vb's with slightly wider adaxial and abaxial strands (Fig. IX, 5) often connecting with the bundle-sheaths to form slightly anchor-shaped girders. Keel vb supported by an inversely anchor-shaped girder as in Fig. IX, 10, but less tall. **Keel** slightly prominent; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma distinctly radiate, the radiating cells being v. long and wide. **Bulliform cells** mostly in groups as in Fig. XV, 2, but some groups tending to be slightly fan-shaped (Fig. XV, 6). **Bundle-sheaths** similar to those of *I. mauritiana*.

MATERIAL EXAMINED: F. Ballard 1299; Ceylon.

ADDITIONAL INFORMATION FROM THE LITERATURE

Potztal (1952), who examined *I. australis* R. Br. and 22 other spp. of *Isachne*, has recorded the following facts, but numerous further details are to be found in her paper. Silica-bodies (not clearly distinguished from silica-cells by Potztal) said to exhibit no form that is characteristic either of the genus as a whole, or of the individual spp.; bodies dumb-bell or cross-shaped, when dumb-bell shaped sometimes lying transversely to the long axis of the leaf. Silica-cells of varied shape, but with sinuous lateral walls, also stated to occur. Bristle hairs, prickles, and thin, elongated, 2-celled micro-hairs usually present. Epidermal cells sometimes with finger-like papillae. The following characters were noted in T.S. of the lamina. Scl. weakly developed in certain spp., consisting of strands of a few fibres or even a single layer of fibres subjacent to the adaxial and abaxial epidermis; in other, more numerous spp., scl. forming adaxial and abaxial girders to the vb's. Mesophyll consisting wholly of assimilatory cells; the v. elongated, loosely arranged cells of the chlorenchyma tending to be radiately arranged around the vb's in some spp., but chlorenchyma irregular in spp. with the O.S. poorly developed. Bundle-sheaths double, but I.S. not always clearly defined.

Potztal notes *I. rigidifolia* (Poir.) Urb., a xeromorphic sp. with thick rigid leaves, as differing in certain respects from the above description. Ten to twenty cells with outwardly directed papillae resembling finger-stalls, present in small depressions in the abaxial surface of the leaf opposite the water-storage cells. Micro-hairs: none observed. Large water-storage cells present on the adaxial surface of the leaf, with the subjacent parenchymatous cells arranged radially in relation to them.[1] Median vb with no I.S., the O.S. being well developed, and the cells with thickened walls. Two to five layers of round cells with thick walls present immediately above and below the median vb, the space between these cells and the adaxial and abaxial epidermis being occupied by strong strands of fibres. Three rows of elongated

[1] These cells are presumably bulliform cells. It is common to find that subjacent cells are orientated radially in relation to an especially large bulliform cell when there is one such cell in a group. C. R. M.

parenchymatous cells lying laterally to, and on either side of, the median vb, radiate outwards into the mesophyll.

Starch in *I. aethiopica* Stapf & C. E. Hubbard and *I. buettneri* Hack. noted by Potztal as consisting of simple grains.

Special Note

The leaf structure is panicoid but of a rather special type. The acutely angled silica-bodies, the long narrow assimilatory cells of the mesophyll, and the almost cubical long-cells are very characteristic of *Isachne* and other related genera of the Isachneae.

Literature

Grob 1896 (leaf); Potztal 1952 (leaf).

ISCHAEMUM

Diagnostic Generic Characters

Short-cells, over the veins, solitary, paired, or in short or long rows. Silica-bodies, over the veins, cross to dumb-bell shaped and sometimes nodular. Micro-hairs present; 2 distinct types noted, both sometimes occurring together in a single sp., one type being short, spherical, and with more or less rounded apices, the other longer and more nearly balanoform; long type occasionally with slightly pointed apices. Stomata mostly with triangular subsidiary cells. Vascular bundles mostly conspicuously angular in outline. Mesophyll with chlorenchyma distinctly or indistinctly radiate. Bundle-sheaths single.

Species Specially Examined

***Ischaemum commutatum* Hack.**

Leaf

Abaxial epidermis

Short-cells, over the veins, and near the leaf margins, mostly paired; those over the smaller veins solitary, paired, or tending to be in rows; common over, but infrequent or absent between, the veins. **Silica-bodies,** over the large veins, cross-shaped (Fig. IA, 16), or, more commonly, intermediate between cross and dumb-bell shaped (Fig. IA, 17); others, over the large veins, dumb-bell shaped, but varying in appearance with the focus (Fig. IB, 21); many of the silica-bodies over the small veins nodular (Fig. IB, 22 (iii)). Silica-bodies near the leaf margins mostly cross-shaped (Fig. IA, 16). **Macro-hairs:** v. long hairs, with walls moderately thickened throughout most of their length, but thicker towards their sunken bases, each base surrounded by tall, cushion-like epidermal cells, v. common between the veins. **Micro-hairs** of 2 distinct types, the longer ones noted only near the leaf margins; short type 17–24 μ long, the basal cells being 8–12 and the distal cells 9–15 μ long, the hairs being more or less spherical with rounded apices (Fig. VII, 2); long type approximately balanoform, 40–48 μ long, the basal cells being 15–18 μ and the distal cells

24–30 μ in length. **Prickle-hairs:** angular prickles (Fig. VI, 3) present at the leaf margins. **Papillae:** usually globose and somewhat oblique (Fig. III, 3) papillae, together with large thin papillae (Fig. III, 6), abundant on the long-cells. **Stomata** rather large; mostly with triangular subsidiary cells (Fig. IV, 1). **Long-cells,** between the veins, with thin, rather coarsely sinuous walls (Fig. V, 3*a–c*), but some of them less elongated than usual for this type.

T.S. lamina

Vascular bundles: smallest vb's with xy. and ph. not easily distinguishable from one another (Fig. VIII, 1); most small vb's pentagonal to hexagonal (Fig. VIII, 4); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** smooth (Fig. XIV, 1), apart from slight irregularities due to the specially tall or cushion-like bulliform cells. Cushion cells even more pronounced on the abaxial surface, and often surrounding the bases of the macro-hairs. **Sclerenchyma:** most small vb's, especially those opposite the bulliform cells, not accompanied by scl. (Fig. IX, 1); other small vb's with minute adaxial and abaxial strands (Fig. IX, 4) sometimes united with extensions from the bundle-sheaths to form girders; large vb's with adaxial and abaxial strands up to about 5 cells wide and 4 cells high; median keel vb accompanied by a broad arc of scl. filling the apex of the keel, and a very thin, flat plate of scl. subjacent to the adaxial epidermis. **Keel** fairly conspicuous, rounded; containing 1 large median vb accompanied on either side by about 4, appreciably smaller, laterals (Fig. XIII, 3). **Mesophyll:** chlorenchyma rather indistinctly radiate in the dried material available. **Bulliform cells** in irregular groups as in Fig. XV, 1, many of the cells being v. tall and occupying about half the thickness of the lamina. **Bundle-sheaths** single; complete round all vb's (Fig. XI, 2*a–b*).

Culm

Culm examined about 2 mm in diameter; slightly flattened on 1 side. Epidermis subtended by a zone of 1–2 layers of fibres of small diameter and with v. thick walls, followed by a zone of thin-walled tissue about 4 cells wide, this zone being bounded internally by a scl. ring about 6 cells wide. Vb's of the outermost circle situated at the outer boundary, and the next circle at the inner boundary, of the scl. ring. Remaining vb's mostly in 1 circle embedded in the peripheral part of the thin-walled ground tissue on the inner side of the scl. ring, but a few vb's penetrating farther towards the centre of the culm. Centre of the culm with a somewhat irregular cavity, or solid.

Material Examined: (1) Cultivated at Kew. (2) F. Ballard 1183; Ceylon.

***Ischaemum santapaui* Bor**

Leaf

Abaxial epidermis

Short-cells, over the veins, mostly in rows of more than 5 cells, but some of them apparently solitary when separated from one another by relatively long cells in the same files; abundant over, but infrequent or absent between, the veins. Some **silica-bodies** intermediate between cross and dumb-bell shaped (Fig. IA, 17), others dumb-bell shaped (Fig. IA, 18 (ii–v)), and sometimes varying

in appearance with the focus (Fig. IB, 21); a few nodular (Fig. IA, 18 (i)). **Macro-hairs:** long hairs having moderately thick walls, acute apices, and swollen, sunken bases, occasional in the intercostal zones (Fig. II, 3). **Micro-hairs:** length 18–24 μ; basal cells 12–18 (mostly 12–15) μ; distal cells 4–8 μ; basal cells somewhat inflated but tapering slightly towards their proximal ends; distal cells hemispherical, with rounded, or occasionally slightly pointed, apices; as Fig. VII, 2, but rather longer than usual for this type. **Prickle-hairs:** prickles (Fig. VI, 1) or small hooks (Fig. VI, 5) v. frequent between the veins. **Papillae:** thin, swollen, often somewhat oblique papillae (Fig. III, 3), abundant on the long-cells. **Stomata** with triangular subsidiary cells (Fig. IV, 1). **Long-cells,** between the veins, with thin, markedly sinuous walls (Fig. V, 3*a–c*, sometimes inflated (Fig. V, 5)). **Transverse veins** numerous.

T.S. lamina

Vascular bundles: most vb's small, crowded, and quadrangular, pentagonal, or hexagonal (Fig. VIII, 1, 4, and 5); medium-sized vb's less markedly angular in outline (Fig. VIII, 6); a few large vb's of basic type (Fig. VIII, 15). **Adaxial surface** smooth (Fig. XIV, 1), apart from slight, but widely spaced, rounded ribs over the large vb's. Small ribs filled with scl. present on the abaxial surface of the midrib. **Sclerenchyma:** most small vb's, especially those opposite the bulliform cells, not accompanied by scl. (Fig. IX, 1); a few other small vb's with adaxial strands only (Fig. IX, 2); medium-sized vb's with adaxial and abaxial strands about 6 cells wide and 4 or 5 cells high (Fig. IX, 4); large vb's with adaxial and abaxial girders up to about 20 cells wide and about the same height, or a little taller, than the strands associated with the medium-sized vb's; adaxial girders sometimes tending to be slightly anchor-shaped. Medium-sized and large vb's in the keel each supported by a large dome-shaped abaxial strand, partly situated in ribs on the abaxial surface of the midrib. A thin, wide plate of scl. also subjacent to the adaxial epidermis of the midrib. **Keel** v. conspicuous, rounded; containing 1 large median vb accompanied on either side by 2 laterals of about the same size, and by about 8 other laterals of unequal sizes, and all appreciably smaller than the median vb (Fig. XIII, 3 and 5). **Mesophyll:** chlorenchyma distinctly radiate. **Bulliform cells** in irregular groups as in Fig. XV, 1, many of the cells being specially large and occupying half the thickness of the lamina. Ground tissue of the midrib composed of large, thin-walled, colourless cells. **Bundle-sheaths** single; complete round most vb's (Fig. XI, 2*a–b*); sheaths round the large vb's with abaxial interruptions only (Fig. XI, 6).

CULM

Culm examined 0·5 cm in diameter. Epidermis subtended by a zone of 1–2 layers of fibres of v. small diameter, followed by a zone of thin-walled tissue about 5 cells wide, this zone being partly or completely traversed here and there by scl. girders extending from the vb's of the outermost circle to the epidermis. Thin-walled tissue bounded on the inner side by a sinuous scl. ring about 5 cells wide in its narrowest parts, but appreciably wider immediately around the vb's embedded in it. Scl. ring with no clearly defined inner boundary, gradually passing over to the thin-walled ground tissue occupying

the whole centre of the culm. Vb's in the outermost circle situated at the outer boundary of the scl. ring; remaining vb's scattered, some penetrating well towards the centre of the culm.

STILT ROOT

Root examined about 2·5 mm in diameter. Bounded externally by a layer of cells resembling an epidermis, but with the shadowy remains of some still more superficial cells adhering to the outer surface, the nature of this outer layer not being obvious from the slides examined. Epidermis subtended by a zone of some 5 layers of rather thin-walled, fibrous cells, followed by a v. wide, somewhat spongy zone resembling a 'cortex', about 6 of the innermost cell layers of this zone being in definite rows radiating from the direction of the centre of the root. Innermost layer of cells in this zone resembling an 'endodermis', the inner tangential walls being strongly thickened. A circle of numerous small protoxylem vessels, marking the position of the outer boundary of the polyarch xy., present not far within the endodermis, but separated from it by a zone consisting largely of thin-walled ph. Remainder of the xy. characterized by a somewhat sinuous circle of v. large metaxylem vessels. Centre of the root occupied by a wide, pith-like tissue.

MATERIAL EXAMINED: Cultivated at Kew (2 collections).

ADDITIONAL INFORMATION FROM THE LITERATURE

1. LEAF

Prat (1937) and Vickery (1935) have recorded the following information.

I. australe R. Br.

Lamina moderately thick. Both surfaces almost or completely flat. Scl. forming adaxial and abaxial girders with the first-order vb's, a smaller amount of scl. being present on the abaxial side of the lesser vb's. Stomata mostly on the adaxial surface. Simple and lobed papillae present on the abaxial epidermis. Midrib conspicuous. Mesophyll with radiate chlorenchyma. Bulliform cells in groups of 4–7, the largest cells occupying nearly half the thickness of the lamina. Colourless ground tissue present in the midrib. Bundle-sheaths single; circular.

I. brachyatherum Fenzl ex Hack.

Both surfaces slightly ribbed. Scl. forming girders only with the first-order vb's, the abaxial scl. being almost circular in T.S. Bulliform cells in the wings in groups above the smallest vb's, the individual cells being triangular.

I. laxum R. Br. (now known as *Sehima nervosum* (Rottl. ex Willd.) Stapf

Lamina fairly thin. Adaxial surface flat, or with slight ribs and furrows; abaxial surface with slight, closely placed ribs. Prickles (emergences) present on the adaxial epidermis. Scl. forming fairly wide adaxial and abaxial girders to the large vb's; present as adaxial strands associated with the second- and third- order vb's, and as strands in the abaxial ribs. Midrib conspicuous. Mesophyll with radiate chlorenchyma. Bulliform cells in groups of about 5 cells, 1 or 2 cells at the centre of each group conspicuously larger than the remainder, each group thus being triangular and occupying more than half the thickness of the lamina. Bundle-sheaths single and circular.

I. rugosum Salisb.

Each pair of large vb's separated by 12–13 smaller ones. Abaxial epidermis papillose. Long cushion hairs present over the veins. Mesophyll with chlorenchyma restricted to a narrow abaxial zone. Bulliform cells well developed except over the large vb's; in the wings occupying two-thirds of the thickness of the rather thin lamina.

I. triticeum R. Br.

Structure v. similar to that of *I. australe*. Bulliform cells in groups of 4–9.

Special Note

Prat (1936) rightly notes that the leaf structure is panicoid.

Ischaemum belongs to the Andropogoneae, and may be related to *Arthraxon*. The occurrence of 2 types of micro-hairs in a single sp. is noteworthy.

Literature

Grob 1896 (leaf); Prat 1936, 1937 (leaf); Vickery 1935 (leaf).

ISCHNURUS = LEPTURUS (see p. 285)

The notes on the leaf structure of *I. pulchellus* Balf. fil. recorded by Hansen and Potztal (1954) include the following particulars.

Leaf figured as narrowly W-shaped in T.S., the central part of the W consisting of the median adaxial rib, which is much less tall than the infolded halves of the lamina on either side of the midrib. Long, stiff macro-hairs and prickles present on the adaxial surface. Silica-bodies in part saddle-shaped and in part shortly dumb-bell shaped. Scl. present as well-developed abaxial girders and much smaller adaxial strands, the strands being widely separated from the bundles. Colourless cells well developed in the adaxial part of the leaf, especially over the midrib. Chlorenchyma restricted to areas between all, and above some, of the vb's.

Special Note

Hansen and Potztal regard *Ischnurus* as a member of the Leptureae.

Literature

Hansen and Potztal 1954 (leaf).

ISEILEMA

The papers by Grob (1896) and Vickery (1935) respectively include the following particulars concerning leaf structure.

I. membranaceum (Lindl.) Domin

Leaf thin, becoming folded on drying. Both surfaces flat. Abaxial epidermis consisting of cells of irregular sizes, the cells being slightly arched or papillose. About 7 large vb's present, with 3–9, usually 7, vb's between each pair of large ones. Scl. forming adaxial and abaxial girders to the large vb's, and sometimes minute girders with every fourth vb, small strands being present on the abaxial, and sometimes on the adaxial, side of most of the remaining vb's. Stomata present on both surfaces,

but mostly abaxial. Midrib conspicuous only through the leaf being folded. Mesophyll with radiate chlorenchyma. Bulliform cells present as a main median group subtended by colourless cells in the midrib, and as groups of 2–3 (rarely 4) large, circular cells elsewhere in the lamina. Bulliform cells in the wings interrupted over every second vb and occupying slightly more than one-third of the thickness of the lamina. Bundle-sheaths single and circular.

I. wightii Anderss. (now known as *I. prostratum* (L.) Anderss.)

Short-cells, over the veins, in rows. Silica-bodies mostly dumb-bell shaped in all zones, but cross-shaped and nodular types sporadic. Micro-hairs present. Papillae: present on both surfaces; solitary and situated at the ends of the cells on which they occur. Stomata each overarched at one end by a papilla.

Special Note

Leaf structure panicoid.

Literature

Grob 1896 (leaf); Vickery 1935 (leaf).

JANSENELLA

Conert (1957), in dealing with the taxonomy of *Jansenella*, has given the following particulars concerning the leaf structure of *J. griffithiana* (C. Muell.) Bor.

Silica-bodies dumb-bell shaped. Adaxial epidermis with v. large prickles and papillae over the vb's. Elongated micro-hairs present between the ribs. Leaf flattened; margins narrow, inrolled. Adaxial surface ribbed; abaxial surface undulating. Scl. present as v. small adaxial strands and abaxial girders to the vb's; a few fibres present in the margins. Midrib not pronounced. Mesophyll with radiate chlorenchyma. Bundle-sheaths always single.

Special Note

Conert treats *Jansenella* as a member of the Arundinelleae. The leaf structure agrees well with that of other genera in the same group.

Literature

Conert 1957 (leaf structure and taxonomy).

JARDINEA

Prat (1937) noted the following characters in the leaf of *J. congoensis* Franch. ex Hack.

Ten to eleven vb's of lower rank present between each pair of first-order vb's; midrib well developed, with no adaxial bulliform tissue; bulliform cells present in the rest of the lamina between most of the vb's and above the smallest vb's.

Special Note

Prat (1936) indicates that the leaf structure is panicoid.

LITERATURE

Prat 1936, 1937 (leaf).

JOUVEA

This genus has been investigated particularly by Prat (1933, 1934, 1936) and Weatherwax (1939), from whose articles the following information has been taken. The leaf, in both of the spp. described, is constricted near the middle or towards the distal end.

LEAF

Epidermis

J. pilosa Scribner

Adaxial surface of the leaf with ribs and furrows. Epidermis at the apex of each rib consisting of a uniform band of tissue including silica- and cork-cells. Apical bands flanked laterally by others marked by prickles of a distinctive type, each prickle being ensheathed at its base by an adjacent long-cell. Epidermis consisting of long-cells bearing papillae and 2-celled micro-hairs, each of these last having a hemispherical distal cell. Abaxial surface of the sheath with silica- and cork-cells, the silica-bodies being dumb-bell or cross-shaped (Prat (1934) elsewhere records the occurrence of saddle-shaped silica-bodies in the genus). Ligule represented by a row of long narrow hairs, some having bases each composed of a uniseriate group of several comparatively short cells.

J. straminea Fournier

Adaxial epidermis of leaf similar in structure to that of *J. pilosa* but papillae stated to be different in structure and figured as oblique and contiguous to one another. Two-celled micro-hairs absent from the adaxial zones with papillae, but abundant on the abaxial surface, each micro-hair having its base deeply sunken in the epidermis, the hair being partially enclosed in a depression. Ligule consisting of a row of uniseriate hairs, the cells being more uniform in size than those of *J. pilosa*.

T.S. lamina

J. pilosa and *J. straminea*

Adaxial surface with well-developed broad, rectangular ribs. Mesophyll with radiate chlorenchyma. Girders of colourless cells traversing the lamina from the bases of the adaxial furrows. Bundle-sheaths: each vb surrounded by a sheath of large parenchymatous cells with lignified walls; large vb's described as being surrounded, especially at the ph. end, by fibres. Structure of *J. straminea* similar to that of *J. pilosa* but adaxial ribs narrower, with more rounded apices, and bulliform cells at the bases of the furrows larger.

SPECIAL NOTE

Prat (1934, 1936) considers that *Jouvea* resembles *Chloris*, *Cynodon*, *Eleusine*, and *Spartina*. This affinity with the Chlorideae is supported by the occurrence of sunken, 2-celled micro-hairs with hemispherical heads; saddle-shaped silica-bodies; the ligule consisting of hairs which are often pluricellular and uniseriate; the occurrence of solitary papillae on the long-cells of the leaf epidermis; the radiate chlorenchyma of the mesophyll.

Weatherwax (1939), unlike Prat, considers that *Jouvea* should be placed in the Festuceae, and that it resembles *Distichlis* and *Uniola*. Here there appears to be some confusion, for *Distichlis* itself exhibits panicoid leaf structure, and the leaf of *Uniola* is also somewhat panicoid although less so than that of *Distichlis*. From the anatomical standpoint there seems to be little reason for including any of these genera in the Festuceae.

LITERATURE

Ogden 1897 (leaf); Prat 1933, 1934, 1936 (leaf); Weatherwax 1939 (morphology and taxonomy).

KOELERIA

DIAGNOSTIC GENERIC CHARACTERS

Short-cells, over the veins, mostly solitary, but sometimes paired and in short rows. Silica-bodies, over the veins, horizontally elongated and with smooth or sinuous outlines. Micro-hairs absent. Stomata with parallel-sided or low dome-shaped subsidiary cells. Vascular bundles: none conspicuously angular in outline. Mesophyll with chlorenchyma not radiate. Bundle-sheaths double.

SPECIES SPECIALLY EXAMINED

***Koeleria cristata* (L.) Pers.** **(see also p. 271)**

LEAF

Abaxial epidermis

Short-cells, over the veins, mostly solitary in the sense of not being sufficiently close to one another in the individual files of cells to be interpreted as in rows; common over, but v. infrequent or absent between, the veins. **Silica-bodies** generally horizontally elongated, with rounded ends and smooth (Fig. 1A, 13), or sinuous (Fig. 1A, 14–15) outlines. **Macro-hairs:** superficial hairs with swollen bases (Fig. II, 1) numerous, chiefly between the veins; of 2 distinct sizes, some being long and others v. short. **Micro-hairs:** none seen. **Prickle-hairs:** prickles (Fig. VI, 1–2) locally common over the veins; a few of the shortly pointed macro-hairs between the veins resembling hooks (Fig. VI, 5). **Stomata** rather infrequent; some with parallel-sided (Fig. IV, 2), and others with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells,** between the veins, with thin, non-sinuous walls (Fig. V, 2*a–c*).

T.S. lamina

Vascular bundles: vb's at the margin of the leaf, and those in the smaller ribs, not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 7 and 15). **Adaxial surface** with ribs and furrows fairly well developed (Fig. XIV, 5), the ribs being of v. unequal sizes; median rib and first lateral rib on either side narrower and with more acute apices than most of the others. A small secondary rib at the base of a primary furrow present near the margin on either side of the leaf. Apices of all ribs rounded. Primary furrows mostly narrow and V-shaped, but those immediately on either side

of the midrib rather wider. Furrows sometimes becoming W-shaped through the development of small secondary ribs at their bases. **Sclerenchyma:** nearly all vb's with small adaxial and abaxial strands (Fig. IX, 4); apex of each adaxial rib over a large vb completely capped by a wide, subepidermal arc of scl., only 1–2 cells high, the corresponding abaxial strands being only about 5 cells wide and 2 cells high. Similar abaxial strands of scl. also present opposite most of the adaxial furrows. **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** in fan-shaped groups at the bases of the furrows (Fig. XV, 6). **Bundle-sheaths** double; all vb's with O.S. not quite complete, or inconspicuous, abaxially (Fig. XII, 2).

MATERIAL EXAMINED: J. K. O'Byrne 124.

Koeleria phleoides (Vill.) Pers. (see also p. 271)

LEAF

Abaxial epidermis

Short-cells, over the veins, mostly solitary, but some paired, and occasionally in rows of 3–5 cells; common over, but v. infrequent between, the veins. **Silica-bodies** horizontally elongated with rounded ends and usually smooth (Fig. IA, 12), but occasionally slightly sinuous (Fig. IA, 14–15), outlines. **Macro-hairs:** short, superficial hairs with swollen bases (Fig. II, 1) common, mostly between the veins. **Micro-hairs:** none seen. **Prickle-hairs:** prickles (Fig. VI, 1–2) common, especially over the smaller veins; also angular prickles (Fig. VI, 3) at the leaf margins. **Stomata** with parallel-sided subsidiary cells (Fig. IV, 2). **Long-cells,** between the veins, with thin, non-sinuous walls (Fig. V, 2*a–c*); certain cells somewhat hexagonal.

T.S. lamina

Vascular bundles: small vb's not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with moderate, rounded or slightly triangular ribs separated from one another by fairly narrow furrows (Fig. XIV, 2–3); median rib wider and more flattened than the others. **Sclerenchyma:** small vb's with minute adaxial (Fig. IX, 2) or abaxial strands only; large vb's with minute adaxial and abaxial strands (Fig. IX, 4). **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells:** groups as in Fig. XV, 2, or occasionally tending to be fan-shaped (Fig. XV, 6). **Bundle-sheaths** double; most vb's with I.S. complete and O.S. not quite complete abaxially (Fig. XII, 2). Cells of the I.S. with U-shaped thickenings.

MATERIAL EXAMINED: Cultivated at Kew.

ADDITIONAL INFORMATION FROM THE LITERATURE

Particulars concerning the leaf structure of a number of spp. of *Koeleria* have been recorded by Lohauss (1905), from whose article the following information has been taken.

K. albescens DC.

Structure similar to that of *K. cristata* and *K. vallesiana* (see below).

K. caudata Steud.

Scl. forming a continuous layer subjacent to the abaxial epidermis. O.S. consisting of chlorenchymatous cells, but not v. conspicuous. Bulliform cells small.

K. cristata (L.) Pers. (see also p. 269)

Epidermis. (i) Abaxial. Cork-cells, over the veins, elliptical. Bristle-hairs present over the veins. Prickles present both over and between the veins. Long-cells, over the veins, in broad bands, the cells having weakly sinuous and infrequently pitted walls; those between the veins rectangular to hexagonal, with straight, unpitted walls. (ii) Adaxial. Similar to the abaxial epidermis, but bulliform cells present. *T.S. lamina.* Lamina approximately U-shaped in T.S., with well-developed adaxial ribs and furrows. Vascular bundles; ratio of large to small vb's 1:1–2; one vb present in each rib, sometimes with small additional vb's below the bulliform cells. Scl. present as abaxial and adaxial strands or girders associated with the vb's, the abaxial strands being the larger; abaxial girders to adjacent vb's sometimes fused together. Midrib not conspicuous. Mesophyll with chlorenchyma consisting of relatively large, isodiametric cells. Bulliform cells small, in groups at the bases of the furrows. Bundle-sheaths double; O.S. consisting of small cells containing chlorophyll. The leaf of *K. cristata* has also been described by Aitenkirch (1894).

K. phleoides (Vill.) Pers. (see also p. 270)

Leaves flexible and soon withering. *Epidermis.* (i) Abaxial. Cork-cells, over the veins, rectangular or elliptical, and variable in size. Long-cells, over the veins, quadrangular to hexagonal, with slightly sinuous walls; those between the veins with straight thin, unpitted walls. (ii) Adaxial. Similar to the abaxial epidermis, but prickles and occasional long cushion hairs present. *T.S. lamina.* Vascular bundles: ratio of large to small vb's 1:2–3. Scl. not well developed, not always impinging directly on the vb's but separated from them by girders of thick-walled, parenchymatous cells; scanty in the leaf margins. Midrib not v. conspicuous. Mesophyll composed of large, lobed cells, with intercellular spaces between them. Bulliform cells fairly large, present in groups on both surfaces between the vb's. Bundle-sheaths double; cells of the I.S. with inner more thickened than the outer walls; O.S. not v. conspicuous and composed of small chlorenchymatous cells.

K. vallesiana (All.) Bertol.

Epidermis. (i) Abaxial. Silica-cells, over the veins, quadrangular to rounded. Long-cells, over the veins, rectangular, with walls thickened in a nodular manner; those over the parenchyma next to the veins also rectangular, with sinuous, regularly pitted walls, occasional rectangular short-cells being present amongst them. (ii) Adaxial. Adaxial epidermis similar to that of *K. cristata* but hairs less frequent. *T.S. lamina.* Similar to *K. cristata* but abaxial scl. girders of adjacent vb's not seen to be fused to one another. The anatomy of *K. vallesiana* has been described and discussed at great length from the ecological standpoint by Stuber (1938).

SPECIAL NOTE

Prat (1936) rightly emphasizes that the leaf characters are festucoid.

LITERATURE

Altenkirch 1894 (leaf of *K. cristata*); Chauveaud 1897 (a few notes on root structure); Duval-Jouve 1875 (leaf); Grob 1896 (leaf); Lewton-Brain 1904 (leaf); Lohauss 1905 (leaf); Pée-Laby 1898 (leaf); Prat 1936 (leaf); Stuber 1938 (ecological leaf anatomy of *K. vallesiana*).

LAGURUS

Diagnostic Generic Characters

Short-cells, over the veins, solitary or in long rows. Silica-bodies, over the veins, horizontally elongated with smooth outlines. Micro-hairs absent. Stomata with parallel-sided subsidiary cells. Vascular bundles: none conspicuously angular in outline. Mesophyll with chlorenchyma not radiate. Bundle-sheaths double.

Species Specially Examined

***Lagurus ovatus* L.**

Leaf

Abaxial epidermis

Short-cells, over the veins, mostly in rows of more than 5 cells, but sometimes solitary; infrequent. **Silica-bodies** horizontally elongated with rounded ends and smooth outlines (Fig. Ia, 12). **Macro-hairs:** fairly long to long, slender, minutely warty hairs abundant. **Micro-hairs** and **prickle-hairs:** none seen. **Stomata** with v. conspicuously parallel-sided subsidiary cells (Fig. IV, 2). **Long-cells,** between the veins, with thin, non-sinuous walls (Fig. V, 2*a–c*); cells rather wide.

T.S. lamina

Vascular bundles: small vb's widely spaced and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with v. slight, wide ribs and furrows (Fig. XIV, 2), or almost smooth (Fig. XIV, 1). **Sclerenchyma:** small vb's not accompanied by scl. (Fig. IX, 1); large vb's with adaxial and abaxial girders up to about 3 cells wide and 5 cells high (Fig. IX, 4). **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells:** none very obvious in the material examined, but groups between the ribs figured by Lewton-Brain (1904). **Bundle-sheaths** double; some vb's with I.S. complete and O.S. not quite complete, or v. inconspicuous, abaxially (Fig. XII, 2); a few large vb's with I.S. complete and O.S. interrupted adaxially and abaxially (Fig. XII, 3*a*); occasional large vb's with I.S. complete and O.S. interrupted abaxially but connected to the adaxial scl. by large cells (Fig. XII, 4).

Culm

Culm examined about 2 mm in diameter. No well-defined scl. ring present, the ground tissue consisting of cells of progressively wider diameter and with thinner walls from the epidermis to the hollow centre of the culm. A few small, flattened columns of assimilatory tissue embedded in the thick-walled ground tissue immediately below the epidermis. Vb's of the outermost circle v. small and situated only about 3 layers of cells below the epidermis; outlines of these vb's obscured by merging into the thick-walled ground tissue. Remaining vb's in 2 more or less distinct circles, embedded amongst ground tissue composed of cells with fairly thick walls and wide lumina.

Material Examined: Cultivated at Kew.

Special Note

Prat (1936) rightly points out that the leaf structure is festucoid.

Literature

Duval-Jouve 1875 (leaf); Grob 1896 (leaf); Lewton-Brain 1904 (leaf); Pée-Laby 1898 (leaf); Prat 1936 (leaf).

LAMARCKIA

Diagnostic Generic Characters

Short-cells, over the veins, in long rows. Silica-bodies, over the veins, horizontally elongated with sinuous outlines. Micro-hairs absent. Stomata with parallel-sided or low dome-shaped subsidiary cells. Vascular bundles: none conspicuously angular in outline. Mesophyll with chlorenchyma not radiate. Bundle-sheaths double.

Species Specially Examined

***Lamarckia aurea* (L.) Moench**

Leaf

Abaxial epidermis

Short-cells, over the veins, in rows of more than 5 cells; abundant over, but absent between, the veins. **Silica-bodies** horizontally elongated, with sinuous outlines (Fig. Ia, 14–15). **Macro-hairs** and **micro-hairs:** none seen. **Prickle-hairs:** prickles (Fig. VI, 1–2) common over some of the veins; angular prickles (Fig. VI, 3) at the leaf margins. **Papillae:** large, thin papillae (Fig. III, 6) present on many of the long-cells, but not v. conspicuous in surface view. **Stomata:** some with parallel-sided (Fig. IV, 2), and others with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells:** those between the veins with thin, non-sinuous walls (Fig. V, 2*a–c*).

T.S. lamina

Vascular-bundles: small vb's rather widely spaced and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** smooth (Fig. XIV, 1) apart from v. slight, rounded ribs over the larger vb's, especially towards the leaf margins. **Sclerenchyma:** a few of the small vb's not accompanied by scl. (Fig. IX, 1); most small vb's with minute adaxial and abaxial strands (Fig. IX, 4), each no more than 2–3 cells wide and high; other small vb's each with an adaxial (Fig. IX, 2) or abaxial strand only; large vb's with adaxial girders up to about 4 cells wide and 3 cells high, and abaxial girders up to about 6 cells wide and 4 cells high (Fig. IX, 4). **Keel** v. prominent, narrow, supported at the apex by a crescent-shaped strand of scl.; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** restricted to a fan-shaped group (Fig. XV, 4) on either side of the midrib. Keel vb connected to a small, overlying, adaxial scl. strand by a girder of large, colourless cells. **Bundle-sheaths** double; most vb's with I.S. complete, but O.S. not quite complete, or inconspicuous, abaxially

(Fig. XII, 2); some large vb's with O.S. interrupted adaxially and abaxially (Fig. XII, 3*a*).

Culm

Culm examined 2 mm in diameter. Epidermis subtended by plates of thin-walled assimilatory tissue at intervals around the culm, and by a ring of scl. about 4 or 5 cells wide, except where interrupted by the assimilatory tissue. Ground tissue on the inner side of the scl. ring consisting of cells of increasing diameter and decreasing wall-thickness from the inner boundary of the scl. ring to the small cavity at the centre of the culm. Vb's of the outermost circle embedded in the scl. ring. Remaining vb's in 2 more or less distinct circles just within the scl. ring. Innermost part of the ground tissue v. spongy.

Material Examined: Cultivated at Kew.

Special Note

Prat (1936) rightly emphasizes that the leaf structure is festucoid. It is, however, unusual to find the short-cells over the veins to be in long rows amongst festucoid grasses.

Literature

Grob 1896 (leaf); Pée-Laby 1898 (leaf); Prat 1936 (leaf).

LAMPROTHYRSUS

Cacares (1956) has published notes on the leaf anatomy of *L. hieronymi* (Kuntze) Pilger.

His illustration of the abaxial epidermis shows the short-cells over the veins to be in long rows, those between the veins being figured as solitary. Silica-bodies somewhat dumb-bell shaped but with the ends of each body not v. much wider than the middle portion. Other features of the abaxial epidermis are the micro-hairs described by the author as filiform, each with the basal much wider than the narrow distal cell, the latter being uniform in diameter throughout its length and with a rounded apex.[1] Stomata with low dome-shaped or slightly triangular subsidiary cells. Intercostal long-cells with rather thick, sinuous walls.

Lamina in T.S. figured as showing wide, flat-topped adaxial ribs separated from one another by narrow, shallow furrows; adaxial and abaxial strands of scl. associated with the vb's. Mesophyll apparently with irregular chlorenchyma, the bundle-sheaths appearing to be double, the cells of the I.S. having thickened walls.

Special Note

The structure clearly indicates that *Lamprothyrsus* cannot be regarded as a member of the Festuceae, and suggests rather that it should be placed with *Schismus* and *Danthonia* in the Danthonieae.

Literature

Cacares 1956 (leaf).

[1] The figures look as if they have been drawn from material in which the distal cells have contracted. C. R. M.

LASIURUS (see also p. 425)

The following description of the leaf of *L. hirsutus* (Forsk.) Boiss. is based on information recorded by Prat (1937) and Sabnis (1921). The last author refers to the sp. under *Elyonurus hirsutus* Munro.

Adaxial surface with well-developed ribs and furrows. Abaxial surface also furrowed between the larger veins. Macro-hairs: long hairs present on both leaf surfaces. Vb's of several distinct orders, there being about 7 lesser vb's between each pair of first-order bundles. Scl. forming adaxial and abaxial girders or absent. Scl. also present beneath the adaxial surface of the midrib, and forming large strands in the pointed leaf margins. Midrib very large; with numerous vb's beneath the surface of the abaxially projecting keel. Mesophyll with radiate chlorenchyma completely surrounding the small vb's, the chlorenchyma around the large vb's being interrupted adaxially and abaxially by scl. Bulliform cells well developed in the thin part of the lamina (none in the midrib), but present only above the small vb's. Ground tissue of the midrib composed of colourless cells.

Special Note

Prat (1936) states that the leaf structure is panicoid, and in his later paper (1937) the genus is treated as a member of the Rottboellieae.

Literature

Prat 1936, 1937 (leaf); Sabnis 1921 (leaf, ecological anatomy; under *Elyonurus hirsutus* Munro.).

LATIPES

Leaf

(*a*) *Epidermis*

Grob (1896) records the few following notes concerning the leaf epidermis of *L. senegalensis* Kunth. Silica-bodies, in all zones, predominantly dumb-bell shaped, but cross-shaped and nodular types sporadic. Micro-hairs club-shaped, each with a relatively short distal cell.

(*b*) *T.S. lamina*

Sabnis (1921) gives these notes concerning *L. senegalensis* Kunth. Adaxial surface with moderate ribs and furrows. Scl. forming relatively small adaxial and larger abaxial girders to the vb's; also present as small strands in the pointed leaf margins. Mesophyll with radiate chlorenchyma, the chlorenchyma completely encircling the small vb's, but interrupted by the adaxial and abaxial scl. girders to the large vb's. Bulliform cells in fan-shaped groups at the bases of the furrows, each group being connected to the abaxial epidermis by a girder of colourless cells. Bundle-sheaths single; each sheath triangular to horse-shoe shaped in T.S. because interrupted abaxially by scl.

Special Note

Leaf structure panicoid. The grass belongs to the Zoysieae.

Literature

Grob 1896 (leaf); Sabnis 1921 (leaf).

LEERSIA

Diagnostic Generic Characters

Short-cells, over the veins, in long rows. Silica-bodies, over the veins, of the *Oryza* type. Micro-hairs present; some approximately uniform in diameter throughout their lengths, but distal cells of others slightly or conspicuously tapered towards their apices, the proportions of each type of hair varying in different spp. Stomata with triangular subsidiary cells. Vascular bundles not more than inconspicuously angular in outline. Mesophyll with chlorenchyma not radiate, the chlorenchyma consisting of arm-cells. Bundle-sheaths double.

Species Specially Examined

Leersia hexandra Swartz

Leaf

Abaxial epidermis

Short-cells, between the veins, paired; those over the veins in rows of more than 5 cells; abundant over, but much less frequent between, the veins. **Silica-bodies,** over the veins, of the *Oryza* type (Fig. Ib, 23); those between the veins tall, narrow (Fig. I, 4), sometimes crescent-shaped, or tending to be slightly crenate (Fig. Ib, 24). **Macro-hairs:** none seen. **Micro-hairs:** difficult to find in the available material; length 22–28 μ; basal cells 9–15 μ; distal cells 10–16 μ; some hairs more or less uniform in diameter throughout their lengths and with rounded apices (Fig. VII, 7), but distal cells of others tapering slightly towards their apices (Fig. VII, 6). **Prickle-hairs:** prickles (Fig. VI, 1–2), with v. large, inflated bases and relatively short points; common over the veins; hooks (Fig. VI, 5) occurring between the veins but rather lost amongst the large papillae. **Papillae:** small, variously shaped, thickened cuticular warts abundant on the long-cells. Much larger, dome-shaped papillae, giving the epidermis a distinctive appearance, also frequent on some of the long-cells, those beside the small grooves in the intercostal zones being especially large (Fig. III, 4). **Stomata** with triangular (Fig. IV, 1) subsidiary cells. **Long-cells,** between the veins, with thin, sinuous walls (Fig. V, 3*a–c*), some of them having v. pronounced sinuations as in Fig. V, 6; interstomatal cells with v. sinuous outlines and concave ends (Fig. V, 10–11).

T.S. lamina

Vascular bundles: most vb's somewhat angular in outline and resembling Fig. VIII, 6; large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with ribs moderately to well developed (Fig. XIV, 3), of unequal heights, and rounded to slightly triangular in outline, the large ribs being over the large vb's. Furrows widely V-shaped, portions of the lamina between the bases of the furrows and the abaxial surface being only 2–3 cells wide. **Sclerenchyma:** small vb's with adaxial and abaxial girders up to about 7 cells wide and mostly 2, but sometimes partly 3 cells high (Fig. IX, 5); combined girders of the median and a few other large vb's somewhat anchor-shaped (Fig. IX, 6). **Midrib** fairly conspicuous, with a slight abaxial projection and a median adaxial rib rather larger than the others; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate, consisting of arm-cells. **Bulliform cells** as fan-shaped groups at the bases of the furrows (Fig. XV, 6). Smaller, but similar, fan-shaped groups present on the abaxial surface opposite those in the adaxial furrows. **Bundle-sheaths** double; small vb's with I.S. complete to incomplete, the O.S. being connected to the adaxial scl. by extensions of colourless cells (Fig. XII, 6); large vb's with I.S. complete and the O.S. with a wide abaxial interruption, but connected to the adaxial scl. by a v. slight extension (Fig. XII, 4).

Culm (Fig. XXI, 5–6)

Culm examined about 2 mm in diameter. Epidermis subtended by only 1–2 layers of fibrous cells. Remainder of the ground tissue about 12 cells wide with a circle of large intercellular spaces embedded in it. Cells of the ground tissue thin-walled and more or less uniform in diameter throughout, but those surrounding the intercellular cavities rather larger than the remainder. Centre of the culm occupied by a v. large cavity. Vb's in 2 circles, those of the outer circle being in the ground tissue between the intercellular cavities, but usually only 1 vb present between every other intercellular cavity. Vb's of the inner circle adjacent to the central cavity of the culm, situated on radii alternating with the intercellular spaces. Vb's nearly twice as numerous in the inner as in the outer of the 2 circles.

Material Examined: Collected specially by G. Jackson in Nyasaland.

Leersia oryzoides (L.) Sw.

Leaf

Abaxial epidermis

Short-cells, over the veins, in rows of more than 5 cells; abundant over, and v. infrequent or absent between, the veins. **Silica-bodies** mostly of the *Oryza* type (Fig. Ib, 23), but some of them tending to be cross-shaped (Fig. Ia, 16). **Macro-hairs:** none seen. **Micro-hairs:** length 32–42 μ; basal cells 14–18 μ; distal cells 16–24 μ; hairs distinctly wider than those of *L. hexandra* and distal cells tapering more conspicuously towards their apices (Fig. VII, 6). (Holm (1892) refers to 3-celled hairs in *L. oryzoides* but none were observed by the author.) **Prickle-hairs:** prickles (Fig. VI, 1–2) with large, v. inflated bases, and relatively short points, common over the veins. **Papillae:** a mixture of small, variously shaped, cuticular papillae, and a few larger, more inflated papillae (Fig. III, 4), abundant on the long-cells. Still larger papillae, similar to those in *L. hexandra*, also present in the intercostal zones. **Stomata** with triangular subsidiary cells (Fig. IV, 1). **Long-cells,** between the veins, with thin, sinuous walls (Fig. V, 3*a–c*), the sinuations being v. pronounced; interstomatal cells with concave ends (Fig. V, 10–11) and v. sinuous outlines.

T.S. lamina

Vascular bundles: small vb's not more than inconspicuously angular in outline (Fig. VIII, 2 and 6); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** smooth (Fig. XIV, 1), or with slight ribs and furrows (Fig. XIV, 2),

the ribs being most marked over the large vb's. **Sclerenchyma :** most vb's with adaxial and abaxial girders up to about 4 cells wide and 3 cells high (Fig. IX, 4); large vb's with short but wider adaxial and abaxial girders (Fig. IX, 5), combined girders supporting the largest vb's tending to be somewhat anchor-shaped (Fig. IX, 6). **Midrib** conspicuous, rounded; projecting adaxially and abaxially; containing 1 large median vb supported abaxially by a wide but short arc of scl. A much smaller median vb, consisting only of ph., also present much closer to the adaxial surface, and supported by a small strand of scl. **Mesophyll :** chlorenchyma not radiate; many of the cells with short, inwardly directed arms. **Bulliform cells,** mostly in groups of the *Sporobolus* type (Fig. XV, 8). One (occasionally 2) large groups of bulliform cells present on either side of the midrib on the abaxial surface of the leaf. (Abaxial bulliform cells were also noted in this and other spp. by Jacques-Félix (1955).) Central ground tissue of the midrib composed of large colourless cells. **Bundle-sheaths** double; small vb's with 2 complete sheaths (Fig. XII, 1), many of them connected to the adaxial scl. by short girder-like extensions of colourless cells (Fig. XII, 6); large vb's with I.S. complete and O.S. interrupted abaxially and adaxially (Fig. XII, 3*a*). I.S.'s of the small vb's not v. clearly defined.

Culm

Culm examined 3 mm in diameter. Epidermis subtended by about 2 or 3 layers of fibres. Remainder of the ground tissue consisting of about 14 layers of thin-walled cells of rather uniform diameter. Centre of the culm occupied by a large cavity. A circle of large intercellular cavities present in the thin-walled ground tissue, the remains of some spongy tissue being present in the cavities. Vb's in 2 distinct circles, those of the outer circle being situated in the ground tissue between some, but not all, of the intercellular cavities. Bundles of the inner circle mostly near the central cavity of the culm, but not so close to it as the corresponding bundles in *L. hexandra*. Vb's of the inner circle sometimes on the same radii as those of the outer circle, i.e. between the intercellular cavities; others in the ground tissue between the intercellular cavities and the large hollow at the centre of the culm. (This is another point of difference from *L. hexandra*.)

Material Examined: Cultivated at Kew.

Additional Information from the Literature

1. Leaf

Holm (1895), who examined the leaves of several spp. of *Leersia*, has drawn attention to the uniformity of structure in the genus. He gives a key to the spp. based on slight variations in the epidermis, vascular bundles, mesophyll, and colourless parenchyma. Brief notes on the anatomy of the leaf of *L. oryzoides* from the ecological standpoint have been given by Hayden (1919).

2. Culm

Chrysler (1906) records that, in *L. oryzoides*, as each small bundle enters a node, it is joined by 2 small bundles from the nodal complex, and the bundle, thus reinforced, runs downward and through the sclerified cortex. *Leersia* is one of the genera

mentioned by Chrysler as having amphivasal bundles in the nodes formed by the fusion of collateral bundles.

Special Notes

The shape of the silica-bodies and the occurrence of arm-cells in the mesophyll indicate that *Leersia* belongs to the Oryzeae.

L. oryzoides occurs rarely in aquatic habitats in southern England, the northern limit of this mainly tropical genus. It is known as 'cut grass'. In normal seasons the inflorescence remains within the leaf sheath.

Literature

Chrysler 1906 (culm); Duval-Jouve 1875 (leaf); Grob 1896 (leaf); Hayden 1919 (leaf; ecological anatomy); Holm 1892, 1895 (leaf); Jacques-Félix 1955 (leaf); Pée-Laby 1898 (leaf).

LEPTASPIS

Diagnostic Generic Characters

Short-cells confined to certain longitudinal files of epidermal cells above or between the veins. Silica-bodies mostly shortly dumb-bell shaped, but a few nodular. Micro-hairs: none seen. Stomata with tall dome-shaped subsidiary cells. Vascular bundles: small vb's v. narrow and angular in outline. Mesophyll with chlorenchyma not radiate, but with a distinctive appearance owing to the presence of a single row of v. conspicuous, inflated, translucent cells.

Species Specially Examined

***Leptaspis cochleata* Thwaites**

Leaf

Abaxial epidermis (Fig. XXV, 6)

Short-cells abundant; confined to certain solitary, longitudinal files of cells above and between the veins, the files usually separated from one another by at least 4 others devoid of short-cells and silica-bodies. Short-cells in rows of more than 5 cells, but silica-bodies sometimes rather widely spaced in the rows. **Silica-bodies** mostly shortly dumb-bell shaped (Fig. Ib, 20); a few nodular (Fig. Ib, 22 (iii)). **Macro-hairs, micro-hairs,** and **prickle-hairs :** none seen. **Papillae :** a large part of the adaxial epidermis consisting of spherical, papillose cells standing out from the surface of the leaf like a multitude of small bladders. **Stomata** infrequent; with tall, dome-shaped subsidiary cells (Fig. IV, 4). **Long-cells** with overlapping end walls (Fig. V, 9), the cells with this type of ending having non-sinuous walls. Other long-cells in the intercostal zones with thin, sinuous walls and not overlapping (Fig. V, 3*a–c*).

T.S. lamina

Vascular bundles : small vb's v. narrow and angular in outline—the *Leptaspis* type (Fig. VIII, 3); large vb's of basic type (Fig. VIII, 9 and 14).

Adaxial surface practically smooth (Fig. XIV, 1), but portions of the epidermis and subjacent layer of cells over each translucent cell in the mesophyll slightly convex outwardly. Lamina consequently slightly less thick at than between the ribs. **Sclerenchyma :** most vb's in the lamina with adaxial girders up to about 10 cells wide and 3 cells high, the abaxial girders being only 2–3 cells wide and high (Fig. IX, 4–5); small vb's in the keel not accompanied, or only slightly supported, by scl. (Fig. IX, 1). A plate of scl., about 100 cells wide and 3 cells high, subjacent to the adaxial epidermis of the midrib. **Midrib** conspicuous, abaxially rounded; containing 1 large median vb accompanied on either side by about 3 much smaller laterals, a single, additional median vb also present just below the adaxial surface of the midrib. **Mesophyll** of a highly distinctive type.

Below the adaxial epidermis is a single layer of thin-walled, cubical, assimilatory cells, separating the epidermis from a number of large **translucent cells,** which, in T.S. of the leaf, appear to be sausage-shaped. These cells, which could easily be mistaken for intercellular spaces, are one of the most conspicuous characters of the leaf. They are arranged in a single row in the middle of the mesophyll, but each such cell is separated from its next nearest neighbours of the same kind either by a girder of smaller colourless cells or by a vb and its surrounding sheath. The girders of colourless cells alternate with the vb's and their surrounding sheaths. In L.S. of the lamina, the cells are circular to oval in outline, and, as they are inflated, their lateral walls press against one another where they are in contact with one another. Each series of these cells thus appears as a set of letter O's pressing against one another where they are in contact laterally, but with intercellular spaces between them towards their adaxial and abaxial ends. On the abaxial side of the translucent cells, and separating them from the abaxial epidermis, there is a single layer of tall, palisade, assimilatory cells.

Typical **bulliform cells** absent, but mesophyll traversed at intervals by girders of colourless cells. Ground tissue of the midrib also largely made up of colourless cells, those in a single horizontal layer across the midrib near its centre being much larger than the remainder. Most colourless cells in the ground tissue of the midrib angular like those in the centre of the culm and in the ground tissue of the petiole, with wall thickenings at the corners. **Bundle-sheaths** could be interpreted as single or double, but I.S. not clearly differentiated from the remaining thick-walled ground tissue of the vb's; O.S. of vb's, other than those in the midrib, somewhat distinctive in appearance owing to the lateral parts of the sheath, on either side of the bundle, being more or less straight, vertical, and almost parallel to one another (Fig. VIII, 3, O.S.). Vb's in the midrib without clearly defined sheaths.

Petiole

Petiole in T.S. resembling the midrib in shape, and slightly winged. Vascular system, excluding about 4 vb's in each of the wings, consisting of an inner abaxial arc of about 10 large bundles, and an outer abaxial arc of about 10 much smaller vb's, the vascular tissue in each small strand consisting chiefly of ph. Each vb. of the outer abaxial arc connected to the abaxial scl. by a girder of fibres staining less readily with safranin than the fibres immediately encircling the vb's. An additional horizontal row of about 4 vb's also present

some 6 cells below the adaxial epidermis. Peripheral ground tissue of the petiole assimilatory. Short, thick-walled, but somewhat sinuous hairs, with constricted, sunken bases, occurring sparsely on the flattened adaxial surface of the petiole. Occasional structures resembling flattened, circular, multicellular scales of various sizes noted in epidermal preparations.

Culm

Culm examined 0·5 cm in diameter; solid, with vb's scattered throughout the T.S. Epidermis subtended by about 6 layers of assimilatory cells. Outermost vb's widely separated from the others, and embedded in a ring of scl., about 10 or 12 cells wide, situated immediately on the inner side of the assimilatory tissue. Central ground tissue distinctive in appearance in T.S. owing to small, triangular, intercellular spaces wherever the thin primary walls (stained readily in methylene blue) of 3 adjacent cells meet together. Primary walls lined by gelatinous, apparently cellulosic, secondary walls, the latter appearing v. thick when mounted in dilute glycerine or chlor-zinc-iodide, but much thinner in dehydrated sections. Secondary walls, when stained blue by chlor-zinc-iodide, exhibiting deep, narrow pits. Lumina of the cells, with the secondary walls fully swollen, appearing somewhat angular in outline and occupying only a small proportion of their total diameter.

Rhizome

V. similar in structure to the culm. Rhizome examined about 0·4 cm in diameter, somewhat oval in outline. Epidermis subtended by a single layer of fibrous cells, followed by a zone of thin-walled parenchyma about 6 cells wide, bounded in turn on its inner side by a cylinder of scl. about 12 cells wide. Ground tissue between the scl. ring and the solid centre of the rhizome consisting of cells with their thin primary, and thick, pitted secondary, walls, similar to those of the cells in corresponding position in the culm. Vb's of the outermost circle embedded in the scl. ring, the remainder being scattered throughout the thin-walled ground tissue at the centre of the rhizome. Each vb in the central ground tissue surrounded by a more or less distinct, single-layered sheath of cells, the sheath-cells differing from their neighbours in their smaller size and thinner secondary walls. Some cells in the central ground tissue filled with, or lined by, an amorphous, possibly mucilaginous material, this deposit being especially thick on the transverse cell walls.

Material Examined: from West and East Africa.

Additional Information from the Literature

From the description given by Page (1947), the leaf structure of *L. angustifolia* Summerhayes and Hubbard appears to be v. similar to that of *L. cochleata* (see above).

Special Note

This genus resembles the bamboos, particularly in the vascular structure of the midrib, whilst the translucent cells in the mesophyll recall the fusoid-cells of bamboo leaves. Unlike the bamboos, *Leptaspis* exhibits no arm-cells in the chlorenchyma. No micro-hairs have been observed in *Leptaspis*, and, in this

respect also, the genus differs from most bamboos. The leaf structure of *Leptaspis* is similar to that of *Pharus*, and both genera belong to the Phareae.

Literature

Brandis 1907 (leaf); Grob 1896 (leaf); Jacques-Félix 1955 (leaf); Page 1947 (leaf); Tateoka 1958*b* (cytology).

LEPTOCARYDION

Diagnostic Generic Characters

Short-cells, over the veins, in long rows. Silica-bodies, over the veins, dumb-bell shaped, but sometimes rather short. Micro-hairs present; each with a hemispherical distal cell. Stomata with triangular, or tall dome-shaped, subsidiary cells. Vascular bundles mostly small and conspicuously angular in outline. Mesophyll with chlorenchyma distinctly radiate. Bundle-sheaths single.

Species Specially Examined

***Leptocarydion vulpiastrum* (De Not.) Stapf**

Leaf

Abaxial epidermis

Short-cells, over the veins, in rows of more than 5 cells; those between the veins mostly solitary, and occasionally in pairs or rows of 3 cells; abundant over, and common between, the veins, but more numerous over some veins than others. **Silica-bodies,** over the veins, mostly dumb-bell shaped (Fig. IA, 18 (ii–v)) or shortly dumb-bell shaped (Fig. IB, 20). Silica-bodies rarely conspicuous between the veins. **Macro-hairs:** none seen. **Micro-hairs:** length 18–22 μ; basal cells 12–15 μ; distal cells 4–8 μ; distal cells hemispherical, with rounded apices; more or less as in Fig. VII, 2, but with the basal cell longer, or similar to those in Fig. VII, 12, but shorter. **Prickle-hairs:** prickles (Fig. VI, 1–2) of moderate size abundant over the veins. **Papillae:** numerous on the long-cells; but seldom more than 1 row per cell; papillae fairly large, oblique, with thickened, rounded apices; more or less as Fig. III, 2, but less elongated; each of certain of the stomata overarched on 1 side by a papilla. **Stomata** with triangular (Fig. IV, 1), or almost tall dome-shaped (Fig. IV, 5), subsidiary cells, the apices of some of the triangles sometimes being blunt or flattened. **Long-cells,** between the veins, with thin, coarsely sinuous walls (Fig. V, 3*a–c*), but rather short; interstomatal cells also v. sinuous, and with concave ends (Fig. V, 10–11).

T.S. lamina

Vascular bundles: most vb's small and conspicuously angular in outline (Fig. VIII, 5); a v. few large vb's of basic type (Fig. VIII, 15). **Adaxial surface** practically smooth (Fig. XIV, 1) apart from a slight suggestion of ribs over the vb's (Fig. XIV, 2), the ribs being rather more pronounced towards the leaf margins than elsewhere. **Sclerenchyma:** most vb's with adaxial girders 1–3 cells wide and 2–3 cells high, and abaxial girders about 10 cells wide and 1–2 cells high (Fig. IX, 4); adaxial and abaxial girders to the large vb's of the same relative widths as those associated with the small vb's but total widths rather greater. **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma distinctly radiate. **Bulliform cells** mostly in groups more or less of the *Sporobolus* type (Fig. XV, 9). **Bundle-sheaths** single; sheaths round all vb's complete, the sheaths being flattened on the abaxial side where in contact with the scl. girders, the cells on the flattened side of each sheath being much smaller than the remaining sheath cells.

Material Examined: Chase 29464; Rhodesia.

Special Note

The leaf structure is panicoid and the micro-hairs are similar to those in *Eragrostis*.

LEPTOCHLOA

Diagnostic Generic Characters

Short-cells, over the veins, in short rows. Silica-bodies, over the veins, cross-shaped. Short-cells and silica-bodies ill-defined in, or absent from, certain spp. Micro-hairs present; each with a hemispherical distal cell, or with the distal cell slightly tapering towards its rounded apex. Stomata with triangular or low dome-shaped subsidiary cells. Vascular bundles mostly small, crowded, and angular in outline. Mesophyll with chlorenchyma distinctly radiate, but doubtfully radiate in certain spp. Bundle-sheaths single and double.

Species Specially Examined

***Leptochloa caerulescens* Steud.**

Leaf

Abaxial epidermis

Short-cells, over the veins, in rows of 3–5 cells; abundant over, but only moderately frequent between, the veins; where present between the veins generally paired and solitary, or occasionally in rows of 3 cells. **Silica-bodies,** over the veins, cross-shaped (Fig. IA, 16); a few between the veins also approximately cross-shaped, but with a distorted appearance, and sometimes narrow. **Macro-hairs:** none seen. **Micro-hairs:** length 24–30 μ; basal cells 16–22 μ; distal cells 7–11 μ; basal cells rather wide and inflated; distal cells hemispherical; as Fig. VII, 2, but with the basal cell longer than usual, or a short form of the type in Fig. VII, 12. **Prickle-hairs:** prickles (Fig. VI, 1–2) usually shortly pointed, with inflated bases and somewhat variable in size, abundant over the veins. **Papillae** present as variously shaped, thickened, cuticular warts (Fig. III, 5); rather large, and usually no more than 1 papilla per cell. **Stomata** with triangular subsidiary cells (Fig. IV, 1). **Long-cells:** nearly or quite cubical; with slightly to moderately sinuous walls (Fig. V, 7*a–b*); interstomatal cells with concave ends (Fig. V, 10).

T.S. lamina

Vascular bundles: most vb's small, crowded, angular (Fig. VIII, 5); large vb's of basic type (Fig. VIII, 9). **Adaxial surface** with low, rounded ribs over the small vb's, separated from one another by narrow shallow furrows (Fig. XIV, 2); ribs over the large vb's rather more pronounced. **Sclerenchyma:** most vb's with adaxial and abaxial girders, the adaxial girders being up to 4 or 5 cells wide and generally 2 cells high, and the abaxial girders up to about 9 cells wide and 2 cells high (Fig. IX, 4); large vb's with adaxial and abaxial girders up to about 16 cells wide and 2 cells high (Fig. IX, 5). **Midrib** fairly prominent, with slight adaxial and abaxial projections; containing 1 main median vb accompanied on either side by 1 smaller lateral (Fig. XIII, 2). **Mesophyll:** chlorenchyma distinctly radiate. **Bulliform cells** in groups of the *Sporobolus* type (Fig. XV, 8); adaxial half of the midrib also made up of colourless cells. **Bundle-sheaths** single and double; large vb's with I.S. complete and O.S. with a wide abaxial interruption (as Fig. XII, 2, but interruption wider); single complete sheaths round all small vb's, each sheath being flattened on the abaxial side of the vb, and many of them with slight extensions to the adaxial scl. Abaxial cells of each sheath appreciably smaller than the remainder.

MATERIAL EXAMINED: Meikle 1282; Nigeria.

***Leptochloa uniflora* Hochst.**

LEAF

Abaxial epidermis

No clearly defined **short-cells** seen either over or between the veins. **Silica-bodies:** none seen. **Macro-hairs:** none seen. **Micro-hairs:** length 13–16 μ; basal cells 7–9 μ; distal cells 6–8 μ, and slightly tapering towards their rounded apices. **Prickle-hairs:** prickles (Fig. VI, 1–2) occasional over certain veins, but difficult to find. **Papillae:** v. numerous on both leaf surfaces, similar to those in Fig. III, 3, but many of them slightly oblique and with slightly thickened apices. **Stomata:** rather obscure, but apparently with triangular (Fig. IV, 1), and low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells,** between the veins, v. variable in width and length; cells in certain files short, with thin, sinuous walls (Fig. V, 7*a–b*), but in most of the files narrower and longer, with thin walls and rather distant, rounded sinuations (Fig. V, 3*a–c*).

T.S. lamina

Vascular bundles: small vb's pentagonal to hexagonal (Fig. VIII, 4) or polygonal (Fig. VIII, 5); median keel vb alone approximating to basic type (Fig. VIII, 15). **Adaxial surface** smooth (Fig. XIV, 1), apart from v. slight ribs over the vb's (Fig. XIV, 2). **Sclerenchyma:** most vb's with small abaxial girders only. An adaxial plate of scl. some 24 cells wide and about 2–4 cells high, together with a slightly narrower abaxial plate, present in the midrib. **Midrib** fairly conspicuous, owing to adaxial and abaxial projections; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma probably not radiate, but v. obscure in the available material. **Bulliform cells:** none visible in the material available. Adaxial part of the midrib consisting of colourless cells. **Bundle-sheaths** single; complete round all vb's (Fig. XI, 2*a–b*), but cells on the adaxial and abaxial side of the vb's much smaller than the exceptionally large lateral cells, one to the right and left of each vb, penetrating into the mesophyll.

MATERIAL EXAMINED: F. Ballard 1489; Ceylon.

ADDITIONAL INFORMATION FROM THE LITERATURE

Canfield (1934) records the occurrence of a sp. of *Leptochloa* with a solid culm from the Jornada Experimental Range.

SPECIAL NOTE

Prat (1936) states that the leaf structure resembles that of the Chlorideae. The micro-hairs, however, appear to the present author to be more like those of *Eragrostis*.

LITERATURE

Canfield 1934 (culm); Grob 1896 (leaf); Prat 1936 (leaf).

LEPTURELLA (see also p. 339)

Notes on the leaf structure of *L. capensis* Stapf recorded by Hansen and Potztal (1954) include the following particulars.

Long, stiff macro-hairs, prickles, and short spherical micro-hairs (Fig. VII, 2) present. Silica-bodies figured as ranging from cross-shaped to shortly dumb-bell shaped, but with only slight indentations between the arms of the crosses, and with the ends of the dumb-bell shaped bodies not much wider than the middle portions (Fig. IB, 19). Scl. shown as small adaxial strands and abaxial girders wider than the vb's themselves. Mesophyll with radiate chlorenchyma. Bulliform cells shown as groups more or less of the *Sporobolus* type (Fig. XV, 8), but each group connected to the abaxial epidermis by a girder of colourless cells (Fig. XV, 13). Bundle-sheaths double; O.S. appearing to be dome-shaped because widely interrupted by scl. on the abaxial side of the vb.

SPECIAL NOTE

Leaf structure similar to that of *Oropetium thomaeum* (see p. 338). Hansen and Potztal regard *Lepturella* as a member of the Leptureae.

LITERATURE

Hansen and Potztal 1954 (leaf).

LEPTURUS

Notes on the leaf structure of *Lepturus* recorded by Hansen and Potztal (1954) refer to the following spp.: *L. cinereus* Burcham, *L. geminatus* C. E. Hubbard, *L. hildebrandtii* Hansen & Potztal, *L. mildbraedianus* Hansen &

Potztal, *L. pilgerianus* Hansen & Potztal, *L. radicans* (Steud.) A. Camus, *L. repens* (G. Forst.) R. Br., and *L. xerophilus* Domin.

It is remarkable that, although these spp. are in the same genus there are very few, if any, microscopical characters of diagnostic importance that are shared by all of them. The chlorenchyma is commonly radiate; the large vb's generally have double bundle-sheaths; silica-bodies exhibit a considerable range of shapes, even within a single sp.; micro-hairs of the Chloridean type (Fig. VII, 2) are commonly present, but were not observed by Hansen and Potztal in certain spp. The adaxial surface of the leaf in all spp. is ribbed, the ribs being rounded and generally wider than the shallow grooves between them, but the ribs vary in height from one sp. to another. Starch grains, where observed, stated to be simple.

Because of this range of structure, the reader may find the following notes on the individual spp. helpful. Where characters listed in the above brief analysis are not mentioned again under the spp. it may be assumed that they are present.

L. cinereus Burcham

Silica-bodies including rounded, slightly crescent-shaped, saddle-shaped, and shortly dumb-bell shaped types. A few prickles present. Micro-hairs absent. Scl. as small adaxial strands and abaxial girders to the vb's.

L. geminatus C. E. Hubbard

Silica-bodies variable, including rounded to shortly dumb-bell shaped types or tending to be crescent-shaped. Long, stiff macro-hairs and prickles present. Scl. as small adaxial and wide abaxial girders to the large vb's; other vb's not accompanied by scl.

L. hildebrandtii Hansen & Potztal

Silica-bodies shortly dumb-bell shaped to rounded, and sometimes rectangular or irregular. Prickles present. Scl.: small vb's accompanied by minute abaxial girders and adaxial strands; large vb's with well-developed abaxial girders and smaller adaxial strands or girders. Mesophyll with chlorenchyma restricted to patches between the vb's. Adaxial part of the mesophyll consisting largely of colourless cells, particularly above the large vb's. Double bundle-sheaths restricted to the large vb's.

L. mildbraedianus Hansen & Potztal

Said to be allied to *L. repens*, but distinguished by short stolons and narrow, closely rolled, spine-like leaves. Silica-bodies varying from dumb-bell shaped to saddle-shaped. Small prickles present at the leaf margins. Micro-hairs absent. Double bundle-sheaths restricted to the large vb's.

L. pilgerianus Hansen & Potztal

This sp. differs from the others in being an annual, and in having remarkably strong roots, the cortex containing large intercellular spaces separated from one another by strips of parenchyma radiating outwards from around the stele. Silica-bodies v. small, saddle-shaped, or irregular. Small prickles and numerous papillae present. Bundle-sheaths of the large vb's conspicuously double.

L. radicans (Steud.) A. Camus

Silica-bodies saddle-shaped. A few prickles present. Micro-hairs absent. Scl. present as girders. Bundle-sheaths single.

L. repens (G. Forst.) R. Br.

Silica-bodies saddle-shaped. Prickles present on the ribs and at the leaf margins. Scl. forming well-developed adaxial and abaxial girders to the principal vb's. Bundle-sheaths to the large vb's double.

L. xerophilus Domin

Silica-bodies described as dumb-bell shaped, but illustrated as a v. short form of this type. Small, stiff macro-hairs and prickles present. Scl. present as low but fairly wide adaxial strands and v. much wider and more massive abaxial girders occupying the low abaxial ribs. Bulliform cells shown as groups of the *Sporobolus* type. Bundle-sheaths double.

Special Note

Lepturus is the type genus of the Leptureae.

Literature

Hansen and Potztal 1954 (leaf); Tateoka 1959 (cytology).

LIMNOPOA

Potztal (1952), who examined *L. meeboldii* (C. E. C. Fisher) C. E. Hubbard, has recorded the following notes about the leaf structure.

Epidermis. Silica-bodies dumb-bell shaped but v. small. Macro-hairs and micro-hairs absent, but prickles present, some of them being individually surrounded by a basal sheath of epidermal cells. Epidermis on both surfaces mainly composed of small cells bearing papillae resembling finger-stalls. *T.S. lamina.* Scl. represented by small adaxial and abaxial strands of fibres associated with the vb's. Mesophyll consisting wholly of chlorenchyma, the cells next to the vb's being arranged in a radiate manner; intercellular spaces absent. Bundle-sheaths double; inner sheaths inconspicuous; cells of the outer sheaths irregularly arranged.

Special Note

The genus belongs to the Isachneae.

Literature

Potztal 1952 (leaf).

LOLIUM

Diagnostic Generic Characters

Short-cells, over the veins, paired and in short rows. Silica-bodies, over the veins, mostly horizontally elongated and with sinuous outlines, but others more nearly cubical with rounded corners. Micro-hairs absent. Stomata with parallel-sided, or low dome-shaped, subsidiary cells. Vascular bundles never conspicuously angular in outline. Mesophyll with the chlorenchyma not radiate. Bundle-sheaths double.

Species Specially Examined

***Lolium multiflorum* Lam.**

Leaf

Abaxial epidermis

Short-cells, over the veins, paired and in rows of 3–5 cells; common over, but infrequent or absent between, the veins. **Silica-bodies** mostly horizontally elongated, with rounded ends and smooth outlines (Fig. IA, 13); others nearly cubical, with rounded corners. **Macro-hairs** and **micro-hairs:** none seen. **Prickle-hairs:** none seen on the abaxial, but present on the adaxial, surface. **Stomata:** some with parallel-sided (Fig. IV, 2), and others with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells:** those lying in the centre of each intercostal zone with thin, non-sinuous walls (Fig. V, 2*a–c*); those next to the veins, but still in the intercostal zones, with thin, sinuous walls (Fig. V, 3*a–c*).

T.S. lamina

Vascular bundles: most vb's small and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 10 and 15). **Adaxial surface** with moderate ribs of unequal heights, those over the small vb's somewhat triangular and less tall than the rounded ribs over the large vb's; furrows moderately wide and deep, mostly U-shaped (Fig. XIV, 3). Abaxial ribs also present in association with the large vb's. **Sclerenchyma:** occasional small vb's opposite the furrows not accompanied by scl. (Fig. IX, 1); many small vb's with minute adaxial strands only (Fig. IX, 2); medium-sized vb's with adaxial and abaxial strands up to about 4 cells wide and 3 cells high (Fig. IX, 4); large vb's with adaxial and abaxial girders up to about 10 cells wide and 8 cells high (Fig. IX, 5). **Keel** conspicuous, rounded; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells:** those towards the leaf margins in groups as in Fig. XV, 2; those towards the midrib in fan-shaped groups at the bases of the furrows (Fig. XV, 6). **Bundle-sheaths** double; large, and some small, vb's with 2 complete sheaths (Fig. XII, 1); other small vb's with I.S. complete, but O.S. not quite complete abaxially (Fig. XII, 2). O.S. of some of the vb's connected to the adaxial scl. by extensions of the colourless cells.

Material Examined: J. K. O'Byrne 150.

Additional Information from the Literature

Burr and Turner's (1933) description of *L. perenne* L. includes the following particulars. Adaxial surface with unequal, somewhat rounded ribs. Scl. present as adaxial strands, 1 at the apex of each rib, abaxial strands sometimes being present as well; vb's never girdered. Scl. also present in the leaf margins and keel. Stomata present on the flanks of the ribs. Prickles (asperities) present on the ribs. Keel present but not v. pronounced. Bulliform cells occurring in the adaxial furrows, but not well defined. This description agrees in the main with the one published by Günzel (1921), who gives some additional particulars concerning the sheath.

Günzel's description of *L. multiflorum* agrees, in the main, with that given above, but additional information concerning the leaf sheath is recorded. He refers to the presence of air-canals in the sheath.

The leaf structure of *L. temulentum* L. has been dealt with by Günzel (1921) and Lewton-Brain (1904). Lewton-Brain's illustration shows the lamina with fairly tall, rounded adaxial ribs; the large vb's each accompanied by an adaxial scl. strand in the apex of the rib above it and by an abaxial girder, the smaller vb's being accompanied by adaxial strands in the apices of the corresponding ribs. According to Günzel prickles are numerous, and colourless parenchyma occurs not only in the midrib but also in some of the large ribs. Prat (1937) found the abaxial epidermis of *L. temulentum* to be more homogeneous than that of the other spp. of *Lolium*, a fact which he interprets as the retention of a juvenile character.

Linehan and Mercer (1931), working in New Zealand, demonstrated that it is possible to distinguish the seedlings of the awnless, long-lived *Lolium perenne* from those of the awned, annual or biennial *L. multiflorum*. This can be done by raising seedlings on white filter-paper and examining them under screened ultra-violet light. In these circumstances seedlings of *L. perenne* are not fluorescent, whereas those of *L. multiflorum*, and of hybrids between the 2 species, exhibit fluorescence. In this way seeds of the 2 groups may be distinguished from one another and the percentages of each in a seeds mixture estimated. These results were obtained by testing 43 samples.

Special Note

Prat (1936) rightly indicates that the leaf structure is festucoid.

Literature

Burr and Turner 1933 (leaf); Cooper 1951 (stem apex); Duval-Jouve 1875 (leaf); Frohnmeyer 1914 (silica deposition); Grob 1896 (leaf); Günzel 1921 (leaf); Lewton-Brain 1904 (leaf); Linehan and Mercer 1931 (identification of seedlings under ultra-violet light); Paratore 1899 (leaf of 1 sp.); Pée-Laby 1898 (leaf); Prat 1932, 1936 (leaf); Rappaport 1938 (root development); Sharman 1947 (stem apex); Soper 1956 (comparison of stem apex of *L. perenne* with that of *Paspalum dilatatum* Poir.); Strecker 1913 (leaf).

LOPHATHERUM

Diagnostic Generic Characters

Short-cells, over the veins, in long rows. Silica-bodies, over the veins, dumb-bell shaped. Micro-hairs present; each with the distal cell tapering to a rounded apex. Stomata with triangular subsidiary cells. Vascular bundles: small vb's widely spaced and conspicuously angular in outline. Mesophyll with chlorenchyma not radiate. Bundle-sheaths double.

Species Specially Examined

***Lophatherum gracile* Brongn.**

Leaf

Abaxial epidermis

Short-cells, between the veins, solitary and paired; those over the veins in rows of more than 5 cells; abundant. **Silica-bodies,** between the veins, sometimes cross-shaped (Fig. IA, 16), many of them having a distorted appearance, or tending to be tall, narrow, and crenate (Fig. IB, 24); those over the veins dumb-bell shaped (Fig. IA, 18 (ii–v)), and sometimes varying in appearance

with the focus (Fig. IB, 21). **Macro-hairs:** none seen (but cushion-hairs recorded by Grob (1896)). **Micro-hairs:** length 36–50 μ; basal cells 18–24 μ; distal cells 18–30 (mostly 22–30) μ; distal cells mostly tapering to rounded apices (Fig. VII, 5–6). **Prickle-hairs:** small prickles (Fig. VI, 1) and hooks (Fig. VI, 5) occasional between the veins. **Stomata** with triangular subsidiary cells (Fig. IV, 1). **Long-cells,** between the veins, with thin, sinuous walls (Fig. V, 3*a–c*).

T.S. lamina

Vascular bundles: most vb's small, widely spaced, pentagonal or hexagonal (Fig. VIII, 4); midrib vb the only one of basic type (Fig. VIII, 15). **Adaxial surface:** smooth (Fig. XIV, 1), apart from v. slight ribs over some of the veins, especially towards the leaf margins. Abaxial ribs over the veins locally more pronounced than those on the adaxial surface. **Sclerenchyma:** most vb's with adaxial and abaxial girders, the abaxial girders being up to about 12 cells wide and 2–3 cells high, and the adaxial girders up to about 5 cells wide and 2–3 cells high (Fig. IX, 4–5); midrib vb with an abaxial strand some 24 cells wide and 2–3 cells high, and an adaxial strand about 9 cells wide and 2–3 cells high. **Keel** fairly conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate, only 1 or 2 cells wide, and occupying less than half the total thickness of the lamina. **Bulliform cells** in irregular groups (Fig. XV, 1), the whole of the epidermis between the veins consisting of bulliform cells appreciably taller than the thickness of the assimilatory tissue. **Bundle-sheaths** double; all vb's with 2 complete sheaths (Fig. XII, 1), the cells of the I.S. having marked, U-shaped thickenings.

MATERIAL EXAMINED: Ballard 1386; Ceylon.

ADDITIONAL INFORMATION FROM THE LITERATURE

Schaefer (1942) has described how certain roots of *L. gracile* have portions about 4 cm long and 4 mm in diameter that are much more swollen than the remainder of the roots, which have a diameter of about 1 mm. A normal root in T.S. exhibits an epidermis bearing root-hairs; a hypodermis consisting of a single layer of cells with wide lumina and unthickened walls; a broad cortex traversed longitudinally by about 16 radiating intercellular spaces, the inner part of the cortex consisting of radially arranged cells; an endodermis interrupted by passage cells; a stele with 12–14 large metaxylem vessels, and about twice as many ph. strands. In the thickened portions of the roots the v. broad cortex mostly consists of parenchymatous cells with starch grains in each cell. The cells of the inner part of the cortex have thickened, pitted, cellulose walls, there being minute intercellular spaces between the cells. The endodermis and stele are similar in structure to those of a normal root. The author can confirm these facts from material examined at Kew.

SPECIAL NOTES

Prat (1936) rightly indicates that the leaf of this genus exhibits a mixture of panicoid and festucoid characters.

Hubbard (verbal communication) considers *L. gracile* to be similar to *Oplismenus*, and that it may also be allied to *Centotheca*. The taxonomic position of the genus is not well established.

LITERATURE

Grob 1896 (leaf); Prat 1936 (leaf); Schaefer 1942 (storage roots).

LOUDETIA (see also *Tristachya* on p. 519)

DIAGNOSTIC GENERIC CHARACTERS

Short-cells, over the veins, in long or short rows, but those near the leaf margins paired in some spp. Silica-bodies, over the veins, mostly dumb-bell shaped, but sometimes rather short. Micro-hairs present, sometimes narrow in proportion to their lengths, but others with the distal cell tapering slightly towards the apex. Stomata usually with low dome-shaped subsidiary cells. Vascular bundles: a few vb's small and not more than inconspicuously angular in outline. Mesophyll with distinctly radiate chlorenchyma. Bundle-sheaths probably all double, but I.S.s of small bundles sometimes inconspicuous.

SPECIES SPECIALLY EXAMINED

***Loudetia superba* de Not. (*Tristachya superba* (De Not.) Schweinf. & Aschers.)**

LEAF

Abaxial epidermis

Short-cells, over the veins, in rows of more than 5 cells; those over the margins of the veins mostly paired but sometimes solitary; abundant over, but infrequent between, the veins except at the leaf margins. **Silica-bodies,** over the veins, mostly dumb-bell shaped (Fig. IA, 18 (ii–v)), sometimes of the type that varies in appearance with the focus (Fig. IB, 21), or shortly dumb-bell shaped (Fig. IB, 20); those at the vein margins often more or less cross-shaped (Fig. IA, 16), but sometimes somewhat distorted. **Macro-hairs:** none seen. **Micro-hairs:** length 60–79 (mostly 66–78) μ; basal cells 36–45 (mostly 36–42) μ; distal cells 24–34 (mostly 24–30) μ; distal cells mostly tapering slightly towards their apices; hairs moderately narrow, mostly as in Fig. VII, 9, but with a tendency to be as in Fig. VII, 8. **Prickle-hairs:** large prickles (Fig. VI, 2) occasional over the veins; hooks (Fig. VI, 5) abundant in the intercostal zones. Some hooks resembling large, lignified papillae. **Stomata** mostly with low dome-shaped (Fig. IV, 3), and a few with slightly triangular (Fig. IV, 1), subsidiary cells. **Long-cells,** between the veins, with thick, or moderately thick, pitted or sinuous walls (Fig. V, 1*a–b*).

T.S. lamina

Vascular bundles: most vb's not specially small and not more than inconspicuously angular in outline (Fig. VIII, 2 and 6); large vb's of basic type (Fig. VIII, 15), but with 1 median and 2 smaller lateral ph. strands embedded in fibrous ground tissue in each vb. **Adaxial surface** with slight ribs over all the veins, separated by shallow furrows (Fig. XIV, 2); ribs over the large vb's appreciably wider than those over the small vb's. Abaxial ribs also occurring over some vb's, especially towards the leaf margins. **Sclerenchyma:** most vb's with adaxial and abaxial girders up to about 12 cells wide and 2–3 cells high;

large vb's with wide, low girders resembling scl. plates, the girders being about 24 cells wide and 2–3 cells high (Fig. IX, 5). Adaxial scl. connecting the epidermis to extensions of the O.S., the boundaries between the scl. and the bundle-sheaths being marked by the contrast between the large sheath cells with wide lumina and the thick-walled scl. fibres of much smaller diameter with narrow lumina. **Keel** bundles with small, abaxial girders only. Adaxial epidermis of the midrib subtended by a wide, thin plate of fibres. **Midrib** fairly conspicuous, owing to a wide, flat-topped, adaxial projection; containing 1 large median vb accompanied on either side by 1 almost equally large lateral and 3 appreciably smaller laterals (Fig. XIII, 3). **Mesophyll:** chlorenchyma distinctly radiate round all vb's, but assimilatory cells rather short. **Bulliform cells** in groups of the *Sporobolus* type (Fig. XV, 8), but united with girders of colourless cells reaching to the abaxial epidermis (Fig. XV, 13). Adaxial part of the midrib consisting of colourless cells. **Bundle-sheaths** double; those round most vb's with the I.S. complete to incomplete; O.S. with an extension to the adaxial scl. (Fig. XII, 6). Sheaths round the large vb's similar, but with wider adaxial extensions (Fig. XII, 7). Single sheaths probably absent, but I.S. inconspicuous round some of the small vb's.

Culm

Culm examined about 0·5 cm in diameter and somewhat oval in outline. Surface of the culm with numerous slight ribs, with a supporting column of scl. subjacent to the epidermis in each rib. Some, but by no means all, of the scl. strands in the ribs extending inwards to form girders with certain of the vb's in the outermost circle, or traversing the assimilatory tissue to connect the vb's of the outermost circle to the scl. ground tissue on the inner side of the assimilatory tissue. Assimilatory tissue in a zone about 2–4 cells wide extending inwards from the subepidermal scl. strands to a single, somewhat interrupted layer of thin-walled, colourless cells. Ground tissue fibrous for some 10 to 12 layers on the inner side of this circle of colourless cells. Vb's of the outermost circle embedded in this fibrous tissue, just to the inside of the single layer of colourless cells. Inner ground tissue thin-walled and extending to a comparatively narrow cavity at the centre of the culm. About 3 irregular circles of vb's embedded in the peripheral part of the inner ground tissue.

Material Examined: Collected specially by G. Jackson in Nyasaland.

Loudetia; unidentified sp. from Japan

Leaf

Abaxial epidermis

Short-cells, over the veins, in rows of 3–5 or more cells; abundant over, but infrequent or absent between, the veins. **Silica-bodies,** over the veins, shortly dumb-bell shaped (Fig. Ib, 20), or dumb-bell shaped and varying in appearance with change of focus (Fig. Ib, 21). **Macro-hairs:** none seen. **Micro-hairs:** length 60–106 (mostly 60–84) μ; basal cells 32–56 (mostly 36–54) μ; distal cells 24–50 (mostly 30–42) μ; hairs v. narrow in proportion to their lengths (Fig. VII, 8). **Prickle-hairs:** large prickles (Fig. VI, 2) abundant over some of the veins. **Stomata:** a few tending to be with triangular (Fig. IV, 1), but mostly with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells,** next to the veins, with thin, rather coarsely sinuous walls (Fig. V, 3*a–c*); other long-cells in the intercostal zones nearly or quite cubical, with slightly to moderately sinuous walls (Fig. V, 7*a–b*).

T.S. lamina

Vascular bundles: most vb's not specially small and not more than inconspicuously angular in outline (Fig. VIII, 2 and 6); large vb's of basic type (Fig. VIII, 15). Median vb in the midrib exhibiting 4 strands of ph., 3 smaller than the fourth, and all in more or less the same horizontal plane immediately on the abaxial side of the xy. Fourth ph. strand slightly larger, and occupying a median, but more abaxial, position in the bundle than the 2 other strands. Division of the ph. of the median bundle into separate strands noted at various levels in the lamina, but not in sections of the petiole. Ph. strands embedded in fibrous ground tissue of the vb. **Adaxial surface** practically smooth (Fig. XIV, 1). **Sclerenchyma:** all vb's, except those in the midrib, with adaxial and abaxial girders, those associated with most of the vb's being up to about 6 cells wide and 2 cells high (Fig. IX, 4); those associated with the few large vb's sometimes slightly wider and higher. Vb's in the midrib with well-marked abaxial girders only (Fig. IX, 3), but midrib also supported throughout its width by a thin plate of fibres subjacent to the epidermis. **Midrib** conspicuous, but varying in appearance in sections taken at different levels in the leaf; sometimes projecting above the level of the lamina both adaxially and abaxially and then containing 1 large median vb accompanied on either side by at least 1 smaller lateral (Fig. XIII, 2); larger and adaxially flattened to slightly concave at a lower level and containing numerous vb's (Fig. XIII, 3). **Mesophyll:** chlorenchyma distinctly radiate round all vb's. **Bulliform cells,** towards the leaf margin, chiefly in fan-shaped groups (Fig. XV, 4), elsewhere in groups of the *Sporobolus* type (Fig. XV, 8), but with a girder of colourless cells extending from each group to the abaxial surface (Fig. XV, 13). Adaxial part of the midrib composed of large colourless cells. **Bundle-sheaths** not definitely recognizable as double, but sometimes with a slight suggestion of an I.S. (cf. *L. superba*). Most vb's with single complete sheaths (Fig. XI, 2*a–b*), often with slight extensions of colourless cells to form girders with the adaxial and abaxial scl.

Petiole

Petiole examined about 2 mm in diameter; round to oval in outline, but with a shallow, concave depression in the adaxial surface. Petiole solid, the centre occupied by colourless, thin-walled parenchyma with no vb's embedded in it. Vb's dispersed in a U-shaped manner around the periphery of the petiole, the vb's being of 2 distinct sizes, the smaller and larger, for the most part, alternating with one another. Vb's embedded in a clearly defined zone of assimilatory tissue about 10–12 cells wide, but assimilatory tissue and vb's

absent from the adaxial side of the petiole. Epidermis subtended by well-developed columns of narrow fibres, with v. thick walls and small lumina, each fibre column usually being opposite, and forming a girder with, a vb. V. slight ribs present on the surface of the petiole over the fibre columns.

Culm

Culm examined about 3 mm in diameter. No well-defined scl. ring present, but cells of the ground tissue gradually increasing in diameter from the epidermis to the large cavity at the centre of the culm. Cells of the outer ground tissue assimilatory. Vb's in 4 more or less distinct circles, those of the outermost circle being appreciably smaller than the remainder. (This particular specimen may be less lignified than usual because of the environmental conditions at Kew.)

Material Examined: Cultivated at Kew.

Additional Information from the Literature

Conert (1957) divides *Loudetia* into 3 sections and 6 subsections, and he treats the genus as consisting of 26 spp. From the information which he gives concerning their leaf anatomy it is clear that there is no close correlation between the leaf structure and the sections and subsections into which the genus is divided. Indeed, the various genera comprising the Arundinelleae are not clearly circumscribed by their leaf structure, so it is not surprising that sections and subsections of any one genus cannot be established by leaf characters alone. On the other hand, leaf characters are of some value for the determination of spp. For this purpose variations in the following characters may be used: (i) the extent to which the midrib is developed; (ii) the shape of the leaf margins in T.S.; (iii) the occurrence, size, and distribution of macro-hairs, prickles, and micro-hairs; (iv) the sizes and distribution of the strands or girders of scl. associated with the vb's; and (v) the amount of colourless parenchyma subjacent to the adaxial epidermis.

In general the leaf characters for *Loudetia* recorded by Conert agree with those given above, if allowance be made for interspecific variations of the types enumerated in (i) to (v) in the last paragraph. It should be noted, however, that *Loudetia* cannot easily be distinguished from all other genera of the Arundinelleae on leaf characters. Furthermore, it does not appear to be entirely certain, on any grounds, to which genus certain taxa rightly belong. Thus the sp. *L. superba* De Not., described above, is placed in *Tristachya* by Conert, and he gives particulars concerning its leaf anatomy under *T. superba* (De Not.) Schweinf. & Aschers., and also deals with 8 closely related spp. of *Tristachya* which he includes in the same section. (See also *Tristachya* on p. 516.)

Special Note

The possession of a petiole, and the divided ph. strands in the large leaf bundles, are noteworthy characters of the unidentified sp. of *L.* cultivated at Kew. *Loudetia* is treated by Conert (1957) as belonging to the Arundinelleae.

Literature

Conert 1957 (leaf anatomy and taxonomy).

LOUDETIOPSIS

Diagnostic Generic Characters

Conert (1957), who examined 13 spp. of *Loudetiopsis*, indicates that the following characters are common to all of them.

Silica-bodies dumb-bell shaped, usually with narrow middle portions, but sometimes shortly dumb-bell shaped. Micro-hairs always present; elongated, and each consisting of 2 narrow cells. Both leaf surfaces usually at least slightly ribbed. Sclerenchyma: abaxial girders well developed in all spp.; adaxial scl. more variable. Mesophyll with radiate chlorenchyma. Bundle-sheaths single or double.

Species Individually Described by Conert

Some of these spp. were formerly in *Tristachya*, *Danthoniopsis*, *Panicum*, *Trichopteryx*, &c.

L. ambiens (K. Schum.) Conert

Stiff macro-hairs and papillae present. Lamina flattened, but inrolled at the triangular margins. Both leaf surfaces ribbed. Ph. of the large vb's divided into 3 small groups of fibres. Scl. present as adaxial and abaxial girders to the large vb's and as small abaxial strands beneath the small vb's. Strands of a few fibres present in the leaf margins. Bulliform cells as groups in the adaxial epidermis united to the abaxial epidermis by girders of colourless cells traversing the mesophyll between the small vb's. Bundle-sheaths single.

L. capillipes (C. E. Hubbard) Conert

Generally similar to *L. chrysothrix*, but differing in the distribution of scl. Scl. forming adaxial girders consisting of 6–8 layers of cells. I.S.s restricted to the ph. ends of the large vb's.

L. chevalieri (Stapf) Conert

Leaf structure similar to that of *L. kerstingii*.

L. chrysothrix (Nees) Conert

Long cushion hairs present between the ribs. A v. few papillae and elongated prickles present on both surfaces. Lamina more or less inrolled, with rounded margins. Adaxial surface strongly ribbed; abaxial surface slightly ribbed or sinuous. Scl. forming adaxial strands, 3–4 cells high, separated from the vb's by 1–2 layers of large colourless cells. Fibres also present in the leaf margins. Midrib not pronounced. Bulliform cells at the bases of the furrows over the small vb's, with the subjacent colourless cells, as in Fig. XV, 10, forming girders of colourless cells on either side of each small vb which connect the adaxial bulliform cells to the abaxial epidermis. I.S. to the large vb's completely closed.

L. fulva (C. E. Hubbard) Conert

Leaf structure similar to that of *L. capillipes* and *L. chrysothrix*.

L. glabrata (K. Schum.) Conert and *L. glabrinodis* (C. E. Hubbard) Conert

Leaf structure similar to that of *L. kerstingii*.

L. kerstingii (Pilger) Conert (*Trichopteryx kerstingii* Pilger)

A few long, stiff hairs present between the ribs, and prickles and papillae on the ribs. Lamina slightly inrolled, with rounded margins. Adaxial surface strongly ribbed; abaxial surface slightly sinuous. Scl., accompanying the vb's of orders 1–3,

present as flattened adaxial strands or girders, and as oval abaxial girders; v. small vb's accompanied only by abaxial strands each consisting of not more than a few fibres. Small fibre strands also occurring in the leaf margins. Midrib not pronounced. Bulliform and subjacent colourless cells present above the third-order vb's and connected to the abaxial epidermis by girders of colourless cells traversing the mesophyll between the small vb's (Fig. XV, 10). Bundle-sheaths to first- and second-order vb's double; I.S. to the third-order vb's restricted to the ph.

L. purpurea (C. E. Hubbard) Conert

Silica-bodies dumb-bell shaped to shortly dumb-bell shaped. Prickles, and sometimes long bristle-hairs, present on the ribs on both surfaces. Lamina flattened, and only slightly inrolled at the rounded margins. Both surfaces slightly sinuous. Scl., accompanying the large vb's, present as oval to rounded adaxial strands or girders and rather larger abaxial strands. A few fibres also present in the leaf margins. Midrib not pronounced. Bulliform and subjacent colourless cells similar to those in *L. kerstingii* (Fig. XV, 10). Bundle-sheaths mostly single, but ph. of larger vb's bounded by an I.S.

L. ternata (Stapf) Conert

Leaf structure similar to that of *L. chrysothrix*. Scl. present as wide strands in the apices of the adaxial ribs, each strand being separated from the accompanying vb by 3–4 layers of large colourless cells. Ph. of large vb's divided by fibres into 3–4 separate groups. Bundle-sheaths to large vb's double, the I.S. being closed.

L. trigemia (C. E. Hubbard) Conert

Leaf anatomy not described.

L. tristachyoides (Trin.) Conert

Leaf anatomy similar to that of *L. purpurea.*

L. villosipes (C. E. Hubbard) Conert

Leaf anatomy similar to that of *L. glabrata* and *L. kerstingii.*

Special Notes

Conert treats *Loudetiopsis* as a member of the Arundinelleae. There are no clearly defined anatomical distinctions in the leaf structure which serve to separate the genera in this group.

Literature

Conert 1957 (leaf and taxonomy).

LUZIOLA

With reference to the leaf epidermis of *L. peruviana* J. F. Gmel., Grob has recorded the following information.

Short-cells, over the veins, on the abaxial surface in rows. Silica-bodies, over the veins, cross or dumb-bell shaped. Silica-cells, over the parenchyma, large, irregular in shape and with projections. Papillae, in several rows per cell, present on certain long-cells.

Special Note

This anatomical information is insufficient to indicate the affinities of the genus. The leaf structure appears to be panicoid.

Literature

Grob 1896 (leaf); Wille 1916 (rhizome).

LYCOCHLOA

Diagnostic Generic Characters

Short-cells, over the veins, mostly in short or long rows. Silica-bodies, over the veins, usually nodular. Micro-hairs: none seen. Vascular bundles: small vb's not conspicuously angular in outline. Mesophyll with chlorenchyma not radiate. Bundle-sheaths double.

Species Specially Examined

***Lycochloa avenacea* Samuelson**

Leaf

Abaxial epidermis

Short-cells, between the veins, solitary; some of those over the veins also solitary, and each accompanied on either side by a prickle, but mostly in rows of 3–5, or occasionally more, cells; abundant both over and between the veins. **Silica-bodies** in the short-cells between the veins tall and narrow (Fig. I, 4), and generally elliptical in outline; those over the veins mostly nodular (Fig. Ia, 18 (i)). **Macro-hairs** and **micro-hairs:** none seen. **Prickle-hairs:** prickles (Fig. VI, 1–2) abundant over most of the veins. **Stomata** absent from the abaxial surface. **Long-cells,** between the veins, with moderately thin, densely sinuous walls (Fig. V, 3*a–c*); some of the cells tending to be hexagonal.

T.S. lamina

Vascular bundles: small vb's not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with slight, widely spaced ribs (Fig. XIV, 2) over the vb's, these ribs being much less conspicuous than those on the abaxial surface. Abaxial surface with rather widely spaced ribs of 2 distinct sizes, those over the large vb's being v. marked and somewhat similar to those in Fig. XIV, 5, but each tall rib separated from the next by about 4 much lower ribs, these ribs being more like those in Fig. XIV, 2. **Sclerenchyma:** most vb's accompanied by adaxial and abaxial girders up to about 6 cells wide and 4 cells high (Fig. IX, 4); large vb's with adaxial girders up to about 12 cells wide and 4–5 cells high, the abaxial girders, about 8 cells wide and 9 cells high, extending to the epidermis at the apices of the large abaxial ribs. Abaxial girders broadening at their distal ends in the ribs. **Keel** conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** rather distorted in the available material, but mostly in groups as in Fig. XV, 2, but some in groups of the *Zea* type (Fig.

XV, 3), and in fan-shaped groups (Fig. XV, 4). **Bundle-sheaths** double; I.S. complete; O.S. interrupted adaxially and abaxially (Fig. XII, 3*a–b*).

MATERIAL EXAMINED: Samuelson 4141; Beyrout.

SPECIAL NOTE

Leaf anatomy mainly festucoid.

LYCURUS

The following information concerning the leaf has been recorded in the literature.

Epidermis. Prat (1936) states that the epidermis tends to be of the Chloridean type, and refers to the presence of swollen micro-hairs. *T.S. lamina.* Holm's (1901–2) information concerning *L. phleoides* H. B. K. includes the following. Adaxial surface furrowed. Both surfaces scabrous. Long, pointed macro-hairs present on the adaxial surface. Scl. as a large girder on the abaxial side of the midrib, and large strands in each leaf margin; elsewhere represented by only a few cells in the ribs. Stomata present on both surfaces; not sunken. Mesophyll consisting of radiately arranged palisade cells. Bulliform cells as small groups between the ribs. Bundle-sheaths double; O.S.s consisting of large, green, thin-walled parenchymatous cells, and the I.S.s of the larger vb's of cells with heavily thickened inner walls. One sp. from the Jornada plains has been described by Canfield (1934) as having sólid culms.

SPECIAL NOTE

Schwabe (1949*b*) states that the leaf structure of *L. alopecuroides* Griseb. and *L. phleoides* H. B. K. resembles that of *Muhlenbergia*, *Epicampes*, and *Sporobolus*, and suggests that it should be classified with the Eragrosteae.

LITERATURE

Canfield 1934 (culm); Holm 1901–2 (leaf); Prat 1936 (leaf); Schwabe 1949*b* (affinities).

LYGEUM

DIAGNOSTIC GENERIC CHARACTERS

Short-cells, over and between the veins, mostly paired. Silica-bodies usually circular to elliptical in outline. Micro-hairs: none seen on the abaxial surface. Stomata with triangular subsidiary cells. Vascular bundles: small vb's not conspicuously angular in outline. Mesophyll with chlorenchyma not radiate. Bundle-sheaths double.

SPECIES SPECIALLY EXAMINED

***Lygeum spartum* L.**

LEAF

Abaxial epidermis

Short-cells, both over and between the veins, mostly paired, but occasionally in short rows of about 3–5 cells over the veins; abundant both over and between the veins. **Silica-bodies** mostly circular and elliptical in outline, each fitting into a concavity in an adjacent cork-cell (Fig. I, 6–7). **Macro-hairs:** none seen. **Micro-hairs:** none seen by the author but see below. **Prickle-hairs:** prickles (Fig. VI, 1–2) occasional over, and hooks (Fig. VI, 5) occasional between, the veins. **Stomata** with triangular (Fig. IV, 1) subsidiary cells. **Long-cells:** those over the veins with thick, pitted or sinuous walls (Fig. V, 1*a–b*); those between the veins similar but sometimes with walls slightly thinner; interstomatal cells with concave ends (Fig. V, 11), mostly rather long, with sinuous walls. Surface of the long-cells, particularly in the intercostal zones, appearing to be minutely and sometimes densely punctate. (The cause of the punctate appearance was not definitely established, but the translucent dots suggested that they might be thin places in the cell-walls rather than papillae, but this needs further investigation.)

T.S. lamina

Leaf acicular, as in Fig. X, 3. **Vascular bundles:** small vb's not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 15), but with slightly sclerosed areas in the ph. (Fig. VIII, 18). **Adaxial surface** with moderate, closely placed, rounded ribs separated from one another by v. narrow, V-shaped furrows (Fig. XIV, 3). **Sclerenchyma:** small vb's opposite the adaxial furrows with well-developed abaxial girders only (Fig. IX, 3); large vb's opposite the ribs with similar, but more massive, abaxial girders, and a cap of fibres at the apex of each of the corresponding ribs. **Mesophyll:** chlorenchyma not radiate. **Bulliform cells:** V-shaped furrows containing bulliform cells of variable size but none of them specially large (Fig. XV, 5, *Elymus* type). **Bundle-sheaths** double; vb's opposite the ribs with I.S. complete, the O.S. being interrupted abaxially and connected to the adaxial scl. by an extension of large colourless cells (Fig. XII, 4). Vb's opposite the furrows with I.S. complete and O.S. interrupted abaxially only (as Fig. XI, 6, but with an I.S.).

MATERIAL EXAMINED: Specimens from Tripoli in the Kew Museums.

ADDITIONAL INFORMATION FROM THE LITERATURE

1. LEAF

Grob (1896) records for *L. spartum* the occurrence of club-shaped micro-hairs, 90–100 μ long, each with a relatively short distal cell, on the adaxial surface. Prat (1932) refers to the presence of short hairs on the adaxial surface of the leaf-sheath. The same author has also recorded certain histological details concerning the floral leaves. Vischer's (1915) description of a normal leaf of *L. spartum* agrees closely with the information given above. Vischer, however, also describes other leaves of which the structure had been modified by growing the plants under special cultural conditions.

2. ROOT

Price (1911) notes the following characters for the root. Roots encased in sandy sheaths; v. short root-hairs present to within an inch or so of the point of insertion of the root; cortex consisting of 4–5 layers of cells with strongly thickened walls; no details of stelar structure given.

Special Notes

Prat (1932) treats *Lygeum* as a member of the Oryzeae, but there appears to be no convincing anatomical evidence to support this suggestion. Arber considers it to be more closely allied to *Nardus*, but the anatomical evidence for this is not wholly convincing.

Literature

Duval-Jouve 1875 (leaf); Grob 1896 (leaf); Hayek 1902 (anatomical differences from *Stipa tenacissima*); Prat 1932 (leaf); Price 1911 (root); Vischer 1915 (ecological anatomy of the leaf); Wille 1916.

MACROCHLOA

M. tenacissima (L.) Kunth is an old name for *Stipa tenacissima* L. (see p. 485). Other spp. formerly in *Macrochloa* are now in *Stipa*.

MANISURIS (see *Hackelochloa*, p. 226)

MEGASTACHYA

Diagnostic Generic Characters

Short-cells, over the veins, in long rows. Silica-bodies, over the veins, intermediate between cross and dumb-bell shaped or dumb-bell shaped. Micro-hairs present; balanoform, the distal cells being inflated and with rounded apices. Stomata with markedly triangular subsidiary cells. Vascular bundles widely spaced and none of them specially angular in outline. Mesophyll with chlorenchyma not radiate, consisting of specially small cells. Bundle-sheaths double.

Species Specially Examined

***Megastachya mucronata* (Poir.) Beauv.**

Leaf

Abaxial epidermis

Short-cells, over the veins, in rows of more than 5 cells; abundant over, but v. infrequent or absent between, the veins. **Silica-bodies,** over the veins, intermediate between cross and dumb-bell shaped (Fig. IA, 17), or dumb-bell shaped (Fig. IA, 18 (ii–v)). **Macro-hairs:** none seen. **Micro-hairs:** length 48–68 (mostly 54–68) μ; basal cells 6–16 (mostly 11–16) μ; distal cells 37–58 (mostly 42–54) μ; hairs balanoform, the distal cells having rounded apices (Fig. VII, 3). **Prickle-hairs:** none seen. **Stomata** with markedly triangular (Fig. IV, 1) subsidiary cells. Large cavities noted in T.S. beneath some of the stomata on the adaxial surface of the leaf. **Long-cells,** between the veins, with thin, rather coarsely sinuous walls as in Fig. V, 3*a–b*, or shorter and tending to be as in Fig. V, 7*a–b*. **Transverse veins** fairly numerous.

T.S. lamina

Vascular bundles: most vb's widely spaced and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 11). **Adaxial surface** practically smooth (Fig. XIV, 1). **Sclerenchyma:** some of the small vb's not accompanied by scl. (Fig. IX, 1); others with adaxial and abaxial girders (Fig. IX, 4), the adaxial girders being about 4–8 cells wide and about 4 cells high, and the abaxial girders about the same width but slightly less tall. Lumina of the adaxial fibres v. variable in outline. Combined girders of the median keel vb low, anchor-shaped (Fig. IX, 6). **Keel** fairly conspicuous, rounded; containing 1 large median vb, accompanied on either side by a minute vb closely associated with it, all 3 bundles having a common sheath. (This is slightly reminiscent of the keel structure in bamboos.) **Mesophyll:** chlorenchyma not radiate; consisting of some 6 layers of minute cells with v. thin walls; occupying less than half the total thickness of the lamina. **Bulliform cells:** adaxial epidermis, except over the principal veins, consisting of large, uniform, bulliform cells occupying about half of the total thickness of the lamina. Bulliform cells difficult to assign to any of the standard types used in this book but tending to be in groups more or less as in Fig. XV, 2, the cells being much more even and regularly arranged than in groups of the type in Fig. XV, 1. **Bundle-sheaths** double; many small vb's with I.S. complete and O.S. with slight abaxial interruptions only (Fig. XII, 2); sheaths of this type tending to be winged by cells of the O.S. at the sides of each vb projecting into the mesophyll. Sheaths round large vb's similar, but adaxial part of the I.S. often obscure.

Material Examined: Meikle 598; Nigeria.

Special Notes

The small cells of the mesophyll and the vascular structure of the midrib are distinctive. The grass is also interesting because it combines panicoid characters, such as the occurrence of micro-hairs and dumb-bell shaped silica-bodies, with widely spaced vb's that are not markedly angular in outline, and double bundle-sheaths, these last 2 characters being festucoid.

MELANOCENCHRIS

Grob (1896) notes that *M. plumosa* Hochst. exhibits club-shaped micro-hairs, each with a relatively short distal cell. This is the type of micro-hair that occurs in *Eragrostis*.

Literature

Grob 1896 (leaf); Jacques-Félix 1958 (leaf); Sabnis 1921 (leaf, ecological anatomy; under *Gracilea royleana*).

MELICA

Diagnostic Generic Characters

Short-cells, over the veins, solitary, paired, or in long rows. Silica-bodies, over the veins, horizontally elongated, with smooth or sinuous outlines.

Micro-hairs absent. Stomata with parallel-sided subsidiary cells. Vascular bundles widely, or fairly widely, spaced and not markedly angular in outline. Mesophyll with the chlorenchyma not radiate. Bundle-sheaths double.

Species Specially Examined

Melica altissima L.

Leaf

Abaxial epidermis (Fig. XXVI, 5)

Short-cells, over the veins, mostly in rows of more than 5 cells, but sometimes appearing to be solitary when separated from one another by relatively long cells in the same files; abundant over, but infrequent or absent between, the veins. **Silica-bodies,** over the veins, horizontally elongated, with rounded ends and smooth (Fig. IA, 12), or sinuous (Fig. IA, 14–15), outlines. **Macro-hairs:** none seen, but occasionally present over the veins according to Lohauss (1905). **Micro-hairs:** none seen. **Prickle-hairs:** prickles (Fig. VI, 1–2), sometimes unpointed (Fig. VI, 6), common over the veins. **Stomata** with parallel-sided subsidiary cells (Fig. IV, 2). **Long-cells:** those between the veins with thin, non-sinuous walls (Fig. V, 2*a–c*); cells lying longitudinally down the centre of each intercostal zone larger and more hexagonal in outline than those immediately beside the veins. **Transverse veins** recorded (Duval-Jouve 1875).

T.S. lamina

Vascular bundles: small vb's fairly widely spaced and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 10). **Adaxial surface** practically smooth (Fig. XIV, 1). Slight ribs on the abaxial surface over the large vb's. **Sclerenchyma:** most vb's with adaxial and abaxial girders 1–4 cells wide and 2–4 cells high (Fig. IX, 4), the abaxial being slightly shorter and wider than the adaxial girders; large vb's with adaxial and abaxial girders up to about 8 cells wide and some 3–4 cells wide. **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). A conspicuous keel in this sp. recorded by Lohauss (1905). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** in well-defined groups as in Fig. XV, 2; intercostal, abaxial epidermal cells also tending to be bulliform, especially on either side of the midrib. **Bundle-sheaths** double; large vb's with I.S. complete and O.S. interrupted adaxially and abaxially (Fig. XII, 3*a*); small vb's with the I.S. complete, but O.S. interrupted abaxially (Fig. XII, 2), or similar but with the O.S. connected to the adaxial scl. by an extension of large cells (Fig. XII, 4). Cells of I.S. uniformly thickened; cells of O.S. not v. conspicuous.

Culm

Culm examined about 2·5 mm in diameter. Ground tissue, apart from about 4 or 5 layers of thin-walled cells surrounding the large central cavity of the culm, consisting of thick-walled cells. Cells of the ground tissue gradually increasing in diameter on passing inwards from the epidermis to the central cavity of the culm, the smallest cells being immediately subjacent to the epidermis. Assimilatory tissue present in longitudinal columns in the outer ground tissue, the columns being replaced at intervals by fibrous tissue, the amount of assimilatory tissue visible in a T.S. thus varying at different levels in the culm. Vb's occasional just beneath the epidermis, but mostly arranged in 1–2 circles.

Material Examined: Cultivated at Kew.

Melica ciliata L.

Leaf

Abaxial epidermis (Fig. XXVI, 6)

Short-cells, between the veins, sometimes solitary, and occasionally paired; pairs also common, and solitary short-cells occasional, over the veins, but many of those over the veins in rows of 3–5, or occasionally more, cells; common both over and between the veins. **Silica-bodies,** between the veins, tall and narrow (Fig. I, 4), those at the edges of the veins sometimes fitting into concavities in adjacent cork-cells (Fig. I, 6–7); those over the veins typically horizontally elongated, with rounded ends and smooth (Fig. IA, 12), or sinuous (Fig. IA, 14–15), outlines, or even as in Fig. IB, 22. **Macro-hairs:** a few short, rigid, thick-walled hairs (Fig. IIA, 10) present on the adaxial surface. **Micro-hairs:** none seen. **Prickle-hairs:** prickles (Fig. VI, 1–2) with large bases and small points, or sometimes unpointed (Fig. VI, 6), present; also angular prickles (Fig. VI, 3) at the leaf margins. **Stomata** absent from the abaxial surface. **Long-cells:** those between the veins with thin, sinuous walls (Fig. V, 3*a–c*).

T.S. lamina

Vascular bundles: most vb's fairly small, not v. closely placed, and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 10). **Adaxial surface** with moderate ribs separated by narrow, fairly deep, V-shaped furrows (Fig. XIV, 3); ribs over the large vb's slightly wider than those over the small vb's, with their apices rounded to slightly flattened. **Sclerenchyma:** most vb's with tall, narrow, adaxial and abaxial girders (Fig. IX, 7), but combined girders usually appearing to be inversely anchor-shaped, the apices of the adaxial ribs being occupied by thin plates of fibres 1–2 cells thick, forming the arms of the anchors. Girders, apart from the anchor arms, 1–5 cells wide and up to about 6 cells tall, the wider girders being associated with the large vb's. Combined girders of the median vb anchor-shaped (Fig. IX, 6); scl. present in the leaf margins. **Keel** fairly conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** in slightly fan-shaped groups (Fig. XV, 6) at the bases of the furrows, or almost of the *Ammophila* type, with no specially large bulliform cells (Fig. XV, 5). **Bundle-sheaths** double; some large vb's with the I.S. complete and O.S. interrupted adaxially and abaxially (Fig. XII, 3*a*); most vb's with the I.S. complete and O.S. interrupted abaxially but connected to the adaxial scl. by large cells (Fig. XII, 4).

CULM

Culm examined 1 mm in diameter. Ground tissue similar to that of *M. altissima* and *M. uniflora*, no clearly defined scl. ring being present. Ground tissue surrounding the large vb's assimilatory although thick-walled. Vb's consisting of a circle of small, rather widely spaced strands embedded in the peripheral fibrous tissue, and larger vb's in a slightly sinuous circle separated from the central cavity of the culm by some 6–12 layers of cells.

MATERIAL EXAMINED: Cultivated at Kew.

Melica uniflora Retz.

LEAF

Abaxial epidermis

Short-cells, over the veins, in rows of 3–5, or more, cells; common to infrequent over, and apparently absent between, the veins. **Silica-bodies,** over the veins, horizontally elongated with markedly sinuous outlines (Fig. IA, 14–15, or even as in Fig. IB, 22). **Macro-hairs:** none seen on the abaxial, but present on the adaxial, surface. **Micro-hairs:** none seen. **Prickle-hairs:** prickles (Fig. VI, 1–2) common over, and hooks (Fig. VI, 5) between, the veins. **Stomata:** none seen on the abaxial surface; those on the adaxial surface mostly with parallel-sided (Fig. IV, 2) subsidiary cells. **Long-cells** with thin, non-sinuous walls (Fig. V, 2*a–c*), many of the cells tending to be hexagonal. **Transverse veins** common.

T.S. lamina

Vascular bundles: most vb's small, fairly widely spaced and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 10 and 15). **Adaxial surface** practically smooth (Fig. XIV, 1). Abaxial surface with slight, rounded ribs over the large veins. **Sclerenchyma:** most vb's with small adaxial and abaxial girders (Fig. IX, 4) up to 5 cells wide and 2–3 cells high, the adaxial generally being slightly narrower than the abaxial girders; large vb's with adaxial and abaxial girders slightly wider and about the same height as those associated with the small vb's (Fig. IX, 5). Keel vb with a flattened adaxial girder some 16 cells long and 4 cells high, and a slightly anchor-shaped abaxial girder (Fig. IX, 6), the head of the anchor occupying the apex of the rounded, abaxial projection that forms the keel. **Keel** conspicuous, narrow; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate; cells mostly polygonal to rounded in T.S. **Bulliform cells** in well-defined groups as in Fig. XV, 2. **Bundle-sheaths** double; all vb's with the I.S. complete and O.S. interrupted adaxially and abaxially (Fig. XII, 3*a–b*).

CULM

Culm examined 2 mm in diameter, with a large central cavity. Ground tissue similar to that of *M. altissima* and *M. ciliata*, no clearly defined scl. ring being present. Six to ten innermost cell-layers of the ground tissue thin-walled. Vb's consisting of 1 small vb embedded in the small-celled tissue

subjacent to the epidermis, most of the vb's being in a single, slightly sinuous circle, embedded in the peripheral part of the thin-walled ground tissue.

MATERIAL EXAMINED: Cultivated at Kew.

ADDITIONAL INFORMATION FROM THE LITERATURE

Besides the spp. mentioned above, Lohauss (1905) and other workers refer to the leaves of the following spp.

M. bauhini All.

Adaxial surface strongly ribbed. Scl. forming adaxial and abaxial girders; small, adaxial, intercostal strands and fairly well developed marginal strands also reported. Bulliform cells moderately large. Bristle-hairs, and less numerous prickles, present over the veins.

M. harfordi Boland.

Adaxial surface with only slight ribs and furrows.

M. macra Nees

Adaxial surface deeply furrowed. Scl. as adaxial and abaxial girders to most of the vb's, the adaxial being twice as tall as the abaxial girders; adaxial girders consisting of thick-walled parenchymatous cells with wide lumina, and the abaxial girders of thick-walled fibres; marginal strands fairly well developed. Midrib not prominent. Bulliform cells present at the base of each furrow, but small and with fairly thick walls. Abaxial epidermal cells opposite the bulliform cells with thickened walls. Prickles alternating regularly with long-cells on the abaxial surface.

M. nutans L.

Adaxial surface practically smooth. Scl.: apart from girders associated with the vb's, small intercostal strands present beneath the epidermis on both leaf surfaces. Bulliform cells confined to the adaxial surface; fairly large; O.S. not very conspicuous. Adaxial epidermis with prickles and occasional, long, flexible hairs.

M. papilionacea L. var. *hyalina* Doell

Adaxial surface furrowed. Scl. consisting of sclerosed parenchymatous cells, with walls only moderately thickened. Adaxial part of each girder broadened in the apex of each rib as a single hypodermal layer. Strands of 2–3 cells also present on the abaxial side opposite the bulliform cells. Marginal strands weak. Midrib not prominent. Mesophyll stated to include chlorenchyma consisting of radially elongated cells. Epidermis with bristle-hairs and prickles.

SPECIAL NOTE

On the whole the structure appears to be festucoid, but Prat (1936) indicates that the genus should be excluded from the Festuceae because the chromosomes are in multiples of 9.

LITERATURE

Burr and Turner 1933 (leaf); Chauveaud 1897 (development of sieve-tubes in roots); Duval-Jouve 1875 (leaf); Grob 1896 (leaf); Lewton-Brain 1904 (leaf); Lohauss 1905 (leaf); Paratore 1899 (leaf of *M. altissima* L.); Pée-Laby 1898 (leaf); Prat 1936 (leaf); Sharman 1947 (apical meristem); Wille 1916.

MELINIS

Diagnostic Generic Characters

Short-cells, over the veins, in long rows. Silica-bodies, over the veins, mostly cross-shaped or intermediate between cross and dumb-bell shaped. Micro-hairs abundant, but distal cells not observed. Stomata with triangular or low dome-shaped subsidiary cells. Vascular bundles mostly small, crowded, and angular in outline. Mesophyll with chlorenchyma distinctly to indistinctly radiate. Bundle-sheaths single or double.

Species Specially Examined

***Melinis minutiflora* Beauv.**

Leaf

Abaxial epidermis

Short-cells, over the veins, in rows of more than 5 cells; abundant over, but v. infrequent or absent between, the veins. **Silica-bodies** mostly cross-shaped (Fig. IA, 16) and intermediate between cross and dumb-bell shaped (Fig. IA, 17), or occasionally nodular (Fig. IA, 18 (i)). **Macro-hairs**: fairly long, thick-walled, stiff hairs, with greatly swollen bases, abundant between the veins; bases of most of the hairs surrounded by cushion-like epidermal cells (Fig. II, 3–4). Similar hairs abundant on the adaxial surface, with their bases deeply sunken amongst the bulliform cells. (See also p. 307 for further particulars of these hairs.) **Micro-hairs** abundant, but distal cells not seen. **Prickle-hairs**: small prickles (Fig. VI, 1) and hooks (Fig. VI, 5) abundant between the veins. **Stomata** mostly with triangular (Fig. IV, 1), but some with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells**, between the veins, with thin, sinuous walls (Fig. V, 3*a–c*), some of them, especially in the middle of each intercostal zone, rather short and sometimes almost or quite cubical (Fig. V, 7*a–b*).

T.S. lamina

Vascular bundles: smallest vb's with xy. and ph. not clearly contrasted (Fig. VIII, 1); most vb's small, crowded and angular in outline (Fig. VIII, 5); large vb's of basic type (Fig. VIII, 10). **Adaxial surface** practically smooth (Fig. XIV, 1). **Sclerenchyma**: a few small vb's, especially those opposite the bulliform cells, not accompanied by scl. (Fig. IX, 1); other small vb's with minute adaxial strands only (Fig. IX, 2), or with adaxial and abaxial strands seldom as many as 6 cells wide and 2–3 cells high (Fig. IX, 4); large vb's with slightly wider adaxial and abaxial girders (Fig. IX, 5). Median keel vb supported by a large abaxial girder (Fig. IX, 3), and by a thin plate of scl., about 1–3 cells tall, subjacent to the adaxial epidermis. **Keel** fairly conspicuous, rounded; containing 1 large median vb accompanied on either side by about 3 smaller laterals (Fig. XIII, 3). **Mesophyll**: chlorenchyma distinctly to indistinctly radiate. **Bulliform cells** mostly in groups of the *Sporobolus* type (Fig. XV, 8). **Bundle-sheaths** double and single; large vb's each surrounded by 2 complete sheaths (Fig. XII, 1); median keel vb with a wide abaxial

interruption to the O.S. (Fig. XII, 2); a single complete sheath surrounding each of the small vb's, the sheaths sometimes triangular in outline.

Culm

Culm examined about 2 mm in diameter; with a slightly ribbed outline and flattened on one side. Epidermis subtended by flattened columns of thin-walled assimilatory tissue embedded in a zone of fibres some 7 cells wide. Assimilatory tissue absent from the flattened side of the culm. Most columns of assimilatory tissue adjacent to certain of the vb's in the outermost circle, but separated from them by a single layer of large, thin-walled cells resembling the cells of the O.S. in the leaves. Vb's in 3 more or less distinct circles, the innermost vb's being quite close to the rather irregular cavity at the centre of the culm.

Material Examined: Collected specially by G. Jackson in Nyasaland.

Additional Information from the Literature

According to Stapf *et al.* (1922) *M. minutiflora* is a perfumed grass, its aroma being due to an oil secreted by the cushion hairs. These cushion hairs were specially examined at the Jodrell Laboratory in 1922 by Mr. S. Dickenson. The hairs, which have glistening droplets of oil at their apices, are most numerous on the leaf-sheath, but are also abundant on both surfaces of the lamina. The hairs are of 2 types which cannot be distinguished when young, but, when mature, they respectively have blunt or sharply pointed apices. The hairs have thick walls which stain yellow with Schultz's solution; but the swollen apex of each rounded hair has the appearance of a cork or plug in the neck of a bottle, and it is stained blue in the same reagent. Some further micro-chemical details concerning these hairs are recorded. Oil is said to be secreted from the blunt hairs and then only when their apices have become plug-like. Some notes on the chemical properties of the oil are given in the same paper.

Special Note

Leaf structure mainly panicoid.

Literature

Grob 1896 (leaf); Stapf *et al.* 1922 (oil-secreting hairs).

MIBORA

All of the references to this genus in the literature appear to refer to *M. minima* (L.) Desv. although this sp. is sometimes designated *M. verna*. The following characters have been recorded.

Leaf epidermis exhibiting short-cells confined to, and hooks infrequent over, the nerves (Prat 1932). Zones consisting wholly of long-cells with smooth walls present between the veins on the abaxial surface of the lamina and sheath, the whole of the apex and adaxial epidermis being composed of long-cells. Long-cells on the abaxial surface of the glumes markedly sinuous. Lamina in T.S. small, exhibiting 3 vb's; adaxial surface almost smooth, apart from an adaxial furrow sometimes formed by the inrolling of the leaf margins; scl. reduced to a trace below the median vb; mesophyll homogeneous; stomata equally numerous on both surfaces, each stoma being

provided with a substomatal chamber; bulliform cells absent; bundle-sheaths double, with the I.S. not strongly thickened.

Special Note

The leaf anatomy, although reduced, confirms Prat's (1936) opinion that the structure is festucoid.

Literature

Duval-Jouve 1875 (leaf; under *Chamagrostis*); Grob 1896 (leaf); Lewton-Brain 1904 (leaf); Pée-Laby 1898 (leaf); Prat 1932, 1936 (leaf); Wille 1916.

MICRAIRA

Diagnostic Generic Characters

Short-cells, over the veins, in long rows. Silica-bodies, over the veins, mostly cross to dumb-bell shaped and rarely nodular. Micro-hairs present; each with the distal cell tapering towards its pointed apex. Stomata with low dome-shaped subsidiary cells. Vascular bundles; none conspicuously angular in outline. Mesophyll with chlorenchyma not radiate. Bundle-sheaths double.

Species Specially Examined

***Micraira subulifolia* F. Muell.**

Leaf

Leaf minute, with a flattened lamina.

Abaxial epidermis

Short-cells, over the veins, in rows of more than 5 cells; abundant over, but v. infrequent or absent between, the veins. **Silica-bodies** mostly intermediate between cross and dumb-bell shaped (Fig. IA, 17); rarely nodular (Fig. IA, 18 (i)). **Macro-hairs:** none seen by the author, but Potztal (1953) refers to short, stiff hairs on both leaf surfaces, and to longer hairs between the adaxial ribs. **Micro-hairs:** length 30–50 (mostly 38–50) μ; basal cells 12–22 (mostly 18–22) μ; distal cells 16–28 (mostly 20–28) μ; distal cells mostly tapering towards their pointed apices (Fig. VII, 6). **Prickle-hairs:** pointed, angular prickles (Fig. VI, 3) present over many of the veins. **Stomata** with low dome-shaped subsidiary cells (Fig. IV, 3). **Long-cells** with thin, sinuous (Fig. V, 3*a–c*), or non-sinuous (Fig. V, 4*a–b*), walls; interstomatal cells with concave ends (Fig. V, 10–11).

T.S. lamina

Vascular bundles: most vb's not conspicuously angular in outline (Fig. VIII, 2); only the largest vb's tending to be of basic type (Fig. VIII, 15). **Adaxial surface** with moderate, rounded ribs, separated from one another by rather widely V-shaped furrows (Fig. XIV, 3). Similar, but less prominent, ribs and furrows also present on the abaxial surface. **Sclerenchyma:** all vb's

with combined girders tending to be anchor-shaped, the anchors having rather thick heads, and short arms, in the abaxial ribs. Girders sometimes showing a slight tendency to be double anchor-shaped, the adaxial part of each girder also being slightly T-shaped, the stems of the T's being about 6 cells high and 2 cells wide. **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** in fan-shaped groups (Fig. XV, 6) at the bases of the furrows. **Bundle-sheaths** double; most vb's with 2 complete sheaths (Fig. XII, 1), but a slight tendency for the O.S. of the largest vb's to be not quite complete abaxially (Fig. XII, 2).

Rhizome

Rhizome examined 1 mm in diameter. T.S. slightly sinuous in outline. Exhibiting a conspicuous, markedly sinuous circle of v. thick-walled fibres about 7 cells wide. Vascular system unusual in appearance, consisting firstly of a mass of minute, closely packed vb's arranged in a circle near the centre of the rhizome, the vb's surrounding a small area of pith-like tissue at the very centre of the rhizome. Each vb consisting of a well-developed, but small-celled, ph. strand accompanied on the sides and towards the centre of the rhizome by a V-shaped group of xy. elements of small diameter. Outermost members of this central circle of congested vb's differing from their neighbours in having much larger, conspicuous tracheal elements. Other vb's, besides the congested strands just described, consisting of a circle of widely spaced vb's embedded in thin-walled ground tissue not far within the conspicuous circle of scl., and others in the peripheral thin-walled ground tissue between the scl. ring and the epidermis.

Material Examined: D. A. Goy; Queensland.

Additional Information from the Literature

Potztal's (1953) description of the leaf of *M. subulifolia* does not entirely agree with the information given above. For example, micro-hairs do not appear to be restricted to the adaxial surface as stated in her article, and the present author, unlike Potztal, found the bundle-sheaths to be double.

Special Note

The leaf exhibits mixed panicoid and festucoid characters.

Literature

Potztal 1953 (leaf).

MICROCHLOA

Günzel (1912) has recorded the following information concerning the leaf of *M. indica* (Linn f.) P. Beauv. under *M. setacea* R. Br.

Epidermis. Short-cells, over the veins, in rows. Silica-bodies, over the veins, mostly saddle-shaped and, more rarely, dumb-bell shaped; silica- and cork-cells between the 2 vb's nearest to the leaf margins wider and especially well developed. Club-shaped micro-hairs present on the abaxial surface between the veins. Prickles occur on the

adaxial surface and at the leaf margins. Bristles numerous on old leaf-sheaths. Papillae abundant on the adaxial, but less frequent on, or absent from, the abaxial surface. Long-cells, between the veins, with sinuous outlines, the walls of those on the abaxial being more markedly sinuous than those on the adaxial surface. *T.S. lamina*. Scl. present on the abaxial side of the midrib, as adaxial and abaxial strands, associated with most of the vb's and as small marginal strands. Mesophyll with radiate chlorenchyma. Bulliform cells present between the vb's, each group subtended by a column of colourless parenchyma extending from the adaxial to the abaxial surface of the leaf.

Hansen and Potztal's (1954) account of the leaf structure of *M. caffra* Nees agrees closely with that given by Günzel for *M. indica*. No reference is made to the occurrence of micro-hairs; the abaxial and adaxial girders of scl. are shown as being of various sizes proportional to the bundles with which they are associated; colourless cells are shown as being well developed above the median vb as well as between the vb's in the 2 halves of the blade. Bundle-sheaths mostly single, but median vb and primary laterals with double sheaths.

Special Note

The microscopical structure indicates that the genus has affinities with the Chlorideae. Hansen and Potztal treat the genus as a member of the Leptureae.

Literature

Grob 1896 (leaf); Günzel 1912 (leaf); Hansen and Potztal 1954 (leaf).

MICROLAENA

Diagnostic Generic Characters

Short-cells, over the veins, in long rows. Silica-bodies, over the veins, cross to dumb-bell shaped. Micro-hairs present; each with the distal cell either with a rounded, or somewhat tapered, apex. Stomata with triangular and low dome-shaped subsidiary cells. Vascular bundles never more than inconspicuously angular. Mesophyll with chlorenchyma not more than slightly radiate. Bundle-sheaths double.

Species Specially Examined

***Microlaena stipoides* R. Br.**

Leaf

Abaxial epidermis

Short-cells, over the veins, mostly in rows of more than 5 cells, but sometimes paired; those between the veins paired and seldom containing conspicuous silica-bodies; abundant over, but rather infrequent between, the veins. **Silica-bodies** cross-shaped (Fig. Ia, 16) or intermediate between cross and dumb-bell shaped (Fig. Ia, 17). **Macro-hairs:** fairly long, thick-walled, superficial hairs with swollen bases frequent over the veins (Fig. II, 1); also short, rigid, thick-walled hairs (Fig. IIa, 10) between the veins. **Micro-hairs:** length 36–54 (mostly 42–50) μ; basal cells 20–28 μ; distal cells 16–28 (mostly 21–28) μ; distal cells either rather uniform in diameter throughout their

lengths and with rounded apices (Fig. VII, 7), or tapering somewhat towards their apices (Fig. VII, 6). **Prickle-hairs:** prickles (Fig. VI, 1–2) present locally over the veins. **Stomata:** some with triangular (Fig. IV, 1), and others with tall dome-shaped (Fig. IV, 4), subsidiary cells. **Long-cells,** between the veins, with thin, sinuous walls as in Fig. V, 3*a–c*; or shorter and broader, with v. marked sinuations (Fig. V, 6); interstomatal cells with concave ends (Fig. V, 10–11).

T.S. lamina

Vascular bundles: small vb's fairly widely spaced and not more than inconspicuously angular in outline (Fig. VIII, 2 and 6); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with slight ribs and furrows (Fig. XIV, 2), the ribs over the large vb's being slightly taller and more flat-topped than those over the small vb's. Abaxial surface also slightly ribbed, the ribs being opposite the bulliform cells on the adaxial surface. **Sclerenchyma:** most vb's with adaxial and abaxial girders up to about 5 cells wide and 3 cells high (Fig. IX, 4); large vb's with adaxial and abaxial girders rather wider than, but about the same height as, those associated with the small vb's. Combined girders to the median keel vb incompletely anchor-shaped. **Keel** fairly conspicuous, rounded; containing 1 main median vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma mostly not radiate, but slightly radiate round some vb's. **Bulliform cells** usually in fan-shaped groups (Fig. XV, 4). **Bundle-sheaths:** most vb's with 2 complete sheaths (Fig. XII, 1), the O.S. sometimes connected to and forming girders with the adaxial scl., by an adaxial extension of colourless cells; large vb's with the O.S. interrupted abaxially and sometimes connected to the adaxial scl. by extensions of colourless cells (Fig. XII, 4).

Culm

Culm examined 3 mm in diameter; v. slightly flattened on one side. Epidermis subtended by columns of assimilatory tissue about 3 cells wide around the periphery of the culm, except below its flattened side, the assimilatory tissue being here replaced by a continuous zone of fibres about 4 cells wide. Columns of assimilatory tissue separated from one another by girders of scl. extending from the outermost vb's to the epidermis, and bounded on the inner side by a ring of scl. about 4 cells wide. Ground tissue between the inner boundary of the scl. ring and the large cavity at the centre of the culm consisting of about 9 layers of thin-walled cells. Vb's consisting of those forming a circle of small strands in the scl. ring, the remainder being in 2 more or less distinct circles embedded in the thin-walled ground tissue.

Material Examined: Collected specially by W. M. Curtis in Tasmania.

Special Note

Prat (1936) rightly indicates that this genus should be excluded from the Phalarideae. On the whole the characters of the epidermis are panicoid, but those visible in T.S. of the leaf are not wholly panicoid.

Literature

Prat 1936 (leaf).

MICROSTEGIUM

Diagnostic Generic Characters

Short-cells, over the veins, sometimes solitary, but mostly in long rows. Silica-bodies, over the veins, cross to dumb-bell shaped and occasionally nodular. Micro-hairs present, but rather sparse; each with the distal cell tapering to a pointed apex. Stomata with triangular or low dome-shaped subsidiary cells. Vascular bundles mostly v. small, crowded, and conspicuously angular in outline. Mesophyll with inconspicuously radiate chlorenchyma. Bundle-sheaths single.

Species Specially Examined

***Microstegium ciliatum* (Trin.) A. Camus**

Leaf

Abaxial epidermis

Short-cells, over the veins, sometimes solitary, but mostly in rows of more than 5 cells; abundant over, but infrequent or absent between, the veins. **Silica-bodies,** over the veins, sometimes intermediate between cross and dumb-bell shaped (Fig. IA, 17) but mostly dumb-bell shaped, but varying in appearance with the focus (Fig. IB, 21); a few nodular (Fig. IA, 18 (i)). **Macro-hairs:** a few moderately long hairs, with sunken constricted bases (Fig. II, 3), present in the intercostal zones; bases of some of these hairs surrounded by specialized epidermal cells. **Micro-hairs:** length 38–54 (mostly 42–54) μ; basal cells 18–28 μ; distal cells 18–32 (mostly 20–26) μ; basal cells mostly tapering towards their proximal ends, and the distal cells tapering towards their pointed apices (Fig. VII, 6 and 9); rather sparse. **Prickle-hairs:** hooks (Fig. VI, 5) present. **Papillae:** large thin papillae (Fig. III, 6) abundant on both surfaces. **Stomata:** some with triangular (Fig. IV, 1), and others with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells:** most of those between the veins with thin, v. markedly and rather coarsely sinuous walls (as Fig. V, 3*a–c*, but sinuations more as in 6).

T.S. lamina

Lamina v. thin. **Vascular bundles:** small vb's numerous and crowded, the smallest with xy. and ph. not clearly contrasted (Fig. VIII, 1); those slightly larger being markedly angular in outline (Fig. VIII, 5); a few large vb's of basic type (Fig. VIII, 15). **Adaxial surface** smooth (Fig. XIV, 1), apart from a pronounced adaxial projection over the midrib. **Sclerenchyma:** smallest vb's not accompanied by scl. (Fig. IX, 1); other small vb's with minute adaxial and abaxial girders (Fig. IX, 4), the abaxial sometimes being appreciably larger than the corresponding adaxial girder; other small vb's with abaxial girders only; largest vb's with abaxial girders about 12 cells wide and 1–2 cells high, the adaxial girders to the same vb's being about 5 or 6 cells wide and 1–2 cells high. Adaxial projection over the midrib supported by a thin plate of fibres some 30 cells wide and 1–2 cells high, and the corresponding abaxial projection supported by a crescent-shaped strand of fibres about 23 cells wide and 4–5 cells high. **Midrib** conspicuous owing to a v. prominent adaxial extension with a flattened apex, and a smaller, rounded abaxial extension; containing 1 large median vb accompanied on either side by 2–3 much smaller laterals (Fig. XIII, 3). **Mesophyll:** chlorenchyma indistinctly radiate. **Bulliform cells:** practically the whole epidermis, except over the large veins, composed of irregular groups of more or less bulliform cells (Fig. XV, 1), the cells being markedly papillose. A fan-shaped group (Fig. XV, 6) also present on either side of the midrib. Adaxial projection of the midrib composed mostly of large, thin-walled, colourless cells. **Bundle-sheaths** single; a complete sheath (Fig. XI, 2*a*) of cells of rather unequal sizes present round each of the small vb's; sheaths of the large vb's with abaxial interruptions (Fig. XI, 6).

Culm

Culm examined 1 mm in diameter; surface v. slightly ribbed. Epidermis subtended by about 4 layers of fibrous cells. Ground tissue of the remainder of the culm, including the solid centre, consisting of large, thin-walled cells. Vb's consisting of those of the outermost circle embedded in the peripheral scl.; those in 2 more or less distinct circles embedded in the peripheral part of the thin-walled ground tissue; 2 isolated vb's also in the thin-walled ground tissue, but much nearer to the centre, and on opposite sides, of the culm.

Material Examined: F. Ballard 1086; Ceylon.

Special Note

Leaf structure panicoid.

MILIUM

The leaf of *M. effusum* L. has received attention particularly from Burr and Turner (1933), Lewton-Brain (1904), and Strecker (1913), from whose articles the following notes have been taken.

T.S. lamina. Lamina thin; leaves drooping. Adaxial surface not more than v. inconspicuously ribbed. Prickles (asperities) present on both surfaces. Scl. present as adaxial and abaxial girders to the principal vb's; and as adaxial and/or abaxial strands to the other vb's, and at the leaf margins. Midrib conspicuous. Bulliform cells in well-defined groups between the vb's; adaxial ground tissue of the midrib composed of colourless cells. Bundle-sheaths double, but I.S. inconspicuous around the small vb's.

With reference to the culm, Roelants (1921) records that subepidermal girders of scl. are present opposite some, but not all, of the vb's.

Special Note

The leaf anatomy is festucoid.

Literature

Burr and Turner 1933 (leaf); Chauveaud 1897 (root ph.); Grob 1896 (leaf); Lewton-Brain 1904 (leaf); Paratore 1899 (leaf of *M. multiflorum* with fig. of T.S.); Parodi and Freier 1945 (leaf); Pée-Laby 1898 (leaf); Roelants 1921 (culm); Strecker 1913 (leaf); Wille 1916.

MISCANTHIDIUM

Diagnostic Generic Characters

Short-cells, both over and immediately beside the veins, mostly solitary and paired, but sometimes in rows. Silica-bodies not standing out clearly in the cells in which present; cross to dumb-bell shaped or occasionally nodular. Micro-hairs present; each with the distal cell slightly tapered towards its apex. Stomata with slightly triangular or low dome-shaped subsidiary cells. Lamina cylindrical in T.S. apart from a shallow adaxial furrow. Vascular bundles not conspicuously angular in outline. Mesophyll with chlorenchyma not radiate and confined to the peripheral part of the T.S.

Species Specially Examined

***Miscanthidium teretifolium* (Stapf) Stapf**

Leaf

Abaxial epidermis

Short-cells, both over and immediately on either side of the veins, mostly solitary and paired, but some of those over the veins appearing to be in rows when separated from one another by relatively short cells in the same files. **Silica-bodies** not standing out clearly in the cells in which present; intermediate between cross and dumb-bell shaped (Fig. IA, 17), shortly dumb-bell shaped (Fig. IB, 20), or occasionally nodular (Fig. IA, 18 (i)). **Macro-hairs:** none seen. **Micro-hairs:** length 34–44 (mostly 36–42) μ; basal cells 18–24 μ; distal cells 13–22 (mostly 16–22) μ; basal cells with a somewhat inflated appearance; distal cells mostly tapering slightly towards their rounded apices. **Prickle-hairs:** none seen. **Stomata** with slightly triangular (Fig. IV, 1), or low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells** with thin, sinuous walls (Fig. V, 3*a–c*); interstomatal cells with concave ends (Fig. V, 10–11).

T.S. lamina

Lamina cylindrical in outline, apart from a v. small, narrow, shallow, adaxial furrow. Abaxial surface slightly ribbed over each of the numerous, crowded vb's. **Vascular bundles** mostly of basic type (Fig. VIII, 15); smallest vb's not conspicuously angular in outline (Fig. VIII, 2). **Sclerenchyma:** all vb's with well-marked abaxial girders only (Fig. IX, 3), many of the girders being about 12 cells tall and some 6 or 8 cells wide, the sizes of the girders varying in proportion to those of the vb's. **Mesophyll:** chlorenchyma not radiate. Assimilatory tissue and vb's confined to the peripheral part of the leaf, the centre consisting wholly of thin-walled, colourless, spongy tissue.

Material Examined: G. Jackson 20; N. Rhodesia.

Special Note

M. teretifolium is of special interest on account of its cylindrical leaf. The leaf structure is mainly panicoid.

MISCANTHUS

Diagnostic Generic Characters

Short-cells, over the veins, sometimes solitary or paired, but mostly in long rows. Silica-bodies, over the veins, cross to dumb-bell shaped and frequently nodular. Micro-hairs present; each with the distal cell usually tapering to its pointed apex. Stomata mostly with triangular, but sometimes with low dome-shaped, subsidiary cells. Vascular bundles mostly small, crowded, and conspicuously angular in outline. Mesophyll with distinctly radiate chlorenchyma. Bundle-sheaths single.

Species Specially Examined

***Miscanthus condensatus* Hack.**

Leaf

Abaxial epidermis

Short-cells, over the veins, sometimes solitary or paired, but mostly in rows of more than 5 cells; rather infrequent between the veins, where present solitary or paired. Occasional **silica-bodies,** between the veins, tall and narrow (Fig. I, 4); those over the veins intermediate between cross and dumb-bell shaped (Fig. IA, 17), shortly dumb-bell shaped (Fig. IB, 20), and frequently nodular (Fig. IA, 18 (i)). **Macro-hairs:** none seen. **Micro-hairs:** length 54–72 (mostly 54–66) μ; basal cells 30–44 (mostly 30–36) μ; distal cells 18–30 (mostly 24–30) μ; basal cells tapering towards their proximal ends; distal cells usually tapering to their finely pointed apices (Fig. VII, 9). **Prickle-hairs:** small prickles (Fig. VI, 1) and hooks (Fig. VI, 5) occurring locally over the veins, and, more frequently, beside the veins and in the intercostal zones. **Papillae:** many of the cells in the stomatal strips with thickened papillae (Fig. III, 2), or some of the papillae more like the large ones in Fig. III, 4. **Stomata** mostly with triangular (Fig. IV, 1), but sometimes with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells:** those on either side of the veins with thin, sinuous walls (Fig. V, 3*a–c*); some of those in the stomatal strips shorter and tending to be cubical (Fig. V, 7*a–b*); interstomatal cells with concave ends (Fig. V, 10–11).

T.S. lamina

Vascular bundles: most vb's small and crowded, the smallest with xy. and ph. not clearly contrasted (Fig. VIII, 1); slightly larger and medium-sized vb's mostly hexagonal (Fig. VIII, 4), but a few of the medium-sized vb's polygonal (Fig. VIII, 5) and rather narrow; largest vb's of basic type (Fig. VIII, 15). **Adaxial surface** practically smooth (Fig. XIV, 1). **Sclerenchyma:** keel vb's with well-marked abaxial girders only (Fig. IX, 3), the girder to the median vb being appreciably wider than the bundle itself; all other vb's with adaxial and abaxial girders varying in size in proportion to the size of the vb's, none of the girders being particularly large (Fig. IX, 4). Adaxial girders to certain of the small vb's lying opposite to the bulliform cells consisting of no more than 1 or 2 cells between the bulliform cells and the bundle-sheath,

the corresponding abaxial girders being 2–3 cells wide and high. Medium-sized vb's, not opposite the bulliform cells, with adaxial and abaxial girders up to about 4 cells wide and high, the girders to the largest vb's being wider still. Adaxial surface of the midrib supported by a wide, subepidermal plate of scl. about 3 cells thick. **Keel** v. conspicuous, rounded; containing 1 large median vb accompanied on either side by 2 laterals nearly as large, and by about 8 other, much smaller laterals (Fig. XIII, 3). **Mesophyll:** chlorenchyma distinctly radiate immediately around each vb. **Bulliform** and **colourless cells** forming arches over some of the small vb's (Fig. XV, 10), the piers of the arches traversing the mesophyll between the vb's and extending to the abaxial surface of the lamina. Ground tissue of the midrib consisting of colourless cells. **Bundle-sheaths** single; nearly all vb's, except the largest, with complete sheaths; sheaths round the vb's of the keel and some of the large vb's of the lamina, interrupted abaxially (Fig. XI, 6), the interruptions associated with the keel bundles being quite wide; sheaths round other large vb's in the lamina interrupted adaxially and abaxially (Fig. XI, 3).

CULM (Fig. XX, 5)

Culm examined 0·6 cm in diameter. No well-defined scl. ring present, apart from a few layers of fibres subjacent to the epidermis. Ground tissue, from the layers of fibres inwards, consisting of cells with progressively wider lumina and thinner walls, the tissue becoming spongy at the centre of the culm. Vb's scattered, but absent from the spongy tissue at the centre of the culm, the outermost vb's being appreciably smaller than the remainder.

MATERIAL EXAMINED: Cultivated at Kew.

***Miscanthus sacchariflorus* (Maxim.) Hack.**

LEAF

Abaxial epidermis

Short-cells, between the veins, paired and solitary; those over the veins sometimes also paired, but mostly in rows of more than 5 cells; common. **Silica-bodies,** over the veins, mostly intermediate between cross and dumb-bell shaped (Fig. IA, 17), or shortly dumb-bell shaped (Fig. IB, 20); others dumb-bell shaped (Fig. IA, 18 (ii–v)), or occasionally nodular (Fig. IA, 18 (i)). **Macro-hairs:** none seen. **Micro-hairs:** length 48–77 (mostly 60–70) μ; basal cells 21–39 (mostly 30–39) μ; distal cells 25–39 (mostly 30–39) μ; distal cells mostly tapering to their pointed apices (Fig. VII, 5 and 6). **Prickle-hairs:** none seen. **Stomata** mostly with triangular (Fig. IV, 1) or approximately triangular, but others tending to have low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells,** between the veins, with thin, sinuous walls (Fig. V, 3*a–c*), but rather short; interstomatal cells with concave ends (Fig. V, 10–11).

T.S. lamina

Vascular bundles: most vb's small, crowded, hexagonal (Fig. VIII, 4) or polygonal (Fig. VIII, 5); a few large vb's of basic type (Fig. VIII, 15). **Adaxial surface** smooth (Fig. XIV, 1), apart from slight ribs over the medium-sized and large vb's (Fig. XIV, 2). Two abaxial ribs present near each of the leaf margins, slight abaxial ribs also occurring over each of the keel bundles. **Sclerenchyma:** keel bundles with well-marked abaxial girders only (Fig. IX, 3), the girder to the median vb being slightly wider than the bundle itself; small vb's opposite the groups of bulliform cells with minute abaxial girders only; medium-sized vb's in the lamina each accompanied by small abaxial and adaxial girders from 1–5 cells wide and about 3 cells high, the adaxial often being rather narrower than the abaxial girders (Fig. IX, 4); large vb's with adaxial and abaxial girders up to some 10 cells wide and about 4 cells high (Fig. IX, 5). Adaxial surface of the midrib supported throughout its width by a plate of fibres up to about 4 layers thick. **Keel** conspicuous, large, rounded; containing 1 large median vb accompanied on either side by 2 laterals nearly as large, and by about 10 other laterals of various sizes, but all of them appreciably smaller than the median vb (Fig. XIII, 3). **Mesophyll:** chlorenchyma distinctly radiate immediately around each vb. **Bulliform** and **colourless cells** forming arches over some of the small vb's (Fig. XV, 10), the piers of the arches traversing the mesophyll between the vb's and extending to the abaxial surface of the lamina. A few groups of bulliform cells as in Fig. XV, 2, or tending to be slightly fan-shaped (Fig. XV, 4), also present on either side of the midrib. Ground tissue of the midrib largely composed of colourless cells. **Bundle-sheaths** single; those round all but the largest vb's being complete (Fig. XI, 2*a*); those round the large vb's in the lamina tending to be interrupted adaxially and abaxially (Fig. XI, 3); sheaths round the keel bundles with abaxial interruptions only (Fig. XI, 6).

CULM

Culm examined 0·7 cm in diameter. Structure v. similar to that of *M. condensatus.*

MATERIAL EXAMINED: Cultivated at Kew.

SPECIAL NOTE

Leaf structure typically panicoid.

MOLINIA

DIAGNOSTIC GENERIC CHARACTERS

Short-cells, over the veins, mostly in long rows, but occasionally solitary or paired. Silica-bodies, over the veins, cross to dumb-bell shaped. Micro-hairs: none seen. Stomata: a few tending to have triangular, but mostly with low dome-shaped, subsidiary cells. Vascular bundles never conspicuously angular in outline, but small ones rather tall and narrow. Mesophyll with chlorenchyma not radiate. Bundle-sheaths double.

Species Specially Examined

***Molinia caerulea* (L.) Moench**

Leaf

Abaxial epidermis

Short-cells, between the veins, paired; those over the veins in rows of more than 5 cells, occasionally appearing to be solitary or paired when separated from one another by fairly long intervening cells in the same files; abundant. **Silica-bodies,** between the veins, tall and narrow (Fig. I, 4) and mostly slightly crescent-shaped in outline, or occasionally crenate (Fig. Ib, 24), some of them fitting into concavities in adjacent cork-cells (Fig. I, 6–7); those over the veins intermediate between cross and dumb-bell shaped (Fig. Ia, 17), dumb-bell shaped (Fig. Ia, 18 (ii–v)), or shortly dumb-bell shaped (Fig. Ib, 20); occasional nodular bodies noted by Grob (1896). **Macro-hairs:** none seen in the material examined, but leaves sometimes hairy. **Micro-hairs:** none seen. **Prickle-hairs:** hooks (Fig. VI, 5) abundant in the intercostal zones; prickles present on the adaxial ribs. **Stomata:** a few tending to have slightly triangular (Fig. IV, 1), but mostly with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells,** between the veins, with thin, sinuous walls (Fig. V, 3*a–c*); many of the cells not v. tall.

T.S. lamina

Vascular bundles: most vb's not conspicuously angular in outline (Fig. VIII, 2), but rather tall and narrow; large vb's of basic type (Fig. VIII, 10 and 15). **Adaxial surface** with low but wide, slightly rounded ribs over each vb, the ribs over the large vb's being slightly taller and wider than the remainder (Fig. XIV, 3). Furrows shallow and much narrower than the ribs. **Sclerenchyma:** all small vb's provided with adaxial girders up to about 5, or occasionally more, cells high and usually 2–3 cells wide, and with abaxial girders about 4–6 cells wide and high (Fig. IX, 7); large vb's with adaxial and abaxial girders up to about 10 cells wide and 3–4 cells high (Fig. IX, 5); combined girders to the median keel bundle tending to be anchor-shaped (Fig. IX, 6); scl. also well developed in the leaf margins. **Keel,** fairly conspicuous, rounded; containing 1 large median vb accompanied on either side by a smaller lateral (Fig. XIII, 2). (Lewton-Brain (1904) shows intercellular air-cavities on either side of the median vb.) **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** in fan-shaped groups (Fig. XV, 4 and 6) at the bases of the shallow furrows. **Bundle-sheaths** double; nearly all vb's, both large and small, with I.S. complete and O.S. interrupted adaxially and abaxially (Fig. XII, 3*a–b*).

Culm

Culm examined 2 mm in diameter. Epidermis, and, to a lesser extent, the 2–3 subjacent layers of cells, with strongly thickened walls, but not strictly fibrous. This zone followed by about 4 layers of parenchymatous cells, bounded on the inner side by a zone of aerenchymatous tissue 2–3 times as wide as the zone composed of the epidermis and subjacent scl. Aerenchymatous tissue v. conspicuous, appearing as radiating plates 1–3 or more

cells wide, each consisting of parenchymatous cells of various sizes forming a somewhat spongy tissue. Plates of spongy tissue separated from one another by radiating intercellular spaces of various widths. Intercellular spaces apparently formed by the breakdown of previously existing cells, persistent fragments of cell walls being visible in some of them. Aerenchyma bounded on the inner side by a fibrous zone some 12 cells wide, the more central ground tissue consisting of larger, rounded cells with small, triangular intercellular spaces between them. Centre of the culm occupied by a rather small cavity sometimes containing remnants of aerenchymatous tissue. Vb's in the outermost circle, and also some of the other vb's, embedded in the peripheral part of the scl. ring; remaining vb's much larger, and embedded in the inner ground tissue. For additional information concerning the culm structure see below.

Material Examined: Collected in Surrey, England.

Additional Information from the Literature

1. Culm

Jefferies (1916) points out that the swollen basal node of the culm is club-shaped and serves for food storage. The swollen portion is about 5 mm in diameter at its widest part and it gradually tapers upwards until the diameter is about 2 mm before expanding to form a slight ridge with the second series of leaves attached. The basal internode in T.S. exhibits the following structure on passing from the exterior to the centre: (i) a cutinized epidermis, with a subjacent zone of about 3 layers of small, thick-walled mechanical cells; (ii) a cortex traversed longitudinally by large air-lacunae, and consisting of about 10 layers of cells with thickened cellulose walls, the lumina of the cells containing reserve food; (iii) an inconspicuous endodermis; (iv) an inner zone of scl.; (v) small vb's embedded in the inner scl. zone, and larger bundles in the outer part of the ground tissue enclosed by the same scl. zone; and (vi) a massive central ground tissue devoid of vb's and serving to store food in the form of granules of starch and protein; the cells of this zone having strongly thickened, pitted, cellulose walls.

Leaves easily detached from the basal nodes owing to the formation of absciss layers, a feature believed to be relatively uncommon amongst grasses.

Jefferies's description of the middle part of the culm agrees in the main with the description of the culm on p. 319 above. With reference to the part of the culm immediately below the inflorescence, he gives the following particulars. Scl. ring united at intervals to the cutinized epidermis by girders of scl., the spaces between consecutive girders being occupied by assimilatory tissue. Vb's all embedded in the scl. ring or in the ground tissue bordering on its inner surface. Large air-lacunae absent, but centre of the culm occupied by a wide cavity.

2. Rhizome

Internodes normally v. short; sympodially branched, each branch turning upwards and terminating in an inflorescence axis; in T.S. exhibiting a confused mass of vb's.

3. Root

Root system very extensive; holding the plant v. firmly in the soil. Jefferies differentiates between the cord roots about 1·5–2·0 mm in diameter springing from the rhizomes, and much branched, fibrous roots 0·3–0·8 mm in diameter arising from the cord roots. On passing from the exterior to the centre of the cord roots, which

remain functional for 3 seasons, the following tissues may be noted: (i) a piliferous layer of axially elongated cells, some bearing root hairs 100–350 μ long; (ii) a thin-walled hypodermis of 1–2 cell-layers; (iii) about 3 layers of narrow, thick-walled, slightly pitted fibres; (iv) a cortex consisting of an outer zone of cells of various sizes and shapes, a middle zone of almost circular cells becoming separated into radiating rows with large air-spaces between them, and an inner zone of radiating rows of closely placed cells; (v) a conspicuous endodermis consisting of cells with the inner tangential walls strongly thickened and finely pitted; and (vi) a stele with small ph. strands alternating with 12–24 xy. strands, every other xy. strand being marked by a v. large, conspicuous, metaxylem vessel, the centre of the stele being occupied by scl. ground tissue of great tensile strength. Fine roots in T.S. exhibiting the same general structural plan, but root-hairs infrequent except on the older portions, and not more than 1–2, or sometimes without any, conspicuous metaxylem vessels in the centre of the stele. Chloroplasts often present in the cortex, especially in roots exposed to the air.

Schaefer (1942) refers to the occurrence of local swellings on the roots.

Special Note

Leaf structure mainly festucoid but with some panicoid characters. It is sometimes treated as one of the Festuceae, but it is also thought to have affinities with *Sieglingia* in the Danthonieae. *Molinia*, unlike *Sieglingia*, does not appear to have micro-hairs.

Literature

Burr and Turner 1933 (leaf); Chauveaud 1897 (root ph.); Grob 1896 (leaf); Jefferies 1916 (ecological anatomy); Lewton-Brain 1904 (leaf); Martin 1955 (leaf epidermis with cell dimensions); Pée-Laby 1898 (leaf); Prat 1936 (leaf); Schaefer 1942 (root seedlings); Strecker 1913 (leaf).

MONELYTRUM

The leaf anatomy of *M. luderitzianum* Hack. has been described by H. G. Schweickerdt (1946), from whose paper the following information has been taken. The description refers particularly to the structure as seen in T.S. through the upper part of the proximal third of the blade of a leaf taken as nearly as possible from the base of the plant, or from a shoot arising from a stolon.

Blade 0·16–0·24 mm thick. Both surfaces flat or nearly so. Vascular bundles: 7–9 of first order, each pair separated from one another by 2–4 third-order bundles. Scl. present as a large hypodermal strand in each of the blunt leaf margins; as small adaxial, and large abaxial, strands or girders supporting the median vb and all of the vb's elsewhere in the lamina. Keel inconspicuous and rounded. Mesophyll with a single layer of radiately arranged chlorenchyma ensheathing each vb, the remaining assimilatory cells containing fewer chloroplasts. Bulliform cells in adaxial groups of 5 (rarely 7) cells between the vb's, the central cell of each group being large, almost spherical, and occupying one-third to one-half of the thickness of the blade. Bundle-sheaths: first-order vb's described as being each surrounded by an I.S. of lignified cells and an O.S. of 13–18 parenchymatous cells filled with chloroplasts, the O.S. sometimes interrupted both adaxially and abaxially. Third-order bundles each

usually with a single, and only rarely with a double, sheath consisting of 8–10 cells densely filled with chloroplasts.

Characters of the epidermis include several files of short-cells above each vb, in which cells containing saddle-shaped silica-bodies alternate with rectangular but horizontally elongated cork-cells with sinuous walls; prickles ('hook cells') alternating with cork-cells also present at the leaf margin; club-shaped, 2-celled micro-hairs on both surfaces near the stomata; papillae on the adaxial bulliform cells.

Special Note

Schweickerdt suggests that the leaf structure resembles that of *Tragus* (see p. 499).

Literature

Schweickerdt 1946 (leaf).

MONERMA

Hansen and Potztal (1954) have recorded the following notes on the leaf structure of *M. cylindrica* (Willd.) Coss. & Dur.

Silica-bodies rounded to oblong; illustrated as resembling those in Fig. I, 10 and IA 13. Macro-hairs: short, stiff hairs resembling those in Fig. IIA, 10, present. Sclerenchyma: large vb's accompanied by minute adaxial strands united to the bundle-sheath by colourless cells (described as collenchyma), and by wider abaxial girders; small vb's accompanied by minute adaxial and abaxial strands. Mesophyll: chlorenchyma not radiate. Bundle-sheaths all apparently double, but rather obscurely illustrated. Starch compound.

Special Note

Hansen and Potztal treat *Monerma* as a member of the Leptureae.

Literature

Hansen and Potztal 1954 (leaf); Tateoka 1959 (cytology).

MUHLENBERGIA

Diagnostic Generic Characters

Short-cells, over the veins, in long rows. Silica-bodies, over the veins, mostly saddle-shaped, but sometimes cross to dumb-bell shaped. Micro-hairs present; each with a hemispherical distal cell. Stomata with low to tall dome-shaped subsidiary cells. Vascular bundles mostly small crowded, and conspicuously angular in outline. Mesophyll with distinctly radiate chlorenchyma (see also p. 325 below). Bundle-sheaths single and double, the double sheaths usually surrounding the large vb's.

Species Specially Examined

***Muhlenbergia racemosa* (Michx.) B. S. P.**

Leaf

Abaxial epidermis

Short-cells, over the veins, in rows of more than 5 cells; abundant over, but infrequent or absent between, the veins. **Silica-bodies,** over the veins,

mostly saddle shaped (Fig. I, 9); a few, especially over the smaller veins, cross shaped (Fig. IA, 16) or intermediate between cross and dumb-bell shaped (Fig. IA, 17). **Macro-hairs:** none seen. **Micro-hairs:** length 36–42 μ; basal cells 26–30 μ; distal cells 9–12 μ; basal cells tapering towards their proximal ends; distal cells hemispherical; hairs approximating to the type shown in Fig. VII, 12, but basal cell rather shorter. **Prickle-hairs:** prickles (Fig. VI, 1–2) fairly frequent over the veins. **Stomata** with low (Fig. IV, 3), or moderately tall (Fig. IV, 4), dome-shaped subsidiary cells. **Long-cells,** between the veins, sometimes rather short and with slightly to moderately sinuous walls (Fig. V, 7*a–b*); others rather longer, with thin, non-sinuous, or only slightly sinuous, walls (Fig. V, 4*a–b*); some interstomatal cells with concave ends (Fig. V, 10–11).

T.S. lamina

Vascular bundles: most vb's small, crowded, and conspicuously angular in outline (Fig. VIII, 5); a few large vb's of basic type (Fig. VIII, 9). **Adaxial surface** practically smooth (Fig. XIV, 1). **Sclerenchyma:** small vb's with adaxial and abaxial girders 3–6 cells wide and mostly not more than 1, but occasionally 2, cells high (Fig. IX, 4); large vb's with adaxial and abaxial girders mostly about 12–14 cells wide and 3–4 cells high (Fig. IX, 5). Adaxial surface of the midrib supported by a thin, wide plate of scl. subjacent to the epidermis. **Keel** conspicuous, rounded; containing 1 large median vb accompanied on either side by a much smaller lateral (Fig. XIII, 2). **Mesophyll:** chlorenchyma distinctly radiate. **Bulliform cells** sometimes in groups tending to be of the *Sporobolus* type (Fig. XV, 8), or in more or less fan-shaped groups (Fig. XV, 4). Adaxial part of the midrib composed of large, colourless cells. **Bundle-sheaths** double and single; a single complete sheath round each small vb (Fig. XI, 2*a*), the component cells all being v. inflated, but rather variable in size; large vb's with I.S. complete but O.S. interrupted adaxially and abaxially (Fig. XII, 3*b*). Sheath round the median midrib vb interrupted abaxially only.

CULM

Culm examined 2 mm in diameter. Epidermis subtended by v. minute strands of assimilatory tissue embedded in a zone of fibres 6–8 cells wide. Ground tissue between the inner boundary of the fibrous ring and the comparatively small cavity at the centre of the culm consisting of fairly thick-walled, lignified cells with minute, triangular intercellular cavities between the cells. Outermost vb's embedded in the peripheral scl. ring and the remainder scattered throughout the ground tissue.

RHIZOME

Rhizome examined 3 mm in diameter. Outer part of the rhizome consisting of a zone of about 12, or rather more, thin-walled, polygonal cells, with some v. small, widely separated vb's embedded in it. Zone of thin-walled tissue bounded on the inner side by a somewhat interrupted zone of fibres some 5–10 cells wide, with numerous vb's embedded in it. Centre of the rhizome occupied by thin-walled ground tissue consisting of cells of smaller diameters

than those of the ground tissue external to the fibrous zone. Numerous vb's scattered in the inner ground tissue, but absent from the very centre of the rhizome.

MATERIAL EXAMINED: Cultivated at Kew.

ADDITIONAL INFORMATION FROM THE LITERATURE

Schwabe (1949), who examined 22 spp. of *Muhlenbergia*, gives diagnostic characters for the leaf in this genus that accord closely with the information given above. He divides the spp. into 3 groups:

A. Leaf with the surface more or less flat, each primary vb alternating with 5–9 secondary vb's, the total number of vb's being about 40. Colourless parenchyma absent from the ribs and furrows. Epidermis relatively simple. E.g. *M. schreberi* Gmelin (*M. diffusa* Willd.).
B. Lamina narrow, convolute or conduplicate; generally with less than 20 vb's. Epidermis relatively complex. E.g. *M. atacamensis* Parodi and other spp.
C. Lamina with pronounced ribs; primary vb's large, alternating with secondary and tertiary vb's. Scl. forming a continuous, abaxial, subepidermal layer. Colourless parenchyma well developed in the ribs. E.g. *M. breviaristata* (Hackel) Parodi and other spp.

Schwabe also classifies the same spp. in 3 ecological groups as follows:

I. Xerophytic annuals which have delicate leaves with adaxial papillae. E.g. *M. atacamensis* Parodi and other spp.
II. Xerophytic perennials with leaves furrowed on both surfaces, and with numerous papillae and spines. E.g. *M. fastigiata* (Presl) Henr.
III. Psammophilous perennials. E.g. *M. breviaristata* (Hackel) Parodi and other spp.

Holm (1901–2), who studied the ecological anatomy of 9 spp. of *Muhlenbergia*, compared woodland spp. with those from dry ground, mountain slopes, and hillsides. The thin, relatively flat, broad scabrous leaves of woodland spp. are characterized by a conspicuous midrib strongly supported by scl.; thick-walled scl. in the leaf margins and abaxial strands associated with the small vb's, the larger vb's being accompanied also by adaxial strands; mesophyll consisting mostly of radiate chlorenchyma; well-developed bulliform cells between the vb's but not over the midrib; double bundle-sheaths. The thicker, narrower leaves of spp. from dry ground, mountain slopes, and hillsides exhibit deep furrows and pointed 'papillae' or long hairs on the adaxial surface; stomata confined to the adaxial furrows and surrounded by 'epidermal projections'; thick-walled scl. not only forming adaxial and abaxial girders with the vb's, but extending as a continuous, abaxial, subepidermal layer; compact mesophyll of radiately arranged cells; bulliform cells more developed than in the woodland spp., and accompanied by subjacent colourless cells; bundle-sheaths double, the O.S. being large-celled and containing green pigment, the walls of the cells of the O.S. being thickened on the adaxial and abaxial sides of each vb. In *M. filipes* Curtis the permanently conduplicate leaves are deeply furrowed and colourless parenchyma is extensively developed in the mesophyll.

Hayden (1919) has published a v. brief note on the ecological anatomy of the leaf of *M. mexicana* (L.) Trin. which is of interest because the leaf is figured as having non-radiate chlorenchyma in the mesophyll.

Canfield (1934) recorded 5 spp. with solid, and 1 with hollow, culms from the Jornada Experimental Range.

Special Notes

Prat (1934, 1936) considers that the structure of the epidermis recalls that of the Chlorideae, and that the anatomy is panicoid.

Schwabe (1949) points out that the leaf anatomy of *Muhlenbergia* is similar to that of *Epicampes*, *Lycurus*, and *Sporobolus*, all of which genera differ considerably from the Agrostideae and in Schwabe's opinion should be classified in the Eragrosteae. The present writer notes that the micro-hairs are similar to those of *Eragrostis*.

Literature

Canfield 1934 (culm); Grob 1896 (leaf); Hayden 1919 (leaf); Holm 1901–2 (leaf); Prat 1934, 1936 (leaf); Schwabe 1949 (leaf).

MUNROA

The following information has been collected from the literature.

1. Leaf

Epidermis

M. mendocina Philippi

Short-cells, over the veins, mostly paired, but occasionally solitary or in short rows. Silica-bodies figured as more or less cross-shaped, but with only shallow indentations between the arms. Prat (1936) refers to the silica-bodies in *Munroa* as being saddle-shaped. Macro-hairs 180–220 μ long, micro-hairs each with a spherical or globose distal cell, and prickles present. (Cacares 1950.)

M. squarrosa (Nutt.) Torr.

Abaxial surface scabrous with 'short papillae', adaxial surface with scattered prickles; macro-hairs absent. (Holm 1901–2, 1905.)

T.S. lamina

M. mendocina Philippi

Vb's 9–11 in number. Adaxial surface with pronounced, rounded ribs separated from one another by narrow furrows. Scl. well developed, present as adaxial and abaxial strands to most vb's, sometimes forming girders, especially on the abaxial side of the large vb's; abaxial girder to the median vb slightly anchor-shaped. A small abaxial strand of scl. also present opposite the first adaxial furrow on either side of the midrib, and scl. also well developed in the leaf margins. Keel moderately prominent. Mesophyll with radiate chlorenchyma. Bundle-sheaths: single parenchymatous sheaths to most vb's; median vb with a conspicuous I.S. of thick-walled cells. (Cacares 1950.)

M. squarrosa (Nutt.) Torr.

Blade narrow. Both surfaces with wide, shallow to deep furrows. Vb's all orbicular in T.S. with the xy. and ph. well differentiated, especially in the larger nerves. Scl. present as a large strand in each margin of the blade, and as smaller adaxial and abaxial strands to the vb's. Mesophyll with radiate chlorenchyma. Bulliform cells large, each group accompanied by a few subjacent layers of colourless cells. Bundle-sheaths: those to the large vb's double; small vb's each with a single sheath of large, thin-walled cells containing green pigment. (Holm 1901–2, 1905.)

2. Culm

M. squarrosa (Nutt.) Torr.

Internodes long; semicylindric, smooth, and almost glabrous at the base; cylindric, deeply furrowed, and scabrous towards their distal ends. Epidermis of small cells with thickened outer walls. Distal end of the culm with a single layer of radiately arranged palisade cells bordering on the parenchymatous sheaths of the peripheral bundles, the ground tissue between the peripheral bundles consisting of round, colourless cells forming a zone about 5 cells wide. Base of the culm devoid of palisade cells, but colourless cells more developed. Scl. present as subepidermal strands in the ridges bordering on the palisade cells, and forming a continuous ring surrounding the inner vb's. Scl. not present in the subepidermis at the base of the culm, but forming a thick ring in the cortex surrounding the outer and inner circles of vb's. Inner ground tissue thin-walled and broken at the centre of the culm. (Holm 1905.)

3. Root

M. squarrosa (Nutt.) Torr.

Roots thin, hairy, v. strong, and not much branched. Mature root with persistent epidermis and moderately thick-walled hypodermis; cortex of 3–4 layers of cells, becoming collapsed in radial strips; endodermis with inner cell walls thickened; ph. as v. small strands: metaxylem marked by a circle of about 10 vessels. Small roots each with a single axile vessel and 4 smaller protoxylem vessels. (Holm 1905.)

Special Note

Cacares (1950), who compared the structure of *Munroa* with that of *Blepharidachne*, *Eragrostis*, and *Tridens*, points out that the anatomy is similar in the 3 genera, all of which he considers should be treated as members of the Eragrosteae. Prat (1936) regards the leaf anatomy as panicoid and the epidermis as Chloridean. He refers to the silica-bodies as saddle-shaped.

Literature

Cacares 1950 (leaf); Holm 1901–2, 1905 (whole plant); Prat 1936 (leaf).

NARDURUS

'*N. lachenalii* (Gmel.) Jodr.', now known as *Micropyrum tenellum* (L.) Link. has a simple leaf. The sheath and lamina exhibit alternating longitudinal bands consisting respectively of long-cells with sinuous walls and those over the veins which include silica- and cork-cells as well as prickles. Near the apex of the lamina the zones over the veins become very narrow and the intercostal zones wide. Prat interprets *N. lachenali* as an 'impoverished' sp. with juvenile characters, and regards it as allied to the Triticeae (Prat 1932).

Literature

Grob 1896 (leaf); Pée-Laby 1898 (leaf); Prat 1932 (leaf).

NARDUS

Diagnostic Generic Characters

Leaf acicular. Short-cells, over the veins, mostly in short to long rows, but sometimes paired at the edges of the veins. Silica-bodies, over the veins, almost round, or oblong. Micro-hairs present; each with the distal cell tapering to its pointed apex. Stomata with triangular subsidiary cells. Vascular bundles: none conspicuously angular in outline. Mesophyll with chlorenchyma not radiate. Bundle-sheaths double.

Species Specially Examined

***Nardus stricta* L.**

Leaf

Leaf setaceous and adaxially inrolled; with a well-marked adaxial groove.

Abaxial epidermis

Short-cells, between the veins, mostly solitary, but sometimes paired; those over the veins mostly in rows of 3–5 or more cells, but pairs also present, particularly along the edges of the veins; common to abundant. **Silica-bodies,** between the veins, mostly tall and narrow (Fig. I, 4), but a few almost cubical; those over the veins oblong (Fig. I, 8); sometimes less elongated and almost round. **Macro-hairs:** numerous, moderately long, rigid hairs, with swollen, slightly sunken bases, present in the intercostal zones; bases of the hairs as in Fig. IIA, 11, but hairs themselves less flexuous. **Micro-hairs:** length 68–100 μ; basal cells 34–54 (mostly 36–48) μ; distal cells 32–47 (mostly 36–42) μ; some basal cells tapering towards their proximal ends; distal cells tapering towards their pointed apices (Fig. VII, 6 and 9). **Prickle-hairs:** angular prickles (Fig. VI, 3) common over some of the veins and on the adaxial surface. **Papillae:** numerous papillose epidermal cells present in the furrows and on the ribs of the adaxial surface. **Stomata** with triangular subsidiary cells (Fig. IV, 1). **Long-cells,** between the veins, with fairly thick, markedly sinuous walls, the sinuations being rather tall and crowded.

T.S. lamina

Vascular bundles: small vb's not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 15). Acicular leaf with 1 median adaxial rib accompanied on either side by 2 lateral ribs, all with rounded apices, the vb's in the median and 2 lateral ribs being of basic type (Fig. VIII, 15), and the vb's in the remaining ribs not conspicuously angular in outline (Fig. VIII, 2). Furrows between the ribs deeply V-shaped. T.S. of leaf somewhat similar to Fig. X, 1, but keel more rounded. **Sclerenchyma** present as well-marked abaxial girders to the marginal vb's. Remaining vb's with slightly T-shaped adaxial girders, the stems of the T's being about 7 cells high and 2 cells wide. Abaxial girders to the same vb's about 6 cells high where in contact with the bundle-sheaths, but broadening towards the abaxial epidermis, and there attaining a width of at least 17, and sometimes over 20, cells. **Mesophyll:** chlorenchyma not radiate. **Bulliform cells:** bases of the V-shaped furrows containing bulliform cells of variable size, but none specially large (Fig. XV, 5) (see also below). **Bundle-sheaths** double; all with the I.S. complete, the individual sheath cells exhibiting U-shaped thickenings; O.S. of the marginal vb's merging abaxially with the adjacent scl. girders; O.S. of the other vb's similar, but merging gradually with the adaxial scl. girders.

Material Examined: Black Mountains, Wales.

Additional Information from the Literature

1. Root Structure

Two types of roots noted by Coulon (1923): (*a*) roots 0·8–1·1 mm in diameter, penetrating deeply into the soil and bearing secondary and tertiary branches; and (*b*) roots 0·4–0·5 mm in diameter penetrating less deeply into the soil. Roots of type (*a*) exhibit the following structure. Root-hairs becoming as long as the diameter of the roots. Cortex with about 2 layers of sclerosed cells towards the exterior; mostly consisting of large, radiating, intercellular cavities separated from one another by parenchymatous cells; inner part composed of a few layers of radially arranged sclerosed cells. Endodermis consisting of cells with the inner tangential and radial walls strongly thickened. Vascular structure ranging from 3 to 50-arch according to the size of the roots; metaxylem vessels arranged in a circle around the sclerosed pith. Roots of type (*b*) similar in structure, but pith more strongly lignified, stele much smaller in diameter, cortex much reduced, and with not more than 3 air-cavities. Mycorrhiza present in small roots. Tissues of roots grown in culture solutions less sclerosed than those from natural habitats, other differences noted being the almost complete absence of root-hairs, and the cortex consisting of rounded cells with small but numerous intercellular spaces between them.

2. Plants grown under Continuous Light

Coulon (1923) noted the following structural modifications in plants grown under continuous electric light at an intensity of 2,000 candle power. Lignification and sclerification of the tissues reduced in leaves and culms, the leaves becoming more pliable. Metaxylem vessels more numerous and bulliform cells much larger. Abnormalities in the inflorescence also induced by the same treatment.

Vischer (1915) has recorded variations in the leaf structure of *N. stricta* correlated with differences of habitat. Considerable variations in the sizes of the bulliform cells were noted.

Special Notes

Prat (1936) refers to the epidermis as panicoid. He states, however, that the silica-bodies are saddle-shaped, but no bodies answering this description were to be seen on the abaxial surface of the leaf material examined by the present author. Prat also points out that the anatomy, as revealed in T.S., is, on the other hand, festucoid. *Nardus* is the sole genus of the Nardeae.

Literature

Burr and Turner 1933 (leaf); Coulon 1923 (physiology, ecology, morphology, and anatomy); Duval-Jouve 1875 (leaf); Grob 1896 (leaf); Lewton-Brain 1904 (leaf); Prat 1932, 1934, 1936 (leaf); Strecker 1913 (leaf); Vischer 1915 (ecological anatomy).

NASSELLA

A few notes concerning *N. trichotoma* (Nees) Hack. have been recorded by Holm (1901–2).

Leaf narrow, conduplicate. Adaxial surface with well-developed ribs and furrows. Scl. forming a continuous hypodermal layer on the abaxial side of the leaf, and also forming small adaxial girders to the vb's. Sunken stomata present in the furrows. Mesophyll with chlorenchyma not radiate, composed of roundish cells. Bulliform cells present in the furrows; none of them particularly large. Bundle-sheaths double; I.S. composed of cells with heavily thickened inner walls; outer sheaths composed of thin-walled colourless cells. Adaxial epidermis with long, pointed macro-hairs on the ribs.

Special Note

Parodi and Freier (1945) note that *Nassella*, together with *Stipa* and *Oryzopsis*, form a closely related group of genera within the Stipeae.

Literature

Grob 1896 (leaf); Holm 1901–2 (leaf); Parodi and Freier 1945 (leaf).

NEOSTAPFIA (see p. 651)

NEURACHNE

For our knowledge of the anatomy of *Neurachne* we are particularly indebted to Vickery (1935) who has examined T.S. of the leaves of 3 spp.

N. alopecuroides R. Br.

Leaves 5–8 cm × 1–2 mm, often inrolled. Structure generally similar to that of *N. mitchelliana* (see below). Vb's about 17–19 in all; alternate bundles large (first or second order) and small (third order). Large vb's with the ph. divided into 2 groups by a strand of fibres. Scl. as small adaxial and wider abaxial strands associated with most vb's, the abaxial strands sometimes united to the large vb's to form girders. Midrib not conspicuous. Bulliform cells in adaxial groups of 5–8 (usually 7) cells. Adaxial epidermis bearing a few long hairs.

N. mitchelliana Nees

Leaves ovate-lanceolate or linear, abruptly pointed at the apex, 1–5 cm × 3–5 mm; somewhat inrolled on drying. Lamina fairly thick. Adaxial surface almost flat or with v. slight ribs; abaxial surface with low ribs beneath the vb's. Vb's more or less similar in size, consisting of 5–7 first-order bundles with 3–4 vb's of third order between each pair. Scl. as moderately large abaxial strands or girders and smaller adaxial strands to each vb, the adaxial strands being separated from the vb's by colourless cells. Adaxial strands more rarely connected directly to the bundle-sheaths to form girders. Midrib not conspicuous. Mesophyll with 2 more or less radiate rows of chlorenchyma cells round each vb, the remaining assimilatory cells being irregularly arranged. Bulliform cells in narrow adaxial groups of 5–6 cells, the central cell in each group being conspicuously larger than the remainder, and occupying one-third to one-half of the thickness of the lamina. Bundle-sheaths double; I.S. of thickened cells; O.S. thin-walled, the cells of the sheaths round the small vb's being rather larger than those of the sheaths round the first order vb's.

N. munroi F. Muell.

Leaves 1–8 cm × 1–3 mm; inrolled on drying. Lamina moderately thick. Adaxial surface with low, rounded ribs over the small vb's and with broader and slightly higher ribs over the large vb's. Vb's about 23 in all, every other vb being of the first or second order and the remainder third order. Scl. present as a strand of fibres in the rib below each vb and an adaxial strand to every second vb, and a larger strand above every fourth vb. Scl. seldom forming girders. Midrib inconspicuous. Mesophyll consisting of irregularly arranged chlorenchyma. Bulliform cells present as a group in each groove, the central cell in each group being the largest. Bundle-sheaths apparently single and circular in outline. Adaxial epidermis bearing numerous pointed hairs; abaxial epidermis with a few scattered hairs and prickles (asperities).

Special Note

Vickery treats *Neurachne* as belonging to the Zoysieae.

Literature

Breakwell 1915 (leaf); Vickery 1935 (leaf).

NEUROLEPIS

Diagnostic Generic Characters

Short-cells, over the veins, solitary and paired. Silica-bodies, over the veins, varying from tall and narrow to slightly crescent-shaped or tall, narrow, and slightly crenate; sometimes fitting into concavities in adjacent cork-cells. Micro-hairs present; each with a wide, inflated basal cell, and a distal cell sometimes tapering to a pointed apex, but v. variable in shape. Stomata with low to fairly tall dome-shaped subsidiary cells. Vascular bundles: none conspicuously angular in outline. Mesophyll with chlorenchyma not radiate; consisting of arm-cells, and partly composed of fusoid-cells. Bundle-sheaths double.

Species Specially Examined

***Neurolepis aristata* (Munro) Hitchcock**

Leaf

Abaxial epidermis

Short-cells, over and at the sides of the veins, paired; abundant over, but v. infrequent between, the veins. **Silica-bodies,** over the veins, rather variable in shape, sometimes tall and narrow (Fig. I, 4), but more often tall and slightly crescent-shaped, to tall, narrow, and slightly crenate (Fig. Ib, 24); frequently tending to fit into concavities in adjacent cork-cells (Fig. I, 6–7). Bases of inconspicuously pointed prickles sometimes filled with silica and then easily mistaken for oblong silica-bodies (Fig. I, 10). **Macro-hairs:** none seen. **Micro-hairs:** length 58–66 μ; basal cells 42–48 μ; distal cells 16–21 μ; basal cells v. wide and inflated; distal cells tapering to pointed apices; rather a distinctive type. **Prickle-hairs:** appendages resembling small prickles (Fig. VI, 1) or large hooks (Fig. VI, 5) abundant over the veins (see also under

'silica-bodies'). **Stomata** with low (Fig. IV, 3), to fairly tall (Fig. IV, 4), dome-shaped subsidiary cells. **Long-cells:** outlines of those in the stomatal strips obscured by papillae; long-cells mostly interstomatal, with concave ends (Fig. V, 10–11).

T.S. lamina

Vascular bundles: most vb's fairly large and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with slight, wide ribs with rounded or flattened apices separated from one another by narrow, shallow furrows (Fig. XIV, 2). **Sclerenchyma:** small vb's with adaxial girders about 5–9 cells wide and 2–3 cells high, and abaxial girders mostly 4–5 cells wide and 3–4 cells high (Fig. IX, 4); some of the adaxial girders extending laterally beneath the epidermis of the ribs to become anchor-shaped. Large vb's with similar, but somewhat wider, adaxial and abaxial girders (Fig. IX, 5). **Midrib** not clearly defined. **Mesophyll:** chlorenchyma not radiate; consisting of arm-cells. A fusoid-cell present on either side of each small vb and on either side of each of a few of the large vb's. **Bulliform cells** in groups of the *Sporobolus* type (Fig. XV, 8) at the bases of the shallow furrows, each group penetrating rather deeply into the mesophyll; apices of the bulliform cells projecting slightly above the general level of the epidermis. **Bundle-sheaths** double; complete round all of the small vb's (Fig. XII, 1), and sometimes with girder-like extensions to the adjacent scl.; cells of both sheaths round the large vb's highly lignified and merging with the adjacent scl. strands.

MATERIAL EXAMINED: Andre 4499; Ecuador.

***Neurolepis nobilis (Munro)* Pilger**

LEAF

Abaxial epidermis

Short-cells, over the veins, solitary and paired; abundant over, but infrequent or absent between, the veins. **Silica-bodies,** over the veins, often fitting into concavities in adjacent cork-cells (Fig. I, 6–7); rather variable in shape, sometimes tall and narrow (Fig. I, 4), or, more frequently, tall and somewhat crescent-shaped. **Macro-hairs:** none seen. **Micro-hairs:** length 42–70 (mostly 42–66) μ; basal cells 28–38 μ; distal cells 10–40 μ; basal cells v. wide and with an inflated appearance, but sometimes tapering towards their proximal ends; distal cells v. variable in appearance in the available material, generally tapering slightly towards their apices, and rather narrower than the basal cells, but sometimes hemispherical. **Prickle-hairs:** shortly pointed prickles (Fig. VI, 1–2), with swollen bases, common over, and immediately on either side of, the veins; hooks (Fig. VI, 5) occasional in the intercostal zones. **Papillae:** small, variously shaped, cuticular warts (Fig. III, 5) abundant in the stomatal strips and sometimes overarching the stomata. **Stomata** with low (Fig. IV, 3) to fairly tall (Fig. IV, 4) dome-shaped, or sometimes triangular (Fig. IV, 1), subsidiary cells. **Long-cells,** over the veins, with thick or sinuous (Fig. V, 1*a–b*) walls, the cells sometimes tending to be hexagonal; some of those between the veins shorter and wider, with

sinuous outlines. Most cells in the stomatal strips with concave ends (Fig. V, 10–11).

T.S. lamina

Vascular bundles: small vb's not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with slight, mostly rounded ribs of rather variable width, separated from one another by shallow, narrow furrows (Fig. XIV, 2). **Sclerenchyma:** small vb's with adaxial girders about 4–10 cells wide and about 8 cells high, the corresponding abaxial girders being about the same size or slightly wider (Fig. IX, 5); large vb's with similar, but slightly wider, adaxial and abaxial girders. Midrib supported both adaxially and abaxially by plates of scl. subjacent to the epidermis. **Midrib** v. conspicuous, and broad; containing a complex adaxial and abaxial series of vb's as in the bamboos, the adaxial vb's being small and embedded in the adaxial scl. plate. **Mesophyll:** chlorenchyma not radiate, consisting of arm-cells. A v. large fusoid-cell, occupying most of the space between the adaxial and abaxial epidermis, present on either side of each vb. **Bulliform cells** in groups of the *Sporobolus* type (Fig. XV, 8), each group penetrating deeply into the mesophyll, and situated above the mesophyll tissue lying between the 2 fusoid-cells in each intercostal zone. **Bundle-sheaths** double; many small vb's each with 2 complete sheaths (Fig. XII, 1); all small and some large vb's in the midrib region with the I.S. complete and the O.S. connected to the adaxial scl. by a broad extension of large, colourless cells (Fig. XII, 4); large vb's elsewhere in the lamina with the O.S. interrupted adaxially and abaxially (Fig. XII, 3*a*).

MATERIAL EXAMINED: Purdie; Colombia.

SPECIAL NOTES

The fusoid-cells and arm-cells in the mesophyll, the complex vascular system of the midrib, and the papillae in the stomatal zones, suggest affinities with the bamboos.

Freier (1945) has also drawn attention to the fact that the leaf anatomy of *Neurolepis* resembles that of the bamboos.

LITERATURE

Freier 1945 (leaf).

NEYRAUDIA

Conert (1959*b*) notes in *Neyraudia madagascariensis* (Kunth) Hook. f.: micro-hairs as in Fig. VII, 7; silica-bodies mostly dumb-bell shaped but sometimes rounded, elliptical and occasionally cross- or saddle-shaped; double bundle-sheaths. The genus, like *Cleistogenes*, is treated as belonging to the Eragrosteae.

LITERATURE

Conert 1959*b* (leaf and taxonomy); Prat 1936 (leaf).

OLYRA

Diagnostic Generic Characters

Short-cells, over the veins, occasionally solitary or paired, but mostly in long rows. Silica-bodies, over the veins, mostly saddle-shaped, but some tending to be cross-shaped or of the *Oryza* type. Micro-hairs present; rather uniform in diameter throughout their lengths; each with an apically rounded distal cell. Stomata with triangular subsidiary cells. Vascular bundles rather widely spaced; none conspicuously angular in outline. Mesophyll with chlorenchyma not radiate; consisting of arm-cells; partly composed of fusoid-cells. Bundle-sheaths double.

Species Specially Examined

***Olyra latifolia* L.**

A large cane-like grass up to 10 ft. high, occurring in or near forests.

Leaf

Abaxial epidermis

Short-cells, between the veins, mostly solitary and paired; those over the veins occasionally solitary or paired, but mostly in long rows; abundant both over and between the veins. **Silica-bodies,** over the veins, mostly saddle-shaped (Fig. I, 9), but some tending to be more nearly cross-shaped (Fig. IA, 16), or even of the *Oryza* type (Fig. IB, 23); those between the veins tall, narrow, and crenate (Fig. IB, 24). **Macro-hairs:** none seen in slides examined by the author, but Grob (1896) refers to cushion hairs in this sp. **Micro-hairs:** length 57–77 (mostly 60–72) μ; basal cells 33–42 μ; distal cells 24–36 μ; hairs rather uniform and narrow in diameter throughout their lengths; distal cells with rounded apices (Fig. VII, 7 and 8). **Prickle-hairs:** prickles (Fig. VI, 1–2) and hooks (Fig. VI, 5) occasional over and between the veins respectively. **Stomata** with triangular (Fig. IV, 1) subsidiary cells. (Grob (1896) refers to the presence of papillae.) **Long-cells,** between the veins, rather short and with v. marked, rather widely spaced sinuations (Fig. V, 6); interstomatal cells also with v. sinuous outlines and concave ends (Fig. V, 10–11). **Transverse veins** numerous.

T.S. lamina

Vascular bundles: small vb's rather widely spaced and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. V, 15). **Adaxial surface** practically smooth (Fig. XIV, 1), apart from a prominent rib over the midrib. **Sclerenchyma:** small vb's accompanied by adaxial and abaxial girders (Fig. IX, 4), the combined girders often appearing somewhat anchor-shaped (Fig. IX, 6), the adaxial portions being mostly 2–3, but occasionally up to 6, cells wide and usually 2–3, or occasionally more, cells high, and the abaxial portion 9–15 cells wide and about 3–5 cells high. Combined girders to the large vb's mostly tending to be anchor-shaped, but rather wider. **Midrib:** conspicuous owing to adaxial and abaxial projections; containing 1 large median vb accompanied v. closely on either side by a smaller lateral, the vascular

structure resembling a v. simple form of the bamboo type. **Mesophyll:** chlorenchyma not radiate; consisting of arm-cells. A v. long, narrow, fusoid-cell present on either side of each vb. **Bulliform cells** mostly in rather wide, fan-shaped groups (Fig. XV, 4); some of the groups towards the midrib tending to be more as in Fig. XV, 2; cells often with thick outer walls. **Bundle-sheaths** double; most small vb's with 2 complete sheaths (Fig. XII, 1); large vb's with I.S. complete but O.S. usually interrupted adaxially and abaxially (Fig. XII, 3*a*).

Culm

Culm examined 0·5 cm in diameter. Centre of the culm occupied by a large cavity. Epidermis appearing in T.S. as tall, thick-walled cells, accompanied on the inner side by a somewhat interrupted layer of thick-walled fibres of appreciably smaller diameter. Fibrous layer followed by a zone of about 3 layers of assimilatory cells bounded on the inner side by a second zone of about 6 layers of scl. tissue, gradually passing over to the larger cells of the inner ground tissue extending to the hollow centre of the culm. Vb's scattered throughout the inner ground tissue, the outermost being smaller than the remainder and abutting directly on to the inner scl. ring.

Material Examined: Meikle 1267; Nigeria.

Additional Information from the Literature

The facts about *O. latifolia* and *O. floribunda* Raddi (= *Raddia brasiliensis* Bertol., see p. 418) recorded by Brandis (1907) are similar to those given for *O. latifolia* above. Page (1947), who examined *O. heliconia* Linderm. states that the leaf of this sp. exhibits most of the characters for bamboo leaves listed by Brandis; the midrib contains 2 or more vb's. Jacques-Félix (1955) also draws attention to the 'bambusoid' structure of the leaf.

Muller (1889) has described in some detail and illustrated the occurrence of vb's that lie free in the central cavities in the internodes of a grass to which he refers as a sp. of *Olyra*.

Literature

Brandis 1907 (leaf); Grob 1896 (leaf); Jacques-Félix 1955 (leaf); Muller 1889 (free vb's in the hollow centre of the culm); Page 1947 (leaf).

OPLISMENUS

Diagnostic Generic Characters

Short-cells, over the veins, mostly in long rows. Silica-bodies, over the veins, cross to dumb-bell shaped or sometimes nodular. Micro-hairs present; either of uniform diameters throughout their lengths and with rounded apices, or each with the distal cell tapering to a pointed apex. Stomata with triangular, or low dome-shaped, subsidiary cells. Vascular bundles; small ones mostly rather widely spaced and conspicuously angular in outline. Mesophyll of a distinctive type; see B on p. 335. Bundle-sheaths single and double.

Species Specially Examined

A. *Oplismenus compositus* (L.) P. Beauv.

Leaf

Abaxial epidermis

Short-cells, between the veins, mostly solitary but sometimes paired; those over the veins mostly in rows of more than 5 cells; abundant. **Silica-bodies,** between the veins, cross-shaped (Fig. Ia, 16), but with a distorted appearance, usually with rather long arms to the crosses; those over the veins cross-shaped, intermediate between cross and dumb-bell shaped (Fig. Ia, 17), dumb-bell shaped (Fig. Ia, 18 (ii–v)) (these last often varying in outline with the focus (Fig. Ib, 21)), or nodular (Fig. Ia, 18 (i)). **Macro-hairs:** none seen. **Micro-hairs:** length 46–59 μ; basal cells 20–29 (mostly 24–29) μ; distal cells 25–33 (mostly 25–30) μ; distal cells sometimes tapering towards their pointed apices, or more uniform in diameter throughout their lengths and with rounded apices (Fig. VII, 6 and 7). **Prickle-hairs:** none seen. **Stomata** with triangular (Fig. IV, 1), slightly triangular, or low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells** rather short, or tending to be cubical, with slightly to moderately sinuous walls (Fig. V, 7*a–b*).

T.S. lamina

Vascular bundles: most vb's small, polygonal (Fig. VIII, 5), and rather widely spaced; a few large vb's of basic type (Fig. VIII, 15). **Adaxial surface** practically smooth (Fig. XIV, 1), apart from about 3 fairly prominent ribs on either side of the midrib. **Sclerenchyma:** all small vb's with adaxial and abaxial strands or sometimes girders (Fig. IX, 4), the adaxial strands or girders being mostly 2–6 cells wide and 1–2 cells high throughout most of the lamina, but up to about 10 cells wide and 5 cells high in the adaxial ribs near the midrib. Corresponding abaxial girders often slightly wider than, but about the same height as, the adaxial girders. Large vb's with adaxial strands or girders 4–5 cells wide and seldom more than about 2 cells high, the corresponding abaxial girders being up to about 15 cells wide and 5 cells high (Fig. IX, 5). Combined girders to the large vb's tending to be anchor-shaped (Fig. IX, 6). **Midrib** conspicuous owing to an abaxial, and a less pronounced adaxial, projection; containing 1 median vb, the next nearest laterals being opposite the adaxial ribs on either side of the midrib. **Mesophyll:** see B. **Bulliform cells** rather variable, most groups as in Fig. XV, 2 but rather long; some groups more of the *Zea* type (Fig. XV, 3). **Bundle-sheaths** single and double; each small vb surrounded by a single complete sheath (Fig. XI, 2*a*), the component cells being v. unequal in size; sheaths sometimes connected to, and forming girders with, the adaxial and abaxial scl. by narrow extensions of colourless cells. Infrequent large vb's each surrounded by 2 complete sheaths (Fig. XII, 1), the O.S. sometimes being connected to, and forming girders with, the adaxial and abaxial scl.

Culm

Culm examined 2 mm in diameter; with slight ribs and furrows around the circumference. Outermost vb's almost immediately subjacent to the epidermis and embedded in scl. strands. Epidermis subtended by 1–3 layers of assimilatory cells alternating with strands of scl. Assimilatory tissue bounded on the inner side by a rather weak ring of scl. connecting the scl. girders, already mentioned, to one another. Inner ground tissue consisting of large, thin-walled cells, even the centre of the culm being occupied by rather spongy tissue. Vb's consisting of those of the outermost circle embedded in the peripheral scl. girders, the remainder being in 2 rather irregular circles in the peripheral part of the thin-walled ground tissue, a few vb's penetrating more deeply towards the centre of the culm.

Material Examined: F. Ballard 1002; Ceylon.

B. *Oplismenus compositus* (L.) P. Beauv.

Leaf

Abaxial epidermis

As A apart from the following points. Intercostal **silica-bodies** rather less numerous. **Macro-hairs:** rather short, stiff hairs with deeply sunken bases, which are sometimes constricted and often with bulbous endings (Fig. II, 2 and 3), common in the intercostal zones; bases of the hairs surrounded by bulliform cells. Similar hairs also present on the adaxial surface. **Micro-hairs:** length 38–56 (mostly 48–54) μ; basal cells 20–25 μ; distal cells 20–33 μ; distal cells occasionally tapering slightly to their pointed apices, but, more commonly, not tapering so much and with rounded apices. **Prickle-hairs:** pointed, angular prickles (Fig. VI, 3) abundant at the leaf margins.

T.S. lamina

As A apart from the following points. **Adaxial surface** practically smooth (Fig. XIV, 1), apart from 1 or 2 slight ribs on either side of the midrib. **Sclerenchyma:** abaxial girders to the large vb's up to about 20 cells wide. **Mesophyll** more completely preserved than in A, and of a distinctive type; cells next to the bundle-sheaths at the xy. end of each vb. exhibiting a rather conspicuous radiate arrangement; cells immediately subjacent to the bulliform cells palisade-like; cells towards the abaxial surface of the lamina irregularly arranged. (Material examined was rather imperfectly preserved, but it looked as if the chloroplasts are mainly concentrated in the irregularly arranged cells towards the abaxial surface of the leaf, but this needs confirmation.)

Culm

V. similar to A, but peripheral ribs less developed and large vb's less markedly in 2 circles.

Material Examined: Specially collected by R. E. Vaughan in Mauritius.

Additional Information from the Literature

Grob (1896) refers to the occurrence of cushion hairs over the parenchyma and amongst the bulliform cells in *O. undulatifolius* (Ard.) Beauv. The other facts that he records about this sp. agree closely with those for *O. compositus* given above.

Special Note

Prat (1936) rightly indicates that the leaf structure is panicoid.

Literature

Grob 1896 (leaf); Prat 1936 (leaf).

ORCUTTIA

Diagnostic Generic Characters

Short-cells, over the veins, in long rows; infrequent or absent between the veins. Silica-bodies mostly intermediate between cross and dumb-bell shaped, or sometimes nodular. Micro-hairs present as long-stalked, somewhat sunken, glandular hairs with spherical unicellular heads. Stomata with tall dome-shaped subsidiary cells. Vascular bundles; small vb's somewhat angular in outline. Mesophyll with radiate chlorenchyma. Bundle-sheaths usually double, but I.S. not always conspicuous.

Species Specially Examined

***Orcuttia pilosa* Hoover**

Leaf

Abaxial epidermis

Short-cells, over the veins, in rows of more than 5 cells; abundant over, but infrequent or absent between, the veins. **Silica-bodies,** over the veins, mostly intermediate between cross and dumb-bell shaped (Fig. IA, 17) with rounded or concave ends, or sometimes nodular (Fig. IA, 18 (i)). **Macro-hairs:** v. long, rigid macro-hairs with pointed apices and sunken, constricted bases (Fig. II, 3) rather sparsely present in the intercostal zones. Longer hairs sometimes appearing uniseriate with occasional transverse septa, but these may be no more than constrictions in the hairs. Shorter, stiff hairs present at the leaf margins. Solitary, stalked glands with unicellular, spherical heads present in pits (Fig. IIA, 9); fairly numerous. **Micro-hairs:** see macro-hairs; the glands could be classified as micro-hairs because 2-celled. **Prickle-hairs:** prickles (Fig. VI, 1–2) common over the veins. **Papillae:** oblique papillae (Fig. III, 2), usually 1 per cell, present on most of the intercostal long-cells. Similar papillae also on the adaxial surface. **Stomata** with fairly tall to tall (Fig. IV, 4) dome-shaped subsidiary cells. **Long-cells,** between the veins, rather short, with smooth, or not more than v. slightly sinuous walls.

T.S. lamina

Vascular bundles: small vb's with the xy. and ph. not v. clearly differentiated from one another, the xy. and ph. being narrow and somewhat angular in outline (Fig. VIII, 1 and 4). Large vb's of basic type (Fig. VIII, 15). **Adaxial surface** practically smooth, apart from slight ribs over the vb's (Fig. XIV, 1 and 2). Abaxial surface almost equally ribbed. **Sclerenchyma:** some small vb's not accompanied by scl. (Fig. IX, 1), but mostly accompanied by strands up to about 10 cells wide and not more than 2 cells high. Large vb's with adaxial

and abaxial strands, or occasionally girders, up to about 14 cells wide, but seldom more than 2 cells high (Fig. IX, 4 and 5). Scl. scanty at the leaf margins. **Midrib** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll** with radiate chlorenchyma. **Bulliform cells** and subjacent colourless cells forming girders extending from the adaxial to the abaxial epidermis (Fig. XV, 13). **Bundle-sheaths** double; most vb's with 2 complete sheaths (Fig. XII, 1), but I.S. not always conspicuous.

Culm

Culm examined about 2 mm in diameter. Epidermis of small cells contrasting with 6–10 subjacent layers of much larger, thin-walled, parenchymatous cells with their long axes parallel to that of the culm. Zone of large cells bounded on the inner side by about 8 layers of narrower, longer, and more fibre-like cells. Ground tissue consisting of thin-walled cells, from the fibrous zone inwards to the solid although somewhat spongy tissue at the centre of the culm. Vb's restricted to a zone bounded on its outer side by the fibrous ground tissue, and on its inner side by the spongy ground tissue at the centre of the culm. Large metaxylem vessels of the vb's not v. conspicuous, being of about the same diameters as the cells of the ground tissue immediately around the vb's (cf. *Neostapfia*). (This type of culm structure is rather distinctive (i) because there is no fibrous zone immediately below the epidermis, and (ii) because the vb's are concentrated in a single zone, there being no outer zone of small bundles as in most grasses.) Culm bearing stalked glands similar to those of the leaf, only the bases of the stalks being sunken below the level of the epidermis. Stalks of these glands occasionally 2–3-celled. Culm flattened or slightly concave on one side near the nodes, the fibrous ground tissue here extending outwards to the epidermis.

Material Examined: Collected specially by L. Mann and G. L. Stebbins in California.

Special Note

Orcuttia shows several interesting resemblances to the related *Neostapfia* (p. 651).

Literature

Crampton 1959.

OROPETIUM

Diagnostic Generic Characters

Short-cells, over the veins, in long rows. Silica-bodies, over the veins, usually saddle-shaped, at least in part, but cuboid and cross-shaped types also recorded. Micro-hairs present; each with the basal cell considerably tapered at the proximal end; distal cells normally hemispherical; hairs occasionally unicellular. Stomata with triangular subsidiary cells. Vascular bundles mostly conspicuously angular in outline. Mesophyll with distinctly radiate chlorenchyma. Bundle-sheaths single; dome-shaped.

Species Specially Examined

***Oropetium thomaeum* (Linn. f.) Trin.**

Leaf

Abaxial epidermis

Short-cells, over the veins, in rows of more than 5 cells; abundant over, but infrequent or absent between, the veins. **Silica-bodies** saddle-shaped (Fig. I, 9). **Macro-hairs:** fairly long, stiff hairs with swollen, constricted bases occasional in the intercostal zones, the bases being surrounded by specialized epidermal cells (Fig. IIA, 5). Rather similar hairs, but with their bases less deeply sunken, present on the apices of the adaxial ribs. **Micro-hairs:** length 16–20 μ; basal cells 7–11 μ; distal cells 6–9 μ; basal cells tapering considerably towards their proximal ends; distal cells normally hemispherical, but many distorted in the available material (Fig. VII, 2); hairs occasionally apparently unicellular (Fig. VII, 1). **Prickle-hairs:** angular prickles (Fig. VI, 3), rather infrequent and inconspicuous, present at the leaf margins. **Stomata** with triangular (Fig. IV, 1) subsidiary cells. **Long-cells,** between the veins, with moderately thick, pitted or sinuous walls (Fig. V, 1*a–b*).

T.S. lamina

Blade narrow and U-shaped in T.S. **Vascular bundles:** most vb's angular in outline (Fig. VIII, 5); a few large vb's of basic type (Fig. VIII, 15), but with the metaxylem vessels of small diameter. **Adaxial surface** with about 9 pronounced ribs with rounded apices separated from one another by deep, fairly narrow, U- or V-shaped furrows (Fig. XIV, 5). Shallow furrows also present on the abaxial surface opposite all of the vb's except the median one. **Sclerenchyma:** most vb's, apart from those in the leaf margins, with adaxial girders 4 cells wide and high, and much wider abaxial girders. Abaxial girders each consisting of 2 parts separated from one another by a groove in the abaxial surface of the leaf, each partial abaxial girder being some 6–12 cells wide and 2–4 cells high. Abaxial girder associated with the median vb less completely divided into 2 parts by an abaxial groove, the single girder being nearly 40 cells wide and some 5 cells high. Combined adaxial and abaxial girders appearing to be anchor-shaped (Fig. IX, 6), but with the 2 arms of each anchor separated from one another by the abaxial grooves. **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma distinctly radiate. **Bulliform cells** in somewhat fan-shaped groups (Fig. XV, 6) at the bases of the adaxial furrows; sometimes connected to the abaxial epidermis by girders of colourless cells. **Bundle-sheaths** single; sheaths interrupted abaxially by the grooves on the abaxial surface of the leaf, the sheaths themselves appearing dome-shaped.

Culm

Culm examined less than 1 mm in diameter; slightly flattened on 1 side. Epidermis subtended by 1, or in some places 2, layers of assimilatory cells, except on the flattened side of the culm. A ring of scl., up to some 8 cells wide, present on the inner side of the assimilatory tissue, and immediately

beneath the epidermis on the flattened side of the culm. Centre of the culm occupied by thin-walled, somewhat spongy, ground tissue. Vb's mostly at the inner boundary of the scl. ring, but 2 vb's penetrating rather deeply into the central ground tissue.

Material Examined: F. Ballard 1458; Ceylon.

Additional Information from the Literature

Jacques-Félix (1955) has recorded the following information concerning the leaf of *O. aristatum* (Stapf) Pilger (correctly *Lepturella aristata* Stapf), a small annual.

Abaxial epidermis

Short-cells, over the veins, in long rows; much less frequent between the veins and paired or solitary. Silica-bodies, over the veins, figured as more or less cuboid but with a slight tendency to be saddle-shaped. Micro-hairs of the chloridoid type (as Fig. VII, 2) present between the veins. Prickles restricted to the adaxial surface above the median vein. Epidermis of basal leaves similar, but prickles absent.

T.S. lamina

Vb's 9–11 in number. Adaxial surface ribbed. Scl. as small adaxial girders to most, and much larger abaxial girders to all, vb's. Mesophyll with radiate chlorenchyma next to the O.S. Bulliform cells forming more or less fan-shaped groups at the bases of the adaxial furrows, many of the groups being connected to the abaxial epidermis by girders of colourless cells. Bundle-sheaths double; O.S. dome-shaped in T.S., each sheath being widely interrupted by the large girder of scl. on the abaxial side of the vb.

Hansen and Potztal (1954) give these notes on *O. africanum* (Coss. & Dur.) Pilger, a sp. which should be in *Tripogon*. Silica-bodies described as cross- to saddle-shaped and illustrated as being cross-shaped, but with no deep indentations between the arms. Stiff macro-hairs (Borstenhaare) present, each with a basal sheath of epidermal cells. Micro-hairs present; illustrated as being similar to those in Fig. VII, 2. Sclerenchyma: each vb. accompanied by a small adaxial strand or girder about 3 cells tall and 5 cells wide, and by a much wider abaxial girder of about the same height. Mesophyll: chlorenchyma conspicuously radiate. Bulliform cells in groups more or less of the *Sporobolus* type (Fig. XV, 8), connected to the abaxial surface by girders of colourless cells (Fig. XV, 13). Bundle-sheaths single; shown in a figure as dome-shaped, owing to each sheath being interrupted abaxially by a wide girder of scl.

Special Notes

Jacques-Félix (1955) regards the dome-shaped O.S. as highly characteristic of the genus. Similar bundle-sheaths have been noted by the present writer in *Perotis* and *Gymnopogon*.

Jacques-Félix regards the leaf characters of *Oropetium* as in some respects intermediate between the chloridoid and festucoid groups.

Hansen and Potztal (1954) treat *Oropetium* as a member of the Leptureae.

Literature

Grob 1896 (leaf); Hansen and Potztal 1954 (leaf); Jacques-Félix 1955 (leaf); Prat 1932 (leaf); Sabnis 1921 (ecological anatomy).

ORTHOCLADA

Prat (1936), who treats *Orthoclada* as being closely related to *Centotheca*, states that the structure of the leaf epidermis is panicoid, and that the anatomy of the leaf is sometimes panicoid and sometimes festucoid.

Literature

Prat 1936 (leaf).

ORYZA

Diagnostic Generic Characters

Short-cells, over the veins, mostly in long rows, but pairs also noted. Silica-bodies, over the veins, mostly of the *Oryza* type, but those in paired short-cells rounded to crescent-shaped and fitting into concavities in adjacent cork-cells. Micro-hairs present; rather short; each with the distal cell of uniform diameter throughout its length and with a rounded apex, or tapered to a more pointed apex. Stomata mostly with triangular, but some with low dome-shaped, subsidiary cells. Vascular bundles; none conspicuously angular in outline. Mesophyll with chlorenchyma not radiate; consisting of arm-cells. Bundle-sheaths double.

Species Specially Examined

Oryza sativa* L. var. *violacea

Leaf

Abaxial epidermis

Short-cells, over the veins, mostly in rows of more than 5 cells, but pairs also present over some of the veins; abundant over, but v. infrequent or absent between, the veins. **Silica-bodies** mostly of the *Oryza* type (Fig. Ib, 23), but those in paired short-cells (especially between the veins) sometimes fitting into concavities in adjacent cork-cells (Fig. I, 6–7), and rounded or crescent-shaped in outline. **Macro-hairs:** none seen. **Micro-hairs:** length 26–39 μ; basal cells 12–15 μ; distal cells 14–24 (mostly 14–22) μ; hairs v. narrow; distal cells either uniform in diameter throughout their lengths and with rounded apices, or tapering slightly to more pointed apices. **Prickle-hairs:** small prickles (Fig. VI, 1) with rather long points, and transitions between these and short, superficial macro-hairs, rather infrequent in the intercostal zones. **Papillae:** a combination of small cuticular papillae, and a few larger, more inflated papillae (Fig. III, 4), present on the long-cells. **Stomata** predominently with triangular (Fig. IV, 1), but a few with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells** with thin, sinuous walls (Fig. V, 3*a–c*), the sinuations being v. marked and rather widely spaced.

T.S. lamina

Vascular bundles: vb's in the lamina, except those in the large adaxial ribs and near the leaf margins, not conspicuously angular in outline (Fig. VIII, 2); large vb's in the tall ribs of basic type (Fig. VIII, 15). **Adaxial surface** with ribs of 2 distinct sizes, those over the small vb's being low, fairly wide, with rounded apices, and separated from one another by much narrower, shallow, furrows (Fig. XIV, 2). Ribs over the large vb's at least twice as tall as the remainder (Fig. XIV, 4–5). **Sclerenchyma:** most vb's with small adaxial and abaxial girders (Fig. IX, 4), those that are adaxial being 5–6 cells wide and 1–2 cells high, or occasionally slightly larger, the abaxial girders being up to about 8 cells wide and mostly 2 cells high. Large vb's with adaxial and abaxial girders up to some 15 cells wide and 2–3 cells high. Adaxial vb's in the midrib supported by adaxial scl. girders, and the abaxial vb's by abaxial girders. **Midrib** conspicuous, owing to a prominent, rounded, abaxial, and a less pronounced, flattened, adaxial projection; containing a number of vb's arranged more or less as shown in Fig. XIII, 6, but none present in the vertical septum between the 2 large air-canals occupying a large part of the midrib. (Diaphragms stated to occur in the canals (Pée-Laby 1898, &c.).) **Mesophyll:** chlorenchyma not radiate; consisting of arm-cells. **Bulliform cells** mostly in fan-shaped groups (Fig. XV, 4) in the adaxial furrows, but some groups tending to be of the *Sporobolus* type (Fig. XV, 8). Tissue surrounding the air-canals in the midrib consisting of colourless cells. **Bundle-sheaths** double; most vb's, apart from those in the midrib, with 2 complete sheaths, the I.S. being rather inconspicuous and the O.S. often with an extension of colourless cells to form girders with the adjacent adaxial scl. O.S. of vb's in the midrib often merging with the colourless cells, and usually interrupted adaxially or abaxially by scl.

Culm (Fig. XXI, 3)

Culm examined about 4 mm in diameter, the T.S. being somewhat oval in outline. Epidermis subtended by 2–3 layers of thick-walled fibres of small diameter. Remaining ground tissue consisting of rather more than 20 layers of rounded to slightly polygonal, thin-walled cells. Centre of the culm occupied by a large cavity. A circle of conspicuous intercellular cavities, of unequal sizes and variable outlines, present in the thin-walled ground tissue. Vb's fairly widely spaced, and mostly arranged in 2 distinct circles, the outer circle being close to, or only a few cells below, the peripheral scl., and the inner circle in the ground tissue between the circle of intercellular spaces and the hollow centre of the culm.

Material Examined: Cultivated at Kew.

Additional Information from the Literature

1. Leaf

Schweickerdt and Marais (1956) noted the following characters, amongst others, in the leaf of *O. barthii* A. Chev. Silica-bodies of the *Oryza* type. Bristle-hairs present on the keel. Lamina 10–12 cells thick including the epidermis on both surfaces. Abaxial surface of the leaf smooth; adaxial surface with ribs and furrows. Vb's of 3 distinct orders. Midrib containing 'superimposed' vb's. Mesophyll with chlorenchyma not radiate and consisting of arm-cells.

2. Culm

Hedayetullah and Chakravarty (1942) found the mechanical tissue (scl.) to be more fully developed in the culms of wild than of cultivated forms of rice.

In a later paper (1948) the same authors found that 6 varieties of transplanted paddy exhibited a constant type of tiller structure, but they noted a marked variation in the number and dimensions of the constituent cells.

Bugnon (1920), by means of serial sections, demonstrated that the transverse bundles in a node of *O. sativa* arise from leaf-trace bundles whose course deviates from the longitudinal in the nodal region.

3. Rhizome

Schweickerdt and Marais (1956) in *O. barthii* note well-developed intercellular spaces in the ground tissue; the lack of a typical endodermis; the occurrence of compound starch grains.

4. Root

Boeke (1940) indicates that intercellular spaces in the roots of rice originate shortly behind the growing point by 'intramembranous rupture' along the middle lamella. These initially small air-cavities become enlarged some 20 mm or more behind the growing point. Later the spaces are enlarged still further when the radial walls of previously contiguous cells come apart, and at the same time the cells themselves shrink. Boeke was unable to determine why the cells do not become separated from one another along their tangential walls.

5. Embryo and Seedling

According to Yung (1938), the rice embryo is in many ways similar to that of the oat. The scutellum is interpreted as the cotyledon. The epiblast, central scale, and coleorhiza are devoid of vascular tissue. The seedling has but one primary root, with a hexarch, radial protostele. The first internode contains 4 vb's. (See also other references under 'Literature'.)

6. Chemical Identification of Hulled Rice

Kondo and Kashara (1941) found that differences in the readiness with which entire or broken kernels of hulled rice become disintegrated when treated with aqueous solutions of caustic potash could be used for the identification of cultivated varieties of rice. Whole kernels were treated with a 2·38 per cent. solution at 20–25° C for 24 hours, 1·7 and 1·8 per cent. solutions being used for 'polished rice' and 'broken kernels' respectively. Tests were applied to 145 varieties, and 'blue rice' and 'dead rice' were found to disintegrate more rapidly than 'new rice'.

Special Notes

Prat (1936) points out that the leaf epidermis is panicoid and that the mesophyll and bundle-sheaths are festucoid. To the present writer, however, the occurrence of arm-cells in the mesophyll and the presence of the characteristic oryzoid silica-bodies, together with the presence of micro-hairs, afford ample evidence that there is no close connexion with the Festuceae. Apart from the lack of fusoid-cells the leaf structure more nearly recalls that of the bamboos. This affinity is also supported by the complex vascular system in the midrib with the 'superimposed' vb's.

This affinity between *Oryza* and the bamboos was also noted by Schweickerdt and Marais (1956) in the course of their work on *O. barthii* A. Chev. They also draw attention to the similarity between this sp. and *Potamophila prehensilis* (Nees) Benth. (see also p. 409).

Literature

Boeke 1940 (intercellular spaces in rice root); Bugnon 1920 (nodal anatomy); Chalam 1942 (shedding characters of rice grain); Chauveaud 1897 (notes on root ph.); Colomb 1887 (vascular strands in ligule); D'Ippolito 1904 (general structure of rice plant); Duong-Huu-Thoi 1941 (structure of rice plant and seedling); Duval-Jouve 1875 (leaf of rice); Grob 1896 (leaf epidermis); Hedayetullah and Chakravarty 1942 (mechanical tissue in culm of rice), 1947, 1948 (small quantitative differences between rice varieties); Hohenauer 1893 (course of bundles in culm); Holm 1896*a* (rice leaf); Jones and Merritt 1942 (adventitious roots on rice panicles); Kondo and Kashara 1941 (identification of rice varieties by treatment of grain with KOH solutions); Majumdar and Biswambahr 1956 (nodes); Pée-Laby 1898 (rice leaf); Prat 1932, 1936 (leaf epidermis and taxonomy); Schlickum 1896 (rice seedling; very detailed); Schweickerdt and Marais 1956 (leaf of *O. barthii*); Sharman 1947 (stem apex); Weatherwax 1928 (general taxonomy); Yung 1938 (seedling anatomy).

ORYZOPSIS

Diagnostic Generic Characters

Short-cells, over the veins, paired or in short or long rows, in different spp. Silica-bodies, over the veins, fitting into concavities in adjacent cork-cells, and mostly oval, rounded, or slightly crescent-shaped; silica-bodies in rows cross to dumb-bell shaped, or occasionally nodular. Micro-hairs absent. Stomata with low, or tall, dome-shaped subsidiary cells. Vascular bundles; none conspicuously angular in outline. Mesophyll with chlorenchyma not more than inconspicuously radiate, and sometimes not radiate. Bundle-sheaths double.

Species Specially Examined

***Oryzopsis asperifolia* Michx.**

Leaf

Abaxial epidermis

Short-cells, both over and between the veins, paired; abundant; a few of those over the veins in short rows. **Silica-bodies** mostly fitting into concavities in adjacent cork-cells (Fig. I, 6–7), and mostly oval, rounded, or slightly crescent-shaped in outline; a few oblong (Fig. I, 10). Crescent-shaped bodies frequently rather tall and narrow. **Macro-hairs:** short, stiff, thick-walled hairs (Fig. IIA, 10) numerous on the adaxial ribs. **Micro-hairs:** none seen. **Prickle-hairs:** prickles (Fig. VI, 1–2) present, and angular prickles (Fig. VI, 3) occurring at the leaf margins. **Stomata** with low (Fig. IV, 3), or moderately tall (Fig. IV, 4), dome-shaped subsidiary cells. **Long-cells,** both over and between the veins, with thick, pitted or sinuous walls (Fig. V, 1*a–b*); each consecutive long-cell in a single file being separated from the next by a pair of short-cells v. markedly at right angles to the horizontal walls.

T.S. lamina

Vascular bundles: most vb's small and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 10 and 11). **Adaxial surface** with well-developed, comparatively wide ribs, separated from one another by narrow, V-shaped furrows (Fig. XIV, 4). Most ribs with flattened apices, but a few distinctly smaller than the others and rounded; a low rib between 2 taller ones causes the associated furrows to be W-shaped. **Sclerenchyma:** vb's opposite the low ribs occasionally with well-marked abaxial girders only (Fig. IX, 3); most vb's with adaxial and abaxial girders much taller than wide (Fig. IX, 7), the adaxial girder being T- and the abaxial girder I-shaped (Fig. IX, 8). Large vb's also with similar, but wider, girders. **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma probably not truly radiate, but appearing to be rather indistinctly radiate owing to the most adaxial of the assimilatory cells in the ribs being somewhat palisade-like. **Bulliform cells** in fan-shaped groups (Fig. XV, 4) at the bases of the furrows. **Bundle-sheaths** double; most vb's with I.S. complete and O.S. interrupted adaxially and abaxially (Fig. XII, 3*a–b*).

MATERIAL EXAMINED: Cultivated at Kew.

Oryzopsis paradoxa (L.) Nutt.

LEAF

Abaxial epidermis

Short-cells between, and a few of those over, the veins, paired; those over the veins mostly in rows of more than 5 cells; abundant. **Silica-bodies,** between the veins, and those in paired short-cells over the veins, tall and narrow (Fig. I, 4), or fitting into concavities in adjacent cork-cells (Fig. I, 6–7), the silica-bodies of this type sometimes being elliptical or slightly crescent-shaped in outline. Silica-bodies in rows of short-cells over the veins, intermediate between cross and dumb-bell shaped (Fig. IA, 17), or shortly dumb-bell shaped (Fig. IB, 20), and occasionally nodular (Fig. IA, 18 (i)). **Macro-hairs** and **micro-hairs:** none seen. **Prickle-hairs:** rather large prickles (Fig. VI, 2) common over the veins. **Stomata** with low (Fig. IV, 3), or tall (Fig. IV, 4), dome-shaped subsidiary cells. **Long-cells,** between the veins, with thin, sinuous walls (Fig. V, 3*a–c*); those over the veins similar, but with thicker walls.

T.S. lamina

Vascular bundles: most vb's small and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 10). **Adaxial surface** with slight, fairly wide ribs, and a slight depression in the apex of each rib, and much narrower, shallow furrows (Fig. XIV, 2). **Sclerenchyma:** a few vb's not accompanied by scl. (Fig. IX, 1), or with small abaxial strands only; most small vb's with adaxial and abaxial girders (Fig. IX, 4), the adaxial girders sometimes being slightly T-shaped, about 1–4 cells wide and high, and connected to adaxial extensions of colourless cells from the O.S.s. Corresponding abaxial girders about 1–6 cells wide and 3–6 cells high. Large

vb's with adaxial and abaxial girders up to 12, or occasionally 14, cells wide and 4 cells high (Fig. IX, 5). **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma mostly not definitely radiate, but cells immediately surrounding each vb exhibiting a slightly radiate arrangement. **Bulliform cells** in fan-shaped groups (Fig. XV, 4). **Bundle-sheaths** double; a few small vb's with 2 complete sheaths (Fig. XII, 1), but O.S. more commonly with a slight abaxial interruption (Fig. XII, 2), and often connected to the adaxial scl. by a girder-like extension of colourless cells (Fig. XII, 4); O.S. to the large vb's usually interrupted adaxially and abaxially (Fig. XII, 3*a*). Cells of the I.S. with U-shaped thickenings.

CULM

Culm examined 2 mm in diameter. Epidermis subtended by a zone of scl. some 12 cells wide, with small columns, and, in some places, wider plates of assimilatory tissue embedded in the scl. Inner ground tissue consisting of progressively larger cells with thinner walls towards the centre of the culm, occupied by irregular cavities in the otherwise spongy ground tissue. Outermost circle of vb's embedded in the peripheral scl. Remaining vb's in 2 or 3 more or less distinct circles embedded in the outer part of the thin-walled ground tissue.

MATERIAL EXAMINED: Cultivated at Kew.

Oryzopsis racemosa (J. E. Smith) Ricker in Hitchc.

LEAF

Abaxial epidermis

Short-cells between, and some of those over, the veins, paired; those over the veins mostly in rows of more than 5 cells; common. **Silica-bodies,** in paired short-cells, both over and between the veins, usually fitting into slight concavities in adjacent cork-cells (Fig. I, 6–7), silica-bodies of this type being tall and narrow (Fig. I, 4), elliptical, cubical, or slightly crescent-shaped in outline. Silica-bodies, over the veins, mostly dumb-bell shaped (Fig. IA, 18 (ii–v)), usually with the middle portion of each body rather thick. **Macro-hairs:** short, stiff, thick-walled hairs (Fig. IIA, 10), resembling hooks (Fig. VI, 5), but with rather long points, common between the veins. **Micro-hairs:** none seen. **Prickle-hairs:** hooks (Fig. VI, 5) abundant between the veins. See also 'macro-hairs'. **Stomata** absent from the abaxial surface. **Long-cells,** between the veins, with thin, sinuous walls (Fig. V, 3*a–c*); those over the veins similar but with slightly thicker walls.

T.S. lamina

Vascular bundles: most vb's small and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 10). **Adaxial surface** with v. slight but wide ribs over the small vb's, and much more pronounced, wide, rounded ribs over the large vb's; intervening furrows shallow, and rather wide (Fig. XIV, 2). V. slight furrows present on the abaxial surface opposite each vb. **Sclerenchyma:** small vb's with adaxial and abaxial strands (Fig. IX, 4) up

to about 4 cells wide and 3 cells high; large vb's with rather wider adaxial and abaxial girders, the combined girders associated with some vb's tending to be inversely anchor-shaped. Keel vb with an abaxial girder over 20 cells wide and a slightly narrower adaxial strand. **Keel** fairly conspicuous, rounded; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** mostly in groups as in Fig. XV, 2, but some groups tending to be slightly fan-shaped (Fig. XV, 4). **Bundle-sheaths** double; all with the I.S. complete, the O.S. round some of the vb's being interrupted abaxially (Fig. XII, 2), those round the large vb's being interrupted adaxially and abaxially (Fig. XII, 3*a*). O.S. round some vb's connected to the adaxial scl. by extensions of the colourless cells (Fig. XII, 4).

MATERIAL EXAMINED: Cultivated at Kew.

ADDITIONAL INFORMATION FROM THE LITERATURE

Günzel (1921) has described *O. miliacea* (L.) Aschers. & Schweinf., and the following notes are taken from his article. Leaf broad, basal leaves sometimes ending in thorns. Surface of the lamina with adaxial, and smaller abaxial, ribs. Vascular bundles; consecutive large vb's separated from one another by 1–3 small vb's. Scl. accompanying the vb's both adaxially and abaxially. Midrib conspicuous on the lower part of the lamina. Mesophyll mostly composed of isodiametric assimilatory cells. Bulliform cells present, between the vb's, on the adaxial surface. Colourless parenchyma present only in the midrib. Bundle-sheaths double. Silica-bodies, over the veins, mostly dumb-bell shaped (those of the leaf sheath said to be oval). Short prickles not infrequent. Long-cells, between the veins, on the abaxial surface with slightly sinuous anticlinal walls.

Holm (1901–2) has compared the leaf structure of woodland spp. of *Oryzopsis* with others from dryer localities. He notes that the mesophyll of *O. micrantha* (Trin. et Rupr.) Thurb. is more conspicuously radiate than that of the other spp. he examined.

Canfield (1934) refers to a sp. of *Oryzopsis* from the Jornada Experimental Range with solid culms.

SPECIAL NOTE

Parodi and Freier (1945) point out that *Oryzopsis*, together with *Stipa* and *Nassella*, form a closely related group of genera within the Stipeae.

LITERATURE

Canfield 1934 (culm); Günzel 1921 (leaf); Holm 1901–2 (ecological anatomy of leaf); Parodi and Freier 1945 (leaf).

PANICUM

DIAGNOSTIC GENERIC CHARACTERS

Short-cells, over the veins, in long rows. Silica-bodies, over the veins, mostly cross to dumb-bell shaped or occasionally nodular, this last type being dominant in a few spp.; cubical or crescent-shaped bodies occasionally noted over large veins. Micro-hairs present; each with the distal cell tapered towards the apex. Stomata usually with triangular, or sometimes with low dome-shaped, subsidiary cells. Vascular bundles mostly small, crowded, or

fairly widely spaced, and conspicuously angular in outline. Mesophyll usually with distinctly radiate chlorenchyma, but chlorenchyma inconspicuously radiate in some spp.; radiating cells of the long, narrow, *Isachne* type noted in a few spp. Bundle-sheaths usually single, but, in some spp., an inconspicuous I.S. present.

SPECIES SPECIALLY EXAMINED

***Panicum capillare* L.**

LEAF

Abaxial epidermis

Short-cells, between the veins, paired; those over the veins in rows of more than 5 cells; abundant. **Silica-bodies,** between the veins, cross-shaped (Fig. IA, 16), many of them having a distorted appearance; those over the veins also cross-shaped, but more uniform and less distorted in outline, or intermediate between cross and dumb-bell shaped (Fig. IA, 17). **Macro-hairs:** long, moderately thick-walled hairs, each with a constricted base surrounded by specialized epidermal cells (Fig. IIA, 5), abundant between the veins. **Micro-hairs:** length 38–58 (mostly 42–54) μ; basal cells 15–18 μ; distal cells 26–44 (mostly 26–34) μ; distal cells slightly tapered towards their apices (Fig. VII, 4). **Prickle-hairs:** none seen. **Stomata** with triangular (Fig. IV, 1) subsidiary cells. **Long-cells,** between the veins, with thin, sinuous walls (Fig. V, 3*a–c*), some of the cells being rather short (Fig. V, 7*a–b*).

T.S. lamina

Vascular bundles: most vb's small, crowded, polygonal (Fig. VIII, 5); large vb's of basic type (Fig. VIII, 9 and 10). **Adaxial surface** with a slight, rounded rib over each vb, the intervening furrows being shallower and much narrower than the ribs (Fig. XIV, 2). Abaxial surface with similar ribs opposite those on the adaxial surface. **Sclerenchyma:** most vb's not accompanied by scl. (Fig. IX, 1); large vb's with adaxial and abaxial girders up to about 8 cells wide and 2–3 cells high (Fig. IX, 5); occasional small vb's with adaxial strands up to about 6 or 8 cells wide and 2 cells high. **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma v. distinctly radiate, the whole of the assimilatory tissue consisting of radiating cells. **Bulliform cells** in fan-shaped groups (Fig. XV, 4), or groups of the *Sporobolus* type (Fig. XV, 8), at the bases of the adaxial furrows, each group being connected to the corresponding furrows on the abaxial surface by a girder of colourless cells (Fig. XV, 13). **Bundle-sheaths** single; most vb's each with 1 complete sheath (Fig. XI, 2*a*), the component cells being of uniform size and almost circular in outline; large vb's with the sheath interrupted abaxially (Fig. XI, 6).

CULM

Culm examined 2 mm in diameter. Surface v. slightly grooved around most of the periphery of the culm. Epidermis subtended by about 2 layers of assimilatory cells around most of the periphery of the culm, the innermost assimilatory cells being locally much larger than the remainder, but vb's of the

outermost circle connected to the epidermis by girders of scl. traversing the assimilatory tissue. Assimilatory tissue bounded on its inner side by a narrow ring of fibres, often no more than about 3 cells wide, except where wider around the vb's, the fibres having comparatively wide lumina and thin walls. Ground tissue on the inner side of the scl. ring consisting of some 8 layers of large cells with thin walls. Centre of the culm occupied by a large cavity. Vb's of the outermost circle embedded in the scl. ring, and remaining vb's in 3 circles embedded in the inner thin-walled ground tissue. Ph. elements conspicuously wide in diameter.

MATERIAL EXAMINED: Cultivated at Kew.

***Panicum clandestinum* L.**

LEAF

Abaxial epidermis

Short-cells, over the veins, in rows of more than 5 cells; abundant over, but infrequent between, the veins. **Silica-bodies,** over the veins, occasionally cross-shaped (Fig. IA, 16), but more frequently intermediate between cross and dumb-bell shaped (Fig. IA, 17) or dumb-bell shaped (Fig. IA, 18 (ii–v)); a few nodular (Fig. IA, 18 (i)). **Macro-hairs:** short, rigid hairs with swollen, constricted bases, and sometimes surrounded by specialized epidermal cells (Fig. IIA, 5), v. frequent in the intercostal zones. **Micro-hairs:** length 65–80 μ; basal cells 30–42 (mostly 36–42) μ; distal cells 35–44 (mostly 38–44) μ; distal cells tapering to their pointed apices (Fig. VII, 4). **Prickle-hairs:** none seen. **Stomata** mostly with slightly triangular (Fig. IV, 1), but others with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells,** between the veins, with thin, sinuous walls (Fig. V, 3*a–c*), many of them being rather short or almost cubical (Fig. V, 7*a–b*); interstomatal cells with concave ends (Fig. V, 10).

T.S. lamina

Vascular bundles: small vb's fairly widely spaced and somewhat angular in outline, although less markedly angular than in Fig. VIII, 5; large vb's of basic type (Fig. VIII, 9 and 10). **Adaxial surface** almost smooth, but with slight, wide ribs over some of the veins (Fig. XIV, 2). Abaxial surface similar, but with more marked ribs over a few of the large veins, especially near the midrib, some rounded ribs being present on the midrib itself. **Sclerenchyma:** a few of the smallest vb's not accompanied by scl. (Fig. IX, 1); most vb's with adaxial and abaxial strands up to some 8 cells wide and 2–3 cells high, connected to the bundle-sheaths by v. long girder-like extensions of colourless cells, the fibre strands appearing v. small in relation to the total thickness of the lamina. Large vb's with adaxial and abaxial girders up to some 12 cells wide and 2 cells high (Fig. IX, 5) connected directly, or almost directly, to the bundle-sheaths, extensions of colourless cells being short or absent. Large vb's of the midrib supported by wide abaxial girders and slightly narrower adaxial strands, the strand and girder to each vb forming an incomplete, anchor-shaped girder (Fig. IX, 6). **Midrib** fairly conspicuous, marked by a rounded abaxial projection and median adaxial groove; midrib in some material apparently double; containing 1 large median vb accompanied on

either side by a smaller lateral (Fig. XIII, 2). **Mesophyll:** chlorenchyma distinctly radiate, the radiating cells around the vb's being of the long, narrow type found in *Isachne*, the remaining assimilatory tissue between adjacent vb's exhibiting no radial structure. Cells subjacent to the bulliform cells palisade-like. **Bulliform cells** rather variable; groups irregular (Fig. XV, 1), as in Fig. XV, 2, or tending to be fan-shaped (Fig. XV, 4). **Bundle-sheaths** double; vb's, especially the small ones, each with an inconspicuous I.S.; O.S. to the small vb's complete, and connected by girder-like extensions of colourless cells to the adaxial and abaxial scl. as Fig. XII, 1, but with longer extensions. Large vb's usually with the O.S. interrupted abaxially and connected to the adaxial scl. by short, wide, adaxial girder-like extensions of colourless cells (Fig. XII, 4). O.S. sometimes not interrupted.

CULM

Culm examined about 3 mm in diameter. Surface of the culm with a slight suggestion of ribs and furrows. Epidermis subtended by 2–3 layers of assimilatory tissue, but vb's of the outermost circle connected to the epidermis by girders of scl. Assimilatory tissue bounded on its inner side by a ring of scl., the ring being about 7 cells wide between, but wider next to the vb's of the outermost circle. Ground tissue on the inner side of the scl. ring consisting of some 20 layers of parenchymatous cells with thin walls, the centre of the culm being occupied by a large cavity. Vb's of the outermost circle embedded in the scl. ring. Remaining vb's v. much larger and embedded in the inner part of the scl. ring or on its inner boundary.

MATERIAL EXAMINED: Cultivated at Kew.

***Panicum maximum* Jacq.**

LEAF

Abaxial epidermis

Short-cells, between the veins, paired; those over the veins in rows of more than 5 cells; abundant. **Silica-bodies,** between the veins, mostly cross-shaped (Fig. IA, 16), but with a rather distorted appearance; those over the veins intermediate between cross and dumb-bell shaped (Fig. IA, 17), and sometimes dumb-bell shaped (Fig. IA, 18 (ii–v)), or nodular (Fig. IA, 18 (i)). **Macro-hairs:** none seen. **Micro-hairs:** length 62–78 (mostly 66–75) μ; basal cells 26–36 μ; distal cells 35–44 μ; distal cells tapering to their slightly pointed apices (Fig. VII, 4 and 5). **Prickle-hairs:** hooks (Fig. VI, 5) frequent between the veins. **Stomata** with markedly triangular (Fig. IV, 1) subsidiary cells. **Long-cells:** those in the centre of each of the intercostal zones tending to be cubical, with sinuous walls (Fig. V, 7*a–b*); those on either side of each of the veins longer, and with sinuous walls (Fig. V, 3*a–c*); interstomatal cells with concave ends (Fig. V, 10–11).

T.S. lamina

Vascular bundles: small vb's crowded, angular, some taller and narrower than others (Fig. VIII, 4 and 5); large vb's of basic type (Fig. VIII, 15).

Adaxial surface practically smooth throughout most of the width of the lamina (Fig. XIV, 1), but with slight ribs over the veins towards the midrib (Fig. XIV, 2). **Sclerenchyma:** some small vb's, especially those next to the large vb's and opposite the groups of bulliform cells, not accompanied by scl. (Fig. IX, 1); other small vb's with minute adaxial and abaxial girders, usually not more than 3 cells wide and 2 cells high (Fig. IX, 4); occasionally with minute adaxial strands or girders only; large vb's with adaxial and abaxial girders up to about 16 cells wide and 1–8 or more cells high. Vb's of the midrib with well-marked abaxial girders only (Fig. IX, 3). Adaxial surface of the midrib supported by a thin plate of scl. expanding into thicker strands opposite some of the vb's. **Midrib** v. conspicuous, abaxially rounded; containing numerous vb's of various sizes, but all of them large or fairly large (Fig. XIII, 5). **Mesophyll:** chlorenchyma cells immediately around the vb's more or less radiately arranged; remainder of the assimilatory tissue not radiate. **Bulliform cells** in irregular groups (Fig. XV, 1), and groups as in Fig. XV, 2; those towards the midrib in fan-shaped groups (Fig. XV, 4), or tending to be in groups of the *Zea* type (Fig. XV, 3). Adaxial part of the midrib composed of colourless cells. **Bundle-sheaths:** none definitely single, an obscure I.S. usually being present around each small vb, and a more definite one around each of the large vb's. O.S. to small vb's complete, the cells of the O.S. being v. variable in size, and giving the sheaths v. uneven outlines. Sheaths round the large vb's with wide abaxial interruptions (Fig. XII, 4–5).

Culm

Culm examined some 0·5 cm in diameter, with a slight depression on 1 side, and a fairly large central cavity. Epidermis subtended by a ring of assimilatory tissue some 6 or 8 cells wide, interrupted at intervals by girders of scl. connecting some of the outermost vb's to the epidermis. Assimilatory tissue bounded on its inner side by some 6 layers of rather thin-walled fibres with wide diameters, this fibrous zone gradually passing over to the large, thin-walled cells of the inner ground tissue. Small, triangular intercellular spaces interspersed amongst the cells of the innermost ground tissue. Vb's, apart from those of the outermost circle, scattered throughout the thin-walled ground tissue. Ph. elements with conspicuously wide diameters.

Material Examined: Specially collected by R. E. Vaughan in Mauritius.

Panicum miliaceum L.

Leaf

Abaxial epidermis

Short-cells, between the veins, paired; those over the veins in rows of more than 5 cells; abundant over, but less frequent between, the veins. **Silica-bodies,** between the veins, cross-shaped (Fig. Ia, 16), but mostly rather tall and narrow, and often with a distorted appearance; those over the veins sometimes also cross-shaped, but less distorted in appearance, or intermediate between cross and dumb-bell shaped (Fig. Ia, 17). Nodular types also recorded

by Prat (1932). **Macro-hairs:** long, rather narrow, slender hairs with sunken, constricted bases (Fig. II, 3), sometimes surrounded by specialized epidermal cells (Fig. IIa, 5), v. frequent in the intercostal zones. **Micro-hairs:** length 60–85 (mostly 60–75) μ; basal cells 24–30 μ; distal cells 36–55 (mostly 36–48) μ; distal cells mostly tapering to pointed apices (Fig. VII, 4 and 5). **Prickle-hairs:** none seen. **Stomata** mostly with triangular (Fig. IV, 1), but sometimes with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells:** some of those between the veins inflated (Fig. V, 5); others between the veins longer, with thin, slightly sinuous (Fig. V, 3*a–c*), or almost non-sinuous (Fig. V, 4*a–b*), walls.

T.S. lamina

Vascular bundles: most vb's small, crowded, and angular (Fig. VIII, 5); large vb's of basic type (Fig. VIII, 10). **Adaxial surface** practically smooth (Fig. XIV, 1) towards the midrib, but with slight, rounded ribs over the veins towards the leaf margins, the ribs being separated from one another by shallow furrows (Fig. XIV, 2). Ribs on the abaxial surface towards the leaf margins as large as or taller than those on the adaxial surface. **Sclerenchyma:** most small vb's not accompanied by scl. (Fig. IX, 1); large vb's in the lamina with adaxial and abaxial girders up to about 8 cells wide and seldom more than about 4 cells high (Fig. IX, 4); median keel bundle with a well-marked abaxial girder (Fig. IX, 3), and the other keel bundles with rather smaller abaxial strands or girders, corresponding adaxial strands also being present beneath the adaxial epidermis, but widely separated from the bundles themselves by the colourless ground tissue of the midrib. **Keel** (midrib) conspicuous, rounded, with a slightly ribbed surface; containing 1 large median vb accompanied on either side by 3 much smaller laterals (Fig. XIII, 3). **Mesophyll:** chlorenchyma distinctly radiate. **Bulliform cells** in groups of the *Sporobolus* type (Fig. XV, 8), some of the groups being connected to the abaxial epidermis by girder-like extensions of colourless cells (Fig. XV, 13). **Bundle-sheaths** single and double; small vb's each with a complete single sheath (Fig. XI, 2*a*), the constituent cells being somewhat unequal in size, the outlines of the sheaths appearing as slightly convoluted circles. Some small vb's with an inconspicuous I.S.; large vb's with I.S. complete, and O.S. interrupted abaxially and adaxially (Fig. XII, 3*a*).

Culm

Culm examined 0·7 cm in diameter, with a large central cavity, and oval outline. Epidermis subtended by an almost continuous zone of assimilatory tissue, about 3 cells wide. Assimilatory tissue bounded on the inner side by a ring of fibres some 6 cells wide, passing over gradually into the thin-walled inner ground tissue. Vb's of the outermost circle embedded in the peripheral scl. Remaining vb's scattered throughout the thin-walled ground tissue, and at the inner margin of the scl. ring. Ph. elements conspicuously large in diameter.

Material Examined: Cultivated at Kew.

***Panicum obtusum* H. B. K.**

LEAF

Abaxial epidermis

Short-cells, between the veins, solitary, or paired; those over the vein in rows of 3–5, or more, cells. **Silica-bodies,** over the veins, nodular (Fig. IA, 18 (i)); those between the veins sometimes fitting into concavities in adjacent cork-cells (Fig. I, 6–7), and rather variable in shape, some elliptical, but others cross-shaped (Fig. IA, 16), but v. distorted in appearance. **Macro-hairs:** none seen. **Micro-hairs:** length 58–70 (mostly 62–70) μ; basal cells 22–30 μ; distal cells 32–40 (mostly 36–40) μ; distal cells mostly tapering to their slightly pointed apices (Fig. VII, 4 and 5). **Prickle-hairs:** prickles (Fig. VI, 1–2) local over the veins. **Stomata** mostly with triangular (Fig. IV, 1) subsidiary cells. **Long-cells** with thin, sinuous walls (Fig. V, 3*a–c*).

T.S. lamina

Vascular bundles: most vb's small, crowded, angular (Fig. VIII, 5), or inconspicuously angular (Fig. VIII, 6); large vb's of basic type (Fig. VIII, 13). **Adaxial surface** with rounded ribs of 2 distinct sizes (Fig. XIV, 2 and 3); the ribs being separated by fairly wide, moderately deep furrows. Smaller ribs present on the abaxial surface opposite most of the vb's. **Sclerenchyma:** some small vb's, especially those opposite certain of the furrows in the adaxial surface, not accompanied by scl. (Fig. IX, 1); many of the other small vb's with well-marked abaxial strands or girders only (Fig. IX, 3), the strands or girders being in the abaxial ribs; remaining small vb's, and the large vb's, with adaxial and abaxial girders up to some 14 cells wide and 12 cells high (Fig. IX, 5). **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma fairly conspicuously radiate round each vb. **Bulliform cells:** those towards the leaf margins in groups as in Fig. XV, 2; groups elsewhere slightly fan-shaped (Fig. XV, 6) or tending to be of the *Sporobolus* type (Fig. XV, 8). **Bundle-sheaths** single; a complete sheath present round each vb (Fig. XI, 2*a–b*).

CULM

Culm examined 2 mm in diameter and slightly oval in outline, with a fairly large central cavity. Epidermis subtended by a more or less continuous zone of assimilatory tissue interrupted at intervals by girders of scl. connecting the vb's of the outermost circle to the epidermis. Assimilatory tissue bounded on its inner side by a ring of scl. about 6 cells wide, the ground tissue on the inner side of the scl. ring consisting of cells with progressively thinner walls and larger diameters towards the centre of the culm. Small, triangular intercellular spaces present between some of the cells of the inner ground tissue. Vb's of the outermost circle embedded in the peripheral scl. ring. Remaining vb's in 2–3 more or less distinct circles, embedded in the inner ground tissue, or abutting on the inner surface of the peripheral scl. ring. Ph. elements conspicuously large in diameter.

MATERIAL EXAMINED: Cultivated at Kew.

***Panicum repens* L.**

LEAF

Abaxial epidermis

Not examined, but see p. 354.

T.S. lamina

Vascular bundles: small vb's angular (Fig. VIII, 5) or inconspicuously angular (Fig. VIII, 6); large vb's of basic type (Fig. VIII, 13). **Adaxial surface** with moderately tall, narrow, crowded ribs, separated from one another by moderately deep, V-shaped furrows (Fig. XIV, 3). Abaxial surface also with ribs over the vb's, but less tall than those on the adaxial surface. **Papillae** numerous on the apices and at the sides of the ribs on the adaxial surface. **Sclerenchyma:** all vb's accompanied by adaxial and abaxial girders in the apices of the ribs, the sizes of the girders being proportional to the sizes of the associated ribs (Fig. IX, 4 and 5). **Midrib** conspicuous, abaxially rounded; adaxial portion apparently containing 4 large intercellular cavities in the material examined (an artefact?); containing a large median vb accompanied on either side by 3 smaller laterals (Fig. XIII, 3). **Mesophyll:** chlorenchyma distinctly radiate. **Bulliform cells** in groups of the *Sporobolus* type (Fig. XV, 8) at the bases of the adaxial furrows, the groups being connected to the abaxial epidermis by girder-like columns of colourless cells (Fig. XV, 13). **Bundle-sheaths** with obscure I.S.s; sheaths to small vb's as in Fig. XII, 6, each connected to the adaxial scl. by an extension of colourless cells; sheaths to large vb's similar, but with an abaxial interruption and a wider adaxial extension (Fig. XII, 4).

MATERIAL EXAMINED: Dawe 786; Sierra Leone.

***Panicum virgatum* L.**

LEAF

Abaxial epidermis

Short-cells, between all, and over certain, of the veins, solitary or paired; those over other veins in rows of more than 5 cells; common both over and between the veins. **Silica-bodies,** between the veins, not v. frequent, but, where present, tall and narrow (Fig. I, 4); those over the large veins occasionally fitting into concavities in adjacent cork-cells (Fig. I, 6–7), and then more or less cubical or crescent-shaped in outline; others, over the veins, almost cross-shaped (Fig. IA, 16), but with v. short arms, or, more commonly, intermediate between cross and dumb-bell shaped (Fig. IA, 17), or dumb-bell shaped (Fig. IA, 18 (ii–v)); occasionally nodular (Fig. IA, 18 (i)). **Macro-hairs:** none seen. **Micro-hairs:** length 54–78 (mostly 60–78) μ; basal cells 24–35 (mostly 28–35) μ; distal cells 30–48 μ; distal cells mostly tapering towards their slightly pointed apices (Fig. VII, 4). **Prickle-hairs:** none seen. **Stomata:** some with triangular (Fig. IV, 1), and others with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells,** between the veins, mostly with fairly thin, sinuous walls (Fig. V, 3*a–c*).

T.S. lamina

Vascular bundles : most vb's small, crowded, angular (Fig. VIII, 5) to inconspicuously angular (Fig. VIII, 6); large vb's of basic type (Fig. VIII, 10). **Adaxial surface** with slight ribs (Fig. XIV, 2) over all vb's, and fairly wide, shallow furrows between them. Similar ribs also present on the abaxial surface. **Sclerenchyma :** a few of the smallest vb's not accompanied by scl. (Fig. IX, 1); others accompanied by minute adaxial strands only (Fig. IX, 2); most small vb's accompanied by adaxial and abaxial strands about 6 cells wide and 2–3 cells high (Fig. IX, 4); large vb's with adaxial and abaxial girders up to about 10 cells wide and 3–4 cells high (Fig. IX, 5). **Midrib** fairly conspicuous, with slight adaxial and abaxial projections; containing a solitary vb (Fig. XIII, 1). **Mesophyll :** chlorenchyma distinctly radiate. **Bulliform cells** in groups of the *Sporobolus* type (Fig. XV, 8), but connected to the abaxial surface by girder-like extensions of colourless cells (Fig. XV, 13). **Bundle-sheaths :** all small vb's with single complete sheaths (Fig. XI, 2*a*); large vb's often with vague I.S.s, and slight abaxial interruptions to the O.S.; O.S. to the median vb with an extension of colourless cells towards the adaxial surface (Fig. XII, 4). Constituent cells of O.S. not v. unequal in size.

Culm

Culm examined 4 mm in diameter; circular in outline; with a large central cavity. Epidermis subtended by a continuous zone of assimilatory tissue, about 3 or 4 cells wide, interrupted at intervals by girders of scl. extending from the vb's of the outermost circle towards the epidermis. Assimilatory tissue bounded on the inner side by a ring of fibres some 6 cells wide merging on the inner side with ground tissue composed of cells of larger diameter but with fairly thick walls. Small, triangular intercellular spaces present between the cells of the inner ground tissue. Vb's of the outermost circle embedded in the outer part of the peripheral scl. ring. Remaining vb's in 2–3 circles, the outermost circle being at the inner boundary of the scl. ring and the remainder embedded in the inner ground tissue.

Material Examined: Cultivated at Kew.

Additional Information from the Literature

Günzel's (1912) description of the leaf of *P. repens* L. agrees essentially with that given on p. 353.

The following notes concerning the epidermis may be added. Silica-bodies, over the veins, mostly cross-shaped, but some approximately dumb-bell shaped. Prickles and cylindrical micro-hairs present in the intercostal zones.

Breakwell (1915) has recorded the following notes concerning 2 Australian spp.

P. benthami Domin.

Bulliform cells in groups of 5 or 6.

P. decompositum R. Br.

Bulliform cells in groups of 3. Colourless cells, between the vb's, extending from the adaxial surface to about half-way across the thickness of the lamina towards the abaxial surface.

Sabnis (1921), in describing the ecological anatomy of 2 Indian spp., notes the following points:

P. antidotale Retz.

Both surfaces grooved. Scl. forming adaxial and abaxial girders to the large vb's. Mesophyll with radiate chlorenchyma. Bulliform cells present in the grooves, but subjacent girders of colourless cells less well developed than in *P. turgidum* Forsk. 'Spiny hairs' present.

P. turgidum Forsk.

Generally similar to *P. antidotale*, but leaf margins noted as blunt and supported by large strands of scl., small adaxial and abaxial girders of scl. also being associated with all vb's.

Special Note

Prat (1936) indicates, as is only to be expected, that the leaf structure is panicoid.

Literature

Breakwell 1915 (leaf); Chauveaud 1897 (notes on root structure of *P. miliaceum*); Duval-Jouve 1869*b* (leaf; some of the spp. described under *Panicum* have since been transferred to *Setaria*); Günzel 1912 (leaf); Hayden 1919 (notes on rhizome of *P. virgatum* L.); Holm 1908 (bundle-sheaths; some spp. described since transferred to *Digitaria*, *Echinochloa*, or *Setaria*), 1929 (rhizome); Krishnaswami and Rangaswami 1942 (leaf of *P. miliare* Lam., and *P. miliaceum* L.); Majumdar 1941 (culm of *P. punctatum* Burm. = *Paspalidium punctatum* (Burm.) A. Camus); Pée-Laby 1898 (leaf of *P. miliaceum*; also refers to 1 sp. since transferred to *Echinochloa*); Prat 1932 (leaf of *P. miliaceum*), 1936 (leaf); Sabnis 1921 (ecological anatomy of *P. turgidum* Forsk. and *P. antidotale* Retz.); Schlickum 1896 (seedling structure of *P. miliaceum* in detail); Siedler 1887 (brief notes on root structure of *P. miliaceum*).

PAPPOPHORUM

Some of the spp. of *Pappophorum* described in the literature have since been transferred to *Enneapogon*. The following information recorded by Lohauss (1905) is believed to refer to spp. that are still generally regarded as belonging to *Pappophorum*.

P. alopecuroideum Vahl = *P. pappiferum* (Lam.) Kuntze (see p. 356)

T.S. lamina. Adaxial surface with ribs and furrows. Vb's of 3 orders, those of the first order alternating with those of the second and third orders. Scl. forming I-girders with the vb's. Midrib not more than moderately conspicuous; containing 1 primary vb. Mesophyll with radiate chlorenchyma. Bulliform cells in groups of 4–6 cells at the bases of the furrows; lumina of the cells sometimes filled with silica; accompanied by 2–3 subjacent layers of colourless cells. Bundle-sheaths double; I.S. stated to become 2-layered near the ph.; O.S.'s composed of large, relatively thick-walled, parenchymatous cells; O.S.'s generally interrupted abaxially by scl., but sheaths to the large vb's complete. *Epidermis.* Short-cells, over the veins, mostly confined to alternate files of cells; usually paired, but sometimes in short rows. Cork-cells rectangular and pitted, silica-bodies oval to saddle-shaped. Prickles and club-shaped micro-hairs present.

P. mucronulatum Nees

Similar to *P. alopecuroideum* but 'papillae' present on the apices of the ribs; bulliform cells occurring on the sides of the ribs as well as at the bases of the furrows; girders of colourless cells traversing the mesophyll between the veins and connecting the bulliform cells to the abaxial epidermis. Chlorenchyma not more than inconspicuously radiate. Long cushion hairs present on the abaxial epidermis.

P. pappiferum (Lam.) Kuntze (as *P. macrostachyum* Schrad.) (see p. 355)

This sp. is similar to *P. alopecuroideum*, but differs in having a hairy leaf sheath.

Special Note

Prat (1936) rightly points out that *Pappophorum* should be excluded from the Festuceae because the leaf anatomy is panicoid and the epidermis is similar to that of *Chloris*. The genus is usually treated as belonging to a special tribe, the Pappophoreae.

Literature

Lohauss 1905 (leaf); Prat 1932, 1936 (leaf).

PARAPHOLIS

Diagnostic Generic Characters

Short-cells, over the veins, paired. Silica-bodies, over the veins, mostly round, elliptical, or occasionally slightly crescent-shaped, and always fitting into concavities in adjacent cork-cells. Micro-hairs absent. Stomata with low dome-shaped subsidiary cells. Vascular bundles never conspicuously angular in outline. Mesophyll with chlorenchyma not radiate. Bundle-sheaths double.

Species Specially Examined

***Parapholis strigosa* (Dum.) C. E. Hubbard**

Leaf

Abaxial epidermis

Short-cells, both over and between the veins, paired; abundant. **Silica-bodies** fitting into concavities in adjacent cork-cells (Fig. I, 6–7), and mostly round, elliptical, or occasionally slightly crescent-shaped in outline. **Macro-hairs** and **micro-hairs:** none seen. **Prickle-hairs:** angular prickles (Fig. VI, 3) present at the leaf margins. **Stomata** infrequent; with low dome-shaped subsidiary cells (Fig. IV, 3). **Long-cells,** between the veins, with thin, sinuous walls (Fig. V, 3*a–c*); those over the veins similar but with slightly thicker walls.

T.S. lamina

Vascular bundles: most vb's small and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with about 9 marked, rounded to slightly triangular ribs, separated from one another by narrow, deep, V-shaped furrows (Fig. XIV, 5). **Sclerenchyma:** most vb's accompanied by minute adaxial strands only (Fig. IX, 2); median vb

with an abaxial girder about 5 cells wide and 3 cells high, and a minute adaxial strand consisting of only a few cells. **Midrib:** not v. conspicuous; although marked by an adaxial rib over the median vb less tall than the adjacent ribs; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells:** V-shaped furrows containing bulliform cells of variable size, but none of them specially large (Fig. XV, 5). **Bundle-sheaths** double; small vb's with I.S. complete and O.S. complete (Fig. XII, 1) or not quite complete, or inconspicuous, abaxially (Fig. XII, 2); sheaths around the median vb similar, but O.S. more widely interrupted (Fig. XII, 4).

Material Examined: J. K. O'Byrne 171; Essex, England.

Additional Information from the Literature

Pée-Laby (1898) notes that *P. incurva* (L.) C. E. Hubbard (as *Lepturus incurvatus* Trin.) exhibits adaxial ribs and furrows, well-developed bulliform cells, and stomata that are more numerous on the adaxial than on the abaxial surface. Potztal and Hansen (1953), in the same sp., note, amongst other characters, the occurrence of rounded or oblong silica-cells (presumably silica-bodies C. R. M.), thus conforming with *P. strigosa* described above.

Special Note

Prat (1932) states that *P. incurva* resembles *Monerma subulata* Beauv. (= *M. cylindrica* Willd.) Coss. & Dur. and *Lolium subulatum* Vis. (= *L. loliaceum* (Borg. & Chaub.) Hand-Mazz., but emphasizes that these similarities are adaptive. The characters are festucoid according to Prat (1936).

Literature

Pée-Laby 1898 (leaf); Potztal and Hansen 1953 (leaf); Prat 1932, 1936 (leaf).

PARIANA

Diagnostic Generic Characters

Short-cells, over the veins, solitary, paired, or in short rows. Silica-bodies, over the veins, cross-shaped, or of the *Oryza* type, occasionally tall, narrow, and crenate. Micro-hairs present; rather uniform in diameter throughout their lengths, apart from being slightly tapered at the proximal ends, or each with the distal cell tapering to a pointed apex. Stomata with triangular or tall dome-shaped subsidiary cells. Vascular bundles widely spaced; small ones not more than inconspicuously angular. Mesophyll with chlorenchyma not radiate and composed of arm-cells; partly composed of long fusoid-cells. Bundle-sheaths double.

Species Specially Examined

***Pariana bicolor* Tutin**

Leaf

Abaxial epidermis

Short-cells, between the veins, mostly solitary, but sometimes paired; those over the veins mostly paired; abundant. **Silica-bodies,** over the veins, cross-

shaped (Fig. IA, 16) and of the *Oryza* type (Fig. IB, 23); those between the veins tall, narrow, crenate (Fig. IB, 24). **Macro-hairs:** none seen on the abaxial surface, but numerous stiff hairs with slightly sunken bases noted on the adaxial surface of the midrib. **Micro-hairs:** length 66–72 μ; basal cells 38–46 μ; distal cells 24–32 μ; hairs mostly slightly tapered towards their proximal ends, but otherwise of rather uniform diameters throughout their lengths (Fig. VII, 7). **Prickle-hairs:** rather large hooks (Fig. VI, 5) frequent between the veins. **Stomata** with triangular subsidiary cells (Fig. IV, 1). **Long-cells** short and broad with v. sinuous walls (Fig. V, 6), the individual sinuations being almost finger-like in appearance; interstomatal cells with concave ends (Fig. V, 10–11), and also markedly sinuous in outline.

T.S. lamina

Vascular bundles: vb's widely spaced, small ones not conspicuously angular in outline (Fig. VIII, 2, 3, and 6); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** practically smooth (Fig. XIV, 1). **Sclerenchyma:** most vb's with adaxial strands 1–2 cells wide and about 4 cells high, the corresponding abaxial girders being 4–5 cells wide and 2–3 cells high; large vb's with similar but rather wider adaxial and abaxial girders; combined girders sometimes slightly anchor-shaped (Fig. IX, 6). Adaxial and abaxial projections of the midrib strongly supported by strands of fibres. **Midrib** conspicuous, with a slight, rounded abaxial, and a more pronounced adaxial, projection; containing 1 large median vb accompanied v. closely on either side by 1 much smaller lateral, the whole group of 3 vb's being embedded in the large-celled colourless ground tissue of the midrib. **Mesophyll:** chlorenchyma not radiate, consisting of arm-cells. V. long fusoid-cells also present. **Bulliform cells** mostly in small, fan-shaped groups (Fig. XV, 4) consisting of specially large cells, some groups almost of the *Zea* type (Fig. XV, 3); also some groups more as in Fig. XV, 2. **Bundle-sheaths** double; most vb's with 2 complete sheaths (Fig. XII, 1); others with the I.S. not quite complete abaxially (Fig. XII, 2).

MATERIAL EXAMINED: Krukof 6949; Brazil.

***Pariana campestris* Aubl.**

LEAF

Abaxial epidermis

Short-cells, both over and between the veins, solitary, or paired; others over the large veins in rows of 3–5 or more cells; abundant. **Silica-bodies,** over the large veins, cross-shaped (Fig. IA, 16) or of the *Oryza* type (Fig. IB, 23); those between the veins, and some of those over the small veins, tall, narrow, and crenate (Fig. IB, 24); a few between the veins tending to be cross-shaped, but rather distorted in appearance. **Macro-hairs:** short to long, rigid, moderately thick-walled (Fig. IIA, 10) hairs present over and between the veins on both surfaces. **Micro-hairs:** length 66–90 (mostly 72–90) μ; basal cells 42–65 μ; distal cells 18–28 (mostly 18–24) μ; hairs mostly tapering towards their proximal ends; distal cells sometimes uniform in diameter throughout their lengths and with rounded apices (Fig. VII, 7); other hairs with their distal cells tapering to pointed apices (Fig. VII, 9). **Prickle-hairs:**

hooks (Fig. VI, 5), often with small or inconspicuous points, abundant between the veins. **Papillae:** small, variously shaped, thick, cuticular warts (Fig. III, 5) present on many of the long-cells, a variable number being present on each cell. Conical papillae also present on the adaxial surface. **Stomata:** a few with slightly triangular (Fig. IV, 1), but others with tall dome-shaped (Fig. IV, 4), subsidiary cells. **Long-cells,** between the veins, mostly fairly short and with v. marked sinuations (Fig. V, 6); interstomatal cells also with markedly sinuous walls and concave ends (Fig. V, 10).

T.S. lamina

Vascular bundles: small vb's widely spaced and not conspicuously angular in outline (Fig. VIII, 2 and 3); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with slight, v. wide ribs separated from one another by wide, shallow furrows (Fig. XIV, 2); ribs slightly more pronounced towards the midrib than near the leaf margins. **Sclerenchyma:** small vb's with adaxial girders mostly 1–2 cells wide and up to about 5 cells high, and abaxial girders up to about 7 cells wide and 2–3 cells high; large vb's with similar but rather wider girders; combined girders tending to be anchor-shaped (Fig. IX, 6). Midrib supported by a wide mass of fibres in the abaxial projection connected to the median vb, and by a somewhat triangular mass of fibres in the adaxial rib. **Midrib** conspicuous, owing to a large, rounded abaxial, and a less pronounced adaxial, projection; containing 1 large median vb accompanied on either side by a smaller lateral, the 3 vb's being embedded in the large-celled colourless ground tissue of the midrib. **Mesophyll:** chlorenchyma not radiate, consisting of arm-cells. V. long fusoid-cells present. **Bulliform cells:** most groups fan-shaped (Fig. XV, 4), but a few tending to be more as in Fig. XV, 2. **Bundle-sheaths** double; small vb's with 2 complete sheaths (Fig. XII, 1); large vb's with I.S. complete and O.S. interrupted abaxially (Fig. XII, 2).

MATERIAL EXAMINED: Herbarium specimen from Surinam.

***Pariana vulgaris* Tutin**

LEAF

Abaxial epidermis

Short-cells, both over and between the veins, mostly solitary and paired; others, over the veins, in rows of 3–5, or occasionally more, cells; abundant. **Silica-bodies** over the veins, mostly cross-shaped (Fig. IA, 16), but some tending to be of the *Oryza* type (Fig. IB, 23); those between the veins tall, narrow, and crenate (Fig. IB, 24). **Macro-hairs:** none seen. **Micro-hairs:** length 63–72 μ; basal cells 30–36 μ; distal cells 32–38 μ; hairs mostly v. conspicuously bent near their bases; distal cells usually uniform in diameter throughout their lengths, and with rounded, or at most only slightly pointed, apices (Fig. VII, 7). **Prickle-hairs:** hooks (Fig. VI, 5) occasional in the intercostal zones. **Papillae:** conical papillae present on the adaxial surface. **Stomata** mostly with somewhat triangular (Fig. IV, 1), but sometimes with tall dome-shaped (Fig. IV, 4), subsidiary cells. **Long-cells,** between the veins, fairly short, with v. marked sinuations (Fig. V, 6); interstomatal cells also with v. sinuous walls and concave ends (Fig. V, 10).

T.S. lamina

Vascular bundles: small vb's widely spaced and not more than inconspicuously angular in outline (Fig. VIII, 2 and 6); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** practically smooth (Fig. XIV, 1), but with slight, v. wide ribs over some of the vb's. **Sclerenchyma:** most small vb's with adaxial girders usually 1–2 cells wide and up to about 4 cells high, and abaxial girders up to, but mostly rather less than, 8 cells wide and 1–2 cells high; large vb's with similar, but rather wider, girders; combined girders tending to appear anchor-shaped (Fig. IX, 6). Midrib supported by a wide abaxial girder of fibres connected to the median vb, and by a taller but narrower adaxial girder. **Midrib** conspicuous, owing to a large, rounded abaxial, and a slightly narrower adaxial, projection; containing 1 large median vb accompanied on either side by a smaller lateral, the 3 vb's being embedded in the large-celled, colourless ground tissue of the midrib. **Mesophyll:** chlorenchyma not radiate, consisting of arm-cells. Long, narrow fusoid-cells present. **Bulliform cells** mostly in somewhat fan-shaped groups (Fig. XV, 4), 1 specially large group being present on either side of the midrib. **Bundle-sheaths** double; small vb's with 2 complete sheaths (Fig. XII, 1); others with the I.S. complete, but O.S. interrupted abaxially (Fig. XII, 2).

MATERIAL EXAMINED: A. C. Smith 2744; Brit. Guiana.

SPECIAL NOTE

Page (1947) rightly points out that *Pariana* exhibits the leaf characters of bamboos, and it seems probable that the genus, which is sometimes treated as the sole representative of the tribe Parianeae, must be related to the Bambuseae.

LITERATURE

Page 1947 (leaf).

PASPALIDIUM

DIAGNOSTIC GENERIC CHARACTERS

Short-cells, over the veins, mostly in long rows; those between the veins paired. Silica-bodies, over the veins, mostly intermediate between cross and dumb-bell shaped. Micro-hairs present; each with the distal cell tapering to a pointed apex. Stomata mostly with triangular subsidiary cells. Vascular bundles not more than inconspicuously angular in outline. Mesophyll with radiate chlorenchyma. Bundle-sheaths single.

SPECIES SPECIALLY EXAMINED

***Paspalidium geminatum* (Forsk.) Stapf**

LEAF

Abaxial epidermis

Short-cells, over the veins, mostly in long rows, but short rows and pairs occurring locally; those between the veins in pairs. **Silica-bodies,** over the veins, mostly intermediate between cross and dumb-bell shaped (Fig. IA, 17), the ends of the individual bodies varying from slightly concave to convex; bodies between the veins variable in outline, often cross-shaped but with a distorted appearance, or occasionally tending to be crescent-shaped. **Macro-hairs:** none seen. **Micro-hairs** present; each with the distal cell longer than the basal cell and tapering to a pointed apex (Fig. VII, 4), but v. few distal cells intact in the material examined; distal cell sometimes appearing to have fine transverse to oblique partitions or striae (artefacts?). **Prickle-hairs:** angular prickles (Fig. VI, 3) noted at the leaf margins, but none seen elsewhere. **Papillae** absent from the abaxial surface, but adaxial ribs densely covered with conical papillae as in Fig. III, 6, but somewhat taller. **Stomata** mostly with triangular (Fig. IV, 1), but some with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells,** between the veins, blunt ended, with thin, almost non-sinuous to v. slightly sinuous walls (Fig. V, 2*c*–3*c*, or tending to be as in 4*b*). Interstomatal cells rather long with concave ends (Fig. V, 11).

T.S. lamina

Vascular bundles: most vb's small and rather inconspicuously angular in outline (Fig. VIII, 6); vb's in the large adaxial ribs of basic type (Fig. VIII, 13). **Adaxial surface** with some 50 ribs of unequal size, large and small ribs for the most part alternating with one another, but ribs towards the leaf margins mostly small; apices of all ribs rounded; furrows between the ribs shallow. Abaxial surface smooth. **Sclerenchyma:** small vb's opposite the bulliform cells not accompanied by scl. (Fig. IX, 1); other small vb's accompanied by abaxial strands up to about 4 cells wide and 2 or 3 cells high, adaxial strands of about the same size sometimes being present as well. Large vb's with adaxial strands up to about 8 cells wide and 2 cells high in the apices of the ribs, and smaller abaxial strands some 2–3 cells wide and high. Scl. strands also well developed in the leaf margins. **Keel** not conspicuous. **Mesophyll** with chlorenchyma radiately arranged immediately around the vb's, but remainder of the tissue between the vb's consisting of irregularly arranged cells with few or no chloroplasts. **Bulliform cells** in more or less fan-shaped groups at the bases of most of the furrows (Fig. XV, 6), but not well developed in furrows towards the leaf margins. **Bundle-sheaths** single; complete round all vb's (Fig. XI, 2*a*–*b*); those of the large vb's connected to the abaxial surface by girder-like extensions of colourless cells.

CULM

Culm examined about 5 mm in diameter with a central cavity about 4 mm in diameter. Epidermis subtended by about 3–4 layers of narrow, thick-walled fibres, followed by a broad zone of parenchyma about 10–12 cells wide with a circle of 26 large intercellular cavities embedded in it, the vestigial remains of a spongy tissue of stellate cells sometimes being visible in the cavities. Each cavity separated from the subepidermal fibres by about 4–5 of the layers of large parenchymatous cells already mentioned, and from the inner scl. ring (see below) by 1–2 layers of cells. Parenchymatous zone bounded on the inner side by a very sinuous zone of fibres varying in different parts from 1 to 3 cells wide, this inner zone of fibres being separated from the central cavity

of the culm by about 3 layers of large parenchymatous cells. Vb's situated along radii from the centre of the culm passing outwards to the epidermis between the large intercellular cavities already mentioned, there being 2 or 3 vb's along each radius, the largest vb in each radiating series being nearest to the centre of the culm and the smallest nearest to the epidermis. Innermost vb of each radiating series of 3 vb's situated in the inner ground tissue, the next at the inner boundary of the inner scl. ring, and the outermost some 3 or 4 cell layers below the outer scl. ring.

MATERIAL EXAMINED: Specially collected by R. E. Vaughan in Mauritius.

ADDITIONAL INFORMATION FROM THE LITERATURE

Breakwell (1915) notes for *P. flavidum* (Retz.) A. Camus (under *Panicum flavidum* Retz.) that the conspicuous midrib contains 3 primary and 2 other vb's, and that the bulliform cells are in groups of 6–7 in 'depressions' (grooves) in the leaf surface.

SPECIAL NOTE

The leaf structure is panicoid.

LITERATURE

Breakwell 1915 (leaf; under *Panicum*).

PASPALUM

DIAGNOSTIC GENERIC CHARACTERS

Short-cells, over the veins, mostly in long rows, but some paired or occasionally solitary. Silica-bodies, over the veins, mostly cross to dumb-bell shaped, or, in some spp., nodular. Micro-hairs present; often v. conspicuously bent; each sometimes with the distal cell tapering to a pointed apex, but others with the apex more rounded. Stomata mostly with triangular, but sometimes with low dome-shaped, subsidiary cells. Vascular bundles mostly small, crowded and conspicuously angular in outline. Mesophyll variable, the chlorenchyma being distinctly radiate, inconspicuously radiate, or even not radiate. Bundle-sheaths single.

SPECIES SPECIALLY EXAMINED

***Paspalum commersonii* Lam.**

LEAF

Abaxial epidermis

Short-cells, over and between the veins, sometimes paired, or, more rarely, solitary; most of those over the veins in rows of more than 5 cells; abundant over, but less frequent between, the veins. **Silica-bodies** between, and some of those over, the veins, cross-shaped (Fig. IA, 16), those between and at the margins of the veins, or over the small veins, often with a distorted appearance; others over the veins intermediate between cross and dumb-bell shaped (Fig. IA, 17). **Macro-hairs:** occasional thick-walled hairs with sunken bases

(Fig. II, 3) present in the intercostal zones. **Micro-hairs,** in Jackson's material: length 36–45 μ; basal cells 14–18 μ; distal cells 21–30 (mostly 21–25) μ; distal cells tapering to pointed apices; basal cells v. conspicuously bent at their proximal ends (Fig. VII, 5 and 6). Micro-hairs, in Meikle 851: similar but shorter, and with more rounded apices. Length of micro-hairs 28–34 μ; basal cells 16–20 μ; distal cells 12–17 μ. **Prickle-hairs:** small somewhat angular prickles (Fig. VI, 3) present at the leaf margins; hooks (Fig. VI, 5) abundant in the intercostal zones. **Stomata** with triangular subsidiary cells (Fig. IV, 1). **Long-cells,** between the veins, with thin coarsely sinuous walls (Fig. V, 3*a–c*), sometimes rather short; interstomatal cells rather long, but often with concave ends (Fig. V, 11).

T.S. lamina

Vascular bundles: most vb's small, crowded, and angular (Fig. VIII, 5) to inconspicuously angular (Fig. VIII, 6) in outline; large vb's of basic type (Fig. VIII, 15). **Adaxial surface** practically smooth (Fig. XIV, 1), apart from a few slight ribs over the midrib (Fig. XIV, 2), and slight projections owing to the apices of the bulliform cells being raised above the level of the epidermis. **Sclerenchyma:** many small vb's, especially those opposite the bulliform cells, not accompanied by scl. (Fig. IX, 1); other small vb's with adaxial girders up to about 4 cells wide and 2 cells high, and abaxial girders up to 10 cells wide and mostly 2, but occasionally 3, cells high (Fig. IX, 4); large vb's with slightly more massive adaxial and abaxial girders. Adaxial surface of the midrib supported by a few, small, thin plates of fibres subjacent to the epidermis. **Midrib,** in Jackson's material: conspicuous abaxially, with a large central **lysigenous cavity** in the ground tissue; containing a large median vb accompanied on either side by 1 lateral of about the same size, and by about 8, much smaller, laterals. No lysigenous cavity seen in Meikle 851. **Mesophyll:** chlorenchyma distinctly radiate round all vb's, and occupying a slightly greater proportion of the lamina in Meikle's as compared with Jackson's material. **Bulliform cells** in groups of the *Zea* type (Fig. XV, 3). **Bundle-sheaths** single; complete (Fig. XI, 2*a–b*) round most vb's; a few large vb's with their sheaths interrupted abaxially (Fig. XI, 6); sheath cells of unequal sizes, the outlines of the sheaths being somewhat sinuous.

CULM

Culm examined about 3 mm in diameter, somewhat oval in outline, and with a large central cavity. A circle of conspicuous, apparently lysigenous, cavities present, a few cell layers within the epidermis. Parenchyma between the cavities extending inwards from the epidermis to a depth of about 5 layers of cells, this parenchyma and the lysigenous cavities being bounded on the inner side by a continuous, but sinuous, circle of fibres about 2–4 cells wide. Ground tissue on the inner side of the scl. ring consisting of large, thin-walled cells with minute, triangular intercellular spaces between them. Vb's of the outermost circle embedded in the tissue between the cavities. Remaining vb's in 2–3 irregular circles, and abutting on the inner margin of the scl. ring or embedded in the large-celled ground tissue.

ROOT

Root examined 1 mm in diameter. Epidermis subtended by 1 layer of fairly large cells with their inner and tangential walls slightly thickened, the cells of the next subjacent layer being smaller and with more uniformly thickened walls. T.S. of the root mostly consisting of a wide, aerenchymatous, inner cortical zone containing v. large intercellular spaces separated from one another by radiating, usually uniseriate rows of collapsed cells. Aerenchymatous zone bounded on the inner side by 2–3 layers of thin-walled cells arranged in a radiating manner, with small, mostly quadrangular spaces between them, followed by a single layer of cells with conspicuously thickened walls resembling an endodermis. Central vascular tissue marked by a circle of 8 conspicuously large metaxylem vessels and minute strands of ph. alternating with them. Centre of the stele consisting of thick-walled fibrous cells.

MATERIAL EXAMINED: (i) Specially collected by G. Jackson in Nyasaland. (ii) Meikle 851; Nigeria.

***Paspalum conjugatum* Berg.**

LEAF

Abaxial epidermis

Short-cells, between the veins, paired; those over the veins in rows of more than 5 cells; common over, but infrequent between, the veins. **Silica-bodies,** between the veins, cross-shaped (Fig. IA, 16), but with a distorted appearance, or tall, narrow, and crenate (Fig. IB, 24); those over the veins also sometimes cross-shaped, but less distorted than those between the veins, or nodular (Fig. IA, 18 (i)). **Macro-hairs:** none seen. **Micro-hairs,** in Vaughan's material: lengths of basal cells not accurately determined because bent; distal cells 29–40 μ long, tapering to pointed apices (Fig. VII, 6). Micro-hairs, in Ballard 1015: similar to those in Vaughan's specimen, but shorter, the distal cell being 24–30 μ long. **Prickle-hairs:** a few rather inconspicuous hooks (Fig. VI, 5) present between the veins. **Papillae:** a few rather obscure papillae present on some of the long-cells. **Stomata** with triangular (Fig. IV, 1) subsidiary cells. **Long-cells** with thin, coarsely sinuous walls (Fig. V, 3*a–c*), but rather short; interstomatal cells also with coarsely sinuous walls with concave ends (Fig. V, 10–11).

T.S. lamina

Vascular bundles: most vb's v. small, crowded, and angular in outline, with xy. and ph. not clearly contrasted (Fig. VIII, 1); a few vb's somewhat larger and angular (Fig. VIII, 5) to inconspicuously angular (Fig. VIII, 6) in outline; a few large vb's of basic type (Fig. VIII, 15). **Adaxial surface** practically smooth (Fig. XIV, 1), or with slight suggestions of wide ribs (Fig. XIV, 2). A wide adaxial furrow present over the midrib. **Sclerenchyma:** numerous small vb's, especially those opposite the bulliform cells, not accompanied by scl. (Fig. IX, 1); medium-sized vb's with adaxial strands up to about 4 cells wide and 2 cells high (Fig. IX, 2), or sometimes with similar abaxial strands as well (Fig. IX, 4); large vb's with adaxial girders about 5 cells wide and 2 cells high, and abaxial girders about 8–20 cells wide and up to about 6 cells high (Fig. IX, 5), the combined girders to these vb's appearing to be slightly anchor-shaped. Median keel vb supported by a wide, crescent-shaped girder occupying the whole of the apex of the keel and by a small adaxial strand widely separated, by ground tissue, from the median vb. **Keel** conspicuous, narrow but rounded; containing 1 large median vb accompanied on either side by 3 or 4 much smaller laterals (Fig. XIII, 4). **Mesophyll:** chlorenchyma rather inconspicuously radiate round all vb's. **Bulliform cells:** mostly in irregular groups (Fig. XV, 1), but some groups tending to be more as in Fig. XV, 2; cells specially large in the adaxial furrows in the midrib. Ground tissue of keel largely composed of colourless cells. **Bundle-sheaths** single; complete round each vb (Fig. XI, 2*a–b*); the component cells being v. unequal in size and the sheaths somewhat sinuous in outline.

CULM

Culm examined 2 mm in diameter; slightly flattened on 1 side, and without a central cavity. Epidermis subtended by about 6 or 7 layers of thin-walled cells; this zone being bounded on its inner side by a scl. ring consisting of some 6 layers of fibres. Inner ground tissue consisting of large, thin-walled cells, the walls being slightly thickened at the corners where several contiguous cells meet. Vb's of the outermost circle embedded in the thin-walled tissue external to the scl. ring, the next circle being in the scl. ring itself. Remaining vb's scattered in the peripheral part of the inner thin-walled ground tissue, 2 of the vb's penetrating much more nearly to the centre of the culm than the remainder.

MATERIAL EXAMINED: (i) Specially collected by R. E. Vaughan in Mauritius. (ii) F. Ballard 1015; Ceylon.

***Paspalum distichum* L.**

LEAF

Abaxial epidermis

Short-cells, over the veins, in rows of more than 5 cells; abundant over, but infrequent or absent between, the veins. **Silica-bodies** mostly nodular (Fig. IA, 18 (i)), but those over some of the small veins tending to be cross-shaped (Fig. IA, 16). **Macro-hairs:** none actually observed, but structures resembling the bases of hairs surrounded by specialized epidermal cells noted in some of the intercostal zones. **Micro-hairs:** basal cells v. short and too bent for the length to be correctly determined; distal cells 28–36 μ long, tapering to pointed apices; as Fig. VII, 6, but with exceptionally short basal cells. **Prickle-hairs:** large angular prickles (Fig. VI, 3) present at the leaf margins. **Papillae:** oblique papillae with thickened endings (Fig. IV, 2) present on some of the long-cells, usually no more than 1 papilla being present on each cell; numerous, thin, conical papillae present on the adaxial surface. **Stomata** with triangular (Fig. IV, 1), slightly triangular, or low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells,** between the veins, with thin, sinuous walls (Fig. V, 3*a–c*); rather short; interstomatal cells sometimes with concave ends (Fig. V, 10–11).

T.S. lamina

Vascular bundles: vb's mostly small and crowded; a few of the smallest angular with xy. and ph. not clearly contrasted (Fig. VIII, 1); most vb's rather larger and angular (Fig. VIII, 5) to inconspicuously angular (Fig. VIII, 6); a v. few large vb's of basic type (Fig. VIII, 15). **Adaxial surface** practically smooth (Fig. XIV, 1). **Sclerenchyma:** numerous small vb's, especially those opposite the bulliform cells, not accompanied by scl. (Fig. IX, 1); medium-sized vb's with adaxial and abaxial strands (Fig. IX, 4) about 6 cells wide and 2–4 cells high; large vb's with similar but slightly larger girders. **Keel** fairly conspicuous; containing a large median vb accompanied on either side by 5 or 6 much smaller laterals of 2 distinct sizes, the smallest being nearer to the abaxial surface of the leaf than the remainder. **Mesophyll:** chlorenchyma not conspicuously radiate. **Bulliform cells** in somewhat fan-shaped (Fig. XV, 4), or short, irregular (Fig. XV, 1) groups. Adaxial part of the ground tissue of the keel composed of colourless cells. **Bundle-sheaths** single; complete round each vb, constituent cells being rather unequal in size, and the sheaths somewhat sinuous in outline.

CULM

Culm examined about 3 mm in diameter. Epidermis subtended by a zone of assimilatory tissue about 6 cells wide, the walls of the cells being rather thick and apparently gelatinous. Assimilatory tissue bounded on the inner side by a ring of scl. about 3–4 cells wide. Ground tissue on the inner side of the scl. ring consisting of cells similar to those of the assimilatory tissue, but with relatively large intercellular spaces between them, this somewhat spongy tissue extending to the solid centre of the culm. Vb's of the outermost circle partly embedded in the scl. ring. Remaining vb's scattered rather sparsely in the central ground tissue.

MATERIAL EXAMINED: Cultivated at Kew.

***Paspalum paniculatum* L.**

LEAF

Abaxial epidermis

Short-cells between, and some of those over, the veins solitary, or paired; those over the veins mostly in rows of more than 5 cells; common over and between the veins. **Silica-bodies** between, and those in solitary and paired short-cells over the veins, cross-shaped (Fig. IA, 16), often with a distorted appearance; those in rows over the veins also often cross-shaped but not distorted in appearance, and others nodular (Fig. IA, 18 (i)), or sometimes tending to be dumb-bell shaped (Fig. IA, 18 (ii–v)). **Macro-hairs:** fairly long, thick-walled hairs with swollen, constricted bases (Fig. II, 3) occasional between the veins. **Micro-hairs:** basal cells longer, and less conspicuously bent, than in the other spp. of *Paspalum* examined by the author; length of hairs 34–42 μ; basal cells 12–20 μ; distal cells 22–25 μ; basal cells tapering towards their proximal ends; distal cells tapering to their pointed apices (Fig. VII, 6). **Prickle-hairs:** hooks (Fig. VI, 5) v. frequent in the intercostal zones.

Stomata with triangular (Fig. IV, 1) subsidiary cells. **Long-cells,** between the veins, with thin, sinuous walls, as in Fig. V, 3*a–c*, but often rather shorter; interstomatal cells with concave ends (Fig. V, 10–11).

T.S. lamina

Vascular bundles: vb's as in *P. distichum*. **Adaxial surface** smooth (Fig. XIV, 1), apart from projecting apices of groups of bulliform cells. Abaxial surface with small ribs over the medium-sized vb's. **Sclerenchyma:** numerous small vb's, especially opposite the bulliform cells, not accompanied by scl. (Fig. IX, 1), or occasionally accompanied by minute abaxial strands only. Medium-sized vb's with adaxial strands up to some 6 cells wide and 1–3 cells high, and abaxial girders up to about 12 cells wide and about 7 or 8 cells high (Fig. IX, 5), the abaxial girders fitting into the abaxial ribs; large vb's with adaxial and abaxial girders about the same size as, to slightly smaller than, those belonging to the medium-sized vb's. Median vb with a wide abaxial girder and a smaller adaxial strand. **Keel** fairly conspicuous, rounded; containing 1 large median vb accompanied on either side by about 5 much smaller laterals (Fig. XIII, 3). **Mesophyll:** chlorenchyma distinctly radiate. **Bulliform cells:** sometimes, especially towards the leaf margins, in short, irregular groups (Fig. XV, 1); elsewhere tending to be in small groups of the *Zea* type (Fig. XV, 3). **Bundle-sheaths** single; those round most vb's complete (Fig. XI, 2*a*), the constituent cells being rather unequal in size and the sheaths somewhat sinuous in outline; sheaths of the large vb's with abaxial interruptions only (Fig. XI, 6).

CULM

Culm examined 2 mm in diameter. Outermost vb's of v. unequal sizes, the smallest being embedded in columns of assimilatory tissue some 6 cells wide lying immediately subjacent to the epidermis, the assimilatory cells round some of the vb's tending to be arranged in a slightly radiating manner. Large outer vb's connected to the epidermis by well-developed scl. girders separating the columns of assimilatory tissue from one another. Cells bounding the assimilatory tissue on the inner side somewhat lignified and fibre-like, this zone gradually passing over to the cells of the inner ground tissue with progressively wider diameters and thinner walls towards the v. loose, spongy tissue at the centre of the culm. Vb's, other than the outer ones already mentioned, in about 2 irregular circles in the peripheral part of the inner ground tissue.

MATERIAL EXAMINED: Specially collected by R. E. Vaughan in Mauritius.

ADDITIONAL INFORMATION FROM THE LITERATURE

Krishnaswami and Rangaswami (1942) have recorded the following notes concerning the leaf of *P. scrobiculatum* L. Both surfaces with slight, widely spaced ribs. Vb's of 3 sizes, only those of the 2 larger sizes being accompanied by scl. Midrib conspicuous; containing more than 1 primary vb and a central air-cavity. Bulliform cells not v. conspicuous.

Prat (1932) notes, for *P. racemosum* Lam., that the silica-cells above the veins on both surfaces of the leaf are arranged like stones in a crazy pavement. Micro-hairs present on the abaxial surface.

Chrysler (1906) draws attention to the occurrence of amphivasal bundles in the culm nodes of *Paspalum*, where they are formed by fusions between collateral bundles.

Soper (1956) has compared the stem apex and leaf structure of *P. dilatatum* Poir. with that of *Lolium perenne*, but the conclusions she reaches are of physiological rather than taxonomic interest.

Special Note

Prat (1936) rightly notes that the leaf structure is panicoid.

Literature

Chrysler 1906 (notes on culm structure); Krishnaswami and Rangaswami 1942 (leaf); Prat 1932, 1936 (leaf); Soper 1956 (stem apex and leaf).

PENNISETUM

Diagnostic Generic Characters

Short-cells, over the veins, in short to long rows or sometimes paired, the proportion of each type varying considerably in different spp. Silica-bodies, over the veins, mostly intermediate between cross and dumb-bell shaped and sometimes with concave ends; a few nodular. Micro-hairs present; each with the distal cell tapering to a pointed apex. Stomata with triangular subsidiary cells. Vascular bundles mostly small, crowded, and conspicuously angular in outline. Mesophyll with chlorenchyma distinctly to inconspicuously radiate. Bundle-sheaths single or inconspicuously double.

Species Specially Examined

***Pennisetum clandestinum* Hochst. ex Chiou.**

Leaf

Abaxial epidermis

Short-cells between, and some of those over, the veins, paired; others, over the veins, in rows of 3–5 or more cells; abundant over, and common between, the veins. **Silica-bodies,** between the veins, seldom conspicuous, tall and narrow (Fig. I, 4), or occasionally tall, narrow, and crenate (Fig. Ib, 24); those in rows over the veins, intermediate between cross and dumb-bell shaped (Fig. Ia, 17), or dumb-bell shaped (Fig. Ia, 18 (ii–v)), the ends of most of the bodies being convex; a few nodular (Fig. Ia, 18 (i)). **Macro-hairs:** long, thick-walled hairs, with swollen, constricted bases (Fig. II, 3) present locally in the intercostal zones. **Micro-hairs:** length 56–66 (mostly 56–64) μ; basal cells 15–20 μ; distal cells 37–46 μ; distal cells tapering to pointed apices (Fig. VIII, 5 and 6). **Prickle-hairs:** none seen. **Stomata** with triangular (Fig. IV, 1) subsidiary cells. **Long-cells,** between the veins, with thin, sinuous walls (Fig. V, 3*a–c*); interstomatal cells rather long and with concave ends (Fig. V, 11).

T.S. lamina

Vascular bundles: most vb's small, crowded, angular (Fig. VIII, 5); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** practically smooth (Fig. XIV, 1) apart from v. slight ribs over the large vb's. **Sclerenchyma:** most small vb's not accompanied by scl. (Fig. IX, 1); occasional small vb's with an adaxial strand only (Fig. IX, 2); large vb's with adaxial and abaxial girders up to about 10 cells wide and 6 cells high (Fig. IX, 5), the adaxial often being rather smaller than the abaxial girders; median keel vb, and a few other vb's in the keel, with well-marked abaxial girders only (Fig. IX, 3). **Keel** conspicuous, rounded; containing 1 large median vb accompanied on either side by about 4 smaller laterals (Fig. XIII, 3). **Mesophyll:** chlorenchyma distinctly radiate round the vb's, including those in the keel. **Bulliform cells:** groups irregular (Fig. XV, 1), and sometimes as in Fig. XV, 2; 1 group of the *Zea* type (Fig. XV, 3) present on either side of the midrib. **Bundle-sheaths:** some single, and others possibly double; small vb's each surrounded by a single complete sheath, the cells having v. conspicuous contents; an obscure I.S. present around each large vb, the O.S. being complete (Fig. XII, 1). O.S. of the median keel vb interrupted adaxially and abaxially (Fig. XII, 3*a*).

Culm

Culm examined about 3 mm in diameter, oval in outline, and with a fairly large central cavity. Epidermis subtended by a zone of assimilatory tissue some 6–7 cells wide, the constituent cells being round, with fairly numerous, polygonal intercellular spaces between them. Assimilatory tissue bounded on the inner side by a well-marked scl. ring about 3–5 cells wide. Inner ground tissue consisting of large, thin-walled cells. Vb's of the outermost circle embedded in the scl. ring, those of the next circle being at the inner periphery of the scl. ring. Remaining vb's in 2–3 irregular circles, embedded in the large-celled inner ground tissue.

Material Examined: Cultivated at Kew.

***Pennisetum macrourum* Trin.**

Leaf

Abaxial epidermis

Short-cells, both over and between the veins, mostly paired, but occasionally in rows of 3–5 cells; abundant. **Silica-bodies,** over the veins, cross-shaped (Fig. Ia, 16), or intermediate between cross and dumb-bell shaped (Fig. Ia, 17); those between the veins mostly tall, narrow, and crenate (Fig. Ib, 24). **Macro-hairs:** none seen. **Micro-hairs:** v. infrequent; length 72–102 μ; basal cells 30–48 μ; distal cells 31–54 (mostly 38–54) μ; hairs of rather wide diameters, especially the basal cells; distal cells mostly tapering to pointed apices (Fig. VII, 4 and 5). **Prickle-hairs:** rather large prickles (Fig. VI, 2) present over some of the veins. **Papillae:** long, thin, rounded papillae present on the sides of the adaxial ribs. **Stomata** with triangular (Fig. IV, 1) subsidiary cells. **Long-cells,** between the veins, with thin, sinuous walls (Fig. V, 3*a–c*); some of them being rather short; interstomatal cells mostly with concave ends (Fig. V, 10–11), sometimes rather long.

T.S. lamina

Vascular bundles: a few of the smallest vb's with xy. and ph. not clearly contrasted (Fig. VIII, 1); most small vb's polygonal (Fig. VIII, 5); medium-sized vb's in the small ribs similar, but less angular (Fig. VIII, 6); large vb's of basic type (Fig. VIII, 8 and 11). **Adaxial surface** with pronounced ribs and furrows (Fig. XIV, 7), the ribs over the large vb's being much taller, and with more flattened apices, than the smaller, more rounded ribs over the medium-sized vb's; smallest vb's situated opposite, or nearly opposite, the furrows. **Sclerenchyma:** smallest vb's not accompanied by scl. (Fig. IX, 1); vb's opposite the small ribs with abaxial girders about 2–8 cells wide, and seldom more than about 3 cells high; large vb's with more robust (Fig. IX, 3) abaxial girders, or occasionally strands, sometimes accompanied by thin plates of scl. in the apices of the adaxial ribs as well, the combined girders then tending to be as in Fig. IX, 10. **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma indistinctly radiate. **Bulliform cells** mostly as fan-shaped groups (Fig. XV, 6) at the bases of the adaxial furrows. Assimilatory tissue replaced by large colourless cells in the distal ends of the adaxial ribs (Fig. XV, 11). **Bundle-sheaths** single; those round most vb's, especially the small ones, complete (Fig. XI, 2*a–b*); those round the large vb's sometimes with slight, abaxial interruptions. Sheaths round the large vb's with girder-like extensions to the abaxial scl. See also under 'bulliform cells' for colourless cells in the distal ends of the ribs.

Culm

Culm examined about 4 mm in diameter; circular in outline, with a relatively small cavity at the centre. Epidermis subtended by a zone of about 8 layers of large, round, assimilatory cells bounded on the inner side by a rather inconspicuous scl. ring, some 2–8 cells wide, between the vb's of the outermost circle. Ground tissue on the inner side of the scl. ring consisting of cells of gradually increasing diameter towards the central cavity of the culm, with minute triangular intercellular spaces between the cells. Vb's of the outermost circle abutting on the outer periphery of the scl. ring, and extending almost to the epidermis. Next circle of vb's abutting on to the inner periphery of the scl. ring at their ph. ends, the remaining vb's being scattered throughout the inner ground tissue.

Material Examined: Cultivated at Kew.

Additional Information from the Literature

The following points concerning the leaf of *P. typhoides* (Burm.) Stapf & C. E. Hubbard have been noted by Krishnaswami and Rangaswami (1942). Both surfaces with slight but widely spaced ribs. Vb's of 3 sizes, those of the 2 larger sizes being accompanied by scl. Midrib containing more than 1 primary vb, but no lacunae present. Bulliform cells present in groups of various sizes.

Special Note

Prat (1936) rightly notes that the leaf structure is panicoid.

Literature

Duval-Jouve 1875 (leaf); Grob 1896 (leaf); Krishnaswami and Rangaswami 1942 (leaf); Prat 1936 (leaf); Rangaswami and Hariharan 1935; Wille 1916.

PENTASCHISTIS

De Wet (1956), with reference to the Danthonieae, restricts the name *Pentaschistis* to spp. with awns, and, unlike some botanists, excludes awnless grasses from the genus and refers them to *Afrachneria*.

De Wet, who examined 32 spp. of *Pentaschistis*, found the mesophyll in all of them to be festucoid. The epidermis of most spp. exhibits micro-hairs, each with the distal cell tapered to a pointed apex, and dumb-bell shaped silica-bodies. In 8 spp. micro-hairs were not found, and the silica-bodies were spherical. In spite of this difference the 2 groups are treated as belonging to the same genus as De Wet found no other grounds for separating them.

Literature

De Wet 1956 (leaf).

PENTAMERIS

De Wet (1956) has recorded festucoid anatomy and epidermis in the leaf of 5 spp. of *Pentameris*. The genus should be in the Danthonieae rather than in the Aveneae.

Literature

De Wet 1956 (leaf).

PENTAPOGON

Diagnostic Generic Characters

Short-cells, over the veins, paired and in short or long rows. Silica-bodies, over the veins, obscure in the material examined, apparently horizontally elongated and with smooth or sinuous outlines. Micro-hairs absent. Stomata probably with parallel-sided or low dome-shaped subsidiary cells, but rather obscure. Vascular bundles: none conspicuously angular in outline. Mesophyll with chlorenchyma not radiate. Bundle-sheaths double.

Species Specially Examined

***Pentapogon quadrifidus* (Labill.) Baill.**

Leaf

Abaxial epidermis

Only v. narrow strips available for examination. **Short-cells** in pairs, and short or long rows; common over, but infrequent or absent between, the veins. **Silica-bodies** not clearly visible in the material examined, but shapes of the short-cells suggesting horizontally elongated bodies with smooth (Fig.

IA, 13), or sinuous (Fig. IA, 14–15), outlines. **Macro-hairs:** moderately long, fairly thick-walled hairs with swollen bases (Fig. II, 1) common. **Micro-hairs:** none seen. **Prickle-hairs:** prickles (Fig. VI, 1–2), often with rather long points, frequent over the veins. **Stomata** sunken, with rather obscure outlines; subsidiary cells probably parallel-sided (Fig. IV, 2), but sometimes appearing to be more nearly low dome-shaped (Fig. IV, 3). **Long-cells,** between the veins, v. long, with thin, to moderately thick, non-sinuous walls (Fig. V, 2*a–c*).

T.S. lamina

Vascular bundles: all vb's of basic type (Fig. VIII, 7 and 15). **Adaxial surface** with moderate ribs and furrows (Fig. XIV, 3), the rib over the median vb being less tall and more rounded at the apex than the others; furrows widely V-shaped. **Sclerenchyma:** small vb's with adaxial strands or girders mostly about 3 cells wide and 2 cells high, and abaxial strands mostly smaller and often consisting of 1 layer of fibres only, but occasionally up to 6 cells wide (Fig. IX, 4); large vb's with adaxial and abaxial girders up to about 6 cells wide and 3–4 cells high, the girders to the median vb being somewhat wider (Fig. IX, 5). **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells:** adaxial furrows containing bulliform cells of various sizes, but usually none specially large (Fig. XV, 5); bulliform cells in certain furrows slightly larger and tending to form fan-shaped groups (Fig. XV, 6). **Bundle-sheaths** double; those round some of the small vb's with the O.S. incomplete or inconspicuous abaxially (Fig. XII, 2); other vb's with 2 complete sheaths, the O.S. sometimes connected to the adaxial scl. by extensions of colourless cells; O.S. to median and other vb's occasionally interrupted both adaxially and abaxially (Fig. XII, 3*a*).

MATERIAL EXAMINED: Supplied specially by W. M. Curtis from Tasmania.

SPECIAL NOTE

Leaf structure festucoid.

LITERATURE

Grob 1896 (a few notes on the leaf).

PERIBALLIA

The epidermis of the lamina of *P. involucrata* (Cav.) Janka and *P. laevis* (Brot.) Aschers. & Graebn. has been figured by Paunero (1955).

LITERATURE

Paunero 1955 (epidermis of lemma).

PEROTIS

DIAGNOSTIC GENERIC CHARACTERS

Short-cells, over the veins, in long rows. Silica-bodies, over the veins, dumb-bell shaped, sometimes with the middle portion of each body long and narrow. Cross-shaped and nodular types stated by Grob (1896) to occur sporadically. Micro-hairs present; each with a hemispherical distal cell. Stomata with variable subsidiary cells including triangular and low and tall dome-shaped types. Vascular bundles mostly small, crowded and conspicuously angular in outline. Mesophyll with chlorenchyma distinctly radiate. Bundle-sheaths single and double. Outer or single sheaths dome-shaped to triangular.

SPECIES SPECIALLY EXAMINED

***Perotis indica* (L.) O. Kuntze**

LEAF

Abaxial epidermis

Short-cells, over the veins, in rows of more than 5 cells; abundant over, but infrequent or absent between, the veins. **Silica-bodies** dumb-bell shaped (Fig. IA, 18 (ii–v)), often varying in appearance with the focus (Fig. IB, 21). **Macro-hairs:** none seen. **Micro-hairs:** length 10–13 μ; basal cells about 6 μ; distal cells 4–7 μ; basal cells rather conspicuously bent; distal cells hemispherical, with rounded apices (Fig. VII, 2). **Prickle-hairs:** angular prickles (Fig. VI, 3) present at the leaf margins. **Stomata** occasionally with slightly triangular (Fig. IV, 1), but mostly low (Fig. IV, 3) to fairly tall (Fig. IV, 4) dome-shaped, subsidiary cells. **Long-cells,** between the veins, with thin walls, varying from slightly to rather coarsely sinuous (Fig. V, 3*a–c*); often rather short, or tending to be as in Fig. V, 7*a–b*; interstomatal cells mostly with concave ends (Fig. V, 10–11).

T.S. lamina

Vascular bundles: most vb's small, crowded, angular (Fig. VIII, 4 and 5); a few large vb's of basic type (Fig. VIII, 15), but metaxylem vessels less conspicuous than usual. **Adaxial surface** practically smooth (Fig. XIV, 1) apart from a slight suggestion of ribs over the crowded vb's. **Sclerenchyma:** most vb's with minute adaxial girders, often no more than 2–3 cells wide and high, and abaxial girders up to about 20 cells wide and some 3 cells high, the combined vb's being anchor-shaped (Fig. IX, 6). **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma distinctly radiate. **Bulliform cells** in groups of the *Sporobolus* type (Fig. XV, 8), with girders of colourless cells connecting the groups to the abaxial surface (Fig. XV, 13). **Bundle-sheaths** single and double; all small vb's with single complete sheaths, the sheaths appearing to be more or less triangular or dome-shaped with flattened abaxial bases, this appearance being caused by the abaxial sheath-cells being much smaller than the others, and by the flattened bases of the triangles or domes resting on the wide abaxial scl. girders. Large vb's with double sheaths.

CULM

Culm examined about 1 mm in diameter; most of the culm consisting of a broad central column of spongy ground tissue. Epidermis subtended by a single layer of specially thick-walled fibrous cells, followed by 1 or 2 layers of

larger cells with thinner walls, bounded on the inner side by 2–3 layers of cells with thicker walls. Vb's in 2–3 more or less distinct circles near the periphery of the culm.

MATERIAL EXAMINED: F. Ballard 1480; Ceylon.

Perotis patens Gandoger

LEAF

Abaxial epidermis

Short-cells, over the veins, in rows of more than 5 cells; abundant over, but infrequent or absent between, the veins. **Silica-bodies,** over the veins, dumb-bell shaped (Fig. IA, 18 (ii–v)), often varying in appearance with the focus (Fig. IB, 21), the middle portions of most of the bodies being long and narrow. **Macro-hairs:** none seen. **Micro-hairs** in Jackson's material: length 13–17 μ; basal cells about 9 μ; distal cells 4–7·5 μ; distal cells mostly hemispherical but sometimes rather distorted (Fig. VII, 2). Micro-hairs in Meikle 999: similar, but rather larger, and situated over the veins. **Prickle-hairs:** none seen. **Stomata** mostly tending to be with triangular (Fig. IV, 1), but sometimes having tall dome-shaped (Fig. IV, 4), subsidiary cells. **Long-cells,** between the veins, with thin, mostly rather coarsely and distantly sinuous walls (Fig. V, 3*a–c*), often rather short (Fig. V, 7*a–b*); interstomatal cells mostly with concave ends (Fig. V, 10–11).

T.S. lamina

Vascular bundles: most vb's small, crowded, and angular (Fig. VIII, 4 and 5); a few large vb's of basic type (Fig. VIII, 15). **Adaxial surface** smooth (Fig. XIV, 1), apart from a v. slight suggestion of ribs over the crowded vb's. **Sclerenchyma:** most vb's with adaxial girders about 2–4 cells wide and high, the corresponding abaxial girders being about 15 or more cells wide and about 3 or 4 cells high, the combined girders being anchor-shaped (Fig. IX, 6); adaxial and abaxial girders to the fairly large vb's exhibiting the same relative sizes, but rather wider than those belonging to the remaining vb's. **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma distinctly radiate. **Bulliform cells** in groups of the *Sporobolus* type (Fig. XV, 8), most groups being connected to the abaxial surface by girders of colourless cells (Fig. XV, 13). **Bundle-sheaths** double and single; all but the largest vb's each surrounded by a single complete sheath (Fig. XI, 2*a*), the sheaths themselves appearing dome-shaped or slightly triangular in outline as in *P. indica*. Large vb's with the I.S. and O.S. interrupted abaxially (Fig. XII, 5).

CULM (Jackson's material)

Culm examined about 2 mm in diameter; central portion occupied by a wide column of somewhat spongy ground tissue. Epidermis subtended by a zone of v. thick-walled fibres, some 8–10 cells wide, with small columns of thin-walled assimilatory tissue embedded in it. Vb's of the outermost circle also embedded in the peripheral scl. Remaining vb's in 2–3 more or less distinct circles in the outer part of the inner, thin-walled ground tissue, an occasional vb penetrating more deeply into the spongy ground tissue towards the centre of the culm.

Culm in Meikle 999 similar, but epidermis subtended by only 1–2 layers of v. thick-walled fibres, bounded on the inner side by a zone of 1–5 layers of large, thin-walled cells, the width of this zone varying in different positions around the periphery of the culm.

MATERIAL EXAMINED: (i) Collected specially by G. Jackson in Nyasaland. (ii) Meikle 999; Nigeria.

ADDITIONAL INFORMATION FROM THE LITERATURE

Vickery's (1935) description of *P. rara* R. Br. includes the following particulars. Leaf thin, fairly flat or inrolled on drying. Both surfaces flat, or adaxial surface with shallow, narrow grooves. Vascular bundles: approximately 21 present, about 7 of them being small, first-order bundles. Sclerenchyma: most vb's each with a narrow adaxial and a wider abaxial girder. Midrib not conspicuous. Mesophyll with radiate chlorenchyma present on either side of, but not above and below, each vb. Bulliform cells present as fan-shaped groups of 5–7 cells between the vb's; central cell in each group v. large and occupying nearly two-thirds of the thickness of the lamina; a few small colourless cells sometimes subjacent to the bulliform cells. Bundle-sheaths: those round the large vb's double, the O.S. forming a distinctly triangular layer around each vb, except when interrupted by abaxial scl. Adaxial epidermis consisting of papillose cells, with occasional prickles (asperities) over the vb's. A v. few hairs sometimes present.

SPECIAL NOTE

Leaf structure mainly panicoid. The characteristic dumb-bell shaped silica-bodies, the short micro-hairs, and the dome-shaped O.S.s resemble those of *Gymnopogon*.

LITERATURE

Grob 1896 (leaf); Vickery 1935 (leaf).

PHAENOSPERMA

DIAGNOSTIC GENERIC CHARACTERS

Short-cells, over the veins, mostly paired, but a few in short rows. Silica-bodies, over the veins, mostly elliptical or slightly crescent-shaped, and fitting into concavities in adjacent cork-cells. Micro-hairs absent. Stomata with low or tall dome-shaped subsidiary cells. Vascular bundles; none conspicuously angular in outline. Mesophyll with chlorenchyma not radiate. Bundle-sheaths double.

SPECIES SPECIALLY EXAMINED

Phaenosperma globosum Munro

LEAF

Abaxial epidermis

Short-cells, both over and between the veins, mostly paired; a few of those over the veins in short rows. **Silica-bodies** fitting into concavities in the adjacent

cork-cells (Fig. I, 6–7), and mostly elliptical or slightly crescent-shaped in outline.[1] **Macro-hairs** and **micro-hairs:** none seen. **Prickle-hairs:** hooks (Fig. VI, 5) occasional in the intercostal zones; small prickles (Fig. VI, 1) present over the veins on the adaxial surface, and clearly visible in T.S. **Stomata** infrequent; with low (Fig. IV, 3), to fairly tall (Fig. IV, 4), dome-shaped subsidiary cells. **Long-cells,** between the veins, with thin, non-sinuous walls (Fig. V, 2*a–c*).

T.S. lamina

Vascular bundles: most vb's small, rather widely spaced, and not conspicuously angular in outline (Fig. VIII, 2); a few large vb's of basic type (Fig. VIII, 10). **Adaxial surface** practically smooth (Fig. XIV, 1), apart from v. slight, wide ribs over the large vb's (Fig. XIV, 2). **Sclerenchyma:** most vb's with small adaxial and abaxial girders (Fig. IX, 4), the adaxial girders being 2–4 cells wide and mostly about 2 cells high, and the corresponding abaxial girders up to about 6, or occasionally 8, cells wide and 2 cells high; large vb's with adaxial and abaxial girders up to 14 or more cells wide and 2–3 cells high (Fig. IX, 5). Abaxial part of the midrib strongly supported by fibres, 3 columns of fibres also being present in the midrib immediately below the adaxial epidermis. **Midrib** v. conspicuous, triangular; containing 1 large median vb accompanied on either side by a smaller lateral (Fig. XIII, 2). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** mostly in groups as in Fig. XV, 2. **Bundle-sheaths** double; I.S. complete round all vb's; O.S. of small vb's mostly interrupted abaxially (Fig. XII, 2); O.S. of the large vb's interrupted adaxially and abaxially (Fig. XII, 3*a*).

Petiole

Shallowly V-shaped in T.S., with an arc of about 20 vb's just below the abaxial surface, the alternate vb's being of 2 distinct sizes. Vb's supported by girders of scl. of about the same widths as the bundles themselves. About 8 columns of scl. also present immediately below the adaxial epidermis. Ground tissue of the petiole composed of large, fairly thin-walled, somewhat polygonal cells.

Culm

Culm examined about 3 mm in diameter; slightly oval in outline; with a fairly large cavity at the centre. Epidermis subtended by an almost continuous zone of assimilatory tissue about 2 cells wide, the assimilatory tissue being interrupted by girders of scl. opposite the vb's of the outermost circle. Assimilatory tissue bounded on the inner side by a ring of scl. consisting of 4 or 5 layers of cells with polygonal outlines. Ground tissue between the scl. ring and the central cavity of the culm consisting of large, thin-walled cells. Vb's, apart from those of the outermost circle, in 2 or 3 more or less distinct circles

[1] Tateoka (1956) also refers to the presence of dumb-bell shaped silica-bodies in the upper epidermis of the same sp.

in the peripheral part of the inner, large-celled, ground tissue, each of the inner vb's being sheathed by several layers of fibres of small diameter.

Material Examined: Cultivated at Kew.

Special Notes

Tateoka (1956*e*) has reviewed the taxonomic position of this genus which has been variously assigned to the Tristegineae, the Sporoboleae, and to a special tribe the Phaenospermeae, to mention but a few of the affinities that have been suggested. To the present author the leaf structure is clearly festucoid, and in this he agrees with Tateoka.

Literature

Tateoka 1956*e* (leaf and taxonomy).

PHALARIS

Diagnostic Generic Characters

Short-cells, over the veins, mostly solitary, but sometimes paired or in short rows. Silica-bodies, over the veins, often horizontally elongated and with smooth or sinuous outlines; a few rounded or cuboid in some spp. Micro-hairs absent. Stomata with parallel-sided or low dome-shaped subsidiary cells. Vascular bundles: none conspicuously angular in outline. Mesophyll with chlorenchyma not radiate. Bundle-sheaths double.

Species Specially Examined

***Phalaris caerulescens* Desf.**

Leaf

Abaxial epidermis

Short-cells, over the veins, mostly solitary, but sometimes paired and occasionally in short rows; common over, but v. infrequent or absent between, the veins. **Silica-bodies,** over the veins, horizontally elongated, with rounded ends and smooth outlines (Fig. Ia, 13). **Macro-hairs** and **micro-hairs:** none seen. **Prickle-hairs:** prickles (Fig. VI, 1–2) with rather long points, and sometimes angular (Fig. VI, 3), abundant on either side of each of the veins. **Stomata** with parallel-sided (Fig. IV, 2), or low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells,** between the veins, with thin, non-sinuous walls (Fig. V, 2*a–c*); cells in the middle of each intercostal zone somewhat hexagonal.

T.S. lamina

Vascular bundles: most vb's moderately small, fairly widely spaced, and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 10–11). **Adaxial surface** with v. slight, wide ribs over the vb's, separated from one another by v. shallow depressions with bulliform cells at their bases (Fig. XIV, 2). Slight ribs also present on the abaxial surface opposite the vb's. **Sclerenchyma:** small vb's with adaxial and abaxial girders

tending to be tall and narrow (Fig. IX, 7), the adaxial girders being 1 or 2 cells wide and 3 or 4 cells tall, and the corresponding abaxial girders generally slightly wider. Adaxial and abaxial girders to the large vb's slightly wider and less tall (Fig. IX, 4). **Keel** fairly conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** in fan-shaped groups (Fig. XV, 4). **Bundle-sheaths** double; each vb surrounded by 2 complete sheaths (Fig. XII, 1).

CULM

Culm examined 3 mm in diameter, with a fairly large cavity at the centre. Epidermis subtended by a zone of fibres some 15 cells wide, with circular or oblong columns of assimilatory tissue embedded in it. Vb's of the outermost circle embedded in the peripheral scl. ring. Remaining vb's scattered in the thin-walled, somewhat spongy ground tissue between the scl. ring and the hollow centre of the culm.

A swollen basal portion of the culm, about 6 mm in diameter, exhibited the following structure in T.S. Outline tending to be oval, the spongy ground tissue extending to the solid centre of the culm. Other differences from the thinner culm already described are as follows. Peripheral scl. consisting of cells with thinner walls and wider lumina, the scl. ring being more dissected, and, in some places, reduced to girders extending from the outermost vb's to the epidermis. Vb's, like those in the thinner culm, mostly scattered in the spongy, inner ground tissue, but penetrating more deeply towards the centre of the culm.

MATERIAL EXAMINED: Cultivated at Kew.

***Phalaris canariensis* L.**

LEAF

Abaxial epidermis

Short-cells, over the veins, solitary, paired, and in short rows; those between the veins paired or solitary. **Silica-bodies,** between the veins, fitting into concavities in adjacent cork-cells (Fig. I, 6–7), the silica-bodies being mostly narrowly oval in outline; those over the veins rather variable, some being rounded to cubical, others horizontally elongated with coarsely sinuous (Fig. IA, 14–15) or smooth (Fig. IA, 13) outlines; a few tending to be intermediate between cross and dumb-bell shaped (Fig. IA, 17). **Macro-hairs** and **micro-hairs:** none seen. **Prickle-hairs:** prickles (Fig. VI, 1–2), with rather long points, abundant over the veins, several rows being present over certain of the larger veins. **Stomata:** some tending to be with parallel-sided (Fig. IV, 2), but others with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells,** between the veins, with thin, non-sinuous walls (Fig. V, 2*a–c*); those in the middle of certain of the intercostal zones hexagonal in outline.

T.S. lamina

Vascular bundles: most vb's rather widely spaced and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with slight, fairly wide ribs over the vb's, separated from one another by fairly wide, shallow furrows (Fig. XIV, 2). Abaxial surface slightly ribbed opposite the adaxial furrows. **Sclerenchyma:** small vb's accompanied by adaxial and abaxial strands up to about 4 cells wide and seldom more than 2 cells high (Fig. IX, 4), these strands connecting with extensions of colourless cells from the outer bundle-sheaths to form girders; large vb's with slightly wider but shorter fibrous girders. Median keel bundle strongly supported by an abaxial girder of fibres. **Keel** fairly conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** with chlorenchyma not radiate. **Bulliform cells** mostly in well-defined groups as in Fig. XV, 2, but some groups tending to be fan-shaped (Fig. XV, 4). Abaxial epidermal cells opposite the bulliform cells often larger than the remainder. **Bundle-sheaths** double; most vb's surrounded by 2 complete sheaths (Fig. XII, 1), the sheaths having girder-like extensions of colourless cells to the adaxial and abaxial epidermis.

CULM

Culm examined about 3 mm in diameter, with a small central cavity. Surface of the culm with about 28 small, fibrous ribs. Epidermis subtended by rounded or oblong columns of assimilatory tissue, 2–3 cells wide, and separated from one another, especially opposite the ribs, but extensions of fibres in the ribs themselves. Assimilatory tissue bounded on the inner side by a continuous ring of fibres some 3 cells wide. Ground tissue between the scl. ring and the hollow centre of the culm consisting of large, thin-walled cells with minute, triangular, intercellular spaces between them. Vb's of the outermost circle embedded in the scl. ring; remaining vb's in about 2 more or less distinct circles in the ground tissue on the inner side of the scl. ring.

MATERIAL EXAMINED: Cultivated at Kew.

***Phalaris minor* Retz.**

LEAF

Abaxial epidermis

Short-cells, over the veins, solitary, paired, and in rows of 3–5 cells; common over, but v. infrequent or absent between, the veins. **Silica-bodies** horizontally elongated, mostly with rounded ends and smooth (Fig. IA, 12 and 13), or occasionally with slightly sinuous (Fig. IA, 14–15), outlines. **Macro-hairs** and **micro-hairs:** none seen. **Prickle-hairs:** none seen apart from a v. few, apparently unpointed, prickles (Fig. VI, 6) over the veins. **Stomata** mostly with parallel-sided (Fig. IV, 2), but some tending to have low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells,** between the veins, with thin, non-sinuous walls (Fig. V, 2*a–c*); interstomatal cells with slightly concave ends (Fig. V, 10–11).

T.S. lamina

Vascular bundles: most vb's small, rather widely spaced, and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 10). **Adaxial surface** with slight but v. wide ribs over the vb's, separated

from one another by fairly wide, v. shallow furrows (Fig. XIV, 2). **Sclerenchyma :** a few small vb's, especially towards the leaf margins, not accompanied by scl. (Fig. IX, 1); most vb's with small adaxial and abaxial girders up to about 4 cells wide and 2–3 cells high (Fig. IX, 4), these columns of scl. serving to connect the rather long, girder-like extensions of colourless cells of the O.S. to the epidermis. Large vb's with similar adaxial and abaxial girders, up to about 6 cells wide (Fig. IX, 5). Keel bundles with well-developed abaxial girders only (Fig. IX, 3). **Keel** fairly conspicuous; surface slightly ribbed over the veins; containing 1 large median vb accompanied on either side by a slightly smaller lateral (Fig. XIII, 2). **Mesophyll :** chlorenchyma not radiate. **Bulliform cells** in rather wide, fan-shaped groups (Fig. XV, 4 and 6) at the bases of the shallow furrows. **Bundle-sheaths** double; each vb surrounded by 2 complete sheaths (Fig. XII, 1), the O.S. usually with girder-like extensions of colourless cells reaching to the scl.

Culm

Culm examined about 2 mm in diameter, with a large, hollow centre. Surface of the culm with about 25 fibrous ribs, the fibre columns in the ribs also extending inwards and forming girders with the vb's of the outermost circle. Spaces between the fibrous girders wholly occupied by 3 or 4 layers of assimilatory tissue, the assimilatory tissue being bounded on the inner side by a continuous ring of fibres 2 or 3 cells wide. Ground tissue between the scl. ring and the hollow centre of the culm consisting of rounded, mostly rather large cells with moderately thin walls, with minute, triangular, intercellular spaces between the cells. Vb's of the outermost circle bounded externally by the fibre girders and internally by the scl. ring. Remaining vb's in 1–2 more or less distinct circles in the ground tissue between the scl. ring and the hollow centre of the culm.

Material Examined: Cultivated at Kew.

Additional Information from the Literature

1. Leaf

P. arundinacea L. figured by Lewton-Brain (1904) as having slight, v. low ribs on both surfaces. He also shows the scl. as small adaxial and abaxial strands connected to the small vb's by narrow girders of colourless cells, the large vb's being supported by much wider adaxial and abaxial girders of scl. Strecker (1913) shows the leaf of the same sp. with moderately tall adaxial ribs and none on the abaxial surface.

Prat (1932) has drawn attention to certain characters of the leaf epidermis of *Phalaris*, especially that of *P. paradoxa* L. Paired silica- and cork-cells particularly numerous on the surface of the sheath. Prickles and hooks v. numerous all over the surface of the lamina, each having a v. much swollen base and a blunt point. Prat also refers to 'exodermal cells with short points' on the external surface of the sheath, which differ from those of the Hordeeae in the thinness of their walls, and in being most numerous in the intercostal zones.

Paunero (1947), in the course of a revision of spp. of *Phalaris* that occur in Spain, has recorded a few anatomical details that can best be noted in her article.

2. Culm

Chrysler (1906) records the occurrence of amphivasal bundles in the culm nodes of *P. arundinacea* L., where they are formed by the fusion of collateral bundles. He also notes in the same sp. that the node bundles are crowded into an annular area surrounding a fistular pith.

Pasquale (1880) has recorded the occurrence, in *P. canariensis* L., of 'latex canals' which are stated to exude a 'red fluid'. With reference to the culms of *P. canariensis*, Roelants (1921) notes that there is a subepidermal girder of scl. opposite each vb. He also found that, although the distribution of scl. varies in consecutive internodes of an individual culm, its distribution is, nevertheless, constant in the corresponding internodes of culms collected from different localities and in different seasons.

Special Note

Prat (1936) regards the leaf structure of *Phalaris* as festucoid, and indicates that it shows characters that are distinctive of the Phalarideae.

Literature

Chauveaud 1897 (notes on root structure); Chrysler 1906 (nodes of culms); Duval-Jouve 1875 (leaf); Frohnmeyer 1914 (deposition of silica); Grob 1896 (leaf); Lewton-Brain 1904 (leaf); Pasquale 1880 (latex canals); Paunero 1947 (1948) (spp. from Spain); Pée-Laby 1898 (leaf); Prat 1932, 1936 (leaf); Roelants 1921 (culm); Rywosch 1909 (initiation and development of lateral roots); Sharman 1947 (stem apex); Strecker 1913 (leaf); Wille 1916.

PHARUS

Diagnostic Generic Characters

Short-cells, confined to certain longitudinal files of cells not necessarily over the veins; in long rows. Silica-bodies intermediate between cross and dumb-bell shaped. Micro-hairs: none seen. Stomata with tall, dome-shaped subsidiary cells. Vascular bundles: small vb's tall, narrow, and angular in outline. Mesophyll with chlorenchyma not radiate; including large, conspicuous, translucent cells. Bundle-sheaths single and more or less straight-sided.

Species Specially Examined

***Pharus latifolius* L.**

Leaf

First and second leaves normally orientated, but subsequent leaves inverted by torsion.

Abaxial epidermis

Short-cells in rows of more than 5 cells, the occurrence of short-cells being confined to certain longitudinal files of cells not all above the veins, there being in some places no more than 4 rows of long-cells between the files with short-cells in them. Epidermal cells adjacent to the files of short-cells often long and fibre-like. Short-cells abundant. **Silica-bodies** intermediate between cross and dumb-bell shaped (Fig. Ia, 17), or shortly dumb-bell shaped (Fig. Ib, 20), the indentations in most of the bodies being v. shallow. **Macro-hairs :** short, stiff, thick-walled hairs, with their bases somewhat constricted and sunken amongst

the epidermal cells, present on the adaxial surface of the lamina. Somewhat longer hairs, sometimes with their apices slightly hooked, and with their bases surrounded by cushion cells projecting above the general level of the epidermis, noted on the abaxial surface of the keel. (The hooked hairs bear some resemblance to those in *Neostapfia* (Fig. IIA, 7), but there are no reasons to believe that *Neostapfia* and *Pharus* are closely related.) **Micro-hairs:** none seen. **Prickle-hairs:** prickles (Fig. VI, 1–2), with large inflated bases and short to fairly long points, frequent in the same files of cells as the silica-bodies. **Stomata** rather infrequent; with tall, dome-shaped (Fig. IV, 4) subsidiary cells. **Long-cells,** apart from the fibrous cells beside the files of short-cells, with thin, sinuous walls (Fig. V, 3*a–c*); some with overlapping end walls (Fig. V, 9). **Transverse veins** present.

T.S. lamina

Vascular bundles: small vb's tall, narrow, and angular, i.e. the *Leptaspis* type (Fig. VIII, 3); large vb's of basic type (Fig. VIII, 11 and 14). **Adaxial surface** practically smooth (Fig. XIV, 1). **Sclerenchyma:** most vb's with adaxial and abaxial girders 2–4 cells wide and high (Fig. IX, 4); large vb's with slightly wider girders. Adaxial surface of the midrib supported by a plate of scl. some 40 cells wide and 2–3 cells high, a few smaller strands also being present above the large lateral vb's. **Keel** conspicuous, rounded; containing, near the abaxial surface, 1 large median vb accompanied on either side by 1 lateral of almost the same size, and by 2 much smaller laterals with the conducting tissue consisting mainly of ph. A minute, median, adaxial vb also present immediately below the adaxial plate of scl. **Mesophyll:** chlorenchyma not radiate; with a rather specialized structure similar to that of *Leptaspis*, the greater part of the thickness of the mesophyll being made up of large, conspicuous, translucent cells, 2 generally being present in each intercostal zone and separated from one another by a short, vertical girder of colourless cells. Chlorenchyma apparently composed of arm-cells, but 'arms' not v. conspicuous or numerous. **Bulliform cells** mostly as rather long groups as in Fig. XV, 2, but some groups tending to be irregular (Fig. XV, 1). **Bundle-sheaths** single; more or less straight-sided and angular, i.e. the *Leptaspis* type.

PETIOLE

With the shape, in T.S., of a half oval with wings, the abaxial–adaxial diameter being about 2 mm. Vb's in a deep crescent-shaped group near the abaxial surface, alternate vb's being of 2 v. distinct sizes, and the small vb's rather closer to the epidermis than the large ones. One large and 3 rather smaller vb's present just below the adaxial scl. Adaxial surface of the petiole supported by some thin, closely placed strands of scl. forming an almost continuous plate immediately subjacent to the epidermis. Ground tissue of the petiole consisting of thin-walled parenchymatous cells, those towards the abaxial surface being assimilatory. A horizontal zone of ground tissue, consisting of conspicuously large cells, present near the middle of the T.S. A few moderately long hairs, with fairly thick walls, and sometimes with pointed, hooked apices, present on the abaxial surface.

CULM

Culm examined about 3 mm in diameter; circular in T.S., with a solid centre. Epidermis subtended by a zone of up to about 6 layers of assimilatory tissue bounded on the inner side by a slightly sinuous circle of scl., consisting of about 3–4 layers of small, rather thick-walled fibres. Inner ground tissue consisting of large, thin-walled cells. Vb's of the outermost circle abutting on to the outer periphery of the scl. ring. Remaining vb's scattered throughout the central ground tissue.

MATERIAL EXAMINED: Cultivated at Kew.

ADDITIONAL INFORMATION FROM THE LITERATURE

The structure of the lamina of *P. parvifolius* Nash., as seen in T.S., appears to be v. similar to that of *P. latifolius* judging from the description by Page (1947).

SPECIAL NOTE

The leaf structure is similar to that of *Leptaspis*, several distinctive characters being common to both genera.

LITERATURE

Brandis 1907 (leaf); Grob 1896 (leaf); Kugler 1929 (leaf torsion); Page 1947 (leaf).

PHLEUM

1. LEAF

The following description of the leaf of *P. pratense* L. is based on the information recorded respectively by Burr and Turner (1933), Duval-Jouve (1875), Lewton-Brain (1904), Pée-Laby (1896), and Strecker (1913). *T.S. lamina.* Adaxial surface with low, rounded ribs. Abaxial surface with small prominences opposite the vb's. Scl. present in the leaf margins and on the adaxial and abaxial sides of the vb's, the large vb's being girdered in mature leaves. Keel often not more than moderately conspicuous, but becoming more prominent in old leaves. Bulliform cells present as well-defined groups at the bases of the furrows. Colourless cells occurring in the adaxial part of the midrib and above the principal veins. Scl. developed to a variable extent. Bundle-sheaths double. Prickles (asperities) present at the leaf margins and on the apices of some of the ribs. Lewton-Brain indicates that the density of the prickles is variable.

Lewton-Brain figures *P. alpinum* L. as having low, rounded, adaxial ribs separated from one another by moderately narrow, shallow furrows; scl. as adaxial and abaxial strands associated with most vb's, the strands associated with the large vb's being connected to them by girders of colourless cells.

The same author notes that the leaf of *P. arenarium* L. has low, flattened or rounded, adaxial ribs and that the I.S.s of the small vb's are inconspicuous. Large vb's accompanied by adaxial and abaxial girders, and the smaller vb's by strands of scl.

In *P. nodosum,* scl. is said by Lewton-Brain to occur as abaxial girders and adaxial strands to the large vb's; smaller vb's accompanied by adaxial and abaxial strands, by abaxial strands only, or scl. may be absent.

2. CULM

Roelants (1921), with reference to the culm of *P. arenarium* L., notes that there is a circle of fibres immediately subjacent to the epidermis, the vb's being partly em-

bedded in this ring and others on the inner side of the ring. He also states, with reference to the same sp., that although various positions throughout the length of the culm are subjected to bending strains of different intensities, the culm exhibits no corresponding structural variations in the mechanical system.

3. Root

The following information has been recorded by Freidenfelt (1904) concerning the roots of *P. arenarium*. Roots of first order 0·34 mm in diameter. Epidermis at first thin-walled, but compressed when old. Exodermis consisting of large, thin-walled cells; inner part consisting of cells with the walls more thickened; cells of the central part of the cortex separated from each other by small, triangular, intercellular spaces. Centre of the root occupied by a single tracheal cell about 33 μ in diameter and accompanied by 5 peripheral groups of vessels.

In *P. alpinum* roots from plants from loose sand and from below moss in a very cold stream were examined. The roots from loose sand had more numerous subsidiary roots and penetrated more deeply into the soil than did the roots from the damp locality. Roots of the second order, 1·3 mm in diameter, from the dry locality exhibited the following characters. Epidermis durable. At least 3 vessels present in each ray of xy. Corresponding roots from the damp locality exhibited an epidermis of which the cells become disorganized but in such a way that the radial walls persist; the central cylinder is relatively smaller, and in consequence the roots finer, the wood rays often including not more than 2 vessels. The first-order roots from both types of habitat are essentially similar in structure, although the epidermis is more durable in material from the dry locality. Cortex consisting of 8–9 layers of cells; walls of the exodermal cells remaining unthickened, but cells becoming disorganized at a late stage in material from the damp locality. Two layers of cells beneath the exodermis become thickened to produce a protective ring. Endodermis similar in both types of material, the inner being more strongly thickened than the outer walls. Central cylinder with 8–9 peripheral groups of vessels and usually 2 central vessels about 28–33 μ in diameter.

Special Note

Prat (1936) rightly points out that the structure is festucoid.

Literature

Avers 1957 (rate of growth of root cells); Burr and Turner 1933 (leaf); Duval-Jouve 1875 (leaf); Freidenfelt 1904 (root); Frohnmeyer 1914 (deposition of silica); Goodwin and Stepka 1945 (development of root apex); Grob 1896 (leaf); Holm 1908 (notes on ecological anatomy); Lewton-Brain 1904 (leaf); Mozingo 1949 (root apex); Nishimura 1922 (developmental anatomy); Oakley and Evans 1921 (rooting stems); Pée-Laby 1898 (leaf); Prat 1936 (root); Roelants 1921 (culm); Sharman 1947 (stem apex); Stafford 1948 (influence of light on seedling leaf structure); Strecker 1913 (leaf); Wille 1916; Ziegenspeck 1926 (structure of stigma).

PHOLIURUS

The brief description of the leaf anatomy of *P. pannonicus* (Host) Trin. published by Hansen and Potztal (1954) includes the following information.

Silica-bodies oblong, rounded (*langlich abgerundet*). (To the author this suggests that they resemble the silica-bodies in Figs. I, 8, or Ia, 13.) Small prickles, arranged in several rows, present over the vb's. Sclerenchyma: most vb's accompanied by small adaxial and abaxial strands; other small baxial strands also present between

the veins. Mesophyll: chlorenchyma not radiate. Bundle-sheaths; all vb's described as having well-developed mestome (inner sclerenchymatous) sheaths. Starch grains stated to be compound.

Special Note

From the scanty information available it would appear that Prat's (1936) opinion that the leaf structure is festucoid is justified. Ascribed to the Leptureae by Hansen and Potztal (1954).

Literature

Hansen and Potztal 1954 (leaf); Prat 1936 (leaf).

PHRAGMITES

Diagnostic Generic Characters

Short-cells, over the veins, mostly paired and in short rows. Silica-bodies, over the veins, fitting into concavities in adjacent cork-cells and usually rounded or slightly crescent-shaped; those in short rows tending to be saddle-shaped or occasionally oblong. Micro-hairs absent. Stomata with low, dome-shaped subsidiary cells. Vascular bundles: small vb's tending to be angular in outline. Mesophyll with chlorenchyma not conspicuously radiate. Bundle-sheaths double, but I.S. sometimes obscure.

Species Specially Examined

***Phragmites communis* Trin.**

Leaf

Abaxial epidermis

Short-cells, between the veins, solitary and paired; those over the veins mostly in pairs and rows of less than 5 cells; common, but generally less frequent between than over the veins. **Silica-bodies** generally fitting into concavities in adjacent cork-cells (Fig. I, 6–7), and usually rounded or slightly crescent-shaped in outline. Silica-bodies in the rows of short-cells tending to be saddle-shaped (Fig. I, 9), but occasionally oblong (Fig. I, 10). **Macro-hairs:** none seen; but soft, sinuous hairs recorded by Grob (1896). **Micro-hairs:** none seen. **Prickle-hairs:** hooks (Fig. VI, 5) abundant between the veins, many not conspicuously pointed and resembling papillae; unpointed prickles (Fig. VI, 6) abundant over the veins. **Stomata** with low dome-shaped subsidiary cells (Fig. IV, 3). **Long-cells,** between the veins, with thin, rather coarsely sinuous walls (Fig. V, 3*a–c*), some of them more closely resembling those in Fig. V, 7*a–b*; certain of the interstomatal cells with concave ends (Fig. V, 10–11).

T.S. lamina

Vascular bundles: small vb's angular or tending to be so (Fig. VIII, 5 and 6); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with slight, rather wide, rounded ribs separated from one another by much narrower, shallow

furrows; ribs over the large vb's slightly wider than the remainder. Abaxial surface also slightly ribbed over the vb's. **Sclerenchyma:** most vb's with small adaxial and abaxial girders (Fig. IX, 4); the abaxial girders being about 2–5 cells wide and about 4 cells high, and the adaxial girders similar or sometimes rather wider. Large vb's with adaxial girders about 16 cells wide and 2 or 3 cells high, the abaxial girders being up to about 9 cells wide and high (Fig. IX, 5). Median keel vb with v. wide adaxial and abaxial girders. Lateral keel vb's with well-marked abaxial girders and smaller adaxial strands, the latter separated from the vb's by wide columns of colourless cells extending from the bundle-sheaths. **Keel** fairly conspicuous, wide, rounded; containing 1 large median vb accompanied on either side by about 3 smaller laterals (Fig. XIII, 3). **Mesophyll:** chlorenchyma not obviously radiate; several layers of palisade cells on the abaxial side of the leaf. **Bulliform cells** in groups of the *Sporobolus* type (Fig. XV, 8), most of the groups penetrating to about half-way between the adaxial and abaxial surface. **Bundle-sheaths** probably all double, but I.S. sometimes rather obscure, particularly around the small vb's; most vb's with 2 complete sheaths, the O.S. often having slight extensions of colourless cells connecting with the scl. (Fig. XII, 1). Large vb's with I.S. complete but O.S. interrupted abaxially (Fig. XII, 2), or abaxially and adaxially (Fig. XII, 3*a*), the interruptions generally rather wide.

Culm

Culm examined 4 mm in diameter, with a large cavity at the centre. Epidermis consisting of thick-walled, lignified cells, and subtended by a zone about 8 cells wide, consisting of only slightly, or moderately, lignified cells with fairly thick walls, followed by a zone of cells with smaller diameters and thicker walls, this zone being about 7 cells wide. Ground tissue between this peripheral sclerosed tissue and the hollow centre of the culm consisting of cells of larger diameters and with thinner walls than the remainder of the ground tissue, with minute triangular, intercellular spaces between the cells. About 4 of the innermost layers of this inner ground tissue composed of cells not quite so wide as those in the middle of the inner ground tissue. Vb's of the outermost circle abutting on to the outer edge of the scl. ring, some of the vb's being connected to the epidermis by girders of scl. Remaining vb's in 2–3 irregular circles embedded in the inner ground tissue. Sieve tubes in all vb's conspicuously wide in diameter.

Material Examined: Cultivated at Kew.

Additional Information from the Literature

1. Culm

Stant (1953), working at the Jodrell Laboratory, made a special study of the culm structure of *P. communis* in relation to the suitability of different samples of reeds for thatching buildings. The following is quoted, with slight modifications, from the summary of her paper.

> 'That the reeds from Norfolk and other parts of the country differ internally in such properties as bulk and firmness is apparent to the naked eye. Study of the internal structure confirms that these differences are the outward manifestation of anatomical variations. The reeds can be divided into two categories: (1) those from Norfolk with more lignification, thicker cell walls, no air-cavities (in the outer ground tissue) and longer fibre cells, (2) those from the south coastal regions with less lignification, a considerable amount of large-celled parenchyma alternating with fibrous tissue, the development of air cavities and shorter fibre cells. Reeds from Fishguard, Weeley and Romney Marsh represent an intermediate type. The Essex reeds are nearer in structure to the Norfolk reeds except for the presence of small air cavities in the Weeley sample, but the Fishguard reeds more closely resemble the south coastal type. Reeds from the Cherwell Valley with cortical aerenchyma are perhaps the softest and least durable.
>
> 'All these factors would account for the greater durability of the Norfolk reeds. Their more extensive lignification, together with the absence of air cavities, would give these reeds greater resistance to decay. Differences of this nature would affect the lasting qualities of the culms and their suitability for use in thatching.
>
> 'It is interesting to speculate upon the causes of these differences; whether they are due to "nature or nurture"? Since all the reeds belong to the one species *Phragmites communis*, the different types may have evolved as local races or varieties, which have become genetically fixed, or the differences may be due to environmental factors. In this connexion, mention should be made of the work of Tobler (1943) who attempted to establish that the mechanical properties of reeds are intimately related to such factors as the calcareous nature of the soil and its nitrogen content, and the water level. The nitrogen content of the soil affects the metabolic balance within the plant cells thus determining the relative proportions of protein and carbohydrate materials synthesised. A high carbon/nitrogen ratio favours the formation of protoplasm and a soft watery tissue. The concentration of the elements calcium and sodium in the soil and its hydrogen ion concentration are also causal factors in cell differentiation and extension. To test these various possibilities it would be necessary to conduct a series of transplant experiments.'

Roelants (1921) refers to 3 categories of vb's in the culm of *P. communis* with girders of scl. opposite the smallest vb's. This refers to thinner culms than those examined by Stant (1953).

2. Rhizome

Hayden (1919*b*) gives the following particulars for the rhizome of *P. communis*. Epidermis of small, thick-walled cells. Primary cortex occupying half the radius of the rhizome in T.S.; containing large, oval air-canals. Vb's consisting of a circle of small strands at the junction between the cortical parenchyma and the vascular cylinder; larger and more numerous anastomosing vb's present throughout the parenchymatous ground tissue towards the hollow centre of the rhizome.

Philipp's (1924) account of the rhizome in the main agrees with that by Hayden, but he particularly emphasizes that the outer protective tissue consists of about 8 layers of cutinized cortical cells of primary origin, the metakutis, and refers to arcs of metakutis extending to the endodermis.

3. Root

Freidenfelt's (1904) description of the roots of *P. communis* includes the following information. First-order roots 1·15 mm in diameter. Epidermis composed of cells of 2 types as in the Cyperaceae; certain of the cells, which are solitary or in groups, have thickened outer walls and retain their initial inflated shape; other epidermal cells with thin outer walls collapse. Epidermis of regular, hexagonal, thin-walled cells, subtended by 1–2 layers of cells transitional in shape between those of the exodermis and those of the 2–3 layers next below again, which are small, somewhat

longer radially than tangentially, and with thickened walls. Outer part of the inner cortex composed of large, thin-walled cells, some collapsing to give rise to intercellular spaces separated from one another by radiating lamellae. Endodermis of arched cells with thickened inner walls. Centre of the root with 5–9 vessels about 39 μ in diameter. Pith cells becoming thickened when fully mature. Roots of second and third orders similar in structure to those of the first order, but with fewer thin-walled cells in the epidermis.

Rywosch (1909) refers to a 'continuous pericycle', without any interruptions from vessel groups, in the roots of *P. communis* and *Elymus arenarius*.

Root also described by Hayden (1919*b*).

Special Note

Prat (1936) notes that the epidermis of the leaf exhibits certain characters that are panicoid, but the structure of both the epidermis and the leaf in T.S. are partly panicoid and partly festucoid.

Literature

Chauveaud 1897 (root, especially the ph.); Douliot 1891 (developmental anatomy); Duval-Jouve 1875 (leaf; under *Arundo*); Freidenfelt 1904 (root); Grob 1896 (leaf); Hayden 1919*b*; Janczewski 1882 (sieve tubes); Lewton-Brain 1904 (leaf; under *Arundo*); Lehauss 1905 (leaf); Pée-Laby 1898 (leaf); Philipp 1924; Prat 1936 (leaf); Roelants 1921 (culm); Rywosch 1909 (root); Stant 1953 (culm).

PHYLLORACHIS

Diagnostic Generic Characters

Short-cells, over the veins, in long rows or sometimes apparently solitary. Silica-bodies, over the veins, mostly of the *Oryza* type, but some saddle- or cross-shaped. Micro-hairs present; each with the distal cell slightly tapered towards the apex. Stomata with triangular subsidiary cells. Vascular bundles: none conspicuously angular in outline. Mesophyll with chlorenchyma not radiate; composed of arm-cells. Bundle-sheaths double.

Species Specially Examined

***Phyllorachis sagittata* Trimen**

Leaf

Abaxial epidermis

Short-cells, between the veins, mostly paired; those over the veins in rows of more than 5 cells, except where appearing to be solitary owing to the intervening cells in the same files being rather long. **Silica-bodies,** between the veins, tall and narrow (Fig. I, 4), and occasionally tending to be slightly crenate (Fig. Ib, 24); those over the veins mostly of the *Oryza* type (Fig. Ib, 23), but some saddle-shaped (Fig. I, 9), or tending to be cross-shaped (Fig. Ia, 16). **Macro-hairs:** short, fairly thick-walled hairs, with superficial, or at most only slightly sunken, but swollen bases (Fig. II, 1), abundant over and between the veins, those over the veins tending to be rather longer than the intercostal hairs. Occasional, much longer hairs with thicker walls and v.

enlarged, sunken bases, present in the intercostal zones (cf. hairs of *Tetrahenia distichophylla*). **Micro-hairs:** length 42–50 μ; basal cells 16–22 μ; distal cells 25–30 μ; distal cells tapering to slightly rounded apices (Fig. VII, 5), or occasionally less tapered (Fig. VII, 7). **Prickle-hairs:** none seen. **Stomata** with acutely triangular (Fig. IV, 1) subsidiary cells. **Long-cells,** between the veins, with thin, v. acutely sinuous walls (Fig. V, 3*a–c*), many of the cells being rather short and more like those in Fig. V, 6.

T.S. lamina

Vascular bundles: most vb's small, v. widely spaced and not conspicuously angular in outline (Fig. VIII, 2); a few large vb's of basic type (Fig. VIII, 10). **Adaxial surface** smooth (Fig. XIV, 1). **Sclerenchyma:** most vb's with small adaxial and abaxial girders (Fig. IX, 4), the adaxial girders being 1–4, or occasionally more, cells wide, and seldom more than 3 cells high, the corresponding abaxial girders being up to about 8 cells wide and mostly about 2 cells high. Adaxial and abaxial girders of the large vb's much wider and about the same height, the combined narrow adaxial and wider abaxial girders sometimes appearing anchor-shaped (Fig. IX, 6). Median keel vb supported by an abaxial girder much wider than the vb itself, and by a much narrower adaxial strand separated from the vb by a wide column of large, colourless cells. **Keel** conspicuous, rounded; containing 1 large median vb accompanied on either side by a much smaller lateral (Fig. XIII, 2). **Mesophyll:** chlorenchyma not radiate; composed of arm-cells. **Bulliform cells** mostly in rather wide groups as in Fig. XV, 2. **Bundle-sheaths** double; small vb's nearly always with 2 complete sheaths (Fig. XII, 1); large vb's with I.S. complete but O.S. interrupted adaxially and abaxially (Fig. XII, 3*a*).

Material Examined: Greenway 4577; W. Africa.

Special Note

Tateoka (1956*d*) has reviewed the various affinities that have been suggested for *Phyllorachis*, and rightly points out that the anatomy suggests affinities with the Oryzeae. The shape of the silica-bodies, the presence of micro-hairs, and the occurrence of arm-cells in the mesophyll all confirm this suggestion.

Literature

Tateoka 1956*d* (leaf and taxonomy).

PIPTOCHAETIUM

The foliar anatomy of *Piptochaetium* appears to need further investigation owing to the somewhat conflicting statements from the few investigators who have studied this genus. Thus Parodi (1944) refers to the structure as 'festucoid', mentioning specifically that the chlorenchyma is not radiate. In this he differs from Holm (1901–2) who states that the chlorenchyma in the spp. which he examined is distinctly radiate. Holm and Parodi agree in indicating that the bundle-sheaths are double and that the bulliform cells are in broad groups at the bases of the furrows. Grob's (1896) statement that the short-

cells over the veins are in rows is surprising in a grass of which the affinities are said to be festucoid.

Holm's study of the leaf structure was confined to some 4 spp. Parodi's account of the leaf structure forms part of a critical revision of the genus, in which 25 spp. of *Piptochaetium* are described, most of them having previously been in *Stipa* or *Oryzopsis* and a few in *Caryochloa* and *Urachne*. Interspecific differences are difficult to summarize briefly, and the reader is referred to Parodi's article for further information. Here it must suffice to say that spp. can be distinguished by variations in the number of vb's visible in a T.S. of the leaf (varying from 3 to 9); by the extent to which the leaf is infolded; by the number of adaxial ribs; by variations in the distribution of scl.; and in the extent to which the leaves are hairy. This last character varies somewhat within certain of the spp. Parodi and Freier (1945) regard *Piptochaetium* as a member of the Stipeae, but point out that the genus is v. distinct from *Stipa* itself.

Literature

Grob 1896 (leaf); Holm 1901–2 (leaf); Parodi 1944 (revision of the genus with leaf anatomy); Parodi and Freier 1945 (leaf and taxonomy).

PLECTRACHNE

Diagnostic Generic Characters

Short-cells, over the veins, solitary, paired, and in short rows in *P. danthonioides* and *P. desertorum*; those of *P. schinzii* in long rows. Short-cells silicified and silica-bodies seldom clearly defined in *P. danthonioides* and *P. desertorum*; silica-bodies much more conspicuous and mostly cross-shaped in *P. schinzii*. Micro-hairs: none seen. Leaf acicular with narrow grooves on the abaxial surface. Vascular bundles not conspicuously angular in outline. Mesophyll with chlorenchyma not radiate. Bundle-sheaths probably double, but difficult to interpret.

Species Specially Examined

***Plectrachne danthonioides* (F. Muell.) C. E. Hubbard**

Leaf

Abaxial epidermis

Only the surface between the grooves could be examined. **Short-cells** solitary, paired, and in rows of 3–5 cells; abundant. Most short-cells silicified, but seldom containing clearly defined silica-bodies. Silicified short-cells cross-shaped (Fig. IA, 16), nodular (Fig. IA, 18 (i)), or sometimes slightly crescent-shaped in outline. A few other short-cells containing rather clearly defined round or elliptical silica-bodies. **Macro-hairs:** numerous short, stiff, acutely pointed hairs with v. slightly sunken bases (Fig. IIA, 10) abundant on the adaxial ribs. **Micro-hairs:** none seen. **Prickle-hairs:** pointed, angular prickles (Fig. VI, 3) abundant and crowded over the files of cells bordering on the furrows. **Papillae:** tall, thickened papillae, often with slightly swollen apices,

lining the grooves on both surfaces. **Stomata** apparently confined to the grooves. **Long-cells** with thick, pitted or sinuous walls (Fig. V, 1*a–b*).

T.S. lamina

Leaf acicular as in Fig. X, 3, but with 16 narrow grooves with constricted openings and slightly wider, rounded bases on the abaxial surface. **Vascular bundles:** small vb's not conspicuously angular in outline (Fig. VIII, 2); large vb's with the ph. partly sclerosed (Fig. VIII, 16); sieve tubes of small diameter. **Adaxial surface** with a deep, narrow, median adaxial furrow, widened at its base, with numerous v. narrow secondary furrows, some on either side of, and others opening into the enlarged base of, the primary furrows. Well-developed ribs, mostly with slightly flattened apices, present between the secondary furrows (Fig. XIV, 4 and 6). **Sclerenchyma:** somewhat similar to that shown in Fig. X, 3. Abaxial surface supported throughout its length, except in the abaxial grooves, by a zone of v. thick-walled, highly lignified fibres subjacent to the epidermis. Each vb connected to the abaxial zone of thick-walled fibres by a wide, well-developed abaxial girder of less lignified fibres. Each vb also almost completely encircled by a sheath of highly lignified fibres, the sheaths varying from about 1–6 cells wide. Apex of each adaxial rib supported by a strand of comparatively unlignified fibres, many of these strands being slightly T-shaped. **Mesophyll:** chlorenchyma not radiate; assimilatory tissue confined to narrow bands on either side of the adaxial and abaxial furrows, and separated from the rest of the mesophyll by rather large, colourless cells, these cells being, in many places, arranged in a single layer. **Bulliform cells:** no typical bulliform cells present, even in the furrows, but ground tissue of the lamina, apart from the scl. and assimilatory tissue, consisting mostly of rather large colourless cells.

Material Examined: Burbidge 2205; Australia.

***Plectrachne desertorum* C. E. Hubbard**

Leaf

Abaxial epidermis

Only the surface of the leaves between the grooves could be examined. **Short-cells** v. difficult to observe; solitary, paired, and in rows of 3–5 or more cells; infrequent. **Silica-bodies** not clearly defined, but outlines of short-cells similar to those of *P. danthonioides*. **Macro-hairs:** short, stiff, acutely pointed hairs, with v. slightly sunken bases (Fig. IIA, 10), abundant on the adaxial ribs. **Micro-hairs:** none seen. **Prickle-hairs:** pointed, angular prickles (Fig. VI, 3) abundant on files of cells bordering on the furrows. **Papillae:** as in *P. danthonioides*, but papillae rather narrower and with less swollen apices. **Stomata** apparently confined to the grooves. **Long-cells** with moderately thin, markedly and coarsely sinuous walls (Fig. V, 3*a–c*).

T.S. lamina

Leaf acicular and in many ways similar to that of *P. danthonioides* (Fig. X, 3). **Vascular bundles:** small vb's not conspicuously angular in outline (Fig. VIII, 2), and sometimes rather narrow at the xy. end; large vb's with the ph.

slightly sclerosed (Fig. VIII, 16), the sclerosis being less marked than in *P. danthonioides*. **Adaxial surface** with a system of ribs and furrows similar to that of *P. danthonioides*, but primary furrows wide and slightly less deep. Abaxial furrows similar to those of *P. danthonioides*. **Sclerenchyma:** each adaxial rib strongly supported by a shortly stemmed, T-shaped girder, the stem of each T extending towards, and sometimes reaching, a vb. Abaxial ribs supported by similar, but rather less well-developed, strands or girders of fibres. **Mesophyll:** chlorenchyma not radiate; assimilatory tissue confined to strips on either side of the adaxial and abaxial grooves, and separated from the rest of the mesophyll by rather large colourless cells, the cells in many places being arranged in a single layer. **Bulliform cells** as in *P. danthonioides*.

MATERIAL EXAMINED: W. Austral. Geol. Survey, Ex.145, H.286.

Plectrachne schinzii Henrard

LEAF

Abaxial epidermis

Only the surface between the furrows was examined. **Short-cells** in rows of more than 5 cells; abundant. **Silica-bodies** much more conspicuous than in the other spp. of *Plectrachne* examined; mostly cross-shaped (Fig. IA, 16), but with v. short arms; others nodular (Fig. IA, 18 (i)). **Macro-hairs:** short, stiff, acutely pointed hairs, with v. slightly sunken bases (Fig. IIA, 10), rather infrequent on the adaxial ribs. **Micro-hairs** and **prickle-hairs:** none seen. **Papillae:** papillae, similar to those of the other spp. of *Plectrachne*, present in the furrows, but rather more sparse. **Stomata** confined to the furrows. **Long-cells** with thick, pitted or sinuous walls (Fig. V, 1*a–b*).

T.S. lamina

Leaf acicular and exhibiting the same general structure as *P. danthonioides* and *P. desertorum*, but with the primary median furrow wider (Fig. X, 3). **Vascular bundles:** small vb's not conspicuously angular in outline (Fig. VIII, 2), and sometimes rather narrow at the xy. end; large vb's of basic type, but with the ph. slightly sclerosed (as Fig. VIII, 15, but with ph. sclerosed as in Fig. VIII, 16). **Adaxial surface** with 7 ribs on either side of the median rib, the 2 ribs next to and on either side of the median rib being smaller than the others. Abaxial surface with only 4, v. small, shallow furrows. **Sclerenchyma:** 1–2 layers of thick-walled fibres subjacent to the abaxial epidermis throughout its length, except in the 4 abaxial furrows. One to two layers of similar fibres also present in the apex of each adaxial rib, but no girders of fibres extending from these strands to the vb's. Vb's embedded in broad columns of colourless cells with wide lumina and fairly thick walls, the columns extending from the adaxial to the abaxial scl. **Mesophyll:** chlorenchyma not radiate; confined to U-shaped strands lining most of the adaxial furrows throughout most of the leaf, but where abaxial and adaxial furrows are opposite one another the assimilatory tissue is in slightly crescent-shaped bands, each band traversing the mesophyll from an adaxial to the corresponding abaxial furrow. **Bulliform cells:** typical bulliform cells absent, but colourless cells present around the vb's as described above, the greater part of the mesophyll on the abaxial side of the leaf towards its margins consisting of colourless cells.

MATERIAL EXAMINED: Gardner 3189; Australia.

SPECIAL NOTE

Burbidge (1946) points out that *Plectrachne* is related to *Triodia*. This affinity is supported by similarities in the leaf structure. In her paper a figure of a T.S. of the leaf of *P. schinzii* beside a similar illustration of *Triodia pungens* illustrates this point very clearly.

LITERATURE

Burbridge 1946 (leaf).

PLEUROPOGON

Holm (1891*b*) has recorded the following particulars concerning *P. californicus* (Nees) Benth. and *P. refractus* (A. Gray) Benth. respectively. Characters that are diagnostic for the genus, so far as the 2 spp. just mentioned are concerned, are the intercostal, hypodermal sclerenchyma strands, and the 'lacunae' in the mesophyll.

P. californicus (Nees) Benth.

Epidermis

Short-cells present on the abaxial, but said to be absent from the adaxial, surface. Prickles present above the veins. Papillae abundant; some of them surrounding, but not overarching, the stomata. Long-cells, on the adaxial surface, rectangular, with thin, slightly sinuous walls.

T.S. lamina

Scl. present as an adaxial strand and an abaxial girder to the median vb, and as small adaxial and abaxial strands to most of the remaining vb's; other small hypodermal strands also present between the veins below both surfaces of the leaf. Midrib conspicuous as a prominent adaxial projection. Mesophyll with chlorenchyma restricted to a narrow band beneath each epidermis in the intercostal regions, the middle part of the mesophyll being occupied by large lacunae.[1]

P. refractus (A. Gray) Benth.

Epidermis

Short-cells stated to be absent. Prickles present over the veins on the adaxial surface; some of them overarching the stomata. Long-cells, on both surfaces, with thin, nearly straight walls.

T.S. lamina

Scl. forming small adaxial girders to the median vb; other vb's accompanied by smaller adaxial and abaxial strands or by adaxial strands only; small adaxial, hypodermal strands also present between the veins. Mesophyll with chlorenchyma most completely developed on either side of the midrib; elsewhere in the 2 halves of the lamina chiefly occupied by large lacunae[1] between the veins. Midrib scarcely

[1] In appearance they resemble the fusoid-cells of the bamboos, but I cannot confirm this as I have not examined this grass. C. R. M.

prominent; consisting of a slight adaxial projection. Bulliform cells restricted to 2 large, fan-shaped groups, 1 on either side of the midrib. Bundle-sheaths to the median vb double.

Special Note

Holm (1891*b*) regards *Pleuropogon* as being closely related to *Uniola* and *Distichlis*.

Literature

Holm 1891*b* (leaf).

POA

Diagnostic Generic Characters

Short-cells, over the veins, solitary and paired. Silica-bodies, those in paired short-cells over the veins tall, narrow, rounded, or sometimes slightly crescent-shaped, and fitting into concavities in adjacent cork-cells; other bodies over the veins, solitary and horizontally elongated. Micro-hairs: absent. Stomata with low dome-shaped or parallel-sided subsidiary cells, the proportion of each type varying with the sp. Vascular bundles never conspicuously angular in outline. Mesophyll with chlorenchyma not radiate. Bulliform cells in many spp. restricted to a single group on either side of the midrib, but this character not universal. Bundle-sheaths double.

Species Specially Examined

Poa glauca Vahl

Leaf

Abaxial epidermis

Short-cells, both over and between the veins, solitary and paired; common to abundant over, but rather infrequent between, the veins, the intercostal short-cells being chiefly near the margins of the veins. **Silica-bodies** in paired short-cells, each fitting into a concavity in an adjacent cork-cell (Fig. I, 6–7), the bodies themselves being tall and narrow or slightly crescent-shaped; solitary bodies over the veins, horizontally elongated with sinuous outlines (Fig. Ia, 14–15). **Macro-hairs** and **micro-hairs:** none seen. **Prickle-hairs:** small hooks (Fig. VI, 5) local over the veins. **Stomata** mostly with low dome-shaped (Fig. IV, 3), but a few tending to have parallel-sided (Fig. IV, 2), subsidiary cells. **Long-cells,** between the veins, with thin, non-sinuous walls (Fig. V, 2*a–c*), the end walls often v. markedly at right angles to the long axes of the cells.

T.S. lamina

Vascular bundles: most vb's small and not conspicuously angular in outline (Fig. VIII, 2); a few large vb's of basic type (Fig. VIII, 9 and 10). **Adaxial surface** practically smooth (Fig. XIV, 1), apart from slight grooves over the vb's, and a single more prominent groove on either side of the midrib. **Sclerenchyma:** a few small vb's not accompanied by scl. (Fig. XI, 1); other small

vb's with minute adaxial and abaxial strands, mostly about 3–4 cells wide and 1–4 cells high (Fig. IX, 4); large vb's with adaxial and abaxial girders slightly wider and taller than the strands to the small vb's. A strand of scl. about 7 cells wide and 3 cells high present in the apex of the keel, the median vb being supported adaxially by a girder about 3 cells wide and high. **Keel** conspicuous, somewhat triangular; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate; assimilatory cells immediately below each epidermis tending to be slightly palisade-like. **Bulliform cells** not well developed except for a rather wide, fan-shaped group (Fig. XV, 6) on either side of the midrib. **Bundle-sheaths** double; small vb's mostly with the I.S. complete but the O.S. interrupted or inconspicuous abaxially (Fig. XII, 2); sheaths round large vb's similar, but with rather wider abaxial interruptions; I.S. composed of cells with U-shaped thickenings.

Material Examined: Cultivated at Kew.

Poa iridifolia Hauman

Leaf

Abaxial epidermis

Short-cells, both over and between the veins, paired; those in certain of the intercostal zones solitary; abundant. **Silica-bodies,** both over and between the veins, sometimes fitting into concavities in adjacent cork-cells, those between the veins being tall and narrow (Fig. I, 4) and occasionally crescent-shaped; those over the veins oblong (Fig. I, 10). **Macro-hairs** and **micro-hairs:** none seen. **Prickle-hairs:** large, somewhat angular, long-pointed prickles (Fig. VI, 3) abundant at the leaf margins. **Stomata** mostly with low dome-shaped (Fig. IV, 3), but some tending to be with parallel-sided (Fig. IV, 2), subsidiary cells. **Long-cells,** between the veins, with thin, non-sinuous (Fig. V, 2*a–c*), or v. slightly sinuous (Fig. V, 3*a–c*), walls, some of the cells tending to be hexagonal.

T.S. lamina

Vascular bundles: most vb's small and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** practically smooth (Fig. XIV, 1). **Sclerenchyma:** a few small vb's not accompanied by scl. (Fig. IX, 1); other small vb's with adaxial girders 2–4 cells wide and 4–5 cells high, and abaxial girders 6–8 cells wide and high (Fig. IX, 4); large vb's with adaxial and abaxial girders up to about 10 cells wide and high. Apex of the keel supported by a slightly crescent-shaped strand of scl. **Keel** v. prominent, narrow; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** not well developed, apart from a conspicuous, fan-shaped group on either side of the midrib (Fig. XV, 6). **Bundle-sheaths** double; small vb's with I.S. complete but O.S. not quite complete, or inconspicuous, abaxially (Fig. XII, 2); large vb's with I.S. complete, but O.S. interrupted adaxially and abaxially (Fig. XII, 3*a*); some vb's with O.S. interrupted abaxially but connected to the adaxial scl. by colourless cells (Fig. XII, 4).

Material Examined: Cultivated at Kew.

***Poa palustris* L.**

LEAF

Abaxial epidermis

Short-cells, both over and between the veins, mostly paired, but sometimes solitary; common over, but rather less frequent between, the veins. **Silica-bodies:** some, both over and between the veins, fitting into concavities in adjacent cork-cells (Fig. I, 6–7), and mostly rounded or slightly crescent-shaped in outline; others, over the veins, horizontally elongated, and with smooth (Fig. IA, 12), or sinuous (Fig. IA, 14–15), outlines. **Macro-hairs** and **micro-hairs:** none seen. **Prickle-hairs:** prickles (Fig. VI, 1–2) with rather long points abundant over the veins. **Papillae:** cells of the adaxial epidermis tending to be papillose. **Stomata** mostly with parallel-sided (Fig. IV, 2), but some tending to be with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells,** between the veins, with thin, mostly slightly sinuous (Fig. V, 3*a–c*) walls; end walls of the long-cells mostly transverse, but sometimes oblique.

T.S. lamina

Vascular bundles: most vb's small and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 10 and 11). **Adaxial surface** practically smooth (Fig. XIV, 1), apart from v. slight ribs over some of the vb's, and a slight furrow on either side of the midrib. **Sclerenchyma:** a few small vb's, especially towards the leaf margin, not accompanied by scl. (Fig. IX, 1); others with minute adaxial strands only (Fig. IX, 2); frequently with adaxial girders 3–4 cells wide and high and abaxial girders v. slightly wider and about the same height (Fig. IX, 4); large vb's with adaxial and abaxial girders up to about 6 cells wide and 5 cells high (Fig. IX, 5). Median vb supported by a well-developed abaxial girder extending into the apex of the keel, and a thin adaxial plate of scl. connected to the vb by a girder of colourless cells. **Keel** conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells:** none present apart from 1 more or less fan-shaped group (Fig. XV, 4) in a slight furrow on either side of the median vb. **Bundle-sheaths** double; small vb's with 2 complete sheaths (Fig. XII, 1) or with the O.S. slightly interrupted abaxially (Fig. XII, 2); large vb's with the O.S. interrupted adaxially and abaxially (Fig. XII, 3*a*).

MATERIAL EXAMINED: Cultivated at Kew.

ADDITIONAL INFORMATION FROM THE LITERATURE

1. LEAF

The leaf structure of numerous spp. has been described by various authors. Information from the literature is summarized below, the sources being given at the end of each sp.

P. alpina L.

Adaxial epidermis. Zones over the scl. consisting mostly of long-cells with v. sinuous, pitted walls; long-cells in the middle of each zone alternating with more or less elliptical short-cells or occasional prickles; in zones over parenchyma some files consisting of long-cells only, and others of long-cells and stomata, the long-cells being rectangular to hexagonal and with sinuous anticlinal walls. *Abaxial epidermis* similar but stomata less frequent, and irregularly shaped short-cells present between the veins. *Lamina.* Ratio of large to small vb's 5:2. Figured as having a well-defined midrib accompanied on either side by a single group of bulliform cells. Scl. present in the margins and keel, and as small adaxial and less frequent abaxial strands; large vb's with adaxial strands and abaxial girders. Cells of the abaxial epidermis described by Lewton-Brain and Prat as being papillose, a feature exceptional amongst the Festuceae. Mesophyll with chlorenchyma differentiated fairly clearly into palisade and spongy portions. (Lewton-Brain 1904; Lohauss 1905; Prat 1932.)

P. annua L.

Adaxial surface ribless. Scl. most abundant in the keel; v. sparse at the leaf margins, and present only as strands above and/or below the principal vb's. Keel well developed. A well-defined group of bulliform cells present on either side of the midrib. Prickles (asperities) generally absent, but recorded by Bobrov on the adaxial surface above the veins. Silica-bodies in the epidermis of the sheath variable in shape but more or less rounded; those in the epidermis of the lamina horizontally elongated. Prat indicates that the epidermis of this sp. is v. simple, silica-bodies being restricted to the region above the veins in the terminal leaf, the remainder of the epidermis consisting of long-cells with straight walls. (Bobrov 1955; Burr and Turner 1933; Günzel 1921; Lewton-Brain 1904; Prat 1932.)

(Bobrov (1955) has pointed out that *P. annua* is v. sensitive to phytotoxic substances in Los Angeles smog, and recommends its use as a bio-assay or indicator plant. The constituents of smog to which it is particularly sensitive are oxidation products of hydrocarbons, which produce a 'tan spot' or 'transverse banding' between the apex and middle of the lamina. These symptoms can be reproduced experimentally by treatment with synthetically produced smog. The first cells to be damaged are those near the substomatal chambers. Histological changes induced by smog are fully described.)[1]

P. badensis Haenke

Abaxial epidermis. Zones over scl. consisting of rectangular long-cells with pitted walls, alternating regularly with rounded to elliptical short-cells. Prickles sporadic. Intercostal zones near the scl. similar but including stomata. Adaxial similar to the abaxial epidermis, but stomata more numerous, and variously shaped short-cells sporadic. *Lamina.* Ratio of large to small vb's 1:1. Scl. as adaxial and abaxial strands associated with some of the vb's; vb's alternating with this first group not accompanied by scl.; a crescent-shaped abaxial strand present below the median vb, but separated from it by chlorenchyma. Midrib slightly protruding. Mesophyll consisting of fairly large, isodiametric cells; not differentiated into palisade and spongy portions. Bulliform cells present in 2 groups of 5–8 cells one on either side of the midrib. (Lohauss 1905.)

P. bulbosa L.

Leaf-sheath with slight abaxial ribs, lower part including air-canals. Adaxial surface with long-cells having straight anticlinal walls; stomata infrequent. Abaxial epidermis characterized by numerous short-cells and long-cells with v. sinuous anticlinal walls. Silica-cells including horizontally elongated types, but somewhat variable. Lamina: prickles present on both surfaces but more numerous on the adaxial than on the abaxial surface. (Günzel 1921.)

[1] Although *P. annua* is doubtless useful as an indicator plant for Los Angeles smog, it is doubtful if it could be used in the same way for smogs in the British Isles, or in Europe generally, where their chemical composition is so different from that of smogs in the Los Angeles area. In England *P. annua* is generally regarded as highly resistant to smog.

P. caespitosa Forst.

Adaxial epidermis. Zones over scl. consisting of mixed rows of rectangular long-cells with thickened, pitted walls alternating with prickles and occasional rectangular short-cells; intercostal zones in files near the veins, exhibiting long-cells with fairly straight walls, stomata, and occasional bristle-hairs. Long-cells in the remaining files in the intercostal zones alternating regularly with prickles. Abaxial similar to the adaxial epidermis over the veins, but rectangular short-cells present in the intercostal zones. *Lamina.* Adaxial surface more or less ribless, but abaxial surface with projecting strands of scl. Ratio of large to small vb's 1:1. Scl. well developed; midrib including a band-like abaxial strand and a much smaller adaxial strand; large vb's in the lamina with well-developed adaxial and abaxial strands or girders, minor vb's accompanied only by small abaxial strands; scl. also present in the leaf margins. Midrib not v. conspicuous. (Lohauss 1905.)

P. chaixi Villars var. *remota* Koch. (= *P. remota* Forselles)

Adaxial epidermis. In files over the veins each rectangular long-cell with thickened, pitted walls followed by a rounded silica-cell accompanied by a crescent-shaped to elliptical cork-cell. Intercostal files sometimes consisting of rectangular long-cells with sinuous walls, but others including stomata, or occasional, approximately rectangular, short-cells. Bristle-hairs present on the midrib. Abaxial similar to the adaxial epidermis, but stomata mostly replaced by rectangular short-cells. Leaf fairly broad. Ratio of large to small vb's 1:1. Scl. present as a massive abaxial strand in the midrib; also forming I-girders with the principal vb's in the lamina, and small strands associated with the minor vb's; relatively weakly developed in the leaf margins. Midrib protruding conspicuously from the abaxial surface. Mesophyll with chlorenchyma slightly differentiated into palisade and spongy portions. (Lohauss 1905.)

P. compressa L.

Abaxial epidermis. In zones over the veins, long-cells with sinuous walls alternating regularly with prickles (sometimes rare), or rectangular short-cells; in the intercostal zones long-cells with flat walls alternating with stomata. Adaxial epidermis similar, but bulliform cells present, and files consisting solely of long-cells predominating. Lewton-Brain refers to a few short hairs, mostly over the veins, on the adaxial surface. *Lamina.* Adaxial surface ribless. Ratio of large to small vb's 1:2. Scl. present in the leaf margins, in the keel, and above and/or below the secondary and principal vb's, forming abaxial girders with some of the principal vb's. Keel well developed. Bulliform cells in well-defined groups, one on either side of the midrib. (Burr and Turner 1933; Lewton-Brain 1904; Lohauss 1905.)

P. cuspidata Nutt. (as *P. brevifolia* Muhl.)

Adaxial epidermis. Most files over the veins consisting of long-cells alternating with prickles, bristle-hairs sometimes replacing the prickles near the bulliform cells; in the intercostal zones files near the veins consisting of long-cells only, other files being composed of long-cells and stomata, the long-cells alternating with prickles and bristle-hairs in the centre of each intercostal zone. Abaxial epidermis similar, but bulliform cells absent, prickles not occurring in the intercostal zones, and stomata more frequent. *Lamina.* Ratio of large to small vb's 1:2. Scl. weakly developed; mostly as adaxial and abaxial strands. Midrib conspicuous. Mesophyll with assimilatory tissue of polygonal or rounded cells; not differentiated into palisade and spongy portions. Bulliform cells of moderate size. (Lohauss 1905.)

P. flaccidula Boiss. & Reut.

Abaxial epidermis. Zones over the veins consisting of rectangular long-cells with v. sinuous, pitted walls, alternating with prickles. Adaxial epidermis as in *P. laxa* Haenke, but bulliform cells more elongated. *Lamina.* Ratio of large to small vb's 1:2–3. Scl. forming I-girders with certain vb's, bundles of this type alternating with others not accompanied by scl.; median vb accompanied by a small adaxial, and a larger abaxial, strand. Mesophyll with chlorenchyma differentiated into palisade and spongy portions, the palisade being in a single layer. Bulliform cells in groups between the vb's, the cells being large and projecting above the leaf surface; groups decreasing in size towards the leaf margins. (Lohauss 1905.)

P. gracillima Vasey

Epidermis similar in structure on both surfaces apart from the presence of adaxial bulliform cells. In the intercostal zones, files near the veins consisting of hexagonal long-cells with straight or slightly sinuous walls, and stomata; other intercostal files devoid of stomata; files over the veins, consisting of rectangular long-cells alternating with prickles and occasional elliptical short-cells. Leaves small and thin. Scl. forming I-girders with the large vb's in the lamina, and adaxial and abaxial strands associated with the small vb's; marginal strands weak; midrib with 2 small strands, one being adaxial and the other abaxial. Midrib scarcely protruding. Mesophyll with chlorenchyma differentiated into spongy and palisade portions. (Lohauss 1905.)

P. havelli Vasey & Scribner (= *P. howellii* Vasey & Scribner)

Abaxial epidermis. Over the veins, rectangular long-cells with sinuous walls alternating with elliptical short-cells, and sometimes with prickles; intercostal files near the veins consisting of hexagonal long-cells and stomata, the remaining intercostal files being composed of long-cells only. Adaxial epidermis similar, but bulliform cells present and stomata more numerous. *Lamina.* Leaf thin. All vb's primary. Scl. forming I-girders with the vb's; midrib with an adaxial strand of only a few cells and a larger abaxial strand. Midrib prominent. Mesophyll with chlorenchyma clearly differentiated into palisade and spongy portions. Bulliform cells not large. (Lohauss 1905.)

P. laxa Haenke

Abaxial epidermis exhibiting sporadic short-cells of variable shape, and rectangular to hexagonal long-cells with slightly sinuous walls. *Adaxial epidermis.* Strips over the veins consisting of rectangular long-cells alternating with prickles, but intercostal long-cells with slightly sinuous walls. *Lamina.* Adaxial surface slightly sinuous. Ratio of large to small vb's 2:1. Scl. poorly developed. Mesophyll with chlorenchyma consisting of tangentially stretched cells. Bulliform cells: groups next to, and on either side of, the midrib larger than the remainder; other groups are progressively smaller towards the leaf margins. (Lohauss 1905.)

P. longifolia Trin.

Epidermis similar on both surfaces, apart from more numerous adaxial bulliform cells. Zones over the veins consisting of long-cells with markedly sinuous, pitted walls, rounded silica-cells, some files consisting of long-cells with slightly sinuous, pitted walls and rectangular short-cells; other files composed of long-cells and stomata. Leaves long. Ratio of large to small vb's 1:1. Scl. in the lamina forming I-girders with the vb's, and an adaxial and abaxial strand present in the midrib. Midrib projecting moderately from the abaxial surface. Mesophyll consisting of polygonal to rounded cells and not differentiated into palisade and spongy portions;

including a considerable proportion of colourless cells, these cells breaking down to produce air-canals. (Lohauss 1905.)

P. masenderana Freyn. & Sint.

Abaxial epidermis. Over the veins, exhibiting rectangular short-cells alternating regularly with rectangular long-cells having v. sinuous walls. Intercostal zones consisting, near the veins, of long-cells with thin, straight walls, and stomata; the remaining intercostal files being composed of long-cells with slightly or irregularly sinuous walls. On the adaxial surface over the veins, long-cells with straight or slightly sinuous walls alternating with prickles. Files in the intercostal zones composed of stomata and long-cells. *Lamina.* Ratio of large to small vb's 1:1. Scl. forming I-girders with the vb's. Midrib prominent. Mesophyll exhibiting, in T.S., 3 layers of tangentially elongated cells. Bulliform cells as elongated groups on both surfaces of the leaf, the groups diminishing in size from the midrib to the leaf margins. (Lohauss 1905.)

P. nemoralis L.

Prickles (asperities) present on both surfaces, and a few short, adaxial hairs over the veins. Adaxial surface ribless; small abaxial prominences present opposite the principal vb's. Scl. scanty, present at the leaf margins, in the keel, and as strands above and/or below the vb's, the large vb's being girdered adaxially and abaxially. Keel well developed. Bulliform cells sometimes described as being restricted to a single well-defined group on either side of the midrib, but Strecker illustrates other groups on both sides of the midrib for this sp. (Burr and Turner 1933; Lewton-Brain 1904; Strecker 1913.)

P. pannonica Kerner

Adaxial epidermis. In zones over the veins, rectangular long-cells with sinuous walls alternating with prickles, elliptical short-cells being occasional. In zones over the parenchyma, some files consisting of rectangular long-cells with flat or slightly sinuous walls alternating with stomata, other files including rectangular short-cells of variable size and ocasional prickles. Abaxial epidermis similar, but bulliform cells absent and prickles over the veins mostly replaced by rectangular short-cells. Ratio of large to small vb's 1:1. Scl. weakly developed, and present as adaxial and abaxial strands to most of the vb's, but 1 vb in each half of the lamina accompanied by adaxial and abaxial girders; marginal strands weak. Midrib protruding conspicuously. Mesophyll with chlorenchyma differentiated into palisade and spongy portions. Bulliform cells of average size. (Lohauss 1905.)

P. pratensis L.

Abaxial epidermis. Zones over the veins consisting of rectangular long-cells, only about twice as long as wide, and with fairly thick sinuous walls, alternating irregularly with prickles. Some files in the intercostal zones consisting of long-cells only, but others including prickles and rectangular to elliptical short-cells of variable size. *Lamina.* Adaxial surface ribless. Ratio of large to small vb's 1:2–3. Scl. present in the leaf margins, in the keel, and as strands above and/or below the principal veins; large vb's sometimes abaxially girdered. Keel well developed. Bulliform cells as 2 well-defined groups, one on either side of the midrib. Intercellular spaces sometimes replacing the colourless cells on either side of the midrib in old leaves. (Burr and Turner 1933; Lewton-Brain 1904; Lohauss 1905; Strecker 1913.)

P. sellowi Nees (*P. sudetica* Haenke var. *sellowi* Trin.; *P. chaixii* Villars var. *sellowi*)

Similar to *P. chaixii. Adaxial epidermis.* In the intercostal zones, some files consisting only of hexagonal long-cells, with v. thin, flat walls, but other files including

stomata; typical short-cells absent. Stomata on the abaxial smaller than those on the adaxial surface. Scl. most conspicuous as a well-developed abaxial strand in the abaxially prominent midrib. (Lohauss 1905.)

P. trivialis L.

Prickles (short asperities) present on the adaxial surface and in the region of the keel. Adaxial surface ribless. Scl. most abundant in the keel, only small strands being present in the margins and above and/or below the principal vb's. Keel well developed. Bulliform cells in 2 groups, 1 on either side of the midrib. (Burr and Turner 1933; Lewton-Brain 1904; Strecker 1913.)

2. Root

P. violacea Bellardi

Buschmann (1952) has pointed out that the cells of the endodermis in the root of *P. violacea* are uniformly thickened on all sides, whereas the corresponding cells in *Festuca* are thickened on the inner tangential and radial walls only, the cells thus having U-shaped thickenings. Buschmann uses this as an argument in favour of keeping *P. violacea* in *Poa* rather than of placing it in *Festuca.*

Special Note

Prat (1936) rightly points out that *Poa* is a genus with typical festucoid characters.

Literature

Bobrov 1955 (leaf structure in relation to smog injury); Burr and Turner 1933 (leaf); Buschmann 1952 (root endodermis); Chauveaud 1897 (root, especially ph.); Duval-Jouve 1875 (leaf); Frohnmeyer 1914 (silica deposition); Grob 1896 (leaf); Günzel 1921 (leaf); Herriott 1906 (leaf of 1 sp. from New Zealand); Holm 1908 (notes on the leaf, culm, and root of a few spp.), 1929 (rhizome); Jirasek 1935 (leaf of 1 sp.); Lewton-Brain 1904 (leaf); Lohauss 1905 (leaf); Marsh 1952 (taxonomy of American spp.); Nishimura 1922 (developmental anatomy); Pée-Laby 1898 (leaf); Prat 1932, 1936 (leaf); Radelkoff 1929 (fruit structure); Sharman 1947 (stem apex); Strecker 1913 (leaf); Vukuloff 1929 (leaf anatomy of spp. from Czechoslovakia); Wiemann 1954 (ecological anatomy); Wille 1916.

POAGROSTIS

De Wet (1956) notes that the leaf of *P. pusilla* (Nees) Stapf has a panicoid epidermis and festucoid internal anatomy. De Wet considers that it has affinities with other members of the Danthonieae, but especially with *Afrachneria* of which it is said to represent a reduced modification.

Literature

De Wet 1956 (leaf and inflorescence).

POGONARTHRIA

Diagnostic Generic Characters

Short-cells, over the veins, paired or solitary. Silica-bodies, over the veins, mostly fitting into concavities in adjacent cork-cells, and rounded, slightly crescent-shaped, or tending to be saddle-shaped or oblong. Dumb-bell shaped

bodies also recorded. Micro-hairs present; each with the basal cell tapered towards its proximal end, the distal cell being inflated but variable in shape. Club-shaped micro-hairs also recorded. Stomata mostly with low dome-shaped, but some tending to have slightly triangular, subsidiary cells. Vascular bundles moderately crowded, and all but the large ones slightly angular in outline. Mesophyll with chlorenchyma distinctly radiate. Bundle-sheaths double, but I.S. often inconspicuous.

Species Specially Examined

***Pogonarthria squarrosa* (Licht.) Pilger**

Leaf

Abaxial epidermis

Short-cells, both over and between the veins, paired, but occasionally solitary; abundant. **Silica-bodies** mostly fitting into concavities in adjacent cork-cells (Fig. I, 6–7), and rounded, slightly crescent-shaped, or tending to be saddle-shaped (Fig. I, 9), in outline; others oblong (Fig. I, 10). **Macro-hairs:** none seen. **Micro-hairs:** length 36–48 μ; basal cells 20–28 μ; distal cells 14–22 μ; basal cells considerably tapered towards their proximal ends; distal cells with an inflated appearance, but v. variable in shape, ranging from almost hemispherical to forms tapering towards their slightly pointed apices. **Prickle-hairs:** none seen. **Stomata** mostly with low dome-shaped (Fig. IV, 3), but sometimes tending to be with slightly triangular (Fig. IV, 1), subsidiary cells. **Long-cells,** both between and over the veins, with rather thick, sinuous walls (Fig. V, 1*a–b*).

T.S. lamina

Vascular bundles: most vb's fairly closely placed, of moderate size, and not more than moderately angular in outline (Fig. VIII, 2 and 6); large vb's of basic type (Fig. VIII, 10 and 15). **Adaxial surface** with slight, rounded ribs over the vb's, the ribs over the large being somewhat wider than those over the small vb's; ribs separated from one another by slight furrows about the same width as the ribs (Fig. XIV, 2). **Sclerenchyma:** most vb's with slightly triangular adaxial and abaxial girders, the bases of the triangles abutting on to the adaxial and abaxial epidermis respectively; adaxial girders up to about 8 cells wide in their broadest parts and seldom more than 5 cells high, the corresponding abaxial girders being slightly wider and about the same height; large vb's with similar, but more massive, adaxial and abaxial girders (Fig. IX, 5), the girders associated with the median vb being about the most massive of all. **Keel** scarcely conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma distinctly radiate. **Bulliform cells** in groups of the *Sporobolus* type (Fig. XV, 8), each group being connected to the abaxial surface by a girder of colourless cells (Fig. XV, 13). **Bundle-sheaths** double, but I.S. not v. clearly defined; O.S. to the small vb's somewhat triangular in outline and usually interrupted abaxially by scl. (Fig. XII, 2); large vb's with O.S. similarly but more widely interrupted on the abaxial side, the sheath being inversely U-shaped rather than triangular.

Culm

Culm examined about 3 mm in diameter, with a large, rather irregular, central cavity. Epidermis subtended by a ring of numerous well-defined, mostly U- or V-shaped strands of assimilatory tissue embedded in a wide ring of thick-walled fibres, the strands of assimilatory tissue being separated from one another by girders of fibres extending from the vb's in the outermost circle to the epidermis. Each strand of assimilatory tissue bounded along its inner margin by a single row of large, conspicuous, colourless cells. Ground tissue on the inner side of the scl. ring consisting of cells with increasingly thin walls and wider diameters towards the centre of the culm. Vb's of the outermost circle embedded in the peripheral scl.; remaining vb's in 2–3 irregular circles embedded in the outer part of the thin-walled ground tissue.

Material Examined: Specially collected by G. Jackson in Nyasaland.

Additional Information from the Literature

1. Leaf

Günzel's (1912) description of the leaf of *P. tuberculata* Pilger includes the following information.

Adaxial epidermis. Intercostal zones, apart from the bulliform cells, consisting of files composed of long-cells with sinuous anticlinal walls, stomata, and micro-hairs. Zones over the veins including dumb-bell shaped and saddle-shaped silica-bodies, together with long cork-cells and prickles; cushion hairs present amongst the bulliform cells. *Abaxial epidermis.* Similar to that on the adaxial surface, but bulliform cells absent. *T.S. lamina.* Adaxial and abaxial surfaces both slightly ribbed. Scl. supporting the vb's on both the adaxial and abaxial sides, and also present in the leaf margins. Mesophyll with radiate chlorenchyma; some colourless cells subjacent to the bulliform cells. Bundle-sheaths double. Günzel also records some particulars concerning the structure of the leaf sheath, which is abaxially ribbed and provided with dermal appendages similar to those of the lamina.

2. Root

With reference to the root of *P. squarrosa*, Goossens (1935) records that he observed 2 steles in a common cortex, a branch root having grown down one of the air-spaces.

Special Note

Structure mainly panicoid, but bundle-sheaths double. The micro-hairs are sometimes similar to those of *Eragrostis*.

Literature

Goossens 1935 (root); Günzel 1912 (leaf).

POGONATHERUM

Diagnostic Generic Characters

Short-cells, over the veins, in long rows. Silica-bodies, over the veins, v. acutely rectangular. Micro-hairs: none seen, but see p. 404 below. Stomata with outlines markedly overarched by papillae. Vascular bundles mostly

small, crowded, and conspicuously angular in outline. Mesophyll with distinctly radiate chlorenchyma. Bundle-sheaths single.

Species Specially Examined

***Pogonatherum paniceum* (Lam.) Hack.**

Leaf

Abaxial epidermis

Short-cells, over the veins, in rows of more than 5 cells; common over, and v. infrequent to absent between, the veins. **Silica-bodies** v. acutely rectangular (Fig. I, 11). **Macro-hairs** abundant, especially over the veins; rather short, v. thick-walled with swollen bases sunken between cushion cells of the epidermis (Fig. IIA, 5). **Micro-hairs:** none seen. **Prickle-hairs:** a few of the v. short macro-hairs over the veins resembling hooks (Fig. VI, 5). **Papillae:** large, thin papillae (Fig. III, 6) abundant between the veins, the number on each cell being v. limited. **Stomata:** outlines masked by overarching papillae. **Long-cells,** between the veins, relatively short, with thin, non-sinuous walls (Fig. V, 4*a–b*); outlines obscured by papillae.

T.S. lamina

Vascular bundles: smallest vb's with xy. and ph. not clearly contrasted (Fig. VIII, 1); most vb's small, crowded, and conspicuously angular in outline (Fig. VIII, 5); a v. few large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with v. slight, rounded ribs over the vb's, separated from one another by scarcely perceptible furrows (Fig. XIV, 2). **Sclerenchyma:** a few of the smallest vb's not accompanied by scl. (Fig. IX, 1); most vb's with minute adaxial and abaxial girders about 1–4 cells wide and 2–3 cells high (Fig. IX, 4); combined girder to median vb anchor-shaped (Fig. IX, 6). **Keel** not v. conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma distinctly radiate. **Bulliform cells** mostly in somewhat irregular groups (Fig. XV, 1), but some groups slightly fan-shaped (Fig. XV, 4). **Bundle-sheaths** single; sheaths round all vb's complete (Fig. XI, 2*a–b*), the component cells of each sheath being unequal in size and the sheath consequently irregular in outline.

Culm

Culm examined less than 1 mm in diameter, with a small cavity at the centre. Epidermis subtended by 1–2 layers of fibrous cells. Ground tissue elsewhere consisting of cells with progressively thinner walls towards the centre of the culm, minute intercellular spaces being present between some of the innermost cells. Vb's in about 2 more or less distinct circles embedded in the thin-walled ground tissue. Metaxylem vessels not immediately conspicuous because of their thin walls.

Material Examined: F. Ballard 1055; Ceylon.

Additional Information from the Literature

The notes concerning the leaf epidermis recorded by Grob (1896) for *P. crinitum* Kunth indicate that this sp. in general resembles *P. paniceum* as described above. Grob, however, refers to the presence of micro-hairs, which are stated to be mostly

paired with prickles and seldom solitary, over the veins on both surfaces, and between the veins as well on the abaxial surface.

Special Notes

Leaf structure panicoid.

The culm structure is v. similar to that of *Pseudanthistiria umbellata* (see p. 413).

Literature

Grob 1896 (leaf).

POLLINIA

Vickery's (1935) description of the leaf of *P. fulva* Benth. (*Erianthus fulvus* Kunth.) includes the following information.

Leaves 5–25 cm × 3–4 mm, glabrous, or with a few hairs near the distal end of the sheath. Lamina thin; flat on both surfaces or with v. shallow grooves over the bulliform cells. Vascular bundles: 7–11 first-order vb's with 3–7 third-order vb's between each pair of large ones. Scl. present as weak adaxial and abaxial girders to the principal, and occasionally to the third-order vb's, but more often forming abaxial strands to the small vb's, adaxial strands sometimes being present as well. Midrib inconspicuous to conspicuous. Mesophyll with radiate chlorenchyma. Bulliform cells in groups between the vb's, the central cell in each group being much larger than its neighbours and occupying slightly less than half the thickness of the lamina. Bundle-sheaths single, circular.

Special Note

Prat (1936) notes that the leaf structure is panicoid.

Literature

Prat 1936 (leaf); Vickery 1935 (leaf).

POLYPOGON

Diagnostic Generic Characters

Short-cells, over the veins, solitary, paired, and in short rows. Silica-bodies, over the veins, horizontally elongated and with sinuous outlines. Micro-hairs absent. Stomata with parallel-sided subsidiary cells. Vascular bundles never conspicuously angular in outline. Mesophyll with chlorenchyma not radiate. Bundle-sheaths double.

Species Specially Examined

***Polypogon chilensis* Pilger**

Leaf

Abaxial epidermis

Short-cells, over the veins, solitary, paired, and in rows of 3–5 cells; apparently absent between the veins. **Silica-bodies** horizontally elongated

and with sinuous outlines (Fig. IA, 14–15), the sinuations sometimes being rather coarse. **Macro-hairs** and **micro-hairs:** none seen. **Prickle-hairs:** prickles (Fig. VI, 1–2) with inflated bases and short points present over some of the veins; unpointed prickles (Fig. VI, 6) also occurring near the leaf margins; somewhat angular prickles (Fig. VI, 3) present at the leaf margins. **Stomata** with parallel-sided subsidiary cells (Fig. IV, 2). **Long-cells,** between the veins, with thin, non-sinuous (Fig. V, 2*a–c*), or slightly sinuous (Fig. V, 3*a–c*), walls.

T.S. lamina

Vascular bundles: small vb's not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 9). **Adaxial surface** with fairly tall, rather widely spaced, rounded ribs over the vb's, the ribs being separated from one another by moderately deep, U-shaped furrows (Fig. XIV, 3). Rather smaller ribs also present on the abaxial surface, opposite the adaxial ribs. **Sclerenchyma:** most small vb's with adaxial and abaxial girders about 2–4 cells wide and about 4 cells high (Fig. IX, 4), but scl. of a few vb's forming strands rather than girders; large vb's with rather wider adaxial and abaxial girders (Fig. IX, 5), those to the median vb being about 6 cells wide. **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** mostly in groups as in Fig. XV, 2, in the furrows, but some groups tending to be fan-shaped (Fig. XV, 6). **Bundle-sheaths** double; some vb's with 2 complete sheaths (Fig. XII, 1); others often with extensions merging imperceptibly with the scl. to form girders (see 'sclerenchyma').

CULM

Culm examined about 2 mm in diameter; with a fairly large central cavity. Epidermis subtended by a practically continuous zone of moderately thick-walled fibres, with flattened columns of assimilatory tissue about 2 or 3 cells wide embedded in it. Ground tissue between the scl. ring and the central cavity of the culm consisting of about 6 layers of large, moderately thin-walled cells, with minute, triangular intercellular spaces between the cells. Vb's of the outermost circle embedded in the scl. ring; remaining vb's in 1–2 rows in the inner ground tissue.

MATERIAL EXAMINED: Cultivated at Kew.

***Polypogon monspeliensis* (L.) Desf.**

LEAF

Abaxial epidermis

Short-cells, over the veins, in rows of 3–5 cells, or sometimes apparently solitary when separated from one another by relatively long cells in the same files; common over, and v. infrequent between, the veins. **Silica-bodies** horizontally elongated with sinuous outlines (Fig. IA, 14–15), the sinuations sometimes being rather coarse. **Macro-hairs** and **micro-hairs:** none seen. **Prickle-hairs:** prickles (Fig. VI, 1–2), mostly rather small and with long points,

abundant over the veins; rather narrower prickles local between the veins. **Papillae:** cells of the adaxial epidermis somewhat papillose. **Stomata** with parallel-sided subsidiary cells (Fig. IV, 2); some with low dome-shaped subsidiary cells figured by Günzel (1921). **Long-cells,** between the veins, with thin, non-sinuous walls (Fig. V, 2*a–c*).

T.S. lamina

Vascular bundles: most vb's small and not conspicuously angular in outline (Fig. VIII, 2); a few large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with moderate, rounded ribs over all the vb's, separated from one another by fairly shallow V- or U-shaped furrows (Fig. XIV, 3). Abaxial surface with less prominent ribs opposite those on the adaxial surface. **Sclerenchyma:** a few small vb's, especially near the leaf margins, not accompanied by scl. (Fig. IX, 1); most vb's with minute adaxial and abaxial strands up to about 3 cells wide and high (Fig. IX, 4); strands occasionally (e.g. with the median vb) becoming converted to girders. **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll** with chlorenchyma not radiate. **Bulliform cells:** cells in the furrows somewhat bulliform, but none of them specially large; as the *Ammophila* type (Fig. XV, 5), but furrows much more shallow. **Bundle-sheaths** double; a few vb's with 2 complete sheaths (Fig. XII, 1); most vb's with I.S. complete and O.S. not quite complete, or inconspicuous, abaxially (Fig. XII, 2).

MATERIAL EXAMINED: Cultivated at Kew.

SPECIAL NOTES

Prat (1936) rightly notes that the leaf structure is festucoid.

The present author noted that the leaf structure of *P. monspeliensis* is similar to that of *Agrostis semiverticillata.*

LITERATURE

Duval-Jouve 1875 (leaf); Grob 1896 (leaf); Günzel 1921 (leaf, including the sheath); Prat 1936 (leaf).

POLYTOCA

Grob (1896) has recorded the following notes concerning the leaf of *P. bracteata* R. Br. (now known as *P. digitata* (L.f.) Druce).

Silica-bodies, over the veins, cross-shaped with deep indentations, or dumb-bell shaped with the middle part of each body short and narrow. Silica-bodies in the intercostal zones also cross-shaped. Cushion hairs present amongst the bulliform cells.

SPECIAL NOTE

The cross-shaped silica-bodies confirm that the genus is rightly included in the Maydeae.

LITERATURE

Grob 1896 (leaf).

POMMEREULLA

Diagnostic Generic Characters

Short-cells, over the veins, in long rows. Silica-bodies, over the veins, saddle-shaped. Micro-hairs present; rather short; each with a hemispherical distal cell. Stomata with markedly triangular subsidiary cells. Vascular bundles crowded and mostly conspicuously angular in outline. Mesophyll with conspicuously radiate chlorenchyma. Bundle-sheaths single and double.

Species Specially Examined

***Pommereulla cornucopiae* Linn. f.**

Leaf

Abaxial epidermis

Short-cells, over the veins, in long rows; those between the veins solitary and paired; abundant over, but infrequent between, the veins. **Silica-bodies,** over the veins, crowded, saddle-shaped (Fig. I, 9); those between the veins mostly narrowly oval or slightly crescent-shaped. **Macro-hairs:** no typical macro-hairs observed, but see under 'prickle-hairs' below. **Micro-hairs** frequent in the intercostal zones; each with a hemispherical, inflated distal cell, and a short basal cell tapering slightly towards its proximal end. **Prickle-hairs:** occasional prickles with inflated bases and v. short points, present over the veins, some with the points v. inconspicuous or absent; smaller prickles, with longer points, occasional between the veins; the longer forms of these could be interpreted as v. short macro-hairs. **Papillae:** short, oblique papillae with rounded apices present on many of the intercostal long-cells, there being 1 or 2 papillae to each cell. Papillae also present on the adaxial epidermis. **Stomata** with markedly triangular subsidiary cells (Fig. IV, 1). **Long-cells:** those in the intercostal zones with thin, densely and deeply sinuous anticlinal walls; outer walls apparently with pits; interstomatal cells similar but with concave ends (Fig. V, 10–11).

T.S. lamina

Vascular bundles: vb's crowded, all but the large ones being conspicuously angular in outline (Fig. VIII, 5). **Adaxial surface** practically smooth towards the leaf margins, but with slight ribs towards the midrib, the ribs being separated from one another by shallow furrows appreciably narrower than the ribs themselves. Slight abaxial ribs also present, especially towards the leaf margin. **Sclerenchyma:** nearly all vb's, apart from those in the keel, accompanied by adaxial and abaxial girders up to about 14 cells wide but seldom more than about 3 or 4 cells high (Fig. IX, 5); vb's in the keel accompanied by abaxial girders only (Fig. IX, 3), the adaxial surface of the midrib being supported by a thin, hypodermal plate of scl., except over the median group of bulliform cells. **Keel** conspicuous; containing a large median vb accompanied on either side by several smaller strands (Fig. XIII, 3). **Mesophyll:** chlorenchyma v. distinctly radiate. Assimilatory tissue in the midrib confined to an abaxial V-shaped area containing the vb's. **Bulliform cells** in

fan-shaped groups (Fig. XV, 6) at the bases of the adaxial furrows, each group subtended by a girder of colourless cells traversing the mesophyll. A single large, median group of bulliform cells present in the adaxial groove over the midrib. Adaxial ground tissue of the midrib consisting of a V-shaped mass of colourless cells. **Bundle-sheaths** single and double; nearly all vb's each surrounded by a single complete sheath (Fig. XI, 2*a*), the sheath being composed of cells of fairly uniform size. Large vb's each surrounded by a complete but rather inconspicuous I.S. and by an O.S. interrupted by scl. on the abaxial side only (Fig. XII, 2), or sometimes both adaxially and abaxially (Fig. XII, 3*a*).

Material Examined: Bourne 3160; Madras.

Special Note

The leaf structure is in many ways similar to that of the Chlorideae. The genus should not be included in Festuceae.

POTAMOPHILA

The following description of the leaf of *P. prehensilis* (Nees) Benth. is based on information published by De Winter (1951*b*). It must be remembered, however, that, in De Winter's opinion, it is doubtful whether *P. prehensilis* really belongs to the same genus as the type sp. *P. parviflora* R. Br.

P. prehensilis is heterophyllous, with (i) lanceolate leaves mostly on lateral shoots, and (ii) caudate, prehensile leaves on sterile main shoots. Graduations between the 2 types of leaves occur, and exhibit intermediate types of structure.

(i) Lanceolate Leaf

Epidermis

Similar on both surfaces but stomata more numerous on, and bulliform cells absent from, the abaxial surface. Short-cells, over the veins, in long rows, the silica-cells being figured as resembling the *Oryza* type, and the cork-cells slightly wider. Macro-hairs occurring sporadically above the veins, and described as long, narrow, acuminate, with bulbous bases, and stated to be 2-celled. Micro-hairs present, each consisting of 2 cells of about equal lengths, the deciduous distal cell having a rounded apex (bambusoid type, Fig. XVI—C. R. M.). Prickles present above the vb's, especially the midrib, and at the leaf margins. Stomata figured as having low dome-shaped subsidiary cells. Cuticular papillae present on the intercostal long-cells, there being a number of papillae to each cell. Long-cells, between the veins, with sinuous anticlinal walls.

T.S. lamina

Blade 4–6 cells thick. Both surfaces flat. Vascular bundles: about 5 vb's of the first order present on either side of the midrib, the midrib itself containing a relatively large abaxial vb, and a second, much smaller, more adaxial, amphivasal vb. Scl. forming a small adaxial and a much wider abaxial girder to each large vb; smaller vb's accompanied by adaxial and abaxial scl. as strands or small girders; midrib supported by a shallow, saucer-shaped, abaxial strand and by a v. much smaller adaxial girder to the adaxial vb. Keel conspicuous, rounded. Mesophyll with chlorenchyma composed of arm-cells. Bulliform cells present as rather wide, somewhat

fan-shaped groups between the vb's. Bundle-sheaths: large vb's with double sheaths; I.S. to the small vb's said to be inconspicuous (difficult to interpret from de Winter's figures—C. R. M.).

(ii) CAUDATE PREHENSILE LEAF

Extreme examples of prehensile leaves anatomically distinct from the lanceolate type. Midrib larger, trapezoid in T.S.; containing a median abaxial vb accompanied on either side by a smaller lateral strand, the adaxial vascular system likewise consisting of a median vb, accompanied on either side by a smaller strand. Two halves of the lamina less wide, but thicker than in leaves of the lanceolate type, the prickles on the midrib and at the leaf margins being more numerous.

SPECIAL NOTES

Superimposed vb's in the midrib of grass leaves are unusual except in the Bambuseae and Oryzeae. *P. prehensilis* also exhibits micro-hairs of the type that is most common in the Bambuseae, as well as chlorenchyma consisting of arm-cells, as in the Bambuseae and Oryzeae. On the other hand, fusoid-cells, which occur in the mesophyll of most bamboo leaves, appear to be lacking in *P. prehensilis*.

LITERATURE

De Winter 1951*b* (leaf).

PRIONANTHIUM

Hansen and Potztal (1954) give the following particulars concerning the leaf of *P. pholiuroides* Stapf.

Micro-hairs present, each with a relatively long basal cell and a variously shaped, shorter distal cell with a rounded apex (Fig. VII, 9). Silica-bodies stated to be dumb-bell shaped, and figured as dumb-bell shaped or nodular. Adaxial surface of the leaf with ribs and furrows. Scl. present as strands in the apices of the ribs and as small abaxial girders to the vb's. Mesophyll with chlorenchyma not radiate. Bundle-sheaths stated to be double. Starch grains simple.

SPECIAL NOTES

The above facts accord with the statement by De Wet (1956) that the leaf of *P. ecklonii* Stapf has a panicoid epidermis and festucoid internal anatomy.

Although De Wet regards *Prionanthium* as a member of the Danthonieae, its affinities within this tribe are stated to be uncertain. Hansen and Potztal, on the other hand, treat the genus as belonging to the Leptureae.

LITERATURE

De Wet 1956 (leaf and inflorescence); Hansen and Potztal 1954 (leaf anatomy and taxonomy).

PSAMMA

Information under *Psamma* in the literature generally refers to *Ammophila arenaria*. See p. 21.

PSAMMOCHLOA

DIAGNOSTIC GENERIC CHARACTERS

Short-cells, over the veins, solitary, paired, and in short or long rows. Silica-bodies inconspicuous, more or less cubical. Micro-hairs absent. Stomata with low or tall dome-shaped subsidiary cells. Vascular bundles: none conspicuously angular in outline. Mesophyll with chlorenchyma not radiate. Bundle-sheaths double.

SPECIES SPECIALLY EXAMINED

***Psammochloa villosa* (Trin.) Bor (*P. mongolica* Hitch.)**

LEAF

Abaxial epidermis (Fig. XXVIII, 4)

Short-cells, between, and some of those over, the veins, solitary and in pairs; others, over the veins, in short or long rows; abundant both over and between the veins. **Silica-bodies** with outlines less conspicuous than usual, the bodies conforming v. closely to the outlines of the cells. Silica-bodies more or less cubical in outline, but their outlines sometimes appearing sinuous with change of focus (Fig. I, 2). **Macro-hairs:** short, rigid, thick-walled hairs (Fig. IIA, 10) numerous on the sides of the adaxial ribs. **Micro-hairs** and **prickle-hairs:** none seen. **Stomata** with low (Fig. IV, 3) to fairly tall (Fig. IV, 4) dome-shaped subsidiary cells. **Long-cells,** between the veins, with thick, pitted or slightly sinuous walls (Fig. V, 1*a–b*).

T.S. lamina

Vascular bundles: a few small vb's not conspicuously angular in outline (Fig. VIII, 2); most vb's of basic type (Fig. VIII, 15), sometimes with the ph. slightly sclerosed. **Adaxial surface** with v. marked ribs of 2 distinct sizes, the large and small ribs alternating with one another; large ribs slightly rounded or flattened at the apices, small ribs narrower with rounded apices and tending to be triangular in outline. Furrows between the large ribs v. deep, and made W-shaped by the small rib at the base of each of them (Fig. XIV, 7). Low ribs also present on the abaxial surface opposite the secondary adaxial ribs. **Sclerenchyma:** most of the vb's in the small ribs, and those near the leaf margins, with well-marked abaxial girders only (Fig. IX, 3); vb's in the large ribs, and a few of those in the small ribs, with conspicuous, adaxial T- and abaxial I-girders (Fig. IX, 8). **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** in small, fan-shaped groups at the bases of the furrows (Fig. XV, 6) (not the *Ammophila* type). **Bundle-sheaths** double; large vb's with the I.S. complete and the O.S. interrupted adaxially and abaxially (Fig. XII, 3*a*); others with I.S. complete and O.S. with rather wide abaxial interruptions.

MATERIAL EXAMINED: R. W. Chaney 502; Tsagar Nor, outer Mongolia (1925).

Special Notes

The morphology, taxonomy, and synonymy of *P. villosa* (Trin.) Bor has been discussed by Bor (1951). There has been confusion between *Psammochloa* Hitch. and *Timouria* Roshev., but Bor points out that *Psammochloa* should be retained as a distinct genus for the inclusion of *P. villosa*. The genus *Psammochloa* is thought of in the present book in Bor's amended sense and not as Hitchcock's genus having the same name.

In his article Bor writes: 'The similarity in habit between our grass and *Ammophila arenaria* (Linn.) Link. is very striking and the anatomy of the leaves is almost identical, doubtless brought about by the similarity of their habitats.' This statement is perfectly correct, but a more detailed study reveals that the leaf of *P. villosa* could not easily be confused with that of *A. arenaria* because in *P. villosa* there are low abaxial ribs opposite the secondary adaxial ribs, stomata occur on the abaxial surface as well as in the adaxial grooves, and the scl. subjacent to the abaxial epidermis does not form a continuous layer over the whole surface of the leaf as it does in *A. arenaria*.

See also under *Timouria* on p. 499 and *Trikeraia* on p. 504.

Literature

Bor 1951 (taxonomy, &c., with a brief reference to leaf structure).

PSEUDANTHISTIRIA

Diagnostic Generic Characters

Short-cells, over the veins, occasionally solitary but mostly in long rows. Silica-bodies, over the veins, occasionally dumb-bell shaped but mostly nodular. Micro-hairs present; each with the distal cell usually tapering to a pointed apex. Stomata mostly with low dome-shaped subsidiary cells. Vascular bundles mostly crowded and conspicuously angular in outline. Bundle-sheaths single.

Species Specially Examined

***Pseudanthistiria umbellata* (Hack.) Hook. f.**

Leaf

Abaxial epidermis

Short-cells: occasional short-cells between the veins, and a few of those over the veins, solitary; most of those over the veins in rows of more than 5 cells; abundant over, but v. infrequent between, the veins. **Silica-bodies,** over the veins, occasionally dumb-bell shaped but varying in appearance with the focus (Fig. IB, 21); most of those over the veins nodular (Fig. IA, 18 (i)) and v. markedly elongated; occasional silica-bodies between the veins more or less cross-shaped (Fig. IA, 16). **Macro-hairs:** none seen. **Micro-hairs:** length 38–58 (mostly 38–48) μ; basal cells 24–36 (mostly 24–32) μ; distal cells 12–24 (mostly 12–20) μ; distal cells mostly tapering to acutely pointed apices (as

Fig. VII, 9, but more acutely pointed). **Prickle-hairs:** none seen. **Papillae:** small, rounded or variously shaped, thin, or thick papillae (Fig. III, 3 and 5) abundant on the long-cells, a single row usually being present on each cell. Papillae also present on some of the adaxial bulliform cells. Each papilla pale yellow and exhibiting a blue cross when examined in polarized light under crossed nicols. **Stomata** mostly with low dome-shaped subsidiary cells (Fig. IV, 3). **Long-cells,** between the veins, with thin, rather remotely sinuous walls (Fig. V, 3*a–c*), the sinuations being rounded.

T.S. lamina

Vascular bundles: most vb's v. small, crowded, with xy. and ph. not clearly contrasted (Fig. VIII, 1); occasional large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with slight, widely spaced ribs over some of the vb's (Fig. XIV, 2), the ribs being more marked towards the leaf margins than elsewhere; ribs separated from one another by rather wider, shallow furrows lined with bulliform cells that are sometimes papillose. Abaxial surface also slightly ribbed over the veins. **Sclerenchyma:** some small vb's opposite the adaxial bulliform cells not accompanied by scl. (Fig. IX, 1); others with minute abaxial strands only; vb's in the ribs with adaxial girders mostly up to 3 cells wide and 2 cells high, but occasionally slightly wider, the corresponding abaxial girders being up to about 6 cells wide and mostly 2 cells high (Fig. IX, 4). **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma v. thin and disorganized in the available material. **Bulliform cells** in wide, irregular groups (Fig. XV, 1). **Bundle-sheaths** single; those round most vb's complete (Fig. XI, 2*a*) and rather irregular in outline owing to the unequal sizes of the component cells; sheaths often appearing to be winged, owing to a cell on either side of each bundle projecting into the adjacent mesophyll. Sheaths to the large vb's with small abaxial interruptions only (Fig. XI, 6).

Culm

Culm examined less than 1 mm in diameter with a small cavity at the centre. Epidermis subtended by 1–3 layers of fibrous cells. Ground tissue between the scl. ring and the hollow centre of the culm consisting of cells with progressively thinner walls and wider lumina, with minute intercellular spaces between some of the inner cells. Vb's in 1–2 more or less distinct circles embedded in the thin-walled ground tissue. A few v. minute vb's also present at the inner margin of the scl. ring. Metaxylem vessels not immediately conspicuous because of their thin cell walls.

Material Examined: F. Ballard 1016; Ceylon.

Special Notes

The leaf structure is panicoid.

The culm structure is v. similar to that of *Pogonatherum paniceum* Ballard 1055 (see p. 404).

PSEUDOBROMUS

De Winter (1951*a*), when making a comprehensive study of *P. africanus* (Hack.) Stapf, the sole S. African sp. of this genus, recorded the following information concerning its anatomy.

1. Leaf

Epidermis

Short-cells absent, both over and between the veins. Prickles present above the veins on both surfaces, and at the leaf margins. Macro-hairs amongst the stomata; short, thick-walled, acutely pointed. Stomata on both surfaces, but most numerous on the adaxial side; figured as having low dome-shaped subsidiary cells. Long-cells on the abaxial surface with thin, smooth walls and mostly with bluntly rounded ends. Bulliform cells also present between the veins on the adaxial surface.

T.S. lamina

Both surfaces practically smooth, but with slight, wide ribs above the vb's on the adaxial surface. Vascular bundles: 6–10 first-order vb's excluding the median vb; up to 12 second-order vb's, and 14–17 third-order vb's. Scl. present as a large abaxial strand in the keel and as a small adaxial strand above the median vb; also forming abaxial strands, or occasionally girders, to all vb's, but adaxial strands associated only with all first order and some third order vb's. Keel prominent, with sloping sides; containing a single median vb, accompanied on either side by 1 second-order vb; ground tissue composed of almost colourless cells containing a few chloroplasts. Mesophyll with chlorenchyma not radiate, and consisting of large cells with smaller, round cells between them, the apparent small cells representing sections through constricted parts of the large cells; chlorenchyma cells exhibiting somewhat sinuous walls when viewed in L.S., there being small intercellular spaces between the cells. Bulliform cells in moderately wide, slightly fan-shaped groups between the vb's. Bundle-sheaths all double.

2. Culm

Long, slender, circular in T.S., with imbricate brown scales at the base. Vb's in 2–3 circles near the periphery of the culm. Centre of the culm hollow.

3. Root

Endodermis composed of strongly lignified cells, especially the inner tangential walls, the wall thickenings being striated and pitted. Cells in some parts of the pericycle thickened, and resembling those of the endodermis.

Special Note

In discussing the taxonomic affinity of *Pseudobromus*, De Winter points out that it resembles both *Bromus* and *Festuca* in certain respects, but he considers *Festuca* to be the nearest ally. In this connexion it appears to the author that the paucity of short-cells in the leaf epidermis suggests affinities with *Bromus* rather than *Festuca*.

Literature

De Winter 1951*a* (whole plant).

PSILURUS

In *P. nardoides* Trin. (now known as *P. incurvus* (Gouan) Schinz & Thell.) Pée-Laby (1898) notes the following characters.

Lamina acicular, with well-developed adaxial ribs; stomata absent from the abaxial surface; bulliform cells not well developed.

Special Note

Prat (1936), who treats *Psilurus* as a member of the Hordeeae, notes that the leaf characters are festucoid.

Literature

Duval-Jouve 1875 (leaf); Grob 1896 (leaf); Pée-Laby 1898 (leaf); Prat 1936 (leaf).

PUCCINELLIA

Diagnostic Generic Characters

Short-cells, over the veins, mostly solitary or paired, but occasionally in short rows. Silica-bodies, over the veins, usually elliptical to slightly crescent-shaped and fitting into concavities in adjacent cork-cells. Micro-hairs absent. Stomata with parallel-sided to slightly dome-shaped subsidiary cells; outlines rather obscure. Vascular bundles: none conspicuously angular in outline. Mesophyll with chlorenchyma not radiate. Bundle-sheaths double.

Species Specially Examined

***Puccinellia fasciculata* (Torr.) Bickn.**

Leaf (see also information from the literature on p. 417)

Abaxial epidermis

Short-cells, both over and between the veins, mostly paired; those over the veins occasionally in short rows; common both over and between the veins. **Silica-bodies** fitting into concavities in adjacent cork-cells (Fig. I, 6–7), and mostly elliptical to slightly crescent-shaped in outline. **Macro-hairs:** short, rigid, thick-walled hairs, with finely pointed apices, present on the adaxial ribs. **Micro-hairs** and **prickle-hairs:** none seen. **Papillae:** oblique papillae with thickened endings (Fig. III, 2) present on most of the intercostal long-cells, there usually being 1 papilla towards 1 end of each cell. **Stomata:** outlines of the subsidiary cells somewhat obscure owing to the stomata being sunken below the surrounding long-cells, and often owing to a single papilla over-arching 1 end of some of the individual stomata; subsidiary cells more or less parallel-sided (Fig. IV, 2) but sometimes tending to be slightly dome-shaped. **Long-cells,** between the veins, with moderately thin, sinuous walls (Fig. V, 3*a–c*); rather short. Long-cells, over the veins, wide, relatively thin-walled, and sometimes tending to be dome-shaped.

T.S. lamina

Vascular bundles: most vb's small and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with moderately well-developed ribs separated from one another by fairly deep, mostly V-shaped furrows (Fig. XIV, 4); most ribs slightly rounded or almost flattened at the apex. A much smaller rib present at the base of each of a few of the furrows, the furrows themselves then being W-shaped. **Sclerenchyma:** small vb's opposite the adaxial furrows, and a few towards the leaf margins, mostly not accompanied by scl. (Fig. IX, 1); occasional vb's in the small ribs with minute abaxial strands only; small vb's in the adaxial ribs accompanied by somewhat triangular adaxial and abaxial strands, the adaxial strands being 5–10 cells wide near the epidermis and no more than 1 or 2 cells wide in their narrower parts, the corresponding abaxial strands seldom being more than 5 cells wide even where abutting on to the abaxial epidermis. Strands united to the bundle-sheaths by girders of colourless cells. Large vb's with similar but slightly wider adaxial and abaxial girders (Fig. IX, 5). Occasional vb's with well-marked abaxial girders only (Fig. IX, 3). **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** in narrow to rather wide, somewhat fan-shaped groups (Fig. XV, 6) at the bases of the furrows. **Bundle-sheaths** double; most vb's with 2 complete sheaths (Fig. XII, 1), with girder-like extensions of colourless cells reaching to the scl.; small vb's opposite the adaxial furrows with I.S. complete and O.S. not quite complete, or inconspicuous, abaxially (Fig. XII, 2). For further particulars concerning this sp. see Lohauss (1905) under *Atropis borreri* Richt.

CULM

Culm examined about 1 mm in diameter; somewhat oval in T.S., with a small cavity at the centre. Epidermis subtended by a continuous zone of fibres about 6–8 cells wide, with numerous oval columns of assimilatory tissue embedded in the scl.; most vb's in the outermost circle connected to the epidermis by scl. girders. Ground tissue between the scl. ring and the cavity at the centre of the culm consisting of cells with increasingly wider diameters and thinner walls, with minute intercellular spaces between some of the inner cells. Vb's of the outermost circle embedded in the scl. ring. Remaining vb's in about 2 irregular circles, and embedded in the thin-walled ground tissue.

MATERIAL EXAMINED: J. K. O'Byrne 175; Burnham-on-Crouch, Essex.

***Puccinellia maritima* (Huds.) Parl.**

LEAF (see also under (*b*) on p. 417)

Abaxial epidermis

Short-cells, both over and between the veins, solitary and in pairs; short rows occasional. **Silica-bodies** mostly fitting into concavities in adjacent cork-cells (Fig. I, 6–7), and rounded, elliptical, or somewhat crescent-shaped in outline. **Macro-hairs, micro-hairs,** and **prickle-hairs:** none seen. **Papillae:** cells of the epidermis lining the adaxial furrow bearing rather long papillae. **Stomata:** subsidiary cells rather obscure, more or less parallel-sided (Fig. IV, 2) to slightly dome-shaped. **Long-cells,** between the veins, with moderately thin, sinuous walls (Fig. V, 3*a–c*); each long-cell generally extending from one pair of short-cells to the next pair in the same file of cells, end walls between contiguous long-cells thus being v. infrequent.

T.S. lamina

Leaf acicular as in Fig. X, 2, apart from distribution of scl. Median furrow deep, with a single rounded rib at the base, and a narrow secondary furrow on either side of the rib; no other secondary furrows present. **Vascular bundles:** most vb's not conspicuously angular in outline (Fig. VIII, 2), but median vb and 1 lateral in each half of the lamina of basic type (Fig. VIII, 15). **Adaxial surface:** see above. **Sclerenchyma:** confined to adaxial and abaxial strands to the large vb's, the strands connected to, and forming girders with, columns of colourless cells extending from the O.S.s. A few of the small vb's with well-developed abaxial girders only, and other vb's not accompanied by scl. **Mesophyll** with chlorenchyma not radiate. **Bulliform cells** confined to a group of rather small cells at the base of each of the 2 secondary furrows, as in the *Ammophila* type (Fig. XV, 5). **Bundle-sheaths** double; small vb's with 2 complete sheaths (Fig. XII, 1), the cells of the O.S. being rather unequal in size; large vb's with O.S. interrupted abaxially, but each O.S. with an extension of colourless cells connecting with the adaxial scl. (Fig. XII, 7).

MATERIAL EXAMINED: J. K. O'Byrne 173; Essex, England.

ADDITIONAL INFORMATION FROM THE LITERATURE

1. LEAF

(*a*) *P. distans* (L.) Parl. (under *Atropis distans* Griseb.)

In general resembling *P. fasciculata* (see above), but no vb's opposite the bulliform cells. Scl. forming narrow adaxial and abaxial girders to most of the vb's. Mesophyll with chlorenchyma obscurely differentiated into palisade and spongy portions. Bulliform cells fairly large; present in the adaxial furrows. Abaxial epidermis mostly composed of rectangular long-cells with v. sinuous, pitted walls; short-cells rectangular, those over the scl. sometimes replaced by prickles. Adaxial epidermis similar apart from the presence of bulliform cells. (Duval-Jouve 1875; Lohauss 1905.)

(*b*) *P. maritima* (Huds.) Parl.

The information concerning the leaf of *P. maritima* recorded by Lohauss does not agree in every detail with the structure seen in material examined by the author and described above. Lohauss refers to the occurrence of prickles and trichomes, which were not observed by the author.

2. ROOT

Freidenfelt (1904) records the following information for *P. maritima* under *Glyceria maritima*. Roots of first order, 0·55 mm in diameter. Young portions of the roots bearing numerous thin-walled root-hairs, but older roots covered externally by an exodermis of somewhat thickened rectangular cells. Outer cortex consisting of 2 layers of rounded cells with thickened walls. Cells of the middle part of the cortex becoming separated from one another to form radiately arranged intercellular cavities. Innermost 6–7 cell layers of the cortex persistent, the 3 innermost layers forming a protective sheath. Stele completely lignified apart from the ph. strands; including a single central vessel and 6 others at the periphery of the stele.

Special Note

Leaf structure typically festucoid.

Literature

Church 1949 (leaf); Duval-Jouve 1875 (leaf; under *Glyceria*); Freidenfelt 1904 (roots; under *Glyceria*); Lohauss 1905 (leaf; under *Atropis*); Sørenson 1953 (leaf).

RADDIA

Page (1947) notes that *R. brasiliensis* Bertol. exhibits most of the leaf characters of bamboos listed by Brandis (1907). The occurrence of fusoid-cells is particularly noteworthy.

Literature

Brandis 1907 (leaf); Page 1947 (leaf).

REIMARIA

Grob (1896) notes for *R. purpurascens* Link. (= *Digitaria stricta* Roth) that dumb-bell shaped silica-bodies, with long, wide middle portions, are dominant, cross-shaped and nodular types being occasional. Cork-cells horizontally elongated. Micro-hairs present.

Literature

Grob 1896 (leaf).

RENDLIA

The leaf anatomy of *R. altera* (Rendle) Chiovenda (from Nyasaland) and *R. mutica* (Hack.) Chiovenda (from the Congo region) has been briefly described by Hansen and Potztal (1954). Their description includes the following information.

Leaf almost circular in T.S. but with a v. shallow, slit-like adaxial groove (cf. *Miscanthidium* on p. 314). Silica-bodies described as dumb-bell shaped to oval, and illustrated as somewhat similar to those in Fig. Ib, 19. Small prickles occasional. Micro-hairs stated to be absent. Vb's all situated just below the abaxial epidermis. Scl. present as well-developed abaxial girders to the median vb and primary laterals. Mesophyll: chlorenchyma restricted to small-celled triangular strands between the vb's: central ground tissue consisting of thin-walled, colourless cells. Bundle-sheaths: those of the small vb's single and of the large vb's double.

Special Note

Rendlia is treated by Hansen and Potztal as a member of the Leptureae.

Literature

Hansen and Potztal 1954 (leaf).

RHYNCHELYTRUM

Diagnostic Generic Characters

Short-cells, over the veins, sometimes solitary and paired, but mostly in long rows. Silica-bodies, over the veins, cross to dumb-bell shaped or occasionally nodular, this last type having concave ends. Micro-hairs present; each with the distal cell tapering to a pointed apex. Stomata mostly with triangular subsidiary cells. Vascular bundles mostly crowded and conspicuously angular in outline. Mesophyll with radiate chlorenchyma. Bundle-sheaths double round the large vb's.

Species Specially Examined

***Rhynchelytrum repens* (Willd.) C. E. Hubbard**

Leaf

Abaxial epidermis

Short-cells between, and some of those over, the veins, solitary and paired; most of those over the veins in rows of more than 5 cells; common, but less frequent over than between the veins. **Silica-bodies,** between the veins, cross-shaped (Fig. Ia, 16), but often with a distorted appearance; some of those over the veins also cross-shaped but not distorted; most of those over the veins intermediate between cross and dumb-bell shaped (Fig. Ia, 17), or nodular (as Fig. Ia, 18 (i) but with concave ends). Interstomatal short-cells and silica-bodies less numerous in Mathews 441 than in Jackson's material. **Macro-hairs:** none seen on the abaxial surface, but Grob (1896) refers to adaxial cushion hairs amongst the bulliform cells, and Günzel (1912) mentions curved bristle-hairs with swollen bases. **Micro-hairs:** (i) those in Jackson's material: length 60–74 μ; basal cells 22–24 μ; distal cells 35–52 (mostly 40–50) μ; basal cells tapering slightly towards their proximal ends; distal cells tapering to their pointed apices (Fig. VII, 4). (ii) those of Mathews 441: length 38–58 (mostly 38–48) μ; basal cells 24–30 μ; distal cells 20–34 (mostly 20–30) μ. **Prickle-hairs:** hooks (Fig. VI, 5) frequent, especially between the veins. **Stomata** mostly with triangular (Fig. IV, 1) subsidiary cells. **Long-cells,** between the veins, with thin, sinuous walls (Fig. V, 3*a–c*).

T.S. lamina

Vascular bundles: most vb's small, crowded, angular (Fig. VIII, 5); a few large vb's of basic type (Fig. VIII, 9). **Adaxial surface** practically smooth (Fig. XIV, 1). V. slight ribs over most of the vb's on the abaxial surface. **Sclerenchyma:** a few small vb's not accompanied by scl. (Fig. IX, 1); most small vb's with minute abaxial strands only; large vb's with slightly triangular adaxial girders about 6 cells wide and 4 cells high, and abaxial girders about 8 cells wide and up to about 5 cells high (Fig. IX, 4). Scl. sometimes occurring as strands rather than girders in association with the large vb's. **Keel** conspicuous to inconspicuous, rounded; containing 1 large median vb Fig. XIII, 1) rarely accompanied by 2 much smaller laterals (Fig. XIII, 3). **Mesophyll:** chlorenchyma radiate, but rather indistinctly so round some vb's. **Bulliform cells:** in groups of the *Sporobolus* type (Fig. XV, 8), but some groups tending

to be fan-shaped (Fig. XV, 4). Rather smaller bulliform cells tending to occur on the abaxial surface. Adaxial ground tissue of the keel composed of colourless cells. **Bundle-sheaths:** large vb's with 2 complete sheaths (Fig. XII, 1), but median vb with the O.S. interrupted abaxially.

CULM

Culm examined about 3 mm in diameter. T.S. in Mathews 441 with slight ribs and more sinuous in outline than Jackson's material. Centre of the culm occupied by somewhat spongy tissue in Jackson's material, but hollow in Mathews 441. Epidermis composed of cells with their outer tangential and radial walls strongly thickened; subtended by a zone of fibres some 8 cells wide merging almost imperceptibly with the thin-walled inner ground tissue. Tangentially elongated, but radially narrower, columns of assimilatory tissue present below the epidermis. Vb's of the outermost circle embedded in the peripheral scl. Remaining vb's in 3 more or less distinct circles embedded in the peripheral part of the thin-walled ground tissue. Individual vb's longer radially than tangentially in T.S. Ph. with rather wide sieve tubes.

MATERIAL EXAMINED: (i) Collected by G. Jackson in Nyasaland. (ii) Mathews 441; cultivated at Kew from S. African seed.

SPECIAL NOTES

Leaf structure panicoid.

From Günzel's (1912) remarks it is evident that the hairiness varies on different parts of an individual leaf and also in leaves of specimens from different localities. The extent to which the midrib or keel is developed is also variable.

LITERATURE

Fisher 1938 (leaf; under *Tricholaena*); Goossens 1935 (root); Grob 1896 (leaf; under *Tricholaena rosea* Nees); Günzel 1912 (leaf; under *Tricholaena rosea* Nees).

RHYTACHNE

DIAGNOSTIC GENERIC CHARACTERS

Short-cells, over the veins, paired. Silica-bodies, over the veins, rounded or elliptical, and mostly fitting into concavities in adjacent cork-cells. Micro-hairs: none seen. Stomata absent from the abaxial surface in the sp. examined. Vascular bundles: none conspicuously angular in outline. Mesophyll with inconspicuously radiate chlorenchyma. Bundle-sheaths obscurely double.

SPECIES SPECIALLY EXAMINED

***Rhytachne rottboellioides* Desv.**

LEAF

Abaxial epidermis

Costal and intercostal zones not sharply contrasted. **Short-cells** paired; abundant. **Silica-bodies** fitting into concavities in adjacent cork-cells (Fig. I, 6–7), and mostly rounded or elliptical in outline. **Macro-hairs:** none seen on the abaxial surface, but numerous, short, stiff hairs with rounded apices (Fig. II, 4*a*) abundant on the adaxial surface. **Micro-hairs** and **prickle-hairs:** none seen. **Stomata** absent from the abaxial surface. **Long-cells** with thick, sinuous walls, the sinuations being tall and crowded; each pair of long-cells separated by a pair of short-cells v. markedly at right angles to the horizontal walls.

T.S. lamina

Lamina closely folded, the 2 halves enclosing a deep, V-shaped furrow. **Vascular bundles:** small vb's not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 9). **Adaxial surface** smooth (Fig. XIV, 1), apart from the single furrow formed by the 2 halves of the leaf being folded together; outline of T.S. as in Fig. X, 1, but no secondary furrows at the base of the main furrow. **Sclerenchyma:** most vb's not accompanied by scl. (Fig. IX, 1); large vb's with well-developed abaxial girders, and most of them with minute adaxial strands connected to the vb's by girders of colourless cells. **Mesophyll:** chlorenchyma obscurely radiate immediately around the vb's, especially the small ones. **Bulliform cells:** typical bulliform cells absent. **Bundle-sheaths:** difficult to determine whether single or double, owing to an obscure I.S. in some of the vb's; if interpreted as single the sheaths round most vb's are complete (Fig. XI, 2*a*); sheaths to the large vb's sometimes interrupted abaxially (Fig. XI, 6).

MATERIAL EXAMINED: Meikle 1324; Nigeria.

ADDITIONAL INFORMATION FROM THE LITERATURE

(*a*) *R. gracilis* Stapf

Leaf acicular; reduced to the midrib, consisting largely of colourless parenchyma, and short, prismatic wings, the wings surrounding a narrow furrow lined with bulliform cells and bearing papillae. Abaxial epidermis also composed of large cells except over the veins. Vb's few; a single second order vb present between each pair of first order vb's. (Prat 1937.)

(*b*) *R. perfecta* Jacques-Félix

Leaf moderately inrolled and exhibiting xerophytic characters. Adaxial surface with numerous ribs of unequal sizes. Vb's numerous and mostly small, the smallest vb's being opposite the adaxial grooves. Scl. forming somewhat triangular adaxial girders to the large vb's and small abaxial strands to the remaining vb's. Bundle-sheaths illustrated as single. Macro-hairs abundant on the adaxial ribs; fairly short, with wide lumina. Stomata said to be absent from the abaxial surface. (Jacques-Félix 1954.)

SPECIAL NOTE

Leaf characters mainly festucoid. The leaf structure does not indicate affinities with the Andropogoneae.

LITERATURE

Jacques-Félix 1954 (leaf); Prat 1937 (leaf).

RICHARDSIELLA

A new monotypic genus from N. Rhodesia, described, with particulars of the leaf anatomy, by Elffers and O'Byrne (1956). The following details concerning the leaf of *R. eruciformis* Elffers and O'Byrne have mostly been taken from their paper.

Leaf

Abaxial epidermis

Short-cells, over the veins, present in all or every alternate file of cells, mostly paired but sometimes solitary, thick-walled and cuboid in shape; those in the intercostal regions present in nearly every file and mostly solitary, thin-walled and more or less oblong with their longitudinal axes at right angles to the longitudinal axis of the leaf. **Silica-bodies** in the costal short-cells stated by Elffers and O'Byrne to be cuboid, but some of those seen by the author tending to be saddle-shaped (Fig. I, 5 and 9); those in the intercostal zones often slightly concave on either side. **Macro-hairs:** each arising from a sunken base surrounded by a somewhat cushion-like group of specialized epidermal cells, and up to 20 mm long, present infrequently and irregularly in the intercostal regions. Short, stiff, thick-walled hairs, usually more in the nature of prickles (Fig. VI, 3) than macro-hairs, present on the ribs on the adaxial surface of the leaf. **Prickles** infrequent on the abaxial surface. **Micro-hairs** frequent but irregularly distributed in the intercostal regions; balanoform (Fig. VII, 3), or each with the distal cell slightly tapered to a broadly rounded apex; up to 275 μ long, the distal cell being about the same length as, or slightly longer than, the proximal cell. **Stomata** with triangular (Fig. IV, 1) subsidiary cells. **Long-cells** with thickly cutinized, sinuous, anticlinal walls; those over the veins narrower and more precisely rectangular than those in the intercostal zones.

T.S. lamina

Vascular bundles of 3 distinct orders; primary (basic type) vb's consisting of the median vb and 1 bundle in each half of the lamina rather towards the leaf margin; secondary vb's alternating with the bulliform cells; tertiary vb's opposite the bulliform cells. Xy. and ph. not easily distinguishable from one another in the tertiary vb's (Fig. VIII, 1). **Adaxial surface** with low ribs opposite the primary and secondary vb's; abaxial surface practically smooth. **Sclerenchyma** forming wide adaxial and abaxial girders to the primary vb's in the 2 halves of the lamina, and less massive girders to the median vb; generally absent elsewhere apart from an occasional adaxial strand. **Midrib** not prominent; containing a single vb (Fig. XIII, 1). **Mesophyll** with chlorenchyma cells collapsed in the available material. **Bulliform cells** sometimes tending to be in slightly fan-shaped groups (Fig. XV, 4), but mostly figured as being in irregular groups (Fig. XV, 1), each group consisting of cells of unequal sizes. **Bundle-sheaths:** those to the large vb's double, but secondary and tertiary vb's with single sheaths sometimes tending to be triangular in outline, the lateral cells being rather larger than the remainder.

Special Notes

The taxonomic position of the genus is uncertain. As pointed out by Elffers and O'Byrne, the leaf structure resembles that of certain Chlorideae and Eragrosteae. In this connexion, however, it should be noted that the micro-hairs are not of the small, sunken type that is common in *Chloris*, nor of the type shown in Fig. VII, 12, which is characteristic of *Eragrostis*. Micro-hairs similar to those of *Richardsiella* occur, e.g., in *Zea*.

Literature

Elffers and O'Byrne 1956 (taxonomy and leaf anatomy).

ROTTBOELLIA

Diagnostic Generic Characters

Short-cells, over the veins, solitary, paired, and in long rows. Silica-bodies, over the veins, cross-shaped or intermediate between cross and dumb-bell shaped. Micro-hairs present; balanoform. Stomata mostly with markedly triangular, but others with low dome-shaped, subsidiary cells. Vascular bundles mostly small, crowded, and conspicuously angular in outline. Mesophyll with radiate chlorenchyma. Bundle-sheaths single.

Species Specially Examined

***Rottboellia exaltata* Linn. f.**

Leaf

Abaxial epidermis

Short-cells, between the veins, and over the small veins, solitary and in pairs; those over the large veins in rows of more than 5 cells; abundant over, and frequent between, the veins. **Silica-bodies,** between the veins, tall, narrow, and crenate (Fig. Ib, 24) in Jackson's material, but corresponding bodies in Ballard 1484 mostly cross-shaped but distorted; those over the veins, in Jackson's material, mostly cross-shaped (Fig. Ia, 16), but sometimes intermediate between cross and dumb-bell shaped (Fig. Ia, 17); those over the veins, in Ballard 1484, mostly dumb-bell shaped (Fig. Ia, 18 (ii–v)), each with a slight concavity at either end, and many others nodular (Fig. Ia, 18 (j)). **Macro-hairs:** none seen. **Micro-hairs** in Ballard 1484; length 36–48 (mostly 42–48) μ; basal cells 15–20 μ; distal cells 20–29 μ; hairs mostly balanoform, the distal cells being rather uniform in diameter throughout their lengths and with rounded apices (Fig. VII, 3), but distal cells sometimes tapering to pointed apices (Fig. VII, 6). Micro-hairs in Jackson's material similar, but not measured. **Prickle-hairs** absent over most of the leaf surface, but abundant angular prickles (Fig. VI, 3) noted near the leaf margin in Ballard 1484. Large prickles with hexagonal bases also recorded by Prat (1937) on the leaf sheath. **Stomata** mostly with markedly triangular (Fig. IV, 1), but others with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells,** between the veins, with thin, rather coarsely sinuous walls (Fig. V, 3*a–c*), some of the cells being a short form of this type (Fig. V, 7*a–b*); many of the interstomatal cells with concave ends.

T.S. lamina

Vascular bundles: most vb's small, crowded, and angular, the smallest with xy. and ph. not clearly contrasted (Fig. VIII, 1), but others resembling those in Fig. VIII, 4 and 5; a few large vb's of basic type (Fig. VIII, 15). (Prat (1937) noted 13–17 small vb's between each pair of large ones.) **Adaxial surface** practically smooth (Fig. XIV, 1) in Ballard 1484, but slightly ribbed (Fig. XIV, 2) in Jackson's material; with slight but wide ribs over the large vb's. Abaxial surface of the leaf also slightly ribbed over the vb's. **Sclerenchyma:** numerous small vb's not accompanied by scl. (Fig. IX, 1); a few small vb's accompanied by minute adaxial (Fig. IX, 2) or abaxial strands only; large vb's with adaxial and abaxial girders (Fig. IX, 4 and 5), those that are adaxial varying from about 3–12 cells wide and 2–3 cells high, the vb's with the widest strands being near the midrib, the corresponding abaxial girders mostly being about 16 cells wide and seldom more than 2 cells high. Most keel bundles with well developed abaxial girders only (Fig. IX, 3). Adaxial surface above the keel supported by a plate of scl. about 2 cells thick. **Keel** v. conspicuous, rounded; in Jackson's material containing 1 large median vb accompanied on either side by 2 laterals nearly as large, and by 6 or more appreciably smaller (Fig. XIII, 3); in Ballard 1484 with about 5 appreciably smaller laterals on either side of the median vb. **Mesophyll:** chlorenchyma radiate immediately around each of the small vb's. **Bulliform cells:** rather variable; those throughout most of the lamina in rather irregular groups (Fig. XV, 1), but some groups as in Fig. XV, 2, and a few of the *Zea* type (Fig. XV, 3). **Bundle-sheaths** single; all small vb's with complete sheaths (Fig. XI, 2*a*), each composed of cells of unequal sizes, the sheaths being somewhat irregular in outline; large vb's with their sheaths interrupted abaxially (Fig. XI, 6), or adaxially and abaxially (Fig. XI, 3).

Culm

Culm examined 8 mm in diameter; flattened on one side; with a solid centre. No well defined scl. ring present, there being a gradual transition between the cells of small diameter subjacent to the epidermis, to the large-celled, thin-walled ground tissue at the centre of the culm. Vb's v. numerous and scattered throughout the culm, each vb being accompanied by fibres, especially next to the protoxylem. Peripheral vb's more strongly supported by scl. than those nearer the centre of the culm.

Root

Root examined about 2 mm in diameter. Root-hairs long; cortex about 12 cells wide, the cells being arranged in v. regular radial rows. Cortex bounded on the inner side by a conspicuous endodermis composed of cells with the inner tangential and radial walls strongly thickened. Xy. including a conspicuous circle of about 12 large metaxylem vessels. Centre of the root occupied by a small, solid pith.

Material Examined: (i) Collected by G. Jackson in Nyasaland. (ii) F. Ballard 1484; Ceylon.

Additional Information from the Literature

In *R. hirsuta* Vahl (= *Lasiurus hirsutus* (see p. 275)), Grob (1896) notes paired silica- and cork-cells above the scl.; cross-shaped and dumb-bell shaped silica-bodies; the presence of micro-hairs, mostly in the intercostal zones; cushion hairs over the abaxial intercostal zones and at the leaf margins.

Special Note

Prat (1936) rightly notes that the leaf structure is panicoid.

Literature

Grob 1896 (leaf); Jacques-Félix 1952 (taxonomy); Pijl, van der 1951 (spike breaks up into pieces each consisting of 1 internode); Prat 1936, 1937 (leaf).

SACCHARUM

Diagnostic Generic Characters

Short-cells, over the veins, solitary, paired, and in short rows. Silica-bodies, over the veins, occasionally cross-shaped, but more commonly intermediate between cross and dumb-bell shaped or sometimes dumb-bell shaped or nodular. Micro-hairs present; each usually with the distal cells tapering to a pointed apex, the shape of the distal cells being variable in some spp. Stomata with triangular or low dome-shaped subsidiary cells. Vascular bundles not more than inconspicuously angular in some spp., but angular outline of the small vb's more marked in others. Mesophyll with incompletely radiate chlorenchyma. Bundle-sheaths mostly single, but sometimes with an obscure I.S.

Species Specially Examined

***Saccharum bengalense* Retz.**

Leaf

Leaf almost triangular in T.S. owing to the v. pronounced keel and narrow lamina only about 0·5 cm wide.

Abaxial epidermis

Short-cells, at the edges of the veins, solitary and paired; pairs also numerous near the leaf margins; those over the veins in rows of 3–5 cells; abundant over, but less frequent between, the veins. **Silica-bodies,** between the veins, infrequent and inconspicuous; those over the veins occasionally cross-shaped (Fig. Ia, 16), but more often intermediate between cross and dumb-bell shaped (Fig. Ia, 17), a few others dumb-bell shaped (Fig. Ia, 18 (ii–v)), but more commonly nodular (Fig. Ia, 18 (i)). Silica-bodies in the short-cells near the leaf margin with outlines conforming closely with those of the lumina of the cells. **Macro-hairs:** none seen. **Micro-hairs:** length 48–72 (mostly 58–64) μ; basal cells 26–42 (mostly 30–42) μ; distal cells 20–33 (mostly 22–29) μ; distal cells mostly tapering to pointed apices (Fig. VII, 9 and 10). **Prickle-hairs:** none seen apart from v. large, angular prickles (Fig. VI, 3) at the leaf margin. **Papillae:** oblique papillae with thickened endings (Fig. III, 2) abundant on

the interstomatal cells, one papilla being present on each cell, other papillae overarching the stomata themselves. **Stomata:** some with triangular (Fig. IV, 1) and some with low dome-shaped (Fig. IV, 3) subsidiary cells; outlines often obscured by the overarching papillae. **Long-cells:** those in the intercostal zones but close to the veins with thin, sinuous walls (Fig. V, 3*a–c*); interstomatal cells with concave ends (Fig. V, 10–11).

T.S. lamina

Vascular bundles: small and medium-sized vb's not, or only inconspicuously, angular in outline (Fig. VIII, 2 and 6); large vb's of basic type (Fig. VIII, 10). **Adaxial surface** with slight, rounded ribs over the large and medium-sized vb's, and fairly wide, shallow furrows over the small vb's (Fig. XIV, 2). Abaxial surface also slightly ribbed over some of the vb's, especially over the keel bundles. **Sclerenchyma:** a few small vb's, especially those opposite some of the adaxial furrows, not accompanied by scl. (Fig. IX, 1); other vb's opposite the adaxial furrows, as well as the midrib bundles, accompanied by well-marked abaxial girders only (Fig. IX, 3); vb's opposite the adaxial ribs with adaxial and abaxial girders, the adaxial girders being about 6–10 cells wide and about 4 cells high, the corresponding abaxial girders usually being slightly narrower. Girders to large vb's mostly rounded in outline and composed of fibres that are circular in T.S., and with v. thick walls and narrow lumina. Adaxial surface above the keel supported by a thin plate of fibres immediately below the epidermis. **Keel** v. conspicuous, rounded; containing about 26 vb's of various sizes, arranged in an arc near the abaxial surface (Fig. XIII, 5). **Mesophyll:** chlorenchyma tending to be inconspicuously radiate around the vb's. **Bulliform cells** in rather large, fan-shaped groups (Fig. XV, 4 and 6) at the bases of the furrows. Adaxial part of the midrib composed of large colourless cells. **Bundle-sheaths** single; small vb's with complete sheaths (Fig. XI, 2*a*), the component cells of each sheath being unequal in size; sheaths to the large vb's with adaxial and abaxial interruptions (Fig. XI, 4); large keel vb's with sheaths reduced to 2 lateral strips at the ph. end (Fig. XI, 5).

MATERIAL EXAMINED: Received from India for identification.

Saccharum officinarum L.

LEAF

Abaxial epidermis

Short-cells between, and most of those over, the veins, solitary and paired; those over the veins occasionally in short rows; common. **Silica-bodies** cross-shaped (Fig. IA, 16), or intermediate between cross and dumb-bell shaped (Fig. IA, 17), those between the veins being somewhat distorted in appearance. **Macro-hairs:** none seen. **Micro-hairs:** length 54–72 (mostly 63–72) μ; basal cells 34–38 μ; distal cells 26–40 (mostly 32–40) μ; distal cells tapering to pointed apices (Fig. VII, 5). **Prickle-hairs:** prickles (Fig. VI, 1–2), sometimes unpointed (Fig. VI, 6), fairly frequent over and at the sides of the veins; occasional hooks (Fig. VI, 5) noted between the veins. **Stomata** with triangular subsidiary cells (Fig. IV, 1). **Long-cells,** immediately beside and over the veins, with thin to fairly thick, sinuous walls (Fig. V, 3*a–c*); those in the stomatal zones shorter and with less frequent but marked sinuations in the walls; interstomatal cells with concave ends (Fig. V, 10–11), the concavities being v. deep and narrow.

T.S. lamina

Vascular bundles: most vb's small and not, or only inconspicuously, angular in outline (Fig. VIII, 2, 5, and 6); large vb's of basic type (Fig. VIII, 15). **Adaxial surface:** ribs over the small vb's scarcely perceptible, but those over the large vb's more pronounced and rounded (Fig. XIV, 2). Abaxial surface of the keel also slightly ribbed. **Sclerenchyma:** some small vb's opposite the bulliform cells not accompanied by scl. (Fig. IX, 1); medium-sized vb's with adaxial and abaxial girders (Fig. IX, 4) seldom more than 2–3 cells wide and high; large vb's with slightly wider adaxial and abaxial girders; keel vb's with well-developed abaxial girders only (Fig. IX, 3). **Keel** v. conspicuous, rounded; containing about 18 vb's of various sizes arranged in an arc not far within the abaxial epidermis (Fig. XIII, 5). **Mesophyll:** chlorenchyma radiate immediately around each vb. **Bulliform cells** chiefly in small groups of specially large cells of the *Zea* type (Fig. XV, 3); also as arches over the veins (Fig. XV, 10), this last character being more common towards the leaf margins than over the midrib. Colourless cells forming the adaxial ground tissue of the keel. **Bundle-sheaths:** small and medium-sized vb's each with a single complete sheath (Fig. XI, 2*a*), some of the sheaths having tail-like extensions of colourless cells connecting them to the adaxial scl. Some vb's apparently with 2 complete sheaths (Fig. XII, 1), the I.S. being obscure.

CULM (Fig. XIX, 5–6)

Portion of a culm nearly 3 cm in diameter examined, the centre of the culm being solid. Epidermis composed of small, v. thick-walled cells. No well-defined scl. ring present, the cells of the ground tissue gradually increasing in diameter towards the centre of the culm. Vb's v. numerous, scattered throughout the ground tissue, and each surrounded by scl., the fibre strands associated with the vb's towards the periphery of the culm being the largest.

MATERIAL EXAMINED: Cultivated at Kew.

Saccharum spontaneum L.[1]

LEAF

Abaxial epidermis

Short-cells, over the veins, mostly in rows of 3–5 cells; common over, but infrequent or absent between, the veins. **Silica-bodies** mostly dumb-bell shaped (Fig. IA, 18 (ii–v)), but sometimes intermediate between cross and dumb-bell shaped (Fig. IA, 17); occasionally nodular (Fig. IA, 18 (i)). **Macro-hairs:** none seen. **Micro-hairs:** length 53–78 (mostly 58–78) μ; basal cells 36–48 μ; distal cells 16–36 (mostly 20–34) μ; basal cells rather conspicuously bent; distal cells somewhat variable in shape and diameter, but mostly tapering to pointed

[1] *S. spontaneum* L. var. *aegyptiacum* (Willd.) Hack., described by Grob (1896) under *S. aegyptiacum* and by Prat (1937) under *S. biflorum* Forsk., is v. similar in structure to *S. spontaneum* L.

apices (Fig. VII, 5). **Prickle-hairs:** interlocking prickles (Fig. VI, 4) overlying the stomata in the grooves. **Stomata** with triangular subsidiary cells (Fig. IV, 1), but outlines obscured by overlying prickles. **Long-cells:** those over and immediately beside the veins with fairly thin, sinuous walls (Fig. V, 1*a–b*, and 3*a–c*); those in the stomatal zones obscured by overlying prickles.

T.S. lamina

Vascular bundles: small vb's not conspicuously angular in outline (Fig. VIII, 2); medium-sized vb's slightly more angular (Fig. VIII, 6); large vb's of basic type (Fig. VIII, 10). **Adaxial surface:** fairly tall, rounded ribs present over the large vb's and less pronounced ribs over the small vb's, some of the most pronounced being near the midrib (Fig. XIV, 3); intervening furrows shallow to moderately deep, and narrower than the ribs. Abaxial surface with numerous slight ribs over all vb's, including those in the keel. **Sclerenchyma:** vb's opposite the bulliform cells, and those in the keel, accompanied by well-developed abaxial girders only (Fig. IX, 3), the girders being slightly anchor-shaped. Large vb's in the lamina accompanied by adaxial girders about 16 cells wide and 4 cells high, the corresponding abaxial girders being narrower and fitting into the abaxial ribs. Adaxial surface of the midrib supported throughout its width by a thin plate of fibres subjacent to the epidermis. **Midrib** v. conspicuous, owing to a rounded abaxial projection, and a less pronounced, flattened, median adaxial rib; containing a large median vb accompanied on either side by a lateral of about the same size, and by 5 or 6 much smaller vb's, the vb's being arranged in an arc near the abaxial surface (Fig. XIII, 3). **Mesophyll** somewhat disorganized in the available material; chlorenchyma apparently restricted to narrow zones around the vb's and obscurely radiate. **Bulliform cells** in conspicuous, fan-shaped groups (Fig. XV, 4 and 6) at the bases of the furrows, commonly with girder-like columns of colourless cells connecting the groups to the abaxial surface and forming arches over the small vb's, i.e. tending to be as in Fig. XV, 10. Colourless ground tissue well developed in the midrib. **Bundle-sheaths** difficult to classify as single or double owing to the presence of an obscure I.S.; all small vb's surrounded by complete sheaths (Fig. XI, 2*a*); sheaths of the large vb's interrupted adaxially and abaxially (Fig. XI, 4), or reduced to 2 lateral strips at the ph. end of each vb (Fig. XI, 5).

MATERIAL EXAMINED: Specimen from the E. Indies in the Kew Museum, 1877.

ADDITIONAL INFORMATION FROM THE LITERATURE

1. DEWLAPS, LIGULES, AND AURICLES OF SUGAR-CANE

The morphology and anatomy of sugar-cane has been well summarized by Van Dillewijn (1952) whose book includes an extensive list of literature references. It should be noted, however, that the accurate identification of sugar-cane varieties by means of vegetative characters has been attempted by a number of investigators. The characters used for diagnostic purposes are not necessarily microscopical, but include, for example, variations in the external form of the dewlaps, ligules, and auricles. For readers not familiar with the term dewlap it must be explained that dewlaps or 'joint-triangles' are 2 more or less wedge-shaped areas on the outer

(abaxial) surface of the leaf-blade just above the point where it joins the leaf-sheath. Dewlaps contain collenchymatous cells and are, therefore, flexible, and they change in shape as the leaf grows older, so that for comparative purposes it is desirable to work only with dewlaps from almost full-grown leaves. Furthermore, since the structure of the leaves is not symmetrical in relation to the midrib, it is desirable to ensure that comparisons between dewlaps from different leaves are made only between those on the corresponding sides of the leaves concerned. Artschwager divided dewlaps into 3 types which are respectively rectangular or almost square, deltoid or triangular, and ligular. Intermediate types also occur.

The membranous, asymmetrical ligule consists of elongated cells, and may be strap-shaped, deltoid, crescent-shaped, or bow-shaped, intermediate types also occurring. Ligules also vary in the extent to which they are pubescent. Auricles may be present on both sides of the leaf at the distal end of the sheath margin, 1 only may be present, or both may be lacking. Further details are available in the articles by Artschwager and Jeswiet respectively as cited by Van Dillewijn (1952). See also Artschwager 1951 *a* and *b*, and 1914.

2. LEAF

Van Dillewijn (1952) cites work by Groot who found variations in the cell pattern in the costal zones of the abaxial leaf epidermis to be of some importance in the identification of cultivated varieties of sugar-cane. In particular the distribution of prickles over the veins is of diagnostic value, and 3 types of arrangement were recognized. In the first type prickles are lacking, in the second there is a central row along each costal zone, and in the third type the costal zones are flanked on both sides by prickles.

Previously, Dunlop (1913) investigated the frequency of stomata on leaves as an aid to identifying different varieties of sugar-cane cultivated in the West Indies, but, judging from the illustrations, the investigation is not very satisfactory by modern standards.

3. CULM

(a) Culm epidermis

Artschwager (1930) has drawn up keys that are claimed to enable certain cultivated varieties of sugar-cane to be identified from the structure of the culm epidermis. For comparative purposes it is necessary to take the epidermal preparations from a standard position, and the middle of a fully elongated internode was selected for this purpose. The keys are based mainly on the number, frequency, and shapes of the cork-cells and their arrangement as solitary cells, in pairs, or in short rows. The frequency of the stomata is also important. It is interesting to note that the structure of the epidermis was found to be but little modified in relation to the environment.

Artschwager, writing in a later paper (1954) with special reference to *S. sinense* Roxb. and *S. barberi* Jeswiet, notes that although stem epidermal patterns have provided valuable diagnostic characters even for a 'closely knit' group, variations in the anatomy of stems, roots, and leaves are of limited specific diagnostic value, and still less useful for the identification of taxa below the level of spp.

(b) Course and structure of the culm bundles

The vascular structure of the culm of sugar-cane has been investigated by Artschwager (1925) whose work refers particularly to the variety Lousiana Purple. The following is a summary of his observations.

The vb's of the sugar-cane are of the normal monocotyledonous type, rhomboid

to oval in cross-section and each surrounded by a well-marked scl. sheath which is enlarged at the xy. and ph. poles to form bundle caps. Ph. and xy. are disposed collaterally in relation to each other. Deviations from this arrangement occur in the node and in the lower part of the leaf-sheath, the bundles here showing a more or less amphivasal structure. True amphivasal arrangement, however, is confined to the larger bud-traces. In the lower part of the leaf-sheath a pseudo-amphivasal arrangement is sometimes produced by the formation of compound bundles.

The xy. is composed of protoxylem and 2 large pitted vessels. The protoxylem, which consists of a short radial row of annular and spiral elements, is more extensive in the node than in the internodes, and reaches its maximum development in that part of the leaf-trace which runs horizontally in the node. The large, pitted vessels of the metaxylem also tend to increase in number as the vb. passes through the node; the large horizontal leaf traces, on the other hand, lack the large vessels altogether. The internodal bundles, except those near the periphery, and the large bundles of the leaf-sheath and the blade, possess a more or less conspicuous protoxylem lacuna. The lacuna is absent from the bundles at the node, the peripheral bundles of the internode, and smaller bundles of the leaf.

The ph. consists of sieve tubes and companion cells. It is most extensive in the bundles of the node and the leaf-sheath, but least conspicuous in the smaller bundles of the leaf-blade, and in the peripheral bundles of the internode.

In the peripheral internodal bundles the scl. caps on the ph. poles are the most conspicuous. In the bundles of the leaf-blade the cells of the scl. sheath become larger, more regular, and contain large chloroplasts. In addition, the leaf bundles possess a fibrous sheath located between the chlorophyll-bearing sheath and the ph. The extent of this fibrous sheath is in direct relation to the size of the bundles.

4. Root

Artschwager (1925) has published a detailed account of the structure of the root of sugar-cane, and Van Dillewijn (1952) repeats many of the details given by Artschwager. The structure of the root of the sugar-cane is v. similar to that of most grass roots (see p. xxx). A young root in T.S. exhibits the following characters. Root bounded externally by a piliferous layer subtended on the inner side by an exodermis consisting of a single layer of thin-walled suberized cells larger than those of the piliferous layer; a 1–2-layered cylinder of scl. cells immediately below the exodermis; a broad cortex of thin-walled cells with minute, triangular, intercellular spaces between the cells; a conspicuous endodermis with the inner tangential and radial walls strongly thickened; the stele with radially arranged xy. and ph., there usually being a circle of 8 large metaxylem vessels in young roots, this number increasing in older and thicker roots; a pith-like ground tissue at the centre of the root. In older roots the vascular tissue, with the exception of the ph., becomes lignified, and large, radiately arranged intercellular spaces arise in the cortex between the outer scl. cylinder and the endodermis, the spaces being separated from one another by narrow strips of cortical parenchyma.

Special Note

Leaf structure typically panicoid.

Literature

Artschwager 1925 (culm and root), 1930 (stem epidermis), 1951 *a* and *b* (ligule and dewlap), 1954 (chiefly exomorphic; some particulars of culm epidermis); Barber 1915, 1916 (exomorphology of sugar-cane varieties); Bremerkamp 1914 (course of bundles in the sugar-cane); 1915 (root cortex of sugar-cane); Dastur and Saxton 1922 (ecological anatomy of *S. munja* Roxb.); Dunlop 1913 (stomata); Duval-Jouve 1870, 1875 (leaf); Flint and Moreland 1946 (development of stomata); Frohnmeyer 1914 (detailed structure of silica-bodies); Grob 1896 (leaf); Kuyper 1914 (stomata); Mameli-Calvino 1926 (detailed description of leaf); Moreland and Flint 1942 (leaf sheath of sugar-cane; development of transverse bundles); Panje 1932 (ligule and leaf); Pée-Laby 1898 (leaf); Prat 1932, 1936, 1937 (leaf); Sharman 1947 (stem apex); Van Dillewijn 1952 (morphology, anatomy, and physiology of sugar-cane); Wieler 1897 (leaf).

SACCIOLEPIS

Diagnostic Generic Characters

Short-cells, over the veins, in long rows. Silica-bodies occasionally dumb-bell shaped, but mostly nodular. Micro-hairs present; each with the distal cell generally tapering to a rounded apex, but distal cell sometimes inflated. Stomata with low dome-shaped subsidiary cells. Vascular bundles mostly angular in outline. Mesophyll variable; sometimes with large intercellular spaces between the veins. Bundle-sheaths single; often adapted to an aquatic or marshy habitat.

Species Specially Examined

***Sacciolepis africana* C. E. Hubbard & Snowden**

Leaf

Abaxial epidermis

Short-cells, over the veins, obscured by overlying papillae. **Silica-bodies** infrequent, scattered, and mostly tending to be dumb-bell shaped (Fig. Ia, 17 and 18), but rather variable in form; short rows of acutely angular silica-bodies also noted here and there (as Fig. I, 11, but rather elongated horizontally). **Macro-hairs:** none seen. **Micro-hairs** present; similar to those of *S. interrupta*. **Prickle-hairs:** none seen. **Papillae:** chains of thick-walled papillae (Fig. III, 1) overlying the veins; oblique papillae also abundant in the intercostal zones, 1 rounded or oblique papilla being present on each cell (Fig. III, 2). **Stomata** with low dome-shaped (Fig. IV, 3), or variable (Fig. IV, 5), subsidiary cells. **Long-cells** in the intercostal zones, short, or almost cubical (Fig. V, 4*a–b*, and 8), with non-sinuous walls.

T.S. lamina

Structure resembling that of *S. interrupta* in all essentials. Both surfaces ribbed, but adaxial ribs slightly taller than those of *S. interrupta*. Conical papillae v. numerous and conspicuous on both surfaces. Intercellular spaces present between the 4 or 5 veins next to and on either side of the midrib. Traces of stellate tissue visible in some of these cavities. **Mesophyll** with rather inconspicuously radiate chlorenchyma, somewhat of the *Isachne* type.

Culm (Fig. XXI, 1–2)

Culm examined 0·6 cm in diameter. The most conspicuous character is a circle of about 14 large intercellular spaces surrounding the central cavity of the culm. The peripheral part of the culm is made up of the small-celled

epidermis subtended by 2 layers of larger, thin-walled parenchymatous cells. Below this peripheral zone are the intercellular spaces, separated from one another by radiating strips of parenchyma 2–3 cells wide, and also from the wide, hollow space at the centre of the culm by a zone of parenchyma 2–3 cells wide, this zone also serving to connect the inwardly directed ends of the radiating parenchymatous strips to one another. The vb's are situated along the same radii as the strips of parenchyma that separate the intercellular spaces from one another. There are usually 3, and occasionally 4, vb's along each of these radii, the outermost vb's in each radial series being subjacent to the epidermis and the remainder in the tissue between the intercellular spaces. A single vb also occurs in the zone of parenchyma which separates the intercellular spaces from the central cavity of the culm. Traces of a tissue consisting of v. thin-walled stellate cells with long narrow arms occur in some of the intercellular spaces, these cells being so fine that they almost resemble fungal hyphae. Their structure could not be made out more closely in the available material.

MATERIAL EXAMINED: Milne-Redhead and Taylor 9211; Tanganyika, Songea district; in 0·5 m of water over laterite.

Sacciolepis chevalieri Stapf

LEAF

Abaxial epidermis

Silica-bodies present only over the veins; rather infrequent, and solitary or in interrupted rows; markedly nodular (Fig. IA, 18 (i)). **Short-cells** occasional in the intercostal zones. **Macro-hairs:** none seen. **Micro-hairs** numerous in the intercostal zones; each consisting of a v. short proximal cell and an inflated distal cell tapering towards its apex (Fig. VII, 3 and 4). **Prickle-hairs:** none seen. **Stomata** infrequent; with low dome-shaped subsidiary cells (Fig. IV, 3). **Long-cells** in the intercostal zones, with thin, slightly sinuous walls (Fig. V, 3*a–c*); not to be confused with the cubical cells lying immediately below them.

T.S. lamina

Leaf rush-like (junciform) in external appearance, and more or less elliptical in outline in T.S., but with a U-shaped adaxial groove. The most conspicuous feature of the internal structure of the leaf is the presence of 8 large air-spaces, showing a gradation in size from the largest, of which 1 occurs on either side of the median plane, to the smallest which are on either side of the adaxial groove. Traces of a tissue of stellate cells sometimes visible in the spaces. Intercellular spaces separated from one another by girder-like strips of parenchyma 1–2 cells wide, 1, or occasionally 2, markedly angular vb's being embedded in the middle of each of the girders. **Sclerenchyma** present as small abaxial strands subjacent to the abaxial epidermis, 1 strand being situated opposite each vb, the strand opposite the median vb being wider than the others. **Mesophyll:** chlorenchyma consisting of a somewhat spongy tissue of rounded cells. **Bulliform cells** present as a single wide, but somewhat fan-shaped group, at the base of the adaxial groove. **Bundle-sheaths** single; each

sheath forming part of the parenchymatous girder in which the vb it surrounds is situated.

ROOT

Root examined about 1 mm in diameter. The most notable characters visible in T.S. include some 20, radially arranged, mostly cigar-shaped, intercellular cavities in the wide cortex, the cavities being separated from one another by radiating plates of parenchymatous cells about 1–3 cells wide; a conspicuous endodermis surrounding the small central stele containing about 7 large, metaxylem vessels.

MATERIAL EXAMINED: Milne-Redhead and Taylor 9359; Tanganyika, Songea district; in 2 dm water in flooded pan on sandy ground.

Sacciolepis huillensis (Rendle) Stapf

LEAF

Abaxial epidermis

Abaxial epidermis v. similar to that of *S. chevalieri*, but costal and intercostal zones more conspicuously contrasted with one another, and stomata much more numerous. **Micro-hairs** abundant in the intercostal zones, and nodular **silica-bodies** v. frequent over the veins.

T.S. lamina

Structure of the leaf intermediate between that of *S. africana* and *S. chevalieri*, the lamina being narrow and infolded but not junciform as in the latter. **Adaxial surface** with about 12, somewhat triangular ribs separated from one another by narrow, V-shaped furrows. Abaxial surface with no more than v. slight ribs opposite the vb's. **Vascular bundles** angular in outline, and corresponding in number to the adaxial ribs. Median vb and the next 2 or 3 vb's on either side separated from one another by rather irregular intercellular cavities in the mesophyll. Short, stiff, pointed **macro-hairs** present on the adaxial ribs. **Bundle-sheaths** single, but each with a narrow, generally uniseriate, girder-like adaxial extension of colourless cells and a wider abaxial extension of similar cells, the outer ends of the extensions resting against small adaxial and abaxial strands of fibres subjacent to the epidermis.

ROOT

Root examined less than 1 mm in diameter. Structure v. similar to that of *S. chevalieri*.

MATERIAL EXAMINED: Milne-Redhead and Taylor 9911; Tanganyika, Songea district; in 7·5 cm stagnant water in pool on rock surface.

Sacciolepis interrupta (Willd.) Stapf

LEAF

Abaxial epidermis

Short-cells, over the veins, in rows of more than 5 cells; common over, but infrequent or absent between, the veins. **Silica-bodies** occasionally dumb-bell

shaped (Fig. IA, 18 (ii–v)), but mostly nodular (Fig. IA, 18 (i)). **Macro-hairs:** none seen. **Micro-hairs:** length 22–32 (mostly 26–32) μ; basal cells 7–12 μ; distal cells 15–20 μ; basal cells wider than the distal cells, which taper to pointed apices (Fig. VII, 11). **Prickle-hairs:** none seen. **Papillae:** chains of globose papillae overlying a few of the veins (Fig. III, 1); oblique papillae with thickened endings (Fig. III, 2) numerous on the intercostal long-cells, 1 papilla being present on each cell. Papillae also occurring on the adaxial surface, especially over the ribs. **Stomata** with low dome-shaped subsidiary cells (Fig. IV, 3). **Long-cells**, between the veins, relatively short with non-sinuous walls (Fig. V, 4*a–b*).

T.S. lamina

Vascular bundles: small vb's crowded, angular (Fig. VIII, 5); large vb's of basic type (Fig. VIII, 9). Adaxial surface with slight to moderate, rounded or slightly triangular ribs over all of the vb's, the ribs being separated from one another by shallower furrows (Fig. XIV, 3). Abaxial surface with ribs over the vb's, the ribs over the large vb's being slightly taller and wider than those over the small vb's. **Sclerenchyma:** occasional small vb's not accompanied by scl. (Fig. IX, 1), or with minute adaxial (Fig. IX, 2) or abaxial strands only; most vb's with minute adaxial and abaxial strands up to about 5 cells wide and 1 or 2 cells high (Fig. IX, 4), the strands being united to, and forming girders with, extensions of colourless cells from the bundle-sheaths. Median vb supported by an abaxial strand about 14 cells wide and 3 or 4 cells high in the apex of the keel, and by an adaxial strand some 6 cells wide and 2 cells high. **Keel** fairly conspicuous, narrow, rounded; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma v. distorted in the available material. **Bulliform cells** rather distorted in the available material, but apparently in somewhat fan-shaped groups at the bases of the furrows (Fig. XV, 6). **Bundle-sheaths** single; sheaths round all vb's complete (Fig. XI, 2*a–b*); those round the medium-sized and large vb's with girder-like extensions of colourless cells connecting the sheaths to the scl.

MATERIAL EXAMINED: F. Ballard 1448; Ceylon.

SPECIAL NOTES

Leaf structure panicoid but, in some spp., of an ecologically specialized type.

The 3 species *S. africana*, *S. chevalieri*, and *S. huillensis* form an interesting series showing various degrees of anatomical specialization to an aquatic habitat. The leaf structure of *S. africana* is most like that of a mesophytic grass, whereas the leaf of *S. chevalieri*, with its reduced lamina and large intercellular spaces in the mesophyll, is clearly more suited to an aquatic habitat, *S. huillensis* being intermediate between the two.

The leaf structure in some respects recalls that of *Hydrothauma* (p. 250).

LITERATURE

Jacques-Félix 1954 (taxonomic notes on *S. ciliocincta* Stapf; genus regarded as panicoid).

SCHEDONNARDUS

The few following particulars concerning *S. paniculatus* (Nutt.) Trelease have been recorded in the literature.

Holm (1901–2) notes the following points. Leaf conduplicate and with furrows on both surfaces, but abaxial furrows slight. Scl. in a large, triangular strand below the midrib, and similar strands in the leaf margins; large vb's accompanied by small abaxial strands, and by even less adaxial scl. Midrib conspicuous. Mesophyll with chlorenchyma restricted to radiately arranged cells in the ribs. Epidermis rendered scabrous by short, obtuse papillae. Stomata on both surfaces restricted to the region of the furrows, slightly projecting; surrounded by papillae. Bulliform cells small and confined to the bases of the narrow adaxial furrows; connected to the abaxial epidermis by subjacent colourless cells, except on either side of the midrib where a small strand of subepidermal scl. is present. Bundle-sheaths double.

Prat (1934) mentions the following epidermal characters. Silica-bodies, over the veins, saddle-shaped; those between the veins irregularly cross- or cudgel-shaped. Micro-hairs with rounded apices present. Papillae generally solitary and resembling those of *Chloris*. Prickles present on the adaxial surface.

SPECIAL NOTE

Prat (1934, 1936) rightly emphasizes that the leaf structure of both the epidermis and lamina resembles that of the Chlorideae.

LITERATURE

Holm 1901–2 (leaf); Grob 1896 (leaf); Prat 1934, 1936 (leaf).

SCHISMUS

The leaf structure of a few spp. has been casually noted or described, as indicated below, by the authors mentioned under each sp.

S. barbatus (Linn.) Thellung (see also below and on p. 436)

Epidermis. Short-cells, over the veins, in rows; those between the veins solitary. Silica-bodies, over the veins, figured as somewhat intermediate between saddle and dumb-bell shaped. Micro-hairs present; illustrated as having distal cells of more or less uniform diameters throughout their lengths, and rounded apices, the proximal cells of each hair being much wider. Long-cells of the intercostal zones more or less rectangular, and shown with fairly thick, sinuous, anticlinal walls. *T.S. lamina.* Adaxial surface with slight, rounded ribs over the vb's. Vb's 7 in number, only the median one exhibiting primary structure. Scl. little developed; consisting of an abaxial and an adaxial strand associated with the median vb, of strands in the leaf margins, and of abaxial strands to the larger vb's in the wings of the lamina. Mesophyll with chlorenchyma not radiate. Bundle-sheaths double. (Cacares 1956.)

S. calycinus Coss. (= *S. barbatus* (see above))

Epidermis. Adaxial surface exhibiting dumb-bell shaped silica-bodies over the veins; numerous prickles; sporadic bristle-hairs (cushion hairs); cylindrical micro-hairs; numerous stomata; long-cells with slightly sinuous anticlinal walls. Abaxial surface of the lamina similar. Abaxial surface of the leaf sheath exhibiting groups of 12–15 short, broad cells amongst the narrow long-cells over the veins. *T.S. lamina.*

Adaxial surface with pronounced, and abaxial surface with slight, ribs. Ratio of large to small vb's 1:2–3. Scl. present on the abaxial, and usually on the adaxial, side of the bundles; also in the leaf margins. Mesophyll with chlorenchyma in the form of elongated cells. Bundle-sheaths double. (Günzel 1921.)

Price (1911) describes the root-hairs of this sp. as being v. long, clothing the whole length of the roots, and as being v. mucilaginous and encased by grains of sand held together by the mucilage.

S. marginatus P. Beauv. (= *S. barbatus* (see p. 435)

Leaf with adaxial ridges and furrows; bulliform cells well developed (Pée-Laby 1898). Cushion hairs present (Grob 1896).

Special Note

Although *Schismus* is sometimes classified amongst the Aveneae, Prat (1936) considers the leaf structure to be panicoid. Cacares (1956) classifies the leaf structure as 'phragmatoid', i.e. with the structure revealed in T.S. of the lamina intermediate between panicoid and festucoid, whilst the epidermal structure is panicoid. In the opinion of the same author the affinities of the genus lie with the Danthonieae, and this view appears to be correct. This view is also supported by De Wet (1956) who has recorded the occurrence of a panicoid leaf epidermis and festucoid anatomy in 3 spp. of *Schismus* which he examined.

Literature

Cacares 1956 (leaf); De Wet 1956 (leaf); Grob 1896 (leaf); Günzel 1921 (leaf); Pée-Laby 1898 (leaf); Prat 1932, 1936 (leaf); Price 1911 (root).

SCHIZACHYRIUM

Diagnostic Generic Characters

Short-cells, over the veins, mostly in long rows but sometimes apparently solitary. Silica-bodies, over the veins, usually dumb-bell shaped or, more rarely, nodular. Micro-hairs present; some with bluntly rounded, and others with tapered, apices. Stomata sometimes having somewhat triangular, and others low dome-shaped, subsidiary cells. Vascular bundles mostly small, crowded, and angular in outline. Mesophyll with distinctly radiate chlorenchyma. Bundle-sheaths single.

Species Specially Examined

***Schizachyrium jeffreysii* (Hack.) Stapf**

Leaf

Abaxial epidermis

Short-cells, over the veins, in rows of more than 5 cells, but sometimes appearing to be solitary when the intervening cells in the same files are fairly long; abundant over, but v. infrequent or absent between, the veins. **Silica-bodies,** over the veins, mostly markedly dumb-bell shaped (Fig. IA, 18 (ii–v)), often varying in appearance with the focus (Fig. IB, 21); rarely nodular (Fig. IA, 18 (i)). **Macro-hairs:** none seen. **Micro-hairs:** length 48–60 μ; basal cells 24–30 μ; distal cells 22–30 μ; some with the distal cells tapering to acute but slightly rounded apices (Fig. VII, 5); others with the distal cells more uniform in diameter, the apices being more bluntly rounded. **Prickle-hairs:** large, angular prickles (Fig. VI, 3) numerous at the leaf margins. **Stomata** mostly with somewhat triangular (Fig. IV, 1), but others with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells,** between the veins, with thin, slightly sinuous walls (Fig. V, 3*a–c*); interstomatal cells with concave ends (Fig. V, 10–11).

T.S. lamina

Vascular bundles with the xy. and ph. not easily distinguished in the smallest vb's (Fig. VIII, 1); most vb's small and angular (Fig. VIII, 5); some medium-sized vb's less angular (Fig. VIII, 6); large vb's of basic type (Fig. VIII, 10). **Adaxial surface** practically smooth (Fig. XIV, 1), apart from a v. slight suggestion of ribs over the large vb's. Abaxial surface of the keel also slightly ribbed. **Sclerenchyma:** most vb's, especially those opposite the bulliform cells, not accompanied by scl. (Fig. IX, 1), or with minute abaxial strands only; medium-sized vb's with adaxial girders about 4–6 cells wide and 3–4 cells high, and abaxial girders mostly 2–3 cells wide and high (Fig. IX, 4); large vb's with abaxial girders 6–10 cells wide and 3 cells high, the abaxial girders being about the same width or slightly narrower. Small vb's in the keel with small abaxial strands only; median keel vb with an abaxial girder some 20 cells wide and 4 cells high, a thin hypodermal plate of scl. being present beneath the adaxial epidermis above the median vb. **Keel** fairly conspicuous; containing a large median vb accompanied on either side by 3 appreciably smaller vb's (Fig. XIII, 3). **Mesophyll:** chlorenchyma distinctly radiate. **Bulliform cells** in irregular groups (Fig. XV, 1) overlying the small vb's. Adaxial ground tissue of the keel consisting of colourless cells. **Bundle-sheaths** single; most vb's each with a complete sheath (Fig. XI, 2*a–b*), the component cells being rather unequal in size; sheaths to the large vb's with abaxial interruptions only (Fig. XI, 6).

Culm

Culm examined 2 mm in diameter; flattened on 1 side; with no cavity at the centre. Epidermis subtended by a ring of v. thick-walled fibres with narrow lumina, about 8 cells wide. Ground tissue on the inner side of the scl. ring consisting of cells with increasingly thin walls and wider diameters towards the centre of the culm. Outermost circle of vb's embedded in the scl. ring. Remaining vb's in about 3 irregular circles, the outer ones being at the inner boundary of the scl. ring and the remainder embedded in the peripheral part of the thin-walled tissue.

Material Examined: Collected by G. Jackson in Nyasaland.

Additional Information from the Literature

S. brevifolium (Sw.) Nees ex Buse

Lamina v. thin. Vascular bundles; each first-order vb separated from the next by 7–11 lesser vb's falling into 2 more or less distinct categories. Scl. present on the

adaxial and abaxial sides of most vb's, only the smallest being unaccompanied by scl. Keel conspicuous. Bulliform cells present in a single group above the median vb; some of the intercostal, adaxial epidermal cells also enlarged but without being organized into bands. Slightly elongated papillae present on both surfaces. (Prat 1937.)

S. compressum (Stapf) Stapf

Leaf structure similar to that of *S. brevifolium*, but bulliform cells more clearly defined above the smaller vb's. (Prat 1937.)

S. obliquiberbe A. Camus

Leaf fairly thin; both surfaces flat. Vascular bundles: leaf containing 7–9 first-order vb's, each separated from the next by 4–7 vb's of the third order. Scl. weakly developed, forming girders above and below, or only below, the larger vb's; other vb's accompanied by less scl. Keel conspicuous. Mesophyll with radiate chlorenchyma. Bulliform cells present as a single large group over the midrib; some of the intercostal cells of the adaxial epidermis also large, and occupying one-quarter to one-third of the thickness of the lamina. Bundle-sheaths single and circular in outline. (Vickery 1935.)

Special Note

The leaf structure is consistent with the genus being included in the Andropogoneae.

Literature

Prat 1937 (leaf); Vickery 1935 (leaf).

SCHMIDTIA

The most complete description of the leaf of a sp. of *Schmidtia* is that by Günzel (1912) which is stated to refer to *S. pappophoroides* Steud. Unfortunately this sp. is not known to occur in SW. Africa in the region from which Günzel obtained his material, and it has been suggested to the author by B. De Winter that it is most likely that the description refers to *S. bulbosa* Stapf.

Lamina. Scl. well developed in the leaf margins. Hairs numerous at the leaf margin. Prickles numerous on both surfaces. *Leaf-sheath.* Stalked glandular hairs of the type found in *Enneapogon* (Fig. IIA, 8) present. Prickles numerous. Long-cells in the intercostal zones on the abaxial surface with sinuous anticlinal walls.

Grob (1896) records that, in *S. quinqueseta* Benth., the short-cells over the veins are in rows, and that the silica-bodies in all zones are mostly dumb-bell shaped, although cross-shaped and nodular types also occur.

Special Note

The reported occurrence of glandular hairs similar to those that appear to be mainly restricted to *Enneapogon* is v. interesting and suggests that the 2 genera must be related to one another.

Literature

Grob 1896 (leaf); Günzel 1912 (leaf).

SCHOENEFELDIA

Grob (1896) records that in the leaf of *S. gracilis* Kunth the short-cells, over the veins, are in rows, and that micro-hairs are present.

Literature

Grob 1896 (leaf).

SCLEROCHLOA

The most complete description referring to *Sclerochloa* that has been found in the literature is Günzel's (1921) account of the leaf of *S. dura* (L.) Beauv.

Lamina. Both surfaces slightly ribbed. Vascular bundles: ratio of large to small vb's 1:2–5. Bulliform cells in small groups, one on either side of the midrib. Long-cells, in the intercostal zones, with straight walls. *Leaf-sheath.* Abaxial surface ribbed. Ratio of large to small vb's 1:1–2. Scl. present on the abaxial side of the vb's. Silica-bodies described as oblong. Long-cells, in the intercostal zones on both surfaces, small, mostly with straight, but some of those on the abaxial surface with sinuous, anticlinal walls. Small air-canals present. Bundle-sheaths double.

Special Note

The above information is insufficient to form an opinion concerning the affinities of the genus.

Literature

Grob 1896 (leaf); Günzel 1921 (leaf).

SCLEROPOA

The spp. described in the literature under *Scleropoa* are now generally included in *Catapodium*, and have been dealt with under that genus in this book (see p. 88).

SCLEROPOGON

An account of the leaf structure of *S. brevifolius* Philippi has been published by Cacares (1951), from whose description the following particulars have mostly been taken.

Epidermis. Short-cells stated to be mostly solitary and sometimes in pairs, but illustrations show the short-cells over the veins mostly in rows.[1] Silica-bodies, especially those over the veins, shortly dumb-bell shaped, but with the middle portion of each body rather thick; silica-bodies in paired short-cells often rounded or elliptical and fitting into concavities in the adjacent cork-cells. Micro-hairs present;

[1] Whether the short-cells are to be interpreted as solitary or in rows depends on the sizes of the cells in the same files as, but lying between, the silica-cells. When the intervening cells are sufficiently small the short-cells can be regarded as being in rows.

each with a hemispherical distal cell and a longer basal cell tapering towards the proximal end. Prickles occurring on the abaxial surface. Solitary papillae present on certain of the long-cells on both surfaces, but more numerous on the abaxial than on the adaxial surface. Long-cells, between the veins on both surfaces, with sinuous anticlinal walls. *T.S. lamina.* Adaxial and abaxial surfaces both with slight ribs, the vb's being situated opposite the ribs. Scl. as small adaxial, and rather larger abaxial, girders to most of the vb's. Vascular bundles: 14–15 vb's present in a T.S. of the lamina, 2 primary bundles being present in the portions of the lamina on either side of the midrib. Mesophyll with radiate chlorenchyma. Bulliform cells in somewhat fan-shaped groups at the bases of the shallow, adaxial furrows, each group extending rather deeply into the mesophyll; outer walls of the bulliform cells sometimes cutinized. Bundle-sheaths double and single; O.S. frequently interrupted abaxially by scl., and always consisting of isodiametric cells with fairly thick walls and containing chloroplasts; I.S. present around and completely encircling each large vb, not apparent around the small vb's. Transverse veins present.

Holm's (1901–2) account of the leaf structure agrees substantially with, but is more complete than, that of Cacares. The culm is stated by Canfield (1934) to be solid.

Special Notes

Cacares (1951) points out that the appearance of the leaf in T.S. resembles that of *Blepharidachne benthamiana* (see p. 56). He also indicates that the structure resembles that of the Chlorideae except that the silica-bodies are dumb-bell shaped rather than saddle-shaped. Prat (1936), however, claims that the silica-bodies are saddle-shaped.

Literature

Cacares 1951 (leaf); Canfield 1934 (brief notes on culm structure); Holm 1901–2 (leaf); Prat 1936 (leaf).

SCOLOCHLOA

The most complete description of the leaf anatomy that has been traced is that given by Lohauss (1905) with reference to *S. festucacea* (Willd.) Link.

Leaf long and broad. *Epidermis.* Silica-bodies, over the veins, more or less rectangular with marked sinuations on their long sides. Cork-cells, over the veins, also rectangular. Short-cells, between the veins, quadratic or rectangular. Prickles occasional over the veins. Long-cells, over the veins, rectangular, with nodular thickenings to the walls; long-cells, in files adjacent to the veins, with sinuous walls; long-cells in files from the middle of the intercostal zones accompanied by quadratic or rectangular short-cells. Abaxial epidermis similar, but prickles more numerous. *T.S. lamina.* Adaxial surface furrowed. Vascular bundles: ratio of large to small vb's 2:1. Scl. fairly well developed, united to the vb's to form I-girders. Midrib projecting slightly, but not v. prominent. Mesophyll with chlorenchyma differentiated into palisade and spongy portions; assimilatory cells stated to have inwardly projecting folds from the cell walls (arm-cells). Bulliform cells in groups at the bases of the adaxial furrows. Bundle-sheaths double; I.S. with inner more strongly thickened than the outer walls; O.S. interrupted adaxially and abaxially by thick-walled cells, but otherwise consisting of colourless cells.

Special Note

The recorded occurrence of arm-cells in the mesophyll is surprising and needs confirmation. Although imperfectly known, the structure appears to be festucoid.

Literature

Lohauss 1905 (leaf).

SCRIBNERIA

Hansen and Potztal (1954), in describing the leaf of *S. bolanderi* (Thurb.) Hack., note the following characters.

Prickles restricted to the leaf margins. Silica-bodies oblong, rounded. Scl. scanty; where present consisting of strands only a few cells wide. Mesophyll with chlorenchyma not radiate. Bundle-sheaths double. Starch grains compound.

Special Note

Hansen and Potztal treat the genus as a member of the Leptureae.

Literature

Hansen and Potztal 1954.

SECALE

Diagnostic Generic Characters

Short-cells, over and between the veins, paired. Silica-bodies rounded, elliptical, or slightly crescent-shaped and fitting into concavities in adjacent cork-cells. Micro-hairs absent. Stomata with low dome-shaped or parallel-sided subsidiary cells. Vascular bundles rather widely spaced and none conspicuously angular in outline. Mesophyll with chlorenchyma not radiate. Bundle-sheaths double.

Species Specially Examined

***Secale cereale* L.**

Leaf

Abaxial epidermis

Short-cells, both over and between the veins, paired; abundant. **Silica-bodies** fitting into concavities in adjacent cork-cells (Fig. I, 6–7), and rounded, elliptical, or slightly crescent-shaped in outline. **Macro-hairs** and **micro-hairs:** none seen. **Prickle-hairs:** none seen in the material examined, but prickles said by Prat (1932) to be well developed on the glumes and pales. **Stomata** mostly with low dome-shaped (Fig. IV, 3), but sometimes with parallel-sided (Fig. IV, 2), subsidiary cells. **Long-cells,** between the veins, with moderately thin, slightly sinuous walls (Fig. V, 3*a–c*).

T.S. lamina

Vascular bundles: small vb's rather widely spaced and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with slight, rather wide, rounded ribs, the ribs being separated from one another by narrow, shallow furrows (Fig. XIV, 2). Abaxial surface also with slight ribs over the large vb's. **Sclerenchyma:** a few of the small vb's not accompanied by scl. (Fig. IX, 1); others with small adaxial strands only (Fig. IX, 2); medium-sized vb's with tall, narrow adaxial and abaxial girders (Fig. IX, 7), the adaxial girders being similar but generally slightly shorter; large vb's with rather wider adaxial and abaxial girders. **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** in well-defined groups as in Fig. XV, 2. **Bundle-sheaths** double; a few vb's with 2 complete sheaths (Fig. XII, 1); mostly with I.S. complete, but O.S. not quite complete, or inconspicuous, abaxially (Fig. XII, 2).

Culm

Culm examined 0·5 cm in diameter, with a v. large central cavity. Epidermis subtended by a ring of scl. 6–8 cells wide with large, flattened columns of assimilatory tissue embedded in it. Ground tissue between the scl. ring and the hollow centre of the culm consisting of about 12 layers of cells, the cells nearest the centre being somewhat larger in diameter than those next to the scl. ring. Vb's of the outermost circle situated at the inner boundary of the scl. ring. Remaining vb's in 1–2 irregular circles embedded in the inner ground tissue.

Material Examined: Cultivated at Kew.

Additional Information from the Literature

Berthold (1883) has recorded that the morphology of the starch grains does not provide characters that are reliable for the detection of wheat-flour as an admixture in rye flour. The 2 ingredients can, however, be distinguished by small differences in the structure of the testa. Roelants (1921) gives brief notes on culm structure.

Blaringhem (1921) states that *Secale* can be distinguished from allied genera such as *Agropyron*, *Aegilops*, and *Triticum* by differences visible in T.S. of the culm taken just below the inflorescence. The relatively thick culms of rye bend easily under the fingers, whereas those of *Haynaldia* and *Triticum monococcum* are more resistant, and recover quickly or fracture if the pressure is too hard. This difference is correlated with the larger size of the central lacuna in rye. Epidermal cells overlying the chlorenchyma bear fairly numerous filiform hairs in rye.

Special Note

Prat (1936) rightly points out that the leaf characters are festucoid.

Literature

Berthold 1883 (flour); Blaringham 1921 (culm); Bromer-Reinders 1959 (spike); Frohnmeyer 1914) silica); Grob 1896 (leaf); Meyer 1925 (vb's in roots); Pée-Laby 1898 (leaf); Prat 1932, 1936 (leaf); Roelants 1921 (culm); Sharman 1947 (stem apex).

SESLERIA

Sesleria is fully described by Lohauss (1905) who notes the following leaf characters for the genus (see also M. Deyl (1946) in *Opera Bot. Cechica*, **3**. 11 et seq.).

Scl. well developed. Macro-hairs infrequent. Mesophyll mostly composed of non-radiate chlorenchyma. Bundle-sheaths double; O.S. not v. conspicuous, and composed of cells containing chlorophyll. The following spp., varieties, and forms are described.

S. caerulea (L.) Ard.

Epidermis. Abaxial surface. Short-cells, over the veins, consisting of elliptical to saddle-shaped cork- and silica-cells. Saddle-shaped cork-cells also present between the veins. Long-cells, both over and between the veins, rectangular. Prickles present over the veins. Adaxial surface. Strips over the veins v. narrow; consisting of elliptical short-cells and rectangular long-cells. Long-cells, between the veins, v. narrow, approximately rectangular, with sinuous walls. *T.S. lamina.* Vascular bundles: ratio of large to small vb's 1:1–2. Scl. forming I-girders with the large vb's; less well developed in association with the small vb's; present as strong marginal strands. (The amount of scl. varies with the habitat, but the pattern of its distribution is a reliable taxonomic character.) Midrib well developed. Mesophyll consisting of a single adaxial layer of palisade cells, the remainder being more lacunar and composed of isodiametric cells containing less chlorophyll. Bulliform cells as a single group of about 8 cells on either side of the midrib. Bundle-sheaths double; O.S. not well developed, chlorenchymatous, the cells being slightly smaller than those of the adjacent mesophyll; O.S.s to small vb's closed; those to large vb's interrupted adaxially and abaxially. I.S. complete round each vb; inner more strongly thickened than the outer walls.

S. caerulea subsp. *calcarea* Hegi. (as *S. caerulea* Ard. forma *calcarea* Opiz.)

As the last sp., but scl. I-girders more developed and vb's larger. Ratio of large to small vb's 1:5. Mesophyll more clearly differentiated into colourless and chlorenchymatous cells.

S. sadleriana Janka (as *S. budensis* Asch. & Grab.)

Epidermis with rounded to saddle-shaped short-cells. Vascular bundles: ratio of large to small vb's 1:2–3. Sclerenchyma: I-girders to vb's consisting of thick-walled parenchyma rather than of typical scl. except near the epidermis. Bundle-sheaths with O.S. well marked and containing chlorophyll.

A few notes also given on *S. heufleuriana* Schur., *S. filifolia* Hoppe and *S. ovata* (Hoppe) Kern. In *S. filifolia*, with a long, thread-like leaf, the ratio of large to small vb's is 1:1; the O.S. is always closed and consists of small cells containing chlorophyll, the I.S. being composed of v. thick-walled cells. *S. ovata* has a small leaf that soon decays, the adaxial surface having well developed ribs and furrows, bulliform cells being present at the bases of the furrows.

Special Note

Prat (1936) rightly indicates that *Sesleria* is a genus with well-defined festucoid characters.

Literature

Duval-Jouve 1875 (leaf); Grob 1896 (leaf); Lohauss 1905 (leaf); Pée-Laby 1898 (leaf); Prat 1936 (leaf); Wille 1916.

SETARIA

Diagnostic Generic Characters

Short-cells, over the veins, mostly in long rows, but some solitary, paired, and in short-rows. Silica-bodies, over the veins, cross to dumb-bell shaped or nodular, the proportion of each type varying with the sp. Micro-hairs present; distal cells with apices rounded or tapered to points. Stomata tending to have triangular, but others with tall or low dome-shaped, subsidiary cells. Vascular bundles mostly small, crowded, and angular. Mesophyll with chlorenchyma slightly or distinctly radiate. Bundle-sheaths single.

Species Specially Examined

Setaria barbata (Lam.) Kunth

Leaf

Abaxial epidermis

Short-cells, over the veins, in rows of more than 5 cells; abundant over, but infrequent or absent between, the veins. **Silica-bodies** dumb-bell shaped, but varying in appearance with the focus (Fig. Ib, 21), often with the middle portion not much thinner than the 2 ends of each body; other bodies nodular (Fig. Ia, 18 (i)). **Macro-hairs:** a few, with sunken bases, noted in T.S. **Micro-hairs:** length 48–87 (mostly 48–67) μ; basal cells 18–29 (mostly 18–24) μ; distal cells 28–52 (mostly 28–40) μ; distal cells sometimes tapering to pointed apices, or more uniform in diameter and with rounded apices (Fig. VII, 5 and 7). **Prickle-hairs:** prickles (Fig. VI, 1–2), with elongated bases, and unpointed prickles (Fig. VI, 6), common over the veins; hooks (Fig. VI, 5) often no more than inconspicuously pointed, or unpointed, frequent in the intercostal zones. **Stomata:** some tending to be with triangular (Fig. IV, 1), but others with more nearly tall dome-shaped (Fig. IV, 4), subsidiary cells. **Long-cells,** between the veins, with thin, slightly sinuous walls (Fig. V, 3*a–c*).

T.S. lamina

Vascular bundles: most vb's small, crowded, and angular (Fig. VIII, 5); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** practically smooth (Fig. XIV, 1) apart from slight ribs over the midrib and some of the large veins in the lamina. Similarly distributed, small ribs also present on the abaxial surface. **Sclerenchyma:** many small vb's not accompanied by scl. (Fig. IX, 1); others with minute abaxial strands only; a few medium-sized vb's with adaxial and abaxial strands or girders about 4 cells wide and 2 cells high (Fig. IX, 4); large vb's accompanied by more massive strands or girders (Fig. IX, 5) occupying the slight ribs opposite the vb's. Large keel vb's with well-developed abaxial girders only (Fig. IX, 3). **Keel** v. conspicuous, somewhat triangular; containing 1 large median vb accompanied on either side by 3 laterals of about the same size and by 5 other, appreciably smaller, laterals (Fig. XIV, 4). **Mesophyll:** chlorenchyma probably slightly radiate, but not v. conspicuously so in the material examined. **Bulliform cells:** some infrequent long groups as in Fig. XV, 2 on the adaxial surface, and occasional groups of the same type on the abaxial surface; some groups of specially large, cushion-like cells of the *Zea* type (Fig. XV, 3) also occurring on both surfaces, often with the sunken bases of macro-hairs embedded in them, a specially large group of this type being present on either side of the midrib on the adaxial surface. Ground tissue of the keel consisting chiefly of thin-walled, colourless cells. **Bundle-sheaths** single; each vb surrounded by a complete sheath (Fig. XI, 2*a–b*).

Material Examined: Specially collected by R. E. Vaughan in Mauritius.

Setaria glauca (L.) Beauv.

Leaf

Abaxial epidermis

Short-cells, over the veins, mostly in rows of more than 5 cells, but sometimes appearing to be solitary or paired when the intervening cells in the same files are fairly long; abundant over, but v. infrequent or absent between, the veins. **Silica-bodies** mostly intermediate between cross and dumb-bell shaped (Fig. Ia, 17) or dumb-bell shaped (Fig. Ia, 18 (ii–v)); sometimes cross-shaped (Fig. Ia, 16), and a few cross-shaped bodies with distorted outlines noted. **Macro-hairs:** none seen. **Micro-hairs:** length 50–70 (mostly 56–66) μ; basal cells 20–29 (mostly 20–26) μ; distal cells 35–40 μ; distal cells tapering to pointed apices (Fig. VII, 5). **Prickle-hairs:** hooks (Fig. VI, 5) occasional between the veins. **Stomata** often tending to be with triangular (Fig. IV, 1), but others with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells:** many of the cells between the veins inflated (Fig. V, 5) (bulliform cells), with non-sinuous walls; long-cells immediately beside the veins with thin, sinuous walls (Fig. V, 3*a–c*); other intercostal cells with thin, non-sinuous walls (Fig. V, 4*a–b*); interstomatal cells with concave ends (Fig. V, 10–11).

T.S. lamina

Vascular bundles: most vb's small, crowded, the xy. and ph. not easily distinguished in the smallest (Fig. VIII, 1); other small vb's conspicuously angular (Fig. VIII, 5); large vb's of basic type (Fig. VIII, 10). **Adaxial surface** practically smooth (Fig. XIV, 1) apart from v. slight, widely spaced ribs over the large vb's. **Sclerenchyma:** most small vb's not accompanied by scl. (Fig. IX, 1); large vb's with minute adaxial and abaxial girders (Fig. IX, 4). **Keel** moderately conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma distinctly radiate round all vb's. **Bulliform cells:** epidermis on both surfaces consisting of somewhat bulliform cells. **Bundle-sheaths:** all vb's with single complete sheaths (Fig. XI, 2*a–b*), the component cells being rather unequal in size.

Culm

Culm examined about 3 mm in diameter; centre occupied by spongy tissue. Epidermis subtended by a ring of scl. about 5 cells wide, with some flattened columns of assimilatory tissue embedded in it. Vb's of the outermost circle embedded in the scl. ring. Remaining vb's scattered throughout the thin-walled ground tissue extending from the scl. ring to the centre of the culm.

Material Examined: Cultivated at Kew.

***Setaria italica* (L.) Beauv.**

LEAF

Abaxial epidermis

Short-cells, over the veins, mostly in rows of more than 5 cells, but sometimes appearing to be solitary or paired where the intervening cells in the same files are fairly long; abundant over, but infrequent or absent between, the veins. **Silica-bodies** cross-shaped (Fig. IA, 16), or intermediate between cross and dumb-bell shaped (Fig. IA, 17); a few dumb-bell shaped (Fig. IA, 18 (ii–v)), or nodular (Fig. IA, 18 (i)). **Macro-hairs:** none seen. **Micro-hairs:** length 34–54 (mostly 38–54) μ; basal cells 16–22 μ; distal cells 16–32 (mostly 18–30) μ; distal cells tapering to pointed apices (Fig. VII, 5). **Prickle-hairs:** shortly pointed prickles (Fig. VI, 1–2) numerous over the veins; hooks (Fig. VI, 5) locally abundant between the veins. **Stomata** mostly with triangular (Fig. IV, 1) subsidiary cells. **Long-cells,** between the veins, with moderately thin, slightly sinuous walls (Fig. V, 3*a–c*); interstomatal cells rather long, with concave ends (Fig. V, 10–11).

T.S. lamina

Vascular bundles: most vb's small, crowded, angular (Fig. VIII, 5); large vb's of basic type (Fig. VIII, 9). **Adaxial surface** practically smooth (Fig. XIV, 1) apart from slight ribs over the medium-sized and large vb's. Similar slight ribs also present on the abaxial surface. **Sclerenchyma:** some small vb's not accompanied by scl. (Fig. IX, 1); others accompanied by minute adaxial and abaxial strands or girders; large vb's with adaxial girders some 10 cells wide and 2 cells high and abaxial girders slightly taller but about the same width (Fig. IX, 4 and 5). Median vb with a well-marked abaxial girder, a thin plate of scl. about 7 cells wide and 2 cells high also being present below the adaxial epidermis above the keel. **Keel** moderately conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma distinctly radiate. **Bulliform cells:** some in irregular groups (Fig. XV, 1), but others in groups more nearly like those in Fig. XV, 2. A large group of colourless cells present between the median vb and adaxial scl. above it. **Bundle-sheaths** single; a complete sheath surrounding each vb (Fig. XI, 2*a–b*), the sheaths round the small vb's consisting of cells of v. unequal sizes.

CULM

Culm examined about 4 mm in diameter; with a moderately large cavity at the centre. Epidermis subtended by a ring of scl., about 10 cells wide, with some flattened strands of assimilatory tissue embedded in it. Inner ground tissue consisting of conspicuously rounded cells with minute, triangular intercellular spaces between them. Vb's of the outermost circle embedded in the scl. ring; remaining vb's scattered in the inner ground tissue.

MATERIAL EXAMINED: Cultivated at Kew.

***Setaria plicata* (Lam.) T. Cooke**

LEAF

Abaxial epidermis

Short-cells, over the veins, mostly in rows of 3–5 cells, but appearing to be solitary or paired where the intervening cells in the same files are moderately long; those between the veins mostly in pairs; abundant over, but infrequent between, the veins. **Silica-bodies,** over the veins, shortly dumb-bell shaped (Fig. IB, 20), the middle portion of each body being v. narrow compared with the ends; many other bodies nodular (Fig. IA, 18 (i)). Infrequent silica-bodies between the veins cross-shaped (Fig. IA, 16), but with distorted outlines, or even tending to be tall, narrow, and crenate (Fig. IB, 24). (Frohnmeyer (1914) states that the silica-cells at first contain a dark siliceous mass which is sandy, porous, or coarse-grained in appearance.) **Macro-hairs:** none seen. **Micro-hairs:** length 60–68 μ; basal cells 20–22 μ; distal cells 38–50 μ; distal cells tapering to pointed apices (Fig. VII, 5). **Prickle-hairs:** prickles (Fig. VI, 1–2) abundant over, and hooks (Fig. VI, 5) between, the veins. **Stomata** mostly with triangular (Fig. IV, 1) subsidiary cells. **Long-cells,** between the veins, with thin, coarsely sinuous walls (Fig. V, 3*a–c*); interstomatal cells rather long, with concave ends (Fig. V, 10–11).

T.S. lamina

Vascular bundles: most vb's small, crowded, the xy. and ph. not easily distinguished in the smallest (Fig. VIII, 1); mostly conspicuously angular in outline (Fig. VIII, 5); large vb's of basic type (Fig. VIII, 10). **Adaxial surface** practically smooth (Fig. XIV, 1) apart from a few conspicuous, rounded ribs over and on either side of the midrib. Slight ribs, supported by scl., also present on the abaxial surface opposite the groups of bulliform cells and the large vb's respectively. **Sclerenchyma:** numerous small vb's not accompanied by scl. (Fig. IX, 1); others with small adaxial (Fig. IX, 2) and abaxial strands or girders; medium-sized vb's accompanied by adaxial and abaxial girders up to about 5 cells wide but seldom more than 2 cells high (Fig. IX, 4); large vb's with dome-shaped abaxial girders, in the ribs, about 10 cells wide at the ends nearest the vb's, and about 7 cells high, the corresponding adaxial girders being about the same width but only 2–3 cells high. Keel bundles with well-marked abaxial girders (Fig. IX, 3), the apices of the adaxial ribs over the midrib also being occupied by scl. **Keel** v. conspicuous, rounded; containing 1 large median vb accompanied on either side by 2 laterals of about the same size, and by about 6 or 8 much smaller laterals (Fig. XIII, 3). **Mesophyll:** chlorenchyma slightly radiate, but not v. conspicuously so in the material examined. **Bulliform cells** mostly in rather large groups resembling those in Fig. XV, 2, alternate groups being on the adaxial and abaxial surfaces respectively. Ground tissue of the keel consisting of colourless cells. **Bundle-sheaths:** nearly all vb's each with a single complete sheath (Fig. XI, 2*a–b*), the sheaths consisting of cells of unequal sizes; sheaths round a few of the large vb's, especially in the midrib, with abaxial interruptions only (Fig. XI, 6).

MATERIAL EXAMINED: Cultivated at Kew.

***Setaria viridis* (L.) Beauv.**

LEAF

Abaxial epidermis

Short-cells, over the veins, in rows of more than 5 cells, but sometimes appearing to be solitary or paired where the intervening cells in the same files are rather long; abundant over, but infrequent or absent between, the veins. **Silica-bodies** mostly cross-shaped (Fig. IA, 16), or intermediate between cross and dumb-bell shaped (Fig. IA, 17). Grob (1896) refers to occasional nodular bodies. **Macro-hairs:** none seen, but Grob (1896) refers to cushion hairs amongst the bulliform cells. **Micro-hairs:** length 45–56 (mostly 48–54) μ; basal cells 18–22 μ; distal cells 21–36 (mostly 28–36) μ; distal cells tapering to pointed apices (Fig. VII, 5). **Prickle-hairs:** prickles (Fig. VI, 1–2) abundant over, and hooks (Fig. VI, 5) between, the veins; large, angular prickles (Fig. VI, 3) abundant at the leaf margins. **Stomata** often tending to be with triangular (Fig. IV, 1), but sometimes with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells,** between the veins, with thin, sinuous walls (Fig. V, 3*a–c*), the sinuations being more marked in some zones than in others.

T.S. lamina

Vascular bundles: most vb's small, crowded, angular (Fig. VIII, 5); large vb's of basic type (Fig. VIII, 10). **Adaxial surface** with slight, rounded ribs over most of the vb's, separated from one another by shallow furrows (Fig. XIV, 2). Similar ribs and furrows also present on the abaxial surface, the ribs over the large vb's being especially well developed. Ribs and furrows on the 2 surfaces opposite one another. **Sclerenchyma:** many small vb's not accompanied by scl. (Fig. IX, 1); other small, and also the large, vb's accompanied by abaxial and adaxial strands in the ribs. Median keel vb with a well-marked abaxial girder only (Fig. IX, 3). Adaxial surface of the midrib supported by a thin plate of scl. **Midrib** conspicuous, owing to a rounded abaxial projection, and a low rounded adaxial rib; containing 1 large median vb accompanied on either side by 2–3 appreciably smaller laterals (Fig. XIII, 3). **Mesophyll:** chlorenchyma distinctly radiate. **Bulliform cells:** epidermis between the ribs consisting of groups of somewhat inflated cells, but rather distorted in the available material. Ground tissue of the midrib between the median vb and the adaxial scl. consisting of large, thin-walled colourless cells. **Bundle-sheaths:** all vb's with single, complete sheaths (Fig. XI, 2*a–b*), the component cells being rather unequal in size.

CULM

Culm examined about 3 mm in diameter; slightly flattened on 1 side and with a large, hollow cavity at the centre. Epidermis subtended by about 3 layers of assimilatory tissue except opposite the vb's of the outermost ring, which are buttressed to the epidermis by scl. Assimilatory tissue bounded on the inner side by a ring of scl. about 3–5 cells wide. Ground tissue between the scl. ring and the hollow centre of the culm consisting of about 12 layers of rounded cells with minute, triangular, intercellular spaces between them. Vb's

of the outermost circle embedded in the scl. ring. Remaining vb's scattered in the inner ground tissue.

MATERIAL EXAMINED: Cultivated at Kew.

ADDITIONAL INFORMATION FROM THE LITERATURE

1. LEAF

Günzel (1912) has described the leaf structure of the 2 following spp. of *Setaria.*

S. sphacelata (Schum.) Stapf & C. E. Hubbard (under *S. aurea* Hochst. ex A. Braun)

Epidermis. Similar on both surfaces. Dumb-bell shaped silica-bodies and cork-cells, together with cylindrical micro-hairs and prickles, present over the scl., the prickles being more numerous on the adaxial than on the abaxial surface. *T.S. lamina.* Epidermis of large cells. Midrib enlarged; the ground tissue consisting of colourless cells with small strands of scl. below the adaxial epidermis. Large median vb of the midrib separated from the abaxial scl. by colourless cells, a point of difference from *S. verticillata.* Bulliform cells not recognizable on either side of the midrib. Bundle-sheaths single. *Leaf-sheath.* Distal part resembling the lamina. Air-canals present.

S. verticillata (L.) P. Beauv.

Epidermis. Dumb-bell shaped silica-bodies and cork-cells, together with prickles and cylindrical micro-hairs, present over the scl. Micro-hairs also present between the veins, and here accompanied by cushion hairs. *T.S. lamina.* Epidermis, on both surfaces, consisting of v. enlarged cells. Adaxial surface not ribbed. Scl. mainly associated with the large vb's, and also present in the leaf margins. Midrib prominent; ground tissue consisting of colourless cells. Mesophyll with radiate chlorenchyma. Bulliform cells present only as a single group on either side of the midrib.

Amidei (1932) notes for *S. palmifolia* (Koen.) Stapf (under *Panicum palmifolium*) that the leaf has a broad, plicate blade, a short petiole and sheath, the leaf being folded conduplicately in the bud.

2. CULM

Hermann (1910) made a detailed study of the distribution of scl. in the culm and leaf of *Setaria* spp., and noted particularly the variable extent to which mechanical tissue is developed in the culm. Falkenburg (1876) has published brief notes on the course of the vb's in the culm of *S. plicata* (Lam.) T. Cooke (under *Panicum plicatum*).

SPECIAL NOTE

Prat (1936) rightly points out that the leaf structure is panicoid.

LITERATURE

Amidei 1932 (leaf); Duval-Jouve 1870, 1875 (leaf); Frohnmeyer 1914 (silica deposition); Goossens 1935 (root); Grob 1896 (leaf); Günzel 1912 (leaf); Hermann 1910 (mechanical tissue of leaf and culm); Holm 1908 (leaf, under *Panicum*); Krishnaswami and Rangaswami 1942 (leaf); Lewton-Brain 1904 (leaf); Nishimura 1922 (developmental anatomy); Pée-Laby 1898 (leaf); Prat 1932, 1936 (leaf); Roelants 1921 (notes on culm).

SIEGLINGIA

Diagnostic Generic Characters

Short-cells, over the veins, mostly in long rows, but rarely solitary or paired. Silica-bodies, over the veins, shortly dumb-bell shaped to almost cross-shaped. Micro-hairs abundant in the intercostal zones, each with the distal cell tapering towards the rounded apex. Stomata mostly with triangular subsidiary cells. Vascular bundles not markedly angular in outline. Mesophyll with chlorenchyma not radiate. Bundle-sheaths double.

Species Specially Examined

***Sieglingia decumbens* (L.) Bernh.**

Leaf

Abaxial epidermis

Short-cells, over the veins, in long rows, v. rarely paired or solitary owing to interruptions of the files of long-cells; those between the veins solitary or paired. **Silica-bodies,** over the veins, shortly dumb-bell shaped to almost cross-shaped; those between the veins confined to the more distal member of each pair, none being present in the solitary cells. Intercostal silica-bodies v. variable in shape, mostly taller than wide, with the long axis vertical, but some more nearly equal in length and breadth and tending to be cubical; narrower silica-bodies occasionally elliptical, but more often crescent-shaped, or with a concavity in both of the long (vertical) surfaces; rarely tending to be cross-shaped. Intercostal silica-bodies mostly overlapping or fitting into concavities in the contiguous cork-cells. **Macro-hairs:** long hairs with constricted, sunken bases (Figs. II, 3 and IIA, 5), frequent in the intercostal zones. **Micro-hairs** abundant in the intercostal zones; the distal cell of each hair either slightly longer than, or about the same length as, the proximal cell, and tapering to a rounded apex (Fig. VII, 5 and 6). **Prickle-hairs:** none seen, but large prickles recorded at the leaf margins. **Stomata** mostly with triangular (Fig. IV, 1) subsidiary cells. **Long-cells,** between the veins, with moderately thick, markedly sinuous or pitted walls (Fig. V, 1*a–b*); in some specimens with thinner, sinuous walls (Fig. V, 3*a–c*).

T.S. lamina

Blade not infolded. **Vascular bundles** not markedly angular in outline; small vb's with xy. and ph. not easily distinguished (Fig. VIII, 1). **Adaxial surface** with about 12, v. low ribs over the vb's, each of the ribs next to and on either side of the midrib being slightly taller than the remainder; furrows narrower and shallow. Abaxial surface v. slightly ribbed over the large vb's. **Sclerenchyma** present as abaxial and adaxial girders to all large vb's, those that are abaxial being about 20 cells wide and 3 or 4 cells high, the adaxial girders being slightly narrower and about the same height. Some small vb's with v. similar but narrower adaxial and abaxial girders, but other small vb's with adaxial girders only; marginal vb's not accompanied by scl. **Keel** conspicuous, rounded; containing a single vb. **Mesophyll** with chlorenchyma not radiate. **Bulliform cells** present as somewhat fan-shaped groups between the vb's, the sizes of the groups decreasing from the keel outwards, and absent between some of the veins towards the leaf margins. **Bundle-sheaths** double; O.S. to the large vb's interrupted adaxially and abaxially by scl. Cells of the I.S. with the inner tangential and radial walls strongly thickened.

Material Examined: (i) J. K. O'Byrne 10; Berkshire. (ii) Collected by H. G. Schweickerdt in Richmond Park, Surrey, in June 1936. (iii) H. K. Airy-Shaw 4778; from east Gloucestershire.

Additional Information from the Literature

Information in the literature referring to *S. decumbens*, often given under *Triodia decumbens* (L.) P. Beauv., in the main confirms the description given above, apart from slight differences of interpretation.

Special Notes

S. decumbens is a grass with panicoid leaf epidermis, but the structure of the lamina in T.S. is festucoid. This has previously been noted by Prat (1936) and De Wet (1956). It is becoming usual to regard *Sieglingia* as closely related to *Danthonia*. This view was expressed, for example, by Hubbard (1954) and more recently by De Wet (1956). The leaf anatomy fully supports this suggested affinity so far as certain spp. of *Danthonia* are concerned, but it must be remembered that the spp. of *Danthonia* fall into 2 or more distinct groups on the basis of their leaf structure, so it is doubtful whether the affinity of *Sieglingia* to *Danthonia* applies to the whole of this last genus as at present understood.

Although *S. decumbens* was at one time known as *Triodia decumbens*, Burbidge (1946) rightly points out that its leaf structure is quite unlike that of Australian spp. of *Triodia* (see under *Triodia* on pp. 506–7).

Literature

Beddows 1931 (floral); Burbidge 1946 (leaf); Burr and Turner 1933 (leaf); Hubbard 1954 (taxonomy); Lewton-Brain 1904 (leaf); Lohauss 1905 (leaf); Pée-Laby 1898 (leaf; under *Danthonia*); Prat 1934, 1936 (leaf); De Wet 1956 (leaf and taxonomy).

SNOWDENIA

Diagnostic Generic Characters

Short-cells, over the veins, mostly in short rows but occasionally solitary. Silica-bodies, over the veins, infrequent, nodular. Micro-hairs present, each with the distal cell tapering to a pointed apex. Stomata with subsidiary cells mostly triangular, but others tall dome-shaped. Vascular bundles mostly small, crowded, and angular in outline. Mesophyll with distinctly radiate chlorenchyma. Bundle-sheaths single.

Species Specially Examined

***Snowdenia polystachya* (Fresen.) Pilger**

Leaf

Abaxial epidermis

Short-cells, over the veins, mostly in rows of 3–5 cells, but occasionally solitary; infrequent over and between the veins. **Silica-bodies** infrequent, nodular (Fig. Ia, 18 (i)). **Macro-hairs:** none seen. **Micro-hairs:** length 28–45 μ; basal cells 12–18 μ; distal cells 16–27 (mostly 16–24) μ; distal cells tapering to pointed apices (Fig. VII, 5). **Prickle-hairs:** small prickles (Fig. VI, 1) and hooks (Fig. VI, 5) occasional between the veins. **Papillae:** chains of globose papillae (Fig. III, 1) overlying the veins. **Stomata:** subsidiary cells mostly tending to be triangular (Fig. IV, 1), but others tall dome-shaped (Fig. IV, 4). **Long-cells:** those between the veins with thin, sinuous walls (Fig. V, 3*a–c*); interstomatal cells with concave ends (Fig. V, 10–11).

T.S. lamina

Vascular bundles: most vb's small, crowded, the xy. and ph. not easily distinguished in the smallest (Fig. VIII, 1), mostly conspicuously angular in outline (Fig. VIII, 5); a few large vb's of basic type (Fig. VIII, 15). **Adaxial surface** practically smooth (Fig. XIV, 1), apart from low ribs over the large vb's (Fig. XIV, 2). Similar ribs also present on the abaxial surface of the midrib. **Sclerenchyma:** numerous small vb's not accompanied by scl. (Fig. IX, 1); a few other small vb's with minute abaxial strands only, but more commonly with minute adaxial and abaxial strands about 2–4 cells wide and 1–2 cells high; large vb's with adaxial and abaxial girders up to about 7 cells wide and 4 cells high (Fig. IX, 4). Keel vb's with abaxial strands, about 5 small strands of scl. also being present beneath the adaxial epidermis. **Keel** conspicuous, somewhat triangular; containing 1 large median vb accompanied on either side by 4 much smaller laterals (Fig. XIII, 4). **Mesophyll:** chlorenchyma distinctly radiate round all vb's. **Bulliform cells:** epidermis partly differentiated as irregular groups of bulliform cells (Fig. XV, 1). Adaxial ground tissue of the keel composed of a wide, V-shaped mass of colourless cells. **Bundle-sheaths:** each vb with a single complete sheath (Fig. XI, 2*a–b*), the component cells of the sheaths round the small vb's being rather unequal in size.

Culm

Culm examined about 7 mm in diameter; slightly concave on 1 side; with a large central cavity. Epidermis subtended by about 3 layers of assimilatory cells except opposite the vb's of the outermost circle, which are connected to the epidermis by scl. Assimilatory tissue bounded on the inner side by a ring of scl. about 2–5 cells wide. Ground tissue between the scl. ring and the hollow centre of the culm consisting of about 20 layers of thin-walled cells. Vb's of the outermost circle embedded in scl., the remaining vb's being scattered in the inner, thin-walled ground tissue.

Material Examined: Cultivated at Kew.

Special Note

Leaf structure typically panicoid.

SORGHUM

Diagnostic Generic Characters

Short-cells, over the veins, mostly in long rows, but sometimes solitary or paired. Silica-bodies, over the veins, usually cross to dumb-bell shaped or nodular. Micro-hairs present; each with the distal cell tapering to a pointed apex. Stomata usually with somewhat triangular subsidiary cells. Vascular bundles mostly small, crowded, and angular in outline. Mesophyll with distinctly radiate chlorenchyma. Bundle-sheaths single.

Species Specially Examined

***Sorghum halepense* (L.) Pers.**

Leaf

Abaxial epidermis

Short-cells, over the veins, sometimes solitary or paired, but mostly in rows of more than 5 cells; solitary and paired short-cells also present beside and between the veins; common over, but infrequent between, the veins. **Silica-bodies:** a few between the veins tall and narrow (Fig. I, 4), and sometimes slightly crescent-shaped; those over the veins mostly cross-shaped (Fig. Ia, 16) or intermediate between cross and dumb-bell shaped (Fig. Ia, 17), and sometimes nodular (Fig. Ia, 18 (i)). **Macro-hairs:** none seen. **Micro-hairs:** length 34–40 μ; basal cells 12–22 (mostly 12–18) μ; distal cells 15–28 (mostly 21–25) μ; distal cells tapering to pointed apices (Fig. VII, 4 and 5). **Prickle-hairs:** angular prickles (Fig. VI, 3) abundant at the leaf margins. **Stomata** mostly with somewhat triangular (Fig. IV, 1) subsidiary cells. **Long-cells:** those on either side of the veins with thin, sinuous walls (Fig. V, 3*a–c*); others between the veins more inflated (bulliform) (Fig. V, 5).

T.S. lamina

Lamina wide and rather thick. **Vascular bundles:** most vb's small, crowded, angular (Fig. VIII, 5); others similar but less markedly angular; large vb's of basic type (Fig. VIII, 10). (Vickery (1935) records 19 vb's of the first order, with 3–15 vb's of third order between each pair.) **Adaxial surface** smooth (Fig. XIV, 1), apart from slight ribs over some of the large vb's. Abaxial surface of the midrib v. slightly ribbed. **Sclerenchyma:** most small vb's not accompanied by scl. (Fig. IX, 1); a few other small vb's with minute adaxial strands only (Fig. IX, 2), or adaxial and abaxial strands about 2–3 cells wide and 1–2 cells high (Fig. IX, 4); large vb's with adaxial girders about 6 cells wide and 2 cells high, and much larger, slightly triangular, abaxial girders up to about 20 cells wide at their bases and about 4 cells high in their tallest parts (Fig. IX, 5); other large vb's with the adaxial and abaxial girders about equal in size. Most keel bundles with well-marked abaxial girders only (Fig. IX, 3),

the adaxial surface above the keel being supported by a wide, thin plate of hypodermal scl. **Keel** conspicuous, slightly triangular; containing 1 large median vb accompanied on either side by a large lateral and by 6–8 appreciably smaller laterals (Fig. XIII, 4). **Mesophyll:** with distinctly radiate chlorenchyma. **Bulliform cells** mostly in irregular groups (Fig. XV, 1). Adaxial ground tissue of the keel consisting of a V-shaped mass of colourless cells. **Bundle-sheaths** single; small vb's each with a single complete sheath (Fig. XI, 2*a*); sheaths to the large vb's with abaxial interruptions only (Fig. XI, 6); sheath cells rather unequal in size.

Culm

Culm examined about 6 mm in diameter and v. slightly concave on 1 side; centre solid. Outer ground tissue consisting of small, scl. cells, but ground tissue mostly composed of larger cells with thinner walls. Numerous vb's scattered throughout the culm.

Rhizome

Rhizome examined about 6 mm in diameter; with a solid centre. Epidermis subtended by a single hypodermal layer of cells of small diameter. Hypodermis bounded on the inner side by about 10 or 12 layers of thin-walled cells with no vb's embedded amongst them, this zone merging with the inner ground tissue, also thin-walled, and containing the vb's. Vb's of various sizes scattered throughout the inner ground tissue, each vb surrounded by a sheath of cells with a solitary silica-body in nearly every cell; the silica-bodies being rather variable in shape and irregular in outline. Vessels in the individual bundles variously distributed.

Material Examined: Cultivated at Kew.

Additional Information from the Literature

1. Leaf

Vickery (1935), besides describing the leaf anatomy of *S. halepense* (see p. 453) also deals with *S. leiocladum* (Hackel) C. E. Hubbard, and her description of this last sp. includes the following particulars. Lamina moderately thin; both surfaces flat or nearly so, but low adaxial ribs present over the vb's. Abaxial epidermis papillose. Vascular bundles: 5–7 first-order vb's present with 3–7 minor vb's between each pair of large ones. Scl. forming insignificant adaxial and abaxial girders to the first-order vb's; less scl. or none associated with the small vb's; a small abaxial girder generally associated with each vb in the conspicuous midrib. Mesophyll with radiate chlorenchyma. Bulliform cells mainly in groups of 5–10 cells and occupying up to slightly less than half the thickness of the lamina, constituting a large part of the adaxial epidermis. Ground tissue of most of the midrib consisting of colourless cells. Bundle-sheaths single; circular in outline.

Prat (1937) has recorded the following particulars concerning the leaf of *S. lanceolatum* Stapf. Lamina in T.S. exhibiting a v. conspicuous, semicircular midrib composed of a mass of large colourless cells, the wings of the lamina being thin and containing little colourless parenchyma. Midrib containing numerous vb's, e.g. 4 first-order and 12–16 lesser vb's. Scl. forming abaxial girders with all vb's in the midrib, but, in the wings, present only on the abaxial side of each large vb; a layer of fibres also present beneath the adaxial epidermis of the midrib. Bulliform cells present between the vb's, but occupying not more than one-quarter to one-fifth of the thickness of the lamina, and less well developed towards the leaf margins than elsewhere.

2. Culm

Chrysler (1906) records the occurrence of amphivasal bundles, formed by fusion between collateral bundles, in the culm nodes of *Sorghum.*

3. Root

Chi (1943) notes in the root of '*Sorghum vulgare* Pers.' the occurrence of 9 protoxylem strands and 2 large, central, metaxylem vessels. Chi also describes the histological development of the ph. in detail. Borissow (1924) refers to the occurrence of small siliceous bodies, interpreted as cystoliths, in the cells of the root epidermis of *S. vulgare* (referred to by Borissow under *Andropogon*). In T.S.'s 1 silica-body is visible, but L.S.'s show a number to be present, in each endodermal cell. Each body often appears spiral or screw-like in shape in T.S., but their appearance and distribution vary with the age of the root. Endodermal cells strongly thickened on the inner tangential walls, and provided with numerous small, simple pits. Similar bodies also noted by Borissow in the roots of *Erianthus* (see p. 202).

Special Note

Prat (1936) rightly points out that the leaf structure is panicoid.

Literature

Borissow 1924 (silica-bodies in root; under *Andropogon*); Chauveaud 1897 (root); Chi 1942 (root); Chrysler 1906 (structure of culm nodes); Duval-Jouve 1870, 1875 (leaf); Frohnmeyer 1914 (silica deposition); Karper 1931 (multiple-seeded spikelets); Krishnaswami and Rangaswami 1942 (leaf); Pée-Laby 1898 (leaf); Prat 1936, 1937 (leaf); Rabechault 1949 (seeds); Rangaswami 1938, Reznik 1934 (seedling anatomy); Sharman 1947 (stem apex); Snowden 1936 (taxonomy); Van Tieghem 1907 (schizostely in rhizome); Vickery 1935 (leaf).

SPARTINA

Diagnostic Generic Characters

Short-cells, over and between the veins, mostly solitary but sometimes paired. Silica-bodies fitting closely into the cells; commonly rectangular in outline, but margins sometimes appearing to be sinuous with change of focus; others tall and narrow. Micro-hairs present; of a rather distinctive type (see p. 457). Stomata infrequent on the abaxial surface, at least in some spp. Vascular bundles not more than inconspicuously angular in outline. Mesophyll with radiate chlorenchyma. Bundle-sheaths single or inconspicuously double.

Species Specially Examined

Spartina maritima (Curt.) Fernald

Leaf

Abaxial epidermis

Short-cells, both over and between the veins, mostly solitary, but occasionally in pairs; abundant. **Silica-bodies** sometimes more or less rectangular but appearing sinuous in outline with change of focus (Fig. I, 2), the silica-bodies

fitting v. closely into the cells; others, especially between the veins, tall and narrow (Fig. I, 4). **Macro-hairs:** none seen. **Micro-hairs:** see *S. townsendii*. **Prickle-hairs:** none seen. **Papillae:** apices and sides of the adaxial ribs minutely papillose. **Stomata:** only a few present on the abaxial surface. **Long-cells,** between the veins, with thin to moderately thick, slightly sinuous walls (Fig. V, 3*a–c*).

T.S. lamina

Vascular bundles: vb's of 2 distinct sizes, but all fairly large, the smallest vb's being slightly angular in outline and somewhat resembling Fig. VIII, 6; large vb's of basic type (Fig. VIII, 11 and 15). **Adaxial surface** with pronounced ribs and furrows (Fig. XIV, 6), the ribs being flat-topped, and the intervening furrows narrow, and deeply V-shaped. Occasional, much smaller ribs with rounded apices also noted. **Sclerenchyma:** all vb's with adaxial and abaxial girders, the adaxial girders occupying the total width of the apex of each of the ribs. Adaxial girders ranging from 4 to about 12 cells wide, but seldom more than 2 cells high, the abaxial girders being about 7–14 cells wide and 2–3 cells high (Fig. IX, 5). **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma cells arranged in a somewhat radiate manner around the large bundle-sheaths and their projections, and most prominently developed on the sides of the ribs. **Bulliform cells** in rather inconspicuous groups at the bases of the V-shaped furrows (Fig. XV, 5). **Bundle-sheaths:** small vb's each with a single complete sheath with a well-developed projection of colourless cells reaching the adaxial scl., the projections being mostly 1–2 cells wide and each sheath with its projection somewhat triangular in outline. Sheaths to the large vb's similar but with rather poorly defined inner sheaths.

ROOT

Root examined about 2 mm in diameter. Exterior bounded by a piliferous layer of thin-walled cells elongated in a direction parallel to the axis of the root. Root-hairs rather infrequent, a single T.S. often showing none. Piliferous layer bounded on the inner side by about 5 or 6 layers of fibrous cells of small diameter; followed by a cortical zone of about 12 layers of thin-walled cells, with conspicuous radiately arranged intercellular spaces between the cells. Two to three layers of cells of small diameter, and an endodermis of cells with thick walls, separate the cortical zone from the polyarch stele, the centre of which is occupied by a pith-like tissue.

MATERIAL EXAMINED: J. K. O'Byrne 180; Essex, England.

***Spartina townsendii* H. & J. Groves**

LEAF

Abaxial epidermis

Short-cells, both over and between the veins, mostly solitary, but occasionally paired; abundant. **Silica-bodies,** in paired short-cells, tall, narrow (Fig. I, 4) and rounded or elliptical in outline; those in solitary short-cells often taller and usually more rectangular in outline (Fig. I, 2). **Macro-hairs:** none seen.

Micro-hairs: solitary, short micro-hairs, each consisting of a dome-shaped distal cell and a greatly enlarged foot-cell, present in shallow depressions in the epidermis on both surfaces of the leaf.[1] **Prickle-hairs:** none seen. **Papillae:** long-cells on the apices and sides of the adaxial ribs minutely papillose; papillae sometimes with forked or branched apices; those on the subsidiary cells of the stomata specially large and branched (Sutherland and Eastwood 1916). **Stomata** absent from, or v. infrequent on, the abaxial surface. **Long-cells,** between the veins, with moderately thick, slightly sinuous walls.

T.S. lamina

T.S. practically indistinguishable from that of *S. maritima*, but scl. girders slightly more massive.

CULM (Fig. XXI, 8–9)

Culm examined about 4 mm in diameter, with a large, hollow centre. A circle of large, conspicuous, mostly oval, intercellular spaces present about 2 cells below the epidermis around the periphery of the culm, the outermost vb's alternating with the spaces. Intercellular spaces followed on the inner side by a somewhat sinuous, continuous ring of fibres about 2–3 cells wide, the fibrous ring being bounded on the inner side by a zone of thin-walled ground tissue about 8–10 cells wide, extending to the hollow centre of the culm. Vb's, apart from those of the outermost circle which alternate with the peripheral intercellular spaces, in 2 more or less distinct circles embedded in the thin-walled inner ground tissue, the outermost of these bundles being in contact with the inner boundary of the scl. ring.

RHIZOME

Lying horizontally at a depth of 2–4 inches; branching sympodially. In T.S. exhibiting a circle of large intercellular spaces, separated from one

[1] These structures have received attention particularly from Sutherland and Eastwood (1916) and from Skelding and Winterbotham (1939). In the respective papers of these authors they are referred to as 'hydathodes', although Sutherland and Eastwood rightly interpreted the hydathodes as specialized hairs. Re-examination by the author has shown that the structure of these organs as described by Skelding and Winterbotham is correct in all essentials, and, as they have aroused so much interest, the following additional particulars are now given. Hydathodes occur on all aerial parts of the plant except the flower, but they are most numerous and easily examined on the lamina of the leaf. They occur in longitudinal rows on both surfaces, but the individual hydathodes in each row are widely separated from one another by long-cells. On the adaxial surface there is commonly a single row of hydathodes on either side of each rib. On the abaxial surface the rows in which they occur are between the veins, a single row, or sometimes 2 rows, being present in each intercostal zone. Each hydathode consists of 2 glandular cells with protoplasmic contents, situated in a shallow cylindrical depression in the epidermis, each depression being surrounded by 4 epidermal cells. The basal cell, of which the dimensions are commonly about $100 \times 30 \times 30\ \mu$, is spindle-shaped, with its long axis lying in the same direction as the long axis of the leaf. It lies partly below the adjacent epidermal cells, and the wall, which consists mainly of cellulose, is perforated by variously shaped pits which communicate with the adjacent epidermal and mesophyll cells. The distal cell, referred to by Skelding and Winterbotham as the cap-cell, is dome-shaped, with a rounded apex and a flattened base which is in contact with the spindle-shaped cell which has just been described. Each 2-celled hydathode arises by the transverse division of a single cell with a large nucleus. The hydathodes secrete sodium chloride in solution. The walls of the adjacent epidermal cells are strongly pitted.

another by radiating plates of parenchyma 1–2 cells wide (Sutherland and Eastwood 1916). Rhizome of *S. pectinatus* Link (*S. michauxiana* Hitchc.) similar in structure (Hayden 1916; Stover 1934).

Root

Root system made up of fine, much-branched, matted, superficial roots, and of unbranched roots penetrating some 2–3 ft into the mud in which the plant grows (Burr and Turner 1933; Sutherland and Eastwood 1916).

Material Examined: Collected by the author at Keyhaven, Hants.

Additional Information from the Literature

The information recorded by Prat (1934) indicates that the leaf structure of *S. patens* (Ait.) Muhl. is, in general, similar to that of the spp. of *Spartina* described above. Prat, however, regards *S. alterniflora* Lois. and several allied spp. as differing somewhat from *S. patens*, notably in having no prickles on the crests of the ribs, whilst the epidermal papillae are more numerous but often shorter. The ligule in *S. patens* and other spp. is composed of uniseriate hairs about 4 cells long, the individual cells increasing in length from the base to the apex of the hair. In the same spp. the cells surrounding the bases of the prickles on the adaxial ribs are papillose. In certain specimens attributed to *S. cynosuroides* (L.) Roth (as *S. cynosuroides* Willd.) papillae were found by Prat to be absent from the adaxial surface of the lamina, and the bulliform tissue at the bases of the furrows to be well developed and provided with thick cuticle.

S. ciliata Kunth. (from S. America) and *S. arundinacea* Carmich. (from islands of St. Paul and Tristan da Cunha) are characterized, according to Prat, by adaxial ribs, with flattened or anvil-shaped apices. The flattened crests of the principal adaxial ribs of *S. ciliata* are furnished with large, swollen cells but bear no papillae; the sides of the principal ribs and apices of the smaller crests have v. long, hollow, often bifurcated papillae, mixed with filiform papillae with pointed ends. In *S. arundinacea* the flattened apices of the principal ribs bear papillae, and secondary vb's occur near the bases of the adaxial grooves.

Special Note

Spartina has been assigned both to the Chlorideae and to the Phalarideae. The leaf structure is neither wholly panicoid nor festucoid. The micro-hairs are something like those of the Chlorideae, but of a specialized type. The short-cells and silica-bodies are unlike those of the Chlorideae.

Literature

Burr and Turner 1933 (leaf); Duval-Jouve 1870, 1875 (leaf); Grob 1896 (leaf); Harshberger 1909 (leaf); Hayden 1919*b* (rhizome); Lauder-Thomson 1933 (nodal anatomy of culm); Pée-Laby 1898 (leaf); Prat 1932, 1934 (leaf); Skelding and Winterbotham 1939 (hydathodes); Stover 1934 (culm and rhizome); Sutherland and Eastwood 1916 (physiological anatomy of whole plant).

SPHAEROCARYUM

Diagnostic Generic Characters

Epidermis: no information. Vascular bundles mostly rather widely spaced and not more than inconspicuously angular in outline. Mesophyll with distinctly radiate chlorenchyma, the cells being long and narrow. Bundle-sheaths single or inconspicuously double.

Species Specially Examined

***Sphaerocaryum malaccense* (Trin.) Pilger**

Leaf

Abaxial epidermis

Not examined. See below.

T.S. lamina

Vascular bundles: most vb's small, rather widely spaced, and not more than inconspicuously angular in outline (Fig. VIII, 6); large vb's also somewhat angular, and seldom including large metaxylem vessels. **Adaxial surface** with slight (Fig. XIV, 2) to moderate (Fig. XIV, 3), rather widely spaced, rounded ribs, separated from one another by wide, shallow furrows. **Sclerenchyma:** most vb's with adaxial and abaxial girders; adaxial girders about 6–12 cells wide and 4–10 cells high, the girders being narrower where in contact with the bundle-sheaths than next to the epidermis. Corresponding abaxial girders v. much smaller, many of them being no more than about 5 cells wide and 2–3 cells high. Combined girders tending to be inversely anchor-shaped. **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma distinctly radiate, but consisting of long, narrow cells of the *Isachne* type. **Bulliform cells** mostly in groups as in Fig. XV, 2 in the shallow furrows. **Bundle-sheaths:** most vb's with single, complete sheaths (Fig. XI, 2*a*), sometimes with slight adaxial extensions; large vb's with rather similar outer sheaths and obscure inner sheaths (Fig. XII, 6); cells of the outer sheaths unequal in size.

Culm

Culm examined about 2 mm in diameter; with a fairly large central cavity. Epidermis v. small-celled, subtended by a zone of large, thin-walled cells, about 4 cells wide, with rather irregular intercellular cavities between the cells, this zone being bounded on the inner side by a conspicuous, somewhat sinuous circle of fibres of v. small diameter, the circle being mostly 1–2, and occasionally up to 3, cells wide. Fibre zone followed by ground tissue consisting of 5 or 6 layers of large, thin-walled cells, extending to the hollow centre of the culm. Outermost vb's embedded in the narrow ring of fibres, the remaining vb's being in 1–2 circles, and embedded in the inner ground tissue, or abutting on to the inner boundary of the fibre ring.

Material Examined: F. Ballard 1515; Ceylon.

Additional Information from the Literature

Potztal (1952) has recorded the following information concerning the leaf epidermis of *S. malaccense* (Trin.) Pilger. This published information may be used to supplement the original description of the T.S. lamina given above. Abaxial epidermis consisting of large, thin-walled cells, of moderately uniform size, and covered

with a thin cuticle. Cells of the adaxial epidermis with papillae resembling finger-stalls. Small micro-hairs present amongst the adaxial papillae, each hair having a foot-cell with its base sunk in the epidermis, and a small, rounded distal cell. Prickles and bristles probably absent, but specially long hairs, visible with the naked eye, present at the leaf margins; each hair standing on a pedestal of small epidermal cells. Silica-cells present only above the vb's; silica-bodies over the middle of the vb's weakly cross-shaped or quadratic; those in cells over the margins of the vb's elongated and dumb-bell shaped. (In material subsequently examined by the author the silica-bodies were of the acutely angular type (Fig. I, 11) that appear to be characteristic of the Isachneae. The uniform, more or less rectangular, epidermal cells of the intercostal zones also resemble those of the Isachneae.)

Special Notes

The leaf structure of this grass indicates that it should be regarded as a member of the Isachneae, the narrow, elongated cells of the mesophyll, radiating around the vb's, especially pointing to this conclusion. The v. acutely angular silica-bodies are also of the *Isachne* type, and quite unlike those that occur in *Sporobolus*. The rounded distal cells of the micro-hairs are similar to those that occur in *Sporobolus*, but they might equally be regarded as resembling those in the other Isachneae but with the shape of the cell somewhat modified. The bulliform cells, unlike those of *Sporobolus*, are not in groups of the *Sporobolus* type. The relatively uniform epidermis, of which the intercostal cells are more or less equidimensional as seen in surface view, at once recalls that of *Heteranthoecia* (Fig. V, 8). This opinion is contrary to that of Potztal (1952) who considers that *Sphaerocaryum* should be removed from the Isachneae and transferred to the Sporoboleae. For the reasons stated above Potztal's view cannot be accepted without further evidence.

Literature

Potztal 1952 (leaf).

SPINIFEX

Diagnostic Generic Characters

Short-cells, over the veins, solitary, in pairs, or long rows. Silica-bodies, over the veins, tall and narrow, cubical, oblong, or, more rarely, intermediate between cross and dumb-bell shaped. Micro-hairs present; distal cells rarely seen. Vascular bundles not more than inconspicuously angular in outline. Mesophyll with inconspicuously radiate chlorenchyma. Bundle-sheaths single or double.

Species Specially Examined

***Spinifex hirsutus* Labill.**

Leaf

Abaxial epidermis

Short-cells, both over and between the veins, often solitary or in pairs; others, over the veins, in rows of more than 5 cells; abundant. **Silica-bodies**

sometimes tall and narrow (Fig. I, 4), but more commonly cubical and tending to fit closely into the short-cells (Fig. I, 2); a few, over the veins, oblong (Fig. I, 10); or intermediate between cross and dumb-bell shaped (Fig. Ia, 17). **Macro-hairs:** fairly long, stiff hairs, with swollen but constricted and sunken bases (Fig. II, 3) (cushion hairs), abundant in the intercostal zones. Hairs also present at the leaf margin (Grob 1896). **Micro-hairs:** length 108–120 μ; basal cells 36–72 (mostly 36–48) μ; distal cells 72–80 μ; v. few hairs with complete distal cells observed, but, where seen, tapering to pointed apices, i.e. as in Fig. VII, 5, but hairs exceptionally long. Micro-hairs difficult to find because obscured by the v. numerous macro-hairs. **Prickle-hairs:** none seen. **Stomata** slightly sunken in pits, and outlines of the subsidiary cells consequently obscure. **Long-cells,** between the veins, mostly relatively short, with thin, non-sinuous walls (Fig. V, 4*a–b*); sometimes almost cubical (Fig. V, 8).

T.S. lamina

Vascular bundles: vb's of 3 distinct sizes but none of them specially small; mostly somewhat angular and resembling those in Fig. VIII, 6; large vb's of basic type (Fig. VIII, 10). **Adaxial surface** with well-developed ribs (Fig. XIV, 7) of 2 distinct sizes, the large and small ribs for the most part alternating with one another, the large ribs having a somewhat club-shaped appearance; furrows mostly W-shaped. **Sclerenchyma:** small vb's opposite the furrows not accompanied by scl. (Fig. IX, 1); scl. to the large vb's forming inversely anchor-shaped girders in conjunction with the bundle-sheaths (Fig. IX, 10). **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma indistinctly radiate. **Bulliform cells** sometimes present as obscurely fan-shaped groups at the bases of the furrows (Fig. XV, 6), but cells at the bases of some of the furrows not specially large, the groups then tending to be of the *Ammophila* type (Fig. XV, 5). **Bundle-sheaths:** small vb's opposite the furrows each with a single complete sheath (Fig. XI, 2*a*); medium-sized vb's with single sheaths with extensions of colourless cells towards the adaxial surface, or sometimes similar but with an obscure I.S. (Fig. XII, 6); large vb's with massive extensions of the O.S. filling the adaxial ribs more or less completely; O.S. to the medium-sized and large vb's sometimes with slight abaxial interruptions.

Culm

Culm examined about 5 mm in diameter, with a slight depression on 1 side, and a small cavity at the centre. Epidermis subtended by 2 layers of fibres, this fibrous zone being bounded on the inner side by a wide zone of rounded assimilatory cells some 10 cells wide. Assimilatory tissue bounded on the inner side by a second zone of fibres some 10 cells wide, the outer periphery of the zone being somewhat sinuous in outline. Ground tissue on the inner side of the inner scl. ring consisting of large, thin-walled cells with minute, triangular, intercellular spaces between them. Vb's of the outermost circle embedded in the inner scl. ring. Remaining vb's scattered throughout the thin-walled ground tissue.

RHIZOME

Rhizome examined about 4 mm in diameter and slightly flattened on 1 side; with a solid centre. Epidermis of small cells with v. thick walls, bounded on the inner side by a cortical zone some 10 or 12 cells wide, followed by a sinuous zone of thick-walled fibres, with a circle of vb's embedded in it, the portions of the fibre zone between the vb's being about 6–10 cells wide. Inner ground tissue consisting of large, moderately thin-walled cells, with triangular intercellular spaces between them. Large vb's scattered throughout the inner ground tissue except at the very centre of the rhizome.

MATERIAL EXAMINED: Supplied specially by W. M. Curtis from SE. Tasmania.

ADDITIONAL INFORMATION FROM THE LITERATURE

Fyson and Balasubrahmanyam (1919) note the secretion of an amorphous substance near the piliferous layer of the roots of *S. squarrosus* L. (= *S. littoreus* (Burm. f.) Merrill). It is non-mucilaginous and has a protective function. According to the same authors, root-hairs are restricted to roots near the surface of the sand.

SPECIAL NOTE

Leaf structure mainly panicoid but not wholly so.

LITERATURE

Breakwell 1915 (leaf); Fyson and Balasubrahmanyam 1919 (root-hairs and secretion from roots); Grob 1896 (leaf).

SPODIOPOGON

The following notes concerning the leaf of *S. sibiricus* Trin. have been recorded by Grob (1896).

Longitudinally elongated cork-cells present on the adaxial surface above the median scl.; short-cells on the abaxial surface consisting solely of rows of silica-cells. Silica-bodies on the abaxial surface mostly nodular, but dumb-bell shaped types dominant on the adaxial surface. Micro-hairs and cushion hairs occurring in the intercostal zones on the abaxial surface. Papillae present, but restricted to the abaxial surface.

SPECIAL NOTE

Although imperfectly known the leaf structure appears to be panicoid.

LITERATURE

Grob 1896 (leaf).

SPOROBOLUS

DIAGNOSTIC GENERIC CHARACTERS

Short-cells, over the veins, mostly paired but sometimes solitary, and more rarely in short rows. Silica-bodies mostly elliptical or slightly crescent-shaped, more rarely somewhat saddle-shaped or tending to be cross-shaped, all of these types fitting into concavities in adjacent cork-cells. Micro-hairs present; v. short, spherical, and often unicellular, but 2-celled in certain spp., distal cell rarely with a slightly pointed apex. Stomata with somewhat triangular or low dome-shaped subsidiary cells. Vascular bundles moderately crowded, the small ones being slightly to conspicuously angular in outline. Mesophyll with the chlorenchyma inconspicuously to conspicuously radiate. Bundle-sheaths; small vb's each with a single more or less triangular sheath; sheaths to large vb's double.

SPECIES SPECIALLY EXAMINED

***Sporobolus africanus* (Poir.) Robyns & Tournay**

LEAF

Abaxial epidermis

Short-cells, both over and between the veins, nearly all paired, but occasionally solitary; abundant. **Silica-bodies** fitting into concavities in adjacent cork-cells (Fig. I, 6–7), the bodies being mostly slightly crescentic in outline. **Macro-hairs:** none seen. **Micro-hairs** unicellular (Fig. VII, 1); single cell spherical, 12–18 μ long. **Prickle-hairs:** none seen on the abaxial surface, but small prickles (Fig. VI, 1) on the adaxial ribs appearing, in T.S. of the leaf, as papillae. **Papillae:** see prickle-hairs. **Stomata** with slightly triangular (Fig. IV, 1), or low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells,** between the veins, with thin, sinuous walls (Fig. V, 3*a–c*); those over the veins with similar but rather thicker walls; interstomatal cells with concave ends (Fig. V, 10–11).

T.S. lamina

Vascular bundles: most vb's small, moderately crowded, angular (Fig. VIII, 5); large vb's of basic type (Fig. VIII, 10). **Adaxial surface** with moderate ribs of 2 distinct types, those over the small vb's being narrower and with more rounded apices than those over the large vb's; intervening furrows shallow and narrowly V-shaped. Adaxial ribs bearing prickles (Goossens 1938). **Sclerenchyma:** smallest vb's at the leaf margin not accompanied by scl. (Fig. IX, 1); small vb's usually with adaxial strands in the apices of the ribs, mostly about 7 cells wide and 2 cells high, and abaxial strands about the same size or slightly narrower and sometimes only 1 cell tall (Fig. IX, 4); large vb's with rather wider and taller adaxial and abaxial girders (Fig. IX, 5). Midrib bundles mostly with well-developed abaxial strands or girders (Fig. IX, 3); adaxial surface of the midrib supported by a thin plate of hypodermal fibres, extending completely across the midrib. **Midrib** conspicuous, mainly owing to the development of a large mass of colourless ground tissue on the adaxial side of the leaf; containing 1 large median vb accompanied on either side by 3 or 4 much smaller laterals (Fig. XIII, 3). Goossens (1938) records lysigenous air-cavities in the midrib. **Mesophyll:** chlorenchyma distinctly radiate. **Bulliform cells** in groups of the *Sporobolus* type (Fig. XV, 8). **Bundle-sheaths:** most small vb's each with a single, more or less triangular sheath with an apical, uniseriate or biseriate extension of colourless cells towards the adaxial scl.; large vb's with double sheaths, the I.S. and O.S. having wide abaxial interruptions (Fig. XII, 5), or sometimes with the I.S. not interrupted (Fig. XII, 4).

CULM

Culm examined 2–3 mm in diameter; oval in outline; with a small central cavity. Epidermis subtended by 2 layers of fibres of small diameter. Many of the vb's of the outermost circle buttressed to the epidermis by scl., but hypodermal scl. elsewhere bounded on the inner side by about 5 layers of relatively large cells with moderately thick walls, triangular intercellular spaces being present between the cells. Zone of large, moderately thick-walled cells followed by a somewhat sinuous circle of fibres about 10 cells wide, the vb's of the outermost circle being embedded in this scl. zone. Inner ground tissue consisting of round, thin-walled cells, with minute, triangular intercellular spaces between the cells. Vb's, apart from those of the outer circle, embedded in the thin-walled ground tissue, 2 of the vb's on opposite sides of the culm penetrating more deeply than the remainder towards the central cavity.

MATERIAL EXAMINED: Supplied specially by R. E. Vaughan from Mauritius.

***Sporobolus diander* (Retz.) Beauv.**

LEAF

Abaxial epidermis

Short-cells, nearly all paired, but occasionally solitary, or in rows of about 3 cells. **Silica-bodies** fitting into concavities in adjacent cork-cells (Fig. I, 6–7), the silica-bodies being elliptical or slightly crescentic in outline. **Macro-hairs:** none seen. **Micro-hairs:** unicellular (Fig. VII, 1), the single cells being spherical and 9–12 μ long. **Prickle-hairs:** none seen on the abaxial surface, but small prickles (Fig. VI, 1) on the adaxial ribs, appearing in T.S. of the leaf as papillae. **Papillae:** see prickle-hairs. **Stomata** with slightly triangular (Fig. IV, 1) subsidiary cells. **Long-cells,** both between and over the veins, with moderately thick, sinuous or pitted walls (Fig. V, 1*a–b*); interstomatal cells with concave ends (Fig. V, 10–11).

T.S. lamina

Vascular bundles: most vb's small, moderately crowded, and somewhat, but not v. conspicuously, angular (Fig. VIII, 5); large vb's of basic type (Fig. VIII, 10). **Adaxial surface** with moderately well-developed, crowded ribs (Fig. XIV, 3), with rounded or somewhat flattened apices, the intervening furrows being shallow and V-shaped. A few, slight, abaxial ribs present over certain of the large vb's, but no abaxial ribs seen near the leaf margins. **Sclerenchyma:** small vb's next to the leaf margins with little or no scl. (Fig. IX, 1); other small vb's with adaxial strands, in the apices of the ribs, 1–6 cells wide and mostly 1–2 cells high, the corresponding abaxial strands being up to 8 cells wide and 1–2 cells high (Fig. IX, 4 and 5); large vb's with rather wider adaxial strands and abaxial strands or girders. **Keel** fairly conspicuous, rounded; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma indistinctly radiate round the small vb's. **Bulliform cells** in groups of the *Sporobolus* type (Fig. XV, 8) at the bases of the furrows. **Bundle-sheaths:** most small vb's each with a single, more or less triangular sheath with an apical extension towards, or connecting with, the adaxial scl. strands; large

vb's with double sheaths, the O.S. having wide abaxial interruptions (Fig. XII, 4).

MATERIAL EXAMINED: F. Ballard 1151; Ceylon.

***Sporobolus indicus* (L.) R. Br.**

LEAF

Abaxial epidermis

Short-cells, both over and between the veins, mostly paired, but occasionally solitary or in rows of about 3 cells. **Silica-bodies** fitting into concavities in adjacent cork-cells (Fig. I, 6–7), the bodies being mostly slightly crescent-shaped, but some much narrower than others. **Macro-hairs:** none seen. **Micro-hairs:** those of the Jamaican plant cultivated at Kew unicellular (Fig. VII, 1), the single cells being spherical, sometimes with slightly pointed apices, and 12–20 (mostly 14–20) μ long. Micro-hairs of Ballard 1170 similar but only 9–13 μ long. **Prickle-hairs:** none seen on the abaxial surface, but some prickles (Fig. VI, 1–2) on the adaxial ribs, when seen in T.S. could be mistaken for papillae; less numerous in the Jamaican plant than in Ballard 1170. **Papillae:** see prickle-hairs. **Stomata** with slightly triangular (Fig. IV, 1), or low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells,** between the veins, with thin, sinuous walls (Fig. V, 3*a–c*); those over the veins similar, but with thicker walls; interstomatal cells with concave ends (Fig. V, 11), but rather long.

T.S. lamina

Vascular bundles: most vb's small, crowded, angular (Fig. VIII, 5); large vb's of basic type (Fig. VIII, 10). **Adaxial surface** with slight, rounded ribs over the vb's, separated from one another by shallow, slightly V-shaped furrows (Fig. XIV, 2). **Sclerenchyma:** vb's nearest to the leaf margins accompanied by little or no scl. (Fig. IX, 1); most small vb's accompanied by adaxial strands up to about 7 cells wide and 2 cells high in the apices of the ribs, and by abaxial strands often slightly wider and about the same height (Fig. IX, 4); large vb's with similar but somewhat wider adaxial and abaxial strands or girders (Fig. IX, 5). **Keel** fairly conspicuous, rounded; containing 1 large median vb usually accompanied on either side by at least 1, and sometimes more, much smaller laterals (Fig. XIII, 2 and 3). **Midrib,** in sections slightly higher up the leaf, less conspicuous and containing only 1 vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma rather inconspicuously radiate around each vb. **Bulliform cells** in groups of the *Sporobolus* type (Fig. XV, 8). Adaxial two-thirds of the keel composed of colourless cells. **Bundle-sheaths:** each small vb surrounded by a markedly triangular, single sheath, with a conspicuous apical extension of 1 or 2 cells towards, or connecting with, the adaxial scl. strands. Large vb's with double sheaths, the outer sheaths having wide abaxial interruptions (Fig. XII, 4).

CULM

Culm examined about 2 mm in diameter; flattened or slightly concave on 1 side; centre occupied by somewhat spongy ground tissue. Epidermis

subtended by a continuous ring of 1 or 2 layers of fibres. A small amount of scl. also associated with the vb's of the outermost circle, but not forming a complete ring. Ground tissue consisting of moderately thin-walled cells, with minute, triangular, intercellular spaces between them. Vb's scattered throughout the ground tissue, except in the spongy tissue at the centre of the culm.

ROOT

Root examined about 1·5 mm in diameter. Surface of the root covered with about 2 layers of v. thin-walled cells bounded on the inner side by a conspicuous ring of fibres about 4 cells wide. There is a cortical zone of thin-walled cells present between the fibrous ring and the endodermis, most of the cells having a somewhat collapsed appearance owing to the occurrence of large, radiately arranged, apparently lysigenous air-canals between them. Peripheral part of the stele consisting of v. thick-walled cells. Metaxylem vessels conspicuous, in a circle of about 12. Centre of the root occupied by a small amount of v. thin-walled tissue.

MATERIAL EXAMINED: (i) Cultivated at Kew; of Jamaican origin. (ii) F. Ballard 1170; Ceylon.

***Sporobolus molleri* Hack.**

LEAF

Abaxial epidermis

Short-cells, both over and between the veins, nearly all paired, but occasionally solitary or in rows of about 3 cells; abundant. **Silica-bodies** fitting into concavities in adjacent cork-cells (Fig. I, 6–7), the bodies being mostly slightly crescent-shaped, but sometimes elliptical, or somewhat saddle-shaped (Fig. I, 9). **Macro-hairs:** none seen. **Micro-hairs:** unicellular (Fig. VII, 1), the single spherical cells being 10–13 μ long. **Prickle-hairs:** angular prickles (Fig. VI, 3) present at the leaf margins. No prickle-hairs noted on the abaxial surface, but small prickles (Fig. VI, 1) present on the adaxial ribs resembling papillae when viewed in T.S.[1] **Papillae:** see prickle-hairs. **Stomata:** a few with slightly triangular (Fig. IV, 1), but mostly with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells:** some of those between the veins with moderately thin, sinuous walls (Fig. V, 3*a–c*), but others between the veins, and those over the veins, with thicker, pitted or sinuous walls (Fig. V, 1*a–b*). Interstomatal cells with concave ends and mostly rather long (Fig. V, 11).

T.S. lamina

Vascular bundles: most vb's small, crowded, and angular (Fig. VIII, 5); a few large vb's of basic type (Fig. VIII, 10–15). **Adaxial surface** with slight, crowded ribs over the vb's, separated from one another by v. shallow, slightly V-shaped furrows (Fig. XIV, 2). **Sclerenchyma:** most small vb's accompanied by adaxial strands up to about 5 cells wide and 1–3 cells high in the apices of the adaxial ribs, and by abaxial strands mostly no more than 2–5 cells wide and 1 cell high (Fig. IX, 4); large vb's with adaxial strands up to about 12 cells wide and 2–3 cells high and abaxial girders up to about 12 cells wide and

[1] These prickle-hairs are smaller than those in some of the other species of *Sporobolus* such as *S. indicus* and *S. poiretii*.

4 cells high (Fig. IX, 5). **Keel** conspicuous, rounded; containing 1 large median vb accompanied on either side by about 3 much smaller laterals (Fig. XIII, 3). **Mesophyll:** chlorenchyma rather inconspicuously radiate around each vb. **Bulliform cells** in groups of the *Sporobolus* type (Fig. XV, 8). Adaxial ground tissue of the keel composed of colourless cells. **Bundle-sheaths:** each small vb surrounded by a markedly triangular, single sheath, with a short, mostly 1-celled apical extension towards the adaxial scl.; large vb's with double sheaths, each O.S. having a wide abaxial interruption (Fig. XII, 4).

CULM

Culm examined about 2 mm in diameter; slightly oval in section, with no central cavity. Epidermis subtended by a zone of scl. some 10 cells wide, with large, flattened columns of assimilatory tissue embedded in it. Remaining ground tissue consisting of thin-walled cells. Vb's confined to the peripheral part of the culm, none being present throughout most of the central ground tissue.

MATERIAL EXAMINED: Specially collected by G. Jackson in Nyasaland.

***Sporobolus poiretii* (Roem. & Schult.) Hitchcock**

LEAF

Abaxial epidermis

Short-cells, both over and between the veins, mostly paired, but sometimes solitary, and occasionally in rows of about 3 cells: abundant. **Silica-bodies** fitting into concavities in adjacent cork-cells (Fig. I, 6–7), the bodies themselves being mostly elliptical or slightly crescent-shaped in outline. **Macro-hairs:** none seen. **Micro-hairs:** unicellular (Fig. VII, 1), the single spherical cells mostly being 13–16 μ long. **Prickle-hairs:** none seen on the abaxial surface, but numerous, fairly large prickles (Fig. VI, 2) present on the adaxial ribs, and sometimes resembling rather large papillae in T.S. of the leaf.[1] **Papillae:** see prickle-hairs. **Stomata** occasionally with slightly triangular (Fig. IV, 1), but mostly with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells,** between the veins, with thin to moderately thick sinuous walls (Fig. V, 3*a–c*); those over the veins with similar but thicker walls (Fig. V, 1*a–b*); outer periclinal walls of the long-cells exhibiting minute translucent dots of undetermined nature resembling pits.

T.S. lamina

Vascular bundles: most vb's small, crowded, and angular (Fig. VIII, 5); a few large vb's of basic type (Fig. VIII, 10). **Adaxial surface** with crowded, moderately well-developed ribs over most of the vb's, those over the small vb's having rounded, and those over the large vb's less rounded or slightly flattened, apices; intervening furrows fairly deep and conspicuously V-shaped (Fig. XIV, 3). **Sclerenchyma:** a well-developed dome-shaped strand of scl., up to about 10 cells wide and 3 or 4 cells high, present in the apex of each

[1] These prickles are somewhat larger than those in some other spp. of *Sporobolus*, and more comparable in size to those of *S. indicus*.

adaxial rib associated with a small vb, the corresponding abaxial strands being mostly about 10 cells wide but only 1 or 2 cells high (Fig. IX, 5). Large vb's accompanied by adaxial strands, commonly about 20 cells wide and about 5 cells high, and by abaxial girders mostly about 12–15 cells wide and 5 or more cells high. Combined girders to some of the large vb's tending to be inversely anchor-shaped. **Keel** conspicuous, or not conspicuous, depending on the level of the section; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma rather inconspicuously radiate, especially round the small vb's. **Bulliform cells** in groups of the *Sporobolus* type (Fig. XV, 8). **Bundle-sheaths:** each small vb surrounded by a markedly triangular, single sheath, with a long, usually at least 3-celled and commonly partly biseriate, apical extension towards the adaxial scl.; large vb's with double sheaths, the O.S. being interrupted abaxially (Fig. XII, 4), or sometimes adaxially and abaxially (Fig. XII, 3*a*).

LEAF-SHEATH

The structure of the sheathing base of the leaf of this, as of other spp. of *Sporobolus*, is markedly different from that of the lamina. In the sheathing base each vb is supported by a very massive abaxial strand of fibres, and there is a continuous zone of fibres some 3 or 4 cells wide immediately subjacent to the abaxial epidermis, scl. being absent from the adaxial surface of the leaf. Adaxial ribs are also absent, the mesophyll exhibits no trace of radiate structure, and clearly defined bundle-sheaths are lacking. The ground tissue consists mostly of rounded, thin-walled, colourless cells.

CULM

Culm examined about 2 mm in diameter; flattened or slightly depressed on 1 side; with no cavity at the centre. Cells of the ground tissue gradually increasing in diameter from the epidermis to the centre of the culm, but no clearly defined ring of scl. present. Vb's arranged in about 3 more or less distinct circles around the periphery of the culm, but none present in the central ground tissue.

MATERIAL EXAMINED: Cultivated at Kew.

***Sporobolus pyramidalis* P. Beauv.**

LEAF

Abaxial epidermis

Short-cells, both over and between the veins, nearly all paired, but occasionally solitary and in rows of about 3 cells. **Silica-bodies** fitting into concavities in adjacent cork-cells (Fig. I, 6–7), the bodies being mostly slightly crescent-shaped in outline. **Macro-hairs:** none seen. **Micro-hairs:** unicellular (Fig. VII, 1), the single cells being spherical, sometimes with slightly pointed apices, and 13–16 μ long. **Prickle-hairs:** none seen on the abaxial surface, but small prickles (Fig. VI, 1) present on the adaxial ribs, and sometimes resembling

papillae when seen in T.S. of the leaf. **Papillae:** see prickle-hairs. **Stomata:** a few with slightly triangular (Fig. IV, 1), but mostly with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells,** both between and over the veins, with rather thick, pitted or sinuous walls (Fig. V, 1*a–b*); outer periclinal walls of the long-cells exhibiting abundant, minute, translucent dots of undetermined nature, resembling pits. Interstomatal cells with concave ends (Fig. V, 10–11).

T.S. lamina

Vascular bundles: most vb's small, moderately crowded, and angular in outline (Fig. VIII, 5); large vb's of basic type (Fig. VIII, 10). **Adaxial surface** with crowded, moderately well-developed ribs over the vb's (Fig. XIV, 3), the ribs over the small vb's being narrower than those over the large vb's; intervening furrows moderately deep and somewhat V-shaped. Abaxial surface also slightly ribbed, especially on the keel. **Sclerenchyma:** small vb's accompanied by adaxial strands, and by abaxial strands and occasional girders. Adaxial strands in the apices of the ribs over the small vb's 3–7 cells wide and mostly 2, or occasionally 3, cells high, the corresponding abaxial strands or girders being about 8–10 cells wide and 1–2 cells high. Large vb's accompanied by adaxial and abaxial girders rather wider than the strands to the small vb's, the combined girders tending to be inversely anchor-shaped. **Keel** fairly conspicuous, rounded; containing 1 large median vb accompanied on either side by about 2 much smaller laterals (Fig. XIII, 3). **Mesophyll:** chlorenchyma rather inconspicuously radiate, especially around the small vb's. **Bulliform cells** in groups of the *Sporobolus* type (Fig. XV, 8); adaxial ground tissue of the keel composed of colourless cells. **Bundle-sheaths:** each small vb surrounded by a markedly triangular, single sheath, with a short, usually 1- or 2-celled, apical extension towards the adaxial scl.; large vb's with double sheaths, the O.S. being interrupted abaxially (Fig. XII, 4).

MATERIAL EXAMINED: Meikle 1412; Nigeria.

***Sporobolus virginicus* (L.) Kunth**

Only some rather imperfect T.S.s of the leaf of this sp. were examined. These, in a general way, exhibited characters similar to those of the other spp. of *Sporobolus* that were examined, but notable features were the tall adaxial ribs with deep furrows between them; the small thickness of the lamina between the adaxial and abaxial epidermis at the bases of the furrows; the v. numerous, tall papillae (probably prickle-hairs in section) at the apices of the adaxial ribs. The papillae were appreciably taller and more numerous than those in the corresponding position in other parts of the leaf. Other features for this sp. noted by Goossens (1938) include the absence of a keel; the mesophyll with radiate chlorenchyma; the ill-defined bulliform cells; the girders of colourless cells extending from the bases of the adaxial furrows to the abaxial surface of the leaf.

MATERIAL EXAMINED: Collected by Chevalier; Dahomey.

***Sporobolus wrightii* Munro ex Scrib.**

LEAF

Abaxial epidermis

Short-cells, both over and between the veins, mostly paired, but some of those over the veins in rows of 3 or 4 cells; abundant. **Silica-bodies** fitting into concavities in adjacent cork-cells (Fig. I, 6–7), the bodies themselves being mostly slightly crescent-shaped, but sometimes tall and narrow, elliptical, or occasionally slightly saddle-shaped. **Macro-hairs:** none seen. **Micro-hairs:** 2-celled, but short and more or less spherical in outline (Fig. VII, 2); length 30–37 μ; basal cells 16–23 μ; distal cells 12–15 μ. **Prickle-hairs:** small prickles (Fig. VI, 1), or hooks (Fig. VI, 5), common in the intercostal zones. A few prickles, resembling papillae when observed in T.S. of the leaf, also present on the adaxial ribs. **Papillae:** see prickle-hairs. **Stomata** mostly with triangular (Fig. IV, 1), but sometimes with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells:** those between the veins with thin, sinuous walls (Fig. V, 3*a–c*); those over the veins with similar but thicker walls (Fig. V, 1*a–b*). Inter-stomatal cells with concave ends (Fig. V, 10–11). Outer periclinal walls of the long-cells exhibiting abundant, minute, translucent dots, of undetermined nature, resembling pits.

T.S. lamina

Vascular bundles: most vb's rather large, fairly crowded, and somewhat angular (Fig. VIII, 5); large vb's of basic type (Fig. VIII, 10) but sometimes with the ph. slightly sclerosed. **Adaxial surface** with crowded, moderately well-developed ribs over most of the vb's (Fig. XIV, 3), the ribs over the large vb's being slightly wider than the remainder; intervening furrows moderately deep and somewhat V-shaped. Smaller ribs present on the abaxial surface opposite those on the adaxial surface. **Sclerenchyma:** occasional, small vb's opposite the adaxial furrows with well-developed abaxial girders only (Fig. IX, 3); other small vb's with adaxial and abaxial girders, the adaxial being 5–10 cells wide and 2–3 cells high, and the abaxial girders 10–15 cells wide and 2–3 cells high (Fig. IX, 5); large vb's with much wider adaxial and abaxial girders, the combined girders being inversely anchor-shaped, or resembling those in Fig. IX, 10. **Keel** fairly conspicuous, rounded, but boundaries rather ill defined; containing a number of alternating large and small vb's (Fig. XIII, 3). **Mesophyll:** chlorenchyma distinctly radiate. **Bulliform cells:** narrow groups of bulliform and associated colourless cells penetrating deeply into the mesophyll (Fig. XV, 7), i.e. the *Arundo* type. Adaxial ground tissue of the keel composed of colourless cells. **Bundle-sheaths:** each small vb with a single, somewhat triangular sheath, and a well-developed apical extension of colourless cells towards, or making contact with, the adaxial scl., most of the extensions being about 3 cells long and 1–3 cells wide. An obscure I.S. present around some of the small vb's. Large vb's with double sheaths, the O.S. being interrupted abaxially (Fig. XII, 4).

CULM

Culm examined about 6 mm in diameter, somewhat oval in outline, with an irregular cavity in the spongy ground tissue at the centre of the culm. Cells between the epidermis and the centre of the culm showing a gradual increase in diameter, those nearest to the epidermis being scl., but no well-defined scl. ring present. Cells throughout most of the ground tissue somewhat prosenchymatous, even when thin-walled. Numerous vb's scattered throughout the ground tissue except in the spongy portion towards the centre of the culm.

MATERIAL EXAMINED: Cultivated at Kew.

***Sporobolus* sp.**

This hexaploid *Sporobolus* from Burma is in many ways v. similar to, or almost indistinguishable from, *S. indicus*. It may be noted, however, that occasional silica-bodies over the veins are cross-shaped (Fig. IA, 16), or intermediate between cross and dumb-bell shaped (Fig. IA, 17). Although a few intercellular spaces have been noted in T.S.s through the sheathing bases of the leaves of *S. indicus*, similar spaces appear to be more numerous and more fully developed in the sheathing bases of the leaves of the Burmese sp. Whether these differences are sufficiently constant to be reliable for diagnostic purposes could be determined only by an investigation of further material.

MATERIAL EXAMINED: Cultivated at Kew; from Burma.

ADDITIONAL INFORMATION FROM THE LITERATURE

Goossens (1938) notes that the leaves of most of the African spp. of *Sporobolus* that he examined are flat, fairly thick, with a distinct midrib, and often with a prominent keel, although the keel is not well developed in certain spp. Sometimes when the keel is well developed, lysigenous air-cavities arise in the ground tissue. In some spp. the chlorenchyma of the mesophyll is distinctly radiate, whilst in others this is not so.

Spp., other than those that are described above, that are dealt with by Goossens include the following.

S. acinifolius Stapf

Adaxial surface with low, rounded ribs, with prickles on the ribs. Abaxial surface with slight ribs. Scl. forming girders with the large vb's. Keel absent. Mesophyll with radiate chlorenchyma. Bulliform cells in groups of the *Sporobolus* type, each group being connected to the abaxial epidermis by a girder of colourless cells. Short-cells in pairs on the abaxial surface.

S. albicans Nees

Adaxial surface with papillose, rounded ribs. Abaxial surface smooth or slightly undulated. Scl. forming more or less definite girders with the large vb's. Keel absent. Mesophyll with radiate chlorenchyma. Bulliform cells in groups of the *Sporobolus* type. Bundle-sheaths not interrupted by scl. Short-cells on the abaxial surface in rows.

S. argutus Kunth

Adaxial surface with slight ribs or more or less smooth; bearing numerous prickles. Abaxial surface also slightly ribbed. Scl. forming inconspicuous girders with the first order vb's, but not v. well developed elsewhere. Keel conspicuous. Mesophyll

with radiate chlorenchyma. Bulliform cells in conspicuous groups of the *Sporobolus* type.

S. artus Stent

Adaxial surface ribbed except above the keel, the ribs often bearing a few prickles (asperities). Abaxial surface undulating or prominently ribbed, the ribs themselves being grooved. Scl. present on the abaxial and adaxial sides of the vb's, the large vb's being girdered except in the keel. Keel usually conspicuous. Mesophyll with chlorenchyma not radiate. Bulliform cells present between the ribs and usually conspicuous. O.S. usually interrupted by abaxial scl. Short-cells on abaxial surface in pairs.

S. bechuanicus Goossens

Adaxial surface with prominent ribs, the ribs opposite the large vb's being flat-topped. Abaxial surface slightly undulating. Scl. present on the adaxial and abaxial sides of the vb's; forming girders with the large vb's outside the keel. Keel more or less distinct. Mesophyll with radiate chlorenchyma. Bulliform cells conspicuous. Short-cells on abaxial surface paired.

S. centrifugus Nees

Adaxial surface with flat-topped ribs, the ribs opposite the large vb's being broader than the others. Abaxial surface undulating. Scl. forming girders with the large vb's. Keel absent, but 2 varieties of this sp. described as having conspicuous keels. Mesophyll with radiate chlorenchyma. Bulliform cells in groups of the *Sporobolus* type. O.S.s to the large vb's interrupted abaxially by scl.; bundle-sheaths to the second-order vb's triangular in outline. Short-cells, on the abaxial surface, paired.

S. conrathii Chiov.

Adaxial surface with 3 low ribs and 2 large marginal projections. Abaxial surface with ill-defined ribs. Scl. forming girders with the vb's. Keel indistinct. Mesophyll with radiate chlorenchyma. Bulliform cells restricted to 4 groups. O.S. to large vb's interrupted abaxially by scl. Short-cells, on the abaxial surface, paired.

S. discosporus Nees

Adaxial surface with rounded papillose ribs. Abaxial surface more or less undulating. Scl. present on the adaxial and abaxial sides of the vb's, and well developed in the pectinate, cilate leaf margins. Keel absent. Mesophyll with radiate chlorenchyma. Bulliform cells in groups of the *Sporobolus* type. Bundle-sheaths not interrupted by scl.

S. festivus Hochst.

Adaxial surface with low, rounded ribs with minute prickles. Abaxial surface smooth or slightly undulated. Scl. present on the adaxial and abaxial sides of the vb's. Keel absent. Mesophyll with radiate chlorenchyma. Bulliform cells in conspicuous groups of the *Sporobolus* type, each group being connected to the abaxial epidermis by a girder of colourless cells. Bundle-sheaths not interrupted by scl.; more or less triangular in outline. Short-cells, on the abaxial surface, in rows.

S. fimbriatus Nees

Adaxial surface prominently ribbed except over the keel, the broad ribs opposite the large vb's being flat-topped and the smaller ribs having rounded apices; prickles on the ribs infrequent. Abaxial surface more or less undulating. Scl. present on the adaxial and abaxial sides of the vb's; large vb's outside the keel girdered. Keel more or less distinct. Mesophyll with radiate chlorenchyma. Bulliform cells in groups of

the *Sporobolus* type. Sheaths to vb's in the keel, and to large vb's outside the keel, interrupted by scl. Short-cells, on the abaxial surface, in rows.

S. fourcadii Stent

Adaxial surface with low ribs, those opposite the large vb's having broad, flat tops. Abaxial surface with indistinct ribs. Scl. present on the adaxial and abaxial sides of the vb's; forming girders with large vb's outside the keel. Keel more or less distinct. Mesophyll with radiate chlorenchyma. Bulliform cells conspicuous, except in the keel, some of the groups being opposite the third-order vb's. O.S. to the first-order vb's, and vb's in the keel, interrupted abaxially by fibres. Short-cells, on the abaxial surface, paired.

S. iocladus Nees

Adaxial surface, outside the keel, with low ribs, those opposite the large vb's being flat-topped. Abaxial surface with ill-defined ribs. Scl. forming girders with the large vb's. Leaf margins minutely pectinate, ciliate. Keel prominent, rounded. Mesophyll with radiate chlorenchyma. Bulliform cells in conspicuous groups of the *Sporobolus* type. O.S. to the vb's in the keel region interrupted abaxially by scl. Short-cells, on the abaxial surface, in pairs or rows.

S. ludwigii Hochst.

Adaxial surface with slight ribs bearing prickles. Abaxial surface similar, but with less frequent prickles. Scl. present on the adaxial and abaxial sides of vb's and in the leaf margins. Keel absent. Mesophyll with radiate chlorenchyma. Bulliform cells in groups of the *Sporobolus* type, each group being connected to the abaxial surface by a girder of colourless cells. Bundle-sheaths not interrupted by scl. Short-cells, on the abaxial surface, in short rows.

S. nebulosus Hack.

Whole lamina rounded in T.S. Adaxial surface with 7 prominent ribs bearing prickles. Abaxial surface with 7 prominent, flat-topped ribs. Vascular bundles 5–7. Mesophyll with radiate chlorenchyma. Bulliform cells inconspicuous. Short-cells, on the abaxial surface, in rows. A few further details concerning what are stated to be varieties of this sp. have been recorded by Günzel (1912).

S. nitens Stent

Adaxial surface distinctly ribbed even over the keel; ribs opposite the large vb's flat-topped. Leaf margins undulating and spinulose, ciliate. Scl. forming girders with the large lateral vb's. Keel prominent. Mesophyll with radiate chlorenchyma. Bulliform cells in conspicuous groups of the *Sporobolus* type. Bundle-sheaths in the keel interrupted abaxially by fibres. Short-cells, on the abaxial surface, in pairs and occasional rows.

S. panicoides A. Rich.

Adaxial surface, outside the keel, with low ribs bearing prickles. Abaxial surface smooth or indistinctly undulating. Scl. forming girders with the large vb's outside the keel region. Keel distinct, rounded. Sheaths to the large vb's interrupted abaxially by scl.

S. pectinatus Hack.

Adaxial surface with distinct, flat-topped ribs. Abaxial surface with undulating ribs. Leaf margin with pectinate hairs. Scl. present on the adaxial and abaxial sides of the vb's, but not forming girders. Keel and midrib ill defined. Mesophyll with radiate chlorenchyma. Bulliform cells conspicuous. Bundle-sheaths not interrupted by scl. Short-cells, on the abaxial surface, alternating with long-cells.

S. pungens Kunth[1] (= *S. virginicus* (L.) Kunth)

Adaxial surface with about 18 well-developed ribs with rounded apices, separated from one another by V-shaped furrows. Abaxial surface smooth. Apices and upper part of the sides of the ribs papillose. (Zemke refers to 'salt glands' on the sides of the ribs, each gland consisting of a weakly cutinized epidermal cell and a larger subjacent cell penetrating into the mesophyll. These glands are probably micro-hairs which Zemke failed to recognize as such. C. R. M.)

S. robustus Kunth

Adaxial surface outside the keel, with low ribs bearing prickles. Abaxial ribs indistinct. Scl. present on the adaxial and abaxial sides of the vb's. Keel more or less distinct. Mesophyll with radiate chlorenchyma. Bulliform cells in groups of the *Sporobolus* type, each group often connected to the abaxial epidermis by a girder of colourless cells. Some groups of bulliform cells opposite the third-order vb's. Sheaths to vb's in the keel interrupted by fibres. Short-cells, on the abaxial surface, in pairs.

S. schlechteri Schweickerdt

Adaxial surface with low, rounded ribs bearing a few asperities (prickles). Abaxial surface faintly undulating. Scl. present above and below the vb's, the large vb's being girdered. Keel absent. Mesophyll with radiate chlorenchyma. Bulliform cells in groups of the *Sporobolus* type. Sheaths to large vb's interrupted abaxially by scl.; those to the small vb's triangular in outline. Short-cells, on the abaxial surface, in rows.

S. sladenianus Bolus.

Adaxial surface with low ribs, the ribs opposite the large vb's being flat-topped and the remainder with rounded apices. Abaxial ribs poorly defined. Scl. forming girders with the large vb's. Keel indistinct. Mesophyll with chlorenchyma not radiate. Bulliform cells in groups of the *Sporobolus* type. Short-cells, on the abaxial surface, in rows.

S. smutsii Stent

Similar to *S. iocladus* (see p. 473).

S. spicatus (Vahl) Kunth

Adaxial surface with flat-topped ribs opposite the large vb's, the ribs bearing a few prickles. Abaxial surface smooth to faintly undulated. Keel more or less distinct. Mesophyll with radiate chlorenchyma. Bulliform cells present outside the keel region, each group connected to the abaxial epidermis by a column of colourless cells. Bundle-sheaths interrupted abaxially by fibres. Short-cells, on the abaxial epidermis, in pairs.

S. subtilis Kunth

Leaf rounded in section. Adaxial surface with prominent ribs opposite the large vb's, and 2 large marginal projections. Abaxial surface smooth. Scl. forming girders with the large and medium-sized vb's. Keel absent. Mesophyll with radiate chlorenchyma. Bulliform cells in 2 groups on either side of the median adaxial rib. Bundle-sheaths of large and medium-sized vb's interrupted by scl. Short-cells, on the abaxial surface, in pairs.

[1] Description based on that by Zemke 1938–9.

S. tenellus Kunth

Adaxial surface with low ribs bearing numerous prickles. Abaxial surface slightly ribbed, with occasional prickles. Scl. present above and below the vb's and in the leaf margins. Keel absent. Mesophyll with radiate chlorenchyma. Bulliform cells present, each group connected to the abaxial epidermis by a girder of colourless cells. Bundle-sheaths not interrupted by scl. Short-cells, on the abaxial surface, in rows.

S. transvaalensis Goossens

Adaxial surface with prominent, low, rounded ribs bearing papillae (prickles). Abaxial surface slightly undulated. Scl. forming girders with the vb's, and also present in the leaf margins. Keel absent. Mesophyll with radiate chlorenchyma. Bulliform cells indistinct. Short-cells, on the abaxial surface, in rows.

S. usitatus Stent

Anatomically similar to *S. smutsii*, but margins not pectinate ciliate.

The leaf structure of *S. marginatus* Hochst. forma *glabrior*, as described by Günzel (1912) is said to be not unlike that of *S. nebulosus* (see p. 473). Schwabe (1949 *a* and *b*) has devoted considerable attention to the leaf anatomy of spp. of *Sporobolus* that occur in Argentina. In general the generic characters which he records are similar to those for the spp. described on pp. 462–71. He mentions, however, that *S. rigens* E. Desv., *S. maximus* Haumann, and *S. virginicus* (L.) Kunth are somewhat atypical for the genus and tend to resemble certain spp. of *Muhlenbergia*. *S. virginicus* is stated also to resemble *Epicampes* and *Lycurus*, and he considers that *Epicampes*, *Lycurus*, and *Muhlenbergia* should be classified with the Eragrosteae. Schwabe gives a key to the Argentinian spp. of *Sporobolus* based on the anatomical characters of the leaf. The separation of the spp. is based on variations in (i) the shape of the leaf in T.S.; (ii) the extent to which ribs and furrows are developed; (iii) the degree to which the O.S.s have girder-like extensions of colourless cells towards the adaxial epidermis; (iv) the extent to which the bundle-sheaths appear to be circular or triangular in T.S.; (v) the form and distribution of the bulliform cells; (vi) the extent to which the midrib is developed; and (vii) the number of different orders of vb's in the leaf. It will be noted that the characters that Schwabe regards as having specific diagnostic value are, for the most part, the same as those employed by Goossens for separating the African spp. that he examined. Similar variations were also of specific diagnostic value for other genera (see p. lv, Introduction). Holm (1901–2) has recorded some notes on the leaf structure of certain American spp. that were included in *Sporobolus* at the time when his paper was written. His outlook has a strong ecological bias.

Canfield (1934) records 6 spp. of *Sporobolus* from the Jornada Range as having solid culms. Bessey (1884) refers to and illustrates glandular tissue, consisting of columnar epidermal cells, on opposite sides of the pedicels of *S. heterolepis* A. Gray. The glandular tissue is subtended on its inner side by chlorenchyma.

Special Notes

Prat (1934, 1936) considers that the leaf epidermis is Chloridean, the swollen micro-hairs particularly pointing to this conclusion. The mesophyll he regards as 'panicoid'. *Sporobolus* is now usually treated as being the type genus of the tribe Sporoboleae. The leaf anatomy, in the author's opinion, indicates that whilst *Sporobolus* can be regarded as being in a distinct tribe, the Sporoboleae,

the affinities of this tribe would appear to be with the Chlorideae and Eragrosteae.

S. wrightii differs from the other spp. of *Sporobolus* examined by the author, and described above, in having micro-hairs that are 2- rather than 1-celled, and bulliform cells in groups of the *Arundo* rather than of the *Sporobolus* type.

Literature

Bessey 1884 (glandular tissue); Canfield 1934 (notes on culms); Duval-Jouve 1870, 1875 (leaf); Goossens 1938 (leaf); Grob 1896 (leaf); Günzel 1912 (leaf); Holm 1901–2 (leaf); Pée-Laby 1898 (leaf); Prat 1932, 1934, 1936, 1948 (leaf); Schwabe 1949 *a* and *b* (leaf); Wille 1916; Zemke 1938 (leaf; ecological anatomy of *S. pungens*).

STENOTAPHRUM

Diagnostic Generic Characters

Short-cells, over the veins, solitary and/or in long rows. Silica-bodies, over the veins, cross- to dumb-bell shaped, mostly nodular in certain spp. Micro-hairs present; each with the distal cell tapering to a pointed apex. Stomata with markedly triangular, or sometimes with low dome-shaped, subsidiary cells. Vascular bundles mostly small, crowded, and conspicuously angular. Mesophyll with partially radiate chlorenchyma. Bundle-sheaths single.

Species Specially Examined

***Stenotaphrum dimidiatum* (L.) Brongn.**

Leaf

Abaxial epidermis

(i) *Vaughan's material.* **Short-cells,** over the veins, solitary, and in rows of more than 5 cells; infrequent over, and v. infrequent or absent between, the veins. Occasional **silica-bodies,** between the veins, tall and narrow (Fig. I, 4); those over the veins cross-shaped (Fig. IA, 16) or intermediate between cross and dumb-bell shaped (Fig. IA, 17), but mostly nodular (Fig. IA, 18 (i)). **Macro-hairs:** none seen. **Micro-hairs** (Fig. VII, 4): length 63–72 μ; basal cells 18–24 (mostly 18–22) μ; distal cells 42–48 μ; distal cells tapering to pointed apices. **Prickle-hairs:** none seen. **Stomata** mostly with markedly triangular (Fig. IV, 1), but some with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells,** between the veins, with thin (Fig. V, 3*a–c*) to moderately thick, sinuous walls, some of the cells being rather short; interstomatal cells mostly with concave ends, the cells being rather long (Fig. V, 11).

(ii) *Ballard 1488.* Essentially similar to Vaughan's Mauritius specimen, but the following differences noted. **Silica-bodies** much more numerous, and those between the veins mostly tall, narrow, and crenate (Fig. IB, 24), or occasionally cross-shaped, but with a distorted appearance. **Prickle-hairs:** angular prickles (Fig. VI, 3) noted at the leaf margins, and hooks (Fig. VI, 5) fairly common in the intercostal zones. **Micro-hairs:** length 45–60 μ; basal cells 18–22 μ; distal cells 25–40 (mostly 32–40) μ.

T.S. lamina

Vascular bundles: most vb's small and densely crowded, the smallest with the xy. and ph. not easily distinguished from one another (Fig. VIII, 1), but most of them conspicuously to inconspicuously angular (Fig. VIII, 5 and 6); a few large vb's of basic type (Fig. VIII, 15). **Adaxial surface** practically smooth (Fig. XIV, 1). **Sclerenchyma:** many of the small vb's not accompanied by scl. (Fig. IX, 1); other small vb's, and the few large vb's, accompanied by minute adaxial and abaxial strands (Fig. IX, 4), many being no more than 1 or 2 cells wide and high, and the largest about 4 cells wide and 2 cells high, the abaxial usually being slightly larger than the corresponding adaxial strands. Median vb accompanied by a large, abaxial, crescent-shaped strand in the apex of the keel. **Keel** conspicuous to v. conspicuous, narrow; containing 1 large median vb accompanied on either side by 1–3 much smaller laterals (Fig. XIII, 2). **Mesophyll:** chlorenchyma radiate, but often not forming a complete halo round each vb, large, colourless cells abutting on to the abaxial side of these vb's. **Bulliform cells:** a single large group, more or less as in Fig. XV, 2, present on the adaxial surface over the median vb, but adaxial bulliform cells otherwise absent. Abaxial half of the mesophyll consisting of large colourless cells, as in the *Chloris* type (Fig. XV, 11), but on the abaxial side of the leaf. **Bundle-sheaths:** each vb surrounded by a single complete sheath (Fig. XI, 2*a–b*), the component cells being rather unequal in size.

Culm

Culm examined about 2 mm in diameter, with a wide, flattened or slightly concave surface on 1 side. Outlines more definitely oval in sections more remote from a node. No cavity present at the centre of the culm, but central ground tissue somewhat spongy. Epidermis subtended by a zone of about 4 layers of fibres on the flattened side of the culm, and elsewhere by only 1 layer of fibres. Hypodermal scl., except on the flattened side of the culm, bounded on the inner side by a zone of about 3–5 layers of large, thin-walled cells, followed by a second scl. ring 2–3 cells wide. Inner and outer scl. rings, on the flattened side of the culm, sometimes united to form the single, relatively thick, hypodermal layer of scl. already mentioned. Thin-walled tissue, between the inner and outer scl. rings, traversed at intervals by scl. girders, each with a single vb of the outermost circle embedded in it. Other vb's of the outermost circle not embedded in scl. girders in this way. All ground tissue enclosed by the inner scl. ring consisting of large, thin-walled cells with minute intercellular spaces between them. Scattered, somewhat angular vb's present in the inner ground tissue except at the v. centre of the culm.

Material Examined: (i) Supplied specially by R. E. Vaughan from Mauritius. (ii) F. Ballard 1488; Ceylon.

***Stenotaphrum secundatum* (Walt.) Kuntze**

Leaf

Abaxial epidermis

Short-cells, between the veins, solitary, and paired; those over the veins mostly in rows of more than 5 cells, but sometimes appearing to be solitary

when separated from one another by fairly long cells in the same files; abundant to common over and between the veins. **Silica-bodies,** between the veins, tall and narrow (Fig. I, 4); those over the veins occasionally cross-shaped (Fig. IA, 16), but more commonly intermediate between cross and dumb-bell shaped (Fig. IA, 17). **Macro-hairs:** none seen. **Micro-hairs:** length 54–75 (mostly 66–75) μ; basal cells 18–24 (mostly 18–22) μ; distal cells 40–62 μ; distal cells tapering to pointed apices (Fig. VII, 5). Hairs in the Kew material slightly shorter than in the Tasmanian material. **Prickle-hairs:** none seen. **Stomata** with markedly triangular (Fig. IV, 1) subsidiary cells. **Long-cells,** between the veins, with thin, sinuous walls (Fig. V, 3*a–c*); interstomatal cells mostly with concave ends, but sometimes rather long (Fig. V, 11).

T.S. lamina

Vascular bundles: most vb's small, crowded, and somewhat angular (Fig. VIII, 6); a few of the smallest with xy. and ph. not easily distinguished from one another (Fig. VIII, 1); a few large vb's of basic type (Fig. VIII, 15). **Adaxial surface** practically smooth (Fig. XIV, 1). **Sclerenchyma:** numerous small vb's not accompanied by scl. (Fig. IX, 1); other small vb's, and the large vb's, accompanied by minute adaxial and abaxial strands, the largest being about 4 cells wide and 2 cells high (Fig. IX, 4). Median vb accompanied by a large, crescent-shaped strand in the apex of the keel. **Keel** conspicuous, narrow; containing a large median vb accompanied on either side by about 2 much smaller laterals (Fig. XIII, 3 and 4). **Bulliform cells:** a single large group resembling Fig. XV, 2, present over the median keel vb; remainder of the adaxial epidermis composed of somewhat papillose cells, but cells not sufficiently large to be regarded as bulliform. Abaxial half of the mesophyll consisting of large colourless cells, as in the *Chloris* type (Fig. XV, 11), but on the abaxial side of the leaf. **Bundle-sheaths:** each vb surrounded by a single, complete sheath (Fig. XI, 2*a–b*), the component cells being slightly unequal in size.

RHIZOME (Tasmanian material)

Rhizome examined approximately oval in T.S. but with one narrow end slightly flattened or concave, the long diameter being about 4 mm. Cavity at the centre of the rhizome small, formed by the breakdown of the somewhat spongy, central ground tissue. Epidermis subtended by a single layer of thick-walled fibres of small diameter around the periphery of the rhizome, including the flattened side. A second, more deeply seated, ring of fibres about 4–6 cells wide also present, separated from the first by a zone of some 10–12 layers of thin-walled assimilatory tissue, with numerous small, scattered vb's embedded in it. Ground tissue enclosed by the inner scl. ring consisting of rounded, thin-walled cells with minute, triangular intercellular spaces between them. Vb's, besides the small vb's in the assimilatory tissue, consisting of larger vb's embedded in the inner fibre ring, and others scattered throughout most of the central, thin-walled ground tissue. Vb's in the central ground tissue mostly somewhat angular in outline.

ROOT (Kew material)

Root examined about 1 mm in diameter. External layer of cells moderately large in diameter, with thickened outer walls, the cells being elongated in a direction parallel with the axis of the root. External layer of cells bounded on the inner side by a zone of about 2–3 layers of fibrous cells slightly smaller in diameter, and with slightly lignified walls. Fibrous zone followed by a broad cortex with well-developed, apparently lysigenous, intercellular spaces in it. Inner boundary of the aerenchymatous part of the cortex separated, by a zone of about 3 layers of radiately arranged cells, from the stele with a circle of 10 conspicuous metaxylem vessels.

MATERIAL EXAMINED: (i) Supplied specially by W. M. Curtis from Botanic Garden, Hobart, Tasmania. (ii) Cultivated at Kew.

SPECIAL NOTE

Prat (1936) rightly regards the leaf structure as panicoid.

LITERATURE

Grob 1896 (leaf); Prat 1936 (leaf).

STIPA

DIAGNOSTIC GENERIC CHARACTERS

Leaf of most spp. acicular or junciform, and strongly supported by scl. Short-cells, over the veins, paired and in long rows; costal and intercostal zones not distinguishable in some spp. Silica-bodies, over the veins, especially when paired, tall and narrow, elliptical, or slightly crescent-shaped and fitting into concavities in adjacent cork-cells; those in rows ranging from cuboid or oblong to cross or dumb-bell shaped. Each dumb-bell shaped body usually not more than slightly constricted in the middle (as in Fig. IA, 18 (iii)), the outlines of the bodies sometimes resembling a figure 8. Micro-hairs absent. Stomata with low or tall dome-shaped subsidiary cells. Vascular bundles seldom small, not closely placed, and not conspicuously angular in outline. Mesophyll with chlorenchyma not radiate. Bulliform cells small or inconspicuous in many spp. Bundle-sheaths double.[1]

SPECIES SPECIALLY EXAMINED

***Stipa calamagrostis* (L.) Wahlenb.**

LEAF

Abaxial epidermis

Short-cells, between the veins, and over the small veins, mostly paired; those over the large veins in rows of more than 5 cells, although appearing to be solitary when separated by fairly long intervening cells in the same files. **Silica-bodies,** between the veins, and over the small veins, mostly fitting into

[1] The present author cannot agree that the O.S. in *Stipa* is obscure, as suggested by Brown (1958), although the cells in certain spp. are rather small.

concavities in adjacent cork-cells (Fig. I, 6–7), the bodies themselves being tall and narrow (Fig. I, 4), oval, or slightly crescent-shaped in outline. Silica-bodies over the large veins, cuboid to oblong (Fig. I, 10). **Macro-hairs :** short, rigid, thick-walled hairs (Fig. IIA, 10) present on the apices of the adaxial ribs, and most clearly visible in T.S. of the lamina. **Micro-hairs :** none seen. **Prickle-hairs :** angular prickles (Fig. VI, 3) at the leaf margins; prickles (Fig. VI, 1–2) also present at the apices of the adaxial ribs, and resembling papillae in T.S. of the leaf. **Papillae :** see prickle-hairs. **Stomata :** infrequent on the abaxial surface; with low (Fig. IV, 3), to tall (Fig. IV, 4), dome-shaped subsidiary cells. **Long-cells,** between the veins, with thin, non-sinuous (Fig. V, 2*a–c*) or only v. slightly sinuous, walls.

T.S. lamina

Vascular bundles : most vb's small to fairly large, not v. closely placed, and not angular in outline. **Adaxial surface** with v. pronounced, wide ribs separated from one another by deep, narrow, V-shaped furrows (Fig. XIV, 7); ribs v. unequal in size, the largest being less rounded at their apices than those over the small vb's. Furrows appearing to be W-shaped when consisting of a V-shaped furrow on either side of a v. low rib. **Sclerenchyma :** a few of the smallest vb's in the smallest ribs not accompanied by scl. (Fig. IX, 1); a few small vb's with well-marked abaxial girders only (Fig. IX, 3); combined girders of most vb's inversely anchor-shaped but of various types (Fig. IX, 8 and 10). **Keel** fairly conspicuous, rounded, but with ill-defined boundaries; could be interpreted as containing 1 median vb, or 1 median vb accompanied by several laterals of unequal sizes. **Mesophyll :** chlorenchyma not radiate. **Bulliform cells :** V-shaped furrows containing bulliform cells of unequal sizes, but none of them specially large (the *Ammophila* type, Fig. XV, 5). **Bundle-sheaths** double; smallest vb's with 2 complete sheaths (Fig. XII, 1), the O.S. sometimes having an extension of colourless cells usually reaching to the adaxial scl. to form part of an inversely T-shaped girder (see sclerenchyma above). Largest vb's with O.S. interrupted abaxially (Fig. XII, 4) or abaxially and adaxially (Fig. XII, 3*a*).

CULM

Culm examined about 3 mm in diameter, more or less circular in outline, and with a large central cavity. Epidermis subtended by a zone of fibres some 8 cells wide. Ground tissue between this fibrous ring and the cavity at the centre of the culm consisting of about 16 layers of moderately thin-walled cells. Vb's of the outermost circle embedded in the peripheral scl., and the remainder scattered throughout the inner ground tissue.

MATERIAL EXAMINED: Cultivated at Kew.

***Stipa dregeana* Steud.**

LEAF

Abaxial epidermis

Short-cells between, and some of those over, the veins, paired; others over the veins in rows of more than 5 cells; abundant both over and between the

veins. **Silica-bodies** between, and those in pairs over the veins, fitting into concavities in adjacent cork-cells (Fig. I, 6–7), the bodies themselves being tall and narrow (Fig. I, 4), elliptical, or slightly crescent-shaped in outline. Silica-bodies in rows over the veins rather variable, a few being oblong (Fig. I, 10), and others intermediate between cross and dumb-bell shaped (Fig. IA, 17), or dumb-bell shaped (Fig. IA, 18 (ii–v)). **Macro-hairs :** a few fairly long hairs, with slightly sunken but swollen and constricted bases, noted in T.S., on the apices of the ribs. **Micro-hairs :** none seen. **Prickle-hairs :** none seen on the abaxial surface, but prickles (Fig. VI, 1–2) present on the adaxial ribs, and resembling large papillae in T.S. of the leaf. **Papillae :** see prickle-hairs. **Stomata** with low dome-shaped subsidiary cells (Fig. IV, 3). **Long-cells,** between the veins, with thin, non-sinuous (Fig. V, 2*a–c*), or slightly sinuous (Fig. V, 3*a–c*), walls.

T.S. lamina

Vascular bundles : most vb's small, rather widely spaced, and not more than slightly angular in outline (Fig. VIII, 2 and 6); large vb's of basic type (Fig. VIII, 10). **Adaxial surface** with low but v. wide ribs (Fig. XIV, 2) over each vb, sometimes with a slight depression in the centre of the apex of the rib; ribs over the large vb's slightly taller than the others and with rounded apices; intervening furrows shallow and v. much narrower than the ribs. **Sclerenchyma :** a few vb's, especially those near the midrib, with well-marked adaxial girders only (Fig. IX, 2); most small vb's with adaxial and abaxial girders (Fig. IX, 4), the adaxial girders being about 3–5, or occasionally 6, cells wide and 2 cells high, and the corresponding abaxial girders slightly taller but not v. different in width. Large vb's with more massive adaxial and abaxial girders (Fig. IX, 5), the adaxial girders being up to about 20 cells wide and 2 or 3 cells high, and the abaxial girders usually rather narrower; combined girders often inversely anchor-shaped. Combined girder to the median keel vb tending to be anchor-shaped (Fig. IX, 6). **Keel** fairly conspicuous, wide and rounded; containing 1 large median vb accompanied on either side by a smaller lateral (Fig. XIII, 2). **Mesophyll :** chlorenchyma not radiate. **Bulliform cells** in fan-shaped groups (Fig. XV, 6) at the bases of the shallow furrows. **Bundle-sheaths** double; most of the small vb's each with 2 complete sheaths (Fig. XII, 1), large vb's with the O.S. interrupted abaxially (Fig. XII, 4) or adaxially and abaxially, and sometimes connected to the adaxial scl. by extensions of colourless cells.

CULM

Culm examined about 2 mm in diameter, circular in outline, and with only a small irregular cavity in the central ground tissue. Epidermis subtended by about 2 layers of small, assimilatory cells around most of the periphery of the culm, except where interrupted by small girders of scl. connecting some of the minute vb's of the outermost circle to the epidermis. Assimilatory tissue bounded on the inner side by a broad but irregular zone of fibres, some of the outer vb's being embedded in, or situated at the inner edge of, the fibrous zone. Inner ground tissue consisting wholly of cells with moderately thick walls and wide lumina, with minute, triangular, intercellular spaces

between many of the cells. Vascular bundles, apart from those already mentioned, embedded in the peripheral part of the inner ground tissue.

MATERIAL EXAMINED: From S. Africa.

Stipa hyalina Nees

LEAF

Abaxial epidermis

Short-cells, both between and over the veins, mostly paired, but some of those over the veins in rows of more than 5 cells, or occasionally in shorter rows; abundant both over and between the veins. **Silica-bodies,** between the veins, and those in paired short-cells over the veins, fitting into concavities in adjacent cork-cells (Fig. I, 6–7), the bodies themselves being tall and narrow (Fig. I, 4), or elliptical to rounded in outline. Bodies in rows of short-cells over the veins more or less cuboid, oblong (Fig. I, 10), or intermediate between cross and dumb-bell shaped (Fig. IA, 17). **Macro-hairs:** short, rigid, thick-walled hairs (Fig. IIA, 10) noted, in T.S. of the leaf, on the apices of the ribs. **Micro-hairs:** none seen. **Prickle-hairs:** none seen on the abaxial surface, but prickles (Fig. VI, 1–2) present on the adaxial ribs, and resembling papillae in T.S. of the leaf. **Papillae:** see prickle-hairs. **Stomata** v. numerous; with low (Fig. IV, 3), to tall dome-shaped (Fig. IV, 4), subsidiary cells. **Long-cells,** between the veins, with thin, slightly sinuous walls (Fig. V, 3*a–c*).

T.S. lamina

Vascular bundles: alternate vb's relatively small, rather widely spaced, and not more than slightly angular in outline (Fig. VIII, 2 and 6); alternating large vb's of basic type (Fig. VIII, 10 and 13). **Adaxial surface** with well-marked ribs, about the same height as, or rather taller than, the remainder of the mesophyll, the apices of the ribs being rounded or slightly flattened (Fig. XIV, 4); intervening furrows as deep as the ribs are tall, but rather narrower and with rounded bases. **Sclerenchyma:** most vb's accompanied by T-shaped adaxial strands, the arms of the T's being mostly 1 cell tall but occupying the full width of the apices of the ribs; stems of the T's 2–3 cells tall and wide, the base of each stem resting on and merging imperceptibly with an adaxial extension from the O.S. of the bundle below; corresponding abaxial girders about 8–16 cells wide and about 6 cells tall, the combined adaxial strands and abaxial girders thus being inversely anchor-shaped, resembling the type in Fig. IX, 10. **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** in fan-shaped groups at the bases of the furrows (Fig. XV, 6). **Bundle-sheaths** double; most vb's each with the I.S. complete and the O.S. either complete, or with a slight abaxial interruption, and an adaxial extension of colourless cells reaching to the scl. in the apices of the ribs (Fig. XII, 4 and 7).

CULM

Culm examined about 2 mm in diameter, circular in outline, with a fairly large central cavity. Epidermis subtended by conspicuous girders of fibres, each about 12 cells tall and some 2–10 cells wide, and serving to connect a vb of the outermost circle to the epidermis. Fibre girders alternating around the periphery of the culm with equally conspicuous columns of assimilatory tissue, these columns being the same height as, but mostly rather wider than, the girders. Girders and assimilatory tissue bounded on the inner side by a ring of thick-walled fibres about 2–8 cells wide. Ground tissue between the fibre ring and the cavity at the centre of the culm about 12 cells wide, the cells having thick walls, wide lumina, and minute, triangular intercellular spaces between them. Vb's, apart from those already noted as being connected to the epidermis by scl. girders, embedded in, or situated at the inner boundary of, the scl. ring.

MATERIAL EXAMINED: Cultivated at Kew.

Stipa pennata L.

LEAF

Abaxial epidermis

Short-cells mostly paired; but a few solitary; no clear distinction between costal and intercostal zones. **Silica-bodies** mostly fitting into slight concavities in the adjacent cork-cells (Fig. I, 6–7), the bodies themselves being tall and narrow (Fig. I, 4), round, elliptical, or slightly crescent-shaped in outline; a few oblong (Fig. I, 10). **Macro-hairs:** a few, short, thick-walled, superficial hairs with swollen bases (Fig. II, 1) present. Shorter, thick-walled hairs (Fig. IIA, 10) numerous on the apices of the adaxial ribs. **Micro-hairs:** none seen. **Prickle-hairs:** prickles (Fig. VI, 1–2), sometimes unpointed (Fig. VI, 6), frequent. **Stomata** absent from the abaxial surface. **Long-cells** with thick, pitted or sinuous walls (Fig. V, 1*a–b*).

T.S. lamina

Leaf acicular, the T.S. being as in Fig. X, 3. **Adaxial surface** with a median rib accompanied on either side by 4 lateral ribs of unequal sizes, the intervening furrows being fairly deep, v. narrow and V-shaped. Apices of the large ribs flattened, or with slight, median depressions. **Sclerenchyma:** smallest vb's with narrow abaxial girders only; all other vb's with adaxial and abaxial girders, the adaxial girders being T-shaped, the arms of the T's being only 1–2 cells tall but the same width as the ribs. Stems of the T's about 4–5 cells tall and about 2–5 cells wide. Corresponding abaxial girders about 6 cells tall and much wider than the adaxial girders. Abaxial epidermis subtended by a layer of fibres, about 2 cells tall, this layer serving to connect the bases of the abaxial girders to one another. **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** in U-shaped groups at the bases of the furrows, the cells not being specially large (Fig. XV, 5, the *Elymus* type). **Bundle-sheaths** double; small vb's with I.S. complete, but O.S. not quite complete abaxially (Fig. XII, 2); large vb's with O.S. interrupted adaxially and abaxially (Fig. XII, 3*a*).

MATERIAL EXAMINED: Cultivated at Kew.

***Stipa splendens* Trin.**

LEAF

Abaxial epidermis

Short-cells, between the veins, mostly paired; some of those over the veins also paired, but mostly in rows of more than 5 cells. **Silica-bodies** in the pairs of short-cells mostly fitting into slight concavities in adjacent cork-cells (Fig. I, 6–7), the bodies themselves mostly being rounded, or elliptical, and less frequently crescent-shaped in outline. Silica-bodies in rows of short-cells mostly oblong (Fig. I, 10). **Macro-hairs:** short, rigid, thick-walled hairs (Fig. IIA, 10) noted, in T.S., on the adaxial ribs. **Micro-hairs:** none seen. **Prickle-hairs:** small prickles (Fig. VI, 1) and hooks (Fig. VI, 5) present in the intercostal zones, but not v. numerous; angular prickles (Fig. VI, 3) at the leaf margins. Prickles also occurring on the apices of the large, adaxial ribs. **Stomata** rather infrequent; with low (Fig. IV, 3), to tall (Fig. IV, 4), dome-shaped subsidiary cells. **Long-cells,** between the veins, with thin (Fig. V, 3*a–c*) to moderately thick (Fig. V, 1*a–b*) sinuous or pitted walls.

T.S. lamina

Vascular bundles: small and large vb's mostly alternating with one another, the small vb's not being markedly angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 15), but many of them with slightly sclerosed ph. **Adaxial surface** with v. tall and much shorter ribs alternating with one another (Fig. XIV, 7), the tall ribs being more than twice as high as the remainder of the mesophyll; furrows between the tall ribs W-shaped, a v. small rib being present at the base of each furrow and forming the middle part of the W. **Sclerenchyma:** small vb's each with a well-marked abaxial girder only (Fig. IX, 3); large vb's with adaxial T- and abaxial I-girders (Fig. IX, 8). **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate, but with a tendency for palisade cells to develop on the sides of the adaxial ribs and below the abaxial epidermis. **Bulliform cells** in fan-shaped groups (Fig. XV, 6) at the bases of the furrows. **Bundle-sheaths** double; some small vb's, especially towards the leaf margin, each with 2 complete sheaths (Fig. XII, 1); large vb's with O.S. interrupted adaxially and abaxially (Fig. XII, 3*a*).

CULM

Culm examined about 3 mm in diameter; circular in outline; with a fairly large central cavity, partly filled with spongy tissue. Epidermis subtended by a more or less continuous zone of assimilatory tissue. Peripheral ground tissue, apart from the assimilatory tissue, consisting of a broad zone of fibrous cells, this zone gradually passing over into the inner ground tissue consisting of larger, thin-walled cells, with minute, triangular intercellular spaces between them. Vb's of the outermost circle deeply embedded in the peripheral scl. and the remainder scattered throughout the outer part of the inner, thin-walled ground tissue.

MATERIAL EXAMINED: Cultivated at Kew.

***Stipa tenacissima* L.**

LEAF

(For further notes on the structure of this sp., which is the main source of Esparto Grass, see information from the literature, below.)

Abaxial epidermis

Short-cells paired; abundant; no clear distinction between the costal and intercostal zones. **Silica-bodies** fitting into concavities in adjacent cork-cells (Fig. I, 6–7), the bodies themselves being mostly round or somewhat elliptical, and only rarely slightly crescent-shaped, the silica-bodies being much less tall than the cork-cells. **Macro-hairs:** none seen on the abaxial surface, but short, rigid, thick-walled hairs (Fig. IIA, 10), sometimes with curved apices, densely covering the adaxial ribs and furrows. **Micro-hairs:** none seen. **Prickle-hairs:** none seen on the abaxial surface, but a few prickles (Fig. VI, 1–2) present amongst the macro-hairs on the adaxial ribs; also recorded on the leaf margins (Mazoyer 1936). **Stomata** absent from the abaxial surface. **Long-cells** with thick pitted or sinuous walls (Fig. V, 1*a–b*).

T.S. lamina

Vascular bundles: most vb's small, not markedly angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 13 and 15). Small subsidiary vb's, either solitary or in pairs, noted on both sides of some of the abaxial scl. girders to the large and medium-sized vb's. **Adaxial surface** with alternate ribs of 2 v. distinct sizes (Fig. XIV, 7), the large ribs being at least twice as tall as the thickness of the rest of the lamina, and with shallow depressions in their apices, small ribs with rounded apices. Large ribs separated from one another by W-shaped furrows, a small rib being present at the base and forming part of each W. Small V-shaped, secondary furrows opening out from the sides and bases of some of the W-shaped furrows. **Sclerenchyma:** many of the small vb's each with a well-marked abaxial girder only (Fig. IX, 3); other vb's with adaxial T-, and v. tall abaxial I-, girders (Fig. IX, 8). Abaxial epidermis subtended throughout by a continuous zone of fibres, about 3–6 cells tall, serving to connect the bases of the abaxial I-girders to one another. **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells:** none present, not even at the bases of the adaxial furrows. **Bundle-sheaths** double; smallest vb's each surrounded by 2 complete sheaths, or O.S. with a slight abaxial interruption (Fig. XII, 2); large vb's with O.S. interrupted adaxially and abaxially (Fig. XII, 3*a*).

MATERIAL EXAMINED: Specimens in the Kew Museums from Tunisia and Spain respectively.

ADDITIONAL INFORMATION FROM THE LITERATURE

(*a*) *Structure of* S. tenacissima *in relation to its commercial uses*

Hoefer (1941–2) has drawn attention to variations in the reaction of fibres in different parts of the leaf when treated with lignin stains. He notes, furthermore, that tests with phloroglucin and hydrochloric acid on the one hand, and with Maule's

reagent on the other, do not give identical results. The application of these tests also shows that there are zonations in the degree of lignification in different layers of the cell-wall of an individual fibre as viewed in T.S. Hoefer states that the explanation of these facts is not fully understood, but it is probably bound up with differences in the chemical constitution of substances that pass under the term 'lignin', which is used by botanists in rather a loose sense.

In 1957 the present author's attention was drawn to the presence of stone-cells and parenchymatous cells in paper-making fibre prepared from Esparto Grass. The presence of the stone-cells was stated to impair the quality of the paper, and in consequence the question of their source became sufficiently important to be investigated. It was found that, although stone-cells do not occur elsewhere in the vegetative parts of the plant, they are present in the swollen basal part of the culm at or just above soil level. It is, therefore, desirable to ensure that the culm bases are not included in the raw material to be used as the source of Esparto fibre.

(*b*) *Notes on other spp. of* Stipa

Günzel (1921) has recorded the following information concerning *S. parviflora* Desf. Leaves bluish green, mostly cylindrical; rolled. Silica-bodies mostly dumb-bell shaped in the lamina, but those on the abaxial surface of the sheath stated to be saddle-shaped or round. Adaxial surface with tall ribs and deep furrows; abaxial surface weakly ribbed. Ratio of large to small vb's 1:1–3. Mesophyll with chlorenchyma not radiate. O.S.s not conspicuous. Günzel refers to air-canals sometimes replacing the colourless tissue between the vb's in the leaf sheath.

Holm (1901–2) gives further details concerning certain spp. of *Stipa*. Characters noted include short papillae on the adaxial surface of *S. avenacea* L. and *S. columbiana* Macoun (*S. minor* Scribn.); long hairs on the adaxial surface in *S. capillata* L., *S. comata* Tr. & Rupr., and *S. occidentalis* Thurb. (as *S. stricta* Vas.).

Pée-Laby (1898) has described the acicular leaf of *S. juncea* L.

Mazoyer (1936) has investigated and described the leaf anatomy of 10 N. African spp. of *Stipa*. The characters noted in these spp. agree with the generic diagnostic characters given on p. 479. Differences in the sinuosities in the walls of the long-cells, and variations in the occurrence and distribution of hairs, prickles, &c., as well as in the shapes of the silica-cells, were found by Mazoyer to be reliable for diagnostic purposes provided that leaves from corresponding positions on the plants were compared. As other authors have noted in other genera, the leaf epidermis was found to reach its maximum specialization in the uppermost leaf of the culm.

Mazoyer gives a key to the spp. based on leaf characters, the details of which can best be consulted in her paper.

Special Notes

Prat (1936) emphasizes that the leaf structure of *Stipa* is festucoid, but points out that the chromosomes in multiples of 12 are aberrant for this group.

Parodi and Freier (1945) regard *Stipa*, together with *Aciachne*, *Aristida*, *Nassella*, *Piptochaetium*, *Milium*, and *Oryzopsis*, as constituting the tribe Stipeae. On the basis of floral and anatomical characters the same authors conclude that *Stipa*, *Nassella*, and *Oryzopsis* form a closely related natural group; that *Piptochaetium* is v. distinct from *Stipa*; that *Aristida* is a distinct genus that cannot be confused with the others; that *Aciachne* is so unlike the other genera that it can best be regarded as constituting a subtribe on its own.

Literature

Chauveaud 1897 (notes on root structure, especially ph.); Duval-Jouve 1875 (leaf); Grob 1896 (leaf); Günzel 1921 (leaf); Haberlandt 1882; Hayek 1902 (leaf of *S. tenacissima* and its distinction from *Lygeum spartum*), Hoeffer 1941–2 (fibres in Esparto Grass); Holm 1901–2 (leaf); Mazoyer 1936 (leaf structure of N. African spp.); Paratore 1899 (leaf of *S. tenacissima*); Parodi and Freier 1945 (leaf); Pée-Laby 1898 (leaf); Prat 1936 (leaf); Stuber 1938 (leaf of *S. capillata*; ecological); Trabut 1889*a* (figures and brief descriptions of T.S. leaf of 5 spp. of *Stipa*, all similar to *S. tenacissima*); Wille 1916.

STREPTOCHAETA

Diagnostic Generic Characters

Short-cells, over the veins, solitary or in pairs. Silica-bodies, over the veins, saddle-shaped. Micro-hairs present; exceptionally long; each with the distal cell tapering to a pointed or rounded apex. Stomata with tall dome-shaped subsidiary cells. Vascular bundles widely spaced and none conspicuously angular in outline. Mesophyll with chlorenchyma not radiate; fusoid-cells present. Bundle-sheaths double.

Species Specially Examined

***Streptochaeta spicata* Schrad.**

Leaf

Abaxial epidermis

Short-cells, over the veins, solitary or paired; common over, but infrequent or absent between, the veins. **Silica-bodies** saddle-shaped (Fig. I, 9). **Macro-hairs:** none seen, but recorded on the adaxial surface by Page (1947). **Micro-hairs:** exceptionally long, but total length not accurately determined owing to the curvature of the basal cell; distal cell 48–76 (mostly 62–72) μ long; distal cells tapering to their pointed, and sometimes rounded, apices (Fig. VII, 5). **Prickle-hairs:** hooks (Fig. VI, 5) with rather long points, occasional in the intercostal zones. **Stomata** with fairly tall to tall dome-shaped subsidiary cells (Fig. IV, 3 and 4). **Long-cells,** between the veins, with thin, sinuous walls (Fig. V, 3*a–c*), some of them being rather short. Interstomatal cells with concave ends (Fig. V, 10–11). **Transverse veins** numerous.

T.S. lamina

Vascular bundles: small vb's widely spaced and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** practically smooth (Fig. XIV, 1), apart from slight, widely spaced ribs (Fig. XIV, 2) over the vb's. (The apparent ribbing may be an artefact in the dried material owing to the greater contraction of the mesophyll in the intercostal zones, as compared with the less contracted tissues where the vb's and associated scl. serve as supports. See also under 'midrib' below.) **Sclerenchyma:** most vb's accompanied by adaxial and abaxial girders some 2–5 cells wide and 2–3 high (Fig. IX, 4); large vb's with similar but slightly wider girders. **Midrib** conspicuous, owing to a marked, shortly stemmed, T-shaped adaxial projection with rather massive arms, and a much smaller, rounded

abaxial projection; containing a solitary vb. **Mesophyll:** chlorenchyma not radiate; distinctive in appearance because of the presence of 2 long, narrow fusoid-cells, with their narrow ends facing each other, in each intercostal zone, the narrow ends of the 2 members of each pair of these cells being separated from one another by a fairly wide girder of assimilatory tissue. **Bulliform cells:** in well-defined, regular groups about 5 cells long, but cells not much larger than those of the remainder of the epidermis (Fig. XV, 2); also in groups of specially large cells (*Zea* type, Fig. XV, 3). **Bundle-sheaths** double; most vb's with 2 complete sheaths (Fig. XII, 1); large vb's with O.S. slightly interrupted abaxially (Fig. XII, 2).

MATERIAL EXAMINED: Mus. Paris 13327; Brazil.

ADDITIONAL INFORMATION FROM THE LITERATURE

Page (1947), who has described the anatomy of the leaf of *S. spicata* Schrad. and *S. sodiroana* Hack., rightly emphasizes that in both spp. the structure of the broad leaves is similar to that of the leaves of the Bambuseae. Further resemblance to the Bambuseae is afforded by the occurrence, in both spp., of a short, pubescent petiole. The 2 spp. differ from one another in the structure of the midrib, for in *S. sodiroana* there are numerous peripheral vb's in this region, with 2 closely placed vb's at the centre. In *S. spicata*, on the other hand, the peripheral vb's are missing. The shapes of the fusoid-cells in the 2 spp. also differ. The ontogenetic development of the lamina, including that of the fusoid-cells, has also been described by Page.

SPECIAL NOTE

Page points out that *Streptochaeta* has been variously classified with the Bambuseae, as an ancestral grass, with the Oryzeae, and in the Paniceae. Of these alternatives, the leaf anatomy favours an affinity with the bamboos.

LITERATURE

Page 1947 (leaf).

STREPTOGYNA

DIAGNOSTIC GENERIC CHARACTERS

Short-cells, over the veins, in long rows. Silica-bodies, over the veins, saddle-shaped. Micro-hairs: none seen. Stomata with triangular subsidiary cells. Vascular bundles rather widely spaced; none conspicuously angular in outline. Mesophyll with chlorenchyma not radiate, the assimilatory tissue consisting of arm-cells; fusoid-cells present. Bundle-sheaths double.

SPECIES SPECIALLY EXAMINED

***Streptogyna crinita* Beauv. (*S. gerontogaea* Hook. f.)**

LEAF

Abaxial epidermis

Short-cells, between the veins, mostly paired, but occasionally in rows of about 3 cells; those over the veins in rows of more than 5 cells; abundant over

and between the veins. **Silica-bodies** saddle-shaped (Fig. I, 9) and rather large, those between being narrower than those over the veins. **Macro-hairs** and **micro-hairs:** none seen. **Prickle-hairs:** shortly pointed prickles (Fig. VI, 1–2), with v. inflated bases, local over the veins, and sometimes abundant; hooks (Fig. VI, 5) occasional between the veins. **Stomata** mostly with triangular (Fig. IV, 1) but some with dome-shaped, subsidiary cells. **Long-cells,** between the veins, with thin, sinuous or coarsely sinuous walls (Fig. V, 3*a–c*), those in the stomatal strips rather shorter than the others and more markedly sinuous (Fig. V, 7*a–b*). Interstomatal cells also coarsely sinuous in outline and with concave ends (Fig. V, 10–11).

T.S. lamina

Vascular bundles: small vb's rather widely spaced and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** practically smooth (Fig. XIV, 1) throughout much of the lamina, apart from slight ribs over some of the veins; much taller ribs with rounded apices present for a short distance on either side of the midrib (Fig. XIV, 3). Abaxial surface also slightly ribbed over the veins. **Sclerenchyma:** a few of the smallest vb's not accompanied by scl. (Fig. IX, 1); most vb's with adaxial and abaxial girders up to about 4 cells wide and 2 cells high (Fig. IX, 4), but girders to vb's near the midrib appreciably taller and wider (Fig. IX, 5), the adaxial ribs in this region being strongly supported by scl. **Keel** conspicuous, rounded, with the surface slightly ribbed; containing a complex system of vb's. (Near the adaxial surface there is a large, median vb connected to the epidermis by an anchor-shaped mass of scl. with 5 v. small, variously orientated vb's embedded in it. About 2 other vb's, on either side of the median vb, are also present near the abaxial surface of the midrib, but not embedded in scl. **Mesophyll:** chlorenchyma not radiate, consisting of arm-cells. A pair of conspicuous fusoid-cells present in each intercostal zone, the narrow ends of the cells being directed towards one another but separated by girders of mesophyll tissue some 2–3 cells wide, each of these girders being situated below a fan-shaped group of bulliform cells. **Bulliform cells** in fan-shaped groups (Fig. XV, 4), the cells penetrating to nearly half-way across the mesophyll; groups of bulliform cells especially large near the midrib. **Bundle-sheaths** double; small vb's with 2 complete sheaths (Fig. XII, 1); the few large vb's with I.S. complete, but O.S. not quite complete abaxially (Fig. XII, 2).

MATERIAL EXAMINED: D. H. Linder 1012; Liberia.

ADDITIONAL INFORMATION FROM THE LITERATURE

Jacques-Félix (1955) has published an illustration of the leaf epidermis of '*Streptogyna gerontogaea* Hook. f.' showing the structure as festucoid. Unlike those in the material described above, the silica-bodies are not shown as saddle-shaped, and the subsidiary cells to the stomata are shown as low dome-shaped and not as triangular.

Special Note

Jacques-Félix refers to the structure as bambuso-festucoid. To the present author the structure of the mesophyll and keel points to affinities with the Bambuseae.

Literature

Jacques-Félix 1955 (leaf and taxonomy); Tateoka 1958 *b* (Cytology), 1958 *c* (Leaf).

TETRAPOGON

Sabnis (1921) gives the following particulars concerning the leaf of *T. villosus* Desf. under *Chloris villosa* Pers.

Adaxial surface with low but numerous ribs separated from one another by narrow, shallow furrows. Scl. as small to low and wide adaxial and abaxial girders to the vb's, the larger vb's being supported by the wider girders. Mesophyll with radiate chlorenchyma, the chlorenchyma being interrupted adaxially and abaxially by the scl. just described. Bundle-sheaths: those to the large vb's illustrated as double and those to the small vb's as single. Bulliform cells and subjacent colourless cells forming girders connecting the adaxial to the abaxial epidermis between the vb's.

Special Note

Leaf structure imperfectly known, but panicoid. The genus belongs to the Chlorideae.

Literature

Sabnis 1921 (leaf).

TETRARRHENA

Diagnostic Generic Characters

Short-cells, over the veins, sometimes paired but mostly in long rows. Silica-bodies, over the veins, mostly slightly cross-shaped or rounded and with slight apical and basal concavities. Short micro-hairs present. Stomata absent from the abaxial surface in the sp. examined. Vascular bundles rather widely spaced and none markedly angular in outline. Mesophyll with chlorenchyma not radiate. Bundle-sheaths double.

Species Specially Examined

***Tetrarrhena distichophylla* R. Br.**

Leaf

Abaxial epidermis

Short-cells between, and a few of those over, the veins paired; others over the veins in rows of more than 5 cells. **Silica-bodies,** between the veins, mostly fitting into concavities in adjacent cork-cells (Fig. I, 6–7), the bodies themselves being tall and narrow (Fig. I, 4), oval, rounded, or occasionally slightly crescent-shaped in outline. Silica-bodies over the veins mostly tending to be

slightly cross-shaped (Fig. IA, 16), or rounded and with slight apical and basal concavities. **Macro-hairs:** short-rigid, superficial hairs (Fig. IIA, 10), and transitions to prickles, abundant in the intercostal zones. Similar but somewhat longer hairs also noted, in T.S. of the leaf, on the adaxial ribs. Bases of occasional, v. much larger hairs also seen on the apices of the adaxial ribs. Occasional, more flexuous hairs occurring in the intercostal zones on the adaxial surface. **Micro-hairs:** length (26–37 (mostly 26–35) μ; basal cells 16–21 μ; distal cells 7–17 (mostly 7–12) μ; hairs rather short and approximating to those in Fig. VII, 2, but the distal cell often tapering to a point, and the basal cells much narrower at the proximal ends than at their apices (Fig. VII, 11). **Prickle-hairs:** certain of the short macro-hairs in the intercostal zones resembling small prickles (Fig. VI, 1), or even hooks (Fig. VI, 5), when sufficiently short-pointed. **Stomata** absent from the abaxial surface. **Long-cells,** between the veins, rather short, with conspicuously, and often acutely, sinuous walls (Fig. V, 6). **Transverse veins** fairly frequent.

T.S. lamina

Vascular bundles: most vb's small, fairly widely spaced, and not markedly angular in outline (Fig. VIII, 2); a few large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with moderately well-developed, rounded ribs of approximately uniform size, the intervening furrows being slightly narrower than the ribs and moderately deep (Fig. XIV, 3). **Sclerenchyma:** all vb's with adaxial girders, the girders to the small vb's appearing to be tall and narrow (Fig. IX, 7); adaxial girders to the small vb's 2–6 cells high and 1–2, or occasionally partly 3, cells wide; corresponding abaxial girders seldom more than 4 cells wide and 2–4 cells high. Girders to the large vb's similar, but sometimes slightly wider. **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** in small, fan-shaped groups (Fig. XV, 6) at the bases of the furrows. **Bundle-sheaths** double; a few small vb's with 2 complete sheaths (Fig. XII, 1); remainder with I.S. complete but O.S. not quite complete abaxially (Fig. XII, 2).

Rhizome

Rhizome examined 2 mm in diameter, circular in outline and with a solid but somewhat spongy centre. Epidermis subtended by about 2 layers of fibres with thick walls and narrow lumina, followed, on the inner side, by a zone of thin-walled cells some 3–6 cells wide, the thin-walled zone being traversed by fibrous girders connecting the few outermost vb's to the hypodermal scl. A few, small, apparently schizogenous, intercellular spaces present in the zone of thin-walled tissue. Thin-walled zone bounded on the inner side by a second zone of thick-walled fibres about 6–10 cells wide. Ground tissue surrounded by the inner scl. zone consisting of thin-walled cells, and becoming progressively more spongy towards the centre of the rhizome. Cells of the central ground tissue containing starch. Vb's confined to the inner zone of fibres.

Material Examined: Specially supplied by W. M. Curtis from Kettering, S. Tasmania.

Special Notes

Prat (1936) points out that the epidermal structure in this genus is panicoid, indicating that the genus should be excluded from the Phalarideae. The leaf characters are not, however, wholly panicoid. The micro-hairs recall those of the Chlorideae.

Literature

Prat 1936 (leaf).

THEMEDA

Diagnostic Generic Characters

Short-cells, over the scl. near the leaf margins, in pairs or sometimes solitary; those over the veins in short or long rows. Silica-bodies, over the veins, cross to dumb-bell shaped; some nodular in certain spp. Micro-hairs usually present, but none seen on the abaxial surface of the leaf in certain spp.; each with the distal cell tapering to a pointed apex, or sometimes more uniform in diameter throughout its length. Stomata mostly with triangular, but sometimes with low dome-shaped subsidiary cells. Vascular bundles mostly small, crowded, and conspicuously angular in outline. Mesophyll with distinctly to inconspicuously radiate chlorenchyma. Bundle-sheaths single.

Species Specially Examined

***Themeda australis* (R. Br.) Stapf**

Leaf

Abaxial epidermis

Short-cells, between the veins, solitary or sometimes paired; those over the scl. near the leaf margins also paired; those over the veins, in rows of more than 5 cells; abundant over, but infrequent between, the veins. Rare **silica-bodies,** between the veins, tall and narrow (Fig. I, 4) or tall, narrow, and crenate (Fig. IB, 24); silica-bodies over the veins mostly cross-shaped (Fig. IA, 16), intermediate between cross and dumb-bell shaped (Fig. IA, 17), or even dumb-bell shaped (Fig. IA, 18 (ii–v)). Silica-bodies in paired short-cells over the scl. near the leaf margin cross-shaped, but with a distorted appearance. **Macro-hairs:** none seen. **Micro-hairs:** length 50–72 (mostly 50–64) μ; basal cells 36–54 (mostly 36–48) μ; distal cells 13–18 μ; distal cells always appreciably shorter than the basal cells, and generally tapering to pointed apices (Fig. VII, 9). **Prickle-hairs:** prickles (Fig. VI, 1–2) with large, swollen bases, common over the veins; small hooks (Fig. VI, 5) occasional in the intercostal zones. **Papillae:** small, thin to moderately thick, somewhat globose and often somewhat oblique papillae (Fig. III, 3) present on the long-cells, each cell usually having only 1 row of papillae. **Stomata** mostly with markedly triangular (Fig. IV, 1) subsidiary cells. **Long-cells,** between the veins, with thin to moderately thick, slightly sinuous walls (Fig. V, 3*a–c*).

T.S. lamina

Leaf often tapering to a filiform point; margins recurved on drying (Vickery 1935). **Vascular bundles:** small vb's numerous and crowded, the smallest with the xy. and ph. not easily distinguished from one another (Fig. VIII, 1); slightly larger vb's pentagonal to hexagonal (Fig. VIII, 4) or polygonal (Fig. VIII, 5); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** practically smooth (Fig. XIV, 1), apart from a wide median groove over the midrib. **Sclerenchyma:** numerous small vb's, especially those opposite the bulliform cells, not accompanied by scl. (Fig. IX, 1); a few other small vb's with minute adaxial girders only (Fig. IX, 2); a few small vb's in the keel with abaxial girders only (Fig. IX, 3); small vb's in the lamina, other than those opposite the bulliform cells, with minute adaxial and abaxial girders (Fig. IX, 4), the adaxial girders often being no more than about 2 cells wide and 3–4 cells high, and the abaxial girders about the same size or, more often, slightly wider. Large vb's with adaxial and abaxial girders up to about 6 cells wide and 1–3 cells high. Median keel bundle strongly supported by a large, crescent-shaped, abaxial girder in the apex of the keel. **Keel** v. conspicuous, narrow; containing 1 large median vb sometimes accompanied on either side by 2 or 3 smaller vb's (Fig. XIII, 3). **Mesophyll:** with distinctly radiate chlorenchyma. **Bulliform cells** in irregular groups (Fig. XV, 1) constituting practically the whole of the adaxial epidermis; also as a single, rather large, more or less fan-shaped group at the base of the adaxial furrow above the keel (Fig. XV, 6). **Bundle-sheaths** single; each small vb surrounded by a single complete sheath, the component cells being rather unequal in size (Fig. XI, 2*a*); large vb's each with a sheath of less inflated, sclerosed cells, the sheaths being interrupted abaxially (Fig. XI, 6).

Culm

Culm examined about 2 mm in diameter; circular to somewhat oval in outline, with somewhat spongy tissue at the centre. Epidermis subtended by a well-marked zone of fibres, some 6 cells wide. Assimilatory tissue probably present, embedded amongst the scl. cells. Remaining ground tissue consisting of large, thin-walled cells with minute, triangular intercellular spaces between them. Vb's of the outermost circle embedded in the peripheral scl. Remaining vb's in about 2 irregular circles, embedded in the outer part of the central, thin-walled ground tissue.

Material Examined: Specially supplied by W. M. Curtis from Queen's Domain, Tasmania.

***Themeda quadrivalvis* (L.) Kuntze**

Leaf

Abaxial epidermis

Short-cells, between the veins, solitary and paired; those over the veins mostly in rows of more than 5 cells; those over the scl. at the leaf margins frequently paired; common over, but rather infrequent between, the veins. **Silica-bodies,** between the veins, seldom to be seen, but, where observed, tall and narrow (Fig. I, 4); those over the veins mostly dumb-bell shaped, with a

rather wide middle portion (Fig. IB, 19); cross-shaped (Fig. IA, 16) and intermediate types (Fig. IA, 17) also present. **Macro-hairs** and **micro-hairs**: none observed. **Prickle-hairs**: a few prickles (Fig. VI, 1–2), with short points and inflated bases, present over the veins; angular prickles (Fig. VI, 3) present at the leaf margins. **Papillae**: small, thin to moderately thick, somewhat globose and often somewhat oblique papillae (Fig. III, 3) present on the long-cells, each cell usually having only 1 row of papillae; interstomatal cells typically with 4–6 papillae in 2 rows. **Stomata** mostly with triangular (Fig. IV, 1), but sometimes with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells,** between the veins, with thin, sinuous walls (Fig. V, 3*a–c*).

T.S. lamina

Vascular bundles: most vb's small, crowded, the smallest with the xy. and ph. not easily distinguished from one another (Fig. VIII, 1); others polygonal (Fig. VIII, 5); a v. few large vb's of basic type (Fig. VIII, 15). **Adaxial surface** practically smooth (Fig. XIV, 1), apart from a large groove over the midrib. **Sclerenchyma**: many small vb's, especially those opposite the bulliform cells, not accompanied by scl. (Fig. IX, 1); other small vb's and most of the large vb's with minute adaxial and abaxial girders, mostly up to 2 or 3 cells wide and high (Fig. IX, 4). Median keel bundle accompanied by a slightly crescent-shaped abaxial girder in the apex of the keel. **Keel** conspicuous, narrow but with a rounded apex; containing 1 fairly large median vb accompanied on either side by a smaller lateral (Fig. XIII, 2). **Mesophyll**: chlorenchyma distinctly, but sometimes rather imperfectly, radiate around the small vb's. **Bulliform cells** in irregular groups (Fig. XV, 1) constituting practically the whole of the adaxial epidermis; a single, large, fan-shaped group (Fig. XV, 6) present at the base of the adaxial groove over the keel. **Bundle-sheaths** single; all vb's each with a complete sheath (Fig. XI, 2*a–b*) consisting of cells of rather unequal sizes.

CULM

Culm examined about 2 mm in diameter, slightly flattened on one side, the centre being occupied by a rather irregular cavity locally plugged with spongy tissue. Epidermis subtended by a zone of fibres some 4–6 cells wide. Ground tissue on the inner side of the scl. ring consisting of large, thin-walled cells, with minute, triangular intercellular spaces between them. Vb's of the outermost circle embedded in the peripheral scl. Remaining vb's scattered throughout the thin-walled ground tissue, the individual bundles being somewhat angular in outline.

MATERIAL EXAMINED: Specially supplied by R. E. Vaughan from Mauritius.

***Themeda tremula* (Nees ex Steud.) Hack.**

LEAF

Abaxial epidermis

Short-cells: those between the veins and over the marginal scl. solitary or paired; those over the veins mostly in short or long rows; common over, but

rather infrequent between, the veins. **Silica-bodies,** between the veins, rather infrequent and tall and narrow (Fig. I, 4), tall, narrow, and crenate (Fig. IB, 24), or cross-shaped (Fig. IA, 16), but with a distorted appearance; those over the veins dumb-bell shaped, but varying in appearance with the focus (Fig. IB, 21), or nodular (Fig. IB, 22 (iii)); a few intermediate between cross and dumb-bell shaped (Fig. IA, 17). **Macro-hairs**: none seen. **Micro-hairs**: length 38–44 μ; basal cells 18–25 (mostly 18–22) μ; distal cells 16–22 (mostly 16–20) μ; distal cells sometimes tapering to pointed apices, but others of more uniform diameter throughout their lengths and with more rounded apices; as Fig. VII, 9 but basal and distal cells much more alike in length. Micro-hairs of Ballard 1159, rather shorter than those of Ballard 1362. **Prickle-hairs**: large prickles (Fig. VI, 2) with v. inflated, oval bases, abundant over the veins; angular prickles (Fig. VI, 3) of unequal sizes present at the leaf margins. Low adaxial and abaxial ribs made to appear more prominent, in T.S. of the leaf, by prickles on their apices. **Papillae**: small, variously shaped, thickened, cuticular warts (Fig. III, 5) abundant on the long-cells, there being several rows of papillae to each cell. **Stomata** mostly with triangular (Fig. IV, 1) subsidiary cells. **Long-cells,** between the veins, with thin, sinuous walls (Fig. V, 3*a–c*), the sinuations being somewhat rounded.

T.S. lamina

Vascular bundles: most vb's small and crowded, the smallest with the xy. and ph. not easily distinguishable from one another (Fig. VIII, 1); others pentagonal to hexagonal (Fig. VIII, 4), or polygonal (Fig. VIII, 5); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with slight, widely spaced ribs (Fig. XIV, 2) over the large, and some of the small, vb's. Similar small ribs also present on the abaxial surface. A single, prominent, adaxial groove present over the midrib. **Sclerenchyma**: many small vb's, especially those opposite the bulliform cells, not accompanied by scl. (Fig. IX, 1); others with minute abaxial strands or girders only; small vb's, other than those opposite the bulliform cells, accompanied by minute adaxial and abaxial strands or girders, usually not more than 2–3 cells wide and high (Fig. IX, 4); large vb's with adaxial and abaxial girders up to 5 cells wide and generally about 2 cells high. Median vb supported by a crescent-shaped strand or girder in the apex of the keel. **Keel** conspicuous, narrow, but with a rounded apex; containing 1 large median vb accompanied on either side by a much smaller lateral (Fig. XIII, 2). **Mesophyll**: chlorenchyma rather indistinctly radiate in the dried material available. **Bulliform cells** in irregular groups (Fig. XV, 1) constituting most of the adaxial epidermis, a single large, fan-shaped group (Fig. XV, 6) being present at the base of the adaxial groove over the keel. **Bundle-sheaths** single; each small vb with a complete sheath consisting of cells of rather unequal sizes (Fig. XI, 2*a*); sheaths to the large vb's with narrow abaxial interruptions.

CULM

Culm examined about 2 mm in diameter; oval in outline; centre occupied by somewhat spongy tissue. Epidermis subtended by 1–2 layers of distinctly fibrous cells of small diameter, followed by ground tissue exhibiting a gradual

transition to the large, thin-walled, spongy cells at the centre of the culm, minute, triangular intercellular spaces being present between some of the cells. Most of the vb's arranged in 2 more or less distinct circles in the peripheral part of the culm. Two bundles, on opposite sides of the culm, penetrating more deeply into the inner ground tissue, these bundles being more markedly angular in outline than the remainder.

MATERIAL EXAMINED: (i) F. Ballard 1362 and (ii) 1159; Ceylon.

***Themeda triandra* Forsk.**

LEAF

Abaxial epidermis

Short-cells, between the veins, mostly solitary, but occasionally paired; pairs also present over the marginal scl.; those over the veins mostly in rows of more than 5 cells. **Silica-bodies:** conspicuous bodies seldom seen between the veins, but, when present, tall and narrow (Fig. I, 4) or cross-shaped (Fig. IA, 16), but often with a distorted appearance; cross-shaped bodies also present over the scl. at the leaf margins; those over the veins intermediate between cross and dumb-bell shaped (Fig. IA, 17), or dumb-bell shaped but varying in appearance with the focus (Fig. IB, 21). **Macro-hairs:** none seen, but hairiness stated by Goossens and Theron (1934) to be variable. **Micro-hairs:** length 26–48 μ; basal cells 14–30 μ; distal cells 10–22 μ; distal cells usually tapering to pointed apices (Fig. VII, 9). **Prickle-hairs:** hooks (Fig. VI, 5) occasional in the intercostal zones. **Papillae:** small, thin to moderately thick, somewhat globose and often somewhat oblique papillae (Fig. III, 3) present on the long-cells, each cell usually having only 1 row of papillae; some papillae more in the nature of cuticular warts (Fig. III, 5); interstomatal cells commonly with a pair of papillae on each cell, the papillae being in 2 rows. **Stomata** with slightly triangular (Fig. IV, 1), or low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells,** between the veins, with thin, slightly sinuous walls (Fig. V, 3*a–c*); interstomatal cells with concave ends (Fig. V, 10–11).

T.S. lamina

Vascular bundles: most vb's small and crowded, the smallest with the xy. and ph. not easily distinguishable from one another (Fig. VIII, 1); others pentagonal to hexagonal (Fig. VIII, 4) or polygonal (Fig. VIII, 5); a few large vb's of basic type (Fig. VIII, 10). **Adaxial surface** practically smooth (Fig. XIV, 1), apart from slight, widely spaced ribs over the large vb's (Fig. XIV, 3), a marked adaxial rib near one of the leaf margins, and a slightly less pronounced rib near the other margin. A single prominent, adaxial groove present over the midrib. **Sclerenchyma:** numerous small vb's, especially those opposite the bulliform cells, not accompanied by scl. (Fig. IX, 1); medium-sized vb's with adaxial and abaxial girders seldom more than about 3 or 4 cells high and wide (Fig. IX, 4); large vb's with adaxial and abaxial girders slightly more robust and often more highly lignified. Median keel vb supported by a large, conspicuous, crescent-shaped girder occupying the whole of the apex of the keel; lateral keel bundles with abaxial girders only. **Keel** conspicuous, narrow,

but with a rounded apex; containing 1 large median vb accompanied on either side by a much smaller lateral (Fig. XIII, 2). **Mesophyll:** chlorenchyma distinctly radiate. **Bulliform cells** in irregular groups (Fig. XV, 1) constituting most of the adaxial epidermis; also a single, large, fan-shaped group (Fig. XV, 6) present at the base of the median groove in the keel. **Bundle-sheaths** single; each small vb with a complete sheath consisting of cells of rather unequal sizes (Fig. XI, 2*a*); sheaths to the large vb's with abaxial interruptions (Fig. XI, 6).

ROOT

For root of *T. triandra* see below.

MATERIAL EXAMINED: F. Ballard 1361; Ceylon.

ADDITIONAL INFORMATION FROM THE LITERATURE

Vickery's (1935) description of *T. avenacea* (F. Muell.) Hack. includes these notes. Leaves narrow, becoming filiform; margins seldom recurved, but leaf folding inwards on drying. Vascular bundles: about 7–11 large vb's present, with 3–7 small vb's between each pair of large ones. Some of the small vb's situated opposite the adaxial grooves. Adaxial surface with low ribs and shallow grooves, or not more than slightly undulating. Abaxial surface flat. Scl. forming girders with every second vb, and present on the abaxial side of, and sometimes connected with, the other vb's. Midrib conspicuous. Mesophyll with chlorenchyma tending to be radiate. Bulliform cells in groups of 3–8 cells at the bases of the grooves, and there occupying a quarter to one-third of the thickness of the leaves. Adaxial portion of the ground tissue of the midrib consisting of colourless cells. Bundle-sheaths single; circular to oval in outline. The information about this sp. recorded by Breakwell (1915) is similar.

The root of *T. triandra* Forsk. has been described by Goosens and Theron (1934), whose description includes the following particulars. Root cap pale yellow in young, but becoming darker and mucilaginous in old, roots. A mucilaginous sheath covers 6 cm from the apex of the root. A 1-, or occasionally 2-, layered exodermis, composed of thickened suberized cells, present next to the epiblem. A zone of scl., 5 cells wide in plants from damp, and 10 cells wide in those from dry, localities, developing on the inner side of the exodermis, followed in turn by a 3-zoned cortex with air-lacunae in the middle zone. Endodermis conspicuous, the inner tangential walls of the component cells being thickened. Stele consisting of a 2–3-layered pericycle composed of parenchymatous cells that become thickened and lignified; ph. in up to about 40 strands; xy. in groups reaching outwards to the pericycle, with a ring of large vessels. Pith thin-walled when young but becoming thickened, with short radiating arms extending outwards between the vessels.

SPECIAL NOTES

Leaf structure mainly panicoid.

Lamina of *T. triandra* distinctly thicker than that of *T. tremula*, partly because the adaxial bulliform cells are much larger.

LITERATURE

Breakwell 1915 (leaf); Goosens and Theron 1934 (root and leaf); Grob 1896 (leaf); Mes and Aymer-Ainslee 1935 (stomata in relation to water loss); Vickery 1935 (leaf).

THYSANOLAENA

Diagnostic Generic Characters

Short-cells, over the veins, in long rows. Silica-bodies, over the veins, mostly cross to dumb-bell shaped, some with slight concavities in their ends. Micro-hairs present; each with a spherical or slightly tapered distal cell. Stomata with slightly triangular or low dome-shaped subsidiary cells. Vascular bundles fairly widely spaced and none markedly angular in outline. Mesophyll with chlorenchyma not radiate and consisting of arm-cells. Bundle-sheaths double.

Species Specially Examined

***Thysanolaena maxima* (Roxb.) Kuntze**

Leaf

Abaxial epidermis

Short-cells, between the veins, mostly paired; those over the veins in rows of more than 5 cells; common to abundant both over and between the veins. **Silica-bodies,** between the veins, sometimes tending to be tall and narrow (Fig. I, 4), but many of them somewhat crescent-shaped, lobed, or even tending to be of the *Oryza* type (Fig. Ib, 23) but with a somewhat distorted appearance; those over the veins mostly intermediate between cross and dumb-bell shaped (Fig. Ia, 17), some of them having slight concavities in their ends. **Macro-hairs:** none seen. **Micro-hairs:** length 20–25 μ; basal cells 8–12 μ; distal cells 10–14 μ; distal cells spherical, although sometimes tapering slightly towards their apices, the basal cells usually being somewhat narrower than the distal cells (Fig. VII, 2 and 11). **Prickle-hairs:** hooks (Fig. VI, 5) v. abundant between the veins. **Stomata:** some with slightly triangular (Fig. IV, 1), but mostly with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells,** between the veins, with thin, v. coarsely sinuous walls (Fig. V, 3*a–c* and 6); interstomatal cells with concave ends (Fig. V, 10–11) and rather variable in length.

T.S. lamina

Vascular bundles: most vb's fairly widely spaced, of moderate size, and not markedly angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with slight, rounded ribs over the vb's, separated from one another by shallow furrows with a group of bulliform cells at the base of each furrow. Ribs on the abaxial surface rather more pronounced, the apex of each being supported by scl. Ribs on both surfaces of the midrib more pronounced than those elsewhere. **Sclerenchyma:** 1 small vb next to and on either side of the median vb with a well-marked abaxial girder only (Fig. IX, 3); vb's throughout most of the lamina with adaxial and abaxial girders of rather uniform size, the adaxial girders being 8–10 cells wide and mostly 3–4 cells high, but those to the large vb's often only 1 cell high; abaxial girders mostly slightly T-shaped, about 6 cells high and 7–10 cells wide between the tips of the arms, those to the large vb's being more massive and less T-shaped than the remainder (Fig. IX, 4 and 6). Median keel vb with a massive, anchor-shaped, abaxial girder. **Keel** conspicuous, wide, ribbed; containing 1 large median vb accompanied on either side by a much smaller lateral, and sometimes by a second, larger vb (Fig. XIII, 2 and 3). **Mesophyll:** chlorenchyma not radiate; consisting of arm-cells. **Bulliform cells** in groups of the *Sporobolus* type (Fig. XV, 8). **Bundle-sheaths** double; most vb's with 2 complete sheaths (Fig. XII, 1), the O.S. sometimes having a slight extension of colourless cells to connect with the adaxial scl.; some large vb's with the O.S. interrupted abaxially (Fig. XII, 2), or abaxially and adaxially (Fig. XII, 3*a*).

Material Examined: Foster 49; North Borneo.

Additional Information from the Literature

The information concerning the leaf structure recorded by Tateoka (1956*h*) agrees quite well with the description given above.

Special Notes

Tateoka (1956*h*) believes that *Thysanolaena* stands out rather conspicuously from other grasses on the basis of its leaf structure, and considers that Hubbard (in Hutchinson 1934) is correct in making it the basis of a distinct tribe. The general combination of leaf characters, to the present author, recalls the structure of bamboos apart from the absence of the fusoid-cells, which are generally characteristic of, but not universally present in, the Bambuseae. It also recalls the Oryzeae in some of its characters.

Literature

Tateoka 1956*h* (leaf; taxonomy), 1957*a*.

TIMOURIA

For the leaf anatomy of the grass previously known as *T. aurita* Hitchcock see under *Trikeraia hookeri* (Stapf) Bor on p. 504. The plants previously known as *Timouria mongolica* (Hitch.) Roshev. and *T. villosa* (Trin.) Hand.-Mazz. are now regarded by Bor (1951) as synonymous with *Psammochloa villosa* (Trin.) Bor. The anatomy of this last grass is described on p. 411.

Literature

Bor 1951, 1954.

TRAGUS

Diagnostic Generic Characters

Short-cells, over the veins, mostly in long rows, but sometimes paired. Silica-bodies, over the veins, mostly saddle-shaped. Micro-hairs: none seen by the author, but recorded in 1 sp. by Grob (1896) and in *T. koelerioides* Aschers. by Schweickerdt (1941). Stomata with slightly triangular or low dome-shaped subsidiary cells. Vascular bundles mostly small, crowded, and conspicuously

angular in outline. Mesophyll obscure in the available material, but shown as radiate in Schweickerdt's (1941) illustrations. Bundle-sheaths; those to small vb's single, but less frequent large vb's with double sheaths.

Species Specially Examined

Tragus berteronianus Schult.

Leaf

Abaxial epidermis

Short-cells, over the veins, in rows of more than 5 cells; occasional pairs noted at the margins of a few of the veins; abundant over, but apparently absent between, the veins. **Silica-bodies** nearly all saddle-shaped (Fig. I, 9), but a few of those in the paired short-cells at the margins of the veins crescent-shaped. **Macro-hairs** and **micro-hairs:** none seen. **Prickle-hairs:** none observed by the author, but see p. 502. **Papillae:** thin, somewhat globose papillae, many somewhat oblique (Fig. III, 3), present on both leaf surfaces, but most numerous on the adaxial side. Papillae most clearly visible in T.S. in the material examined. **Stomata** mostly with slightly triangular (Fig. IV, 1), but others with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells,** between the veins, with thin, rather distantly sinuous walls (Fig. V, 3*a–c*), or cells often somewhat inflated (Fig. V, 5); interstomatal cells with concave ends (Fig. V, 10–11).

T.S. lamina

Vascular bundles: most vb's small, crowded, and angular (Fig. VIII, 5); a few large vb's of basic type (Fig. VIII, 10). **Adaxial surface:** apices of the groups of bulliform cells raised slightly above the general level of the epidermis in the dried material available for examination. Abaxial surface with v. slight, rounded ribs over the vb's, the intervening furrows being shallow and v. much narrower than the ribs. **Sclerenchyma:** all, or nearly all, vb's accompanied by small adaxial and abaxial strands sometimes united with the vb's to form girders (Fig. IX, 4); adaxial strands about 1–10 cells wide and 1–2 cells high, abaxial strands generally slightly wider and mostly about 3 cells tall. Abaxial strands v. much wider and taller in material examined by Schweickerdt (1941). **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not clearly visible in the available material, but figured by Schweickerdt (1941) as being radiate. **Bulliform cells** in groups of the *Sporobolus* type (Fig. XV, 8), the tall, narrow, central cell in each group penetrating v. deeply into the mesophyll (see also p. 502). **Bundle-sheaths:** those to the relatively infrequent large vb's double; more numerous small vb's each with a single, complete, usually circular sheath (Fig. XI, 2*a*), composed of cells of uniform size.

Culm

Culm examined about 1·5 mm in diameter; slightly concave on 1 side; centre occupied by thin-walled ground tissue. Epidermis subtended by a zone of about 3–4 layers of thin-walled assimilatory tissue followed, on the inner side, by a circle, about 3–6 cells wide, consisting of thick-walled fibres with small lumina. Ground tissue between the fibre ring and the culm centre consisting of thin-walled cells. A few, small, inconspicuous vb's embedded in the scl. ring. Remaining vb's in 2–3 irregular circles embedded in the peripheral part of the thin-walled ground tissue. Most vb's rather angular in outline.

Material Examined: Univ. California No. 10535; Andes.

Tragus racemosus (L.) All.

Leaf

Abaxial epidermis

Short-cells, between the veins, mostly paired; a few of those over the veins also paired, but mostly in rows of more than 5 cells; abundant over, but infrequent, except locally, between, the veins. **Silica-bodies,** over the veins, saddle-shaped (Fig. I, 9); infrequent bodies between the veins taller than wide and crescent-shaped. Prat (1932) noted elongated, ovoid silica-bodies with a slight concavity at either end, over the large vb's. **Macro-hairs:** a few, short to long hairs with broad, superficial bases (Fig. II, 1), present at the leaf margins. Marginal trichomes described by Grob (1896) as cushion hairs, and by Vickery (1935) as 'tubercle-based'. **Micro-hairs:** none seen, but club-shaped hairs, each with a short distal cell, recorded by Grob (1896) and Prat (1932), especially near the leaf margins. **Prickle-hairs:** angular prickles (Fig. VI, 3), mostly with rather long points, frequent at the leaf margins. **Papillae:** small conical papillae abundant on the adaxial surface, and v. clearly visible in T.S. of the leaf. **Stomata** sometimes with slightly triangular (Fig. IV, 1), but mostly with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells,** between the veins, with thin, mostly rather distantly sinuous walls (Fig. V, 3*a–c*); cells sometimes inflated (Fig. V, 5). Transverse veins noted by Duval-Jouve (1875).

T.S. lamina

Leaves short, narrow; lamina moderately thin (Vickery 1935). **Vascular bundles:** most vb's crowded, angular (Fig. VIII, 5); a few large vb's of basic type (Fig. VIII, 10). **Adaxial surface** practically smooth (Fig. XIV, 1), but with v. slight ribs over some of the vb's towards the leaf margins. Abaxial surface with slight, rounded ribs over all vb's, the intervening furrows being much narrower than the ribs, shallow and V-shaped. **Sclerenchyma:** nearly all vb's accompanied by small adaxial and abaxial strands (Fig. IX, 4), occasionally connected to the bundle-sheaths to form girders. Adaxial strands seldom more than 3 cells wide and mostly 1, or occasionally 2, cells high; abaxial strands about 6–12 cells wide and 1–2 cells high. Median vb with an abaxial girder conspicuously larger than the remainder. **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** v. obscure in the available material, but chlorenchyma stated by Duval-Jouve (1875) and Pée-Laby (1898) to be radiate, and by Vickery (1935) to consist of unusually narrow cells. **Bulliform cells** in groups of the *Sporobolus* type (Fig. XV, 8), but distorted in the available material; central cell of each group rather large and penetrating deeply into the mesophyll (see on p. 502). **Bundle-sheaths:** those round the small vb's single, complete (Fig. XI, 2*a*), each sheath composed

of cells of more or less uniform size, thus making the sheaths markedly circular in outline; sheaths to the large vb's similar, but with a rather obscure I.S. (Fig. XII, 1).

MATERIAL EXAMINED: de Winter 259; S. Africa.

ADDITIONAL INFORMATION FROM THE LITERATURE

Schweickerdt (1941) studied the leaf structure of 4 S. African spp. of *Tragus*, i.e. *T. berteronianus* Schult., *T. koelerioides* Aschers., *T. pedunculatus* Pilger, and *T. racemosus* (L.) All. The structure was found to be so similar in all 4 spp. that Schweickerdt gives a single description of the leaf to cover all of them. In general the description agrees quite well with the information given above, but attention must be drawn to the following differences.

Micro-hairs reported to occur in *T. koelerioides*, and figured as having the basal cell much longer and wider than the short, apically rounded, distal cell, the basal cell being considerably narrowed at its proximal end. Prickles recorded at the leaf margins. Papillae stated to be restricted to the bulliform cells, the illustrations showing only 1 papilla on each cell. (Papillae, in the material described above, were larger and more conspicuous on, but not restricted to, the bulliform cells.) Vb's numerous; consisting of 5–9 first-order vb's, separated from one another by 2–5 third-order vb's. Mesophyll with radiate chlorenchyma. Bulliform cells in groups of the *Sporobolus* type (Fig. XV, 8) figured as being connected to the abaxial epidermis by girders of colourless cells between the veins. (Girders of colourless cells not more than obscurely visible in the material described on p. 500.) Bundle-sheaths as described above, but O.S. to large vb's sometimes interrupted abaxially by scl.

SPECIAL NOTES

Prat (1936), because of its leaf structure, indicates that *Tragus* should be regarded as a member of the Chlorideae, but Vickery (1935) treats it as belonging to the Zoysieae. Schweickerdt (1946) has pointed out that the structure of *Tragus* is strikingly similar to that of *Monelytrum*.

LITERATURE

Duval-Jouve 1875 (leaf); Goosens 1935 (notes on root structure); Grob 1896 (leaf); Günzel 1912 (leaf); Pée-Laby 1898 (leaf); Prat 1932, 1936 (leaf; taxonomy); Schweickerdt 1941, 1946 (leaf; taxonomy).

TRICHOLAENA

The references to the anatomy of *Tricholaena* which have been found in the literature refer to *Rhynchelytrum* (see p. 417).

TRICHOPTERYX (see also under *Loudetiopsis*)

The leaf anatomy of 7 spp. of *Trichopteryx* has been investigated by Conert (1957), several of the spp. having previously been included in *Arundinella*. The leaf structure is said not to be reliable for specific diagnosis, but the following particulars are common to the spp. that were investigated.

Silica-bodies dumb-bell shaped or sometimes cross-shaped. Macro-hairs; bristle-hairs present between the ribs. Micro-hairs also present, each consisting of a narrow,

basal and a narrow, terminal cell. Prickles and a few papillae occurring on both surfaces. Leaf-blade slightly inrolled at the margins. Both surfaces with ribs and furrows. Scl. present as short but rather wide adaxial and abaxial girders to the medium-sized and large vb's; small vb's not accompanied by scl. Midrib not prominent. Mesophyll with radiate chlorenchyma. Bulliform cells figured as consisting of irregular groups of cells, the cells themselves being of unequal sizes.

SPECIAL NOTE

The genus is generally regarded as a member of the Arundinelleae.

LITERATURE

Conert 1957 (leaf; taxonomy); Jacques-Félix 1950 (taxonomy).

TRIDENS

The leaf anatomy of certain spp. of *Tridens* has been described in the literature under *Triodia*. In the opinion of Burbidge (1946) the name *Triodia* should be restricted to Australian spp. which have been placed in this genus, and the anatomy of *Triodia* in this restricted sense is described on p. 506 of this book. The following account of *Tridens* refers to information given by Lohauss (1905) concerning American spp. that were formerly in *Triodia*.

T. flavus (L.) Hitchc. (*Triodia cuprea* Jacqu.)

Epidermis. Short-cells, over the veins, consisting of variously shaped cork-cells and silica-cells containing saddle-shaped or dumb-bell shaped silica-bodies. Short-cells, in the intercostal zones, rectangular. Short micro-hairs present on the adaxial surface. Prickles with short points present over the veins and midrib on the adaxial surface. *T.S. lamina.* Midrib well developed, and composed mainly of colourless ground tissue with a number of vb's embedded in it, but midrib decreasing in thickness from the base to the apex of the leaf. Some cells of the adaxial epidermis papillose. Vascular bundles; ratio of large to small vb's 1:6. Scl. forming I-girders with the vb's, and also well developed in the leaf margins. Mesophyll: cells of the chlorenchyma narrow and radiately arranged. Bulliform cells present at the bases of the adaxial furrows, each group accompanied by colourless cells penetrating deeply into the mesophyll. Bundle-sheaths double, at least round the large vb's; I.S. to the large vb's consisting of large, relatively thin-walled cells in the neighbourhood of the xy. and of several layers of cells with thick walls adjoining the ph. O.S. of each small vb closed, but sheaths round the large vb's interrupted adaxially and abaxially by scl., those round the midrib bundles being interrupted on the abaxial side only.

T. grandiflorus (Vasey) Woot. & Standl.

Epidermis. Short-cells, over the veins, consisting of approximately rectangular cork-cells alternating with silica-cells, each containing a saddle-shaped silica-body. Silica-bodies described by Prat (1934) as being of the *Chloris* type. Macro-hairs, in the form of a dense felt of soft hairs and cushion hairs, present in the intercostal zones. Short micro-hairs also present; figured by Prat (1934) as having spherical distal cells. Long-cells, in the intercostal zones, rectangular to hexagonal, with slightly sinuous anticlinal walls. Some cells in the centre of the intercostal zones said to be swollen to form vesicles. *T.S. lamina.* Midrib v. prominent; containing only 1 vb and no colourless tissue. Vascular bundles: ratio of large to small vb's 1:3–4

Scl. forming weak I-girders with the vb's, and a large abaxial girder to the median vb; also present in the leaf margins. Mesophyll: cells of the chlorenchyma mostly isodiametric but radiately arranged. Bulliform cells present at the bases of the adaxial furrows, each group being connected to the abaxial epidermis by a girder of colourless cells. The 2 groups of bulliform cells next to the midrib frequently coalescing. Bundle-sheaths double, but with the I.S. often incomplete, especially around the small vb's, the I.S. being developed only next to the ph. O.S.'s complete, apart from the abaxially interrupted sheath surrounding the midrib vb.

T. muticus (Torr.) Nash (*Triodia mutica* Scrib.)

Epidermis. Short-cells, over the veins, consisting of rectangular cork-cells, and silica-cells containing dumb-bell shaped or nodular silica-bodies. Short-cells, between the veins, rectangular or rounded. Club-shaped micro-hairs present in the intercostal zones. Prickles present at the leaf margins, and numerous on the adaxial surface over the veins. Long-cells, between the veins, with sinuous anticlinal walls. *T.S. lamina.* Vascular bundles; ratio of large to small vb's 1:3. Scl. almost completely filling the adaxial ribs, and forming I-girders with the vb's; also present in the leaf margins. Mesophyll; chlorenchyma restricted to narrow strips at the sides of the adaxial ribs, and consisting of small isodiametric cells. Bulliform cells in groups of 2–6 between the ribs. Bundle-sheaths double; I.S. closed; O.S. also usually closed, but sheaths to the large vb's rarely interrupted abaxially by scl. O.S. said to be particularly conspicuous and to contain chlorophyll.

Special Notes

Leaf structure mainly, but not wholly, panicoid. The genus is commonly included in the Eragrosteae.

Burbidge (1946*b*) notes that the leaf structure of *Triplasis purpurea* is similar to that of *Tridens* (see p. 508).

Literature

Burbidge 1946 (leaf); Lohauss 1905 (leaf); Prat 1934 (leaf).

TRIKERAIA

Diagnostic Generic Characters

Short-cells, over the veins, usually in short rows. Silica-bodies, over the veins, rounded, cuboid, or oblong. Micro-hairs: none seen. Stomata with outlines obscured by overarching papillae. Vascular bundles; none conspicuously angular in outline. Mesophyll with chlorenchyma not radiate. Bundle-sheaths double.

Species Specially Examined

***Trikeraia hookeri* (Stapf) Bor (*Stipa hookeri* Stapf, *Timouria aurita* Hitchc.)**

Leaf

Abaxial epidermis (Fig. XXVIII, 5–6)

Short-cells, over the veins, usually in rows of 3–5 cells; rather infrequent over, and v. infrequent between, the veins. **Silica-bodies:** rather difficult to see in the available material; variable in shape, being rounded, elliptical, cuboid, or oblong (Fig. I, 10). **Macro-hairs:** short, stiff hairs, with swollen, superficial bases (Fig. IIA, 10) abundant in the intercostal zones. Similar hairs also noted, in T.S. of the leaf, on the surfaces of the adaxial ribs. **Micro-hairs:** none seen. **Prickle-hairs:** large prickles (Fig. VI, 2) abundant over the veins. **Papillae:** small, variously shaped, thickened, cuticular warts (Fig. III, 5) abundant on the long-cells, there usually being a single row of papillae on each long-cell. Other papillae over-arching the stomata. **Stomata:** outlines obscure, the stomata being sunken in pits and protected by the overarching papillae. **Long-cells** with moderately thick, somewhat sinuous walls (Fig. V, 1*a–b* and 3*a–c*).

T.S. lamina

Vascular bundles: large and small vb's generally alternating with one another, but, in some places, 2 small vb's occurring between a pair of large vb's. Small vb's not markedly angular in outline (Fig. VIII, 2), and fairly widely spaced; large vb's of basic type (Fig. VIII, 10). **Adaxial surface** with pronounced adaxial ribs, mostly having rounded apices, but apices of the ribs over some of the large vb's distinctly flattened; intervening furrows deep, V-shaped, and somewhat narrower than the ribs (Fig. XIV, 3). One rib on either side of and next to the midrib much smaller than the remainder, each situated in a W-shaped furrow. **Sclerenchyma:** a v. few of the smallest vb's not accompanied by scl. (Fig. IX, 1); most small vb's with tall, narrow adaxial girders, and sometimes with abaxial girders as well (Fig. IX, 7), the adaxial girders being about 12 cells high and 1–2 cells wide, sometimes slightly T-shaped, and the abaxial girders 4–5 cells high and 1–2 cells wide; large vb's with adaxial T- and abaxial I-girders (Fig. IX, 8), the abaxial girders being slightly shorter and wider than the stems of the adaxial T-girders. **Midrib** slightly conspicuous, owing to a small abaxial projection, its position also being marked by an especially small adaxial rib on either side; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate, practically the whole of the mesophyll consisting of assimilatory tissue. **Bulliform cells** not specially large, and restricted to small groups at the bases of the adaxial furrows (Fig. XV, 5). **Bundle-sheaths** double; small and medium-sized vb's each with 2 complete sheaths (Fig. XII, 1); large vb's with I.S. complete and O.S. interrupted adaxially and abaxially (Fig. XII, 3*a*).

Material Examined: W. G. Thorold 124; Tibet, 14,800 ft.

Special Note

Trikeraia Bor is based on the plant previously known as *Stipa hookeri* Stapf or *Timouria aurita* Hitchc. It is distinguished from *Stipa* by having a scabrid bristle on either side of the awn on the lemma.

Literature

Bor 1951, 1954 (leaf and taxonomy).

TRIODIA

Most of the anatomical information under *Triodia* that has been found in the literature refers to *Sieglingia* (p. 450) and *Tridens* (p. 503). Burbidge (1946) considers that the name *Triodia* should be confined to Australian spp. and the information given below refers to the genus in this restricted sense.

The spp. of *Triodia* examined by Burbidge have the common character of being xerophytic, almost shrub-like grasses, with narrow, thick-bladed leaves. The 2 halves of each blade become folded towards one another on either side of the midrib so that a T.S. of the leaf is almost circular in outline but with a deep adaxial furrow divided into 2 main branches at its base, 1 branch being on either side of the midrib. Other particulars concerning the leaf structure as seen in T.S. are as follows. Adaxial surface of each half of the folded leaf provided with flat-topped ribs separated from one another by narrow furrows, the furrows varying in depth in different spp. Apices of the adaxial ribs capped by strands, or, in a few species only, by girders of scl., the thickness, from the epidermis inwards, of the hypodermal scl. varying from sp. to sp. Abaxial scl., in a few spp., forming an almost or quite continuous layer except in a few shallow grooves in the median part of the leaf surface. Whole of the abaxial surface in other spp. provided with shallow grooves opposite to the corresponding grooves on the adaxial surface. All grooves lined at the sides, and sometimes at the bases as well, by small patches of chlorenchyma. Assimilatory cells obscure in their detailed structure, even in fresh material, the cells being thin-walled and with dense contents. Opposed adaxial and abaxial grooves separated from one another by colourless, somewhat bulliform cells of the mesophyll. Vb's consisting of the median strand and 5–7 laterals, the exact number varying from one sp. to another. Ph. in the large vb's sometimes split into 2–3 groups.

Epidermis. Burbidge has recorded the following particulars. Short-cells mostly paired but sometimes in rows of 3; absent from the abaxial surface of the sheath. Cork-cells rectangular, sometimes square. Silica-bodies varying from approximately square to saddle-shaped. Macro-hairs: stiff and straight (in *T. pungens* R. Br.), or coiled and tangled, multicellular hairs present in pubescent spp., and on the auricular ridges of other spp. Micro-hairs (2-celled) said to be present at the bases of the grooves in all spp., but to vary in abundance from one sp. to another. Each micro-hair consisting of a bulbous basal cell embedded between the epidermal cells, and a small apical cell. *T. pungens* differs from other spp. in having a resin-secreting epidermis on the abaxial surface of the flange of the leaf sheath and continuing up the margins to the auricular ridge. 'Papillae':[1] blunt or sharp-pointed papillae present on all parts of the adaxial surface, but those on the abaxial surface confined to the grooves, the papillae on either side of any one groove interlocking with each other. Abaxial grooves of *T. pungens* exceptional in being devoid of papillae.

Species described by Burbidge

T. angustata N. T. Burbidge

About 10 abaxial grooves. Scl. in adaxial and abaxial ribs not more than v. slightly developed as caps to the ribs. Median vb accompanied on either side by 5–6 laterals.

[1] It seems probable that Burbidge uses the term 'papillae' in a rather different sense to that adopted by the author in this book; her papillae would appear to be more in the nature of prickles.

T. basedowii Pritzel

About 10 abaxial grooves. Scl. in the adaxial and abaxial ribs in the form of shortly-stemmed, T-shaped strands. Median vb accompanied on either side by about 5 laterals.

T. brizoides N. T. Burbidge

About 8 abaxial grooves. Scl. in adaxial and abaxial ribs in the form of shortly-stemmed, T-shaped strands. Median vb accompanied on either side by about 4 laterals.

T. fitzgeraldii N. T. Burbidge

About 10 abaxial grooves. Scl. in adaxial and abaxial ribs in the form of massive, triangular strands with the apices of the adaxial strands in contact with the vb's, and the apices of the much larger abaxial strands approaching and sometimes making contact with the vb's. Median vb accompanied on either side by about 5 laterals.

T. irritans R. Br.

About 9 abaxial grooves. Scl. in the adaxial ribs forming shortly-stemmed, T-shaped strands; the strands to the median vb and adjacent laterals uniting with them to form girders; abaxial scl. forming triangular girders with all vb's. Median vb accompanied on either side by about 4 laterals.

T. lanigera Domin

About 12 abaxial grooves. Scl. in adaxial and abaxial ribs in the form of shortly-stemmed, T-shaped strands; strands in the adaxial ribs on either side of the median rib with little scl. Median vb accompanied on either side by about 6 laterals.

T. longiceps J. M. Black

About 12 abaxial grooves. Scl. in adaxial and abaxial ribs in slightly T-shaped strands not connected to the vb's, the abaxial being much larger than the adaxial strands. Median vb accompanied on either side by about 6 laterals.

T. pungens R. Br.

About 4 abaxial grooves, 2 being on either side of the median vb. Scl. present in the abaxial ribs and forming a continuous layer beneath the ungrooved portion of the abaxial epidermis. Scl. also present as small strands forming caps to the adaxial ribs. Median vb accompanied on either side by about 6 vb's. (The leaf structure is v. similar to that of *Plectrachne schinzii* Henrard, see p. 392.)

T. secunda N. T. Burbidge

About 10 abaxial grooves. Scl. in the adaxial and abaxial ribs not more than slightly developed, and forming caps in the ribs (cf. *T. angusta*). Median vb accompanied on either side by about 5 laterals.

T. wiseana C. A. Gardner

About 8 abaxial grooves. Scl. in the adaxial and abaxial ribs in the form of shortly-stemmed, T-shaped strands, not connected to the vb's. Median vb accompanied on either side by 5 laterals.

Special Note

The occurrence of micro-hairs suggests panicoid affinities, possibly with the Danthonieae.

LITERATURE

Burbidge 1945, 1946 *a* and *b* (leaf).

TRIPLACHNE

Grob (1896) notes that micro-hairs are absent from *T. nitens* (Guss.) Link.

LITERATURE

Grob 1896.

TRIPLASIS

Burbidge (1946*b*) notes that the leaf structure of *T. purpurea* (Walt) Chapm. is similar to that of *Tridens* (see p. 503), but both surfaces are more definitely grooved and there is no midrib.

LITERATURE

Burbidge 1946*b* (leaf).

TRIPLOPOGON

DIAGNOSTIC GENERIC CHARACTERS

Short-cells, over the veins, in short to long rows, or sometimes apparently solitary. Silica-bodies, over the veins, mostly nodular, but others cross to dumb-bell shaped. Micro-hairs present; each with the distal cell usually tapering to a pointed apex. Stomata with triangular or tall, dome-shaped subsidiary cells. Vascular bundles mostly small, crowded and conspicuously angular in outline. Mesophyll with distinctly radiate chlorenchyma. Bundle-sheaths single.

SPECIES SPECIALLY EXAMINED

***Triplopogon spathiflorus* (Hook. f.) Bor**

LEAF

Abaxial epidermis

Short-cells, over the veins, in rows of more or less than 5 cells, or appearing to be solitary when separated from one another by relatively long cells in the same files; rather infrequent generally, but especially between the veins. **Silica-bodies,** over the veins, mostly nodular (Fig. IB, 22 (iii)); others intermediate between cross and dumb-bell shaped (Fig. IA, 17), or dumb-bell shaped but varying in appearance with the focus (Fig. IB, 21). **Macro-hairs:** long, rigid hairs, with swollen but constricted bases surrounded by specialized epidermal cells common in the intercostal zones. **Micro-hairs:** length 24–44 (mostly 31–44) μ; basal cells 12–16 μ; distal cells 13–29 (mostly 16–29) μ; distal cells usually tapering to pointed apices (Fig. VII, 4 and 5). **Prickle-hairs:** v. infrequent; an occasional hook (Fig. VI, 5) noted between the veins. **Papillae:** swollen, thin, somewhat globose and often somewhat oblique papillae present on the intercostal long-cells, there usually being a single row of papillae to each cell. Similar papillae visible on both surfaces in T.S. Solitary papillae overarching some of the stomata. **Stomata** with tall, somewhat triangular (Fig. IV, 1), or rather tall dome-shaped (Fig. IV, 4), subsidiary cells. **Long-cells,** between the veins, often with thin, rather distant but conspicuous, rounded sinuations (Fig. V, 3*a–c*); some cells similar but rather shorter (Fig. V, 7*a–b*). **Transverse veins:** numerous.

T.S. lamina

Vascular bundles: most vb's small, crowded, the smallest with the xy. and ph. not easily distinguishable (Fig. VIII, 1), but others polygonal (Fig. VIII, 5); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** practically smooth (Fig. XIV, 1) apart from a single rounded rib on 1 side of the midrib. Abaxial surface of the midrib with small ribs over the vb's. **Sclerenchyma:** small vb's opposite the bulliform cells not accompanied by scl. (Fig. IX, 1); other small vb's with minute abaxial strands only, or with adaxial and abaxial strands (Fig. IX, 4) often united with the bundle sheaths to form girders, the strands or girders seldom being more than 4 cells wide and 2 cells high. Large vb's in the lamina with slightly wider adaxial and abaxial girders. Keel bundles mostly with well-marked abaxial girders only (Fig. IX, 3). Adaxial surface of the midrib supported by a thin, wide plate of hypodermal scl. **Keel:** v. conspicuous, rounded; containing 1 large median vb accompanied on either side by 1 lateral of about the same size, and by about 6 or 7 much smaller laterals (Fig. XIII, 5). **Mesophyll:** chlorenchyma distinctly radiate. **Bulliform cells** in irregular groups (Fig. XV, 1). Most of the ground tissue of the keel consisting of large, thin-walled, colourless cells. **Bundle-sheaths** single; all small vb's each with a complete sheath (Fig. XI, 2*a*), the sheaths being composed of cells of v. unequal sizes. Large vb's also with complete sheaths, or sheaths having slight abaxial interruptions.

CULM

Culm examined about 2 mm in diameter; circular in T.S.; centre occupied by somewhat spongy ground tissue. Epidermis subtended by a single layer of fibres with relatively thick walls, the ground tissue on the inner side of this layer exhibiting a gradual transition to the thin-walled, spongy cells at the centre of the culm. Vb's scattered throughout the ground tissue, but mainly concentrated in the peripheral part of the culm.

STILT ROOT

Root examined about 2 mm in diameter. Epidermis consisting of a single layer of large cells, followed by a conspicuous zone of thick-walled fibres some 4–6 cells wide. Fibre zone bounded on the inner side by a cortex some 10–12 cells wide, consisting of cells arranged in v. regular radial rows, with small, mostly diamond-shaped, intercellular spaces between the cells. Xy. relatively narrow, exhibiting a ring of about 14 v. conspicuous metaxylem vessels, the centre of the root being occupied by a wide pith.

MATERIAL EXAMINED: Cultivated at Kew.

Special Notes

According to Bor (1954*a*) *T. spathiflorus* belongs to the subtribe Ischaeminae of the Andropogoneae.

It is an annual grass, so strongly supported by stilt roots that the culm does not penetrate the ground at all, and in this respect it resembles *Pandanus* (family Pandanaceae).

Literature

Bor 1954*a* (taxonomy).

TRIPOGON

The leaf structure of *T. minimus* Hochst. ex. A. Rich. has been described by Jacques-Félix (1955) whose description of the flat leaves, which are mostly basal, includes the following particulars.

Abaxial epidermis

(*a*) *Culm leaf.* Short-cells, over the veins, in pairs. Silica-bodies mostly quadrangular. Micro-hairs present; of the *Chloris* type (Fig. VII, 2), each consisting of a spherical distal cell and an equally short or shorter basal cell. Stomata figured as having low dome-shaped subsidiary cells. Long-cells, both over and between the veins, with markedly sinuous outlines.

(*b*) *Basal leaf.* Differing from the culm leaf in having the short-cells over the veins in rows, the cork-cells tending to be cross-shaped and many of them figured as being nodular. Silica-bodies similar to those in the culm leaves.

T.S. lamina

Blade not inrolled. Adaxial surface practically smooth. Vascular bundles: 29–31 in each basal leaf, the number falling to 9 in culm leaves; vb's uniform in size, but with the median vb and 2 next to it on either side somewhat larger. Scl. forming v. small adaxial and much wider, flattened abaxial strands to most vb's, both the adaxial and abaxial strands sometimes uniting with the bundle-sheaths to form girders. Mesophyll with radiate chlorenchyma reduced to a single layer of cells on either side of each vb. Bulliform cells in groups of the *Sporobolus* type (Fig. XV, 8), the central cell in each group being v. much larger than the remainder and penetrating deeply into the mesophyll. Bundle-sheaths of most vb's single and triangular in outline, the base of each triangle being towards the abaxial surface.

Special Note

Jacques-Félix treats *Tripogon* as a member of the Eragrosteae and states that it recalls *Lepturidium*. He also notes that the structure is v. similar to that of *Sporobolus*. To the present writer the similarity of the leaf structure to that of *Sporobolus* appears to be v. marked, although long rows of short-cells do not normally occur over the veins in *Sporobolus*.

Literature

Jacques-Félix 1955.

TRIPSACUM

Diagnostic Generic Characters

Short-cells, over the veins, mostly in short, and less frequently in long, rows; a few solitary and in pairs. Silica-bodies, over the veins, cross to dumb-bell shaped. Micro-hairs present; sometimes balanoform, but often with their distal cells taperd towards their apices. Stomata with slightly to markedly triangular, or low dome-shaped, subsidiary cells. Vascular bundles mostly small, crowded, and conspicuously angular in outline. Mesophyll with chlorenchyma not radiate. Bundle-sheaths single and double.

Species Specially Examined

***Tripsacum dactyloides* (L.) L.**

Leaf

Abaxial epidermis

Short-cells between, and a few of those over, the veins, solitary and in pairs; most of those over the veins in rows of 3–5, or occasionally more, cells. **Silica-bodies,** between the veins, either cross-shaped (Fig. Ia, 16), often with a somewhat distorted appearance, or tall, narrow, and crescent-shaped, or crenate (Fig. Ib, 24). Bodies over the veins sometimes cross-shaped, but less distorted in appearance than those between the veins, the indentations between the arms of the cross being v. narrow and shallow; other bodies intermediate between cross and dumb-bell shaped (Fig. Ia, 17). **Macro-hairs:** long, stiff hairs with swollen, constricted bases sunken amongst, and surrounded by, cushion cells, present particularly, if not exclusively, in the intercostal zones of the adaxial surface (Fig. II, 3 or IIa, 5). **Micro-hairs:** length 49–78 (mostly 49–72) μ; basal cells 24–43 (mostly 24–30) μ; distal cells 25–45 (mostly 25–40) μ; hairs rather wide in diameter and sometimes balanoform (Fig. VII, 3), but distal cells sometimes tapering to pointed, and frequently rounded, apices (Fig. VII, 4 and 5). **Prickle-hairs:** none seen on the abaxial surface, but hooks (Fig. VI, 5) frequent on the adaxial surface, particularly between the veins. **Stomata** with markedly triangular (Fig. IV, 1) subsidiary cells. **Long-cells,** between the veins, with thin, densely and minutely sinuous walls; some of the cells rather inflated (Fig. V, 5).

T.S. lamina

Vascular bundles: most vb's small, crowded, the smallest with the xy. and ph. not easily distinguishable from one another (Fig. VIII, 1); but mostly polygonal (Fig. VIII, 5), or rather less conspicuously angular (Fig. VIII, 6); large vb's of basic type (Fig. VIII, 10). **Adaxial surface** practically smooth (Fig. XIV, 1) apart from v. slight, wide ribs over the large vb's, and a single more prominent rib on one side of the midrib. **Sclerenchyma:** numerous small vb's, especially those opposite the bulliform cells, not accompanied by scl. (Fig. IX, 1); other small vb's with adaxial and abaxial girders (Fig. IX, 4), the adaxial girders being 5–6 cells wide and 3–4 cells high, and the abaxial girders 3–5 cells wide and 2–3 cells high; large vb's with adaxial and abaxial girders

up to about 14 cells wide but seldom more than 4 cells high (Fig. IX, 5). Keel bundles mostly with well-marked abaxial girders only (Fig. IX, 3). Adaxial surface of the keel supported by a thin but wide hypodermal plate of scl. **Keel** v. conspicuous, rounded; containing a large median vb accompanied on either side by about 7 laterals, all smaller but of various sizes (Fig. XHI, 3). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** mostly in well-defined groups as in Fig. XV, 2, but some in groups of specially large cells, i.e. the *Zea* type (Fig. XV, 3). **Bundle-sheaths** single; all small vb's with complete sheaths, composed of cells of v. unequal sizes (Fig. XI, 2*a*); sheaths to the large vb's also mostly complete, but occasionally, especially in the keel, with abaxial interruptions (Fig. XI, 6).

Culm

Culm examined about 4 mm in diameter; slightly concave on 1 side; with a small cavity, or spongy ground tissue, at the centre. Outermost vb's usually connected to the epidermis by broad girders of fibres, the girders broadening out beneath the epidermis, those associated with neighbouring bundles extending towards one another, but seldom meeting. Peripheral ground tissue small-celled, fibrous, and gradually passing over to the large, thin-walled cells of the ground tissue at the centre of the culm. Vb's scattered throughout the ground tissue, but most numerous around the periphery of the culm.

Material Examined: Cultivated at Kew.

Special Note

Leaf structure panicoid, and consistent with the inclusion of *Tripsacum* in the Maydeae.

TRIRAPHIS

Diagnostic Generic Characters

Short-cells, over the veins, paired or in rows of 3–5 cells. Silica-bodies cross to dumb-bell shaped. Micro-hairs present; each with the distal cell tapering to a pointed apex. Stomata with slightly triangular, to low dome-shaped, subsidiary cells. Vascular bundles mostly angular in outline. Mesophyll; chlorenchyma obscure in the available material. Bundle-sheaths single and double.

Species Specially Examined

***Triraphis pumilio* R. Br.**

Leaf

Abaxial epidermis

Short-cells, over the veins, paired and in rows of 3–5 cells; common over, but infrequent or absent between, the veins. **Silica-bodies** occasionally cross-shaped (Fig. IA, 16), but mostly intermediate between cross and dumb-bell shaped (Fig. IA, 17), or dumb-bell shaped (Fig. IA, 18 (ii–v)). **Macro-hairs:** none seen. **Micro-hairs:** length 40–66 (mostly 48–66) μ; basal cells 16–24

(mostly 18–22) μ; distal cells 31–46 (mostly 30–42) μ; distal cells usually tapering to pointed apices (Fig. VII, 4). **Prickle-hairs:** prickles (Fig. VI, 1–2) with narrow but large bases and fine points, abundant on the ribs; angular prickles (Fig. VI, 3) present at the leaf margins. **Stomata** commonly with slightly triangular (Fig. IV, 1), but sometimes with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells,** between the veins, with thin, non-sinuous (Fig. V, 2*a–c*), or only v. slightly sinuous (Fig. V, 3*a–c*), walls; interstomatal cells elongated but with concave ends (Fig. V, 11).

T.S. lamina

Vascular bundles: most vb's moderately crowded, angular (Fig. VIII, 5), and not specially small; a few large vb's of basic type (Fig. VIII, 9 and 10). **Adaxial surface** with low, rounded ribs over the vb's, the intervening furrows being shallow and much narrower than the ribs themselves (Fig. XIV, 2). Abaxial surface with similar, or slightly more pronounced ribs opposite those on the adaxial surface, the ribs over the large, being rather taller and wider than those over the small, vb's. **Sclerenchyma:** nearly all vb's accompanied by small adaxial and abaxial strands (Fig. IX, 4), the abaxial strands of the large vb's sometimes connecting with the bundle-sheaths to form girders. Strands to the small vb's about 3–6 cells wide and 2–4 cells high; strands or girders to the large vb's often rather larger and sometimes incompletely anchor-shaped. **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not clearly radiate in the available material. **Bulliform cells** mostly in groups approximating to the *Sporobolus* type (Fig. XV, 8). **Bundle-sheaths** single and double; small vb's each with a single complete sheath, the sheaths tending to be v. slightly triangular in outline (Fig. XI, 2*a*); large vb's each surrounded by 2 complete sheaths (Fig. XII, 1), or with O.S. slightly interrupted abaxially (Fig. XII, 2).

Material Examined: Trott 1567; Arabia.

Additional Information from the Literature

Prat (1934), referring to *T. fleckii* Hack. and other spp. of *Triraphis*, notes the following leaf characters. Silica-bodies, over the veins of the sheath and lamina, dumb-bell shaped; those between the veins cross-shaped or resembling knuckle-bones (nodular). Somewhat elongated micro-hairs present. Basal part of the ligule membranous; distal part ending in rounded papillae and long hairs, some of the hairs being uniseriate and consisting of cells of v. unequal lengths. (Similar to *Uniola*.)

Special Note

Prat (1936) notes that the leaf structure is panicoid or sometimes similar to that of the Chlorideae. In the material examined by the author the mesophyll did not exhibit conspicuously radiate chlorenchyma. The micro-hairs are longer than those in many of the Chlorideae.

Literature

Duval-Jouve 1875 (leaf); Frohnmeyer 1914 (deposition of silica); Grob 1896 (leaf); Jacques-Félix 1958 (leaf); Prat 1932, 1936 (leaf).

TRICHACHNE = VALOTA

Diagnostic Generic Characters

Short-cells, over the veins, mostly in long rows. Silica-bodies, over the veins, cross to dumb-bell shaped. Micro-hairs present; distal cells variable in shape; hairs sometimes v. long. Stomata with triangular to low dome-shaped subsidiary cells. Vascular bundles mostly small, crowded, and often conspicuously angular in outline. Mesophyll probably with chlorenchyma not radiate. Bundle-sheaths not observed.

Species Specially Examined

***Trichachne insularis* (L.) Nees = *Valota insularis* (L.) Chase**

Leaf

Abaxial epidermis

Short-cells, over the veins, mostly in rows of more than 5 cells; those between the veins mostly solitary; abundant over, but infrequent between, the veins. **Silica-bodies,** over the veins, cross-shaped (Fig. IA, 16), intermediate between cross and dumb-bell shaped (Fig. IA, 17), or dumb-bell shaped (Fig. IB, 19) but with a rather wide middle part. **Macro-hairs:** none seen. **Micro-hairs:** v. long and numerous; each consisting of 2 cells of about equal lengths, or with the distal cell longer than the basal cell; distal cells rather variable in shape, but generally tapering to rounded apices (Fig. VII, 4 and 5). **Prickle-hairs:** large prickles (Fig. VI, 2) v. occasional over the veins in the specimen from Jamaica, but with smaller, much more numerous prickles in the specimen from Brazil. Hooks (Fig. VI, 5), between the veins, also present in the Brazilian specimen. **Stomata** mostly with triangular (Fig. IV, 1), but some with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells,** between the veins, with fairly thin, slightly sinuous walls (Fig. V, 3*a–c*), but rather short.

T.S. lamina

The following description is based on the Jamaican specimen.

Vascular bundles: most vb's small, crowded, angular (Fig. VIII, 4 and 5); medium-sized vb's not so markedly angular (Fig. VIII, 6); a few large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with slight to moderate ribs over the medium-sized and large vb's, the size of the ribs being proportional to the vb's; small ribs also present over some of the small vb's, but other small vb's opposite the mostly shallow and rather wide, adaxial furrows (Fig. XIV, 2). Small rounded ribs also present on the abaxial surface opposite most of the vb's, the ribs being occupied by scl. **Sclerenchyma:** smallest vb's, when situated between an adaxial and an abaxial furrow, not accompanied by scl. (Fig. IX, 1); small vb's, when between an adaxial furrow, or group of bulliform cells, and an abaxial rib, accompanied by abaxial strands or girders only. Medium-sized vb's with adaxial and abaxial strands (Fig. IX, 4), the adaxial strands being slightly concave abaxially and about 4 cells wide and 3 cells high; abaxial strands 6 or more cells wide and 4 or 5 cells high. Large vb's with rather wider adaxial and abaxial strands or girders (Fig. IX, 5). Median keel bundle strongly

supported on the abaxial side by an arc of scl., an adaxial strand of scl. about 2 cells high and 8 cells wide also being present just below the adaxial epidermis above the median vb. **Keel** fairly conspicuous, rounded; containing 1 large median vb accompanied on either side by 3 or 4 much smaller laterals (Fig. XIII, 3). **Mesophyll:** chlorenchyma probably not radiate, but rather distorted in the available material. **Bulliform cells** mostly in irregular groups (Fig. XV, 1). Colourless cells also present in the adaxial part of the midrib. **Bundle-sheaths:** no information.

Material Examined: (i) J. Waters, ex Herb. Hook.; Jamaica. (ii) Sir Alexander Todd; Brazil.

Special Note

Leaf structure mainly panicoid.

TRISETARIA

Paunero (1948–9), under *Trisetaria,* has published illustrations of T.S. of certain spp. which are more commonly included in *Avena* or *Trisetum.*

Literature

Paunero 1948–9 (leaf).

TRISETUM

Only scattered references to the anatomy of *Trisetum* have been noted in the literature, most of these being concerned with *T. flavescens* (L.) Beauv. The following particulars concerning this sp. have been taken from the respective articles by Burr and Turner (1933), Duval-Jouve (1875), Pée-Laby (1898), and Strecker (1913).

T. flavescens is a loosely tufted perennial with silky, reflexed hairs on the culms, sometimes with hairs on the leaves, and with roots that are yellowish in colour. *T.S. lamina.* Adaxial surface with low, rounded ribs separated from one another by wide, shallow furrows. Scl. forming adaxial and abaxial girders with the principal vb's, and also present on the adaxial and/or abaxial side of some of the smaller vb's. Scl. also present in the leaf margins and in the form of a large abaxial strand in the keel, together with a smaller adaxial strand above the median vb. Keel well developed. Mesophyll; chlorenchyma not radiate. Bulliform cells in groups between the vb's.

Special Note

Prat (1936) rightly indicates that the leaf structure is festucoid, and Hubbard (1954) says that *Trisetum* is closely allied to *Helictotrichon.*

Literature

Burr and Turner 1933 (leaf; under *Avena*); Duval-Jouve 1875 (leaf); Frohnmeyer 1914 (silica deposition); Grob 1896 (leaf); Holm 1908 (leaf); Hubbard 1954 (taxonomy); Pée-Laby 1898 (leaf); Potztal 1951 (refers to *Arrhenatherum*); Prat 1936 (leaf); Strecker 1913 (leaf).

TRISTACHYA (see also *Loudetia*)

Diagnostic Generic Characters

Short-cells, over the veins, mostly in long rows. Silica-bodies, over the veins, mostly dumb-bell shaped, many of them greatly enlarged at their ends, which are connected to one another by narrow middle portions; nodular bodies occasional. Micro-hairs present, but not observed in all spp.; each with the distal cell usually tapering to a pointed apex. Stomata; some with slightly triangular, but mostly with low dome-shaped, subsidiary cells. Vascular bundles mostly fairly small and crowded, and somewhat angular in outline. Mesophyll partly consisting of radiate chlorenchyma. Bundle-sheaths mostly single.

Species Specially Examined

***Tristachya hispida* (L. f.) K. Schum.**

Leaf

Abaxial epidermis

Short-cells, between the veins, solitary and in pairs; those over the veins in rows of more than 5 cells; abundant over, but much less frequent between, the veins. **Silica-bodies,** over the veins, mostly dumb-bell shaped (Fig. IA, 18 (ii–v)), many of them each having large oval ends connected to one another by a narrow middle portion, but other bodies rather shorter and with less contrast between the ends and middle portion (Fig. IB, 20). **Macro-hairs:** abundant, long, slightly pointed hairs with moderately thick walls and wide lumina, and with bulbous, sunken bases embedded amongst the bulliform cells (Fig. IIA, 5), present in the intercostal zones. **Micro-hairs:** length 48–63 (mostly 54–60) μ; basal cells 24–33 (mostly 24–30) μ; distal cells 23–30 (mostly 23–28) μ; distal cells usually tapering to pointed apices; as Fig. VII, 5, but basal cells often slightly longer than the distal cells. **Prickle-hairs:** prickles (Fig. VI, 1–2) abundant over, and hooks (Fig. VI, 3) between, the veins. **Stomata:** some with slightly triangular (Fig. IV, 1), but mostly with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells,** between the veins, with thin, to moderately thick, sinuous walls (Fig. V, 3*a–c*).

T.S. lamina

Vascular bundles: most vb's moderately small and crowded, and not more than slightly angular in outline (Fig. VIII, 6); large vb's of basic type (Fig. VIII, 13). **Adaxial surface** practically smooth (Fig. XIV, 1) except where the apices of some of the groups of bulliform cells are raised above the general level of the epidermis. **Sclerenchyma:** small vb's opposite the groups of bulliform cells not accompanied by scl. (Fig. IX, 1); other small vb's with adaxial and abaxial girders (Fig. IX, 4), the adaxial being up to about 8 cells wide and 3 cells high, and the abaxial girders about the same size or slightly wider. Large vb's with short-stemmed, adaxial T-, and short, wide, abaxial I-girders, the combined girders tending to be inversely anchor-shaped; large vb's in the midrib with combined girders anchor-shaped (Fig. IX, 6), but incomplete.

Occasional large vb's near the leaf margins with well-developed abaxial girders only (Fig. IX, 3). **Keel** moderately conspicuous, owing to a slight, wide, rounded abaxial projection; containing 1 large median vb accompanied on either side by about 3 laterals of various sizes, but all of them smaller than the median vb (Fig. XIII, 3). **Mesophyll:** radiate immediately around the vb's, but radiate chlorenchyma constituting only a small part of the mesophyll. **Bulliform cells** in groups of specially large cells of the *Zea* type (Fig. XV, 3), but these groups are accompanied by colourless cells overarching the small vb's, the piers of the arches extending across the mesophyll to the abaxial epidermis (Fig. XV, 10). Small groups of cushion-like bulliform cells also present in the abaxial epidermis. Adaxial ground tissue of the midrib consisting of colourless cells. Bases of the macro-hairs embedded amongst the bulliform cells on both surfaces. **Bundle-sheaths** single; all small vb's surrounded by complete sheaths (Fig. XI, 2*a*), each sheath consisting of cells of rather variable sizes, but none of them specially large; large vb's each with an abaxially interrupted sheath (Fig. XI, 6).

Culm

Culm examined about 2 mm in diameter; circular in outline, with a small irregular cavity in the centre. Surface of the culm with between 30 and 40 low ribs, a strand of thick-walled fibres occupying the apex of each rib. Strands of assimilatory tissue, about 3–6 cells wide, and arc-shaped, subjacent to the fibre strands in the apices of the ribs. Strands of assimilatory tissue separated from one another by girders of scl. extending inwards from the epidermis, especially at the bases of the furrows between the ribs. Each strand of assimilatory tissue bounded on part of its inner side by a single layer of conspicuously large cells, serving to separate the assimilatory tissue from a vb. Assimilatory tissue elsewhere bounded on its inner side by a zone of v. thick-walled fibres about 2–4 cells wide. Ground tissue between the fibre zone and the hollow centre of the culm consisting of larger cells with thinner walls, with minute, triangular spaces between the cells. Vb's of the outermost circle abutting on to the assimilatory tissue. A second circle of vb's present at the inner boundary of the fibre zone, and a few other vb's embedded in the peripheral part of the thin-walled ground tissue.

Root

Root examined about 1 mm in diameter. Cortex consisting of a series of rows of cells radiating from the centre of the root; cavities, apparently lysigenous, arising between the radiating cell rows in the inner part of the cortex. Stele surrounded by an endodermis consisting of cells with thickened inner tangential and radial walls. Endodermis subtended on the inner side by about 3 layers of cells with thick walls, the radial being much greater than the tangential diameters of these cells. Metaxylem vessels about 16 in number, and less conspicuously large than in many other grasses. Centre of the root occupied by a pith.

Material Examined: Specially supplied by G. Jackson from Nyasaland.

***Tristachya inamoena* K. Schum.**

LEAF

Abaxial epidermis

Short-cells, between the veins, solitary or paired; those over the veins in rows of more than 5 cells; abundant both over and between the veins. **Silica-bodies:** short-cells between the veins seldom containing conspicuous silica-bodies; silica-bodies, over the veins, mostly dumb-bell shaped (Fig. IA, 18 (ii–v)), the 2 enlarged ends of each body standing out in marked contrast to the long, narrow, middle portion; a few of the bodies over the veins nodular (Fig. IA, 18 (i)). **Macro-hairs:** none seen on the abaxial surface, but see under 'bulliform cells'. **Micro-hairs:** none seen. **Prickle-hairs:** large, shortly pointed prickles (Fig. VI, 2) abundant over, and small hooks (Fig. VI, 5) between, the veins. Conspicuous prickles also noted, in T.S. of the leaf, on the adaxial surface above the medium-sized vb's. **Stomata:** rather infrequent on the abaxial surface; with slightly triangular (Fig. IV, 1), or low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells,** between the veins, with thin to moderately thick, sinuous walls (Fig. V, 3*a–c*).

T.S. lamina

Vascular bundles: most vb's small to moderately small and crowded, but not more than slightly angular in outline (Fig. VIII, 6); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with v. slight, narrow ribs, filled with scl., over each medium-sized vb; ribs over the large vb's slightly taller and much wider (Fig. XIV, 2). **Sclerenchyma:** small vb's opposite the bulliform cells accompanied by minute abaxial strands or girders only; medium-sized vb's with adaxial and abaxial girders (Fig. IX, 4), those that are adaxial being mostly about 8–10 cells wide and 3–6 cells tall, and some of them slightly T-shaped in outline, the corresponding abaxial girders being about the same size but not T-shaped. Large vb's with short-stemmed, adaxial T-girders and low but wide, abaxial girders, the combined girders tending to be inversely anchor-shaped, the T-girders being 15–20 cells wide between the ends of the arms, and the stems of the T's seldom more than 3–4 cells high. **Keel** fairly conspicuous, owing to a rounded abaxial projection; containing 1 large median vb accompanied on either side by 1 or 2 smaller laterals (Fig. XIII, 2 and 3). **Mesophyll:** inconspicuously radiate immediately round the vb's, but radiate chlorenchyma constituting only a small part of the mesophyll. **Bulliform cells** in groups of specially large cells approximately of the *Zea* type (Fig. XV, 3), or sometimes more nearly fan-shaped (Fig. XV, 4); some (but not all as in *T. hispida*) of these groups accompanied by colourless cells overarching certain of the small vb's, the piers of the arches extending across the mesophyll to the abaxial epidermis (Fig. XV, 10). No bulliform cells noted on the abaxial surface of the leaf as in *T. hispida*. Bases of short macro-hairs embedded in certain of the groups of bulliform cells. **Bundle-sheaths** single; all small and medium-sized vb's each with a complete sheath (Fig. XI, 2*a*) composed of cells of rather variable sizes but none of them specially large; sheaths to the large vb's with adaxial and abaxial interruptions (Fig. XI, 4).

CULM

Culm examined about 2 mm in diameter; circular in outline; centre with no cavity in the material examined. General structure v. similar to that of *T. hispida*, but assimilatory tissue in much smaller strands, and scl. girders extending to the epidermis much more numerous. Strands of fibres opposite the outermost bundles connected to the bundles in the form of girders, and not restricted to the apices of the ribs opposite the bundles. Culms of the 2 spp. otherwise remarkably similar.

MATERIAL EXAMINED: Specially supplied by G. Jackson from Nyasaland.

ADDITIONAL INFORMATION FROM THE LITERATURE

The few notes recorded by Grob (1896) concerning *Tristachya* agree very closely with those given on p. 516 as being diagnostic for the genus.

Notes on the leaf structure of some 20 spp. of *Tristachya* have been published by Conert (1957). Conert, who places *Tristachya* in the Arundinelleae, divides the genus into 5 sections, but the sections are not separated from one another v. clearly by differences in their leaf structure. His section *Tristachya* includes *T. superba* (De Not.) Schweinf. & Aschers. which, in this book, is dealt with under *Loudetia superba* De Not. (see p. 291). In the section *Apochaete*, which includes *T. tholloni* Franch. and *T. hispida* (L. f.) K. Schum., the last sp. of which is described on p. 516, the leaf surface is described as being sinuous on both surfaces, but this character is not restricted to the spp. included in the section *Apochaete*. The leaf in the section *Dolicochaete* (consisting of *T. nodiglumis* K. Schum. and 5 related spp.) is specially characterized by 1–2 layers of large colourless cells immediately beneath the abaxial epidermis which serve to separate the abaxial fibre strands from the chlorenchyma. *T. inamoena* K. Schum., described on p. 518, is included by Conert in the section *Piptostachya*. Further details can best be taken from Conert's article.

LITERATURE

Conert 1957 (leaf and taxonomy); Grob 1896 (leaf epidermis).

TRITICUM

DIAGNOSTIC GENERIC CHARACTERS

Short-cells, over the veins, mostly solitary or paired, but solitary bodies appearing to be in rows when separated by sufficiently short intervening cells. Silica-bodies, over the veins, mostly horizontally elongated with sinuous outlines; a few bodies over and between the veins in certain spp. oval, rounded, or slightly crescent-shaped, and fitting into concavities in adjacent cork-cells. Micro-hairs absent. Stomata with parallel-sided or low dome-shaped subsidiary cells. Vascular bundles mostly rather widely spaced and not conspicuously angular in outline. Mesophyll with chlorenchyma not radiate. Bundle-sheaths double.

SPECIES SPECIALLY EXAMINED

***Triticum dicoccoides* Koern.**

LEAF

Abaxial epidermis

Short-cells, over the veins, mostly solitary, but appearing to be in rows when separated by sufficiently short intervening cells; common to abundant over, but v. infrequent or absent between, the veins. **Silica-bodies** mostly horizontally elongated, with sinuous outlines (Fig. IA, 14–15). **Macro-hairs:** rather short, rigid hairs, with swollen, superficial, or at most only slightly sunken, bases, abundant in the intercostal areas, and at the margins of the veins. V. short forms of these hairs (Fig. IIA, 10) also occur. **Micro-hairs:** none seen. **Prickle-hairs:** no typical hairs of this type noted, but shortest of the macro-hairs sometimes resembling small prickles. **Stomata:** some tending to be with parallel-sided (Fig. IV, 2), but mostly with low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells,** between the veins, with thin, non-sinuous walls (Fig. V, 2*a–c*), many of the cells narrower at their ends than in the middle.

T.S. lamina

Vascular bundles: vb's mostly rather widely spaced and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 7 and 15). **Adaxial surface** with low, wide ribs over all vb's, the apices of the ribs being rounded (Fig. XIV, 2); intervening furrows wide, shallow, and somewhat V-shaped. **Sclerenchyma:** a few of the smallest vb's not accompanied by scl. (Fig. IX, 1); most small vb's with adaxial and abaxial strands seldom more than 4 cells wide and 2 cells high (Fig. IX, 4); Large vb's with similar, but slightly wider, adaxial and abaxial strands, the adaxial strands sometimes being united to the O.S.s to form girders. **Keel** only slightly conspicuous, owing to a small, median, abaxial rib occupied by scl.; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** mostly in slightly fan-shaped groups at the bases of the furrows (Fig. XV, 6), or sometimes tending to be in regular groups approximating to those in Fig. XV, 2. **Bundle-sheaths** double; each vb generally with 2 complete sheaths (Fig. XII, 1), but O.S. sometimes inconspicuous on the abaxial side of the vb (Fig. XII, 2).

MATERIAL EXAMINED: Cultivated at Kew.

***Triticum dicoccum* Schrank**

LEAF

Abaxial epidermis

Short-cells, over the veins, mostly solitary, occasionally paired; or sometimes appearing to be in rows when separated by sufficiently short intervening cells in the same files; infrequent over, and still less frequent or absent between, the veins. **Silica-bodies** horizontally elongated with sinuous outlines (Fig. IA, 14–15). **Macro-hairs:** thick-walled, usually short hairs with swollen, superficial bases (Fig. II, 1) abundant between, and to a lesser extent over, the veins (see also p. 522). **Micro-hairs** and **prickle-hairs:** none seen. **Stomata** mostly with parallel-sided (Fig. IV, 2), but some tending to have low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells,** between the veins, with thin, non-sinuous walls (Fig. V, 2*a–c*), most of the cells being low and much narrower at their ends than in the middle.

T.S. lamina

Vascular bundles: most vb's small, rather widely spaced, and not conspicuously angular in outline (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 10 and 15). **Adaxial surface** with slight, widely spaced, rounded ribs, the intervening furrows being shallow and appreciably narrower than the ribs (Fig. XIV, 2). **Sclerenchyma:** small vb's quite commonly not accompanied by scl. (Fig. IX, 1), or with no more than small adaxial and abaxial strands (Fig. IX, 4); medium-sized vb's with adaxial and abaxial girders about 1–3 cells wide and about 4 cells high; large vb's with adaxial and abaxial girders about 6 cells wide and 4 cells high (Fig. IX, 5). **Keel** moderately conspicuous, owing to a narrow abaxial projection with a rather acute apex; containing a solitary vb (Fig. XIII, 1), or with a small lateral on either side of the median vb (Fig. XIII, 2). **Mesophyll** with chlorenchyma not radiate. **Bulliform cells** mostly in regular groups as in Fig. XV, 2. **Bundle-sheaths** double; most vb's with the I.S. complete but the O.S. not quite complete, or inconspicuous, abaxially (Fig. XII, 2); O.S.s of the large vb's interrupted abaxially by scl., and sometimes connected to the adjacent scl. by extensions of colourless cells.

MATERIAL EXAMINED: Cultivated at Kew.

***Triticum polonicum* L.**

LEAF

Abaxial epidermis

Short-cells, both over and between the veins, mostly paired; common over, but less frequent between, the veins. **Silica-bodies** between, and some of those over, the veins fitting into concavities in the adjacent cork-cells, the bodies being oval, rounded, or slightly crescent-shaped in outline; other bodies, over the veins, horizontally elongated with sinuous outlines (Fig. IA, 14–15), or cuboid. **Macro-hairs:** short, rigid, finely pointed, superficial hairs with swollen bases (Fig. II, 1) common in the intercostal zones. **Micro-hairs:** none seen. **Prickle-hairs:** rather small, angular prickles (Fig. VI, 3) present at the leaf margins. **Stomata** with parallel-sided (Fig. IV, 2), or low dome-shaped (Fig. IV, 3), subsidiary cells. **Long-cells:** those in the middle of the intercostal zones with thin, non-sinuous walls (Fig. V, 2*a–c*), many of the cells being narrower at the ends than in the middle; those in the intercostal zones, but closer to the veins, with thin, slightly sinuous walls (Fig. V, 3*a–c*), the cells being more markedly rectangular in outline; interstomatal cells rather long but with concave ends (Fig. V, 11).

T.S. lamina

Vascular bundles: vb's rather widely spaced, most of them small to medium-sized, and not conspicuously angular in outline (Fig. VIII, 2); large vb's of

basic type (Fig. VIII, 10 and 15). **Adaxial surface** with low, wide, rounded ribs over the medium-sized and small vb's, the ribs being separated from one another by v. wide, shallow furrows (Fig. XIV, 2). Abaxial surface with v. slight ribs over some vb's. **Sclerenchyma:** most of the small vb's not accompanied by scl. (Fig. IX, 1), or at most with minute adaxial (Fig. IX, 2) or abaxial strands; medium-sized vb's with adaxial and abaxial girders (Fig. IX, 4) about 2–4 cells wide and 4 or 5 cells high; large vb's with adaxial and abaxial girders about 4 or 5 cells wide and high; keel bundles, especially the median one, with well-marked abaxial girders only (Fig. IX, 3). **Keel** conspicuous, owing to a narrow, rounded, abaxial projection; containing 1 large median vb, accompanied on either side by at least 1, much smaller, lateral (Fig. XIII, 2). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells** in regular groups as in Fig. XV, 2, at the bases of the furrows. **Bundle-sheaths** double; small and medium-sized vb's mostly with I.S. complete and O.S. not quite complete or inconspicuous abaxially (Fig. XII, 2); large vb's with I.S. complete, but O.S. interrupted abaxially and adaxially (Fig. XII, 3*a*).

Culm

Culm examined about 5 mm in diameter, circular in outline, with a large cavity at the centre. Epidermis subtended by about 2 layers of assimilatory cells around part of the periphery of the culm. Assimilatory tissue bounded on the inner side by a zone of about 6 layers of fibres, the fibrous zone abutting directly on to the epidermis elsewhere. Ground tissue between the fibrous zone and the hollow centre of the culm consisting of 10 or 12 layers of large, relatively thin-walled cells. Vb's of the outermost circle embedded in the scl. ring. Remaining vb's in 1–2 irregular circles embedded in the thin-walled ground tissue.

Material Examined: Cultivated at Kew.

Additional Information from the Literature

Since *Triticum* is the genus that includes the cultivated varieties of wheat it is not surprising to find that its anatomy has received considerable attention. The following account briefly reviews some of the available information, but for further details the reader should consult the list of literature. In particular, Percival's (1921) classical treatise on the wheat plant is worthy of attention.

1. Leaf

Amongst the great wealth of detail recorded by Percival (1921) concerning the cultivated wheats, he refers to the variations in the length and stoutness of the macrohairs on the leaf. In *T. dicoccum* Schrank. and *T. turgidum* L. with velvety leaves, the hairs may be as much as 300–400 μ long. On the leaf of *T. aegilopoides* Bal. they are sparsely distributed and 1 mm or more long.

The anatomy of the glume and leaf of cultivated varieties of wheat has been described by Wilkens (1928). Whilst it was found that the leaf structure is, on the whole, remarkably uniform, the O.S.s showed variations. They were, for example, complete and clearly defined around the bundles, except the v. smallest, in Wilhelmina; complete round the large bundles, but discontinuous round the ph. end of the small vb's in Rivet, and, in this same variety, the cells of the I.S. were thick walled and more conspicuous than those of the O.S. With reference to the glumes, Wilkens noted that

there are variations in the distribution of the assimilatory tissue, but these differences are of no particular significance or interest, however, as they show no correlation with the type of endosperm or quality of the grain, and they were in fact found to be inconstant in any one variety from season to season.

Prat (1932), discussing the epidermis of the glumes and leaves of spp. of *Triticum* that include cultivated varieties of wheat, noted that the differences between spp. and varieties are shown by gradations of characters. For example, in the intercostal zones in *T. polonicum* L. there are large areas of epidermis made up wholly of long-cells. In *T. monococcum* L., on the other hand, the whole of the epidermis is less uniform and shows a higher proportion of specialized epidermal cells such as prickles. He also notes that when 2 varieties of wheat belonging to the same group are compared, the epidermis of a variety that matures rapidly is less differentiated into cells of different types than in a variety that matures more slowly.

Burström (1942) has put forward evidence to support the view that the mechanism by which wheat leaves unroll as they emerge from the bud, and by which they become folded when mature, is not controlled by the bulliform cells, which, in fact, have cutinized outer walls (see also p. xxvi).

Kato (1933*b*), who writes in Japanese, and gives no more than a brief summary in English, claims, as a result of his investigation of spodograms of wheat leaves, that those in cultivation can be identified by differences in the sizes and shapes of stomata, silica-bodies, and hairs. It has not been possible to check Kato's work, and the reliability of his conclusions cannot, therefore, be assessed.

2. Culm

Blaringhem and Miége (1913) found the number of vb's in T.S.s of cultivated varieties of wheat to be of diagnostic value. They noted that, in winter varieties, the cell walls are thicker and the number of vb's per culm is greater than in spring varieties. Moldenhawer (1914) has also recorded that in 19 varieties of wheat he found the number of vb's in the culm to be diagnostic for each variety. The number of bundles was also found to differ in varieties cultivated in maritime and continental climates respectively. It is hardly necessary to mention that fair comparisons in the number of vb's can be obtained only by examining the corresponding nodes in the culms of the varieties concerned. Blaringhem (1921) has described characters that are visible in T.S.s of the culm taken just below the inflorescence, which he maintains are of diagnostic value when considering *Triticum* in relation to the allied genera *Aegilops*, *Agropyron*, *Haynaldia*, and *Secale*. A v. detailed account of the anatomy of the culm of *T. turgidum* L. has been published by Athanassoff (1928), and the structure of the embryo and seedling of wheat and other cereals investigated by Avery (1930). The occurrence of amphivasal bundles, formed by the fusion of collateral strands, was observed by Chrysler (1906) in the culm nodes of *Triticum* and other genera.

3. Root

The roots of *Triticum* spp. exhibit the following characters.—Primary root exarch, with 7–11 protoxylem strands. Epidermis present as a single layer of thin-walled cells of which some bear root-hairs. Cortex at first consisting of 4–8 layers of parenchymatous cells with small intercellular spaces between the angles of the cells, but eventually becoming disintegrated. Endodermis, when young, consisting of cells that are thin-walled apart from the casparian strips, but radial, end, and inner tangential walls becoming thickened when fully mature. Pericycle 1-layered. Centre of the root occupied by a single, large metaxylem element. Endodermis and pericycle becoming thickened and serving as a protective layer after the epidermis and cortex have disintegrated.

Adventitious roots, arising from intercalary meristems at the bases of the culms, differ from the primary roots in having a more persistent cortex protected externally by a few layers of sclerotic cells, and several large central metaxylem vessels instead of a single one. For further details see Hayward (1938) and other references cited under 'Literature'.

Dunn (1921) notes the occurrence of intercellular cavities in the roots of certain varieties of *Triticum* when grown in water culture. They were thought to arise in response to the aqueous medium in which the plants were grown, and their development was found to be independent of the nature of the chemical solution, and of the temperature.

4. Developmental Anatomy

The structure and developmental anatomy of the wheat plant have been described in considerable detail by Hayward (1938), and the development of sieve tubes in *T. aestivum* L. (*T. sativum* Lam.) by Chauveaud (1897).

5. Wheat Grain

The detection of wheat flour as an admixture in that of rye has been discussed by Berthold (1883). Particulars of differences in the histology of cross-sections of the grain of different varieties of wheat have been recorded by Bates (1943).

Special Note

Leaf structure typically festucoid.

Literature

Alexandrov 1937 (fruit structure); Alexandrova 1937 (fruit structure and starch); Athanassoff 1928 (stem); Avery 1930 (embryo); Barnard 1955 (inflorescence and flowers); Bates 1943 (wheat grain); Berthold 1883 (flour); Blaringhem 1921 (culm); Blaringhem and Miége 1913 (culm); Burström 1942 (leaf rolling); Chauveaud 1897 (sieve tubes); Christiansen-Weniger 1928 (development and structure of leaf and inflorescence of wheat); Chrysler 1906 (nodes of culm); Dunn 1921 (roots of wheat in water culture); Duval-Jouve 1875 (leaf); Grob 1896 (leaf); Hayward 1938 (structure of wheat plant); Kato 1933*b* (spodograms); Kondo 1913 (fruit structure); Meyer 1925 (brief notes on root structure); Moldenhawer 1914 (culm); Paratore 1899 (leaf); Pée-Laby 1898 (leaf); Percival 1921 (wheat plant); Prankerd 1920 (statocytes); Prat 1932, 1933, 1936 (leaf); Schroder 1931 (phylogeny and taxonomy); Sharman 1947 (shoot apex); Van Tieghem 1891 (sieve tubes); Vrede 1930 (leaf rolling); Wilkens 1928 (glume and leaf of wheat); Wille 1916.

UNIOLA

Diagnostic Generic Characters

Short-cells, over the veins, in long rows. Silica-bodies, over the veins, cross to dumb-bell shaped. Micro-hairs present, each with the distal cell usually tapering to a pointed apex. Stomata with triangular subsidiary cells. Vascular bundles mostly small, rather widely spaced, and not more than inconspicuously angular in outline. Mesophyll with chlorenchyma not radiate. Bundle-sheaths double.

Species Specially Examined

***Uniola latifolia* Michx.**

Leaf

Abaxial epidermis

Short-cells, over the veins, in rows of more than 5 cells; abundant over, but infrequent or absent between, the veins. **Silica-bodies** mostly cross-shaped (Fig. Ia, 16), but some intermediate between cross and dumb-bell shaped (Fig. Ia, 17), or dumb-bell shaped (Fig. Ia, 18 (ii–v)). Grob (1896) also noted occasional nodular bodies. **Macro-hairs:** none seen. Prat (1934) notes that the ligule consists of multicellular hairs on a membranous base. **Micro-hairs:** length 42–54 μ; basal cells 15–22 μ; distal cells 28–36 (mostly 30–36) μ; distal cells usually tapering to pointed apices (Fig. VII, 6). **Prickle-hairs:** none seen. **Stomata** mostly with markedly triangular (Fig. IV, 1) subsidiary cells. **Long-cells,** between the veins, with thin, sinuous walls (Fig. V, 3*a–c*), the sinuations being rounded and not v. tall; interstomatal cells with concave ends, many of the cells being rather long (Fig. V, 11).

T.S. lamina

Vascular bundles: most vb's small, rather widely spaced, and not more than moderately angular in outline (Fig. VIII, 2 and 6); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** practically smooth (Fig. XIV, 1). **Sclerenchyma:** most small vb's with adaxial and abaxial girders 4–10 cells wide and 2–4 cells high (Fig. IX, 4), the abaxial generally being rather wider than the adaxial girders; large vb's with adaxial and abaxial girders 10–15 or more cells wide, and mostly 2, but occasionally more, cells high (Fig. IX, 5); median keel bundle supported by a wide, almost anchor-shaped abaxial girder and by a much smaller adaxial strand. **Keel** conspicuous, rounded; containing a median vb accompanied on either side by a smaller lateral (Fig. XIII, 2). **Mesophyll:** chlorenchyma not radiate. **Bulliform cells:** some, especially near the leaf margins, in regular groups as in Fig. XV, 2, but mostly in fan-shaped groups (Fig. XV, 4). Most of the ground tissue of the keel consisting of large, colourless cells. **Bundle-sheaths** double; most small vb's with 2 complete sheaths (Fig. XII, 1); large vb's with O.S. interrupted abaxially (Fig. XII, 2), or adaxially and abaxially (Fig. XII, 3*a*).

Culm

Culm examined about 2 mm in diameter, more or less circular in outline, with a large, irregular cavity at the centre. Epidermis subtended by flattened columns of assimilatory tissue of various sizes, but mostly about 2 cells wide, embedded in a zone of 6 or 8 layers of thick-walled fibres of small diameter. Ground tissue between the fibre zone and the cavity at the centre of the culm consisting of 6–8 layers of large, thin-walled cells. Vb's of the outermost circle embedded in the ring of fibres; remaining vb's in 1–2 irregular circles embedded in the thin-walled ground tissue.

Material Examined: Cultivated at Kew.

Additional Information from the Literature

The description of the leaf of *U. latifolia* by Holm (1891 *a* 1) differs so greatly from that given above that it seems v. doubtful whether Holm can have been using correctly identified material. In his later paper of the same year, Holm (1891 *a* 2) describes the leaf structure of several other spp. of *Uniola*, and here, although Holm's descriptions are less complete, the structure that he describes is much more similar to that of *U. latifolia* given above, thus suggesting that, for his later paper, he was using accurately named material.

Special Notes

Prat (1934) has drawn attention to the similarity of the leaf characters in *Uniola* to those in *Triraphis* (see p. 512). Prat (1936) also points out that although *Uniola* has sometimes been regarded as a member of the Festuceae, in his opinion the leaf epidermis and anatomy are panicoid. From the information recorded above this appears to be only partly true, for, although the epidermis exhibits panicoid characters, the structure of the lamina in T.S. is more nearly festucoid.

Literature

Duval-Jouve 1875 (leaf); Frohnmeyer 1914 (deposition of silica); Grob 1896 (leaf); Holm 1891 *a* and *b* (leaf structure; see remarks under Information from the Literature); Prat 1934, 1936 (leaf).

URELYTRUM

Prat's (1937) description of the leaf of *U. annuum* Stapf includes the following particulars.

Midrib conspicuous, projecting considerably from the abaxial and slightly from the adaxial surface. Adaxial surface smooth elsewhere, but abaxial surface with ribs over the large vb's. T.S. exhibiting 3–5 bundles between each pair of large ones. Scl. well developed in the keel and as a fairly broad hypodermal band beneath the adaxial surface of the midrib. Bulliform cells well developed in the wings of the lamina, forming a more or less continuous layer above the small vb's, and interrupted only above the first order vb's.

Special Note

Prat notes that the structure is similar to that of *Vossia* (see p. 531), and he treats both genera as belonging to the Rottboellieae.

Literature

Prat 1937 (leaf).

UROCHLOA

Diagnostic Generic Characters

Short-cells, over the veins, in long rows. Silica-bodies, over the veins, cross to dumb-bell shaped. Micro-hairs present; distal cells variable, sometimes of uniform diameter throughout their lengths and with rounded apices, others

tapering towards their rounded apices. Stomata with triangular subsidiary cells. Vascular bundles mostly moderately small, crowded, and angular. Mesophyll with inconspicuously radiate chlorenchyma. Bundle-sheaths single and double.

Species Specially Examined

***Urochloa pullulans* Stapf**

Leaf

Abaxial epidermis

Short-cells, between the veins, paired; those over the veins in rows of more than 5 cells; abundant over, and v. frequent between, the veins. **Silica-bodies,** between the veins, mostly cross-shaped (Fig. IA, 16), but many of them with a distorted appearance; a few more nearly of the tall, crenate type (Fig. IB, 24); some of those over the veins cross-shaped and not distorted, but more frequently intermediate between cross and dumb-bell shaped (Fig. IA, 17). **Macro-hairs:** fairly long, stiff hairs with swollen, sunken, constricted bases (Fig. II, 3) occasional in the intercostal zones. **Micro-hairs:** length 52–60 (mostly 52–58) μ; basal cells 20–24 μ; distal cells 30–38 (mostly 30–36) μ; distal cells sometimes tapering to rounded apices, but others with more rounded apices and more uniform in diameter throughout their lengths. **Prickle-hairs:** large, angular prickles (Fig. VI, 3) present at the margins of the leaf, and occasional small hooks (Fig. VI, 5) in the intercostal zones. **Stomata** mostly with triangular (Fig. IV, 1) subsidiary cells. **Long-cells,** beside the veins, with moderately thin, acutely sinuous (Fig. V, 3*a–c*) walls; those in the middle of the intercostal zones rather a short form of this type (Fig. V, 7*a–b*). Interstomatal cells with concave ends (Fig. V, 10–11), and somewhat variable in length.

T.S. lamina

Vascular bundles: most vb's moderately small, crowded, and angular (Fig. VIII, 5); large vb's of basic type (Fig. VIII, 15). **Adaxial surface** with v. slight ribs over the vb's, the intervening furrows being v. shallow and narrow (Fig. XIV, 2). Abaxial surface also with v. slight ribs, opposite those on the adaxial surface. **Sclerenchyma:** a few small vb's, especially those towards the leaf margins, not accompanied by scl. (Fig. IX, 1); most other small vb's with minute adaxial and abaxial strands, many of them being no more than 1 or 2 cells high and wide (Fig. IX, 4); large vb's with adaxial and abaxial strands or girders slightly larger than the strands to the small vb's. Median keel vb supported by a low, wide, somewhat anchor-shaped abaxial girder and by 3 small, flattened strands subjacent to the adaxial epidermis. **Keel** fairly conspicuous, rounded; containing a single median vb (Fig. XIII, 1), or a median vb accompanied on either side by 1 or 2 small laterals (Fig. XIII, 2). **Mesophyll:** chlorenchyma inconspicuously radiate in the material examined. **Bulliform cells** in fan-shaped groups (Fig. XV, 4), the central cell of each of certain of the groups penetrating rather deeply into the mesophyll. **Bundle-sheaths** single and double; small vb's each surrounded by a single complete sheath (Fig. XI, 2*a*), the component cells being v. unequal in size, and the outlines

of the sheaths markedly sinuous; large vb's with the I.S. complete and the O.S. interrupted abaxially (Fig. XII, 2); median vb with O.S. interrupted abaxially but connected to the adaxial scl. by large, colourless cells (Fig. XII, 4).

CULM

Culm examined oval in outline, but with 1 side flattened or v. slightly concave, the longer diameter being about 4 mm; centre of the culm occupied by spongy ground tissue. Epidermis subtended by a single layer of fibrous cells bounded on the inner side by a zone of assimilatory tissue about 3–5 cells wide. Assimilatory tissue followed by a zone of fibres some 6 cells wide, passing over gradually into the increasingly large-celled, thin-walled, spongy ground tissue at the centre of the culm. Numerous, minute, triangular intercellular spaces present between the cells of the thin-walled ground tissue. Vb's of the outermost circle embedded in scl. Remaining vb's scattered throughout the inner ground tissue, except in the spongy tissue at the centre of the culm.

MATERIAL EXAMINED: Supplied specially by G. Jackson from Nyasaland.

ADDITIONAL INFORMATION FROM THE LITERATURE

The few following particulars concerning the leaf of *U. trichopus* (Hochst.) Stapf are given by Günzel (1912) under *Panicum trichopus* Hochst. Leaf with a conspicuous midrib. Large cushion hairs present on both surfaces and at the leaf margins. Scl. only slightly developed on the adaxial and abaxial sides of the secondary vb's. Günzel also notes the following characters of the leaf sheath. Abaxial surface ribbed. Long-cells in the intercostal zones of the abaxial epidermis with sinuous anticlinal walls. Colourless parenchyma well developed in the midrib.

SPECIAL NOTE

Leaf structure is mainly panicoid.

LITERATURE

Günzel 1912 (leaf; under *Panicum trichopus* Hochst.).

UROCHONDRA

Hubbard (1950*e*), who has published a detailed, illustrated description of *U. setulosa* (Trin.) C. E. Hubbard, includes a diagram of a T.S. of a small part of a leaf which shows the following characters.

Adaxial and abaxial surfaces both ribbed, the furrows between the blunt abaxial ribs being deep and v. narrow, and those between the adaxial ribs wider. Short, stiff, macro-hairs present, particularly on the adaxial, and to a smaller extent on the abaxial, ribs. Structures resembling v. short hairs or papillae also shown in the narrow abaxial grooves. Scl. strands well developed at the apices of the adaxial and abaxial ribs. Mesophyll with the chlorenchyma radiately arranged around each of the small vb's, and similarly arranged, but interrupted adaxially and abaxially by the scl. in the ribs, around the large vb's. Bulliform cells present at the bases of the adaxial furrows and connected to the corresponding abaxial grooves by girder-like strips of colourless cells traversing the lamina between the vb's. Colourless parenchyma also present in, and forming the central ground tissue of, the ribs, being

enclosed by the surrounding chlorenchyma and scl. Bundle-sheaths surrounding the small vb's somewhat triangular in outline, the sheaths to the large vb's being interrupted adaxially and abaxially by the scl. in the apices of the ribs.

SPECIAL NOTE

Urochondra is stated by Hubbard to be related to *Crypsis* and *Sporobolus*. The rather incomplete information concerning the structure of the leaf is not inconsistent with this suggestion.

LITERATURE

Hubbard 1950*e* (leaf and taxonomy).

VALOTA (see TRICHACHNE on p. 514)

VENTENATA

Only scattered statements concerning the leaf anatomy of *V. avenacea* Koel., = *V. dubia* (Leers) F. Schultz, have been found in the literature.

Adaxial surface with ribs and furrows. Bulliform cells well developed. Silica-bodies mostly circular to elliptical, but sometimes more irregular in outline.

SPECIAL NOTE

Prat (1936) states that the leaf characters are festucoid.

LITERATURE

Grob 1896, Pée-Laby 1898, Prat 1936 (all referring to leaf structure).

VETIVERIA

DIAGNOSTIC GENERIC CHARACTERS

Short-cells, over the veins, paired. Silica-bodies, over the veins, mostly cross-shaped but with v. short arms. Micro-hairs present; often balanoform. Stomata with triangular or low dome-shaped subsidiary cells. Vascular bundles: only the smallest vb's conspicuously angular in outline. Mesophyll highly distinctive in the sp. examined, with the radiate chlorenchyma mainly as a narrow strip subjacent to the abaxial epidermis, the greater part of the lamina between the vb's being occupied by v. large intercellular cavities. Bundle-sheaths: those round the small vb's single.

SPECIES SPECIALLY EXAMINED

***Vetiveria zizanioides* (L.) Nash**

LEAF

Abaxial epidermis

Short-cells, both over and between the veins, paired; abundant. **Silica-bodies** mostly cross-shaped (Fig. IA, 16), but with v. short arms, some of them having a distorted appearance. **Macro-hairs:** none seen. **Micro-hairs:** length 39–54 μ; basal cells 14–22 μ; distal cells 25–33 μ; hairs often balanoform (Fig. VII, 3), the distal cells frequently being somewhat inflated and with

rounded apices; hairs rather wide in proportion to their lengths. **Prickle-hairs:** v. large, angular prickles (Fig. VI, 3) present at the leaf margins. **Stomata:** many with somewhat triangular (Fig. IV, 1), but often with low dome-shaped (Fig. IV, 3) subsidiary cells. **Long-cells,** both over and between the veins, with moderately thick, sinuous walls (Fig. V, 3*a–c*).

T.S. lamina

Vascular bundles: smallest vb's, i.e. the only ones wholly embedded in assimilatory tissue, angular in outline (Fig. VIII, 5); medium-sized vb's not conspicuously angular (Fig. VIII, 2); large vb's of basic type (Fig. VIII, 12), and somewhat pear-shaped in outline. **Adaxial surface** practically smooth (Fig. XIV, 1). Abaxial surface with slight ribs over the large and medium-sized vb's. **Sclerenchyma:** smallest vb's mostly not accompanied by scl. (Fig. IX, 1), but some of them with abaxial girders only (Fig. IX, 3); medium-sized and large vb's with well-marked abaxial I-girders and v. much smaller adaxial strands, the strands being connected to the bundle-sheaths by girder-like columns of colourless cells traversing the lamina vertically and serving to separate the large intercellular spaces in the adaxial part of the mesophyll from one another. **Midrib** conspicuous, partly on account of an abaxial projection, but chiefly owing to the main part of the lamina being much wider between the adaxial and abaxial epidermis than the midrib itself. Lamina further demarcated by a single, fairly deep, abaxial furrow on either side of the midrib. Midrib containing 1 large median vb, accompanied on either side by about 3, v. much smaller, laterals (Fig. XIII, 3). **Mesophyll** of a highly distinctive type, owing to the chlorenchyma being chiefly confined to a comparatively narrow strip subjacent to the abaxial epidermis, with extensions along the sides of the medium-sized and large vb's. Greater part of the lamina occupied by v. large, intercellular cavities extending from the assimilatory tissue to just below the adaxial epidermis. A single large cavity of this type present between each pair of girders of colourless cells connecting the large and medium-sized vb's to the adaxial epidermis, a total of 7 of these large intercellular cavities occurring on either side of the midrib in the material examined. Lamina much thinner towards the leaf margins, intercellular spaces here being absent, and the adaxial part of the mesophyll consisting of colourless cells. Assimilatory tissue itself markedly radiate. **Bulliform cells** confined to a single large group on the adaxial surface of the midrib. Colourless cells, besides those forming girders, and those in the adaxial part of the lamina towards the leaf margins, also constituting the ground tissue of the midrib between the adaxial bulliform cells and the assimilatory tissue in the keel. **Bundle-sheaths:** each small angular vb in the assimilatory tissue completely surrounded by a single sheath (Fig. XI, 2*a*); sheaths to the large and medium-sized vb's difficult to classify, but appearing to be single, and to have an abaxial interruption (Fig. XI, 6).

MATERIAL EXAMINED: F. Ballard 1491; Ceylon.

ADDITIONAL INFORMATION FROM THE LITERATURE

Vickery (1935) has described the leaf structure of *V. elongata* C. E. Hubbard (*Chrysopogon elongatus* Benth., *C. gryllus* var. *spicigera* Maiden & Betche), and her

description includes the following particulars. Leaf rather thick; becoming folded on drying. Both surfaces more or less flat, or abaxial surface slightly undulating. Scl. present on the adaxial and abaxial sides of, and sometimes forming girders with, the large vb's; small vb's not accompanied by scl. Midrib small but conspicuous. Mesophyll with chlorenchyma consisting of short, rounded cells arranged rather regularly around each of the somewhat closely spaced vb's, but other similar cells also present between the vb's and grading imperceptibly into the adaxial colourless cells. Conspicuous air-cavities present between the large vb's. Bulliform cells restricted to a single group below the adaxial surface of the midrib and accompanied by subjacent colourless cells. Bulliform cells also occasional towards the leaf margins. Colourless cells forming a more or less continuous band beneath the adaxial surface above the air-cavities, and between the large vb's and the adaxial epidermis, grading into the scl. Colourless cells and air-cavities together occupying one half to three quarters of the leaf thickness. Bundle-sheaths single; circular in outline.

The structure of *V. zizanioides* as described by Prat (1937) agrees in essentials with the description of this same sp. given above. From Prat's remarks, *V. fulvibarbis* (Trin.) Stapf appears to be similar in structure, but the bulliform cells in the group over the midrib are stated to project outwards. It is pointed out, however, that there are considerable variations in structure throughout the length of the lamina, and these should be taken into account when dealing with interspecific differences.

SPECIAL NOTE

Prat (1936) indicates that the leaf structure is panicoid, and in a general way this is true. It is noteworthy, however, that the mesophyll is somewhat distinctive on account of the restricted distribution of the chlorenchyma and the presence of large intercellular spaces between the vb's.

LITERATURE

Prat 1936, 1937, Vickery 1935 (all referring to leaf structure).

VIGUIERELLA

Prat (1936) notes that *Viguierella*, which is sometimes placed in the Festuceae, exhibits a panicoid epidermis and leaf anatomy. The genus is sometimes included in the Eragrosteae.

LITERATURE

Prat 1936 (leaf).

VOSSIA

Prat's (1937) description of the leaf structure of *V. cuspidata* (Roxb.) Griff. includes the following particulars.

Lamina with a large midrib projecting above the adaxial surface and appearing trapezoid in section. Wings of the lamina thin. Adaxial surface with ribs and furrows, the ribs having pointed apices bearing prickles. Adaxial surface of the midrib bearing warts and supported by a thin layer of scl. Abaxial surface of the lamina flat but papillose. Vascular bundles: 7–10 vb's of unequal sizes and status present between each pair of large vb's. Bulliform cells present at the bases of the adaxial furrows

situated above the smallest vb's. Bulliform tissue absent from the adaxial surface of the midrib.

Special Notes

Prat (1937) treats the genus as a member of the Rottboellieae.

Furlong and Coomber (1944), who examined *V. cuspidata* as a possible source of paper-making material, suggest that its greatest promise is for making printing and writing papers where no great mechanical strength is required. The sample which was examined by Furlong and Coomber had an average fibre length of 1·6 mm.

Literature

Furlong and Coomber 1944 (paper-making properties); Prat 1937 (leaf).

VULPIA

The following notes on the leaf structure of *Vulpia* have been taken from the literature, where the genus is referred to under *Festuca*.

V. myurus (L.) C. C. Gmel.

A tufted, somewhat hairy annual. Leaves often appearing to be setaceous because rolled, but blade sometimes expanded. Adaxial surface with prominent acute ribs. Short macro-hairs and prickles present on the adaxial surface. Scl. scanty; present in the leaf margins, in the keel, and as abaxial and/or adaxial strands opposite the vb's. Keel present, but not v. prominent. Bulliform cells well developed at the bases of the furrows.

V. bromoides (L.) S. F. Gray

In this sp. there are but few ribs on the adaxial surface, and the hairs on the ridges are rather short but strong.

Literature

Burr and Turner 1933 (leaf); Lewton-Brain 1904 (leaf); Parodi 1956 (taxonomy of the Argentine spp., but without anatomical details); Pée-Laby 1898 (leaf).

WILLKOMMIA

Grob (1896) notes that the leaf of an annual form of *W. sarmentosa* Hack. (as *W. annua* Hack.) exhibits club-shaped micro-hairs, each with a relatively short distal cell, and cushion hairs.

Literature

Grob 1896 (leaf).

ZEA

Diagnostic Generic Characters

Short-cells, over the veins, sometimes paired but others in short or long rows. Silica-bodies, over the veins, cross-shaped. Micro-hairs present; mostly balanoform. Stomata with triangular subsidiary cells. Vascular bundles mostly small, crowded, and conspicuously angular in outline. Mesophyll with the chlorenchyma at least inconspicuously radiate. Bundle-sheaths single.

Species Specially Examined

***Zea mays* L.**

Leaf

Abaxial epidermis (Fig. XXVI, 3)

Short-cells: most of those between, and some of those over, the veins paired; others over the veins in rows of 3–5, or sometimes more, cells. **Silica-bodies,** between the veins, mostly tall, narrow, and crenate (Fig. Ib, 24), or occasionally cross-shaped but with a distorted appearance; those over the veins typically cross-shaped (Fig. Ia, 16). **Macro-hairs:** none seen by the author, but cushion hairs reported by Prat (1948*a*), and by Grob (1896) amongst the bulliform cells. **Micro-hairs:** length 44–55 (mostly 48–55) μ; basal cells 12–22 μ; distal cells 32–38 μ; hairs typically balanoform (Fig. VII, 3), the inflated distal cells having rounded apices. Micro-hairs present on both surfaces, mostly over the parenchyma and sporadically over the scl.; only exceptionally amongst the stomata (Grob 1896). **Prickle-hairs:** none seen. **Stomata** with markedly triangular (Fig. IV, 1) subsidiary cells. For stomata of special type on the leaf-sheath see p. 534. **Long-cells,** between the veins, with thin, sinuous walls (Fig. V, 3*a–c*), the sinuations being v. marked and mostly acute; some cells similar but rather shorter (Fig. V, 7*a–b*).

T.S. lamina

Vascular bundles: most vb's small, crowded, angular, the smallest with xy. and ph. not easily distinguishable (Fig. VIII, 1); other small vb's as in Fig. VIII, 5; a few large vb's of basic type (Fig. VIII, 10). Transverse vb's present. **Adaxial surface** practically smooth (Fig. XIV, 1), except where the bulliform cells project above the level of the surface of the leaf. **Sclerenchyma:** numerous small vb's not accompanied by scl. (Fig. IX, 1); large vb's with adaxial and abaxial girders, mostly about 12–15 cells wide and about 6 cells high (Fig. IX, 5); a few of the small vb's also with adaxial and abaxial girders appreciably smaller than those to the large vb's; keel vb's with well-marked abaxial girders only (Fig. IX, 3), but adaxial surface of the midrib supported by small, hypodermal strands of scl. **Keel** v. conspicuous, owing to a v. wide, rounded, abaxial projection; containing 1 large median vb, accompanied on either side by a lateral almost as large as the median vb and by about 14 much smaller laterals of rather variable size (Fig. XIII, 3). **Mesophyll:** chlorenchyma slightly radiate, but rather inconspicuously so in the material examined. Assimilatory cells tending to be palisade-like below both surfaces of the leaf. **Bulliform cells** in small groups of specially large cells (the *Zea* type, Fig. XV, 3). Adaxial ground tissue of the midrib consisting of colourless cells. **Bundle-sheaths** single; sheaths to the small vb's complete (Fig. XI, 2*a*); those to the large vb's with abaxial interruptions.

INFLORESCENCE AXIS

Axis examined about 4 mm in diameter, the T.S. showing 3 large lobes. Epidermis subtended by a somewhat interrupted ring of fibres, about 2–4 cells wide. All ground tissue between this fibre ring and the centre of the axis thin-walled, the cells gradually increasing in diameter towards the centre. Outer layers of thin-walled tissue containing chloroplasts. Minute, triangular intercellular spaces present between some of the cells of the ground tissue. Vb's v. numerous; scattered throughout the thin-walled ground tissue except in the extreme centre of the axis; outer vb's smaller than those towards the centre. (For further particulars see under 'Culm' below.)

ROOT (see also p. 535)

Root examined about 5 mm in diameter; circular in outline. Cortex about 3 cells wide, the cells gradually increasing in diameter towards the endodermis. Innermost 3 or 4 cell layers of the cortex arranged in v. definite radial rows. Irregular intercellular cavities present in the middle portion of the cortex. Endodermis conspicuous because of the thickening of the inner tangential and radial walls of the cells. More than 50 large, conspicuous, metaxylem vessels present, these vessels being arranged in a rather irregular circle. Centre of the root occupied by thin-walled spongy tissue.

Hayward (1938) describes some of the adventitious roots as 'prop roots'; these are wider than the others and contain more numerous protoxylem strands. Epidermis of portions of prop roots above soil level persistent, and becoming cutinized.

MATERIAL EXAMINED: Cultivated at Kew.

ADDITIONAL INFORMATION FROM THE LITERATURE

1. LEAF

Warncke (1911) has described and figured stomata of an unusual type on the inner (adaxial) surface of the leaf sheath of maize. These stomata are shown with 2 subsidiary cells abutting on the guard cells in the usual way, but, in addition, there are 2 additional subsidiary cells at right angles to the long axis of the stomatal pore. This arrangement of subsidiary cells is quite usual in a number of monocotyledonous families, ranging from the Scheuchzeriaceae to the Palmae, but not in the Gramineae.

The cells of the bundle-sheaths in maize leaves, in common with those of many other grasses, contain green plastids resembling large chlorophyll granules. Rhoades and Carvalho (1944) indicate that these bodies are concerned with the elaboration of starch. The starch arises in 'vacuole-like regions' in the plastids; it accumulates by day and disappears by night.

2. CULM

Hayward (1938) points out that the structure of the first internode of the seedling is intermediate between that of a mature culm and a root. The epidermis and cortex surround an endodermis and pericycle, but the vascular elements are mostly in an annular zone surrounding the central pith, and they are not all organized into vb's as in the more mature stem.

The nodes of the mature culm are made woody and rigid by a complex vascular system. This vascular complex is mostly formed by anastomoses between numerous v. fine branches given off by the entrant leaf-traces, and by their fusion with the peripheral bundles in the culm. Some of the leaf traces entering the culm at a node immediately pass downwards near the periphery of the culm. Other traces extend inwards horizontally to greater depths in the node before passing downwards and then v. gradually outwards to the periphery, becoming more or less completely vertical at lower levels in the culm. Some bundles extend downwards through several nodes before becoming branched or anastomosing with other vascular strands. Observations on retted material indicate that a bundle seldom passes through more than 2–3 nodes without branching. Although numerous leaf traces enter the culm at every node, the number of vb's visible in a T.S. of an internode near the base of the plant is stated to be not much greater than in a T.S. of a higher internode. This is because the number is kept more or less constant by anastomoses at the nodes. It has already been noted that those leaf traces that penetrate to a deep level at a node immediately on entering a culm gradually pass outwards towards the periphery of the culm at a lower level. One consequence is that bundles are seen to be more crowded at the periphery than near the centre of the culm in a T.S. through an internode.

Chrysler's (1906) views on the course of the vb's in maize culms are similar to those given by Hayward. He notes the occurrence of amphivasal bundles in the positions from which axillary buds and adventitious roots arise. Chrysler also records that the cortex towards the base of the plant is broader, more spongy, and with larger intercellular spaces than elsewhere. Towards the base of the plant there is also a well-marked endodermis consisting of a single layer of rounded cells with suberized walls.

Hershey and Martin (1930–1), who studied the ontogeny of the vb's in maize culms by cutting sections of the first and second internodes at frequent time intervals, found that about 30 per cent. of the bundles assumed mature characters after 15 days. The formation of bundles continued rapidly for 45 days by when 92 per cent. had developed. The same authors also note that the number of vb's in a culm is reduced by shading and crowding.

Heinemann (1925) has published a v. detailed description of the epidermis of the culm. He refers to the occurrence of calcium oxalate crystals, but this supposition must be accepted with reserve because calcium oxalate crystals are doubtfully present in the Gramineae.

Hunter and Dalbey (1937) found that variations in the ease with which maize culms break when exposed to strong winds is bound up with the number of sub-epidermal layers of scl. and the extent to which the cells are lignified. The resistance of the culms to being broken by strong winds could be predicted not only by the way the peripheral sclerosed tissues reacted to lignin stains such as safranin, but also by the ease with which sections of the culms could be cut.

3. ROOT

Although Van Tieghem and Duliot (see Rywosch 1909) observed 6–7 large metaxylem vessels in adventitious roots of the first order in *Zea*, Rywosch (1909) found that sometimes as many as 20 occur. Lateral roots are initiated in the first instance by cell-divisions opposite a ph. group. Later, a meristematic zone extends round a wide arc of the circumference where it lies between the protoxylem and protophloem strands on the one hand and the large metaxylem vessels on the other, the lateral root thus being initiated within the tissues of the vascular strand itself and not in the pericycle.

Dunn (1921) notes the occurrence of intercellular cavities in the roots of certain varieties of *Z. mays* when grown in water culture. Their formation is independent of the chemical composition of the culture solution and of the temperature. The cortical air-cavities in the root of maize have also been investigated by McPherson (1939) who records that the formation of the cavities is preceded by death of the protoplasm in certain groups of cells, and that the protoplasm is killed by scarcity of oxygen.

4. Necrosis

Cook (1936) notes a breakdown in the ph., and sometimes in the adajcent parenchyma, of maize infected by 'stripe' disease. Sometimes additional fibres are formed and there may be an increase in the thickness of the fibre wall.

Special Notes

Prat (1936, 1948*a*) rightly indicates that the epidermal structure of *Zea*, a member of the Maydeae, is of the panicoid type. The recognized affinity of the Maydeae to the Andropogoneae is confirmed by epidermal characters.

Literature

Owing to the great economic importance of maize its anatomy has been studied from many different points of view. The following articles all have some bearing on maize anatomy.

Abbe, Phinney, and Baer 1951 (shoot apex); Avery 1930 (embryo and seedling; scutellum interpreted as a cotyledon); Campbell 1881 (ontogeny of stomata); Chauveaud 1897 (root sieve tubes); Chrysler 1906 (culm); Cook 1936 (ph. necrosis); Cutler and Cutler 1948 (morphology, mostly floral); Dunn 1921 (root); Duval-Jouve 1875 (leaf); Esau 1943 (ontogenetic studies show vb's to be wholly primary); Evans 1928 (nodal anatomy revealed by retting); Falkenberg 1876, Frohnmeyer 1914 (deposition of silica); Gérard 1881 (pp. 412–14 deal with the maize seedling); Grob 1896 (leaf epidermis); Haga 1922 (anatomy of culm nodes); Hanausek 1911 (structure of fruits and starch grains); Hayward 1938 (general morphology and anatomy); Heimsch, Whaley, and Rabideau 1950 (growth and morphology of maize); Heinemann 1925 (culm epidermis); Hershey and Martin 1930 (ontogeny of vascular system); Hunter and Dalbey 1937 (culm structure in relation to ease of falling); Janczewski 1874 (brief notes on root structure); Kumazawa 1940*a* (vascular structure of male inflorescence), 1940*b* (course of leaf traces), see also 1941; Lopriori 1930 (zygomorphy in roots); McPherson 1939 (air-cavities in root cortex); Mericle 1950 (ontogeny and genetics); Meyer 1929 (morphology of vb's); Nickerson 1954 (inflorescence morphology); Pée-Laby 1898 (leaf); Prat 1932, 1936, 1948*a* (leaf and taxonomy); Rehfous 1920 (experimental modification of stomatal structure); Rhoades and Carvalho 1944 (plastids in bundle-sheaths); Russell 1937 (influence of X-rays on root structure); Rywosch 1909 (root structure); Sharman 1942*a* (vascular structure revealed by retting), 1942*c* (ontogeny of culm), 1947 (shoot apex); Sifton 1945 (ontogeny of air-cavities in maize roots); Smith and Kerston 1942 (influence on root structure of previous X-ray treatment of seed); Stover 1934 (shoot apex); Warncke 1911 (stomata on inner side of leaf sheath similar to those of Liliaceae rather than of Gramineae); Weatherwax 1923 (general), 1930 *a* and *b* (ontogeny of maize plant and endosperm); Weaver 1955 (initiation of procambium in the shoot apex); Whaley, Heimsch, and Rabideau 1950 (ontogeny and genetics); Whaley, Mericle, and Heimsch 1956 (wall structure of meristematic cells in root tips); Wilcox 1949 (pits in cell-walls of scutellum).

ZENKERIA, see p. 653

ZEUGITES

McCoy (1934) gives the following particulars concerning the petiolate leaf of *Z. munroana* Hemsl.

Lamina 1·5–3 cm long and 5–10 mm wide. Vb's consisting of a median strand and 6 others almost as large, together with numerous smaller bundles, the main vascular strands diverging at the base of the blade and converging at its apex. Transverse vascular strands numerous. Scl. occurring as adaxial and abaxial strands to the vb's, or sometimes connecting with the bundle-sheaths to form girders. Mesophyll: chlorenchyma not radiate. Bundle-sheaths double; O.S. of the large vb's interrupted abaxially by scl.

Median vb, and 6 other large vb's, passing through the leaf-sheath and petiole, lying parallel to one another and appearing as a crescent in T.S. Eight small vb's also entering the petiole and alternating with the large vb's and thus also forming part of the crescent. Members of each of the outermost pairs of small strands becoming united at both ends of the petiole and passing through it as single strands, the 6 remaining small vascular strands forming a separate group on the dorsal side of the petiole. Vb's in the petiole not interconnected and not individually supported by scl., but some scl. present on the adaxial side of the petiole.

Developmental studies showed that the lamina and sheath are differentiated by lateral expansion of the distal and proximal parts of the leaf primordium, the petiole becoming intercalated between the blade and sheath during development.

Special Note

Prat (1934) notes that the leaf epidermis of *Zeugites* is panicoid, but claims that the leaf, in T.S., exhibits a mixture of panicoid and festucoid characters. To the present author, however, it appears that the structure of the lamina in T.S. is wholly festucoid.

Literature

McCoy 1934 (development and vascular structure of the leaf); Prat 1934 (leaf and taxonomy.)

ZIZANIA

Diagnostic Generic Characters

Short-cells, over the veins, paired or appearing to be in rows when the intervening cells in the same files are sufficiently short. Silica-bodies, over the veins, of the *Oryza* type. Micro-hairs present; each hair widest at the transverse wall between the 2 cells and tapering towards its apex and base. Stomata with triangular subsidiary cells, but outlines obscured by papillae. Vascular bundles in the wings of the lamina fairly widely spaced, not more than moderately angular in outline. Mesophyll with chlorenchyma not radiate and consisting of arm-cells; large fusoid cells present. Bundle-sheaths double.

Species Specially Examined

***Zizania latifolia* (Griseb.) Turcz.**

Leaf

Abaxial epidermis

Short-cells, between the veins, paired; those over the veins also paired, or appearing to be in rows of more than 5 cells when the intervening cells in the same files are sufficiently short; abundant both over and between the veins. **Silica-bodies,** over the veins, of the *Oryza* type (Fig. Ib, 23); those between the veins similar, but usually much narrower, and often sufficiently narrow to be classified as tall, narrow, and crenate (Fig. Ib, 24). **Macro-hairs:** short, rigid, thick-walled hairs (Fig. IIa, 10) noted in T.S., particularly on the adaxial ribs. **Micro-hairs:** length 26–36 (mostly 30–36) μ; basal cells 12–18 μ; distal cells 14–18 μ; hairs mostly widest in the region of the wall separating the 2 cells and tapering towards the apices and bases, the apices usually being pointed (Fig. VII, 11). **Prickle-hairs:** exceptionally large, mostly solitary

prickles (Fig. VI, 2) present over the veins, the prickles usually having short points, but some of them unpointed (Fig. VI, 6). **Papillae:** papillae of 2 distinct sizes (Fig. III, 4) present on most of the long-cells, there being 1 large, oblique, thickened papilla (Fig. III, 2), and numerous smaller papillae, on each cell. Stomata also usually overarched by papillae. Similar papillae present on both leaf surfaces. **Stomata** usually with triangular (Fig. IV, 1) subsidiary cells, but stomatal outlines often obscured by the overarching papillae. **Long-cells,** between the veins, with thin, v. conspicuously and acutely sinuous walls (Fig. V, 3*a–c*), some of the cells being shorter than the remainder and approximating to those in Fig. V, 6; interstomatal cells with v. sinuous walls and concave ends (Fig. V, 10–11).

T.S. lamina

Vascular bundles: vb's in the lamina fairly widely spaced, most of them being of moderate size, narrowly oval, and not more than moderately angular in outline (Fig. VIII, 2 and 6); large vb's of basic type (Fig. VIII, 11). Ph. composed of sieve tubes of conspicuously wide diameter. Margins of the leaf much thickened and each containing an especially large vb. **Adaxial surface** with slight to moderate, wide ribs over all vb's, those over the large vb's being somewhat taller and with slightly more triangular apices than the rounded apices of the smaller ribs. Triangular appearance of the taller ribs accentuated by the occurrence of large apical prickles, a single prickle being visible in T.S. at the apex of each of the ribs concerned. Furrows shallow and v. much narrower than the ribs. Abaxial surface of the leaf practically smooth apart from the occurrence of v. prominent prickle hairs over certain of the vb's. **Sclerenchyma:** nearly all, or all, vb's in the lamina with small adaxial and abaxial girders (Fig. IX, 4), those to the small vb's being about 4–10 cells wide and 1–2, or occasionally 3, cells high, and the girders to the large vb's generally rather more robust and up to about 15 cells wide (Fig. IX, 5), but seldom more than 3 cells high. Keel bundles nearest the abaxial surface mostly supported by well-marked abaxial girders only (Fig. IX, 3), and some of those near the adaxial surface by adaxial girders. Median abaxial keel bundle supported by a v. wide, crescent-shaped strand in the apex of the keel. **Keel** v. conspicuous, rounded; containing a characteristic system of intercellular spaces, and a rather complex and specialized arrangement of vb's (Fig. XIII, 6). Transverse diaphragms of stellate cells noted in some of the intercellular cavities. **Mesophyll:** chlorenchyma not radiate, consisting of arm-cells. A single, conspicuous, **fusoid-cell** present on either side of each of the vb's, as in the bamboos. **Bulliform cells** in small, fan-shaped groups (Fig. XV, 4) at the bases of the furrows, or in groups tending to be of the Sporobolus type (Fig. XV, 8), a single, wider group being present immediately on either side of the midrib. **Bundle-sheaths** double; all vb's with 2 complete sheaths, the O.S. often having a slight adaxial, and sometimes also an abaxial, extension to the adjacent scl.

PETIOLE

Structure, as revealed in T.S., similar to that of the lamina, but lamina reduced to small 'wings' on either side of the midrib.

MATERIAL EXAMINED: Cultivated at Kew.

ADDITIONAL INFORMATION FROM THE LITERATURE

CULM

The following particulars concerning *Z. aquatica* L. have been recorded by Chrysler (1906). Upper internodes exhibiting, in T.S., a narrow cortex bounded internally by a ring of scl. with a number of small vb's embedded in it, and other vb's between the scl. ring and the hollow centre of the culm. All vb's in the internode collateral but with the xy., but not the ph., reduced, sometimes to no more than a cavity, in correlation with the aquatic habitat of the grass. Some vb's anastomosing at the nodes and becoming amphivasal in structure. Leaf trace bundles of at least 3 sizes, the largest penetrating to within the sclerotic ring. Second-order traces also penetrating to within the sclerotic ring, but some of them passing outwards again at a lower level and forming the vb's passing downwards through the next lower internode at the outer periphery of the sclerotic ring. Small leaf-traces penetrating only to the sclerotic ring.

Base of culm with well-developed intercellular spaces in the broader, more spongy cortex. An endodermis of rounded cells with suberized walls also present, together with a band of scl. in contact with the pith. Leaf-traces entering the central cylinder through wide gaps in the endodermis and scl. ring, the endodermis and scl. ring becoming continuous with each other at these points. Upper and basal nodes appearing v. different in T.S. owing to the absence of amphivasal bundles from the centre of the culm in the upper nodes.

SPECIAL NOTES

The *Oryza* type silica-bodies, and the arm-cells in the mesophyll, suggest affinities between this genus and the Oryzeae, to which group it is, in fact, usually assigned. The fusoid-cells and the complex vascular system of the midrib and petiole, on the other hand, are suggestive of affinities with the bamboos, although the midribs of the bamboos, unlike that of *Z. latifolia*, are not known to contain intercellular spaces with transverse diaphragms of stellate cells. This last character is, however, quite likely to be an ecological specialization which has arisen in response to the aquatic environment in which the grass grows.

LITERATURE

Chrysler 1906 (nodal anatomy); Grob 1896 (leaf); Ohki 1939 (spodograms of leaf); Schlickum 1896 (embryo); Stover 1928–9 (root structure).

ZOYSIA

The following notes on the leaf of *Z. macrantha* Desv. (*Z. brownii* C. Muell., *Z. pungens* Benth.) have been recorded by Grob (1896) and Vickery (1935) respectively.

The grass is a perennial with creeping rhizomes; all leaves confined to the culms, of which alternate internodes are sometimes long and short respectively.

Epidermis. Short-cells in pairs or groups, each pair, especially over the scl. and near the leaf margins, consisting either of 2 cork-cells, or other pairs each comprising a cork-cell and a silica-cell. Silica-bodies said to be saddle-shaped. Micro-hairs present, but restricted to the scl. on the adaxial surface; said by Grob to be club-shaped, or sometimes thorn-like. Papillae present, but restricted to the adaxial surface, some of them overarching the stomata.

T.S. lamina. Lamina thin; both surfaces flat or almost so. Vascular bundles: about 7 first-order vb's present, each separated from the next by 3–5 (usually 4) third-order vb's. Scl. forming small adaxial and abaxial girders to the large vb's, the first-order vb nearest to the leaf margin being more heavily girdered than the remainder. Small vb's accompanied by abaxial girders only. Small abaxial, hypodermal strands of fibres also present opposite the groups of bulliform cells. Midrib not distinct. Mesophyll with radiate chlorenchyma, but usually interrupted above and below each vb by scl. Bulliform cells in fan-shaped groups of 5–7 cells between the vb's, the central cell in each group being much larger than the remainder and occupying nearly one-third of the thickness of the leaf. Central cell in each group often subtended abaxially by a row of colourless cells extending towards the abaxial epidermis. Outer walls of the bulliform cells fairly thin and papillose. Bundle-sheaths double round the large vb's, the I.S. consisting of small, thick-walled cells. Outer sheaths mostly approximately triangular in outline with adaxial apices.

Special Note

Zoysia is the type genus of the tribe Zoysieae.

Literature

Grob 1896 (leaf); Vickery 1935 (leaf).

II. GENERA IN THE BAMBUSEAE

Diagnostic Characters for the Group

Attention has already been drawn on pp. xxii and liii to some of the general morphological and anatomical characters of bamboo leaves. It is, therefore, unnecessary to do more here than to remind readers that the bamboos form a remarkably homogeneous group so far as the structure of their leaves is concerned. The salient diagnostic characters are as follows.

Short-cells, over and between the veins, v. commonly paired; others, over the veins, in short rows; rows more than 5 cells long relatively infrequent, but noted, e.g. in species of *Phyllostachys*, *Shibataea*, and *Thyrsostachys*. Silica-bodies exhibiting a range of shapes; those over the veins mostly saddle-shaped, but others of the *Oryza* type, slightly cross-shaped, intermediate between cross and dumb-bell shaped or occasionally oblong; those between the veins often of the same types, but, when saddle-shaped, usually narrower than those over the veins; tall and narrow, crescent-shaped, or narrow crenate forms also occurring between the veins in certain species. Micro-hairs commonly present but varying in frequency in different species; exhibiting the range of forms shown in Fig. XVI. Uniseriate micro-hairs characteristic of *Guaduella oblonga* (Fig. XVI, 23), and 3-celled types also noted in *Arundinaria vagans* (Fig. XVI, 13). Micro-hairs with deposits of silica on the transverse walls between the 2 cells noted, e.g. in *Bambusa vulgaris* (Fig. XVI, 15) and *Oreobambos buchwaldii* (Fig. XVI, 30). Papillae v. common and often abundant on the long-cells, but frequency varying in different species; v. often 1 or a number of papillae projecting above and overarching the individual stomata, thus obscuring the outlines of the subsidiary cells in surface view. Stomata usually with

low dome-shaped subsidiary cells. Long-cells, between the veins, usually with the anticlinal walls coarsely and conspicuously sinuous. Leaf-blade often with the 2 halves of the lamina not symmetrical on either side of the midrib. Adaxial surface generally with more or less pronounced ribs and furrows. Vascular bundles: small vb's usually not conspicuously angular in outline, and with no conspicuously large vessels (Fig. VIII, 2), but sometimes tending to be of the *Leptaspis* type (Fig. VIII, 3);[1] large vb's usually of the basic type (Fig. VIII, 15). Sclerenchyma: both large and small vb's almost invariably supported by girders, rather than strands, the adaxial commonly being narrower than the abaxial girders. Midrib or keel nearly always well developed (but see *Merostachys riedeliana* on p. 564), strongly supported by sclerenchyma, and nearly always exhibiting a complex vascular system (Fig. XVII). Mesophyll (Fig. XVIII, 3, 4, 6, 7): chlorenchyma not radiate, consisting of arm-cells. Fusoid-cells generally present, but none, or only a few, observed in certain species of *Phyllostachys*. Bundle-sheaths all double.

On the following pages the leaf structure of a number of genera is described. No attempt has been made to list the diagnostic characters for the individual genera because the characters of the genera overlap. The anatomical data obtained during the present writer's own investigations are summarized in Table I on p. 586.

ARTHROSTYLIDIUM

Species Specially Examined

***Arthrostylidium capillifolium* Griseb.**

Leaf

Abaxial epidermis

Short-cells, over and between the veins, paired; abundant. **Silica-bodies** saddle-shaped (Fig. I, 9 (iv–v)). **Macro-hairs:** none seen. **Micro-hairs** (Fig. XVI, 1) v. rare; sometimes with both cells of more or less equal length, but distal cell generally shorter than the basal cell; basal cell 20–31 μ long; distal cell 11–24 μ long. **Prickle-hairs:** prickles occasional (Fig. VI, 1–2). **Papillae:** none seen. **Stomata** with low dome-shaped subsidiary cells (Fig. IV, 3). **Long-cells,** over the veins, with thick, pitted or sinuous walls (Fig. V, 1*a–b*); those in the intercostal zones with thin, sinuous walls (Fig. V, 3*a–c*). **Transverse veins:** only a few seen.

T.S. lamina

Adaxial surface with pronounced ribs and furrows, the ribs being of 2 distinct sizes, the tall type enclosing the large vb's. **Sclerenchyma:** small vb's accompanied by adaxial and abaxial girders, mostly about 3 cells wide, the adaxial and the abaxial girders being of about the same size (Fig. IX, 4); large bundles tending to be accompanied by adaxial T, and short wide, abaxial girders (Fig. IX, 8). **Keel:** vascular system and scl. of type V (Fig. XVII, 3).

[1] For list of bamboos in which vascular bundles of the *Leptaspis* type were noted by the author see p. 617.

Mesophyll with arm-cells, but arms not so marked as in many bamboos. **Fusoid-cells** v. infrequent; horizontal diameter 22–26 μ; vertical diameter 13–15 μ. **Bulliform cells** in fan-shaped groups (Fig. XV, 4) with the cells projecting above the epidermis. **Bundle-sheaths:** small vb's with 2 complete sheaths (Fig. XII, 1), or with the O.S. slightly interrupted abaxially (Fig. XII, 2); large vb's infrequent, each with the O.S. interrupted abaxially.

MATERIAL EXAMINED: Herman 780; Cuba.

***Arthrostylidium pubescens* Rupr.**

LEAF

Abaxial epidermis

Short-cells, over and between the veins, paired; slight tendency, over the veins, to be in rows of 3–5 cells; abundant. **Silica-bodies** mostly saddle-shaped (Fig. I, 9 (iv–v)). **Macro-hairs:** none seen. **Micro-hairs** (Fig. XVI, 2): some with the distal cell slightly longer than the basal cell and tapering to a rounded point; others with both cells of about equal length, or with the basal slightly longer than the distal cell; numerous and rather variable in shape; basal 20–33 μ long; distal cell 20–26 μ long. **Prickle-hairs:** prickles (Fig. VI, 1–2) and hooks (Fig. VI, 5) occasional. **Papillae** present: large, thin-walled; poorly developed and not conspicuous. **Stomata** with low dome-shaped subsidiary cells (Fig. IV, 3). **Long-cells,** both over and between the veins, with thin, sinuous walls (Fig. V, 3*a–c*); cells in the stomatal bands shorter than those elsewhere. **Transverse veins:** only a few observed.

T.S. lamina

Adaxial surface with slight to moderate, rounded ribs, and narrow, shallow furrows; abaxial ribs fairly well developed. **Sclerenchyma:** a few small vb's accompanied by small adaxial and abaxial girders (Fig. IX, 4), but most vb's with narrow, 2–3-seriate adaxial, and smaller abaxial, girders; combined girders of large vb's anchor-shaped (Fig. IX, 6). **Keel:** vascular system and scl. of type V (Fig. XVII, 3). **Fusoid-cells** v. scarce; 26–31 μ in horizontal, and 13–15 μ in vertical, diameter. **Bulliform cells** mostly in fan-shaped groups (Fig. XV, 4), but some groups, especially near the midrib, tending to be of the *Sporobolus* type (Fig. XV, 8). **Bundle-sheaths:** most small vb's with 2 complete sheaths (Fig. XII, 1); large vb's with O.S. interrupted abaxially, or, v. rarely, with slight adaxial interruptions as well.

MATERIAL EXAMINED: Fendler 1428; Venezuela.

ARUNDINARIA

SPECIES SPECIALLY EXAMINED

***Arundinaria auricoma* Mitford = *A. variegata* (Miq.) Makino**

LEAF

Abaxial epidermis

Short-cells, over the veins, solitary and, more frequently, paired, a few in rows of 3–5 or occasionally more cells; common over, but infrequent between,

the veins. **Silica-bodies,** over the veins, saddle-shaped (Fig. I, 9 (iv–v)); the few between the veins tall, narrow, and crenate in outline (Fig. IB, 24). **Macro-hairs** numerous, fairly long, with swollen but unconstricted bases. **Micro-hairs:** each with the basal cell appreciably longer than the distal cell; distal cell variable in shape, sometimes pointed; basal cell 40–44 μ and distal cell 18–33 μ long. **Prickle-hairs:** hooks (Fig. VI, 5) occurring sparsely in the intercostal zones. **Papillae:** most unspecialized epidermal cells with small, variously shaped thick-walled papillae, arranged in one or more rows per cell and not usually overarching the individual stomata. **Stomata** with low dome-shaped (Fig. IV, 3) subsidiary cells. **Long-cells,** in the intercostal zones, and over the small veins, with thin, sinuous walls (Fig. V, 3*a–c*); narrower and less sinuous over the large veins.

T.S. lamina

Adaxial surface with shallow furrows, and low, wide ribs. **Sclerenchyma:** small vb's accompanied by adaxial and abaxial girders (Fig. IX, 4), and others by taller, narrow, adaxial and abaxial girders (Fig. IX, 7); combined girders of large vb's anchor-shaped (Fig. IX, 6), but arms of the anchor not well developed. **Keel:** vascular system and scl. of type IV (Fig. XVII, 9 and 11). **Fusoid-cells:** 81–101 μ in horizontal, and 13–29 μ in vertical, diameter. **Bulliform cells** in fan-shaped groups. **Bundle-sheaths:** most vb's with 2 complete sheaths (Fig. XII, 1), but large vb's with O.S. interrupted abaxially (Fig. XII, 2).

MATERIAL EXAMINED: Cultivated at Kew.

***Arundinaria* (*Semiarundinaria*) *fastuosa* (Mitford) Makino**

LEAF

Abaxial epidermis

Short-cells, over the veins, solitary or paired; those over the large veins, in rows of more than 5 cells; infrequent between the veins apart from those paired with hooks; common over the veins. **Silica-bodies** saddle-shaped (Fig. I, 9 (iv–v)). **Macro-hairs:** none observed. **Micro-hairs** (Fig. XVI, 3): some with the distal longer than the basal cell; others with basal cell longer than the distal cell; distal cell variable in shape, sometimes pointed; basal cell 22–33 μ long; distal cell 20–26 μ long. **Prickle-hairs:** prickles (Fig. VI, 1–2) and hooks (Fig. VI, 5) numerous between the veins. **Papillae** locally numerous, especially in the stomatal bands; swollen, rather thick; some overarching the individual stomata. **Stomata** with low (Fig. IV, 3), or tall (Fig. IV, 4), dome-shaped subsidiary cells. **Long-cells,** in the intercostal zones, with thin, sinuous walls (Fig. V, 3*a–c*); obscure over large veins; interstomatal cells with concave ends (Fig. V, 10). **Transverse veins** numerous.

T.S. lamina

Adaxial surface with v. slight ribs and furrows. **Sclerenchyma:** most bundles with narrow adaxial, and smaller, shorter, abaxial, girders (Fig. IX, 4);

combined girders to the large vb's anchor-shaped (Fig. IX, 6), but arms of the anchor only slightly developed. **Keel:** vascular system and scl. of type IV (Fig. XVII, 9 and 11). **Fusoid-cells** 37–53 μ in horizontal, and 11–20 μ in vertical, diameter. **Bulliform cells** mostly in fan-shaped groups (Fig. XV, 4); slight tendency for some groups to be of the *Sporobolus* type (Fig. XV, 8). **Bundle-sheaths:** most vb's with the I.S. complete and the O.S. with a slight adaxial projection, the latter consisting of only 1 cell; large vb's with O.S. interrupted abaxially (Fig. XII, 2).

MATERIAL EXAMINED: Cultivated at Kew.

Arundinaria fortunei A. & C. Riv. = *A. variegata* (Miq.) Makino

LEAF

Abaxial epidermis

Short-cells, especially those between the veins, solitary or, more commonly, paired; those over the veins (especially the large veins) in rows of 3–5 cells; common. **Silica-bodies,** over the veins, saddle-shaped (Fig. I, 9 (iv–v)); those between the veins rather variable, some tending to be saddle-shaped, but more often tall, narrow, and crenate (Fig. IB, 24). **Macro-hairs** present; stiff, with swollen, constricted bases. **Micro-hairs** (Fig. XVI, 4): generally with the basal cell appreciably longer than the distal cell; distal cell rather variable in shape, and sometimes pointed; basal cell 31–42 μ long; distal cell 22–33 μ long. **Prickle-hairs:** none definitely seen, but structures (possibly young macro-hairs) resembling unpointed prickles (Fig. VI, 6) noted locally over the veins. **Papillae** present; a mixture of small cuticular, and a few larger, more inflated, papillae, arranged in 1 or more rows per cell; only a few of the individual stomata overarched by papillae. **Stomata** mostly with low (Fig. IV, 3), or occasionally with tall (Fig. IV, 4), dome-shaped subsidiary cells. **Long-cells,** in intercostal zones, with thin, sinuous walls (Fig. V, 3*a–c*); those over the veins similar, but with rather thicker walls; interstomatal cells with concave ends (Fig. V, 10). **Transverse bundles** numerous.

T.S. lamina

Adaxial surface with shallow furrows, and slight, rather wide ribs. **Sclerenchyma:** most vb's with small adaxial and abaxial girders (Fig. IX, 4), the adaxial often being slightly taller and narrower than the abaxial girders; combined girders of large vb's anchor-shaped (Fig. IX, 6), arms of the anchor not well developed. **Keel:** vascular system and scl. of type II (Fig. XVII, 8). **Fusoid-cells** 35–96 μ in horizontal, and 15–24 μ in vertical, diameter. **Bulliform cells** mostly in fan-shaped groups (Fig. XV, 4), but cells in some groups more uniform in size and shape. **Bundle-sheaths:** some small vb's with 2 complete sheaths (Fig. XII, 1); all large, and other small, bundles with O.S. interrupted abaxially (Fig. XII, 2).

MATERIAL EXAMINED: Cultivated at Kew.

Arundinaria graminea (Bean) Makino

LEAF

Abaxial epidermis

Short-cells sometimes solitary or paired; others in rows of 3–5 or more cells; abundant over, but infrequent between, the veins, apart from those paired with hooks. **Silica-bodies,** over the veins, saddle-shaped (Fig. I, 9 (iv–v)); those between the veins inconspicuous and narrow. **Macro-hairs:** none observed. **Micro-hairs:** basal cell slightly to much longer than the distal cell; distal cell rather variable in shape; basal cell 29–40 μ long; distal cell 18–31 μ long (Fig. XVI, 5). **Prickle-hairs:** hooks (Fig. VI, 5) v. numerous between the veins. **Papillae** present; small, variously shaped, cuticularized; mostly 1 row per cell; some overarching the individual stomata. **Stomata** mostly with low (Fig. IV, 3), but some with tall (Fig. IV, 4), dome-shaped subsidiary cells; outlines obscured by overarching papillae. **Long-cells,** in the intercostal zones, with thin, sinuous walls (Fig. V, 3*a–c*); those over the veins similar, but with thicker walls. **Transverse bundles** numerous.

T.S. lamina

Adaxial surface with narrow, shallow furrows and much wider, low ribs. **Sclerenchyma:** most vb's accompanied by tall, narrow, adaxial girders; abaxial girders also narrow but much less tall (Fig. IX, 7); combined girders to large vb's anchor-shaped (Fig. IX, 6), but arms of the anchor not v. pronounced. **Keel:** vascular system and scl. of type II (Fig. XVII, 8). **Fusoid-cells** 35–70 μ in horizontal, and 13–20 μ in vertical, diameter. **Bulliform cells** in fan-shaped groups (Fig. XV, 4). **Bundle-sheaths:** some small vb's with 2 complete sheaths (Fig. XII, 1); all large, and some small, vb's with the O.S. interrupted abaxially (Fig. XII, 2).

MATERIAL EXAMINED: Cultivated at Kew.

Arundinaria japonica Sieb. et Zucc.

LEAF

Abaxial epidermis

Short-cells, between the veins, mostly, and those over the veins sometimes, in pairs; others, over the veins, in rows of 3–5 or more cells; generally common, but infrequent between the veins, apart from those paired with hooks. **Silica-bodies** partly saddle-shaped (Fig. I, 9 (iv–v)), but some barrel-shaped to slightly cross-shaped. **Macro-hairs:** none seen. **Micro-hairs** (Fig. XVI, 6): with the basal slightly to considerably longer than the distal cell; distal cell variable in shape, sometimes pointed; basal cell 22–33 μ long; distal cell 20–22 μ long. **Prickle-hairs:** prickles (Fig. VI, 1–2), sometimes unpointed (Fig. VI, 6), present over the veins; hooks abundant between the veins. **Papillae** present; small, variously shaped, cuticularized; mostly 1 row per cell; a few papillae overarching the individual stomata. **Stomata** mostly with low (Fig. IV, 3), and sometimes with tall (Fig. IV, 4), dome-shaped subsidiary cells. **Long-cells,** between the veins, with thin, sinuous walls (Fig. V, 3*a–c*); walls of cells over the veins, rather thicker. **Transverse bundles** numerous.

T.S. lamina

Adaxial surface with narrow, shallow furrows; ribs much wider, but not tall. **Sclerenchyma:** most vb's with tall, narrow, adaxial girders; abaxial girders also narrow but much less tall (Fig. IX, 7); combined girders to large vb's anchor-shaped (Fig. IX, 6), but arms of the anchors not prominent. **Keel:** vascular system and scl. of type II (Fig. XVII, 8). **Fusoid-cells** 66–90 μ in horizontal, and 18–26 μ in vertical, diameter. **Bulliform cells** mostly in fan-shaped groups. **Bundle-sheaths:** most small vb's with 2 complete sheaths (Fig. XII, 1); all large, and a few small, vb's with O.S. interrupted abaxially (Fig. XII, 2).

MATERIAL EXAMINED: Cultivated at Kew.

Arundinaria marmorea (Mitford) Makino

LEAF

Abaxial epidermis

Short-cells, between the veins, solitary or paired; those over the veins in rows of 3–5, or rarely more, cells; infrequent. **Silica-bodies** intermediate between cross and dumb-bell shaped (Fig. IA, 17). **Macro-hairs:** none seen. **Micro-hairs** (Fig. XVI, 7): with the basal cell appreciably longer than the distal cell; distal cell rounded or tapering to a point; basal cell 33–44 μ long; distal cell 15–22 μ long. **Prickle-hairs:** prickles (Fig. VI, 1–2) present, and hooks (Fig. VI, 5) fairly frequent between the veins. **Papillae** present; small, variously shaped, cuticularized; 1, or rarely 2, rows per cell; some papillae overarching the individual stomata. **Stomata** with low (Fig. IV, 3), or tall (Fig. IV, 4), dome-shaped subsidiary cells. **Long-cells** with thin, sinuous walls (Fig. V, 3*a–c*); some, especially those on either side of the veins, shorter and broader. **Transverse veins** abundant.

T.S. lamina

Adaxial surface almost smooth, with v. shallow, narrow furrows and wider, but low, ribs. **Sclerenchyma:** most vb's with small adaxial and abaxial girders (Fig. IX, 4), but adaxial somewhat taller than the abaxial girders; combined girders of the large vb's tending to be anchor-shaped (Fig. IX, 6), but arms of the anchor scarcely developed. **Keel** with vascular system and scl. of type II (Fig. XVII, 8). **Fusoid-cells** 26–45 μ in horizontal, and 18–22 μ in vertical, diameter. **Bulliform cells** mostly in fan-shaped groups. **Bundle-sheaths:** large and small vb's with I.S. complete and O.S. interrupted abaxially (Fig. XII, 2).

MATERIAL EXAMINED: Cultivated at Kew.

Arundinaria murielae Gamble

LEAF

Abaxial epidermis

Short-cells, over the veins, solitary, paired, and in rows of 3–5 or more cells; generally common, but infrequent between the veins, apart from those paired with hooks. **Silica-bodies** commonly saddle-shaped (Fig. I, 9 (iv–v)), but some tending to be cross-shaped (Fig. IA, 16) with v. shallow indentations. **Macro-hairs:** none seen. **Micro-hairs** (Fig. XVI, 8): mostly with the basal cell slightly to appreciably longer than the distal cell; distal cells always narrow and rather variable in shape; basal cell 33–46 μ long; distal cell 22–29 μ long. **Prickle-hairs:** a few hooks (Fig. VI, 5) present between the veins. **Papillae** present; small, variously shaped, cuticularized; usually 1 row per cell, but rarely more; a few papillae overarching the individual stomata. **Stomata** with triangular (Fig. IV, 1) subsidiary cells. **Long-cells,** in the intercostal zones, with thin, sinuous walls (Fig. V, 3*a–c*); those over the veins longer and with thicker walls; some cells, on either side of the veins, tending to be shorter and broader. **Transverse bundles** numerous.

T.S. lamina

Adaxial surface with narrow, shallow furrows; ribs wider and not high. **Sclerenchyma:** some vb's accompanied by small adaxial and abaxial girders (Fig. IX, 4); most vb's with the adaxial slightly taller and narrower than the abaxial girders; large vb's with low, but slightly broadened, adaxial and abaxial girders (Fig. IX, 5). **Keel:** vascular system and scl. of type VI (Fig. XVII, 5). **Fusoid-cells** mostly long and narrow, but a few shorter and taller; 35–66 μ in horizontal, and 9–15 μ in vertical, diameter. **Bulliform cells** sometimes, particularly towards the margins of the lamina, tending to consist of specially large cells (*Zea* type; Fig. XV, 3); mostly in fan-shaped groups (Fig. XV, 4) with the cell apices projecting above the leaf surface. **Bundle-sheaths:** small vb's mostly with 2 complete sheaths (Fig. XII, 1); large vb's with I.S. complete and O.S. interrupted abaxially (Fig. XII, 2).

MATERIAL EXAMINED: Cultivated at Kew.

Arundinaria nitida Mitford

LEAF

Abaxial epidermis

Short-cells, over and between the veins, occasionally solitary; others between the veins paired; those over the veins mostly in rows of 3–5 cells; generally common, but infrequent between the veins, apart from those paired with hooks. **Silica-bodies** intermediate between cross and dumb-bell shaped (Fig. IA, 17). **Macro-hairs:** none seen. **Micro-hairs** (Fig. XVI, 9); with the basal cell appreciably longer than the distal cell; distal cell with a pointed or rounded apex; basal cell 53–66 μ long; distal cell 18–22 μ long. **Prickle-hairs:** prickles (Fig. VI, 1–2) common over, and hooks (Fig. VI, 5) between, the veins. **Papillae** present: small, variously shaped, cuticularized; some of them overarching the individual stomata; a single row on each cell. **Stomata** with low (Fig. IV, 3), or tall (Fig. IV, 4), dome-shaped subsidiary cells, but rather obscure. **Long-cells,** in the intercostal zones, with v. sinuous walls (as Fig. V, 3*a–c*, but sinuations more marked); those over the veins probably similar, but obscure. **Transverse bundles** numerous.

T.S. lamina

Adaxial surface with narrow, shallow furrows; ribs much broader, low and rounded. **Sclerenchyma :** most vb's accompanied by small adaxial and abaxial girders, the adaxial being slightly taller and narrower than the abaxial girders (Fig. IX, 4 or 7); combined girders of large vb's slightly anchor-shaped (Fig. IX, 6). **Keel :** vascular system and scl. of type IV (Fig. XVII, 9 and 11). **Fusoid-cells** 42–70 μ in horizontal, and 9–18 μ in vertical, diameter. **Bulliform cells :** most groups fan-shaped (Fig. XV, 4), but some tending to be of the *Sporobolus* type (Fig. XV, 8). **Bundle-sheaths :** most small vb's with 2 complete sheaths (Fig. XII, 1); other small vb's with I.S. complete, but O.S. interrupted abaxially (Fig. XII, 2); large vb's with the O.S. interrupted adaxially and abaxially (Fig. XII, 3 *a* and *b*).

MATERIAL EXAMINED: Cultivated at Kew.

Arundinaria pumila Mitford

LEAF

Abaxial epidermis

Short-cells, both over and between the veins, occasionally solitary, or sometimes paired; most of those over the veins in rows of 3–5 or more cells; abundant. **Silica-bodies,** over the veins, mostly saddle-shaped (Fig. I, 9 (iv–v)); silica-bodies, between the veins, rather infrequent, narrower, and sometimes exhibiting a suggestion of saddle-shaped structure. **Macro-hairs** represented by a few, short, stiff, hairs with swollen constricted bases. **Micro-hairs** (Fig. XVI, 10): mostly with the basal cell slightly, or even appreciably, longer than the distal cell; distal cells rather variable in shape; basal cell 22–29 μ long; distal cell 20–24 μ long. **Prickle-hairs :** a few prickles (Fig. VI, 1–2) over, and hooks (Fig. VI, 5) abundant between, the veins. **Papillae** present; small, variously shaped, cuticularized; a single row on each cell. **Stomata :** a few with triangular (Fig. IV, 1), but more frequently with low dome-shaped (Fig. IV, 3), subsidiary cells; individual stomata not more than slightly overarched by papillae. **Long-cells,** both over and between the veins, with thin, sinuous walls (Fig. V, 3*a–c*). **Transverse bundles** numerous.

T.S. lamina

Adaxial surface almost smooth. **Sclerenchyma :** some small vb's accompanied by small, adaxial and abaxial girders, but adaxial usually slightly taller and narrower than the abaxial girders (Fig. IX, 4 and 7); combined girders of the large vb's anchor-shaped (Fig. IX, 6), but arms of the anchor not pronounced. **Keel :** vascular system and scl. of type II (Fig. XVII, 8). **Fusoid-cells** 75–90 μ in horizontal, and 15–29 μ in vertical, diameter. **Bulliform cells** in narrow, fan-shaped groups (Fig. XV, 4); some groups tending to be of the *Sporobolus* type (Fig. XV, 8). **Bundle-sheaths :** nearly all small vb's with 2 complete sheaths (Fig. XII, 1); large vb's with the O.S. interrupted abaxially (Fig. XII, 2).

MATERIAL EXAMINED: Cultivated at Kew.

Arundinaria simonii A. & C. Riv.

LEAF

Abaxial epidermis

Short-cells, between the veins, solitary or paired; those over the veins in rows of 3–5 or more cells; common. **Silica-bodies** tall, saddle-shaped (Fig. I, 9 (iv–v)). **Macro-hairs :** none seen. **Micro-hairs** (Fig. XVI, 11): sometimes with the basal cell appreciably longer than the distal cell; others with both cells of about equal length; distal cell variable in shape; basal cell 26–33 μ long; distal cell 20–29 μ long. **Prickle-hairs :** prickles (Fig. VI, 1–2) common over, and hooks (Fig. VI, 5) abundant between, the veins. **Papillae** present; small, variously shaped, cuticularized; a single row on each cell; some papillae overarching the individual stomata. **Stomata** with low (Fig. IV, 3), or tall (Fig. IV, 4), dome-shaped subsidiary cells; outlines obscured by the overarching papillae. **Long-cells,** both over and between the veins, with thin, sinuous walls (Fig. V, 3*a–c*). **Transverse bundles** numerous.

T.S. lamina

Adaxial surface with narrow, shallow furrows; ribs wider, low and slightly rounded. **Sclerenchyma :** most vb's accompanied by small adaxial and abaxial girders (Fig. IX, 4), the adaxial always being taller than the abaxial girders; combined girders of the large vb's anchor-shaped (Fig. IX, 6), but arms of the anchor not pronounced. **Keel :** vascular system and scl. of type II (Fig. XVII, 8). **Fusoid-cells** 33–66 μ in horizontal, and 13–24 μ in vertical, diameter. **Bulliform cells** in fan-shaped groups (Fig. XV, 4). **Bundle-sheaths :** nearly all small vb's with 2 complete sheaths (Fig. XII, 1); large vb's with O.S. interrupted abaxially (Fig. XII, 2).

MATERIAL EXAMINED: Cultivated at Kew.

Arundinaria tessellata (Munro) Bean = *A. ragamowski* Pfitzer

LEAF

Abaxial epidermis

Short-cells, over and between the veins, solitary and paired; others, over the veins, in rows of more than 5 cells; common. **Silica-bodies,** over the veins, saddle-shaped (Fig. I, 9 (iv–v)); infrequent between the veins. **Macro-hairs** v. infrequent; stiff, with swollen constricted bases. **Micro-hairs** (Fig. XVI, 12): some tending to be long and narrow in relation to width; mostly with the basal cell appreciably longer than the distal cell; distal cell varying in shape, with a rounded or pointed, tapering apex; basal cell 33–40 μ long; distal cell 22–29 μ long. **Prickle-hairs :** hooks (Fig. VI, 5) occurring sparsely between the veins. **Papillae** present; small, variously shaped, cuticularized; some of them overarching the individual stomata. **Stomata** with low (Fig. IV, 3), or tall (Fig. IV, 4), dome-shaped subsidiary cells, but outlines obscured by overarching papillae. **Long-cells,** between the veins, with fairly thin, sinuous walls (Fig. V, 3*a–c*). **Transverse bundles** numerous.

T.S. lamina

Adaxial surface smooth, or with slight ribs and furrows; furrows shallow and narrow, ribs much broader, not high, slightly rounded. **Sclerenchyma:** most vb's accompanied by fairly tall, narrow adaxial girders, the abaxial girders also being narrow, but rather shorter (Fig. IX, 7); some large vb's with short but wide adaxial and abaxial girders (Fig. IX, 5); combined girders to other large vb's anchor-shaped (Fig. IX, 6), with arms of the anchor comparatively well developed. **Keel:** vascular system and scl. of type I (Fig. XVII, 1*c* and 10). **Fusoid-cells** larger towards the midrib than towards the margin; those towards the midrib 97–125 μ in horizontal, and 26–33 μ in vertical, diameter; those towards the margin 55–90 μ in horizontal, and 20–22 μ in vertical, diameter. **Bulliform cells** in narrow, fan-shaped groups (Fig. XV, 4). **Bundle-sheaths:** all small vb's with 2 complete sheaths (Fig. XII, 1); large vb's with O.S. interrupted abaxially (Fig. XII, 2).

MATERIAL EXAMINED: Cultivated at Kew.

***Arundinaria vagans* Gamble**

LEAF

Abaxial epidermis

Short-cells, over and between the veins, solitary or paired; others, over the veins, in rows of 3–5 or more cells; common. **Silica-bodies,** over the veins, saddle-shaped (Fig. I, 9 (iv–v)), or tending to be cross-shaped (Fig. IA, 16) but with v. shallow indentations. Silica-bodies, between the veins, infrequent, narrower than those over the veins, and sometimes tending to be crescentic or crenate. **Macro-hairs:** fairly numerous, stiff, with swollen, constricted bases. **Micro-hairs** (Fig. XVI, 13) mostly with both cells of about equal length and uniform in diameter; others with the basal cell appreciably longer, or occasionally shorter, than the distal cell; distal cell sometimes subdivided; basal cell 26–37 μ long; distal cell 22–33 μ long. **Prickle-hairs:** a few prickles (Fig. VI, 1–2) over, and hooks (Fig. VI, 5) between, the veins. **Papillae** present; small, variously shaped, cuticularized; a single row on each cell; many, but by no means all, stomata overarched by papillae. **Stomata** mostly with low (Fig. IV, 3), and a few with tall (Fig. IV, 4), dome-shaped, or even triangular, subsidiary cells. **Long-cells,** in the intercostal zones, with thin, sinuous walls (Fig. V, 3*a–c*); a few interstomatal cells with concave ends (Fig. V, 10). **Transverse** bundles numerous.

T.S. lamina

Adaxial surface almost smooth, but with slight ribs and furrows; furrows v. shallow and narrow; ribs wider, but low and rounded. **Sclerenchyma:** most vb's accompanied by small adaxial and abaxial girders (Fig. IX, 4); some small vb's with tall narrow adaxial, and shorter abaxial, girders (Fig. IX, 7); combined girders to large vb's anchor-shaped (Fig. IX, 6). **Keel:** vascular system and scl. of type II (Fig. XVII, 8). **Fusoid-cells** 48–68 μ in horizontal, and 11–20 μ in vertical, diameter. **Bulliform cells** mostly in rather narrow, fan-shaped groups (Fig. XV, 4); some groups tending to be of the *Sporobolus* type (Fig. XV, 8). **Bundle-sheaths:** nearly all small vb's with 2 complete sheaths (Fig. XII, 1); large vb's with O.S. interrupted abaxially (Fig. XII, 2).

MATERIAL EXAMINED: Cultivated at Kew.

ATRACTOCARPA

SPECIES SPECIALLY EXAMINED

***Atractocarpa olyraefolia* Franch.**

LEAF

Abaxial epidermis

Short-cells, between the veins, mostly, and those over the veins, occasionally, paired; those over the veins mostly in rows of more than 5 cells; abundant. **Silica-bodies,** in the intercostal zones, tall and narrow (Fig. I, 4), or tending to be crescent-shaped; those over the veins mostly saddle-shaped (Fig. I, 9 (viii) dominant); others over the veins tending to be oblong (Fig. I, 10). **Macro-hairs, micro-hairs, prickle-hairs,** and **papillae:** none seen. **Long-cells,** in intercostal zones, with thin, deeply sinuous walls (Fig. V, 3*a–c*), each of the long-cells in a single file being separated from its neighbours by a pair of tall short-cells v. markedly at right angles to the horizontal walls (as Fig. V, 6, but short-cells paired); cells over the veins similar. Interstomatal cells with concave ends, but rather long and with deeply sinuous walls. **Transverse veins** infrequent.

T.S. lamina

Adaxial surface with slight, v. wide ribs and shallow furrows. **Sclerenchyma:** all, or most, vb's with small adaxial and abaxial girders (Fig. IX, 4). **Keel:** vascular system and scl. of type III (Fig. XVII, 7). **Fusoid-cells** abundant, occupying a large proportion of the mesophyll; 165–297 μ in horizontal, and 28–55 μ in vertical, diameter. **Bulliform cells** in fan-shaped groups (Fig. XV, 4), but groups not quite typical. **Bundle-sheaths:** most vb's probably with 2 complete sheaths (Fig. XII, 1), but available material rather distorted; large vb's with O.S. interrupted abaxially (Fig. XII, 2).

MATERIAL EXAMINED: Chevalier 11123. Brazzaville, Equatorial Africa.

ADDITIONAL INFORMATION FROM THE LITERATURE

Jacques-Félix (1955) refers briefly to the leaf of *A. olyraefolia*, and notes the absence of micro-hairs from this genus.

BAMBUSA

SPECIES SPECIALLY EXAMINED

***Bambusa nana* Roxb. (*B. multiplex sensu* Merrill) = *B. glaucescens* (Willd.) Sieb. ex Munro**

LEAF

Abaxial epidermis

Short-cells, between the veins, nearly always paired; those over the veins in rows of more than 5 cells; abundant. **Silica-bodies** saddle-shaped (Fig. I,

9 (v)); tall form tending towards the *Oryza* type (Fig. IB, 23). **Macro-hairs:** fairly frequent, rather short, with swollen, constricted bases. **Micro-hairs** (Fig. XVI, 14) mostly with the basal cell appreciably longer than the distal cell; distal cell occasionally with a rounded apex, but usually tapering to a fine point; basal cell 22–29 μ long; distal cell 15–22 μ long. **Prickle-hairs:** hooks (Fig. VI, 5) infrequent between the veins. **Papillae** small, variously shaped, cuticularized; a single row on each cell; some slightly overarching the individual stomata. **Stomata:** slight tendency for some to be with triangular (Fig. IV, 1), and others low (Fig. IV, 3), or tall (Fig. IV, 4), dome-shaped, subsidiary cells, the last type being dominant. **Long-cells,** between the veins, with thin, sinuous walls (Fig. V, 3*a–c*); those over the veins similar, but with thicker walls; interstomatal cells with concave ends, the cells being rather long (Fig. V, 11). **Transverse veins** infrequent.

T.S. lamina

Adaxial surface smooth, or with v. slight suggestions of ribs and furrows. **Sclerenchyma:** minor vb's accompanied by small adaxial and abaxial girders; adaxial girders mostly uniseriate and about 2 or 3 cells high, the abaxial girders each consisting of a horizontally flattened plate of fibres 1 cell tall, the combined girders thus tending to be anchor-shaped; combined girders to large vb's also anchor-shaped (Fig. IX, 6), the arms of the anchor being only 1 or 2 cells tall. **Keel:** vascular system and scl. of type II (Fig. XVII, 8). **Fusoid-cells** small; 13–51 μ in horizontal, and 4–11 μ in vertical, diameter. **Bulliform cells** mostly in fan-shaped groups (Fig. XV, 4), with the apices tending to project above the epidermis. **Bundle-sheaths:** a few small vb's probably with 2 complete sheaths (Fig. XII, 1), but all large, and most small, vb's with the O.S. interrupted abaxially (Fig. XII, 2).

MATERIAL EXAMINED: Cultivated at Kew.

***Bambusa vulgaris* Schrad.**

LEAF

Abaxial epidermis

Short-cells, between the veins, occasionally solitary, but mostly inconspicuously paired; some of those over the veins also paired, but mostly in rows of more than 5 cells; common to abundant. **Silica-bodies** saddle-shaped (Fig. I, 9 (iv–v)). **Macro-hairs:** none seen. **Micro-hairs** (Fig. XVI, 15) with both cells of about equal length and more or less uniform in diameter, but distal cell usually slightly shorter than the basal cell, and ending in a rounded point; some with conspicuous silica deposits on the transverse walls; basal cell 35–37 μ long; distal cell 29–33 μ long. **Prickle-hairs:** hooks (Fig. VI, 5) and small prickles (Fig. VI, 1) abundant between the veins. **Papillae** present; small, variously shaped, cuticularized; of local occurrence, but frequently overarching the individual stomata. **Stomata:** some with triangular (Fig. IV, 1), and others with tall dome-shaped (Fig. IV, 4), subsidiary cells. **Long-cells,** both over and between the veins, with thin, deeply sinuous walls, sometimes tending to be short; interstomatal cells mostly with concave ends and conspicuously sinuous walls. **Transverse veins** infrequent.

T.S. lamina

Adaxial surface smooth, or with slight but wide, rounded ribs, and narrow, v. shallow furrows. **Sclerenchyma:** occasional vb's accompanied by small adaxial and abaxial girders (Fig. IX, 4); combined girders of most vb's, both large and small, anchor-shaped (Fig. IX, 6), the adaxial girders of the small vb's being uniseriate or biseriate, and only 2 or 3 cells high; adaxial girders of the large vb's rather wider. **Keel:** vascular system and scl. of type II (Fig. XVII, 8). **Fusoid-cells** 77–110 μ in horizontal, and 13–22 μ in vertical, diameter. **Bulliform cells** mostly in fan-shaped groups (Fig. XV, 4), some tending to project above the level of the epidermis. **Bundle-sheaths:** some small vb's with 2 complete sheaths (Fig. XII, 1); other small, and all large, vb's with O.S. interrupted abaxially (Fig. XII, 2).

MATERIAL EXAMINED: Cultivated at Kew.

CEPHALOSTACHYUM

SPECIES SPECIALLY EXAMINED

***Cephalostachyum capitatum* Munro**

LEAF

Abaxial epidermis

Short-cells and **silica-bodies** difficult to interpret in the material available. Short-cells apparently occurring over and between the veins, except in the stomatal bands; abundant, tall, narrow, paired with hooks. Alternate short-cells in certain files each containing a vague, vertically elongated, silica-body, slightly resembling those of the *Oryza* type (Fig. IB, 23), but small and in 2 parts. (These may be no more than slightly silicified papillae.) **Macro-hairs:** none seen. **Micro-hairs** (Fig. XVI, 16): situated in the interstomatal bands of the intercostal zones, and often almost in the stomatal bands themselves; both cells of about equal length, and more or less uniform in diameter; distal cell tapering slightly towards the apex in some hairs; numerous and long; basal cell 42–46 μ long; distal cell 35–48 μ long. **Prickle-hairs:** hooks (Fig. VI, 5) abundant over and between the veins, paired with tall, narrow silica-cells; v. infrequent in, or absent from, the stomatal bands. **Papillae:** see under silica-bodies above; a few overarching the individual stomata. **Stomata** obscured by overarching papillae. **Long-cells** with thin, deeply sinuous walls; interstomatal cells also sinuous and with concave ends (Fig. V, 10–11). **Transverse bundles:** none seen.

T.S. lamina

Adaxial surface smooth apart from a few tall ribs on one side of the midrib. **Sclerenchyma:** combined girders of most vb's anchor-shaped (Fig. IX, 6), the adaxial part of each girder being tall, narrow and 1–2-, or occasionally 3-, seriate; a few ribs near the midrib more massively supported by sclerenchyma. **Keel:** vascular system and scl. of type II (Fig. XVII, 8). **Fusoid-cells** abundant; 88–121 μ in horizontal, and 22–33 μ in vertical, diameter; those with low

horizontal diameters tending to have high vertical diameters. **Bulliform cells:** groups mostly narrowly fan-shaped, but those near the midrib consisting of specially large cells. **Bundle-sheaths:** all vb's with I.S. complete and O.S. interrupted abaxially (Fig. XII, 2).

MATERIAL EXAMINED: Wenger 399; Assam.

CHLOOTHAMNUS

SPECIES SPECIALLY EXAMINED

***Chloothamnus elegantissimus* (Hasskarl) Henr.**[1]

LEAF

Abaxial epidermis

Short-cells, between the veins, and over the small veins, paired; those over the large veins in rows of more than 5 cells; abundant. **Silica-bodies,** over the veins, saddle-shaped (Fig. I, 9); those between the veins tall and narrow (Fig. I, 4). **Macro-hairs:** none seen. **Micro-hairs** (Fig. XVI, 17): mostly in the interstomatal bands of the intercostal zones, occasionally over the veins; cells mostly of about equal length and uniform diameter, but some with the distal cell slightly longer, or shorter, than the basal cell; basal cell 26–31 μ long; distal cell 20–31 μ long. **Prickle-hairs:** a few hooks (Fig. VI, 5) occurring in the stomatal bands. **Papillae** abundant; small, variously shaped, cuticularized; some overarching the individual stomata. **Stomata:** outlines obscured by overarching papillae. **Long-cells** with thin, sinuous (Fig. V, 3*a–c*), or v. sinuous, walls, each long-cell in a single file of cells separated from the next long-cell by a pair of tall short-cells v. markedly at right angles to the horizontal walls (as Fig. V, 6, but short-cells paired). **Transverse veins:** only a few seen.

T.S. lamina

Adaxial surface with wide, rounded ribs, and narrow, shallow furrows; also a few taller ribs near the midrib. **Sclerenchyma:** many small vb's accompanied by small adaxial and abaxial girders; other vb's with fairly tall, mostly 3-seriate, adaxial and small abaxial girders; large vb's tending to be supported by slightly anchor-shaped girders (Fig. IX, 6), but arms of the anchor not pronounced. **Keel:** vascular structure and scl. of type IV (Fig. XVII, 9 and 11). **Fusoid-cells** numerous; 64–77 μ in horizontal, and 15–22 μ in vertical, diameter. **Bulliform cells** in fan-shaped groups (Fig. XV, 4), but some groups tending to be of the *Sporobolus* type (Fig. XV, 8). **Bundle-sheaths:** all, or nearly all, small vb's with 2 complete sheaths (Fig. XII, 1); a few large vb's with the O.S. interrupted abaxially (Fig. XII, 2).

MATERIAL EXAMINED: H. Winkler 1906; Malabar.

[1] *Chloothamnus* should probably be united with *Nastus*. See Holttum 1955.

CHUSQUEA

SPECIES SPECIALLY EXAMINED

***Chusquea abietifolia* Griseb.**

LEAF

Abaxial epidermis

Short-cells frequently between the veins, and locally over the veins, in pairs; most of those over the veins in rows of more than 5 cells; abundant. **Silica-bodies** between, and some of those over, the veins, saddle-shaped (Fig. I, 9 (iv–v)); most of those over the veins intermediate between cross and dumb-bell shaped (Fig. IA, 17). **Macro-hairs:** none seen. **Micro-hairs:** v. badly preserved in the material examined; with both cells of about equal length and more or less uniform diameter; one only measured, with basal cell 15 μ, and distal cell 20 μ, long. **Prickle-hairs:** a few large prickles (Fig. VI, 2) present. **Papillae** abundant; small, variously shaped, cuticularized. **Stomata** sometimes tending to be with triangular subsidiary cells (Fig. IV, 1), but apices of the triangles blunt; mostly with low dome-shaped subsidiary cells (Fig. IV, 3). **Long-cells,** in the intercostal zones, with thin, sinuous walls (Fig. V, 3*a–c*); those in the interstomatal bands of the intercostal zones rather longer than those in the stomatal zones; long-cells, over the veins, with much thicker, and only slightly sinuous, or straight, walls (Fig. V, 1*b*). **Transverse bundles:** a few seen.

T.S. lamina

Adaxial surface smooth, apart from a few slight ribs, especially near the margins; furrows wide and not very deep. **Sclerenchyma:** most vb's accompanied by small adaxial and abaxial girders (Fig. IX, 4), the mostly 1–2-seriate adaxial girders standing out in contrast to the small but wider abaxial girders. **Keel:** vascular system and scl. of type VII (Fig. XVII, 6). **Fusoid-cells** numerous but small; 31–44 μ in horizontal, and 11–18 μ in vertical, diameter. **Bulliform cells** in numerous, exceptionally wide, fan-shaped groups (Fig. XV, 4), the bulliform cells merging with the other conspicuously large epidermal cells. **Bundle-sheaths:** most, if not all, vb's with 2 complete sheaths (Fig. XII, 1); O.S.'s associated with some of the large vb's possibly with abaxial interruptions (Fig. XII, 2).

(This sp. has narrow leaves. Nearly all of the adaxial epidermal cells, besides the bulliform cells, are conspicuously larger than the cells of the abaxial epidermis.)

MATERIAL EXAMINED: Ekman 6950; Brazil.

***Chusquea tenella* Nees**

LEAF

Abaxial epidermis

Short-cells, over the veins, occasionally paired; others over the veins in rows of 3–5 or more cells; common over the veins, but rare in the intercostal zones. **Silica-bodies:** a few saddle-shaped (Fig. I, 9 (v)), but mostly intermediate between cross and dumb-bell shaped (Fig. IA, 17), or occasionally

tending to be cross-shaped (Fig. IA, 16). **Macro-hairs:** none seen. **Micro-hairs** (Fig. XVI, 18) mostly amongst the stomata; short, moderately frequent; both cells usually of about equal length; basal cell 13–22 μ long; distal cell 13–18 μ long. **Prickle-hairs:** prickles (Fig. VI, 2) numerous over and between the veins; hooks (Fig. VI, 5) and transitional structures also present. **Papillae** abundant, but not v. conspicuous; small, variously shaped, cuticularized. **Stomata** mostly with triangular subsidiary cells (Fig. IV, 1), but triangles with blunt apices; others tending to have low (Fig. IV, 3), or tall (Fig. IV, 4), subsidiary cells. **Long-cells,** over and between the veins, with thin, deeply sinuous walls (Fig. V, 3*a–c*); interstomatal cells also v. sinuous, and with concave ends. **Transverse bundles** v. infrequent.

T.S. lamina

Adaxial surface smooth, apart from specially large papillae or prickles over and between the veins, and one v. large rib next to the midrib. **Sclerenchyma:** most small vb's accompanied by small adaxial and abaxial girders, the combined girders tending to appear anchor-shaped (Fig. IX, 6) owing to the contrast between the mostly 1-, but sometimes 2- or occasionally 3-, seriate adaxial girders and the wider abaxial girders. **Keel:** vascular system and scl. of type VIII (Fig. XVII, 4). **Fusoid-cells** numerous; 114–39 μ in horizontal, and 13–15 μ in vertical, diameter. **Bulliform cells** in fan-shaped groups, but groups rather narrow, except those near the midrib. **Bundle-sheaths:** all, or nearly all, small vb's with 2 complete sheaths (Fig. XII, 1); a few large vb's with O.S. interrupted abaxially (Fig. XII, 2).

MATERIAL EXAMINED: Parodi 15188; Brazil.

DENDROCALAMUS

SPECIES SPECIALLY EXAMINED

***Dendrocalamus brandisii* Kurz**

LEAF

Abaxial epidermis

Short-cells: a few over the veins, solitary; others paired or in rows of more than 5 cells; generally common, but absent between the veins apart from short-cells paired with hooks. **Silica-bodies** saddle-shaped (Fig. I, 9 (iv–v)), sometimes rather tall. **Macro-hairs:** none seen. **Micro-hairs** mostly beside the small veins; both cells of about equal length and diameter, but often with the basal cell slightly longer than the distal cell; basal cell 31–33 μ long; distal cell 18 (contracted) to 37 μ long. **Prickle-hairs:** hooks (Fig. VI, 5) abundant between the veins; paired with tall short-cells. **Papillae** present; small, variously shaped, cuticularized; more than 1 row per cell; v. seldom overarching the individual stomata. **Stomata** with triangular (Fig. IV, 1), or tall dome-shaped (Fig. IV, 4), subsidiary cells. **Long-cells,** between the veins, often short and broad, with thin, v. sinuous walls (Fig. V, 7*b*); others longer, but likewise with v. sinuous walls; interstomatal cells mostly with concave ends, but usually rather long (Fig. V, 11). **Transverse bundles** infrequent.

T.S. lamina

Adaxial surface smooth. **Sclerenchyma:** a few small vb's accompanied by small adaxial and abaxial girders (Fig. IX, 4); combined girders to most vb's anchor-shaped (Fig. IX, 6), the adaxial girders of both small and large bundles being uniseriate to triseriate and rarely, if ever, more than 3 cells high; abaxial girders of some vb's short and wide. **Keel:** vascular system and scl. of type I (Fig. XVII, 1 *a–c*). **Fusoid-cells** smaller towards the margins than near the midrib, smaller still and fading out at the margin itself; those near the midrib 86–97 μ in horizontal, and 33–40 μ in vertical, diameter; those near the margin 51–79 μ in horizontal, and 26–33 μ in vertical, diameter. **Bulliform cells,** especially those near the midrib, in small groups of specially large cells (*Zea* type; Fig. XV, 3); groups more commonly fan-shaped (Fig. XV, 4), or tending towards the *Sporobolus* type (Fig. XV, 8), sometimes projecting above the epidermis. **Bundle-sheaths:** some small vb's with 2 complete sheaths (Fig. XII, 1); other small vb's, and all large vb's, with O.S. interrupted abaxially (Fig. XII, 2).

MATERIAL EXAMINED: Cultivated at Kew.

***Dendrocalamus giganteus* Munro**

LEAF

Abaxial epidermis

Short-cells, over the veins, infrequently solitary, but mostly in rows of more than 5 cells; those between the veins paired; common. **Silica-bodies,** over the veins, mostly saddle-shaped (Fig. I, 9 (v)), but rather tall, the tallest tending to be almost of the *Oryza* type (Fig. IB, 23); those between the veins tall, narrow, and crenate (Fig. IB, 24), infrequent except where hooks fail to develop. **Macro-hairs:** none seen. **Micro-hairs** (Fig. XVI, 19): some with both cells of about equal length, but distal cell sometimes slightly shorter than the basal cell; basal cell 26–33 μ long; distal cell 22–33 μ long. **Prickle-hairs:** a few prickles present (Fig. VI, 1–2) over the veins; hooks (Fig. VI, 5) abundant between the veins. **Papillae** present; small, variously shaped, cuticularized; 1 row per cell; individual stomata overarched by papillae, but not many papillae overarching any one stoma. **Stomata** with triangular (Fig. IV, 1), or tall dome-shaped (Fig. IV, 4), subsidiary cells. **Long-cells** with thin, v. sinuous walls (Fig. V, 3*a–c*), both between and over the veins, but difficult to see over the veins; interstomatal cells with concave ends and v. sinuous walls. **Transverse bundles** abundant.

T.S. lamina

Adaxial surface with slight but wide ribs and narrow furrows, the latter occupied by projecting bulliform cells. **Sclerenchyma:** combined girders to most vb's, both large and small, anchor-shaped (Fig. IX, 6), the adaxial portions being narrow, and commonly 1–2-seriate; other bundles, especially near the midrib, tending to be supported by tall, narrow, adaxial, and shorter but wider abaxial, girders. **Keel:** vascular system and scl. of type II (Fig. XVII, 8).

Fusoid-cells larger towards the midrib than towards the margin; still smaller as the margin is approached, and fading out at the margin itself; those towards the midrib 55–97 μ in horizontal, and 26–33 μ in vertical, diameter; those nearer the margin 77–92 μ in horizontal, and 18–22 μ in vertical, diameter. **Bulliform cells** as small groups of specially large cells (*Zea* type; Fig. XV, 3), especially near the midrib, and also in fan-shaped groups (Fig. XV, 4), but most groups tending to be of the *Sporobolus* type (Fig. XV, 8); cells projecting above the level of the epidermis. **Bundle-sheaths:** many small vb's with 2 complete sheaths (Fig. XII, 1); all large, and other small, vb's with O.S. interrupted abaxially (Fig. XII, 2).

MATERIAL EXAMINED: Cultivated at Kew.

DINOCHLOA

SPECIES SPECIALLY EXAMINED

***Dinochloa m'clellandii* Kurz**

LEAF

Abaxial epidermis

Short-cells, over the veins, sometimes paired, but others, especially those over the large veins, mostly in rows of 3–5 or more cells; those between the veins not v. conspicuous, and mostly paired. **Silica-bodies,** over the veins, saddle-shaped; those between the veins tall, and v. narrow. **Macro-hairs:** short, superficial, with swollen bases, some appearing to be rigid and thick-walled. **Micro-hairs** (Fig. XVI, 20): basal cells rather longer and wider than the distal cells of rather variable shape; fairly numerous; basal cell 40–53 μ long; distal cell 24–31 μ long. **Prickle-hairs:** none seen. **Papillae** abundant; small, variously shaped, cuticularized; some overarching the individual stomata. **Stomata:** outlines obscured by overarching papillae. **Long-cells,** over and between the veins, with thin, v. sinuous walls (Fig. V, 3*a–c*); interstomatal cells also with v. sinuous walls, and usually with concave ends. **Transverse bundles:** none seen.

T.S. lamina

Adaxial surface smooth apart from 2 large ribs, next to, and on one side of, the midrib. **Sclerenchyma:** most small vb's accompanied by small adaxial and abaxial girders (Fig. IX, 4), but combined girders tending to appear anchor-shaped (Fig. IX, 6) owing to the narrow, mostly 1–3-seriate, adaxial girders contrasting with the wider abaxial girders. **Keel:** vascular system and scl. of type II (Fig. XVII, 8). **Fusoid-cells** v. conspicuous and large; 95–145 μ in horizontal, and 29–44 μ in vertical, diameter; those which are short horizontally frequently tending to be tall vertically. **Bulliform cells** in fan-shaped groups (Fig. XV, 4), some of the groups being rather narrow. **Bundle-sheaths:**

all, or nearly all, small vb's with 2 complete sheaths (Fig. XII, 1); a few large bundles with the O.S. interrupted abaxially (Fig. XII, 2).

MATERIAL EXAMINED: C. E. Parkinson 5228; Burma.

GIGANTOCHLOA

SPECIES SPECIALLY EXAMINED

***Gigantochloa ligulata* Gamble**

LEAF

Abaxial epidermis

Short-cells, between the veins, and some of those over the veins, paired; others over the veins in rows of more than 5 cells, owing to the amalgamation of pairs; abundant. **Silica-bodies,** over the veins, mostly saddle-shaped (Fig. I, 9 (iv–v)); those between the veins tall, narrow (Fig. I, 4), and frequently rather inconspicuous. **Macro-hairs:** none seen. **Micro-hairs** (Fig. XVI, 21): distal cells v. obscure in the available material, but both cells of more or less equal length; basal cell 31–42 μ long; distal cell, only one accurately measured, 40 μ long. **Prickle-hairs:** prickles (Fig. VI, 1–2) present, often with rather long points; also transitions to hooks (Fig. IV, 5). **Papillae** abundant; small, variously shaped, cuticularized; some papillae overarching the individual stomata. **Stomata:** outlines obscured by overarching papillae. **Long-cells:** rather short, with thin, v. sinuous walls (Fig. V, 7); tendency for the development of interstomatal cells with concave ends, but cell endings obscured by the papillae surrounding the stomata. **Transverse bundles:** only a few seen.

T.S. lamina

Adaxial surface with numerous low, but v. regular, slightly triangular ribs, and shallow, much narrower furrows; about 3 large ribs on one side of the midrib. **Sclerenchyma:** most vb's accompanied by small adaxial and abaxial girders (Fig. IX, 4), but tending to be with tall, narrow, 1–6-seriate adaxial, and shorter but slightly wider abaxial, girders. **Keel:** vascular system and scl. of type I (Fig. XVII, 10). **Fusoid-cells** noteworthy owing to the vertical diameter being greater in relation to the horizontal diameter than in many bamboos; horizontal diameter 66–108 μ and vertical diameter 55–62 μ near the midrib, the upper limit for the vertical diameter not being much less than the lower limit for the horizontal diameter. Fusoid-cells nearer the margin; slightly more elongated horizontally, and much less tall; 68–117 μ in horizontal, and 29–40 μ in vertical, diameter. **Bulliform cells** in fan-shaped groups (Fig. XV, 4), the central cell in each group being v. tall; some groups tending to be of the *Sporobolus* type (Fig. XV, 8), but each group with an extension of colourless cells reaching to the abaxial surface. **Bundle-sheaths:** all, or nearly all, small vb's with 2 complete sheaths (Fig. XII, 1); a few large vb's with O.S. interrupted abaxially (Fig. XII, 2).

MATERIAL EXAMINED: F. R. Hamid 8256; Malay Peninsula, Perak.

GRESLANIA

Species Specially Examined

***Greslania rivularis* Bal.**

LEAF

Abaxial epidermis

Short-cells, over and between the veins, mostly paired; others over the veins less frequently in rows of more than 5 cells. **Silica-bodies,** over the veins, mostly saddle-shaped (Fig. I, 9 (iv–v)); those between the veins tending to be tall and narrow (Fig. I, 4). **Macro-hairs** rather infrequent; superficial, with swollen bases; rather a short form, with fine, inconspicuous, transverse septa. **Micro-hairs** with both cells of about equal length; not sufficiently well preserved to be drawn in the material available. **Prickle-hairs** infrequent; hooks (Fig. VI, 5), with transitions to macro-hairs, present over and between the veins. **Papillae,** confined to the stomatal bands; small, variously shaped, cuticularized; some overarching the individual stomata. **Stomata:** outlines obscured by overarching papillae. **Long-cells** with thick, pitted, or sinuous walls; tendency for the development of interstomatal cells with concave ends, but cell ends made inconspicuous by the papillae overarching the stomata.

T.S. lamina

Adaxial surface with moderate ribs and furrows; ribs numerous, regularly arranged, moderately wide, with slight tendency to be triangular in section; furrows narrow. **Sclerenchyma:** some vb's, especially towards the margins, accompanied by small but broad adaxial and abaxial girders (Fig. IX, 5); most small vb's with tall, narrow, 3–6-seriate, adaxial girders, and much shorter, slightly wider, abaxial girders. **Keel:** vascular system and scl. of type II (Fig. XVII, 8). **Fusoid-cells** large and conspicuous; those near the midrib with vertical diameter high in relation to the horizontal diameter; 110–32 μ in horizontal, and 40–50 μ in vertical, diameter in this region; fusoid-cells nearer the margin 84–110 μ in horizontal, and 22–33 μ in vertical, diameter. **Bulliform cells** in fan-shaped groups (Fig. XV, 6) in furrows. **Bundle-sheaths:** many of the small vb's with 2 complete sheaths (Fig. XII, 1); other small and large vb's with O.S. interrupted abaxially (Fig. XII, 2).

MATERIAL EXAMINED: Franc 2173; New Caledonia.

GUADUA

Species Specially Examined

***Guadua paniculata* Munro**

LEAF

Abaxial epidermis

Short-cells nearly all paired; abundant, but much more numerous and larger over the veins than between them. **Silica-bodies,** over the veins, saddle-shaped (Fig. I, 9 (iv–v)); those between the veins v. much smaller and less numerous,

and mostly slightly crescent-shaped. **Macro-hairs** infrequent; superficial, with swollen bases. **Micro-hairs** (Fig. XVI, 22) mostly in the interstomatal bands of the intercostal zones, a few at the margins of the veins; numerous; with both cells of about equal length, or with the distal cells somewhat shorter than the basal cell; basal cell 29–35 μ long; distal cell 24–31 μ long. **Prickle-hairs:** prickles (Fig. VI, 1–2), with transitions to macro-hairs, present over, and hooks (Fig. VI, 5) between, the veins. **Papillae** rather obscure; small, variously shaped, cuticularized. **Stomata** with low dome-shaped subsidiary cells (Fig. IV, 3). **Long-cells** with thin, sinuous walls (Fig. V, 3*a–c*); tendency for the development of interstomatal cells with concave ends (Fig. V, 10–11); interstomatal cells also with v. sinuous walls. **Transverse bundles:** none seen.

T.S. lamina

Adaxial surface with slight ribs and furrows; most ribs more or less regularly distributed, not v. wide, and slightly rounded, but a few ribs slightly more pronounced than the others. **Sclerenchyma:** most small vb's with tall, narrow, 1–3-seriate, adaxial girders, the abaxial girders being much shorter; combined girders of the large vb's anchor-shaped (Fig. IX, 6), with the arms of the anchor fairly well developed. **Keel:** vascular system and scl. somewhat resembling type IV (Fig. XVII, 9 and 11). **Fusoid cells** small and relatively infrequent; 25–35 μ in horizontal, and 13–20 μ in vertical, diameter. **Bulliform cells** in narrow, fan-shaped groups (Fig. XV, 4), many of the groups tending to be of the *Sporobolus* type (Fig. XV, 8). **Bundle-sheaths:** all, or nearly all, small vb's with 2 complete sheaths (Fig. XII, 1); occasional large vb's with the O.S. interrupted adaxially and abaxially (Fig. XII, 3*a–b*); other large vb's with the O.S. interrupted abaxially only (Fig. XII, 2).

MATERIAL EXAMINED: A. Chase 12564; Venezuela.

GUADUELLA

Species Specially Examined

***Guaduella oblonga* Hutch.**

LEAF

Abaxial epidermis

Short-cells, between the veins, in pairs; those over the veins in rows of more than 5 cells; abundant. **Silica-bodies,** over and between the veins, saddle-shaped (Fig. I, 9 (iv–v)), but those between much narrower than those over the veins. **Macro-hairs:** none seen. **Micro-hairs** (Fig. XVI, 23): of a highly distinctive, uniseriate type, not observed in other grasses, each hair consisting of a long basal cell and a distal, uniseriate row of 2–5, much shorter cells; basal cell 44–88 μ long; distal cells together 35–75 μ long. **Prickle-hairs:** none seen. **Papillae:** some overarching the individual stomata. **Stomata:** outlines obscured by overarching papillae. **Long-cells,** in the intercostal zones, with thin, v. sinuous walls (Fig. V, 3*a–c*); long-cells in each file separated from one another by pairs of short-cells v. markedly at right angles to the horizontal walls (as Fig. V, 6, but short-cells paired); interstomatal cells with concave ends,

but end walls obscured by the overarching papillae. **Transverse bundles:** none seen.

T.S. lamina

Adaxial surface smooth, but 1 tall rib next to the midrib. **Sclerenchyma:** most vb's accompanied by small adaxial and abaxial girders (Fig. IX, 4), many of the combined girders appearing to be anchor-shaped, owing to the contrast between the 1–2-seriate adaxial girders, and the wider abaxial girders. **Keel:** vascular system and scl. of type I (Fig. XVII, 1 and 10). **Fusoid-cells** conspicuous, horizontally elongated, and not v. tall; 73–119 μ in horizontal, and 13–20 μ in vertical, diameter. **Bulliform cells** mostly in well-defined groups 3 or more cells long, the individual cells in each group being rather uniform in size; fan-shaped groups less frequent. **Bundle-sheaths:** some large vb's with I.S. complete and O.S. interrupted adaxially and abaxially (Fig. XII, 3*a–b*); all other vb's, both large and small, with O.S. interrupted abaxially (Fig. XII, 2).

MATERIAL EXAMINED: Thomas 4400; Sierra Leone.

ADDITIONAL INFORMATION FROM THE LITERATURE

The brief illustrated description of the leaf of *G. oblonga* given by Jacques-Félix (1955) in the main agrees with that given above. It should be noted, however, that the fusoid-cells are wrongly described as intercellular spaces.

MELOCALAMUS

SPECIES SPECIALLY EXAMINED

***Melocalamus compactiflorus* (Kurz) Benth.**

LEAF

Abaxial epidermis

Short-cells, between, and most of those over, the veins, in pairs; abundant. **Silica-bodies,** over the veins, mostly tall saddle-shaped (Fig. I, 9 (iv–v); a few being a small form of the tall and narrow type (Fig. I, 4); many silica-bodies, between the veins, narrow and crenate (Fig. IB, 24), but rather small. **Macro-hairs:** none seen. **Micro-hairs** (Fig. XVI, 24): both cells of about equal length, but distal cell sometimes rather longer than the basal cell; fairly frequent; distal cell seldom conspicuous in the material examined; basal cell 22–24 μ long; distal cell 24–29 μ long. **Prickle-hairs:** none seen. **Papillae:** usually 4, or sometimes a few more, overarching each stoma. **Stomata:** outlines obscured by overarching papillae. **Long-cells,** in the intercostal zones, a short form with thin, sinuous walls (Fig. V, 6); those over the veins similar, but rather longer; interstomatal cells with concave ends, but end walls tending to be obscured by the overarching papillae. **Transverse bundles:** none seen.

T.S. lamina

Adaxial surface smooth, apart from a few ribs on one side of the mid-rib. **Sclerenchyma:** most small vb's accompanied by small adaxial and abaxial girders (Fig. IX, 4), but adaxial taller and narrower than the abaxial girders, being 1–2- or sometimes 3–4-seriate; slight tendency for the combined girders

of the large vb's to be anchor-shaped (Fig. IX, 6). **Keel:** vascular system and scl. somewhat resembling type III (Fig. XVII, 7). **Fusoid-cells** conspicuous; those near the midrib somewhat longer horizontally than those towards the leaf margins, becoming small and fading out altogether near the margins themselves; those near the midrib 70–84 μ in horizontal, and 24–37 μ in vertical, diameter; those near the margins 62–75 μ in horizontal, and 31–37 μ in vertical, diameter. **Bulliform cells** in fan-shaped groups (Fig. XV, 4); cells v. tall, especially the middle one in each group. **Bundle-sheaths** all, or nearly all, small vb's with 2 complete sheaths (Fig. XII, 1); the infrequent large vb's with the O.S. interrupted abaxially (Fig. XII, 2).

MATERIAL EXAMINED: Poilane 940; Assam.

MELOCANNA

SPECIES SPECIALLY EXAMINED

***Melocanna bambusoides* Trin. = *M. baccifera* (Roxb.) Skeels**

LEAF

Abaxial epidermis

Short-cells, over and between the veins, commonly paired; occasionally in rows of 3–5 cells over the veins; abundant. **Silica-bodies,** over the veins, mostly saddle-shaped (Fig. I, 9 (v)); those between the veins tall and narrow (Fig. I, 4), but small. **Macro-hairs:** none seen. **Micro-hairs** (Fig. XVI, 25) numerous; mostly with both cells of about equal length; basal and distal cells each 35–44 μ long. **Prickle-hairs:** none seen. **Papillae** confined to the stomatal bands; small, variously shaped, cuticularized; some papillae overarching the individual stomata. **Stomata** with outlines obscured by overarching papillae. **Long-cells:** a short form with thin, sinuous walls (Fig. V, 7*b*); those over the veins rather less sinuous than those in the intercostal zones; interstomatal cells with concave ends, but end walls obscured by the v. numerous papillae. **Transverse bundles:** none seen.

T.S. lamina

Adaxial surface with v. slight, widely spaced ribs; furrows not v. definite; 3 larger ribs on one side of the midrib. **Sclerenchyma:** most small vb's accompanied by small adaxial and abaxial girders, but adaxial girders sometimes not more than 2–3-seriate; combined girders to the large, and some small, vb's anchor-shaped (Fig. IX, 6), but arms of the anchor not v. pronounced. **Keel:** vascular system and scl. of type I (Fig. XVII, 1 and 10). **Fusoid-cells** conspicuous; slightly larger near the midrib than elsewhere; 92–128 μ in horizontal, and 33–40 μ in vertical, diameter. **Bulliform cells** in fan-shaped groups (Fig. XV, 4); cells rather tall and groups sometimes tending slightly towards the *Sporobolus* type (Fig. XV, 8). **Bundle-sheaths:** a few vb's near the leaf margins with the I.S. complete and the O.S. interrupted abaxially and adaxially (Fig. XII, 3*a–b*); most vb's, both large and small, with O.S. interrupted abaxially (Fig. XII, 2).

MATERIAL EXAMINED: Herb. Hook. 1867; Chittagong.

MEROSTACHYS

Species Specially Examined

***Merostachys riedeliana* Rupr.**

Leaf

Abaxial epidermis

Short-cells, over and between the veins, mostly solitary, each being paired with a hook rather than another short-cell; a few paired with other short-cells; those paired with hooks numerous. **Silica-bodies** tall and narrow (Fig. I, 4), sometimes inconspicuous. **Macro-hairs:** none seen. **Micro-hairs** (Fig. XVI, 26); present on either side of, and occasionally over, the veins; mostly with the distal cell slightly longer than the basal cell; distal cell rather variable in shape; basal cell 24–31 μ long; distal cell 26–42 μ long. **Prickle-hairs:** hooks (Fig. VI, 5) numerous over and between the veins. **Papillae** numerous, and ubiquitous; small, variously shaped, cuticularized; some overarching the individual stomata. **Stomata** with outlines obscured by overarching papillae. **Long-cells** variable in length; with thin, sinuous walls (Fig. V, 3*a–c*); tendency for the development of interstomatal cells with concave ends. **Transverse bundles:** a few seen.

T.S. lamina

Adaxial surface smooth. **Sclerenchyma:** most small vb's accompanied by small adaxial and abaxial girders (Fig. IX, 4), but most vb's, even the large ones, with the adaxial girders 1–2-seriate, the abaxial girders being wider and shorter. Adaxial and abaxial strands of scl. also occurring independently of the vb's, i.e. on either side of the adaxial bulliform cells, and opposite the adaxial bulliform cells beneath the abaxial surface of the leaf. **Keel** and keel bundles absent. **Fusoid-cells** fairly conspicuous, but smaller than in many bamboos; 55–90 μ in horizontal, and 20–24 μ in vertical, diameter. **Bulliform cells** mostly in fan-shaped groups (Fig. XV, 4), but some groups showing a slight tendency towards the *Sporobolus* type (Fig. XV, 8). **Bundle-sheaths:** most small vb's with the I.S. complete and the O.S. interrupted abaxially (Fig. XII, 2); a few large, and occasional small, vb's with the O.S. interrupted adaxially and abaxially (Fig. XII, 3*a–b*).

Material Examined: Ynes Mexia 4770; Brazil.

NASTUS

Species Specially Examined

***Nastus capitatus* Kunth**

Leaf

Abaxial epidermis

Short-cells between, and many of those over, the veins, paired; others over the veins, in rows of 3–5 or more cells; abundant. **Silica-bodies,** over the veins, mostly saddle-shaped (Fig. I, 9 (iv–v)); those between the veins tall and narrow. **Macro-hairs:** none seen. **Micro-hairs** (Fig. XVI, 27); distal cell about the same length as, or rather longer than, the basal cell, sometimes tapering to a rounded point; basal cell 24–35 μ long; distal cell 22–46 μ long. **Prickle-hairs:** hooks (Fig. VI, 5) locally abundant, and locally sparse between the veins, where present, each hook often paired with a tall, narrow silica-cell. **Papillae:** absent, apart from those overarching the individual stomata. **Stomata:** outlines obscured by overarching papillae. **Long-cells:** those in the intercostal zones rather short, with thin, sinuous walls (Fig. V, 7); those over the veins similar, but rather longer and with thicker walls; tendency for the development of interstomatal cells with concave ends. **Transverse bundles** occasional.

T.S. lamina

Adaxial surface smooth, apart from 2 moderate-sized ribs on one side of the midrib. **Sclerenchyma:** most vb's accompanied by small adaxial and abaxial girders (Fig. IX, 4); the adaxial girders usually being 1–2-seriate and not more than 3 cells high, and the abaxial girders wider; combined girders of the large vb's anchor-shaped (Fig. IX, 6), but ends of the anchor not well developed. **Keel:** vascular system and scl. resembling type II (Fig. XVII, 8). **Fusoid-cells:** rather small, 26–55 μ in horizontal, and 9–15 μ in vertical, diameter. **Bulliform cells** mostly in fan-shaped groups (Fig. XV, 4), but some groups showing a tendency towards the *Sporobolus* type (Fig. XV, 8). **Bundle-sheaths:** a few small vb's with 2 complete sheaths (Fig. XII, 1); most vb's, both large and small, with I.S. complete and O.S. interrupted abaxially (Fig. XII, 2); occasional large vb's with O.S. interrupted both adaxially and abaxially (Fig. XII, 3*a–b*).

Material Examined; Baron 2591; Madagascar.

***Nastus elongatus* A. Camus**

Leaf from near Inflorescence

Abaxial epidermis

Short-cells, both over and between the veins, mostly paired, but tending to be in rows of 3–5 cells over the veins; abundant. **Silica-bodies,** both over and between the veins, saddle-shaped (Fig. I, 9), rather squat, those between being much smaller than those over the veins. **Macro-hairs:** none seen. **Micro-hairs** (Fig. XVI, 28): cells of about equal length or distal cell slightly longer or shorter than the basal cell; basal cell 26–48 μ long, distal cell 35–46 μ long. **Prickle-hairs:** hooks (Fig. VI, 5) occasional between the veins, especially at the margins of the stomatal bands. **Papillae** present both in the stomatal bands and over the veins; small, variously shaped, cuticularized; some overarching the individual stomata. **Stomata** with outlines obscured by overarching papillae. **Long-cells** of variable length, some of those in the interstomatal bands specially long; tendency for the development of interstomatal cells with concave ends. **Transverse bundles** not v. numerous.

T.S. lamina

Adaxial surface with marked, rounded ribs and wide, U-shaped furrows; one specially tall rib over the midrib. **Sclerenchyma:** a few small vb's accom-

panied by small adaxial and abaxial girders (Fig. IX, 4); a few small and large bundles each with an adaxial T- and an abaxial I-girder; combined girders of a few large vb's tending to be anchor-shaped (Fig. IX, 6). **Keel:** vascular system and scl. somewhat resembling type II (Fig. XVII, 8). **Fusoid-cells** small and inconspicuous; not measured because distorted in the available material. **Bulliform cells** as fan-shaped groups in furrows (Fig. XV, 6); cells not v. tall. **Bundle-sheaths:** most vb's with I.S. complete and O.S. interrupted abaxially (Fig. XII, 2); tendency for the O.S. in some vb's, especially the large ones, to be interrupted adaxially and abaxially (Fig. XII, 3*a–b*).

MATERIAL EXAMINED: Perrier de la Bathie 10846; Madagascar.

OCHLANDRA

SPECIES SPECIALLY EXAMINED

***Ochlandra setigera* Gamble**

LEAF

Abaxial epidermis

Short-cells, both over and between the veins, mostly paired; others over the veins in rows of 3–5 or more cells. **Silica-bodies,** over the veins, saddle-shaped (Fig. I, 9 (iv–v)); those between the veins tall and narrow (Fig. I, 4). **Macro-hairs** superficial, with swollen bases. **Micro-hairs** (Fig. XVI, 29): chiefly at the margins of the stomatal bands, and on either side of the veins; with both cells of about equal length, but basal cell sometimes longer than the distal cell; basal cell 22–33 μ long; distal cell 22–26 μ long. **Prickle-hairs:** hooks (Fig. VI, 5) occasional between the veins. **Papillae** ubiquitous; small, variously shaped, cuticularized; some overarching the individual stomata. **Stomata** with outlines obscured by overarching papillae. **Long-cells,** especially those between the veins, with v. sinuous walls, each long-cell separated from the next in the same file by a pair of short-cells v. markedly at right angles to the horizontal walls (as Fig. V, 6, but short-cells in pairs); tendency for the development of interstomatal cells with concave ends. **Transverse bundles:** none seen.

T.S. lamina

Adaxial surface more or less smooth apart from 2 ribs near the midrib; elsewhere showing a tendency towards wide, v. low ribs and narrow, shallow furrows. **Sclerenchyma:** most vb's accompanied by narrow, mostly 3–4-seriate adaxial, and wider abaxial, girders; tendency for the combined girders of the large, and of some small, vb's to be anchor-shaped (Fig. IX, 6), but arms of the anchor not v. pronounced. **Keel:** vascular system and scl. of type II (Fig. XVII, 8). **Fusoid-cells** of moderate size, those near the leaf margin less horizontally elongated than those near the midrib; those near the midrib 77–88 μ in horizontal, and 18–22 μ in vertical, diameter; those nearer the margin 46–79 μ in horizontal, and 15–22 μ in vertical, diameter. **Bulliform cells** v. tall, in fan-shaped groups (Fig. XV, 4), the central cell in each group penetrating almost to the centre of the lamina. **Bundle-sheaths:** most small vb's with 2 complete sheaths (Fig. XII, 1); the few large, and some small, vb's with the O.S. interrupted abaxially (Fig. XII, 2).

MATERIAL EXAMINED: E. Barnes 2175; India.

OREOBAMBOS

SPECIES SPECIALLY EXAMINED

***Oreobambos buchwaldii* K. Schum.**

LEAF

Abaxial epidermis

Short-cells, both over and between the veins, nearly all paired; locally in rows of 3–5, or more, cells over the veins; abundant. **Silica-bodies** mostly saddle-shaped (Fig. I, 9), but rather variable; those between the veins tending to be tall, narrow, and crenate (Fig. IB, 24). **Macro-hairs** rather long, but sometimes only the swollen bases persisting; superficial. **Micro-hairs** (Fig. XVI, 30): both cells of more or less equal length and uniform diameter, but some with the basal cell rather longer than the distal cell; basal and distal cells each 31–44 μ long; a special type, with a silica deposit on the proximal side of the transverse wall between the 2 cells. **Prickle-hairs:** hooks (Fig. VI, 5) local between the veins; also transitions to structures more like prickles (Fig. VI, 1–2), or even small macro-hairs. **Papillae** ubiquitous; small, variously shaped, cuticularized; some overarching the individual stomata. **Stomata:** some probably with triangular subsidiary cells (Fig. IV, 1), but outlines obscured by overarching papillae. **Long-cells** with thin, sinuous walls (Fig. V, 3*a–c*); intercostal cells tending to exhibit particularly sinuous walls, and to be separated from one another in each file by pairs of tall, or narrow crenate, short-cells v. markedly at right angles to the horizontal walls (as Fig. V, 6, but short-cells in pairs); tendency for the development of interstomatal cells with concave ends. **Transverse bundles** occasional.

T.S. lamina

Adaxial surface smooth, apart from 2 ribs on one side of the midrib. **Sclerenchyma:** most vb's accompanied by small adaxial and abaxial girders (Fig. IX, 4), the adaxial being only slightly narrower than the abaxial girders; combined girders of a few large vb's tending to be anchor-shaped (Fig. IX, 6), but arms of the anchor not v. pronounced. **Keel:** vascular system and scl. of type I (Fig. XVII, 1 and 10). **Fusoid-cells:** those near the leaf margins and midrib respectively not v. different in size; 106–30 μ in horizontal, and 37–44 μ in vertical, diameter. **Bulliform cells** in fan-shaped groups (Fig. XV, 4), the central cell in each group being v. tall, and almost triangular. **Bundle-sheaths:** most small vb's with 2 complete sheaths (Fig. XII, 1); all large, and a few small, vb's with the O.S. interrupted abaxially (Fig. XII, 2).

MATERIAL EXAMINED: Thomas 3775; Uganda.

OXYTENANTHERA

Species Specially Examined

***Oxytenanthera abyssinica* (A. Rich.) Munro**

Leaf

Abaxial epidermis

Short-cells, over and between the veins, mostly paired; a few of those over the veins in rows of 3–5 cells; inconspicuous and rather infrequent between the veins. **Silica-bodies,** over the veins, saddle-shaped (Fig. I, 9 (iv–v)); those between the veins tall, narrow, and crenate (Fig. Ib, 24). **Macro-hairs:** none seen. **Micro-hairs** (Fig. XVI, 31): some with the basal cell appreciably longer than the distal cell, others with the distal cell longer than the basal cell; distal cell rather variable in shape; basal cell 29–42 μ long; distal cell 24–44 μ long. **Prickle-hairs:** prickles (Fig. VI, 1–2), hooks (Fig. VI, 5), and bodies of somewhat intermediate type, abundant over and between the veins. **Papillae** small, variously shaped, cuticularized; 1 or more rows per cell; some overarching the individual stomata. **Stomata:** some tending to be with triangular (Fig. IV, 1), and others with low (Fig. IV, 3), or tall (Fig. IV, 4), dome-shaped subsidiary cells; outlines obscured by overarching papillae. **Long-cells,** both over and between the veins, with thin, sinuous walls (Fig. V, 3*a–c*); others, between the veins, shorter and broader, with v. marked sinuations (Fig. V, 7); interstomatal cells with concave ends. **Transverse veins:** none seen.

T.S. lamina

Adaxial surface smooth, or with slight ribs and furrows, the projecting bulliform cells occupying the narrow furrows. **Sclerenchyma:** most vb's with small adaxial and abaxial girders (Fig. IX, 4), the adaxial being taller and narrower than the abaxial girders; combined girders to the large vb's anchor-shaped (Fig. IX, 6), but arms of the anchors not v. pronounced. **Keel:** vascular system and scl. of type II (Fig. XVII, 8). **Fusoid-cells** larger towards the midrib than towards the margin, and fading out at the margin itself; those near the midrib 84–99 μ in horizontal, and 37–51 μ in vertical, diameter; those towards the margin 66–84 μ in horizontal, and 22–33 μ in vertical, diameter. **Bulliform cells** in fan-shaped groups (Fig. XV, 6) of distinctive form; some groups tending towards the *Sporobolus* type (Fig. XV, 8); cells mostly projecting prominently above the epidermis. **Bundle-sheaths:** most small vb's with 2 complete sheaths (Fig. XII, 1); large vb's with the O.S. interrupted abaxially (Fig. XII, 2).

Material Examined: Meikle 734; Nigeria.

PHYLLOSTACHYS

Species Specially Examined

***Phyllostachys bambusoides* Sieb. et Zucc.**

Leaf

Abaxial epidermis

Short-cells, between the veins, solitary or paired, and not v. numerous apart from those paired with hooks; those over the veins in rows of 3–5 or more cells. **Silica-bodies,** over the veins, saddle-shaped (Fig. I, 9 (iv–v)); those between the veins tall and narrow (Fig. I, 4), but not v. conspicuous in the material examined. **Macro-hairs:** none seen. **Micro-hairs** (Fig. XVI, 32) mostly with cells of about equal length and uniform diameter; all of them rather narrow; basal cell 22–26 μ long; distal cell 22–33 μ long. **Prickle-hairs:** prickles (Fig. VI, 1–2) abundant over, and rather large hooks (Fig. VI, 5) abundant between, the veins. **Papillae** present; small, variously shaped, cuticularized; 1 or more rows per cell; some overarching the individual stomata. **Stomata** with low (Fig. IV, 3), or tall (Fig. IV, 4), dome-shaped subsidiary cells; outlines obscured by overarching papillae. **Long-cells,** both over and between the veins, with thin, v. sinuous walls (Fig. V, 3*a–c*); some rather shorter, with specially marked sinuations; interstomatal cells with v. sinuous walls, rather long, and with concave ends (Fig. V, 11). **Transverse bundles** crowded.

T.S. lamina

Adaxial surface practically smooth, but with slight ribs and furrows, especially towards the margins of the lamina. **Sclerenchyma:** most vb's accompanied by narrow, adaxial girders each about 1–3 cells wide and seldom more than about 3 cells high; combined girders of the large vb's anchor-shaped (Fig. IX, 6), but arms of the anchor not well developed. **Keel:** vascular system and scl. of type IV (Fig. XVII, 11). **Fusoid-cells** rare, only 2 seen near the midrib in the sections examined; 46–51 μ in horizontal, and 15–18 μ in vertical, diameter. **Bulliform cells** mostly in fan-shaped groups (Fig. XV, 4), but some groups tending to be of the *Sporobolus* type (Fig. XV, 8); cells occasionally projecting above the epidermis. **Bundle-sheaths:** all, or most, small vb's with 2 complete sheaths (Fig. XII, 1); large vb's with the O.S. interrupted adaxially and abaxially (Fig. XII, 3*a–b*).

Material Examined: Cultivated at Kew.

***Phyllostachys castillonis* (Marl.) Mitford**

(F. A. McClure (verbal communication) considers *P. castillonis* is a small form of *P. bambusoides*.)

Leaf

Abaxial epidermis

Short-cells, over the veins, solitary, and in rows of 3–5 or more cells; generally abundant, but infrequent and inconspicuous between the veins

apart from those paired with hooks; others between the veins solitary. **Silica-bodies,** over the veins, saddle-shaped (Fig. I, 9 (iv–v)); those between the veins tall and narrow (Fig. I, 4). **Macro-hairs:** none seen. **Micro-hairs** (Fig. XVI, 33) with the distal cell shorter than the basal cell in some hairs, and v. slightly longer than the basal cell in others; basal cell 22–29 μ long; distal cell 15–26 μ long. **Prickle-hairs:** prickles (Fig. VI, 1–2) abundant over, and hooks (Fig. VI, 5) between, the veins. **Papillae** present; small, variously shaped, cuticularized; 1 or more rows per cell; some rather long and overarching the individual stomata. **Stomata** with low (Fig. IV, 3), or tall (Fig. IV, 4), dome-shaped subsidiary cells; outlines obscured by overarching papillae. **Long-cells,** both over and between the veins, with thin, v. sinuous walls (Fig. V, 3*a–c*); some rather short (Fig. V, 7); interstomatal cells with concave ends, mostly rather long and with v. sinuous walls (Fig. V, 11). **Transverse bundles** v. numerous.

T.S. lamina

Adaxial surface smooth, or with slight but wide ribs, and v. shallow, narrow furrows. **Sclerenchyma:** most vb's accompanied by relatively tall, narrow, adaxial girders about 2–3 cells wide, and small abaxial girders (Fig. IX, 7). **Keel:** vascular system and scl. a small form of type II (Fig. XVII, 8). **Fusoid-cells** apparently absent. **Bulliform cells** in fan-shaped groups (Fig. XV, 4), but some groups tending to be of the *Sporobolus* type (Fig. XV, 8); cells tending to project above the epidermis. **Bundle-sheaths:** nearly all small vb's with 2 complete sheaths (Fig. XII, 1); large vb's with the O.S. interrupted adaxially and abaxially (Fig. XII, 3*a–b*), or, more frequently, abaxially only (Fig. XII, 2).

MATERIAL EXAMINED: Cultivated at Kew.

Phyllostachys heterocycla (Carrière) Matsum

(F. A. McClure (verbal communication) regards this sp. as a large form of *P. pubescens* Mazel ex H. de Lehaie.)

LEAF

Abaxial epidermis

Short-cells: some of those over, and all of those between, the veins solitary or paired; most of those over the veins in rows of more than 5 cells; common. **Silica-bodies,** over the veins saddle-shaped (Fig. I, 9 (iv–v)); those between the veins infrequent, tall, and narrow (Fig. I, 4). **Macro-hairs:** none seen. **Micro-hairs** (Fig. XVI, 34) mostly with both cells of approximately equal length; distal cell rather variable in shape; basal cell 26–35 μ long; distal cell 22–33 μ long. **Prickle-hairs:** prickles (Fig. VI, 1–2) fairly frequent over, and hooks (Fig. VI, 5) abundant between, the veins. **Papillae** present; small, variously shaped, cuticularized; mostly 1 row per cell; some overarching the individual stomata. **Stomata** with low (Fig. IV, 3), or tall (Fig. IV, 4), dome-shaped, subsidiary cells; outlines obscured by overarching papillae. **Long-cells,** both over and between the veins, with thin, sinuous walls (Fig. V, 3*a–c*); interstomatal cells of variable length, with concave ends. **Transverse bundles** v. numerous.

T.S. lamina

Adaxial surface practically smooth, or with slight ribs, and shallow, narrow furrows. **Sclerenchyma:** most vb's accompanied by adaxial girders 1–2 cells wide, and v. small abaxial girders; combined girders of large vb's anchor-shaped (Fig. IX, 6), but arms of the anchor not pronounced. **Keel:** vascular system and scl. of type IV (Fig. XVII, 9 and 11). **Fusoid-cells** apparently absent. **Bulliform cells:** groups fan-shaped (Fig. XV, 4), or tending to be of the *Sporobolus* type (Fig. XV, 8). **Bundle-sheaths:** most small vb's with 2 complete sheaths (Fig. XII, 1); some large vb's with the O.S. interrupted adaxially and abaxially (Fig. XII, 3*a–b*); other large, and a few small, vb's with the I.S. interrupted abaxially only (Fig. XII, 2).

MATERIAL EXAMINED: Cultivated at Kew.

Phyllostachys nigra (Lodd.) Munro

LEAF

Abaxial epidermis

Short-cells, over the veins, occasionally solitary or paired, but mostly in rows of more than 5 cells; common over, but infrequent or absent between, the veins. **Silica-bodies,** over the veins, saddle-shaped (Fig. I, 9), but less tall than is typical for the saddle-shaped type in bamboos, some over the large veins tending to be oblong and concave at either end. **Macro-hairs** occasional; short, stiff, with swollen, constricted bases. **Micro-hairs** (Fig. XVI, 35) with both cells of approximately equal length, but distal cell variable in shape; basal cell 22–37 μ long; distal cell 22–26 μ long. **Prickle-hairs:** none seen. **Papillae** present; small, variously shaped, cuticularized; seldom overarching the individual stomata to any appreciable extent; 1 row per cell. **Stomata** with low (Fig. IV, 3), or tall (Fig. IV, 4), dome-shaped subsidiary cells. **Long-cells,** over the small veins, and between the veins, with thin, sinuous walls (Fig. V, 3*a–c*); those over the large veins with thicker, more or less non-sinuous walls (Fig. V, 1). **Transverse bundles** v. numerous.

T.S. lamina

Adaxial surface smooth, or with slight ribs, and shallow, narrow furrows. **Sclerenchyma:** some small vb's, especially those towards the leaf margins, accompanied by small adaxial and abaxial girders; most vb's with narrow, usually 1–2-seriate, adaxial, and v. small abaxial, girders; combined girders to the large vb's tending to be anchor-shaped (Fig. IX, 6), but arms of the anchor not pronounced. **Keel:** vascular system and scl. of type IV (Fig. XVII, 9 and 11). **Fusoid-cells** apparently absent. **Bulliform cells** mostly in fan-shaped groups (Fig. XV, 4), but some groups tending to be of the *Sporobolus* type (Fig. XV, 8). **Bundle-sheaths:** some vb's with I.S. complete, but O.S. not quite complete abaxially (Fig. XII, 2); others with the O.S. interrupted adaxially and abaxially (Fig. XII, 3*a–b*).

MATERIAL EXAMINED: Cultivated at Kew.

***Phyllostachys reticulata* C. Koch.**

LEAF

Abaxial epidermis

Short-cells, between the veins, inconspicuous, solitary, or paired; those over the veins mostly in rows of more than 5 cells, but sometimes appearing solitary when separated from one another in each file by relatively long cells; common. **Silica-bodies,** over the veins, mostly saddle-shaped (Fig. I, 9), but not v. tall; the infrequent intercostal silica-bodies tending to be tall and narrow (Fig. I, 4). **Macro-hairs** fairly common; stiff, with swollen, constricted bases. **Micro-hairs** (Fig. XVI, 36); distal cells longer or shorter than the basal cells and variable in shape; basal cell 24–35 μ long; distal cell 20–33 μ long. **Prickle-hairs:** a few hooks (Fig. VI, 5) present between the veins. **Papillae** present; small, variously shaped, cuticularized; 1 row per cell; seldom overarching the individual stomata. **Stomata** with low (Fig. IV, 3), or tall (Fig. IV, 4), dome-shaped subsidiary cells. **Long-cells,** over and between the veins, with thin, sinuous walls (Fig. V, 3*a–c*); those over the large veins with thicker and more or less non-sinuous walls (Fig. V, 1*a*). **Transverse bundles** v. numerous.

T.S. lamina

Adaxial surface smooth, or with slight ribs, and narrow, v. shallow furrows. **Sclerenchyma:** small vb's accompanied by small adaxial and abaxial girders, the adaxial girders, especially those to vb's near the midrib, being 1–3-seriate, and the corresponding abaxial girders often no more than 1–2 cells tall and about 3 cells wide. Occasional uniseriate girders, not associated with vb's, also present. **Keel:** vascular system and scl. of type IV (Fig. XVII, 9 and 11). **Fusoid-cells** occurring rather sporadically; 9 of them measured 33–53 μ in horizontal, and 9-18 μ in vertical, diameter. **Bulliform cells** mostly in fan-shaped groups (Fig. XV, 4); other groups tending to be of the *Sporobolus* type (Fig. XV, 8). **Bundle-sheaths:** most small vb's with 2 complete sheaths (Fig. XII, 1); other small vb's with the O.S. not quite complete abaxially (Fig. XII, 2); large vb's with the O.S. interrupted adaxially and abaxially (Fig. XII, 3*a–b*).

MATERIAL EXAMINED: Cultivated at Kew.

***Phyllostachys viridi-glaucescens* (Carrière) A. & C. Riv.**

LEAF

Abaxial epidermis

Short-cells, between the veins, mostly solitary, and occasionally paired; those over the veins chiefly in rows of more than 5 cells, but sometimes appearing to be solitary when separated from one another in the individual files by rather long cells; common. **Silica-bodies,** over the veins, saddle-shaped (Fig. I, 9); but some tending to be intermediate between cross and dumb-bell shaped (Fig. IA, 17); silica-bodies, between the veins, rare, tall, and narrow (Fig. I, 4). **Macro-hairs:** none seen. **Micro-hairs** (Fig. XVI, 37): some with both cells of about equal length and of uniform diameter, but distal cells of other hairs rather longer, or shorter, than the basal cell; distal cell variable in shape; basal cell 22–33 μ long; distal cell 24–33 μ long. **Prickle-hairs:** prickles (Fig. VI, 1–2)

common over the veins; hooks (Fig. VI, 5) present but rare between the veins. **Papillae** present; small, variously shaped, cuticularized; 1 row per cell; many stomata prominently overarched by a few, often 4, papillae. **Stomata** with low (Fig. IV, 3), or tall (Fig. IV, 4), dome-shaped subsidiary cells. **Long-cells:** those in the intercostal zones and over the small veins with thin, sinuous walls (Fig. V, 3*a–c*); cells over large veins with thicker, less sinuous walls (Fig. V, 1*a*); interstomatal cells with concave ends, some of these cells rather long (Fig. V, 11). **Transverse bundles** numerous.

T.S. lamina

Adaxial surface smooth, or with v. slight, narrow furrows. **Sclerenchyma:** most vb's accompanied by narrow, 1–2-seriate adaxial, and much smaller abaxial, girders; combined girders to the large vb's anchor-shaped (Fig. IX, 6), but arms of the anchor not v. pronounced. **Keel:** vascular system and scl. of type IV (Fig. XVII, 11). **Fusoid-cells** relatively small, inconspicuous, sporadically distributed, but, on the whole, most fully developed near the midrib; 4 of them measured 37–62 μ in horizontal, and 15–20 μ in vertical, diameter. **Bulliform cells** mostly in fan-shaped groups (Fig. XV, 4), but slight tendency for some of the groups to be of the *Sporobolus* type (Fig. XV, 8). **Bundle-sheaths:** all, or nearly all, small vb's with 2 complete sheaths (Fig. XII, 1); large vb's with the O.S. interrupted adaxially and abaxially (Fig. XII, 3*a–b*), or abaxially only (Fig. XII, 2).

MATERIAL EXAMINED: Cultivated at Kew.

PSEUDOSTACHYUM

SPECIES SPECIALLY EXAMINED

***Pseudostachyum polymorphum* Munro**

LEAF

Abaxial epidermis

Short-cells, both over and between the veins, nearly always paired; occasionally in rows of 3–5 cells over the veins; abundant. **Silica-bodies** all saddle-shaped (Fig. I, 9 (iv–v)), but those between much narrower than those over the veins. **Macro-hairs:** none seen. **Micro-hairs** (Fig. XVI, 38); both cells of more of less equal length, but distal cell sometimes slightly longer, or shorter, than the basal cell; distal cell of some hairs tapering to a rounded point; fairly numerous; basal cell 29–33 μ long; distal cell 24–37 μ long. **Prickle-hairs:** hooks (Fig. VI, 5) abundant between the veins. **Papillae** rather small; none observed apart from those overarching the individual stomata. **Stomata** probably with low dome-shaped subsidiary cells (Fig. IV, 3), but outlines obscured by overarching papillae. **Long-cells** with thin, sinuous walls (Fig. V, 3*a–c*); tendency for the development of interstomatal cells with concave ends (Fig. V, 10). **Transverse veins** rather infrequent.

T.S. lamina

Adaxial surface smooth, apart from 2 or 3 slight ribs on one side of the midrib. **Sclerenchyma:** most vb's accompanied by small adaxial and abaxial

girders (Fig. IX, 4), but adaxial girders often only 1–3-seriate, and narrower than the abaxial girders; combined girders of all large, and some small, vb's tending to be anchor-shaped (Fig. IX, 6). **Keel:** vascular system and scl. approximating to type III (Fig. XVII, 7), but with 3 adaxial vb's. **Fusoid-cells** large and conspicuous; those towards the leaf margins being, on the whole, slightly smaller than those towards the midrib; those near the midrib 110–43 μ in horizontal, and 31–37 μ in vertical, diameter; those towards the margins 99–110 μ in horizontal, and 22–26 μ in vertical, diameter. **Bulliform cells** in fan-shaped groups (Fig. XV, 4), the central cell in each group being much taller and wider than the others. **Bundle-sheaths:** most small vb's with 2 complete sheaths (Fig. XII, 1); most large, and some small, vb's with the O.S. interrupted abaxially (Fig. XII, 2).

MATERIAL EXAMINED: Leg. G. Mann; Assam.

PUELLIA

SPECIES SPECIALLY EXAMINED

***Puellia ciliata* Franch.**

LEAF

Abaxial epidermis

Short-cells, both over and between the veins, almost exclusively paired; sometimes in rows of 3–5 or more cells over the veins; abundant. **Silica-bodies** saddle-shaped (Fig. I, 9), but mostly rather narrow, both over and between the veins; silica-bodies, over the large veins, sometimes about equal in height and width. **Macro-hairs** and **micro-hairs:** none seen. **Prickle-hairs:** hooks (Fig. VI, 5) v. frequent in the interstomatal bands of the intercostal zones. **Papillae:** none seen. **Stomata:** subsidiary cells mostly low (Fig. IV, 3), or tall (Fig. IV, 4), dome-shaped, sometimes with a slight tendency to be triangular (Fig. IV, 1). **Long-cells** with thin, sinuous walls (Fig. V, 3*a–c*) both over and between the veins; tendency for the walls to be especially sinuous in the intercostal zones; each long-cell separated from the next in the same file by a pair of tall short-cells v. markedly at right angles to the horizontal walls (as in Fig. V, 6, but short-cells in pairs). Interstomatal cells with slightly concave ends, but this character not v. noticeable owing to the stomata being widely spaced in the files. **Transverse bundles:** none seen.

T.S. lamina

Adaxial surface with slight, v. wide ribs, and shallow, not v. wide furrows. **Sclerenchyma:** most small vb's accompanied by small, narrow adaxial, and slightly wider abaxial, girders; combined girders of some of the large vb's tending to be anchor-shaped (Fig. IX, 6). **Keel:** vascular system and scl. of type III (Fig. XVII, 7). **Fusoid-cells** mostly exceptionally large, but decreasing in size towards, and absent at, the leaf margins; 229–64 μ in horizontal, and 40–66 μ in vertical, diameter. **Bulliform cells** in regular groups about 5 cells long, the cells being of uniform size (Fig. XV, 2); also in groups of the

Sporobolus type (Fig. XV, 8). **Bundle-sheaths:** most small vb's with 2 complete sheaths (Fig. XII, 1), but most large, and a few small, vb's with the O.S. interrupted abaxially (Fig. XII, 2).

MATERIAL EXAMINED: J. Lebrun 2670; Belgian Congo.

SCHIZOSTACHYUM

SPECIES SPECIALLY EXAMINED

***Schizostachyum gracile* (Munro) Holttum var. *erectum* Holttum**[1]

LEAF

Abaxial epidermis

Short-cells, over and between the veins, paired; abundant. **Silica-bodies,** both over and between the veins, tall and narrow (Fig. I, 4). Structures resembling small silica-bodies of the *Oryza* type (Fig. IB, 23), but perhaps more in the nature of slightly silicified papillae, present both over and between the veins. **Macro-hairs:** none seen. **Micro-hairs** (Fig. XVI, 39): both cells of about equal length, or with the distal cell considerably longer, or sometimes rather shorter, than the basal cell; distal cell tapering to a rounded point; fairly numerous; basal cell 31–35 μ long; distal cell 26–37 μ long. **Prickle-hairs:** hooks (Fig. VI, 5) v. occasional between the veins. **Papillae:** see under silica-bodies above; also v. large papillae overarching the individual stomata. **Stomata:** outlines obscured by overarching papillae. **Long-cells** with thin, sinuous walls (Fig. V, 3*a–c*), those of the intercostal zones separated from each other in the individual files by pairs of tall short-cells v. markedly at right angles to the horizontal walls (as Fig. V, 6, but short-cells paired); tendency for the development of interstomatal cells with concave ends. **Transverse bundles:** a few observed.

T.S. lamina

Adaxial surface smooth, apart from 2 or 3 ribs on one side of the midrib. **Sclerenchyma:** most vb's accompanied by small, adaxial and abaxial girders, the 1–2-seriate adaxial girders being narrower and taller than the abaxial girders; combined girders of the large vb's tending to be anchor-shaped (Fig. IX, 6), with the arms of the anchor fairly well developed. **Keel:** vascular system and scl. of type IV (Fig. XVII, 9 and 11). **Fusoid-cells:** 55–70 μ in horizontal, and 15–20 μ in vertical, diameter. **Bulliform cells** in regular groups about 5 cells long, with the cells of rather uniform size (Fig. XV, 2); other groups fan-shaped (Fig. XV, 4). **Bundle-sheaths:** most small vb's with 2 complete sheaths (Fig. XII, 1); other small, and some large, vb's with the O.S. intertupted abaxially (Fig. XII, 2); also a few of the large vb's with the O.S. interrupted both adaxially and abaxially (Fig. XII, 3*a–b*).

MATERIAL EXAMINED: Ridley 6892; Malaya.

[1] See Henrard 1936.

SHIBATAEA

Species Specially Examined

***Shibataea kumasasa* (Zoll. ex Steud.) Makino (*S. ruscifolia* (Nichols.) Makino)**

Leaf

Abaxial epidermis

Short-cells, between the veins, mostly inconspicuous and solitary; those over the veins usually in rows of more than 5 cells, but sometimes appearing to be solitary or paired when separated from one another in the individual files by fairly long cells; common. **Silica-bodies,** over the veins, intermediate between cross and dumb-bell shaped (Fig. Ia, 17), or almost cuboid; rare silica-bodies between the veins tending to be tall and narrow (Fig. I, 4). **Macro-hairs:** common; fairly short, with swollen, constricted bases. **Micro-hairs** (Fig. XVI, 40): some with both cells of about equal length and more or less uniform diameter, but distal cell sometimes slightly shorter or longer than the basal cell; hairs rather narrow; distal cell variable in shape; basal cell 24–35 μ long; distal cell 24–31 μ long. **Prickle-hairs:** hooks (Fig. VI, 5) locally abundant between the veins. **Papillae** present; small, variously shaped, cuticularized; more than 1 row per cell; slightly overarching the individual stomata. **Stomata** with low (Fig. IV, 3), or tall (Fig. IV, 4), dome-shaped subsidiary cells. **Long-cells,** between the veins, with thin, sinuous walls (Fig. V, 3*a–c*); those over the veins with thicker walls; interstomatal cells with concave ends (Fig. V, 10). **Transverse bundles:** none seen.

T.S. lamina

Adaxial surface with v. slight, wide ribs, and v. shallow, narrow furrows. **Sclerenchyma:** some small vb's, especially towards the margins, accompanied by small adaxial and abaxial girders (Fig. IX, 4); most small vb's with narrow, 1–2- or occasionally 3-seriate adaxial, and much smaller abaxial, girders; combined girders of the large vb's weakly anchor-shaped (Fig. IX, 6), but with arms of the anchor not pronounced. **Keel:** vascular system and scl. of type II (Fig. XVII, 2*b*). **Fusoid-cells** small, inconspicuous and of sporadic occurrence, recalling those of *Arundinaria*; 5 of them measured 33–48 μ in horizontal, and 11–13 μ in vertical, diameter. **Bulliform cells** in fan-shaped groups (Fig. XV, 4); groups sometimes reduced. **Bundle-sheaths:** most small vb's with 2 complete sheaths (Fig. XII, 1); other small vb's with the O.S. slightly interrupted abaxially (Fig. XII, 2); large vb's with the O.S. more widely interrupted abaxially.

Material Examined: Cultivated at Kew.

***Shibataea ruscifolia* (Nichols.) Makino (synonymous with *S. kumasasa*)**

Leaf

Abaxial epidermis

Short-cells, between the veins, sometimes solitary or paired; those over the veins chiefly in rows of more than 5 cells, but appearing solitary when separated from one another in the individual files by fairly long cells; common.

Silica-bodies, over the veins, saddle-shaped (Fig. I, 9); others tending to be intermediate between cross and dumb-bell shaped (Fig. Ia, 17). Silica-bodies, between the veins, not clearly differentiated in the material available. **Macro-hairs** fairly frequent; short, stiff, with swollen, constricted bases. **Micro-hairs** (Fig. XVI, 41) with the basal cell generally rather longer than the distal cell, the latter being somewhat variable in shape; basal cell 22–26 μ long; distal cell 13–15 μ long. **Prickle-hairs:** hooks (Fig. VI, 5) common between the veins. **Papillae** present; small, variously shaped, cuticularized; 1 row per cell; seldom overarching the individual stomata. **Stomata** with low (Fig. IV, 3), or tall (Fig. IV, 4), dome-shaped subsidiary cells. **Long-cells,** between the veins, and over the small veins, with thin, sinuous walls (Fig. V, 3*a–c*); those over the large veins obscure; interstomatal cells with concave ends, many of them rather long (Fig. V, 11). **Transverse bundles** v. numerous.

T.S. lamina

Adaxial surface smooth, or with slight ribs, and narrow, shallow furrows. **Sclerenchyma:** some small vb's accompanied by small adaxial and abaxial girders (Fig. IX, 4); most small vb's with 1–2-seriate adaxial, and v. small abaxial, girders; combined girders of large vb's weakly anchor-shaped (Fig. IX, 6), but arms of the anchor not pronounced. **Keel:** vascular system and scl. of type II (Fig. XVII, 8). **Fusoid-cells** occurring sporadically; where present small and not v. clearly demarcated from the adjacent cells; 4 of them measured 37–51 μ in horizontal, and 11–13 μ in vertical, diameter. **Bulliform cells** in fan-shaped groups (Fig. XV, 4), some groups being rather reduced. **Bundle-sheaths:** many small vb's with 2 complete sheaths (Fig. XII, 1), or with the O.S. slightly interrupted abaxially (Fig. XII, 2); large vb's with the O.S. interrupted adaxially and abaxially (Fig. XII, 3*a–b*).

Material Examined: Cultivated at Kew.

THYRSOSTACHYS

Species Specially Examined

***Thyrsostachys oliveri* Gamble**

Leaf

Abaxial epidermis

Short-cells, over the veins, in rows of more than 5 cells; those between the veins mostly paired; abundant. **Silica-bodies,** over and between the veins, saddle-shaped (Fig. I, 9); those in the intercostal zones much smaller than those over the veins. **Macro-hairs** sparse; short, with swollen bases. **Micro-hairs** (Fig. XVI, 42): both cells of about equal length, or distal cell slightly longer, or shorter, than the basal cell; basal cell 22–29 μ long; distal cell 24–31 μ long. **Prickle-hairs:** hooks (Fig. VI, 5) numerous between the veins. **Papillae** rather infrequent; small, variously shaped, cuticularized; some overarching the individual stomata. **Stomata:** outlines obscured by overarching papillae. **Long-cells** with thin, sinuous walls (Fig. V, 3*a–c*); those in the intercostal zones with v. sinuous walls; tendency for the development of inter-

stomatal cells with concave ends (Fig. V, 10). **Transverse bundles** numerous, at least locally.

T.S. lamina

Adaxial surface smooth, apart from 2 ribs of unequal heights on one side of the midrib. **Sclerenchyma:** most small vb's accompanied by small adaxial and abaxial girders, the adaxial girders being 1–3-seriate, and the abaxial girders shorter and wider; combined girders to the large vb's tending to be anchor-shaped, but arms of the anchor not v. well developed. **Keel:** vascular system and scl. of type I (Fig. XVII, 1 and 10). **Fusoid-cells** of moderate size; those near the midrib slightly larger than those towards the leaf margins; 66–88 μ in horizontal, and 15–31 μ in vertical, diameter. **Bulliform cells** in regular groups up to about 5 cells long; the cells being of uniform size (Fig. XV, 2); also in fan-shaped groups (Fig. XV, 4), and groups of the *Sporobolus* type (Fig. XV, 8); central cell of the fan-shaped groups tall, sometimes penetrating nearly to the middle of the mesophyll. **Bundle-sheaths:** some small vb's with 2 complete sheaths (Fig. XII, 1); large, and the other small, vb's with the O.S. interrupted abaxially (Fig. XII, 2).

MATERIAL EXAMINED: Leg. G. Rogers; Burma

CULM STRUCTURE OF BAMBOOS (Fig. XIX, 7–10)

Transverse sections through the internodes of bamboo culms show that there are certain characters that are common to all of them. Owing to the relatively low magnification that is needed to observe the characters that are of diagnostic value, and because of the difficulty of preparing sections without a sledge microtome, it often saves time and trouble to examine smoothly cut transverse surfaces of the culms with a good hand lens. Alternatively, small blocks of the culms can be examined on the stage of a simple dissecting microscope. The smooth, transverse surfaces can be prepared with a really sharp pocket knife or with a razor blade with a rigid back. Unless the canes are freshly gathered it is as well to immerse the end of the cane to be cut in boiling water, or even to boil short lengths of cane in water for a time, as this facilitates cutting.

Sections, or smooth transverse surfaces, exhibit the following characters. The exterior of the culm is bounded by an epidermis of cells that are generally very thick-walled. This is usually, but not invariably, bounded on the inner side by 1–3 layers of thick-walled hypodermal cells that are frequently similar to the epidermal cells themselves. Then follows a narrow zone of up to about 8 layers of moderately thick-walled parenchymatous cells that often contain chloroplasts. The epidermis, hypodermis, and subjacent parenchyma collectively constitute no more than a thin crust on the surface of the culm. On the inner side of the photosynthetic layer there are scattered vascular bundles supported by bundles of fibres with very thick walls and narrow lumina, the vascular bundles and their associated sclerenchyma being separated from one another by a ground tissue of moderately thick-walled cells with relatively wide lumina, the cells of the ground tissue standing out in marked contrast to the darker vascular bundles and associated sclerenchyma. The vascular

bundles nearest to the epidermis are always smaller than those nearest to the centre of the culm, those between exhibiting a gradual transition in size. There is a corresponding gradation in the extent to which the vascular bundles are supported by sclerenchyma, the smaller, closely placed peripheral bundles having much more massive mechanical support than the more widely spaced, larger vascular bundles towards the centre of the culm. The xylem of each vascular bundle usually has one conspicuously large metaxylem vessel on either side of, and slightly nearer to the phloem than, the protoxylem which normally breaks down to form an intercellular canal at the inner pole of each vascular bundle. The metaxylem vessels are especially large in the inner bundles where they are clearly visible with a simple hand lens. Each vascular bundle also exhibits a more or less cylindrical strand of phloem which appears in transverse sections under the hand lens as a circle towards the outer pole of the bundle. The microscope reveals that the phloem consists chiefly of sieve tubes which are remarkable for their very wide diameters. Some of the innermost vascular bundles, especially in thick culms, are inversely orientated, the xylem then being at the outer and the phloem at the inner pole. Incompletely inverted vascular bundles also occur.

The internodes of most bamboos are circular in transverse section, but sometimes, e.g. in *Phyllostachys*, they are flattened on one side. The centre of the culm, as in most grasses, is hollow except at the nodes, but exceptions occur. In some bamboos a few of the layers of cells next to and surrounding the central cavity of the culm become converted to thick-walled, pitted sclereids. This has been noted, for example, in *Guadua angustifolia*. The ground tissue often contains abundant starch, which, however, appears to have a local distribution in some specimens.

When transverse surfaces of bamboo culms are compared with one another it is important, for taxonomic purposes, to take the diameter of the culm into consideration, since the sizes of the sclerenchyma strands increase with age. When it is impossible to measure the diameter because the material is too fragmentary, the length of the radius from the outer edge of the central cavity of the culm to the epidermis should be given.

Characters that appear to be of diagnostic value include (i) the outline of the transverse section, e.g. flattened on one side in *Phyllostachys*; (ii) the presence of a zone of sclereids surrounding the central cavity, e.g. in *Guadua angustifolia*; and (iii) variations in the size, shape, and distribution of the fibre bundles (sclerenchyma) in relation to the vascular bundles. The author has examined too few bamboo culms to enable him to assess the reliability or full taxonomic significance of these characters, but, on the whole, the distribution pattern of sclerenchyma appears to hold out the greatest promise for this purpose.

When it is possible to examine relatively thick culms the distribution of sclerenchyma can easily be observed on a smoothly cut transverse surface because the sclerenchyma is darker in colour than the xylem and phloem of the vascular bundles or than the interfascicular ground tissue. For diagnostic purposes it is necessary to note the distribution of the sclerenchyma in relation to the small outer bundles, as well as in relation to the less densely crowded inner bundles. Although there is a gradation rather than a clear line of demar-

cation between the outer and the inner bundles, the observer should quickly be able to form a mental picture of those bundles that can be roughly classified, for taxonomic purposes, as 'outer' and 'inner' respectively, because the 'inner' bundles and their associated sclerenchyma are always separated from one another by relatively broad masses of lighter coloured ground tissue.[1] The light coloured ground tissue between the outer bundles, on the other hand, appears under the lens as only narrow areas of fine lines, and sometimes the strands of the meshwork of interfascicular ground tissue may be only 1–2 cells wide, when it is often necessary to resort to the compound microscope before it becomes clearly visible. Where the strands of interfascicular ground tissue are very narrow the outer ground tissue appears under the simple lens as a continuous dark coloured mass of sclerenchyma. Even when, e.g. in *Phyllostachys*, lines of ground tissue between the outer vascular bundles are too narrow to be easily discerned with the simple lens, they are clearly visible with the compound microscope. In other bamboos, e.g. *Dendrocalamus*, the lines of light coloured, interfascicular ground tissue are wide enough to be clearly visible with a simple lens alone.

In using the distribution pattern of sclerenchyma for diagnostic purposes the reader should realize that each vascular bundle may be accompanied by sclerenchyma in up to 4 separated positions. The positions are: (*a*) at the outer (phloem) pole; (*b*) at the inner (xylem) pole; and (*c*) as 2 lateral strands, one on either side of the xylem, where they are generally in contact with the outer edges of the 2 large metaxylem vessels. The sclerenchyma in each of these positions consists of a longitudinal strand (bundle) of fibres which, in transverse sections, appears as a cap. Each vascular bundle may thus have 2 polar and 2 lateral caps, and if these caps become joined to one another, the bundle then appears to be wholly surrounded by, or embedded in, sclerenchyma. Variations of taxonomic importance are due to: (*a*) the absence of 1 or more of the 4 caps; (*b*) differences in the relative sizes of the 4 caps; and (*c*) the inner cap being either in direct contact with the xylem or separated from it by interfascicular ground tissue. The following notes on the distribution of sclerenchyma in a small sample of genera and species of bamboos may help to make these points clear.

ARUNDINARIA (Fig. XIX, 9)

Outer vb's, together with the associated scl., separated from one another by narrow lines of ground tissue; outer scl. caps much smaller than the rounded inner scl. caps of the individual vb's. Inner vb's with small outer, inner, and lateral scl. caps. This structure noted, in culms with the radius from the central cavity to the epidermis ranging from 1·5 to 2·5 cm, in *A. auricoma* (= *variegata*), *fastuosa*, *fortunei* (= *variegata*), *graminea*, *japonica*, and *pumila*.

Similar, but with outer vb's almost wholly embedded in scl. in culms with

[1] It is frequently necessary, for descriptive purposes, to draw a further distinction between the 'inner' and 'innermost' vascular bundles, since those that lie next to the central cavity of the culm sometimes differ from their nearest neighbours on the outer side in some small but important respect.

a radius of 1–2 mm, in *A. marmorea*, *murielae*, *nitida*, *simonii*, *tessellata* (= *ragamowski*), and *vagans*.

A zone of sclereids some 5 cells wide lining the central cavity noted only in *A. fastuosa*.

MATERIAL EXAMINED: All of the *Arundinaria* culms examined were cultivated at Kew.

BAMBUSA

Outer vb's together with the associated scl., separated from one another by narrow lines of ground tissue; outer much smaller than the inner scl. caps. Inner vb's supported by small inner, outer, and lateral caps of scl.; supplementary strands of less lignified scl., composed of cells with wider lumina, also present on the inner side of, but separated by ground tissue from, many of the vb's. Innermost vb's with inner scl. caps sometimes considerably reduced. Centre of the culm solid. This structure noted in a culm of *B. glaucescens* 5 mm in diameter.

Outer vb's and associated scl. separated from one another by moderately wide lines of ground tissue; xy. and ph. completely or almost entirely surrounded by scl. Otherwise similar to the previous specimen. This structure seen in a culm of *B. glaucescens* with a radius of 3 mm and in culms of *B. vulgaris* with a radius of up to 14 mm.

The independent inner scl. caps to the inner vb's may be characteristic of *Bambusa*, although similar inner caps have also been noted in *Dendrocalamus*.

MATERIAL EXAMINED: *B. glaucescens* (Willd.) Sieb. ex Munro and *B. vulgaris* Schrad. Material of both species in part cultivated at Kew and in part supplied by N. W. Simmonds from Trinidad.

ADDITIONAL INFORMATION FROM THE LITERATURE

Montemontini (1904), who examined the intercellular air-spaces in *B. macroculmis* A. Riv., refers to the occurrence of a sclerotic calyptra (*Wurzelhaube*) on the roots when young. Aerenchyma, composed of cells with slightly suberized cell walls, develops in the cortex of the roots. The outer tissues become detached from the roots when older, leaving only the strands consisting of the central vascular system. Even the vascular tissue breaks off in due time, leaving a small opening in the culm where the roots were originally attached. Intercellular spaces also occur in the cortex of the culm.

Garofolo (1950) refers to traumatic anomalies in the internodal growth of *B. macroculmis* and *B. vulgaris*. These are attributed to scarcity of soil water and to the environmental temperature being too high.

Molisch (1918) refers to the occurrence of calcium oxalate crystals, as well as silica-bodies, in *B. stricta*. This observation is interesting, if correct, as there are few, if any, well established examples of the occurrence of calcium oxalate crystals in grasses.

DENDROCALAMUS

Outer vb's, together with the associated scl., separated from one another by moderately wide strands of ground tissue; outer much smaller than the inner

caps of scl., but bundles sometimes appearing to be completely embedded in scl. Inner vb's supported by inner, outer, and lateral scl. caps, the inner and outer caps being approximately equal in size, and the inner caps not in direct contact with the xy., but separated from it by ground tissue (cf. *Bambusa*). This structure noted in a culm of *D. brandisii* 4 mm in diameter, in culms of *D. giganteus* with radii ranging from 3 to 21 mm, and in a culm of *D. strictus* with a radius of 14 mm.

MATERIAL EXAMINED: *D. brandisii* cultivated at Kew; *D. giganteus* in part cultivated at Kew, and in part supplied by N. W. Simmonds from Trinidad; *D. strictus* supplied by N. W. Simmonds from Trinidad.

GUADUA

Outer vb's, together with the associated scl., separated from one another by fine, narrow lines of ground tissue; supported by relatively small outer, and much larger inner, caps of scl., the apices of the caps being rounded or pointed, the caps tending to be triangular when pointed. Inner vb's supported by well developed outer and lateral scl. caps, the inner caps being much smaller than the others, or almost absent. Hollow centre of the culm surrounded by a zone of sclereids about 6–8 cells wide, the sclereids having thick, pitted walls and narrow lumina. This structure noted in a culm of *G. angustifolia* Kunth with a radius of about 7 mm.

MATERIAL EXAMINED: Supplied by N. W. Simmonds from Trinidad.

OXYTENANTHERA

Outer vb's more or less embedded in scl., but vb's and their associated scl. separated from one another by narrow strands of ground tissue. Inner vb's with slight outer and inner caps of scl., but lateral caps scarcely noticeable. This structure noted in a culm only 3 mm in diameter.

MATERIAL EXAMINED: Meikle 734; Nigeria.

PHYLLOSTACHYS (Fig. XIX, 7, 8, and 10)

Culms differing from those of other genera examined in being flattened on one side (Fig. XIX, 8 and 10). Outer vb's, together with the associated scl., separated from one another by strands of ground tissue often no more than 1–2, or occasionally 3, cells wide; supported by small outer and much larger inner scl. caps. Inner vb's (Fig. XIX, 7) supported by inner, outer, and lateral caps of scl., all of the caps being in contact with the vb's and decreasing in size as the observer's eye passes inwards towards the centre of the culm. This structure observed in culms 8 mm in diameter, and with a radius of 5 mm, of *P. bambusoides*, *castillonis*, *heterocycla*, *nigra*, *reticulata*, and *viridiglaucescens*.

MATERIAL EXAMINED: All cultivated at Kew.

SCHIZOSTACHYUM

Outer vb's more or less embedded in scl., each vb being supported by a small outer and a much larger inner scl. cap; vb's and associated scl. separated from one another by strands of ground tissue 1–3 or more cells wide. Inner vb's supported by inner, outer, and lateral caps of scl., the fibres being less lignified than in some of the other species examined. Innermost vb's with relatively small inner scl. caps. This structure noted in a portion of a large cane of *S. grande* Ridl. with a radius of 7 mm.

MATERIAL EXAMINED: Hamid 8257; Malaya (from the Kew Herbarium).

SHIBATAEA

Structure v. similar to that of *Phyllostachys*, but culm not appreciably flattened on one side. This structure noted in a culm of *S. kumasasa* (Zoll. ex Steud.) Makino, 3 mm in diameter.

MATERIAL EXAMINED: Cultivated at Kew.

THYRSOSTACHYS

Outer vb's, together with the associated scl., separated from each other by fine lines of ground tissue; supported by well developed inner and outer, dome-shaped caps of scl., the inner and outer caps being about equal in size; xy. visible as light coloured strips between the 2 polar caps of scl.; lateral scl. caps absent. Inner vb's and associated scl. similar, but more widely separated from one another by light coloured ground tissue. The absence of lateral caps of scl. seems to be a distinctive character. This structure noted in a culm of *T. siamensis* Gamble with a radius of 8 mm.

MATERIAL EXAMINED: Supplied by N. W. Simmonds from Trinidad.

NOTES ON LEAF STRUCTURE IN RELATION TO THE TAXONOMY OF THE BAMBUSEAE

Ohki (1927–34) has published an extensive series of articles on the structure of the epidermis of bamboo leaves. His investigations were based on a study of leaves incinerated by the method first made public by Werner (1928) and discussed more recently, amongst others, by Uber (1940). The structure is thus revealed in the form of carbonized preparations known as spodograms. Ohki's results are published mainly in Japanese, but one lengthy account of his work is in English (Ohki 1932). It is impossible to summarize Ohki's work in any detail in this book. It must suffice to say that he recognizes 8 types of leaf structure that are characteristic respectively of *Bambusa*, *Dendrocalamus*, *Phyllostachys*, *Pleioblastus*, *Sasa*, *Semiarundinaria*, *Shibataea*, and *Sinobambusa*. To the present writer it does not appear that these 8 types are as distinct from one another as Ohki implies. In the main, whenever he and the present writer have

examined the same species, Ohki's descriptions agree fairly well with the original descriptions of the epidermis given in this book, although Ohki's descriptions are far more detailed. There are points of difference here and there. For example, the shapes of the silica-bodies, as given by Ohki, do not always agree with those described by the present writer, and the reasons for this discrepancy are not quite clear. Then again Ohki noted the presence of 'hooks' in certain species in which none were observed at Kew. This discrepancy is not so surprising, especially as there are local variations in different parts of an individual leaf and also in different leaves from a single species.

The facts recorded by Ohki seem to the present writer to support the view that there are no very clear-cut divisions between the genera on the basis of characters revealed in spodograms. On the other hand, variations in the occurrence and distribution of macro-hairs, micro-hairs, and prickle-hairs, variations in the width of the bands of bulliform cells, differences in the number and distribution of papillae on the long-cells have specific diagnostic value. This applies also to quantitative characters such as the dimensions of stomata and prickle-hairs. For the identification of some species it is important to know whether the walls of the basal cells of the micro-hairs are smooth or scabrous, and whether or not the walls of the prickle-hairs bear protuberances.

The anatomical data obtained for the leaves of the various bamboos examined by the present writer have been brought together in Table I. Perusal of this table confirms the opinion already expressed that there are no clear-cut distinctions between any of the genera that have been examined so far as leaf structure is concerned. This is not very surprising, for we have been reminded by Holttum (1956) that the classical schemes for the classification of bamboos are themselves unsatisfactory. Holttum himself has put forward suggestions for improving the classification and, in his scheme, differences in the structure of the ovary are thought to be much more important than has hitherto been realized. It is of interest to note that differences in ovary structure do not appear to be accompanied by corresponding differences in leaf anatomy. Indeed, the Table shows that the range of leaf structure in different species of a single genus such as *Arundinaria* is almost as great as it is throughout all of the genera of which representatives have been examined. From this it would seem that ovary structure may turn out to be more valuable than leaf structure in the classification of the bamboos. At the moment leaf characters of restricted occurrence appear to be amongst the most valuable for diagnostic purposes. Thus we find uniseriate micro-hairs only in *Guaduella oblonga* amongst the species examined by the author. Then again *Phyllostachys* is the only genus from certain species of which fusoid-cells appear to be absent. It will be impossible to assess the taxonomic significance of facts such as these until a much more comprehensive survey of the leaf anatomy of the bamboos has been completed. Meanwhile it is hoped that the data that have been collected will serve as a useful guide to those who may wish to pursue the subject further. It would be misleading to attempt to base any further taxonomic conclusions on the anatomical evidence that is at present available.

It is noteworthy that the highly specialized and distinctive type of mesophyll that occurs in the Bambuseae is to be found also in a few other genera of

grasses that are not included in the Bambuseae. On the face of things it seems improbable that this very characteristic type of mesophyll has been evolved more than once, and, if this be so, it seems reasonable to conclude that all grasses that are not bamboos, but which have this type of mesophyll, must have affinities with the Bambuseae. Genera with bambusoid leaves include *Leptaspis*, *Olyra*, *Pharus*, *Streptogyna*, and *Streptochaeta*.

The bamboos stand out in marked contrast to most other grasses on account of the complex vascular system in the midrib or keel (Fig. XVII). Sections taken at different levels in a single petiole vary considerably in structure (Fig. XVII, 1*a–c* and 2*a–b*). Nevertheless, the midrib structure is sufficiently constant at any one level to provide a useful basis for comparing different species of bamboos. Figs. XVII, 3–11 show a selection of midribs in sections taken midway between the apex and base of the lamina. As indicated in the diagrams the midrib structure falls into 8 more or less distinct but intergrading types. The data in Table I indicate that, although the types of vascular structure in the midrib are of specific diagnostic value, they appear to be of little or no value for the recognition of genera.

Literature

Brandis 1907 (leaf structure); Chih-Ying Wu 1958 (leaf); Chowdhury 1956 (culm fibres); Colomb 1887 (morphology and anatomy of the ligule); Freier 1945 (similarity of *Neurolepis* to bamboos); Garafolo 1947 (abnormalities in structure); Garudacher 1930 (hydrogen cyanide in culms); Grob 1896 (leaf; passing reference only); Hayata 1929 (comparative leaf anatomy of *Sasa*; in Japanese); Haberlandt 1880, 1882 (arm-cells in chlorenchyma); Henrard 1936 (taxonomy); Hohenauer 1893 (culm structure of *Bambusa stricta*); Holttum 1946, 1955, 1956 (taxonomy); Jacques-Félix 1955 (leaf of African bamboos); Karelstschicoff 1868 (early, correct description of arm-cells and fusoid-cells); Metcalfe 1956 (leaf structure); Molisch 1918 (alleged occurrence of crystals as well as silica-bodies, in *Bambusa*); Montemartini 1904 (intercellular spaces); Ohki 1927–34 (spodograms of bamboo leaves); Page 1947 (fusoid-cells); Philipp 1924 (culm structure of *Arundinaria hookeriana* with special reference to suberized cell walls); Porterfield 1937 (ontogeny of stomata and leaf epidermis); Saito 1900 (fibres); Shibata 1900 (culm growth, &c.); Takenouchi 1931 *a* and *b* (morphology and anatomy of bamboos).

TABLE I (*for Special Notes see pp. 588–9*)

Species	Short-cells: Paired between veins	Short-cells: Paired over veins	Short-cells: In rows over veins	Silica-bodies: Saddle-shaped over veins	Silica-bodies: Saddle-shaped between veins	Silica-bodies: Cross to dumb-bell shaped over veins	Silica-bodies: Tall and narrow between veins	Macro-hairs present	Papillae: Abundant	Papillae: Infrequent	Papillae: Overarching stomata	Prickle-hairs: Hooks	Prickle-hairs: Prickles	Micro-hairs: Present	Micro-hairs: Absent	Micro-hairs: Long basal cell	Micro-hairs: Uniseriate	Keel bundles: I	Keel bundles: II	Keel bundles: III	Keel bundles: IV	Keel bundles: V	Keel bundles: VI	Keel bundles: VII	Keel bundles: VIII	Fusoid-cell dimensions	Bulliform cells: Fan-shaped groups	Bulliform cells: Sporobolus type	Bundle-sheaths: Both complete	Bundle-sheaths: O.S. interrupted abax.	Bundle-sheaths: O.S. interrupted adax.	Bundle-sheaths: O.S. interrupted abax. and adax.
1. *Arthrostylidium capillifolium* Griseb.	X	X	..	X	X	..	..	..	..	..	..	..	(X)	X	..	..	..	..	..	..	..	X	..	..	..	22–26 13–15	X	..	X	(X)	..	X
2. *A. pubescens* Rupr.	X	X	(X)	X	X	..	..	..	..	X	..	(X)	(X)	X	..	..	..	..	..	..	..	X	..	..	..	26–31 13–15	X	(X)	X	(X)	..	(X)
3. *Arundinaria auricoma* Mitford	..	X	(X)	X	..	..	X	X	X	..	..	(X)	..	X	..	(X)	..	..	..	..	X	..	..	..	..	81–101 13–29	X	..	X	(X)	..	..
4. *A. fastuosa* Mak.	..	X	(X)	X	..	..	..	..	X	..	X	X	X	X	..	..	..	..	..	..	X	..	..	..	..	37–53 11–20	X	(X)	X	(X)	..	..
5. *A. fortunei* A. & C. Riv.	X	X	X	X	(X)	..	X	X	X	..	(X)	..	..	X	..	..	..	..	X	..	..	..	..	..	..	35–96 15–24	(X)	..	X	(X)	..	..
6. *A. graminea* Makino	(X)	X	X	X	..	..	(X)	..	X	..	X	X	..	X	..	X	..	..	X	..	..	..	..	..	..	35–70 13–20	X	..	X	X	..	..
7. *A. japonica* S. & Z.	(X)	(X)	X	X	..	(X)	..	..	X	..	(X)	X	X	X	..	X	..	..	X	..	..	..	..	..	..	66–90 18–26	X	..	X	X	..	..
8. *A. marmorea* Makino	X	..	X	..	..	X	..	..	X	..	X	(X)	X	X	..	X	..	..	X	..	..	..	..	..	..	26–45 13–22	X	..	..	X	..	..
9. *A. murielae* Gamble	..	X	X	X	..	X	..	..	X	..	(X)	X	..	X	..	(X)	..	..	..	..	..	..	X	..	..	35–66 9–15	X	..	X	X	..	..
10. *A. nitida* Mitford	(X)	..	X	..	..	X	..	..	X	..	X	X	X	X	..	X	..	..	..	..	X	..	..	..	..	42–76 9–18	X	(X)	X	X	..	X
11. *A. pumila* Mitford	X	X	X	X	(X)	..	(X)	..	X	..	(X)	X	(X)	X	..	..	..	..	X	..	..	..	..	..	..	75–90 15–29	X	(X)	X	X	..	..
12. *A. simonii* A. & C. Riv.	X	..	X	(X)	..	..	..	..	X	..	X	X	X	X	..	..	..	..	X	..	..	..	..	..	..	33–66 13–24	X	..	X	X	..	..
13. *A. ragamowski* Pätzer	X	X	X	X	..	..	..	(X)	X	..	X	(X)	..	X	..	(X)	..	X	..	..	..	..	..	..	..	97–125 26–33	X	..	X	X	..	..
14. *A. vagans* Gamble	X	X	X	X	..	X	(X)	X	X	..	(X)	..	..	X	..	..	..	..	X	..	..	..	..	..	..	48–68 11–20	X	(X)	X	X	..	..
15. *Atractocarpa olyraefolia* Franch.	X	(X)	X	X	..	..	X	..	..	..	..	..	..	..	X	..	..	..	..	X	..	..	..	..	..	165–297 28–55	X	..	X	(X)	..	..
16. *Bambusa nana* Roxb.	X	..	X	X	X	..	..	X	X	..	(X)	(X)	..	X	..	(X)	..	..	X	..	..	..	..	..	..	13–51 4–11	X	..	(X)	X	..	..
17. *B. vulgaris* Schrad.	(X)	(X)	X	X	X	..	..	..	X	X	X	X	X	X	..	..	..	..	X	..	..	..	..	..	..	77–110 13–22	X	..	(X)	X	..	..
18. *Cephalostachyum capitatum* Munro	X	..	..	See note 18				..	..	..	X	X	..	X	..	..	..	..	X	..	..	..	..	..	..	88–121 22–33	X	..	..	X	..	..
19. *Chloothamnus elegantissimus* (Hasskarl) Henr.	X	X	X	X	..	..	X	..	X	..	X	(X)	..	X	..	..	..	..	..	..	X	..	..	..	..	64–77 15–22	X	(X)	X	(X)	..	..
20. *Chusquea abietifolia* Griseb.	X	(X)	X	(X)	X	X	..	..	X	..	..	..	(X)	X	..	..	..	..	..	..	..	..	..	X	..	31–44						
21. *C. tenella* Nees	..	(X)	X	(X)	..	X	..	..	X	..	..	X	X	X	..	..	..	..	..	..	..	..	..	..	X	11–18 114–39 13–15	X	..	X	(X)	..	..
22. *Dendrocalamus brandisii* Kurz	..	(X)	X	X	..	..	..	..	X	..	(X)	X	..	X	..	..	..	..	..	X	..	..	..	..	..	86–97						
23. *D. giganteus* Munro	X	..	X	X	..	..	X	..	X	..	(X)	X	(X)	X	..	..	..	..	X	..	..	..	..	..	..	33–40 55–97 26–33	X	(X)	X	X	..	..
24. *Dinochloa m'clellandii* Kurz	..	(X)	X	X	..	..	(X)	X	X	..	X	..	..	X	..	(X)	..	..	X	..	..	..	..	..	..	95–145 29–44	X	..	X	(X)	..	..
25. *Gigantochloa ligulata* Gamble	X	X	(X)	X	..	..	X	..	X	..	X	X	X	X	..	..	..	X	..	..	..	..	..	..	..	66–117 29–62	X	(X)	X	(X)	..	..
26. *Greslania rivularis* Bal.	X	X	(X)	X	..	..	X	X	..	X	X	(X)	..	X	..	..	..	..	X	..	..	..	..	..	..	84–132 22–50	X	..	X	X	..	..
27. *Guadua paniculata* Munro	X	X	..	X	..	..	X	(X)	X	..	..	X	X	X	..	..	..	..	..	..	..	..	..	..	..	26–35 13–20	X	X	X	X	..	(X)
28. *Guaduella oblonga* Hutch.	X	..	X	X	X	..	..	..	..	X	X	..	..	..	..	..	X	..	..	..	X	..	..	..	..	73–119 13–20	X	..	..	X	..	(X)
29. *Melocanna bambusoides* Trin.	X	X	(X)	X	..	..	X	..	..	X	X	..	..	X	..	..	..	X	..	..	..	..	..	..	..	92–128 33–40	X	(X)	..	X	..	(X)
30. *Merostachys riedeliana* Rupr.	X	X	..	..	..	..	X	..	X	..	X	X	..	..	..	..	..	Absent								55–90 20–24	X	(X)	..	X	..	(X)
31. *Nastus capitatus* Munro	X	X	X	X	..	..	X	..	..	..	X	X	..	X	..	..	..	..	X	..	..	..	..	..	..	26–55 9–15	X	(X)	(X)	X	..	(X)
32. *N. elongatus* A. Camus	X	X	X	X	..	..	..	..	X	..	(X)	(X)	..	X	..	..	..	..	..	..	..	..	..	..	..	..	X	..	..	X	..	X
33. *Ochlandra setigera* Gamble	X	X	(X)	X	..	..	X	X	X	..	X	(X)	..	X	..	..	..	..	X	..	..	..	..	..	..	46–88 15–22	X	..	X	X	..	..
34. *Oreobambos buchwaldii* K. Schum.	X	X	(X)	X	..	..	X	X	X	..	X	X	(X)	X	..	(X)	..	X	..	..	..	..	..	..	..	106–130 37–44	X	..	X	X	..	..
35. *Oxytenanthera abyssinica* (A. Rich.) Munro	(X)	X	(X)	X	..	..	X	..	X	..	X	X	X	X	..	..	..	..	X	..	..	..	..	..	..	84–99 37–51	X	(X)	X	(X)	..	..
36. *Phyllostachys bambusoides* Sieb. & Zucc.	(X)	..	X	X	..	..	X	..	X	..	X	X	X	X	..	..	..	..	..	..	X	..	..	..	..	46–51 15–18	X	(X)	X	..	..	(X)
37. *P. castillonis* Mitford	..	X	X	X	..	..	X	..	X	..	X	X	X	X	..	..	..	..	X	..	..	..	..	..	..	Absent	X	(X)	X	X	..	(X)
38. *P. heterocycla* (Carriere) Mak.	(X)	(X)	X	X	..	..	X	..	X	..	X	X	X	X	..	..	..	..	..	..	X	..	..	..	..	,,	X	(X)	X	X	..	X
39. *P. nigra* Munro	..	(X)	X	X	..	..	..	X	X	..	(X)	..	..	X	..	..	..	..	..	..	X	..	..	..	..	,,	X	(X)	..	X	..	X
40. *P. reticulata* C. Koch	(X)	(X)	X	X	..	(X)	X	..	X	..	(X)	(X)	..	X	..	..	..	..	..	..	X	..	..	..	..	33–53 9–18	X	(X)	X	X	..	X
41. *P. viridi-glaucescens* A. & C. Riv.	..	..	X	X	..	(X)	..	..	X	..	(X)	(X)	X	X	..	..	..	..	X	..	X	..	..	..	..	37–62 15–20	X	(X)	X	X	..	X
42. *Pseudostachyum polymorphum* Munro	X	X	(X)	X	..	..	..	..	..	..	X	X	..	X	..	..	..	..	..	..	..	..	..	..	..	99–143 22–37	X	..	X	X	..	..
43. *Puellia ciliata* Franch.	X	X	(X)	X	..	..	..	..	..	..	..	X	..	..	X	..	..	..	..	X	..	..	..	..	..	229–64 40–66	X	..	X	X	..	..
44. *Schizostachyum gracile* (Munro) Holttum var. *erectum* Holttum	X	X	..	..	..	..	X	..	X	..	X	(X)	..	X	..	..	..	..	..	..	X	..	..	..	..	55–70 15–20	X	..	X	X	..	X
45. *Shibataea kumasaca* Makino	(X)	..	X	..	..	X	X	X	X	..	(X)	X	..	X	..	..	..	..	X	..	..	..	..	..	..	33–48 11–13	X	..	X	X	..	..
46. *S. ruscifolia* Makino	..	..	X	X	..	(X)	..	X	X	..	(X)	X	..	X	..	(X)	..	..	X	..	..	..	..	..	..	37–51 11–13	X	..	X	X	..	X
47. *Thyrsostachys oliveri* Gamble	X	..	X	X	X	..	..	X	..	X	X	X	..	X	..	..	..	X	..	..	..	..	..	..	..	66–88 15–31	X	X	X	X	..	..

TABLE I. *Special Notes*

General note. Where micro-hairs are marked as 'present', but without further particulars, this means that they are of the general type that is common in bamboos (Fig. XVI).

3. *Arundinaria auricoma* = *A. variegata.* Silica-bodies, between the veins, tall, narrow, and crenate.

4. *A. fastuosa.* Outer bundle-sheath with a slight adaxial extension, often consisting of only 1 cell.

7. *A. japonica.* Some silica-bodies barrel-shaped to slightly cross-shaped.

9. *A. murielae.* Some silica-bodies tending to be cross-shaped with v. shallow indentations.

12. *A. simonii.* Silica-bodies a tall form of saddle-shaped.

14. *A. vagans.* Silica-bodies, between the veins, tending to be crescentic or crenate.

15. *Atractocarpa olyraefolia.* Silica-bodies, over the veins, tending to be oblong.

16. *Bambusa nana* = *B. glaucescens.* Silica-bodies a tall form of saddle-shaped; tending towards the *Oryza* type.

17. *B. vulgaris.* Some micro-hairs with conspicuous silica-bodies on the transverse walls.

18. *Cephalostachyum capitatum.* Papillae of an obscure type; could be confused with the *Oryza* type silica-bodies. Short-cells probably of tall, narrow form as in *Merostachys riedeliana.*

20. *Chusquea abietifolia.* Bulliform cells in fan-shaped groups that are numerous and exceptionally wide; merging with other conspicuously large epidermal cells.

21. *C. tenella.* Papillae not conspicuous.

22. *Dendrocalamus brandisii.* Saddle-shaped silica-bodies sometimes rather tall. Some bulliform cells in groups of the *Zea* type.

23. *D. giganteus.* Tall, saddle-shaped silica-bodies, over the veins, tending to be of the *Oryza* type; those between the veins tall, narrow, and crenate. Some bulliform cells in groups of the *Zea* type.

26. *Greslania rivularis.* Macro-hairs rather short, with fine, transverse septa that can be easily overlooked.

28. *Guaduella oblonga.* Bulliform cells mostly in well defined groups about 3 or more cells long, the individual cells being rather uniform in size.

30. *Merostachys riedeliana.* Most short-cells solitary both over and between the veins because paired with hooks. All silica-bodies tall and narrow. Cf. *Schizostachyum gracile* var. *erectum.*

33. *Ochlandra setigera.* Bulliform cells exceptionally tall, the central cell in each group penetrating almost to the centre of the lamina.

34. *Oreobambos buchwaldii.* Silica-bodies, between the veins, tall, narrow, and crenate; those over the veins saddle-shaped, but rather variable. Central cell in each group of bulliform cells v. tall or almost triangular.

35. *Oxytenanthera abyssinica.* Silica-bodies, between the veins, tall, narrow, and crenate.

36. *Phyllostachys bambusoides.* Silica-bodies, between the veins, not v. numerous.

37. *P. castillonis.* Macro-hairs all tending to be rather narrow.

39. *Phyllostachys nigra.* Silica-bodies saddle-shaped, but less tall than is usual for this type in bamboos; some over the large veins tending to be horizontally elongated and concave at either end.

40. *P. reticulata.* Saddle-shaped silica-bodies not v. tall.

42. *Pseudostachyum polymorphum.* Silica-bodies, between the veins, saddle-shaped, but much narrower than those over the veins. Central cell in each group of bulliform cells tall and wide.

43. *Puellia ciliata.* Saddle-shaped silica-bodies mostly rather narrow, although sometimes about equal in height and width over some of the large veins. Bulliform cells mostly in groups about 5 cells long, the cells being of rather uniform size; cf. *Schizostachyum gracile* var. *erectum.*

44. *Schizostachyum gracile* var. *erectum.* [In the opinion of Holttum this species should be included in *Nastus.*] All silica-bodies tall and narrow, cf. *Merostachys riedeliana.* Papillae apparently of a special type, and v. large where overarching the stomata. Bulliform cells in well defined groups about 5 cells long, with cells of rather uniform size, cf. *Puellia ciliata.*

45–46. *Shibataea kumasasa* and *S. ruscifolia* are synonymous, the first of these being the older name.

47. *Thyrsostachys oliveri.* Silica-bodies between the veins saddle-shaped, but narrower than those over the veins. Bulliform cells mostly in well defined groups up to about 5 cells long, the cells being of more or less uniform size.

LISTS OF GENERA AND SPECIES IN WHICH CERTAIN DIAGNOSTIC CHARACTERS OCCUR

In a book on the anatomy of grasses it would evidently be very helpful if it were possible to include a key enabling the genera and species to be identified from the microscopical characters of the leaves. In practice this is not possible because, even now, there are countless species of which the leaf structure has not been examined. This state of affairs applies not only to grasses but to most of the families of flowering plants. In spite of this paucity of diagnostic microscopical data, it is clearly evident that the presentation of the available information in tabular form will at least serve as a guide. A botanist who has prepared slides of a grass leaf in the hope of being able to identify it, or at least to determine its affinities, may well be anxious to find out in which genera and species the diagnostic characters that it exhibits are known to occur. It is to assist a botanist in this position that the following tables have been compiled.

It would be quite easy for the reader, if he so desired, to transfer the data from these tables to perforated index cards, which simplifies identification by enabling the cards to be mechanically sorted. This method, as is well known, is commonly used for timber identification (Clarke 1938). The author has applied this same technique to the diagnostic characters for grass leaves. It is only necessary to assign a number to each diagnostic character to enable the information to be transferred to perforated index cards.

The data recorded in the following tables refer only to the author's own observations, and those made by Miss R. Hungerbühler (now Mrs. Beckmann), on slides in the reference collection at Kew. No attempt has been made to include information recorded in the literature, mainly because published data are seldom presented in a sufficiently precise form to ensure their being accurately transferred to the tables. The author is greatly indebted to Miss Hungerbühler for her painstaking assistance in preparing the tables.

When results are expressed in tables, it is, because of the rigidity imposed by this method of presentation, often impossible to indicate the ranges of form that occur. For this reason the reader should use these tables only as a guide, and should turn to the descriptions of the species in the text for further particulars.

In using the tables the reader should remember three important facts. (1) The data recorded refer only to the abaxial epidermis of the leaf. The adaxial surface usually, but not invariably, exhibits somewhat similar structure. The culm epidermis often exhibits characters that are strikingly different. (2) Owing to the great labour involved, it has not been possible to examine more than a very limited amount of material of any one species. It is, therefore, very probable that the data here recorded do not represent the full range of structural variation for the species. (3) It is only seldom that the characters listed occur in isolation in any one species. For example, if a species is listed as having short-cells in pairs, it should *not* be assumed that all of the short-cells

are necessarily in pairs. It may be that pairs occur in the intercostal zones and long rows of short-cells over the veins. Then again the leaf of an individual species may have several kinds of silica-bodies, stomata with more than one type of subsidiary cell, and so on. It cannot be too strongly emphasized that the reader will not be using the tables to the best advantage if they are consulted in isolation from one another, and, if the tables point towards any particular genus or species, the descriptive matter in the main body of the text should be consulted before any firm conclusions are drawn.

SHORT-CELLS

Solitary

(+ between veins; ++ over veins; +++ over and between veins)

Aegilops crassa ++
„ triaristata ++
„ ventricosa ++
Aeluropus littoralis +
Agropyron caninum +++
„ elongatum +++
„ intermedium +++
„ laxum +++
Agrostis semiverticillata ++
„ stolonifera var. palustris ++
Alopecurus myosuroides ++
„ pratensis ++
Ammophila arenaria +++
Andropogon amplectens (occasional over veins)
Anthochloa lepidula ++
Anthoxanthum odoratum ++
Apluda mutica var. aristata +
Aristida ciliata var. capensis +++
„ longiflora +
„ setacea +
„ Japanese sp. +
Arrhenatherum elatius ++
Arundinella metzii +++
Avena ludoviciana ++
„ pubescens ++
„ strigosa ++
Bothriochloa pertusa + (generally) ++ (locally)
Bouteloua curtipendula ++
Brachypodium sylvaticum +
Bromus carinatus ++
„ coloratus ++
„ inermis ++
„ japonicus ++
„ sterilis +++
„ tectorum +++ (infrequent)
„ unioloides ++
Brylkinia caudata +++
Buchloe dactyloides +++
Calamagrostis epigejos +++
Calamovilfa longifolia +++
Capillipedium sp. +++
Cenchrus pauciflorus +++
Centotheca lappacea ++ (1 out of 3 samples)
Chloris filiformis +
„ pycnothrix +
Cleistachne sorghoides +
Cortaderia conspicua +++
„ selloana +++
Cymbopogon citratus ++
„ martinii +
„ nardus +++
„ validus +
Cynodon dactylon + (2 out of 3 samples)
Danthonia compressa +++
„ flavescens +++
Desmostachya bipinnata +++
Diarrhena americana +
Digitaria brazzae ++
„ milanjiana ++
Elyonurus chevalieri +
„ hirtifolius +++
Eragrostis curvula +
„ diplachnoides +++
„ gangetica +++
„ unioloides +++
Eriachne pallescens +
Erianthus hostii +
Eulalia phaeothrix +++
Festuca arundinacea +
„ „ × Lolium perenne +++
Festuca glauca +++
„ heterophylla +++ (leaves of both types)
Festuca 'punctoria' +++
Fingerhuthia africana +++
Glyceria fluitans ++
„ maxima +++
Hakonechloa macra +
Helictotrichon albinerve ++
„ planiculme +++

Solitary (cont.)

Helictotrichon pubescens ++
Heteranthelium piliferum ++
Heteropogon contortus +
Hierochloe redolens +++
Holcus lanatus ++
„ mollis ++
Hordelymus europaeus ++
Hordeum jubatum ++
„ murinum ++
„ secalinum +++
„ stenostachys +++
Imperata cylindrica +
Isachne walkeri ++
Ischaemum commutatum ++
„ santapaui ++
Koeleria cristata ++
„ phleoides ++
Lagurus ovatus ++
Leptocarydion vulpiastrum +
Leptochloa caerulescens +
Lophatherum gracile +
Loudetia superba ++
Lycochloa avenacea +
Melica altissima ++
„ ciliata +++
Microstegium ciliatum ++
Miscanthidium teretifolium +++ (occasional between veins)
Miscanthus condensatus +++
„ sacchariflorus +
Molinia caerulea ++
Nardus stricta +
Neurolepis nobilis ++
Olyra latifolia +++
Oplismenus compositus +
Panicum obtusum +
„ virgatum +++
Pariana bicolor +
„ campestris +++
„ vulgaris +++
Paspalum commersonii +++
„ paniculatum +++
Phalaris caerulescens ++
„ canariensis +++
„ minor ++
Phragmites communis +
Phyllorachis sagittata ++
Plectrachne danthonioides (over scl.)
„ desertorum (over scl.)
Poa glauca +++
„ iridifolia +
„ palustris +++
Pogonarthria squarrosa +++
Polypogon chilensis ++
Polypogon monspeliensis ++
Psammochloa villosa +++
Pseudanthistiria umbellata +++
Puccinellia maritima +++
Rhynchelytrum repens +++
Rottboellia exaltata +++
Saccharum bengalense +++
„ officinarum +++
Setaria glauca ++
„ italica ++
„ plicata ++
„ viridis ++
Snowdenia polystachya ++
Sorghum halepense ++
Spartina maritima +++
„ townsendii +++
Spinifex hirsutus +++
Sporobolus africanus +++
„ diander +++
„ indicus +++
„ molleri +++
„ poiretii +++
„ pyramidalis +++
Stenotaphrum dimidiatum ++
„ secundatum +
Streptochaeta spicata ++
Themeda australis +
„ quadrivalvis +
„ tremula +
„ triandra +
Trichachne insularis +
Triplopogon spathiflorus ++
Tripsacum dactyloides +++

Paired

(+ between veins; ++ over veins; +++ over and between veins)
Acroceras zizanioides +
Aegilops crassa ++
„ triaristata ++
„ ventricosa ++
Aeluropus littoralis +
Agropyron caninum +++
„ elongatum +++
„ intermedium +++
„ laxum +++
Agrostis stolonifera var. palustris ++
Alopecurus myosuroides ++
„ pratensis ++
Ampelodesmos mauritanica +++
Andropogon amplectens +
Anomochloa marantoidea +++
Anthochloa lepidula ++
Anthoxanthum odoratum ++ (1 out of 2 samples)
Aristida ciliata var. capensis +++
„ longiflora +
„ setacea +
„ sp. +
Arrhenatherum elatius ++
Arundinella metzii +++

Arundinella villosa +++
Astrebla squarrosa +
Avena ludoviciana ++
„ strigosa ++
Bothriochloa caucasica ++
„ pertusa +
Bouteloua curtipendula ++
Brachiaria distichophylla +
„ jubata +
„ paspaloides +
„ reptans +
Brachypodium pinnatum +++
Briza erecta +++
Bromus carinatus ++
„ coloratus ++
„ fibrosus +++
„ inermis ++
„ japonicus ++
„ sterilis +++
„ tectorum ++
„ unioloides ++
Brylkinia caudata +++
Buchloe dactyloides +++
Calamagrostis epigejos +++
Calamovilfa longifolia +++
Capillipedium sp. +++
Cenchrus ciliaris ++
„ pauciflorus +++
Centotheca lappacea + (2 out of 3 samples)
„ lappacea ++ (1 out of 3 samples)
Chloris barbata (mostly at margins of veins)
„ filiformis +
„ pycnothrix +
„ robusta +
Chrysopogon zeylanicus +++
Coix lacryma-jobi +
Cortaderia conspicua +++
„ selloana +++
Cymbopogon citratus ++
„ giganteus +++
„ martinii +
„ nardus +++
Cynodon dactylon ++ (1 out of 3 samples)
Cynosurus cristatus ++
Danthonia compressa +++
„ flavescens +++
„ spicata +
„ „ var. typica +
Desmostachya bipinnata +++
Diarrhena americana +++
Dichanthium aristatum +
„ sericeum +
Dichelachne crinita +++
Digitaria brazzae (mostly near leaf margins)
„ milanjiana (at edges of veins)
Distichlis distichophylla +++
Echinochloa colonum +
Ectosperma alexandrae +
Ehrharta villosa var. maxima +++
Eleusine indica +++
Elymus arenarius +++
„ canadensis +++
„ (Taeniatherum) caput-medusae +++
„ condensatus +++
„ virginicus +++
Elyonurus chevalieri +++
„ hirtifolius +++
Eragrostiella bifaria +
Eragrostis aspera +++
„ chloromelas +++
„ curvula +++
„ gangetica +++
„ unioloides +++
Eriachne pallescens +
Erianthus hostii +
Euchlaena perennis +
Eulalia phaeothrix +++
Festuca arundinacea +++
„ „ × Lolium perenne +++
„ glauca +++ (pairs infrequent)
„ heterophylla +++
„ 'punctoria' +++ (pairs abundant)
Fingerhuthia africana +++
Garnotia courtallensis +++
Glyceria fluitans ++
„ maxima +++
Hakonechloa macra +
Helictotrichon albinerve ++
„ planiculme +++
„ pubescens ++
Hemarthria uncinata +++
Heteranthelium piliferum ++
Heteropogon contortus +
Hierochloe redolens +++
Holcus lanatus ++
„ mollis ++
Hordelymus europaeus ++
Hordeum agriocrithon ++
„ jubatum ++
„ murinum ++
„ secalinum +++
„ stenostachys +++
Imperata cylindrica +
Isachne walkeri ++
Ischaemum commutatum ++
Koeleria phleoides ++
Leersia hexandra +
Leptocarydion vulpiastrum +
Leptochloa caerulescens +
Lolium multiflorum ++
Lophatherum gracile +
Loudetia superba ++ (mostly at edges of veins)
Lygeum spartum +++
Melica ciliata +++

Paired (cont.)

Miscanthidium teretifolium ++ (some at edges of veins)
Miscanthus condensatus +++
„ sacchariflorus +++
Molinia caerulea +++
Nardus stricta +++
Neurolepis aristata ++ (some at edges of veins)
Neurolepis nobilis ++
Olyra latifolia +++
Oplismenus compositus +
Oryza sativa var. violacea ++
Oryzopsis asperifolia +++
„ paradoxa +++
„ racemosa +++
Panicum capillare +
„ maximum +
„ miliaceum +
„ obtusum +
„ virgatum +
Parapholis strigosa +++
Pariana bicolor +++
„ campestris +++
„ vulgaris +++
Paspalidium geminatum +
Paspalum commersonii +++
„ conjugatum +
„ paniculatum +++
Pennisetum clandestinum +++
„ macrourum +++
Phaenosperma globosum +++
Phalaris caerulescens ++
„ canariensis +++
„ minor ++
Phragmites communis +++
Phyllorachis sagittata +
Plectrachne danthonioides (over scl.)
„ desertorum (over scl.)
Poa glauca +++
„ iridifolia +++
„ palustris +++
Pogonarthria squarrosa +++
Polypogon chilensis ++
Psammochloa villosa +++
Puccinellia fasciculata +++
„ maritima +++
Rhynchelytrum repens +++
Rhytachne rottboellioides +++
Rottboellia exaltata +++
Saccharum bengalense ++ (some near leaf margins)
Saccharum officinarum +++
Secale cereale +++
Setaria glauca ++
„ italica ++
„ plicata ++
„ viridis ++
Sorghum halepense ++
Spartina maritima +++
„ townsendii +++
Spinifex hirsutus +++
Sporobolus africanus +++
„ diander +++
„ indicus +++
„ molleri +++
„ poiretii +++
„ pyramidalis +++
„ wrightii +++
Stenotaphrum secundatum +
Streptochaeta spicata ++
Streptogyna crinita +
Tetrarrhena distichophylla +++
Themeda australis +
„ quadrivalvis +
„ tremula +
„ triandra +
Thysanolaena maxima +
Tragus berteronianus ++
Tripsacum dactyloides +++
Triraphis pumilio ++
Urochloa pullulans +
Vetiveria zizanioides +++
Zizania latifolia +

Short-cells; in rows of 3–5 (nearly always over the veins)

Acroceras tonkinense
Aegilops crassa
Agrostis semiverticillata
„ stolonifera var. palustris
Alopecurus myosuroides
„ pratensis
Andropogon amplectens
Anomochloa marantoidea
Anthochloa lepidula
Arundinella metzii
Arundo donax
Avena strigosa
Bothriochloa caucasica
Brachypodium pinnatum
Bromus coloratus
„ japonicus
„ sterilis
„ tectorum
„ unioloides
Calamagrostis epigejos
Calamovilfa longifolia
Centotheca lappacea (1 out of 3 samples)
Chloris virgata
Chrysopogon zeylanicus
Cortaderia selloana
Cymbopogon citratus
„ giganteus
„ nardus

Cymbopogon validus
Cynosurus cristatus
Cyrtococcum trigonum
Danthonia compressa
„ flavescens
Deyeuxia quadriseta
Diarrhena americana
Dichelachne crinita
Ectosperma alexandrae
Elymus caput-medusae
„ europaeus
„ virginicus
Elyonurus chevalieri
Eragrostis aspera
„ chloromelas
„ curvula
„ gangetica
Erianthus hostii
Eulalia phaeothrix
Festuca arundinacea × Lolium perenne
Garnotia courtallensis
Glyceria maxima
Hakonechloa macra
Helictotrichon albinerve
Hemarthria uncinata
Heteranthelium piliferum
Heteropogon contortus
Hierochloe odorata
„ redolens
Holcus lanatus
„ mollis
Hordelymus europaeus
Hordeum agriocrithon
„ murinum
Ischaemum commutatum
Koeleria phleoides
Leptocarydion vulpiastrum
Leptochloa caerulescens
Lolium multiflorum
Loudetia sp.
Lycochloa avenacea
Lygeum spartum
Melica ciliata
„ uniflora
Nardus stricta
Oryzopsis asperifolia
Panicum obtusum
Pariana campestris
„ vulgaris
Pennisetum clandestinum
„ macrourum
Phalaris caerulescens
„ canariensis (1 out of 3 samples)
„ minor
Phragmites communis
Plectrachne desertorum
Polypogon chilensis
„ monspeliensis
Psammochloa villosa
Puccinellia fasciculata
„ maritima
Saccharum bengalense
„ officinarum
„ spontaneum
Setaria plicata
Snowdenia polystachya
Sporobolus diander
„ indicus
„ poiretii
„ pyramidalis
„ wrightii
Streptogyna crinita
Themeda tremula
Trikeraia hookeri
Triplopogon spathiflorus
Tripsacum dactyloides
Triraphis pumilio

Short-cells; in rows of more than 5 (always over veins)

Acroceras tonkinense
„ zizanioides
Aegilops triaristata
„ ventricosa
Aeluropus littoralis
Alloteropsis cimicina
Alopecurus myosuroides (1 out of 2 samples)
Andropogon amplectens
„ schirensis
Anthochloa lepidula
Apluda mutica var. aristata
Aristida longiflora
„ setacea
„ sp.
Arthraxon quartinianus
Arundinella metzii
„ villosa
Arundo donax
Astrebla squarrosa
Beckeropsis uniseta
Bothriochloa caucasica
„ pertusa
Bouteloua curtipendula
Brachiaria deflexa
„ distichophylla
„ jubata
„ paspaloides
„ reptans
Brachypodium sylvaticum
Bromuniola gossweileri
Bromus japonicus
„ tectorum
Buchloe dactyloides
Calamagrostis epigejos

Short-cells; in rows of more than 5 (always over veins) (cont.)

Calamovilfa longifolia
Cenchrus biflorus
„ ciliaris
„ pauciflorus
Centotheca lappacea (2 out of 3 samples)
Chloris barbata
„ filiformis
„ pycnothrix
„ robusta
„ (Eustachys) uliginosa
„ virgata
Cleistachne sorghoides
Coelachne hackellii
„ perpusilla
„ simpliciuscula
Coelachyrum brevifolium
Coix lacryma-jobi
Cymbopogon giganteus
„ martinii
„ validus
Cynodon dactylon
Cyrtococcum trigonum
Dactyloctenium aegyptium
„ giganteum
Danthonia compressa
„ spicata
„ „ var. typica
Desmostachya bipinnata
Deyeuxia quadriseta
Diarrhena americana
Dichanthium aristatum
„ sericeum
Digitaria borbonica
„ brazzae
„ horizontalis
„ milanjiana
„ wallichiana
Dimeria thwaitesii
Echinochloa colonum
„ crus-galli
Ectosperma alexandrae
Ehrharta abyssinica
Elyonurus chevalieri
„ hirtifolius
Enneapogon cenchroides
Eragrostiella bifaria
Eragrostis chloromelas
„ curvula
„ gangetica
Eriachne pallescens
Erianthus hostii
Euchlaena perennis
Euclasta condylotricha
Eulalia geniculata
Garnotia courtallensis
Heteranthoecia guineensis
Heteropogon contortus
Hierochloe odorata
Hordelymus europaeus
Hordeum agriocrithon
Hyparrhenia dissoluta
Imperata cylindrica
Isachne kunthiana
„ mauritiana
„ walkeri
Ischaemum santapaui
Lagurus ovatus
Lamarckia aurea
Leersia hexandra
„ oryzoides
Leptaspis cochleata
Leptocarydion vulpiastrum
Lophatherum gracile
Loudetia superba
„ sp.
Lycochloa avenacea
Megastachya mucronata
Melica altissima
„ ciliata
„ uniflora
Melinis minutiflora
Micraira subulifolia
Microlaena stipoides
Microstegium ciliatum
Miscanthidium teretifolium
Miscanthus condensatus
„ sacchariflorus
Molinia caerulea
Muhlenbergia racemosa
Nardus stricta
Olyra latifolia
Oplismenus compositus
Oropetium thomaeum
Oryza sativa var. violacea
Oryzopsis racemosa
Panicum capillare
„ clandestinum
„ maximum
„ miliaceum
„ obtusum
„ virgatum
Pariana campestris
„ vulgaris
Paspalidium geminatum
Paspalum commersonii
„ conjugatum
„ distichum
„ paniculatum
Pennisetum clandestinum
Perotis indica
„ patens
Pharus latifolius
Phyllorachis sagittata
Plectrachne desertorum
„ schinzii
Pogonatherum paniceum

Psammochloa villosa
Pseudanthistiria umbellata
Rottboellia exaltata
Sacciolepis interrupta
Schizachyrium jeffreysii
Setaria barbata
„ glauca
„ italica
„ viridis
Sorghum halepense
Spinifex hirsutus
Stenotaphrum dimidiatum
„ secundatum
Streptogyna crinita
Tetrarrhena distichophylla
Themeda australis
„ quadrivalvis
„ tremula
„ triandra
Thysanolaena maxima
Tragus berteronianus
Trichachne insularis
Triplopogon spathiflorus
Tripsacum dactyloides
Uniola latifolia
Urochloa pullulans
Zizania latifolia

Short-cells; infrequent or absent between the veins

Aegilops crassa
„ triaristata
„ ventricosa
Agrostis semiverticillata
Alloteropsis cimicina
Alopecurus geniculatus
„ myosuroides
„ pratensis
Andropogon schirensis
Anthochloa lepidula
Anthoxanthum odoratum
Aristida setacea
„ sp.
Arrhenatherum elatius
Arthraxon quartinianus
Arundo donax
Avena ludoviciana
„ strigosa
Beckeropsis uniseta
Bothriochloa caucasica
„ pertusa
Bouteloua curtipendula
Brachiaria deflexa
Brachypodium sylvaticum
Bromuniola gossweileri
Bromus carinatus
Bromus inermis
„ coloratus
„ japonicus
„ sterilis
„ tectorum
„ unioloides
Cenchrus biflorus
„ ciliaris
„ pauciflorus
Centotheca lappacea (2 out of 3 samples)
Chloris barbata
„ (Eustachys) uliginosa
„ virgata
Coelachne hackelii
„ perpusilla
„ simpliciuscula
Coelachyrum brevifolium
Cymbopogon citratus
„ nardus
„ validus
Cynodon dactylon (1 out of 3 samples)
Cynosurus cristatus
Cyrtococcum trigonum
Dactyloctenium aegyptium
„ giganteum
Deyeuxia quadriseta
Digitaria borbonica
„ brazzae
„ horizontalis
„ milanjiana
„ wallichiana
Dimeria thwaitesii
Echinochloa colonum
„ crus-galli
Ectosperma alexandrae
Ehrharta abyssinica
Elymus interruptus
„ virginicus
Enneapogon cenchroides
Eriachne pallescens
Erianthus hostii
Euclasta condylotricha
Eulalia geniculata
„ phaeothrix
Garnotia courtallensis
Glyceria fluitans
Helictotrichon albinerve
„ pubescens
Heteranthelium piliferum
Heteranthoecia guineensis
Hierochloe odorata
Holcus lanatus
„ mollis
Hordelymus europaeus
Hordeum agriocrithon
„ jubatum
„ murinum
Hyparrhenia dissoluta
Isachne kunthiana

Short-cells; infrequent or absent between the veins (cont.)

Isachne mauritiana
„ walkeri
Ischaemum commutatum
„ santapaui
Koeleria cristata
„ phleoides
Lamarckia aurea
Leersia oryzoides
Lolium multiflorum
Loudetia superba
„ sp.
Megastachya mucronata
Melica altissima
„ uniflora
Melinis minutiflora
Micraira subulifolia
Microlaena stipoides
Microstegium ciliatum
Miscanthus condensatus
Muhlenbergia racemosa
Neurolepis aristata
„ nobilis
Oropetium thomaeum
Oryza sativa var. violacea
Panicum clandestinum
„ obtusum
Paspalidium geminatum
Paspalum conjugatum
Paspalum distichum
Perotis indica
„ patens
Phalaris caerulescens
„ canariensis
„ minor
Pogonatherum paniceum
Polypogon chilensis
„ monspeliensis
Pseudanthistiria umbellata
Saccharum spontaneum
Sacciolepis interrupta
Schizachyrium jeffreysii
Setaria barbata
„ glauca
„ italica
„ plicata
„ viridis
Snowdenia polystachya
Sorghum halepense
Stenotaphrum dimidiatum
Streptochaeta spicata
Themeda australis
„ quadrivalvis
„ tremula
Tragus berteronianus
„ racemosus
Trichachne insularis
Trikeraia hookeri
Triplopogon spathiflorus
Uniola latifolia

SILICA-BODIES

Tall and narrow (Fig. I, 4)

Acroceras zizanioides
Aegilops ventricosa
Agropyron caninum
„ elongatum
„ intermedium
„ laxum
Agrostis stolonifera var. palustris
Anomochloa marantoidea
Aristida setacea
Arundinella metzii
„ villosa
Bothriochloa pertusa
Brachiaria distichophylla
Bromus carinatus
„ fibrosus
„ inermis
„ sterilis
„ unioloides
Brylkinia caudata
Buchloe dactyloides
Calamagrostis epigejos
Calamovilfa longifolia
Capillipedium sp. (Andropogon venustus)
Cenchrus ciliaris
Chloris filiformis
„ pycnothrix
„ robusta
Coix lacryma-jobi
Cortaderia selloana
Danthonia compressa
„ flavescens
„ spicata
„ „ var. typica
Desmostachya bipinnata
Diarrhena americana
Distichlis distichophylla
Eleusine coracana
„ indica
Elymus arenarius
„ condensatus
„ virginicus
Elyonurus chevalieri
„ hirtifolius
Eragrostis chloromelas
„ curvula
„ diplachnoides
„ unioloides

Euchlaena perennis
Festuca heterophylla (leaves of both types)
Leersia hexandra
Lycochloa avenacea
Melica ciliata
Miscanthus condensatus
Molinia caerulea
Nardus stricta
Neurolepis aristata
„ nobilis
Oryzopsis paradoxa
„ racemosa
Panicum virgatum
Pennisetum clandestinum
Phyllorachis sagittata
Poa iridifolia
Sorghum halepense
Spartina maritima
„ townsendii
Spinifex hirsutus
Stenotaphrum dimidiatum
„ secundatum
Tetrarrhena distichophylla
Themeda australis
„ quadrivalvis
„ tremula
Thysanolaena maxima

Saddle-shaped (Fig. I, 5 and 9)

Agropyron caninum
„ laxum
Aristida setacea
Astrebla squarrosa
Bouteloua curtipendula
Buchloe dactyloides
Calamovilfa longifolia
Chloris barbata
„ filiformis
„ pycnothrix
„ robusta
„ (Eustachys) uliginosa
„ virgata
Coelachyrum brevifolium
Cynodon dactylon
Dactyloctenium aegyptium
„ giganteum
Danthonia flavescens
Desmostachya bipinnata
Distichlis distichophylla
Ehrharta abyssinica
Eleusine coracana
„ indica
Eragrostiella bifaria
Eragrostis aspera
„ chloromelas
„ curvula
„ diplachnoides
Eragrostis gangetica
„ unioloides
Euclasta condylotricha
Fingerhuthia africana
Garnotia courtallensis
Muhlenbergia racemosa
Olyra latifolia
Oropetium thomaeum
Phragmites communis
Phyllorachis sagittata
Pogonarthria squarrosa
Streptochaeta spicata
Streptogyna crinita
Tragus berteroneanus

Fitting into concavity in cork-cell (Fig. I, 6–7)

Aegilops ventricosa
Agropyron caninum
„ intermedium
Agrostis stolonifera var. palustris
Ampelodesmos mauritanica
Anomochloa marantoidea
Arrhenatherum elatius
Brachypodium pinnatum
Briza erecta
Bromus sterilis
Cortaderia selloana
Cynosurus cristatus
Danthonia spicata
„ „ var. typica
Dichelachne crinita
Ehrharta villosa var. maxima
Elymus canadensis
„ caput-medusae
„ condensatus
„ virginicus
Elyonurus chevalieri
„ hirtifolius
Eragrostis curvula
„ diplachnoides
„ unioloides
Festuca arundinacea
„ „ × Lolium perenne
„ glauca
„ heterophylla (leaves of both types)
„ 'punctoria'
Garnotia courtallensis
Helictotrichon planiculme
Hordeum secalinum
„ stenostachys
Lygeum spartum
Melica ciliata
Molinia caerulea
Neurolepis aristata
„ nobilis
Oryza sativa var. violacea

Fitting into concavity in cork-cell (cont.)

Oryzopsis asperifolia
„ paradoxa
„ racemosa
Panicum virgatum
Parapholis strigosa
Phaenosperma globosum
Phalaris canariensis
Phragmites communis
Poa glauca
„ iridifolia
„ palustris
Pogonarthria squarrosa
Puccinellia fasciculata
„ maritima
Rhytachne rottboellioides
Secale cereale
Sporobolus africanus
„ diander
„ indicus
„ molleri
„ poiretii
„ pyramidalis
„ wrightii
Tetrarrhena distichophylla

Oblong (Fig. I, 8 and 10)

Aegilops triaristata
Anomochloa marantoidea
Aristida ciliata var. capensis
Brachypodium pinnatum
Buchloe dactyloides
Dactyloctenium giganteum
Danthonia flavescens
Ectosperma alexandrae
Elymus (Taeniatherum) caput-medusae
Eragrostis curvula
Festuca arundinacea × Lolium perenne
„ heterophylla (leaves of both types)
Nardus stricta
Neurolepis aristata
Oryzopsis asperifolia
Phragmites communis
Poa iridifolia
Pogonarthria squarrosa
Trikeraia hookeri

Acutely Angled (Fig. I, 11)

Coelachne hackelii
„ perpusilla
„ simpliciuscula
Heteranthoecia guineensis
Isachne kunthiana
„ mauritiana
„ walkeri
Pogonatherum paniceum

Horizontally elongated with rounded ends and smooth outlines (Fig. IA, 12–13)

Aegilops crassa
Agropyron caninum
Agrostis stolonifera var. palustris
Alopecurus myosuroides
„ pratensis
Anthochloa lepidula
Anthoxanthum odoratum
Arrhenatherum elatius
Bromus carinatus
„ coloratus
„ inermis
„ japonicus
„ tectorum
Brylkinia caudata
Deyeuxia quadriseta
Dichelachne crinita
Elymus interruptus
„ virginicus
Festuca arundinacea × Lolium perenne
Helictotrichon pubescens
Heteranthelium piliferum
Hierochloe redolens
Holcus lanatus
„ mollis
Hordelymus europaeus
Hordeum agriocrithon
„ jubatum
„ murinum
Koeleria gracilis
„ phleoides
Lagurus ovatus
Lolium multiflorum
Melica altissima
„ ciliata
Phalaris caerulescens
„ canariensis
„ minor
Poa palustris

Horizontally elongated with sinuous outlines (Fig. IA, 14–15)

Aegilops crassa
„ triaristata
„ ventricosa
Agrostis semiverticillata
„ stolonifera var. palustris
Alopecurus geniculatus
„ myosuroides
„ pratensis
Anthoxanthum odoratum
Avena ludoviciana
„ strigosa
Brachypodium sylvaticum
Bromus carinatus

Bromus coloratus
„ inermis
„ japonicus
„ sterilis
„ tectorum
„ unioloides
Brylkinia caudata
Cynosurus cristatus
Dichelachne crinita
Elymus (Taeniatherum) caput-medusae
„ interruptus
„ virginicus
Glyceria fluitans
„ maxima
Helictotrichon pubescens
Heteranthelium piliferum
Hierochloe odorata
Holcus mollis
Hordelymus europaeus
Hordeum agriocrithon
„ jubatum
„ murinum
„ secalinum
Koeleria cristata
„ phleoides
Lamarckia aurea
Melica altissima
„ ciliata
„ uniflora
Phalaris canariensis
„ minor
Poa glauca
„ palustris
Polypogon chilensis
„ monspeliensis
Triticum dicoccoides
„ dicoccum
„ polonicum

Cross-shaped (Fig. IA, 16)

Acroceras zizanioides
Aeluropus littoralis
Andropogon amplectens
Aristida setacea
Arundo donax
Bothriochloa caucasica
„ pertusa
Brachiaria jubata
„ paspaloides
„ reptans
Bromuniola gossweileri
Cenchrus biflorus
„ ciliaris
„ pauciflorus
Centotheca lappacea (2 out of 3 samples)
Chrysopogon zeylanicus
Coelachyrum brevifolium
Coix lacryma-jobi
Cymbopogon citratus
„ giganteus
„ martinii
Cyrtococcum trigonum
Diarrhena americana
Dichanthium aristatum
„ sericeum
Digitaria milanjiana
Echinochloa colonum
Eragrostis diplachnoides
„ gangetica
Euchlaena perennis
Euclasta condylotricha
Eulalia phaeothrix
Hemarthria uncinata
Hyparrhenia dissoluta
Imperata cylindrica
Isachne mauritiana
„ walkeri
Ischaemum commutatum
Leersia oryzoides
Leptochloa caerulescens
Lophatherum gracile
Loudetia superba
Melinis minutiflora
Microlaena stipoides
Muhlenbergia racemosa
Olyra latifolia
Oplismenus compositus
Panicum capillare
„ clandestinum
„ maximum
„ miliaceum
„ obtusum
„ virgatum
Pariana bicolor
„ campestris
„ vulgaris
Paspalidium geminatum
Paspalum commersonii
„ conjugatum
„ distichum
„ paniculatum
Pennisetum macrourum
Phyllorachis sagittata
Plectrachne danthonioides
„ schinzii
Pseudanthistiria umbellata
Rhynchelytrum repens
Rottboellia exaltata
Saccharum bengalense
„ officinarum
Setaria glauca
„ italica
„ plicata
„ viridis
Sorghum halepense

Cross-shaped (cont.)

Stenotaphrum dimidiatum
„ secundatum
Themeda australis
„ quadrivalvis
„ tremula
„ triandra
Trichachne insularis
Tripsacum dactyloides
Triraphis pumilio
Uniola latifolia
Urochloa pullulans
Vetiveria zizanioides

Intermediate between cross and dumb-bell shaped (Fig. IA, 17)

Apluda mutica var. aristata
Aristida sp.
Arthraxon quartinianus
Arundinella metzii
„ villosa
Arundo donax
Beckeropsis uniseta
Bothriochloa caucasica
Brachiaria distichophylla
Cenchrus biflorus
„ ciliaris
„ pauciflorus
Centotheca lappacea
Coelachyrum brevifolium
Coix lacryma-jobi
Cymbopogon citratus
„ giganteus
„ nardus
„ validus
Cyrtococcum trigonum
Danthonia compressa
Diarrhena americana
Dichanthium aristatum
Digitaria borbonica
„ brazzae
„ horizontalis
„ milanjiana
Echinochloa colonum
Ehrharta abyssinica
Elyonurus chevalieri
„ hirtifolius
Enneapogon cenchroides
Erianthus hostii
Eulalia geniculata
„ phaeothrix
Garnotia courtallensis
Hemarthria uncinata
Heteropogon contortus
Hyparrhenia dissoluta
Ischaemum commutatum
„ santapaui
Melinis minutiflora
Micraira subulifera
Microlaena stipoides
Microstegium ciliatum
Miscanthidium teretifolium
Miscanthus condensatus
„ sacchariflorus
Molinia caerulea
Muhlenbergia racemosa
Oplismenus compositus
Oryzopsis paradoxa
Panicum capillare
„ clandestinum
„ maximum
„ miliaceum
„ virgatum
Paspalum commersonii
Pennisetum clandestinum
„ macrourum
Phalaris canariensis
Pharus latifolius
Rottboellia exaltata
Saccharum bengalense
„ officinarum
„ spontaneum
Setaria glauca
„ italica
„ viridis
Sorghum halepense
Stenotaphrum dimidiatum
„ secundatum
Themeda australis
„ quadrivalvis
„ tremula
„ triandra
Thysanolaena maxima
Trichachne insularis
Triplopogon spathiflorus
Tripsacum dactyloides
Triraphis pumilio
Uniola latifolia
Urochloa pullulans

Dumb-bell shaped (Fig. IA, 18)

Acroceras tonkinense
Aristida longiflora
„ sp.
Arthraxon quartinianus
Arundinella metzii
Beckeropsis uniseta
Bothriochloa caucasica
„ pertusa
Brachiaria deflexa
Centotheca lappacea (1 out of 3 samples)
Cleistachne sorghoides
Danthonia spicata
„ „ var. typica
Diarrhena americana
Dichanthium aristatum

Dichanthium sericeum
Digitaria wallichiana
Echinochloa colonum
Elyonurus hirtifolius
Enneapogon cenchroides
Eragrostis gangetica
Eulalia geniculata
„ phaeothrix
Garnotia courtallensis
Hakonechloa macra
Imperata cylindrica
Ischaemum santapaui
Leptocarydion vulpiastrum
Lophatherum gracile
Loudetia superba
Megastachya mucronata
Miscanthus sacchariflorus
Molinia caerulea
Oplismenus compositus
Oryzopsis racemosa
Panicum clandestinum
„ maximum
„ virgatum
Paspalidium geminatum
Paspalum paniculatum
Pennisetum clandestinum
Perotis indica
Saccharum bengalense
„ spontaneum
Sacciolepis interrupta
Schizachyrium jeffreysii
Setaria glauca
„ italica
Themeda australis
„ quadrivalvis
Trichachne insularis
Triraphis pumilio
Tristachya hispida
„ inamoena
Uniola latifolia

Shortly dumb-bell shaped (Fig. IB, 20)

Beckeropsis uniseta
Brachiaria deflexa
„ paspaloides
„ reptans
Bromuniola gossweileri
Cenchrus biflorus
„ ciliaris
„ pauciflorus
Coix lacryma-jobi
Cymbopogon martinii
„ validus
Danthonia spicata
„ „ var. typica
Ehrharta abyssinica
Hakonechloa macra
Leptaspis cochleata
Leptocarydion vulpiastrum
Loudetia superba
„ Japanese sp.
Miscanthidium teretifolium
Miscanthus condensatus
„ sacchariflorus
Molinia caerulea
Oryzopsis paradoxa
Pharus latifolius
Setaria plicata
Tristachya hispida

Dumb-bell shaped but varying in appearance with focus owing to uneven deposition of silica (Fig. IB, 21)

Acroceras tonkinense
Alloteropsis cimicina
Andropogon schirensis
Apluda mutica var. aristata
Bothriochloa pertusa
Cymbopogon martinii
„ nardus
Digitaria borbonica
„ horizontalis
Dimeria thwaitesii
Ehrharta abyssinica
Euclasta condylotricha
Eulalia phaeothrix
Heteropogon contortus
Imperata cylindrica
Ischaemum commutatum
„ santapaui
Lophatherum gracile
Loudetia superba
„ sp.
Oplismenus compositus
Paspalidium geminatum
Paspalum conjugatum
Perotis indica
„ patens
Pseudanthistiria umbellata
Schizachyrium jeffreysii
Setaria barbata
Themeda tremula
„ triandra
Triplopogon spathiflorus

Nodular (Fig. IA, 18 (i) and IB, 22 (iii))

Alloteropsis cimicina
Apluda mutica var. aristata
Aristida longiflora
Bothriochloa caucasica
Brachiaria deflexa
„ distichophylla
„ paspaloides
„ reptans

Nodular (cont.)

Calamagrostis epigejos
Cenchrus ciliaris
Cleistachne sorghoides
Cymbopogon martinii
Diarrhena americana
Dimeria thwaitesii
Echinochloa colonum
„ crus-galli
Ehrharta abyssinica
Elyonurus chevalieri
Enneapogon cenchroides
Euclasta condylotricha
Garnotia courtallensis
Hakonechloa macra
Heteropogon contortus
Hyparrhenia dissoluta
Imperata cylindrica
Ischaemum commutatum
„ santapaui
Leptaspis cochleata
Lycochloa avenacea
Melica uniflora
Melinis minutiflora
Micraira subulifera
Microstegium ciliatum
Miscanthidium teretifolium
Miscanthus condensatus
„ sacchariflorus
Oplismenus compositus
Panicum maximum
„ obtusum
Paspalidium geminatum
Paspalum distichum
„ paniculatum
Pennisetum clandestinum
Phalaris canariensis
Plectrachne danthonioides
„ schinzii
Pseudanthistiria umbellata
Rhynchelytrum repens
Saccharum bengalense
„ spontaneum
Schizachyrium jeffreysii
Setaria barbata
„ italica
„ plicata
Snowdenia polystachya
Sorghum halepense
Stenotaphrum dimidiatum
Themeda tremula
Triplopogon spathiflorus

Tall, narrow, and crenate (Fig. IB, 24)

Aristida sp.
Arundo donax
Coix lacryma-jobi
Cymbopogon giganteus
„ martinii
Dichanthium aristatum
Euchlaena perennis
Eulalia phaeothrix
Hemarthria uncinata
Leersia hexandra
Lophatherum gracile
Molinia caerulea
Neurolepis aristata
Olyra latifolia
Panicum clandestinum
Pariana bicolor
„ campestris
„ vulgaris
Paspalum conjugatum
Pennisetum clandestinum
„ macrourum
Phyllorachis sagittata
Rottboellia exaltata
Setaria plicata
Themeda tremula
Tripsacum dactyloides
Urochloa pullulans
Zizania latifolia

Oryza type (Fig. IB, 23)

Eriachne pallescens
Isachne mauritiana
Leersia hexandra
„ oryzoides
Olyra latifolia
Oryza sativa var. violacea
Pariana bicolor
„ campestris
„ vulgaris
Phyllorachis sagittata
Thysanolaena maxima
Zizania latifolia

MACRO-HAIRS

Superficial; usually with enlarged bases (Fig. II, 1)

Acroceras zizanioides
Aegilops crassa
„ triaristata
Aegilops ventricosa
Anthoxanthum odoratum
Brachypodium sylvaticum
Bromus japonicus
„ sterilis
„ unioloides

Elyonurus hirtifolius
Festuca glauca
„ 'punctoria'
Helictotrichon planiculme
„ pubescens
Holcus lanatus
„ mollis
Hordeum jubatum
„ murinum
Koeleria cristata
„ phleoides
Phyllorachis sagittata
Tragus racemosus
Triticum dicoccum
„ polonicum

Slender hairs with sunken bulbous bases

Cynodon dactylon (1 out of 3 samples)
Digitaria borbonica
„ wallichiana
Oplismenus compositus

Stiff hairs with sunken, usually constricted bases, and sometimes surrounded by specialized epidermal cells (Figs. II and IIA, 3 and 5)

Acroceras tonkinense
Alloteropsis cimicina
Andropogon amplectens
„ schirensis
Arthraxon quartinianus
Arundinella metzii
Bothriochloa caucasica
„ pertusa
Brachiaria paspaloides
Bromus fibrosus
Buchloe dactyloides
Chrysopogon zeylanicus
Cleistachne sorghoides
Cyrtococcum trigonum (1 out of 2 samples)
Dactyloctenium aegyptium
Danthonia spicata
Digitaria horizontalis
Distichlis distichophylla
Eriachne pallescens
Euclasta condylotricha
Garnotia courtallensis
Heteranthelium piliferum
Heteranthoecia guineensis
Heteropogon contortus
Hyparrhenia dissoluta
Isachne kunthiana
„ mauritiana
„ walkeri
Ischaemum commutatum
„ santapaui
Melinis minutiflora
Microstegium ciliatum
Oplismenus compositus
Oropetium thomaeum
Panicum capillare
„ clandestinum
„ miliaceum
Paspalum commersonii
„ paniculatum
Pennisetum clandestinum
Pogonatherum paniceum
Sieglingia decumbens
Spinifex hirsutus
Triplopogon spathiflorus
Tripsacum dactyloides
Tristachya hispida
Urochloa pullulans

Crozier hairs (Fig. IIA, 7)

Neostapfia colusana

Long-stalked glandular hairs with unicellular heads (Fig. IIA, 8)

Enneapogon cenchroides

Stalked, slightly sunken, glandular hairs (Fig. IIA, 9)

Neostapfia colusana
Orcuttia pilosa

Short, rigid, thick-walled hairs (Fig. IIA, 10)

Agropyron caninum
Ammophila arenaria
Aristida longiflora
Bothriochloa caucasica
Bouteloua curtipendula
Brachiaria deflexa
„ distichophylla
Brachypodium sylvaticum
Bromus fibrosus
Coelachne simpliciuscula
Cortaderia selloana
Danthonia compressa
„ spicata
Ehrharta villosa var. maxima
Elymus arenarius
„ condensatus
Festuca arundinacea
„ „ ×Lolium perenne
Hierochloe redolens
Holcus mollis
Hyparrhenia dissoluta
Melica ciliata
Microlaena stipoides
Oryzopsis asperifolia

Short, rigid, thick-walled hairs (cont.)

Pariana campestris
Plectrachne danthonioides
„ desertorum
„ schinzii
Psammochloa villosa
Tetrarrhena distichophylla
Trikeraia hookeri
Triticum dicoccoides
Zizania latifolia

MICRO-HAIRS

Spherical, unicellular (Fig. VII, 1)

Anomochloa marantoidea
Coelachne simpliciuscula
Cynodon dactylon
Dactyloctenium aegyptium
Diarrhena americana
Dimeria thwaitesii
Ischaemum commutatum
Sporobolus africanus
„ diander
„ indicus
„ molleri
„ poiretii
„ pyramidalis

More or less spherical, consisting of 2 short cells about equal in length (Fig. VII, 2)

Aeluropus littoralis
Anomochloa marantoidea
Astrebla squarrosa
Bouteloua curtipendula
Buchloe dactyloides
Chloris barbata
„ filiformis
„ pycnothrix
„ robusta
„ (Eustachys) uliginosa
„ virgata
Coelachne hackelii
„ simpliciuscula
Cynodon dactylon
Dactyloctenium giganteum
Eleusine coracana
„ indica
Eragrostiella bifaria
Ischaemum commutatum
„ santapaui
Leptochloa caerulescens
„ uniflora
Perotis indica
Sporobolus wrightii
Tetrarrhena distichophylla
Thysanolaena maxima

Balanoform (Fig. VII, 3)

Acroceras zizanioides
Anomochloa marantoidea
Bromuniola gossweileri
Centotheca lappacea
Coix lacryma-jobi
Eragrostis diplachnoides
„ gangetica
Euchlaena perennis
Euchlazea mertonensis
Neurolepis nobilis
Tripsacum dactyloides
Vetiveria zizanioides

With a relatively short basal cell, and longer distal cell tapering to a rounded apex (Fig. VII, 4–6)

Alloteropsis cimicina
Andropogon amplectens
Aristida longiflora
„ setacea
Arundinella metzii
„ villosa
Beckeropsis uniseta
Bothriochloa caucasica
„ pertusa
Brachiaria deflexa
„ distichophylla
„ jubata
„ paspaloides
„ reptans
Bromuniola gossweileri
Cenchrus biflorus
„ ciliaris
„ pauciflorus
Centotheca lappacea (2 out of 3 samples)
Chrysopogon zeylanicus
Cleistachne sorghoides
Coelachne perpusilla
Cymbopogon martinii
Danthonia compressa
„ spicata
„ „ var. typica
Dichanthium aristatum
Digitaria borbonica
„ brazzae
„ horizontalis
„ milanjiana
„ wallichiana
Ehrharta abyssinica
Elyonurus chevalieri
„ hirtifolius

Eragrostis diplachnoides
„ gangetica
„ unioloides
Eriachne pallescens
Eulalia geniculata
„ phaeothrix
Garnotia courtallensis
Hakonechloa macra
Hemarthria uncinata
Imperata cylindrica
Isachne kunthiana (1 out of 2 samples)
„ mauritiana
„ walkeri
Leersia hexandra
„ oryzoides
Lophatherum gracile
Megastachya mucronata
Micraira subulifera
Microlaena stipoides
Miscanthidium teretifolium
Miscanthus sacchariflorus
Neurolepis nobilis
Oplismenus compositus
Oryza sativa var. violacea
Panicum capillare
„ clandestinum
„ maximum
„ miliaceum
„ obtusum
„ virgatum
Paspalidium geminatum
Paspalum commersonii
„ conjugatum
„ paniculatum
Pennisetum clandestinum
„ macrourum
Phyllorachis sagittata
Rhynchelytrum repens
Rottboellia exaltata
Saccharum officinarum
„ spontaneum
Sacciolepis interrupta
Schizachyrium jeffreysii
Setaria barbata
„ glauca
„ italica
„ plicata
„ viridis
Sieglingia decumbens
Snowdenia polystachya
Sorghum halepense
Spinifex hirsutus
Stenotaphrum dimidiatum
„ secundatum
Streptochaeta spicata
Triplopogon spathiflorus
Tripsacum dactyloides
Trichachne insularis
Triraphis pumilio
Tristachya hispida
Uniola latifolia

Both cells about equally long and uniform in diameter (Fig. VII, 7; *7a with collapsed distal cell*)

Aristida sp.
Cymbopogon martinii
Digitaria borbonica
Echinochloa colonum
„ crus-galli
Erianthus hostii
Microlaena stipoides
Miscanthus condensatus
Olyra latifolia
Pariana bicolor
Schizachyrium jeffreysii

Both cells long and narrow (Fig. VII, 8)

Loudetia superba
„ Japanese sp.
Olyra latifolia
Pariana campestris
Setaria barbata

Short, conspicuously bent, with hemispherical distal cell. (*As* Fig. VII, 2, *but more bent and basal cell slightly longer*)

Bouteloua curtipendula
Buchloe dactyloides
Chloris filiformis
Coelachne hackelii
Coelachyrum brevifolium
Muhlenbergia racemosa

Basal cell longer than the distal cell (Fig. VII, 9–10)

Acroceras tonkinense
Apluda mutica var. aristata
Arundo donax
Cyrtococcum trigonum (1 out of 2 samples)
Danthonia compressa
„ spicata
„ „ var. typica
Desmostachya bipinnata
Dichanthium sericeum
Eragrostis aspera
Erianthus hostii
Euclasta condylotricha
Heteropogon contortus
Imperata cylindrica
Isachne kunthiana
„ mauritiana
Miscanthus condensatus
„ sacchariflorus

Basal cell longer than the distal cell (cont.)

Nardus stricta
Pariana bicolor
„ campestris
„ vulgaris
Pseudanthistiria umbellata
Saccharum bengalense
Themeda australis
„ tremula
„ triandra

Basal cell much longer than the hemispherical distal cell; often appearing to be thick-walled but this is usually, if not always, an artefact (Fig. VII, 12)

Calamovilfa longifolia
Cymbopogon validus (sometimes)
Eragrostis aspera
„ chloromelas
Fingerhuthia africana
Pogonarthria squarrosa (sometimes)

Both cells relatively short, but longer than in Fig. VII, 2; distal cell tapered towards the apex (Fig. VII, 11)

Leersia hexandra
Tetrarrhena distichophylla
Thysanolaena maxima
Zizania latifolia

Shortly stalked, 2-celled hairs with spherical heads situated in pits (Fig. IIA, 13). *See under shortly-stalked, 2-celled 'papillae; on p. 609)*

Eleusine coracana
Spartina townsendii

CORK-CELLS

Conspicuously pitted (Fig. 1, 4, P.C.)

Agropyron rigidum
Bromus inermis

PRICKLE-HAIRS (Fig. VI)

Prickle-hairs are so common throughout the Gramineae that it would serve no useful purpose to list all of the species in which they have been observed. Only a few special types have been tabulated.

Interlocking prickles overlying stomata in grooves (Fig. VI, 4)

Saccharum spontaneum

Unpointed prickles (Fig. VI, 6)

Aristida ciliata var. capensis
Arundo donax
Coix lacryma-jobi
Eulalia geniculata
Glyceria maxima
Heteropogon contortus
Hierochloe redolens
Hordeum agriocrithon
„ stenostachys
Melica altissima
„ ciliata
Phalaris minor
Phragmites communis
Polypogon chilensis
Saccharum officinarum
Setaria barbata
Zizania latifolia

PAPILLAE

Chains of globose papillae overlying the veins (Fig. III, 1)

Alopecurus geniculatus
Glyceria fluitans
Sacciolepis interrupta
Snowdenia polystachya

Oblique papillae with thickened distal ends (Fig. III, 2)

Aeluropus littoralis
Astrebla squarrosa
Chloris pycnothrix
„ (Eustachys) uliginosa

Chloris virgata
Cleistachne sorghoides
Cynodon dactylon (1 out of 3 samples)
Dactyloctenium aegyptium
Dichanthium sericeum
Echinochloa colonum
„ crus-galli
Euclasta condylotricha
Glyceria fluitans
Hyparrhenia dissoluta
Leptocarydion vulpiastrum
Miscanthus condensatus
Paspalum distichum
Puccinellia fasciculata
Saccharum bengalense
Sacciolepis interrupta
Zizania latifolia

Thin papillae, usually globose and mostly somewhat oblique (Fig. III, 3)

Chloris pycnothrix
Cleistachne sorghoides
Coelachne hackelii
„ simpliciuscula
Cyrtococcum trigonum (1 out of 3 samples)
Dactyloctenium aegyptium
Elymus (Taeniatherum) caput-medusae
Eulalia geniculata
Heteranthoecia guineensis
Heteropogon contortus
Isachne mauritiana
Ischaemum commutatum
„ santapaui
Leptochloa uniflora
Neostapfia colusana
Pseudanthistiria umbellata
Themeda australis
„ quadrivalvis
„ triandra
Tragus berteronianus
„ racemosus
Triplopogon spathiflorus

Combination of small cuticular papillae and a few larger, more inflated papillae (Fig. III, 4)

Leersia oryzoides
Miscanthus condensatus
Oryza sativa var. violacea

Small, variously shaped, thick, cuticular papillae (Fig. III, 5)

Aristida sp.
Bothriochloa caucasica
Chloris barbata
Cynodon dactylon (1 out of 3 samples)
Leersia hexandra
Leptochloa caerulescens
Neurolepis aristata
„ nobilis
Pariana campestris
Pseudanthistiria umbellata
Themeda tremula
„ triandra
Trikeraia hookeri

Large, thin papillae (Fig. III, 6)

Arthraxon quartinianus
Bothriochloa pertusa
Cymbopogon martinii
„ nardus
Cyrtococcum trigonum (1 out of 2 samples)
Dactyloctenium giganteum
Dimeria thwaitesii
Ischaemum commutatum
Microstegium ciliatum
Pogonatherum paniceum

Shortly stalked, 2-celled papillae, in pits (Fig. IIA, 13). *These should perhaps be regarded as micro-hairs*

Cynodon dactylon (2 out of 3 samples)
Dactyloctenium giganteum
Eleusine coracana

Papillae overarching the individual stomata

Hyparrhenia dissoluta
Leptocarydion vulpiastrum
Trikeraia hookeri
Triplopogon spathiflorus

SPECIAL NOTES ON PAPILLAE

(i) Papillae as recorded in the literature, are sometimes prickles which have been wrongly interpreted as papillae through having been observed only in transverse sections. This applies for example, in *Sporobolus* spp.

(ii) There is sometimes confusion between papillae and micro-hairs, e.g. in *Spartina*.

Subsidiary cells triangular (Fig. IV, 1). (*Often accompanied by stomata with dome shaped subsidiary cells*)

Acroceras tonkinense
„ zizanioides
Aeluropus littoralis
Alloteropsis cimicina
Andropogon amplectens
„ schirensis
Anomochloa marantoidea
Apluda mutica var. aristata
Aristida ciliata var. capensis
Arthraxon quartinianus
Arundinella metzii
„ villosa
Arundo donax
Astrebla squarrosa
Beckeropsis uniseta
Bothriochloa pertusa
Brachiaria deflexa
„ distichophylla
„ jubata
„ paspaloides
„ reptans
Bromuniola gossweileri
Buchloe dactyloides
Calamovilfa longifolia
Cenchrus biflorus
„ ciliaris
„ pauciflorus
Centotheca lappacea
Chloris barbata
„ filiformis
„ pycnothrix
„ robusta
„ virgata
Chrysopogon zeylanicus
Cleistachne sorghoides
Coelachne perpusilla
„ simpliciuscula
Coelachyrum brevifolium
Coix lacryma-jobi
Cymbopogon citratus
„ giganteus
„ martinii
„ nardus
„ validus
Cynodon dactylon
Cyrtococcum trigonum (1 out of 2 samples)
Dactyloctenium giganteum
Desmostachya bipinnata
Dichanthium aristatum
„ sericeum
Digitaria borbonica
„ brazzae
„ horizontalis
Digitaria milanjiana
„ wallichiana
Dimeria thwaitesii
Distichlis distichophylla
Echinochloa colonum
„ crus-galli
Eleusine coracana
„ indica
Elyonurus chevalieri
„ hirtifolius
Enneapogon cenchroides
Eragrostis aspera
„ chloromelas
„ curvula
„ diplachnoides
„ gangetica
„ unioloides
Erianthus hostii
Euchlaena perennis
Euclasta condylotricha
Fingerhuthia africana
Garnotia courtallensis
Hemarthria uncinata
Heteropogon contortus
Hyparrhenia dissoluta
Imperata cylindrica
Isachne walkeri
Ischaemum commutatum
„ santapaui
Leersia hexandra
„ oryzoides
Leptocarydion vulpiastrum
Leptochloa caerulescens
„ uniflora
Lophatherum gracile
Loudetia superba
„ sp.
Lygeum spartum
Megastachya mucronata
Melinis minutiflora
Microlaena stipoides
Microstegium ciliatum
Miscanthidium teretifolium
Miscanthus condensatus
„ sacchariflorus
Molinia caerulea
Nardus stricta
Neurolepis nobilis
Olyra latifolia
Oplismenus compositus
Oropetium thomaeum
Oryza sativa var. violacea
Panicum capillare
„ clandestinum
„ maximum
„ miliaceum
„ obtusum

Panicum virgatum
Pariana bicolor
„ campestris
„ vulgaris
Paspalidium geminatum
Paspalum commersonii
„ conjugatum
„ distichum
„ paniculatum
Pennisetum clandestinum
„ macrourum
Perotis indica
„ patens
Phyllorachis sagittata
Pogonarthria squarrosa
Rhynchelytrum repens
Rottboellia exaltata
Saccharum bengalense
„ officinarum
„ spontaneum
Schizachyrium jeffreysii
Setaria barbata
„ glauca
„ italica
„ plicata
„ viridis
Snowdenia polystachya
Sorghum halepense
Sporobolus africanus
„ diander
„ indicus
„ molleri
„ poiretii
„ pyramidalis
„ wrightii
Stenotaphrum dimidiatum
„ secundatum
Streptogyna crinita
Themeda australis
„ quadrivalvis
„ tremula
„ triandra
Thysanolaena maxima
Tragus berteronianus
„ racemosus
Trichachne insularis
Triplopogon spathiflorus
Tripsacum dactyloides
Triraphis pumilio
Tristachya hispida
„ inamoena
Uniola latifolia
Urochloa pullulans
Vetiveria zizanioides
Zizania latifolia

Subsidiary cells parallel sided (Fig. IV, 2)

Aegilops crassa
„ triaristata
Aegilops ventricosa
Agrostis stolonifera var. palustris
Alopecurus geniculatus
„ myosuroides
„ pratensis
Anthochloa lepidula
Anthoxanthum odoratum
Aristida setacea
Arrhenatherum elatius
Avena ludoviciana
„ (Helictotrichon) pubescens
„ strigosa
Bothriochloa caucasica
Brachypodium sylvaticum
Bromus carinatus
„ coloratus
„ fibrosus
„ inermis
„ japonicus
„ tectorum
„ unioloides
Calamagrostis epigejos
Coelachne hackelii
Cynosurus cristatus
Deyeuxia quadriseta
Dichelachne crinita
Elymus (Taeniatherum) caput-medusae
„ condensatus
„ interruptus
„ virginicus
Festuca arundinacea × Lolium perenne
„ heterophylla (Broad leaves)
Glyceria fluitans
Helictotrichon albinerve
„ planiculme
„ pubescens
Heteranthelium piliferum
Hierochloe odorata
Holcus lanatus
„ mollis
Hordelymus europaeus
Hordeum agriocrithon
„ jubatum
„ murinum
„ secalinum
„ stenostachys
Koeleria cristata
„ phleoides
Lagurus ovatus
Lamarckia aurea
Lolium multiflorum
Melica altissima
„ uniflora
Phalaris caerulescens
„ canariensis
„ minor
Poa glauca
„ iridifolia
„ palustris

Subsidiary cells parallel sided (cont.)

Polypogon chilensis
„ monspeliensis
Secale cereale
Triticum dicoccoides
„ dicoccum
„ polonicum

Subsidiary cells low, dome-shaped (Fig. IV, 3). (*Often accompanied by stomata with triangular subsidiary cells*)

Aeluropus littoralis
Agropyron elongatum
„ intermedium
„ laxum
Agrostis semiverticillata
„ stolonifera var. palustris
Andropogon schirensis
Anomochloa marantoidea
Anthochloa lepidula
Aristida ciliata var. capensis
„ longiflora
„ setacea
Arthraxon quartinianus
Arundo donax
Astrebla squarrosa
Avena ludoviciana
„ strigosa
Bothriochloa pertusa
Brachiaria deflexa
„ distichophylla
„ jubata
„ paspaloides
Bromus fibrosus
„ sterilis
„ tectorum
Brylkinia caudata
Calamagrostis epigejos
Calamovilfa longifolia
Cenchrus ciliaris
Chloris filiformis
„ pycnothrix
„ robusta
„ (Eustachys) uliginosa
Coelachne simpliciuscula
Coelachyrum brevifolium
Cortaderia conspicua
„ selloana
Cymbopogon citratus
„ martinii
„ nardus
„ validus
Cynodon dactylon
Cyrtococcum trigonum (1 out of 2 samples)
Dactyloctenium aegyptium
„ giganteum
Danthonia flavescens
Deyeuxia quadriseta
Diarrhena americana
Dichanthium aristatum
Digitaria borbonica
„ brazzae
„ horizontalis
„ milanjiana
„ wallichiana
Echinochloa colonum
„ crus-galli
Ectosperma alexandrae
Ehrharta abyssinica
Elymus arenarius
„ canadensis
„ (Taeniatherum) caput-medusae
„ condensatus
„ interruptus
„ virginicus
Enneapogon cenchroides
Eragrostiella bifaria
Eragrostis aspera
„ chloromelas
„ curvula
„ diplachnoides
„ gangetica
„ unioloides
Eriachne pallescens
Eulalia geniculata
„ phaeothrix
Festuca arundinacea
„ heterophylla (broad leaves)
Glyceria fluitans
„ maxima
Helictotrichon planiculme
„ pubescens
Hierochloe odorata
Hordelymus europaeus
Hordeum jubatum
„ murinum
„ secalinum
„ stenostachys
Hyparrhenia dissoluta
Koeleria cristata
Lamarckia aurea
Leptochloa uniflora
Lolium multiflorum
Loudetia superba
„ sp.
Melinis minutiflora
Micraira subulifolia
Microstegium ciliatum
Miscanthidium teretifolium
Miscanthus condensatus
„ sacchariflorus
Molinia caerulea
Muhlenbergia racemosa

Neurolepis aristata
„ nobilis
Oplismenus compositus
Oryza sativa var. violacea
Oryzopsis asperifolia
„ paradoxa
Panicum clandestinum
„ miliaceum
„ virgatum
Parapholis strigosa
Paspalidium geminatum
Perotis indica
Phaenosperma globosum
Phalaris caerulescens
„ canariensis
„ minor
Phragmites communis
Poa glauca
„ iridifolia
„ palustris
Pogonarthria squarrosa
Psammochloa villosa
Pseudanthistiria umbellata
Puccinellia fasciculata
„ maritima
Rottboellia exaltata
Saccharum bengalense
Sacciolepis interrupta
Schizachyrium jeffreysii
Secale cereale
Setaria glauca
„ viridis
Sporobolus africanus
„ indicus
„ molleri
„ poiretii
„ pyramidalis
„ wrightii
Stenotaphrum dimidiatum
Themeda quadrivalvis
„ triandra
Thysanolaena maxima
Tragus berteronianus
„ racemosus
Trichachne insularis
Triraphis pumilio
Tristachya hispida
„ inamoena
Triticum dicoccoides
„ dicoccum
„ polonicum
Vetiveria zizanioides

Subsidiary cells tall dome-shaped (Fig. IV, 4)

Brylkinia caudata
Cymbopogon citratus
Cymbopogon nardus
Danthonia flavescens
Digitaria borbonica
„ wallichiana
Distichlis distichophylla
Ehrharta abyssinica
Elyonurus chevalieri
Eulalia geniculata
„ phaeothrix
Leptaspis cochleata
Leptocarydion vulpiastrum
Microlaena stipoides
Muhlenbergia racemosa
Neostapfia colusana
Neurolepis aristata
„ nobilis
Oryzopsis asperifolia
„ paradoxa
Pariana campestris
„ vulgaris
Perotis indica
Phaenosperma globosum
Pharus latifolius
Psammochloa villosa
Setaria barbata
Snowdenia polystachya
Streptochaeta spicata
Triplopogon spathiflorus

Subsidiary cells variable in outline (Fig. IV, 5)

Astrebla squarrosa
Coelachne simpliciuscula
Cyrtococcum trigonum
Heteranthoecia guineensis
Isachne kunthiana
„ mauritiana
„ walkeri
Oplismenus compositus

Absent from or very infrequent on the abaxial surface

Agropyron caninum
Ammophila arenaria
Danthonia compressa
„ spicata
„ „ var. typica
Festuca glauca
„ heterophylla (narrow basal leaves)
Hakonechloa macra
Hierochloe redolens
Lycochloa avenacea
Melica ciliata
„ uniflora
Oryzopsis racemosa
Plectrachne danthonioides
„ desertorum

Absent from or very infrequent on the abaxial surface (cont.)

Plectrachne schinzii
Rhytachne rottboellioides
Spartina maritima
„ townsendii
Tetrarrhena distichophylla

LONG-CELLS

Some types of long-cells occur so widely amongst the grasses that their diagnostic value is limited, and tabulated data are here given only for those that are of diagnostic value because of their comparatively restricted occurrence. The lists refer mainly to intercostal long-cells.

Nearly or quite cubical; with slightly to moderately sinuous walls (Fig. V, 7). *This type often accompanied by longer cells*

Acroceras tonkinense
Aeluropus littoralis
Alloteropsis cimicina
Brachiara deflexa
Chloris barbata
„ (Eustachys) uliginosa
Coelachne perpusilla
Cyrtococcum trigonum
Dactyloctenium giganteum
Dichanthium sericeum
Digitaria borbonica
„ horizontalis
„ milanjiana
Echinochloa colonum
Isachne kunthiana
„ walkeri
Leptochloa caerulescens
„ uniflora
Loudetia sp.
Megastachya mucronata
Melinis minutiflora
Miscanthus condensatus
Muhlengergia racemosa
Neostapfia colusana
Oplismenus compositus
Panicum capillare
„ clandestinum
„ maximum
Perotis indica
„ patens
Phragmites communis
Rottboellia exaltata
Triplopogon spathiflorus
Urochloa pullulans

Cells seldom longer than tall; with walls not sinuous (Fig. V, 8)

Coelachne hackelii
„ simpliciuscula
Heteranthoecia guineensis
Isachne kunthiana
„ walkeri
Spinifex hirsutus (in part)

Cells with overlapping end walls (Fig. V, 9)

Leptaspis cochleata
Pharus latifolius

Interstomatal cells with concave ends (Fig. V, 10–11). (*Interstomatal cells are cells in the same longitudinal files as, and situated between, the stomata*)

Acroceras tonkinense
„ zizanioides
Aegilops triaristata
Agropyron intermedium
„ laxum
Andropogon amplectens
„ schirensis
Anomochloa marantoidea
Aristida ciliata var. capensis
Astrebla squarrosa
Beckeropsis uniseta
Bothriochloa caucasica
„ pertusa
Bouteloua curtipendula
Brachiaria jubata
Bromus carinatus
Calamovilfa longifolia
Cenchrus biflorus
Centotheca lappacea
Chloris barbata
„ robusta
„ virgata
Cleistachne sorghoides
Coelachyrum brevifolium
Coix lacryma-jobi
Cymbopogon citratus
„ giganteus
„ nardus
„ validus
Cynodon dactylon
Dactyloctenium aegyptium
Desmostachya bipinnata
Dichanthium aristatum
Digitaria borbonica
„ horizontalis
„ milanjiana
Eleusine coracana
Erianthus hostii

Euchlaena perennis
Eulalia geniculata
Glyceria maxima
Imperata cylindrica
Leersia hexandra
„ oryzoides
Leptocarydion vulpiastrum
Leptochloa caerulescens
Lygeum spartum
Micraira subulifolia
Miscanthus condensatus
„ sacchariflorus
Muhlenbergia racemosa
Neurolepis aristata
„ nobilis
Olyra latifolia
Panicum clandestinum
„ maximum
Pariana bicolor
„ campestris
„ vulgaris
Paspalum commersonii
„ conjugatum
„ distichum
„ paniculatum
Pennisetum clandestinum
„ macrourum
Perotis indica
„ patens
Phalaris minor
Saccharum bengalense
„ officinarum
Schizachyrium jeffreysii
Setaria plicata
Snowdenia polystachya
Sporobolus africanus
„ diander
„ pyramidalis
„ wrightii
Streptochaeta spicata
Streptogyna crinita
Themeda triandra
Thysanolaena maxima
Tragus berteronianus
Uniola latifolia
Urochloa pullulans
Zizania latifolia

Interstomatal cells with concave ends, but longer than in the species in previous list

Alopecurus myosuroides
Arundinella villosa
Sporobolus molleri
Stenotaphrum dimidiatum
„ secundatum
Triraphis pumilio
Triticum polonicum
Uniola latifolia

VASCULAR BUNDLES IN THE LEAF

Outlines of Xylem and Phloem

The term 'outline' is used here with reference to the outer boundary of the xylem and phloem in transverse sections. It does *not* refer to the outer boundary of the single bundle-sheath where there is but one, or to that of the outer bundle-sheath where there are two. It is common to find a bundle of which the xylem and phloem are angular in outline enclosed by a bundle-sheath that is more or less circular to oval, or even 'winged'.

Bundles, usually small, with xylem and phloem not conspicuously angular in outline (Fig. VIII, 2)

Aegilops crassa
„ triaristata
„ ventricosa
„ littoralis
Agropyron caninum
„ elongatum
„ intermedium
„ laxum
Agrostis semiverticillata
„ stolonifera var. palustris
Alopecurus geniculatus
myosuroides
Alopecurus pratensis
Ammophila arenaria
Ampelodesmos mauritanica
Andropogon schirensis
Anthochloa lepidula
Anthoxanthum odoratum
Aristida ciliata var. capensis
„ longiflora
„ pungens
„ setacea
Arrhenatherum elatius
Arundinella villosa
Arundo donax
Astrebla squarrosa
Avena ludoviciana

Bundles, usually small, with xylem and phloem not conspicuously angular in outline (cont.)

Avena (Helictotrichon) pubescens
„ strigosa
Bouteloua curtipendula
Brachypodium pinnatum
„ sylvaticum
Briza erecta
Bromus carinatus
„ coloratus
„ fibrosus
„ inermis
„ japonicus
„ sterilis
„ tectorum
„ unioloides
Brylkinia caudata
Calamovilfa longifolia
Capillipedium sp.
Centotheca lappacea
Coix lacryma-jobi
Cortaderia conspicua
„ selloana
Cymbopogon citratus
„ giganteus
Cynosurus cristatus
Danthonia compressa
„ flavescens
„ spicata
„ „ var. typica
Desmostachya bipinnata
Deyeuxia quadriseta
Diarrhena americana
Dichelachne crinita
Ectosperma alexandrae
Ehrharta abyssinica
„ villosa var. maxima
Elymus arenarius
„ canadensis
„ (Taeniatherum) caput-medusae
„ condensatus
„ interruptus
„ virginicus
Eragrostis curvula
Festuca arundinacea
„ „ ×Lolium perenne
„ glauca
„ heterophylla
„ 'punctoria'
Glyceria fluitans
„ maxima
Hakonechloa macra
Helictotrichon albinerve
„ planiculme
„ pubescens
Heteranthelium piliferum
Heteranthoecia guineensis
Hierochloe odorata
Hierochloe redolens
Holcus lanatus
„ mollis
Hordelymus europaeus
Hordeum jubatum
„ murinum
„ secalinum
„ stenostachys
Imperata cylindrica
Koeleria cristata
„ phleoides
Lagurus ovatus
Lamarckia aurea
Leersia hexandra
„ oryzoides
Lolium multiflorum
Loudetia superba
„ sp.
Lycochloa avenacea
Lygeum spartum
Megastachya mucronata
Melica altissima
„ ciliata
„ uniflora
Micraira subulifolia
Microlaena stipoides
Miscanthidium teretifolium
Molinia caerulea
Nardus stricta
Neurolepis aristata
„ nobilis
Olyra latifolia
Oryza sativa var. violacea
Oryzopsis asperifolia
„ paradoxa
„ racemosa
Parapholis strigosa
Pariana bicolor
„ campestris
„ vulgaris
Perotis patens
Phaenosperma globosum
Phalaris caerulescens
„ canariensis
„ minor
Phyllorachis sagittata
Plectrachne danthonioides
„ desertorum
„ schinzii
Poa glauca
„ iridifolia
„ palustris
Pogonarthria squarrosa
Polypogon chilensis
„ monspeliensis
Psammochloa villosa
Puccinellia fasciculata
„ maritima
Rhytachne rottboellioides

Saccharum bengalense
„ officinarum
„ spontaneum
Secale cereale
Streptochaeta spicata
Streptogyna crinita
Tetrarrhena distichophylla
Thysanolaena maxima
Trikeraia hookeri
Uniola latifolia
Triticum dicoccoides
„ dicoccum
„ polonicum
Uniola latifolia
(Vetiveria zizanioides)
(Zizania latifolia)

Bundles tall and narrow with their vertical sides more or less parallel to one another— Leptaspis *type* (Fig. VIII, 3)

Anomochloa marantoidea
Apluda mutica var. aristata
Leptaspis cochleata
Pariana bicolor
„ campestris
„ vulgaris
Pharus latifolius

Bundles mostly small with their xylem and phloem conspicuously angular in outline (Fig. VIII, 4–5)

Acroceras tonkinense
„ zizanioides
Aeluropus littoralis
Agrostis semiverticillata
Alloteropsis cimicina
Andropogon amplectens
Anomochloa marantoidea
Apluda mutica var. aristata
Arthraxon quartinianus
Beckeropsis uniseta
Bothriochloa caucasica
„ pertusa
Bouteloua curtipendula
Brachiaria deflexa
„ distichophylla
„ jubata
„ paspaloides
„ reptans
Bromuniola gossweileri
Buchloe dactyloides
Cenchrus biflorus
„ ciliaris
„ pauciflorus
Chloris barbata
„ filiformis
„ pycnothrix
„ robusta
„ (Eustachys) uliginosa
„ virgata
Chrysopogon zeylanicus
Cleistachne sorghoides
Coelachne hackelii
„ perpusilla
„ simpliciuscula
Coelachyrum brevifolium
Coix lacryma-jobi
Cymbopogon citratus
„ giganteus
„ martinii
„ nardus
„ validus
Cynodon dactylon
Cyrtococcum trigonum
Dactyloctenium aegyptium
„ giganteum
Dichanthium aristatum
„ polyptychum
„ sericeum
Digitaria borbonica
„ brazzae
„ horizontalis
„ milanjiana
Dimeria thwaitesii
Distichlis distichophylla
Echinochloa colonum
„ crus-galli
Eleusine coracana
„ indica
Elyonurus chevalieri
„ hirtifolius
Enneapogon cenchroides
Eragrostiella bifaria
Eragrostis aspera
„ chloromelas
„ curvula
„ diplachnoides
„ gangetica
„ unioloides
Euchlaena perennis
Euchlaezea mertonensis
Euclasta condylotricha
Eulalia geniculata
„ phaeothrix
Fingerhuthia africana
Garnotia courtallensis
Hemarthria uncinata
Heteropogon contortus
Hyparrhenia dissoluta
Isachne kunthiana
„ walkeri
Ischaemum commutatum
„ santapaui

Bundles mostly small with their xylem and phloem conspicuously angular in outline (cont.)

Leptocarydion vulpiastrum
Leptochloa caerulescens
„ uniflora
Lophatherum gracile
Melinis minutiflora
Microstegium ciliatum
Miscanthus condensatus
„ sacchariflorus
Muhlenbergia racemosa
Neostapfia colusana
Oplismenus compositus
Oropetium thomaeum
Panicum capillare
„ clandestinum
„ maximum
„ miliaceum
„ obtusum
„ repens
„ virgatum
Paspalidium geminatum
Paspalum commersonii
„ conjugatum
„ distichum
„ paniculatum
Pennisetum clandestinum
„ macrourum
Perotis indica
„ patens
Phragmites communis
Pogonatherum paniceum
Pseudanthistiria umbellata
Rhynchelytrum repens
Rottboellia exaltata
Saccharum officinarum
Sacciolepis interrupta
Schizachyrium jeffreysii
Setaria barbata
„ glauca
„ italica
„ plicata
„ viridis
Snowdenia polystachya
Sorghum halepense
Sporobolus africanus
„ diander
„ indicus
„ molleri
„ poiretii
„ pyramidalis
„ wrightii
Stenotaphrum dimidiatum
Themeda australis
„ quadrivalvis
„ tremula
„ triandra
Tragus berteronianus
Tragus racemosus
Trichachne insularis
Triplopogon spathiflorus
Tripsacum dactyloides
Triraphis pumilio
Urochloa pullulans
(Vetiveria zizanioides)

Small bundles with xylem and phloem not more than inconspicuously angular (Fig. VIII, 6). *Merges with the non-angular type of bundle* (Fig. VIII, 2)

Andropogon schirensis
Arundinella metzii
Cenchrus ciliaris
Chloris robusta
Chrysopogon zeylanicus
Coelachne perpusilla
„ simpliciuscula
Cymbopogon giganteus
Dichanthium polyptychum
„ sericeum
Eragrostiella bifaria
Eragrostis aspera
„ chloromelas
„ curvula
Erianthus hostii
Heteranthoecia guineensis
Hyparrhenia dissoluta
Imperata cylindrica
Isachne kunthiana
„ mauritiana
„ walkeri
Ischaemum santapaui
Leersia hexandra
„ oryzoides
Loudetia superba
„ sp.
Microlaena stipoides
Panicum obtusum
„ repens
„ virgatum
Pariana bicolor
Paspalum conjugatum
„ distichum
„ paniculatum
Pennisetum macrourum
Phragmites communis
Pogonarthria squarrosa
Saccharum bengalense
„ officinarum
„ spontaneum
Schizachyrium jeffreysii
Sorghum halepense
Spartina maritima
„ townsendii
Sphaerocaryum malaccense

Spinifex hirsutus
Stenotaphrum dimidiatum
„ secundatum
Trichachne insularis
Tristachya hispida
„ inamoena
Uniola latifolia
Zizania latifolia

SCLERENCHYMA (Fig. IX)

In the text of this book sclerenchyma associated with the vascular bundles is described as consisting of 'girders' when it extends from the epidermis to the bundle-sheath or to the xylem and phloem (e.g. Fig. IX, 3–8). When it is not in contact with the bundle-sheath it is described as consisting of 'strands' (e.g. Fig. IX, 2). In order to reduce the number of illustrations, the various types of sclerenchyma distribution have been shown mostly as girders and only a few as strands. The reader should bear in mind that all of the types of sclerenchyma shown as girders can also exist as strands, and those shown as strands can also exist as girders. In the descriptions of the species it has always been stated as clearly as possible whether 'strands', 'girders', or both are present.

Some types of sclerenchyma distribution occur so widely that they are of little taxonomic value except as confirmatory characters for the indentification of species. This applies for example to vascular bundles accompanied by small adaxial and abaxial strands or girders (Fig. IX, 4) which are to be found in a great many grass species, which may or may not be closely related to one another. These widespread types of sclerenchyma have not been included in the following tables. The reader must not, therefore, assume that the types of sclerenchyma distribution shown in the following tables are the only ones for the species concerned. For example, *Setaria barbata* is listed amongst the species having vascular bundles accompanied by well marked abaxial girders only. This does not mean that all of the bundles in *Setaria barbata* are accompanied only by well marked abaxial girders. On the contrary, reference to the description of this species on p. 444 will show that bundles accompanied by abaxial girders are restricted to the keel.

Well marked abaxial girder only (Fig. IX, 3). (*Often restricted to the keel bundles or a few large bundles*)

Aegilops ventricosa
Agropyron elongatum
„ intermedium
„ laxum
Ampelodesmos mauritanica
Andropogon schirensis
Apluda mutica var. aristata
Aristida ciliata var. capensis
„ longiflora
„ pungens
Astrebla squarrosa
Brachiaria jubata
Briza erecta
Bromus coloratus
„ fibrosus
Calamagrostis epigejos
Chloris robusta
Chloris virgata
Chrysopogon zeylanicus
Coix lacryma-jobi
Cortaderia conspicua
Cymbopogon citratus
„ giganteus
Dactyloctenium giganteum
Danthonia flavescens
Desmostachya bipinnata
Diarrhena americana
Dichanthium polyptychum
Eleusine coracana
„ indica
Elymus arenarius
„ canadensis
„ condensatus
Eragrostis gangetica
Erianthus hostii
Euchlaena perennis
Euchlaezea mertonensis

Well marked abaxial girder only (cont.)

Festuca arundinacea
Hierochloe odorata
Hordeum murinum
„ stenostachys
Lygeum spartum
Melinis minutiflora
Miscanthidium teretifolium
Miscanthus condensatus
„ sacchariflorus
Nardus stricta
Oryzopsis asperifolia
Panicum maximum
„ miliaceum
„ obtusum
Pennisetum clandestinum
„ macrourum
Psammochloa villosa
Puccinellia fasciculata
„ maritima
Rottboellia exaltata
Saccharum bengalense
„ officinarum
„ spontaneum
Setaria barbata
„ plicata
„ viridis
Sorghum halepense
Sporobolus africanus
„ wrightii
Themeda australis
Thysanolaena maxima
Triplopogon spathifolius
Tripsacum dactyloides
Tristachya hispida
Triticum polonicum
Vetiveria zizanioides
Zizania latifolia

Combined girders anchor-shaped (Fig. IX, 6). (*Frequently restricted to large vb's or to the median vb*)

Anomochloa marantoidea
Arthraxon quartinianus
Bothriochloa pertusa
Brachypodium pinnatum
„ sylvaticum
Bromuniola gossweileri
Bromus carinatus
„ coloratus
„ inermis
„ japonicus
„ sterilis
„ tectorum
„ unioloides
Capillipedium sp.
Centotheca lappacea
Cymbopogon giganteus
Dactyloctenium aegyptium
Danthonia compressa
Dichanthium polyptychum
Eragrostiella bifaria
Festuca arundinacea
Fingerhuthia africana
Garnotia courtallensis
Hordelymus europaeus
Hyparrhenia dissoluta
Isachne kunthiana
Leersia hexandra
„ oryzoides
Megastachya mucronata
Melica ciliata
„ uniflora
Molinia caerulea
Olyra latifolia
Oplismenus compositus
Oropetium thomaeum
Panicum clandestinum
Pariana bicolor
„ campestris
„ vulgaris
Perotis indica
„ patens
Phyllorachis sagittata
Pogonatherum paniceum
Thysanolaena maxima (tendency)
Tristachya hispida
Uniola latifolia
Urochloa pullulans

Combined girders inversely anchor-shaped (*Converse of* Fig. IX, 6)

Andropogon schirensis
Aristida setacea
Diarrhena americana
Isachne mauritiana
Melica ciliata
Oryzopsis racemosa
Sphaerocaryum malaccense
Sporobolus poiretii (large vb's)
„ pyramidalis (large vb's)
„ wrightii (large vb's)

Adaxial and abaxial girders tall and narrow (Fig. IX, 7)

Alopecurus pratensis
Brachypodium pinnatum
Briza erecta
Brylkinia caudata
Calamagrostis epigejos
Danthonia compressa
„ flavescens
„ spicata var. typica
Ehrharta villosa var. maxima
Elymus condensatus

Festuca arundinacea
Helictotrichon planiculme
Hierochloe odorata
Holcus lanatus
„ mollis
Hordeum nodosum
Melica ciliata
Molinia caerulea
Oryzopsis asperifolia
Phalaris caerulescens
Secale cereale
Tetrarrhena distichophylla (small vb's)
Trikeraia hookeri (small vb's)

Bundles with an adaxial T- *and abaxial* I-*girder* (Fig. IX, 8)

Agropyron elongatum
„ intermedium
Ammophila arenaria
Aristida ciliata var. capensis
„ longiflora
„ pungens
Danthonia flavescens
Elymus arenarius
Hierochloe redolens
Hordeum stenostachys
Oryzopsis asperifolia
Psammochloa villosa

Specialized types as illustrated (Fig. IX, 9–11)

Ampelodesmos mauritanica
Cortaderia conspicua
„ selloana
Isachne mauritiana
„ walkeri
Pennisetum macrourum
Spinifex hirsutus

LAMINA OUTLINE

Lamina a solid cylinder with a slight adaxial groove

Miscanthidium teretifolium

KEEL OR MIDRIB BUNDLES

Keel or midrib large, abaxially rounded, containing an arc of numerous vascular bundles of equal or unequal sizes (Fig. XIII, 3 and 5)

Andropogon schirensis
Apluda mutica var. aristata
Arundinella metzii
Astrebla squarrosa
Beckeropsis uniseta
Bothriochloa pertusa
Brachiaria deflexa
„ jubata
„ paspaloides
Cenchrus biflorus
„ ciliaris
„ pauciflorus
Chloris barbata
„ pycnothrix
Cleistachne sorghoides
Coix lacryma-jobi
Cymbopogon citratus
„ martinii
„ validus
Dactyloctenium aegyptium
„ giganteum
Desmostachya bipinnata
Diarrhena americana
Dichanthium aristatum
„ sericeum
Digitaria borbonica
„ brazzae
„ horizontalis
„ milanjiana
Echinochloa colonum
Eragrostis aspera
Erianthus hostii
Euchlaena perennis
Euchlaezea mertonensis
Euclasta condylotricha
Eulalia geniculata
Hemarthria uncinata
Heteropogon contortus
Hyparrhenia dissoluta
Ischaemum commutatum
„ santapaui
Loudetia superba
Melinis minutiflora
Microstegium ciliatum
Miscanthus condensatus
„ sacchariflorus
Panicum maximum
„ miliaceum
„ repens
Paspalum commersonii
„ paniculatum
Pennisetum clandestinum
Phragmites communis
Rhynchelytrum repens

Keel or midrib large, abaxially rounded, containing an arc of numerous vascular bundles of equal or unequal sizes (cont.)

Rottboellia exaltata
Saccharum bengalense
„ spontaneum
Schizachyrium jeffreysii
Setaria viridis
Sporobolus africanus
„ indicus
„ molleri
„ pyramidalis
„ wrightii
Stenotaphrum secundatum
Themeda australis
Thysanolaena maxima
Trichachne insularis
Triplopogon spathiflorus
Tripsacum dactyloides
Tristachya hispida
„ inamoena
Vetiveria zizanioides

Keel large, abaxially triangular; containing numerous vascular bundles of equal or unequal sizes (Fig. XIII, 4)

Apluda mutica var. aristata
Bromus unioloides
Chloris virgata
Chrysopogon zeylanicus
Dichanthium polyptychum
Eleusine coracana
Paspalum conjugatum
Setaria barbata
Snowdenia polystachya
Sorghum halepense

Keel containing a complex system of vascular bundles and air-cavities (*the* Zizania *type*) (Fig. XIII, 6)

Oryza sativa var. violacea
Zizania latifolia

Keel large; containing a complex system of vascular bundles and associated sclerenchyma (*the bamboo type*) (Fig. XVII)

Olyra latifolia
Pariana spp. (tending to be this type)
Pharus latifolius (tending to be this type)
Streptogyna crinita

MESOPHYLL

Chlorenchyma conspicuously radiate (*including the Isachne type*)

Acroceras tonkinense
Aeluropus littoralis
Alloteropsis cimicina
Andropogon amplectens
„ schirensis
Apluda mutica var. aristata
Aristida sp.
Astrebla squarrosa
Bothriochloa caucasica
„ pertusa
Bouteloua curtipendula
Brachiaria distichophylla
Buchloe dactyloides
Calamovilfa longifolia
Cenchrus biflorus
„ ciliaris
„ pauciflorus
Chloris robusta
„ virgata
Chrysopogon zeylanicus
Cleistachne sorghoides
Coelachne hackelii
„ perpusilla
„ simpliciuscula
Cymbopogon citratus
Cymbopogon martinii
„ nardus
„ validus
Cynodon dactylon
Cyrtococcum trigonum (1 out of 2 samples)
Dactyloctenium giganteum
Dichanthium aristatum
„ polyptychum
„ sericeum
Digitaria brazzae
„ horizontalis
Dimeria thwaitesii
Distichlis distichophylla
Echinochloa colonum
„ crus-galli
Eleusine indica
Elyonurus chevalieri
Eragrostiella bifaria
Eragrostis aspera
„ chloromelas
„ curvula
„ gangetica
Erianthus hostii
Euclasta condylotricha
Eulalia geniculata
Fingerhuthia africana
Heteropogon contortus

Hyparrhenia dissoluta
Imperata cylindrica
Isachne kunthiana
„ mauritiana
„ walkeri
Ischaemum santapaui
Leptocarydion vulpiastrum
Leptochloa caerulescens
Loudetia superba
Melinis minutiflora
Miscanthus condensatus
„ sacchariflorus
Muhlenbergia racemosa
Oropetium thomaeum
Panicum capillare
„ clandestinum
„ miliaceum
„ repens
„ virgatum
Paspalum commersonii
„ paniculatum
Pennisetum clandestinum
Perotis indica
„ patens
Pogonarthria squarrosa
Pogonatherum paniceum
Rhynchelytrum repens
Schizachyrium jeffreysii
Setaria glauca
„ italica
„ viridis
Snowdenia polystachya
Sorghum halepense
Spartina maritima
Sphaerocaryum malaccense
(Spinifex hirsutus)
Sporobolus africanus
(„ virginicus)
„ wrightii
Stenotaphrum dimidiatum
Themeda australis
„ quadrivalvis
„ tremula
„ triandra
Triplopogon spathiflorus

Chlorenchyma inconspicuously or incompletely radiate

Acroceras zizanioides
Aristida setacea
Arthraxon quartinianus
Arundo donax
Beckeropsis uniseta
Brachiaria deflexa
„ jubata
„ paspaloides
„ reptans
Bromuniola gossweileri
Centotheca lappacea
Chloris barbata
„ filiformis
„ pycnothrix
„ (Eustachys) uliginosa
Coelachyrum brevifolium
Cortaderia selloana
Cyrtococcum trigonum (1 out of 2 samples)
Dactyloctenium aegyptium
Desmostachya bipinnata
Digitaria borbonica
„ horizontalis
„ milanjiana
Eleusine coracana
Elyonurus hirtifolius
Eragrostis unioloides
Eulalia phaeothrix
Hemarthria uncinata
Ischaemum commutatum
Melinis minutiflora
Microlaena stipoides
Microstegium ciliatum
Oplismenus compositus
Oryzopsis asperifolia
„ paradoxa
Panicum maximum
„ obtusum
Paspalidium geminatum
Paspalum conjugatum
Pennisetum macrourum
Rhynchelytrum repens
Rhytachne rottboellioides
Rottboellia exaltata
Saccharum bengalense
„ officinarum
Setaria barbata
„ plicata
Spartina maritima
Spinifex hirsutus
Sporobolus diander
„ indicus
„ molleri
„ poiretii
„ pyramidalis
Tragus berteronianus
„ racemosus
Tristachya hispida
„ inamoena
Urochloa pullulans

Chlorenchyma not radiate

Aegilops crassa
„ triaristata
„ ventricosa
Agropyron caninum

Chlorenchyma not radiate (cont.)

Agropyron elongatum
„ intermedium
„ laxum
Agrostis semiverticillata
„ stolonifera var. palustris
Alopecurus geniculatus
„ myosuroides
„ pratensis
Ammophila arenaria
Ampelodesmos mauritanica
Anomochloa marantoidea
Anthochloa lepidula
Anthoxanthum odoratum (1 out of 2 samples)
Aristida ciliata var. capensis
„ pungens
Arrhenatherum elatius
Arthraxon quartinianus
Arundinella metzii
Arundo donax
Avena ludoviciana
„ (Helictotrichon) pubescens
„ strigosa
Brachiaria deflexa
„ paspaloides
Brachypodium pinnatum
„ sylvaticum
Briza erecta
Bromus carinatus
„ coloratus
„ fibrosus
„ inermis
„ japonicus
„ sterilis
„ tectorum
„ unioloides
Brylkinia caudata
Calamagrostis epigejos
Coix lacryma-jobi
Cortaderia conspicua
„ selloana
Cynosurus cristatus
Danthonia compressa
flavescens
„ spicata
„ „ var. typica
Deyeuxia quadriseta
Diarrhena americana
Dichelachne crinita
Ehrharta abyssinica
„ villosa var. maxima
Elymus arenarius
„ canadensis
„ (Taeniatherum) caput-medusae
„ condensatus
„ interruptus
„ virginicus
Euchlaena perennis
Euchlaezea mertonensis
Festuca arundincaea
„ „ ×Lolium perenne
„ glauca
„ heterophylla
„ 'punctoria'
Garnotia courtallensis
Glyceria fluitans
„ maxima
Hakonechloa macra
Helictotrichon albinerve
„ planiculme
„ pubescens
Heteranthelium piliferum
Hierochloe odorata
„ redolens
Holcus mollis
Hordelymus europaeus
Hordeum jubatum
„ murinum
„ secalinum
„ stenostachys
Koeleria cristata
„ phleoides
Lagurus ovatus
Lamarckia aurea
Leersia hexandra
„ oryzoides
Leptaspis cochleata
Leptochloa uniflora
Lolium multiflorum
Lophatherum gracile
Lycochloa avenacea
Lygeum spartum
Megastachya mucronata
Melica altissima
„ ciliata
„ uniflora
Micraira subulifolia
Microlaena stipoides
Miscanthidium teretifolium
Molinia caerulea
Nardus stricta
Neostapfia colusana
Neurolepis aristata
„ nobilis
Olyra latifolia
Oryza sativa var. violacea
Oryzopsis asperifolia
„ paradoxa
„ racemosa
Parapholis strigosa
Pariana bicolor
„ campestris
„ vulgaris
Paspalum distichum
Pentapogon quadrifidus
Phaenosperma globosum
Phalaris caerulescens

Phalaris canariensis
„ minor
Pharus latifolius
Phragmites communis
Phyllorachis sagittata
Plectrachne danthonioides
„ desertorum
„ schinzii
Poa glauca
„ iridifolia
„ palustris
Polypogon chilensis
„ monspeliensis
Psammochloa villosa
Puccinellia fasciculata
„ maritima
Secale cereale
Sieglingia decumbens
Streptochaeta spicata
Streptogyna crinita
Tetrarrhena distichophylla
Thysanolaena maxima
Trichachne insularis
Trikeraia hookeri
Tripsacum dactyloides
Triticum dicoccoides
„ dicoccum
„ polonicum
Uniola latifolia
Zizania latifolia

Chlorenchyma consisting of arm-cells

Anomochloa marantoidea
Leersia hexandra
Neurolepis aristata
„ nobilis
Olyra latifolia
Oryza sativa var. violacea
Pariana bicolor
„ campestris
„ vulgaris
Phyllorachis sagittata
Streptogyna crinita
Thysanolaena maxima
Zizania latifolia

BULLIFORM AND COLOURLESS CELLS

Cells of unequal sizes in irregular groups (Fig. XV, 1)

Andropogon amplectens
„ schirensis
Anomochloa marantoidea
Apluda mutica var. aristata
Arrhenatherum elatius
Arthraxon quartinianus
Beckeropsis uniseta
Bothriochloa caucasica
„ pertusa
Cenchrus ciliaris
Centotheca lappacea (1 out of 2 samples)
Chrysopogon zeylanicus
Cleistachne sorghoides
Coix lacryma-jobi
Cymbopogon citratus
„ giganteus
„ martinii
„ nardus
„ validus
Dichanthium aristatum
„ polyptychum
Digitaria borbonica
„ brazzae
„ horizontalis
„ milanjiana
Dimeria thwaitesii
Echinochloa colonum
„ crus-galli
Elyonurus chevalieri
„ hirtifolius
Euclasta condylotricha
Heteropogon contortus
Hyparrhenia dissoluta
Ischaemum commutatum
„ santapaui
Lophatherum gracile
Megastachya mucronata
Microstegium ciliatum
Panicum clandestinum
„ maximum
Paspalum conjugatum
„ distichum
„ paniculatum
Pennisetum clandestinum
Pharus latifolius
Pogonatherum paniceum
Pseudanthistiria umbellata
Rottboellia exaltata
Schizachyrium jeffreysii
Setaria italica
Snowdenia polystachya
Sorghum halepense
Themeda australis
„ quadrivalvis
„ tremula
„ triandra
Trichachne insularis
Triplopogon spathiflorus

Cells of uniform size in well-defined groups (Fig. XV, 2)

Acroceras tonkinense
Aegilops crassa
„ triaristata
„ ventricosa
Agropyron caninum
„ intermedium
„ laxum
Agrostis semiverticillata
„ stolonifera var. palustris
Alopecurus geniculatus
„ myosuroides
„ pratensis
Anthoxanthum odoratum
Arrhenatherum elatius
Arundinella metzii
Avena ludoviciana
„ strigosa
Beckeropsis uniseta
Brachypodium pinnatum
„ sylvaticum
Bromuniola gossweileri
Bromus carinatus
„ coloratus
„ inermis
„ japonicus
„ sterilis
„ tectorum
Brylkinia caudata
Cenchrus biflorus
„ pauciflorus
Centotheca lappacea
Coelachne hackelii
„ perpusilla
„ simpliciuscula
Coix lacryma-jobi
Cyrtococcum trigonum
Danthonia spicata
„ „ var. typica
Diarrhena americana
Digitaria brazzae
Ehrharta abyssinica
Elymus canadensis
„ condensatus
„ interruptus
„ virginicus
Erianthus hostii
Garnotia courtallensis
Hakonechloa macra
Heteranthelium piliferum
Holcus lanatus
„ mollis
Hordelymus europaeus
Hordeum murinum
„ secalinum
Hyparrhenia dissoluta
Isachne kunthiana
Isachne mauritiana
„ walkeri
Koeleria phleoides
Lolium multiflorum
Lycochloa avenacea
Megastachya mucronata
Melica altissima
„ uniflora
Miscanthus sacchariflorus
Olyra latifolia
Oplismenus compositus
Oryzopsis racemosa
Panicum clandestinum
„ maximum
„ obtusum
Pariana bicolor
„ campestris
Paspalum conjugatum
Pennisetum clandestinum
Phaenosperma globosum
Phalaris canariensis
Pharus latifolius
Phyllorachis sagittata
Polypogon chilensis
Rottboellia exaltata
Secale cereale
Setaria barbata
„ italica
„ plicata
Sphaerocaryum malaccense
Stenotaphrum dimidiatum (1 median group only)
Stenotaphrum secundatum
Streptochaeta spicata
Tripsacum dactyloides
Triticum dicoccoides
„ dicoccum
„ polonicum
Uniola latifolia (near leaf margins)

Cells in groups of the Zea *type* (Fig. XV, 3)

Beckeropsis uniseta
Cleistachne sorghoides
Diarrhena americana
Dichanthium aristatum
„ sericeum
Euchlaena perennis
Euchlaezea mertonensis
Eulalia phaeothrix
Lycochloa avenacea
Oplismenus compositus
Pariana bicolor
Paspalum commersonii
„ paniculatum
Pennisetum clandestinum

Saccharum officinarum
Setaria barbata
Tripsacum dactyloides
Tristachya hispida
„ inamoena
Zea mays

Cells in fan-shaped groups (Fig. XV, 4 and 6)

Acroceras zizanioides
Aegilops triaristata
„ ventricosa
Agropyron elongatum
„ intermedium
„ laxum
Agrostis stolonifera var. palustris
Alloteropsis cimicina
Alopecurus geniculatus
„ myosuroides (1 out of 2 samples)
Alopecurus pratensis
Anthoxanthum odoratum
Arundinella metzii
„ villosa
Avena ludoviciana
„ strigosa
Bothriochloa pertusa
Brachiaria deflexa
„ distichophylla
„ jubata
Brachypodium pinnatum
Briza erecta
Bromus carinatus
„ fibrosus
„ inermis
„ unioloides
Brylkinia caudata
Calamagrostis epigejos
Capillipedium sp.
Cenchrus biflorus
„ pauciflorus
Coelachyrum brevifolium
Cynosurus cristatus
Cyrtococcum trigonum
Danthonia spicata
„ „ var. typica
Diarrhena americana
Dichanthium aristatum
„ polyptychum
„ sericeum
Dichelachne crinita
Ectosperma alexandrae
Ehrharta abyssinica
„ villosa var. maxima
Elymus canadensis
Elyonurus hirtifolius
Enneapogon cenchroides
Eulalia phaeothrix
Festuca arundinacea
„ „ ×Lolium perenne
„ heterophylla
„ 'punctoria'
Glyceria fluitans
„ maxima
Hakonechloa macra
Helictotrichon planiculme
„ pubescens
Heteranthoecia guineensis
Heteropogon contortus
Hierochloe odorata
„ redolens
Holcus lanatus
Hordelymus europaeus
Hordeum jubatum
„ murinum
„ secalinum
„ stenostachys
Isachne kunthiana
„ walkeri
Koeleria cristata
„ phleoides
Lamarckia aurea
Leersia hexandra
Lolium multiflorum
Lycochloa avenacea
Melica ciliata
Micraira subulifolia
Microlaena stipoides
Microstegium ciliatum
Miscanthus sacchariflorus
Molinia caerulea
Muhlenbergia racemosa
Olyra latifolia
Oropetium thomaeum
Oryza sativa var. violacea
Oryzopsis asperifolia
„ paradoxa
„ racemosa
Panicum capillare
„ clandestinum
„ obtusum
Pariana bicolor
„ campestris
„ vulgaris
Paspalum distichum
Pennisetum macrourum
Pentapogon quadrifidus
Phalaris caerulescens
„ canariensis
„ minor
Poa iridifolia
Polypogon chilensis
Psammochloa villosa
Puccinellia fasciculata
Rhynchelytrum repens
Saccharum bengalense
„ spontaneum

Cells in fan-shaped groups (cont.)

Sacciolepis interrupta
Spinifex hirsutus
Streptogyna crinita
Tetrarrhena distichophylla
Themeda australis (1 median group only)
,, quadrivalvis (1 median group only)
Themeda tremula (1 median group only)
,, triandra (1 median group only)
Tristachya inamoena
Triticum dicoccoides
Uniola latifolia
Urochloa pullulans
Zizania latifolia

Cells not large; in deep furrows (Ammophila *type*) (Fig. XV, 5)

Ammophila arenaria
Ampelodesmos mauritanica
Cortaderia conspicua
,, selloana
Danthonia flavescens
Deyeuxia quadriseta
Distichlis distichophylla
Ectosperma alexandrae
Elymus arenarius
Festuca glauca
,, heterophylla (large type of leaf only)
Helictotrichon albinerve
Heteranthoecia guineensis
Hierochloe redolens
Lygeum spartum
Melica ciliata
Nardus stricta
Parapholis strigosa
Pentapogon quadrifidus
Polypogon monspeliensis
Puccinellia maritima
Spartina maritima
,, townsendii
(Spinifex hirsutus)
Trikeraia hookeri

Arundo *type* (Fig. XV, 7)

Arundo donax
Sporobolus wrightii

Sporobolus *type* (Fig. XV, 8–9)

Alloteropsis cimicina
Aristida sp.
Bouteloua curtipendula
Brachiaria deflexa
,, distichophylla
,, jubata
,, paspaloides
,, reptans
Buchloe dactyloides
Calamovilfa longifolia
Cenchrus ciliaris
Chloris barbata
,, filiformis
,, pycnothrix
,, robusta
,, virgata
Dactyloctenium aegyptium
,, giganteum
Distichlis distichophylla
Eleusine coracana
,, indica
Enneapogon cenchroides
Eragrostiella bifaria
Eragrostis aspera
,, chloromelas
,, curvula
,, diplachnoides
,, gangetica
,, unioloides
Eulalia geniculata
Heteropogon contortus
Imperata cylindrica
Leersia oryzoides
Leptocarydion vulpiastrum
Leptochloa caerulescens
Loudetia superba
Melinis minutiflora
Muhlenbergia racemosa
Neurolepis aristata
,, nobilis
Oryza sativa var. violacea
Panicum capillare
,, miliaceum
,, obtusum
,, repens
,, virgatum
Perotis indica
,, patens
Phragmites communis
Rhynchelytrum repens
Sporobolus africanus
,, diander
,, indicus
,, molleri
,, poiretii
,, pyramidalis
Thysanolaena maxima
Tragus berteronianus
,, racemosus
Triraphis pumilio
Zizania latifolia

Bulliform and colourless cells as arches over the vb's (Fig. XV, 10)

Erianthus hostii
Imperata cylindrica
Miscanthus condensatus
,, sacchariflorus
Saccharum officinarum
,, spontaneum
Tristachya hispida
,, inamoena

Adaxial half of the mesophyll consisting of colourless cells (Chloris *type* (Fig. XV, 11)

Andropogon schirensis
Chloris barbata
,, virgata
Cymbopogon citratus
,, giganteus
,, martinii
,, nardus
,, validus
Dactyloctenium aegyptium
,, giganteum
Elyonurus chevalieri
Hemarthria uncinata
Pennisetum macrourum
Stenotaphrum dimidiatum (converse of *Chloris* type with abaxial colourless cells)
Stenotaphrum secundatum (converse of *Chloris* type with abaxial colourless cells)

Wide girders of colourless cells extending from the bases of adaxial furrows almost to the vb's (Fig. XV, 12)

Aristida pungens

Groups of the Sporobolus *type* (*as* Fig. XV, 8–9) *with narrow, often uniseriate, girders of colourless cells extending to the abaxial surface* (Fig. XV, 13)

Aristida sp.
Astrebla squarrosa
Bouteloua curtipendula
Buchloe dactyloides
Chloris filiformis
,, robusta
Cynodon dactylon (2 out of 3 samples)
Distichlis distichophylla
Eleusine coracana
,, indica (1 out of 2 samples)
Eragrostiella bifaria
Eragrostis chloromelas
,, gangetica
,, unioloides
Eulalia geniculata
Fingerhuthia africana
Imperata cylindrica
Loudetia superba
Panicum capillare
,, miliaceum
,, repens
Perotis indica
,, patens
Pogonarthria squarrosa

Girders of colourless cells, often relatively wide, extending from the adaxial to the abaxial epidermis (Fig. XV, 14)

Aeluropus littoralis
Aristida ciliata var. capensis
,, longiflora
,, pungens
,, setacea
Desmostachya bipinnata
Distichlis distichophylla

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NEOSTAPFIA

DIAGNOSTIC GENERIC CHARACTERS

Short-cells infrequent. Silica-bodies: none seen. Hairs: crozier-hairs, stalked sunken glands and multicellular emergences present. Stomata with tall dome-shaped subsidiary cells. Vascular bundles mostly small, rather widely spaced, and not very conspicuously angular in outline. Mesophyll with chlorenchyma conspicuously radiate. Bundle-sheaths single and double.

SPECIES SPECIALLY DESCRIBED

Neostapfia colusana (Davy) Davy

LEAF

Abaxial epidermis

Short-cells infrequent. **Silica-bodies:** none observed in the available material; probably absent or very rare. **Macro-hairs:** crozier-hairs (Fig. II*a*, 7) 60–72 μ in length, with hooked, often silicified, apices, common on both surfaces but especially on the ribs and in the furrows on the abaxial surface. Solitary, slightly sunken, stalked glands, each with a spherical unicellular head 10–15 μ in diameter (Fig. II*a*, 9), and a large foot at the base of the stalk, common, especially on the abaxial surface. **Micro-hairs:** the stalked glands just described are probably homologous with micro-hairs being 2-celled. **Prickle-hairs:** none seen. **Emergences:** large, solitary, conspicuous, multicellular, wart-like apparently glandular emergences, frequent both over and between the veins on the abaxial surface and at the leaf margins. (These emergences vary considerably in size and in the number of cells of which each is composed and they consist, for the most part, of large, thin-walled cells, the proximal part of each emergence being somewhat stalk-like and about 3–6 cells wide and 1–3 cells high, some stalks being of uniform diameter throughout their lengths, but others tapering somewhat towards their bases. Cells of the stalks sometimes axially elongated, this character being most pronounced in the tallest emergences. Apices of the emergences rounded or dome-shaped, and each consisting of a single layer, up to about 8 cells wide, of cells with a somewhat glandular appearance. The apical cell-layers of the largest of the emergences almost resemble the caps of small agaric fructifications, since they are slightly wider than the stalks.) **Papillae:** unthickened, globose papillae (Fig. III, 3) abundant on both leaf surfaces; most easily visible in transverse sections in the available material. **Stomata** with tall dome-shaped (Fig. IV, 4) subsidiary cells. **Long-cells:** most of those in the stomatal strips nearly or quite cubical, with moderately sinuous, thin walls (Fig. V, 7*a–b*); others in the intercostal zones similar but longer (Fig. V, 3*a–c*), or with thin, non-sinuous walls (Fig. V, 2*a–c*).

T.S. lamina

Vascular bundles: most vb's small, rather widely spaced and somewhat angular in outline, but rather less so than in Fig. VIII, 5; large vb's of basic

type (Fig. VIII, 13). **Adaxial surface** practically smooth (Fig. XIV, 1), or with v. slight ribs over the vb's (Fig. XIV, 2). Abaxial surface with well marked, rounded ribs over the vb's, the ribs over the large vb's being rather taller and wider than those over the small vb's. Abaxial ribs separated from one another by rather wide, rounded furrows. Furrows between the abaxial ribs more marked in the material collected by Mann and Stebbins than in Hoover's specimen, probably due to differences in the way the cells collapsed in drying. **Sclerenchyma:** many of the small vb's with well-marked adaxial strands or girders (Fig. IX, 2), the constituent fibres of each strand having moderately thick walls and lumina of somewhat irregular shape, the strands being some 4–8 cells wide and up to 5 cells tall, each individual strand sometimes appearing to be wedge-shaped in T.S. through being wider at the end next to the epidermis than at the end nearest to the bundle-sheath. A few small vb's accompanied by similar adaxial strands and by smaller abaxial strands in the ribs (Fig. IX, 4). Large vb's accompanied by adaxial girders up to some 14 cells wide and 5 cells high, and by much smaller abaxial strands or girders. Transverse sections of certain leaves showing bundles, including even the large ones, accompanied by little or no scl. (Fig. IX, 1). **Keel** not conspicuous; containing a solitary vb (Fig. XIII, 1). **Mesophyll:** chlorenchyma conspicuously radiate round the small vb's. **Bulliform cells:** none clearly visible in the rather imperfect material examined. **Bundle-sheaths** single round the small, and double round the large vb's. Sheaths round the small vb's not interrupted by scl. and more or less circular in outline, the component cells being rather uniform in size. Sheaths to the large vb's often interrupted adaxially or adaxially and abaxially by scl.

Culm

Culm examined about 2 mm. in diameter. Epidermis subtended by about 4 layers of fairly large, assimilatory cells, followed by a rather ill-defined scl. ring some 6 cells wide, the ground tissue from the scl. ring to the centre of the culm consisting of cells of progressively wider diameters and increasingly thinner walls. Centre of the culm solid. A few small vb's embedded in the scl. ring and in the peripheral chlorenchyma, but most of the numerous vb's larger and scattered in the ground tissue between the scl. ring and the centre of the culm. Vascular bundles in the material collected by Mann and Stebbins not containing any conspicuously large metaxylem vessels as in most grasses, the diameters of the metaxylem vessels being about the same as, or slightly less than, those of the cells of the ground tissue immediately around the vb's, the vb's resembling those of *Orcuttia* in this respect. Metaxylem vessels, in a culm from Hoover's material small, but standing out more clearly in the bundles, partly on account of their relatively thick walls. A few stalked, glandular hairs, similar to those on the leaf, noted on the epidermis of the culm.

Material Examined: (i) Collected by R. F. Hoover; Stanilav Country Near Waterford, California. (ii) Collected specially by L. Mann and G. L. Stebbins in California.

Special Notes

The anatomy of this species needs to be further investigated. The grass is v. rare in some seasons, but large stands of it are to be seen in favourable conditions. That the genus must occupy a somewhat isolated taxonomic position is indicated by the interesting anatomical characters which it exhibits. Thus crozier hairs similar to those of *Neostapfia* have not been noted in any other grass. The sunken stalked glands are also unusual amongst the Gramineae, but they are similar to the glandular hairs of *Orcuttia*, and, although much longer stalked, they also recall the sunken glandular papillae that occur in *Eleusine coracana*. With rather more imagination the stalked glands of *Enneapogon* could also be likened to the glandular hairs of *Neostapfia*. The single sheaths round the vascular bundles of *Neostapfia* are also distinctive because of the v. uniform size of the component cells. *Neostapfia* also resembles *Orcuttia* (see p. 336) in the distribution and structure of the vascular bundles in the culm.

Literature

Crampton 1959 (morphology and ecology).

ZENKERIA

Diagnostic Generic Characters

Short-cells, over the veins, usually in long rows, but sometimes appearing to be solitary when separated from one another by relatively long-cells in the same files; those between the veins mostly solitary or, less frequently, paired or in short rows. Silica-bodies, over the veins, mostly saddle-shaped or tending to be of the *Oryza* type; usually rare between the veins. Micro-hairs present but often infrequent; each with the distal cell tapering to a rounded or somewhat pointed apex (Fig. VIII, 5*a*). Stomata mostly with low dome-shaped but occasionally with triangular subsidiary cells. Long-cells, both over and between the veins, with moderately thick, sinuous walls. T.S. lamina with ribs on both surfaces, the ribs on the abaxial being wider but less tall than those on the adaxial surface. Leaf margins strongly supported by scl. Vascular bundles not conspicuously angular in outline. Mesophyll with chlorenchyma not radiate. Bulliform cells in fan-shaped groups between the adaxial ribs. Bundle-sheaths double.

Species and Material Examined

***Z.* elegans Trin.** J. S. Gamble 12138. Nilgiris, Madras 1883.

Silica-bodies, over the veins, mostly saddle-shaped (Fig. 1, 9) or tending to be of the *Oryza* type (Fig. 1B, 23); less often more or less cubical.

***Z.* obtusifolia (Thw.) Benth.** Thwaites C.P. 3470; Ceylon.

Silica-bodies, over the veins, very variable and often appearing to be solitary; including cubical, elliptical, saddle-shaped and slightly cross-shaped types.

Z. **stapfii Henrard.** Perrottet 1336. Nilgiris.

Silica-bodies, over the veins, each appearing to have a saddle-shaped core surrounded by a halo of silica of different consistency, making the peripheral outlines of the bodies cubical with rounded corners. **Micro-hairs** not clearly seen.

Special Note

The structure indicates that *Zenkeria* is more closely allied to the Danthonieae than to the Aveneae.

ILLUSTRATIONS

FIG. I. SHORT-CELLS

1. ***Ammophila arenaria.*** (*a*), (*c*), (*d*) Short-cells each containing a closely fitting silica-body. The outlines of the silica-bodies are often less clearly visible than in the diagram. (*b*) Short-cell with granular, probably protoplasmic, contents.

2. ***Cortaderia conspicua.*** (*a*), (*b*) Short-cells, each containing a closely fitting silica-body; (*a'*), (*b'*) the same short-cells at a different focus.

3. ***Agropyron elongatum.*** A pair of silicified short-cells with a nucleus still visible in each. With paired short-cells, the one on the right, which is more towards the apex of lamina, is often more silicified, or contains a more conspicuous silica-body, than its left-hand neighbour.

4. ***Bromus fibrosus.*** (*a*), (*b*) Two pairs of short-cells. In each pair the left-hand, more proximal, cell is pitted, whereas its more distal, right-hand neighbour contains a conspicuous silica-body. (*c*) Four tall, narrow silica-bodies.

5. ***Eleusine indica.*** (*a*) A pair of short-cells, and (*b*) a solitary short-cell. (*c*) Four silica-bodies. In this species the short-cells are all more or less silicified, but some cells are thinly lined with silica, others each contain a conspicuous silica-body. The less silicified cells usually contain a nucleus (N). Small granules in the silica-bodies may represent the remains of disintegrated nuclei.

6. ***Briza erecta.*** (*a*)–(*d*) Pairs of short-cells somewhat similar to those in (7). The silica-body in (*d*) overlaps the cell-wall at a slightly higher level of focus.

7. ***Elymus canadensis.*** (*a*)–(*d*) Four pairs of short-cells, the right-hand, more distal, member of each pair containing a silica-body that projects convexly above and fits into a concavity in the wall of the left-hand cell of each pair; (*a*) represents the same pair of cells as (*c*) but at a higher level of focus.

8. ***Brachypodium pinnatum.*** (*a*) Pair of short-cells, with elliptical silica-body in right-hand cell. (*b*) Pair of short-cells with oblong silica-body in each cell. (*c*) Two silica-bodies with granules.

9. ***Chloris robusta.*** (*a*) Row of four short-cells with a silica-body with granules in two of the cells. (*b*) Eight silica-bodies of variable shape, (iv)–(viii) being more or less saddle-shaped.

10. ***Aristida ciliata*** var. ***capensis.*** (*a*) Solitary short-cell containing a silica-body with granules. (*b*) Pair of short-cells with a silica-body in the right-hand cell. (*c*) Five silica-bodies of variable shape, the more horizontally elongated being oblong. Cf. silica-bodies of *A. longiflora* in Fig. IA, 18.

11. ***Heteranthoecia guineensis.*** (*a*) Five of a row of short-cells with an acutely angled silica-body in each of three cells. Thickness of cell-walls somewhat exaggerated. (*b*) Seven acutely angled silica-bodies showing variations in shape.

G. granules. G.C. granular, probably protoplasmic cell contents. N. nucleus. P.C. pitted cells. S.B. silica-body. All ×500.

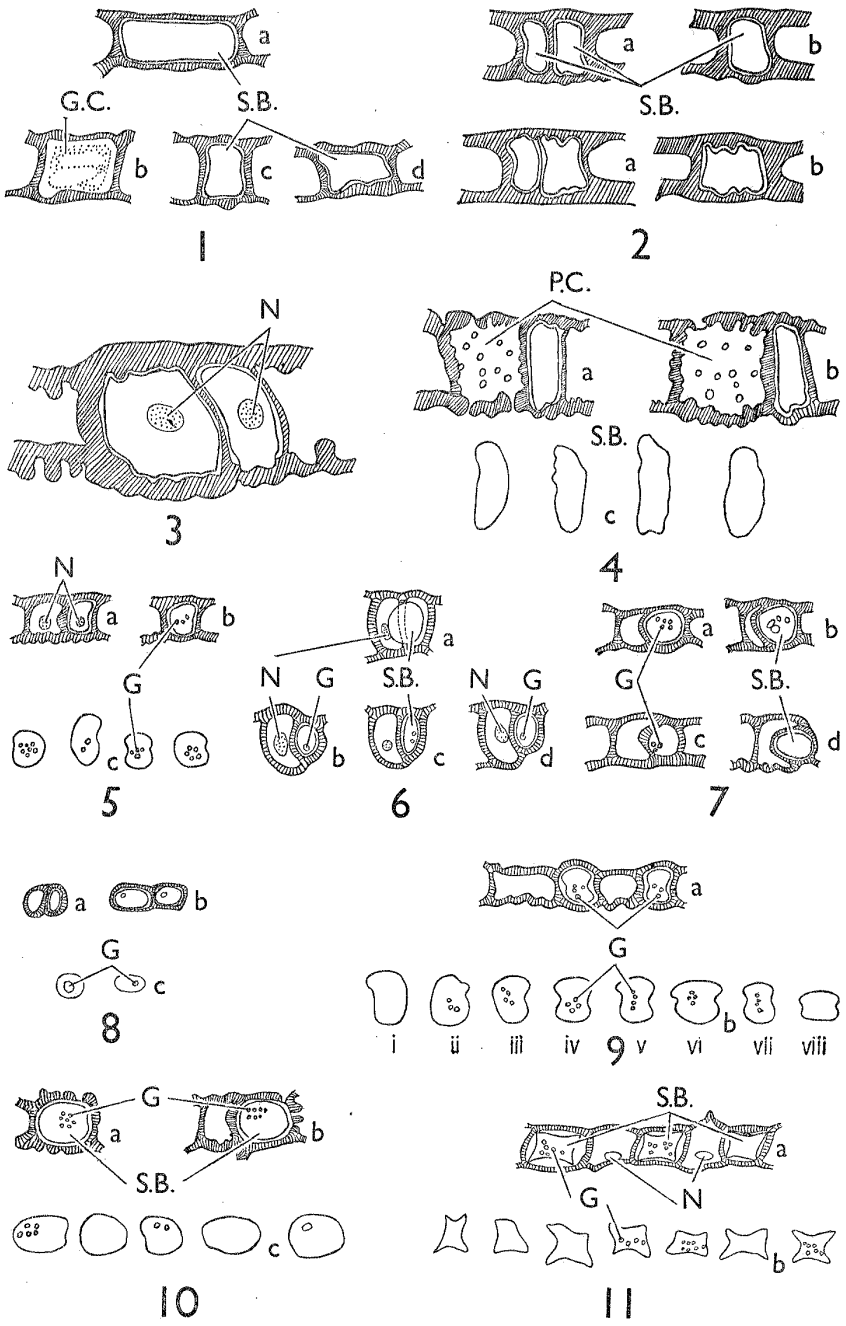


FIG. I

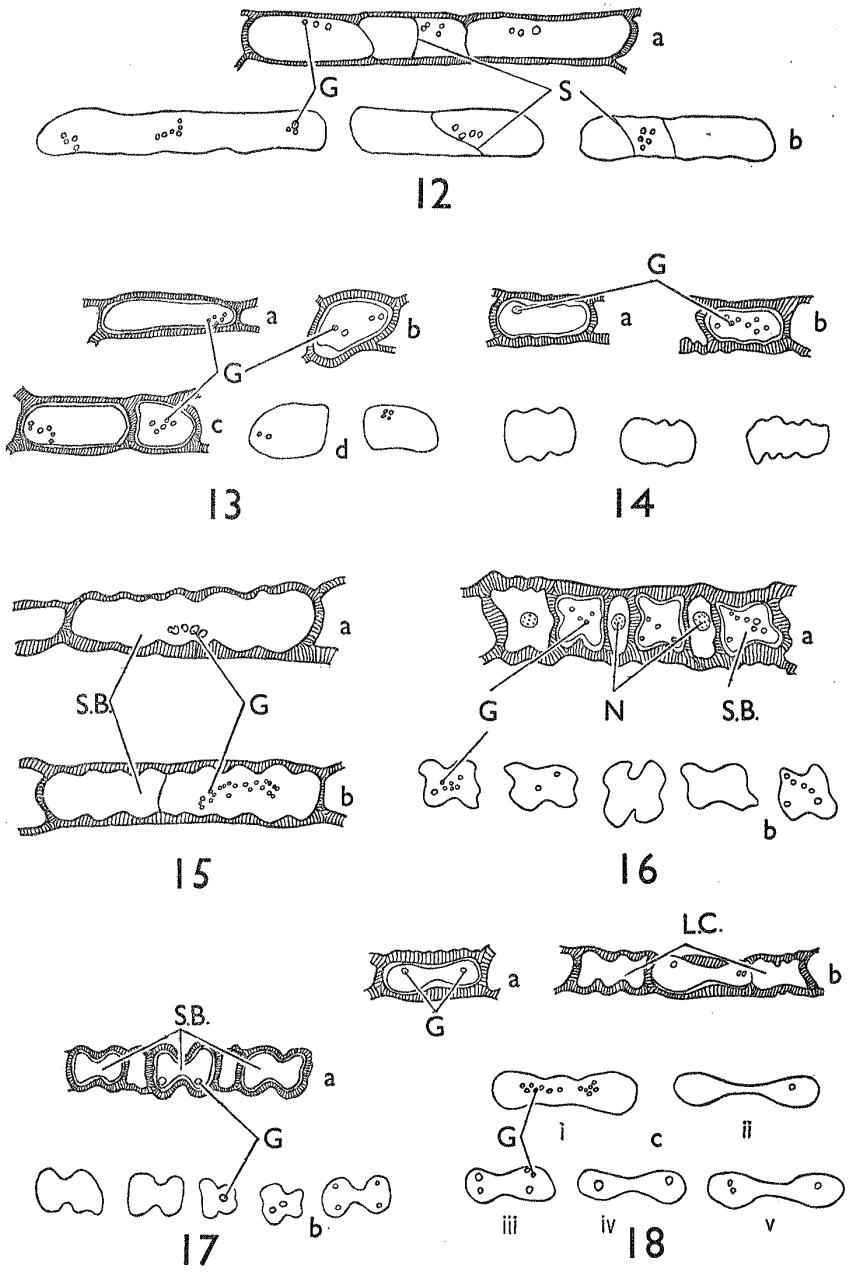


FIG. IA

FIG. IA. SHORT-CELLS (*cont.*)

12. ***Bromus coloratus.*** (*a*) Three of a row of short-cells each containing a horizontally elongated silica-body with somewhat rounded corners. (*b*) Three 'elongated-smooth' silica-bodies.

13. ***Anthochloa lepidula.*** (*a*)–(*b*) Two solitary, and (*c*) a pair of short-cells, with a silica-body in each cell. (*d*) Two silica-bodies. The longer silica-bodies could be classified as 'elongated-smooth'.

14. ***Poa glauca.*** (*a*)–(*b*) Two solitary short-cells each containing a slightly elongated silica-body with sinuous outlines. (*c*) Three slightly elongated, sinuous silica-bodies. Elongated, sinuous bodies should not be confused with the nodular type (Fig. IA, 18 (i)).

15. ***Avena ludoviciana.*** (*a*)–(*b*) Short-cells each containing a horizontally elongated, sinuous silica-body. The silica-bodies project above the epidermis and, at a higher level of focus, the sinuations overlap part of the anticlinal walls.

16. ***Euchlaena perennis.*** (*a*) Part of a long row of short-cells; three of the cells shown each contain a cross-shaped silica-body, and in each of the three alternating cells there is a nucleus. (*b*) Five cross-shaped silica-bodies showing variations in form.

17. ***Cyrtococcum trigonum.*** (*a*) Part of a row of short-cells, three of which each contain a silica-body. (*b*) Five silica-bodies intermediate between cross and dumb-bell shaped.

18. ***Aristida longiflora.*** (*a*) A single short-cell containing a dumb-bell shaped silica-body. (*b*) Three short-cells, of which the one in the middle contains a dumb-bell shaped silica-body; the remaining two cells have their horizontal walls somewhat lobed. (*c*) (i) A nodular silica-body; (ii)–(v) dumb-bell shaped silica-bodies with narrow middle portions. Silica-bodies (ii)–(v) similar to but larger than those in Fig. IB, 20.

G. granules. L.C. lobed short-cells. N. nucleus. S. Striations or fractures in silica-bodies. S.B. silica-body. All × 500.

FIG. IB. SHORT-CELLS (*cont.*)

19. ***Arthraxon quartinianus.*** (*a*) Part of a long row of short-cells each of three of which contains a dumb-bell shaped silica-body with thick middle portion. (*b*) Four dumb-bell shaped silica-bodies with thick middle portions.

20. ***Loudetia*** sp. (*a*) Part of a long row of short-cells, each of three of which contains a dumb-bell shaped silica-body. (*b*) Four dumb-bell shaped silica-bodies showing variations in form. The silica-bodies are similar to, but smaller than, those in Fig. IA, 18.

21. ***Euclasta condylotricha.*** (*a*) Four silica-bodies somewhat similar to those in Figs. IA, 18 and IB, 20, but varying in appearance with the focus owing to the less even distribution of the silica. (*b*) Two silica-bodies, each of which is shown as it appears at a high and low focus.

22. ***Brachiaria distichophylla.*** (*a*) Part of a row of short-cells, one of which contains a nodular silica-body. (*b*) Four silica-bodies, showing the range of form; (i) more or less cross-shaped; (ii) and (iv) shortly dumb-bell shaped; (iii) nodular.

23. ***Leersia oryzoides.*** (*a*) Part of a long row of short-cells in which each alternate cell contains a silica-body of the *Oryza* type in which the vertical axis is nearly always longer than the horizontal axis. (*b*) Two silica-bodies, showing the appearance of each at both a low and high focus. (*c*) Six *Oryza*-type silica-bodies showing variations in form.

24. ***Olyra latifolia.*** (*a*) Part of a row of cells from an area between two veins showing two long-cells separated from one another by a pair of tall, narrow short-cells, one of which contains a tall, narrow, crenate silica-body. (*b*) Six narrow, crenate silica-bodies showing variations in form.

G. granules. L.C. long-cells. S.B. silica-body. All × 500.

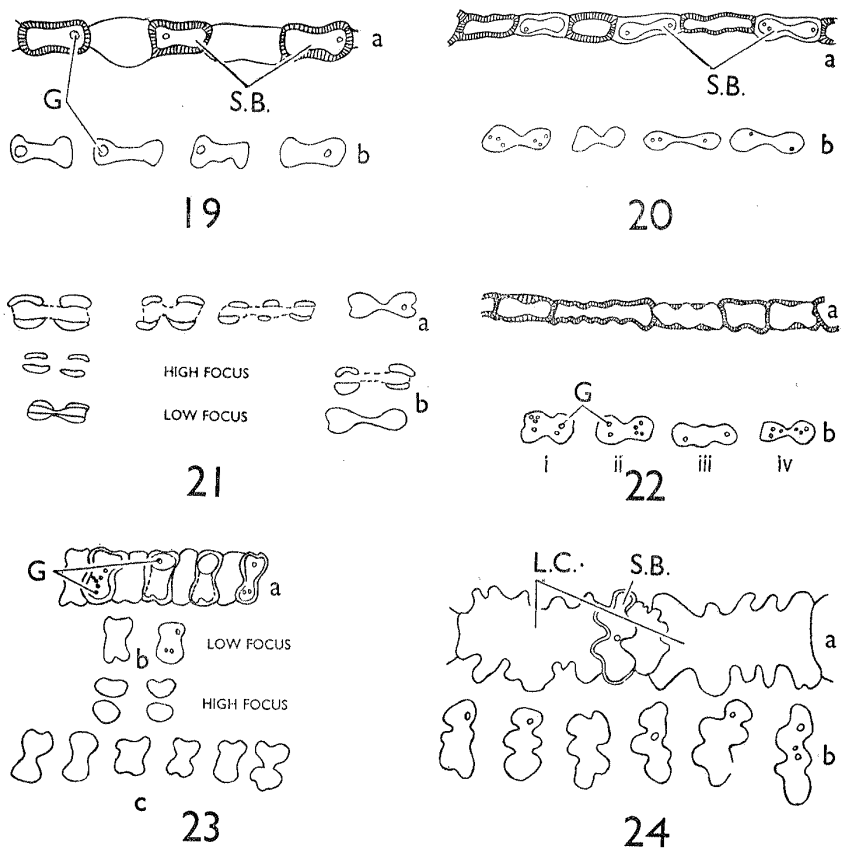


FIG. IB

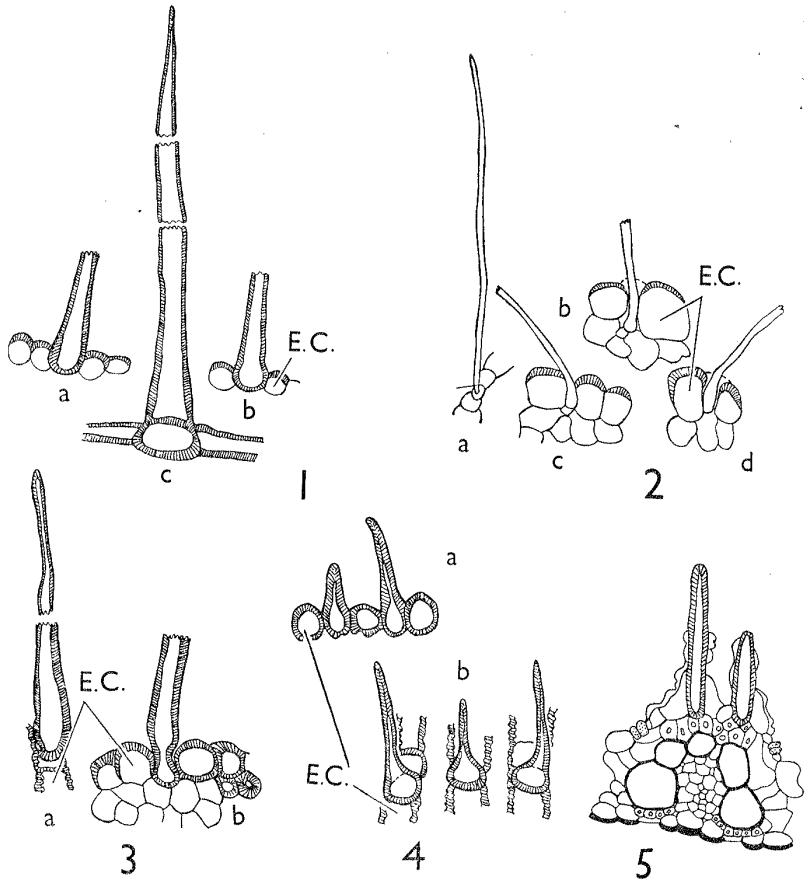


FIG. II

FIG. II. MACRO-HAIRS

1. ***Bromus japonicus.*** (*a*)–(*b*) Bases of hairs in section. (*c*) Hair as seen in surface preparation. Note shallow penetration of hair bases into the leaf. × 200.
2. ***Digitaria borbonica.*** (*a*) Slender hair as seen in surface preparation. (*b*)–(*d*) Deeply sunken bases of hairs as seen in T.S.: (*b*) from adaxial surface, (*c*)–(*d*) from abaxial surface. × 200.
3. ***Danthonia spicata.*** (*a*) Hair as seen in surface view. (*b*) Sunken base of hair in T.S. Note constriction of hair just above its proximal end. × 200.
4. ***Bromus fibrosus.*** (*a*) Short, thick-walled hairs, with superficial, slightly sunken bases as seen in T.S. (*b*) Hairs as seen in surface preparations. × 200.
5. ***Indopoa pauperculus*** Stapf. Specialized hairs partly surrounded by raised epidermal cells, as seen in T.S. lamina. × 137.

E.C. epidermal cells.

FIG. IIA. MACRO-HAIRS (*cont.*)

5. ***Heteranthoecia guineensis.*** (*a*) T.S. showing hair base and adjacent cells. (*b*)–(*d*) Hairs in surface view. × 200.

6. ***Bromus tectorum.*** (*a*)–(*b*) Hairs in surface view. (*c*) T.S. showing hair base and adjacent cells. × 100.

7. ***Neostapfia colusana.*** Crozier hair. × 500.

8. ***Enneapogon cenchroides.*** Hairs with glandular heads. × 500.

9. ***Neostapfia colusana.*** Club-shaped hairs in shallow depressions as seen in T.S. Drawn from herbarium material. × 500.

10. ***Aristida longiflora.*** Short, thick-walled hairs, as seen on the adaxial leaf surface, in T.S. × 200.

11. ***A. ciliata*** var. ***capensis.*** Straight and flexuose hairs from the adaxial leaf surface, as seen in T.S. × 200.

12. ***Elyonurus chevalieri.*** (*a*), (*b*) Sunken hairs from the adaxial leaf surface, as seen in T.S. × 200.

13. ***Eleusine coracana.*** Two-celled hairs: (*a*)–(*b*) in surface view, (*c*), (*d*) in T.S. × 600. (These hairs are of the same type as those in Fig. VII, 1. They could be mistaken for papillae.)
E.C. epidermal cells. H.B. hair base. S. silicified cells.

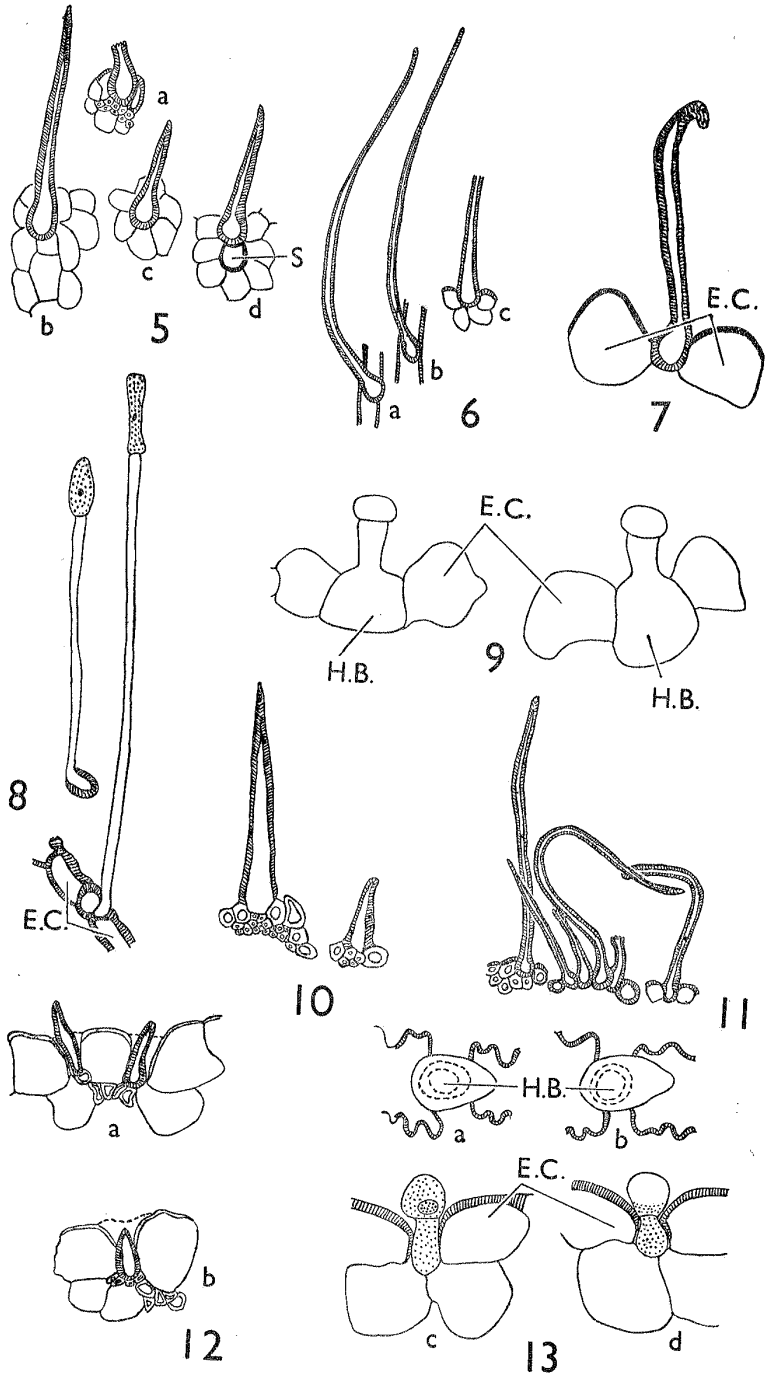


FIG. IIA

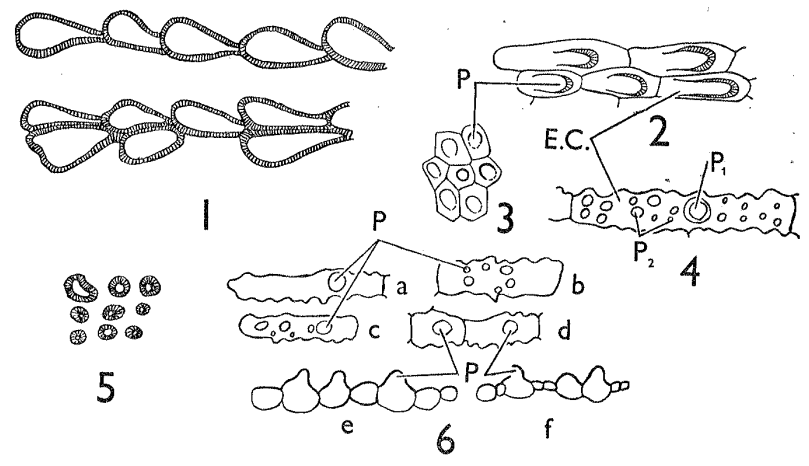


FIG. III

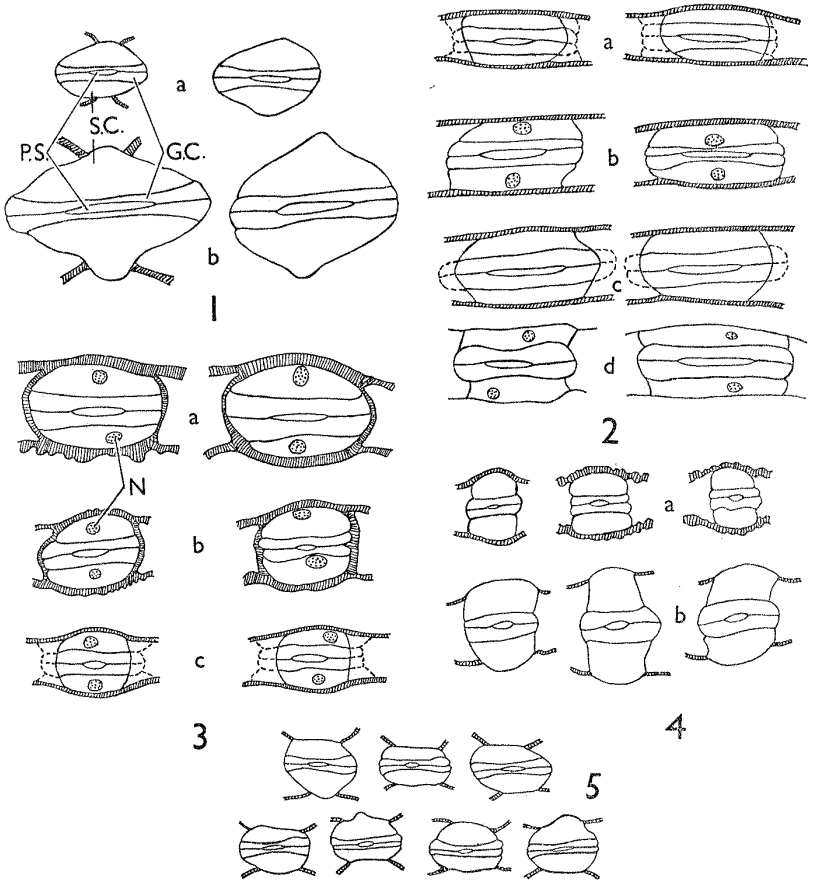


FIG. IV

FIG. III. PAPILLAE

1. ***Alopecurus geniculatus.*** Rows of oblique, inflated papillae from above the veins; in surface view. × 200.
2. ***Echinochloa crus-galli.*** Epidermal cells each with an oblique papilla. Surface view. × 200.
3. ***Heteranthoecia guineensis.*** Small epidermal cells with more or less circular, dome-shaped papillae. Surface view. × 200.
4. ***Leersia oryzoides.*** Single epidermal cell with one large papilla (P1) and numerous small cuticular papillae (P2). × 500.
5. ***Trikeraia hookeri.*** Thick, cuticular papillae. × 500.
6. ***Arthraxon quartinianus.*** (*a*)–(*d*) Epidermal cells with papillae of various sizes. (*e*)–(*f*) Papillae as seen in T.S. of the epidermis. × 200.

E.C. epidermal cells. P. papillae.

FIG. IV. STOMATA IN SURFACE VIEW SHOWING VARIATIONS IN THE SHAPES OF THE SUBSIDIARY CELLS

1. (*a*) ***Sorghum halepense*** } Subsidiary cells triangular.
   (*b*) ***Zea mays*** }
2. (*a*) ***Poa palustris*** }
   (*b*) ***Phalaris minor*** }
   (*c*) ***Polypogon chilensis*** } Subsidiary cells parallel-sided.
   (*d*) ***Lagurus ovatus*** }

   Broken lines represent low focus outline.
3. (*a*) ***Festuca arundinacea*** }
   (*b*) ***Stipa splendens*** } Subsidiary cells low-dome-shaped; similar to (4) but vertical diameter of the subsidiary cells smaller in relation to the horizontal diameter.
   (*c*) ***Poa iridifolia*** }

   Broken lines represent low focus outline.
4. (*a*) ***Oryzopsis paradoxa*** }
   (*b*) ***Neostapfia colusana*** } Subsidiary cells tall dome-shaped; similar to (3) but vertical diameter of the subsidiary cells greater in relation to the horizontal diameter.
5. ***Heteranthoecia guineensis.*** Subsidiary cells variable in shape.

G.C. guard cells. N. nuclei. P.S. pore of stoma. S.C. subsidiary cells. All × 430.

FIG. V. LONG-CELLS FROM INTERCOSTAL ZONES

Except where otherwise labelled, the cells in this series of figures are all in the 'long' category in spite of the considerable range of size that they exhibit. A few grasses, e.g. *Leptaspis cochleata* (Fig. V, 9), are distinctive because the ends of the cells overlap or interlock. An individual sp. often exhibits more than one type of long-cell.

1. (*a*) ***Ammophila arenaria.*** Walls thick; often pitted, but pits not shown.
   (*b*) ***Agropyron elongatum.*** Walls thick; sinuous.
2. (*a*) ***Brachypodium*** sp. (accompanied by 4 (*a*); adaxial surface).
   (*b*) ***Agropyron caninum***
   (*c*) ***Bromus carinatus*** } Walls thin; not sinuous.
3. (*a*) ***Cyrtococcum trigonum*** (from near the veins; accompanied by 7 (*b*)).
   (*b*) ***Acroceras zizanioides***
   (*c*) ***Alopecurus pratensis*** } Walls thin; sinuous.
4. (*a*) ***Brachypodium*** sp. (accompanied by 2 (*a*); adaxial surface).
   (*b*) ***Cenchrus biflorus.*** Cells relatively short; with thin, non-sinuous walls.
5. ***Ischaemum santapaui.*** Continuous lines show the outline at a high focus. Broken lines show the outline at a low focus. Cells thin-walled; inflated.
6. ***Olyra latifolia.*** Cells relatively short, with thin, markedly sinuous walls.
7. (*a*) ***Brachiaria deflexa.***
   (*b*) ***Cyrtococcum trigonum*** (remote from veins; accompanied by 3 (*a*)). Cells almost cubical, with slightly to moderately sinuous walls.
8. ***Heteranthoecia guineensis*** (for simplicity the solitary papillae on each of the cells have been omitted). Cells cubical, with non-sinuous walls.
9. ***Leptaspis cochleata.*** Three sets of cells, with overlapping end walls.
10. (*a*) ***Acroceras zizanioides***
    (*b*) ***Olyra latifolia*** } Interstomatal cells short, with concave ends.
11. ***Alopecurus pratensis.*** Interstomatal cells long, with concave ends.

S.C. short-cells. S. stomata. All × 200.

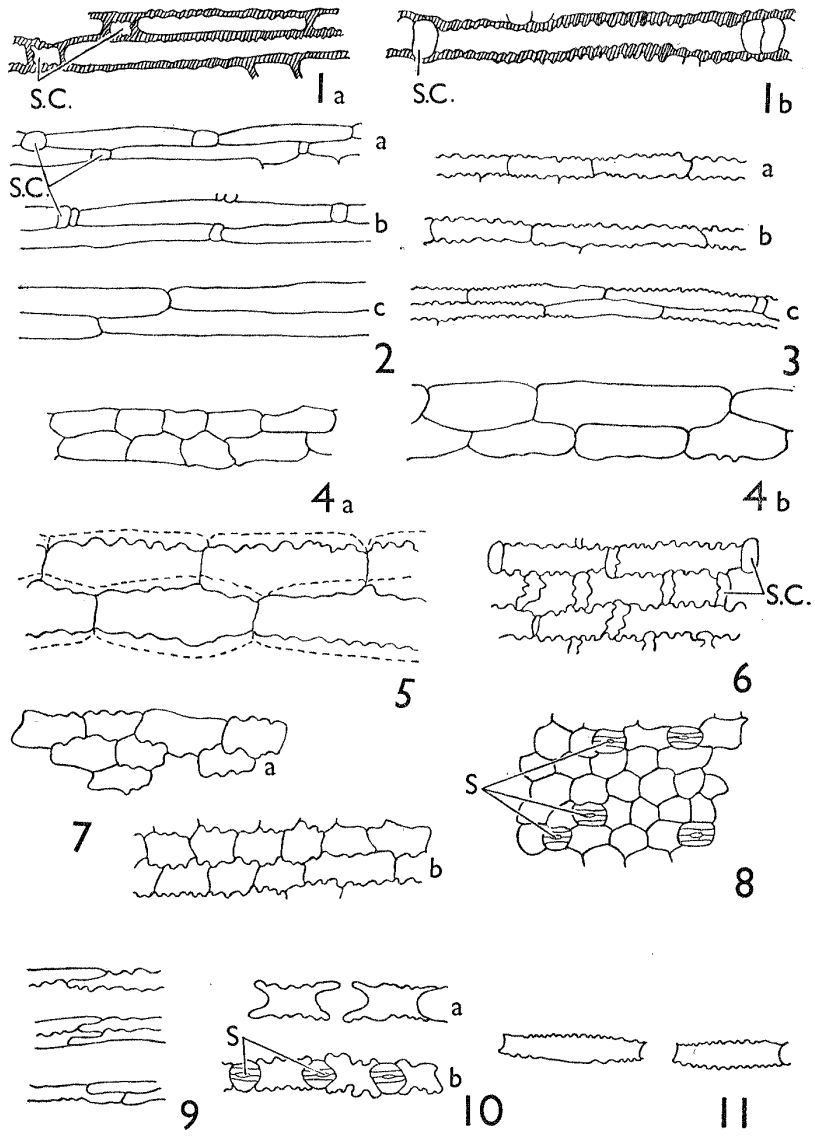


FIG. V

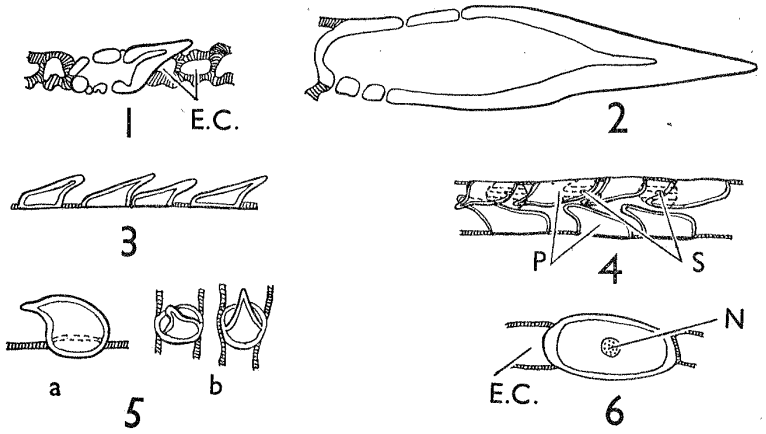


FIG. VI

FIG. VI. PRICKLES

1. ***Loudetia*** sp. Small prickle. Side view. × 500.
2. ***Hordeum*** sp. Large prickle. From above. × 500.
3. ***Bromus unioloides.*** Angular prickles, from leaf margin. × 200.
4. ***Saccharum spontaneum.*** Interlocking prickles above a furrow in which stomata are situated. × 200.
5. ***Brachypodium sylvaticum.*** Hooks: (*a*) side view; (*b*) surface view. × 500.
6. ***Arundo donax.*** Unpointed prickle. × 500.

E.C. epidermal cells. N. nucleus. P. prickles. S. stomata.

FIG. VII. MICRO-HAIRS (*Winkelhaare*)

Hairs of these types are commonly, but not invariably, bent.

1. ***Sporobolus indicus.*** (*a*)–(*c*) Unicellular, rounded micro-hairs—the *Sporobolus* type.
2. ***S. wrightianus.*** (*a*)–(*b*) Small, rounded, two-celled micro-hairs—the *Chloris* type.
3. ***Euchlaezea mertonensis.*** Micro-hairs (*a*) with remains of cytoplasm; (*b*) cytoplasm not shown. Distal cell inflated, with rounded apex and much longer than the basal cell—the balanoform type.
4. ***Panicum miliaceum***
5. ***Setaria*** sp.
6. ***Cenchrus pauciflorus***

   Basal cell shorter than the distal cell which tapers towards the apex—the panicoid type. Variations in the shapes of the distal cells are mainly due to distortion. Distal cell sometimes missing, e.g. in 5 (*b*).
7. ***Echinochloa crus-galli.*** Basal and distal cells about equal in length, the distal cell usually with a rounded apex unless distorted, e.g. as in (*a*)—the *Echinochloa* type.
8. ***Loudetia*** sp. Basal and distal cells long and narrow and both uniform in diameter throughout their lengths—the *Loudetia* type. Granular cytoplasm in the basal cell of (*b*).
9. ***Euclasta condylotricha***
10. ***Arundo donax***

    Basal cell longer than the apically tapered distal cell—the *Arundo* type.
11. ***Zizania latifolia.*** Basal and distal cells both short and about equal in length, the distal cell being apically tapered—the *Zizania* type.
12. ***Eragrostis chloromelas.*** With the basal cell much longer than the dome-shaped distal cell—the *Eragrostis* type.

Dotted areas represent cytoplasm. Hatched areas represent portions of walls of adjacent epidermal cells. All × 500.

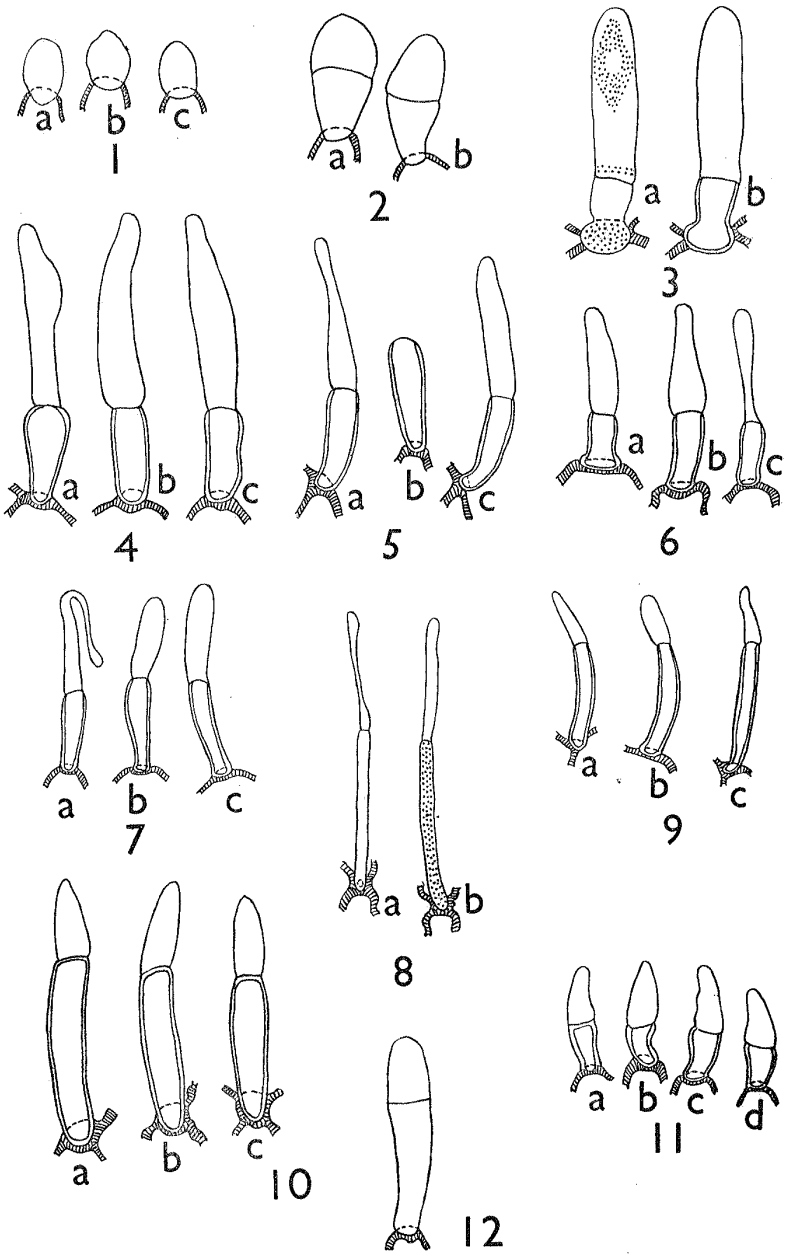


FIG. VII

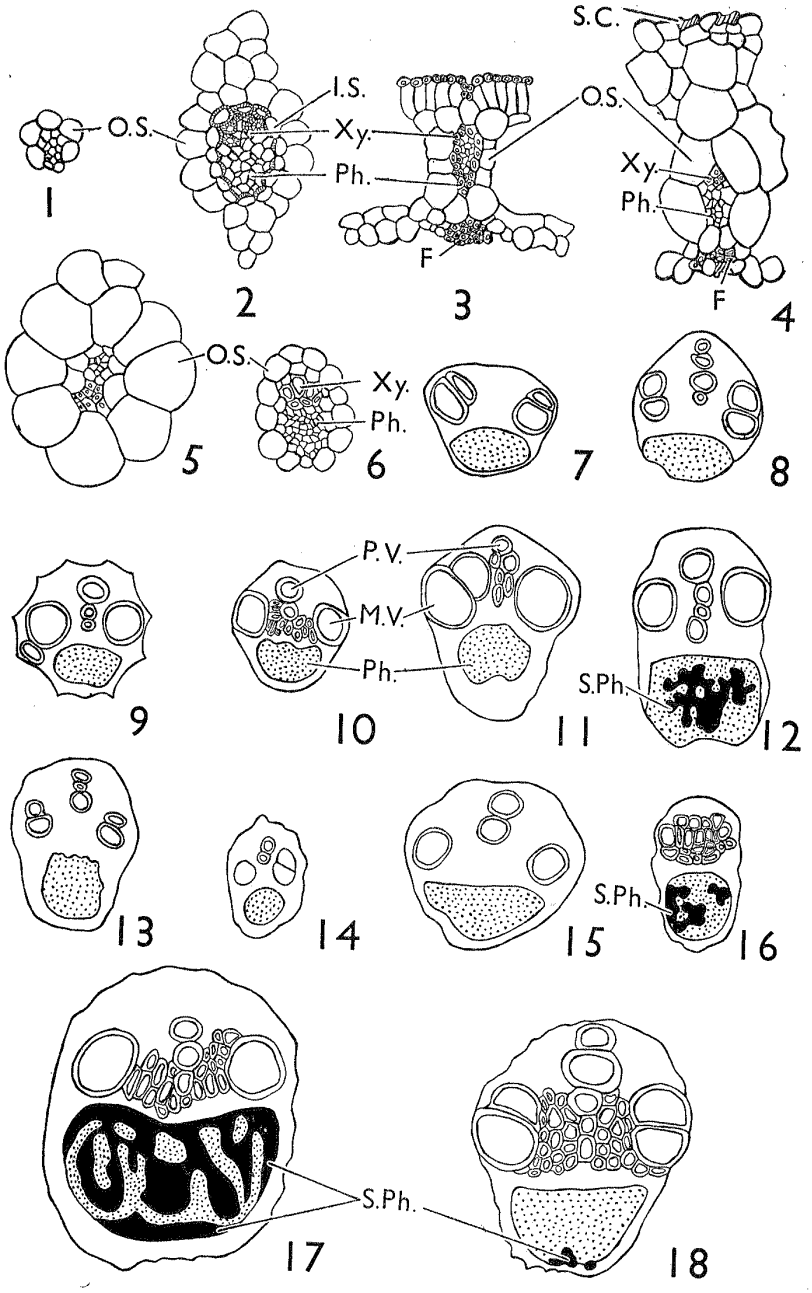


FIG. VIII

FIG. VIII. VASCULAR BUNDLES, SHOWING DIFFERENT TYPES OF XYLEM AND PHLOEM

1. ***Ischaemum santapaui.*** Bundle small, with xylem and phloem not easy to distinguish; conspicuously large metaxylem vessels absent.

2. ***Agropyron laxum.*** Xylem and phloem easy to distinguish; conspicuously large metaxylem vessels absent; bundle not angular in outline. Cf. 6.

3. ***Leptaspis cochleata.*** Xylem and phloem fairly easy to distinguish, but conspicuously large metaxylem vessels absent; bundle tall, narrow, and somewhat angular; vertical sides of the bundle-sheath straight and parallel to one another.

4. ***Eustachis* sp.** Bundle small and pentagonal in outline; conspicuously large metaxylem vessels absent.

5. ***Eleusine coracana.*** Bundle small, octagonal in outline; conspicuously large metaxylem vessels absent.

6. ***Erianthus hostii.*** Bundle small; not more than inconspicuously angular in outline; conspicuously large metaxylem vessels absent.

7. ***Agropyron elongatum***
8. ***Bromus fibrosus***
9. ***Eleusine coracana***
10. ***Elymus canadensis***
11. ***Cymbopogon citratus***
12. ***Cortaderia selloana***
13. ***Danthonia flavescens***
14. ***Leptaspis cochleata***
15. ***Agropyron elongatum***

A series of intergrading types of bundles that occur in most grasses. It is often difficult to assign a bundle to any particular type in this series, and the types are not sufficiently constant in any one species to be of diagnostic value. (9) is distinctive because it is more angular in outline than the others. (12) is noteworthy because of the sclerenchyma in the phloem. All of these bundles, which are characterized by conspicuously large metaxylem vessels, are classified as being of the 'basic type', since they occur in nearly all grasses.

16. ***Cortaderia selloana.*** Bundle small; xylem elements all moderately wide in diameter, but no metaxylem vessels conspicuously wider than the other elements. Phloem partly sclerosed.

17. ***Desmostachya bipinnata.*** Basic type bundle with phloem heavily sclerosed.

18. ***Elymus* sp.** Basic type bundle with phloem slightly sclerosed.

F. fibres. I.S. inner bundle-sheath. M.V. metaxylem vessels. O.S. outer bundle-sheath. Ph. phloem. P.V. protoxylem vessels. S.C. silica-cells. S.Ph. sclerosed phloem. Xy. xylem. Solid black areas are sclerenchyma. Dotted areas, phloem. All × 200.

FIG. IX. CIRCUMVASCULAR SCLERENCHYMA

i.e. sclerenchyma surrounding, in contact with, or opposite, the vascular bundles

1. ***Agropyron elongatum.*** Small bundle with no associated sclerenchyma.
2. ***Panicum virgatum.*** Adaxial strand of sclerenchyma opposite a bundle.
3. ***Elymus arenarius.*** Small bundle accompanied by an abaxial girder of sclerenchyma.
4. ***Buchloe dactyloides.*** Bundle accompanied by narrow adaxial and abaxial girders of sclerenchyma.
5. ***Arundo donax.*** Bundle accompanied by wide adaxial and abaxial girders of sclerenchyma.
6. ***Brachypodium pinnatum.*** Keel bundle accompanied by a narrow adaxial and a very broad abaxial girder of sclerenchyma.
7. ***Briza erecta.*** Bundle accompanied by tall, narrow adaxial and abaxial girders of sclerenchyma.
8. ***Elymus arenarius.*** Large bundle accompanied by a T-shaped adaxial and a short but fairly wide abaxial I-girder of sclerenchyma.
9. ***Cortaderia conspicua.*** Medium-sized bundle accompanied by an adaxial T-shaped girder, with extensions of the bundle-sheath on either side of the stem of the T. Abaxial strand resembling an inverted T with a very short stem.
10. ***Cortaderia selloana.*** Sclerenchyma similar to that in (9), but bundle embedded in lignified sheath cells that stand out in contrast to the adaxial and abaxial sclerenchyma.
11. ***Cortaderia conspicua.*** A variant of (10) that occurs in association with large bundles.

F. base of furrow in the adaxial epidermis. Sclerenchyma solid black. Phloem dotted. Horizontal lines indicate lignified sheath cells that have thinner walls and wider lumina than the cells in the black areas. All × 200.

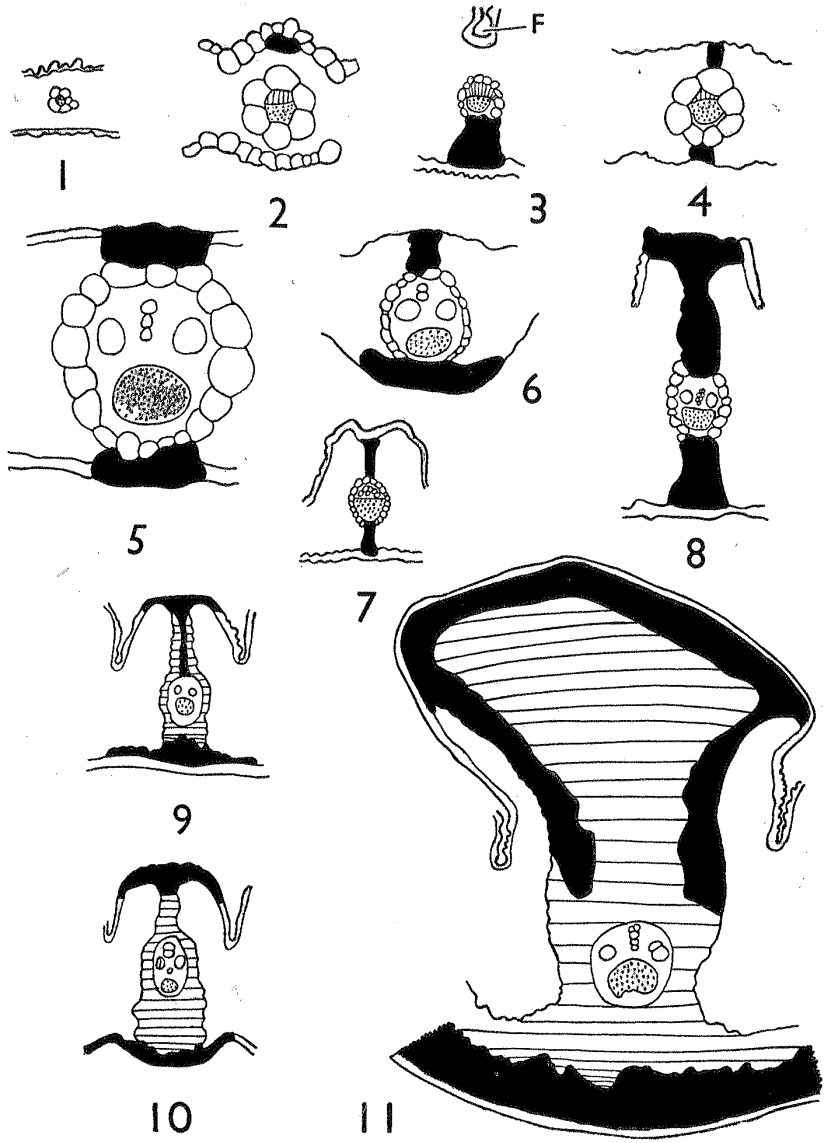


FIG. IX

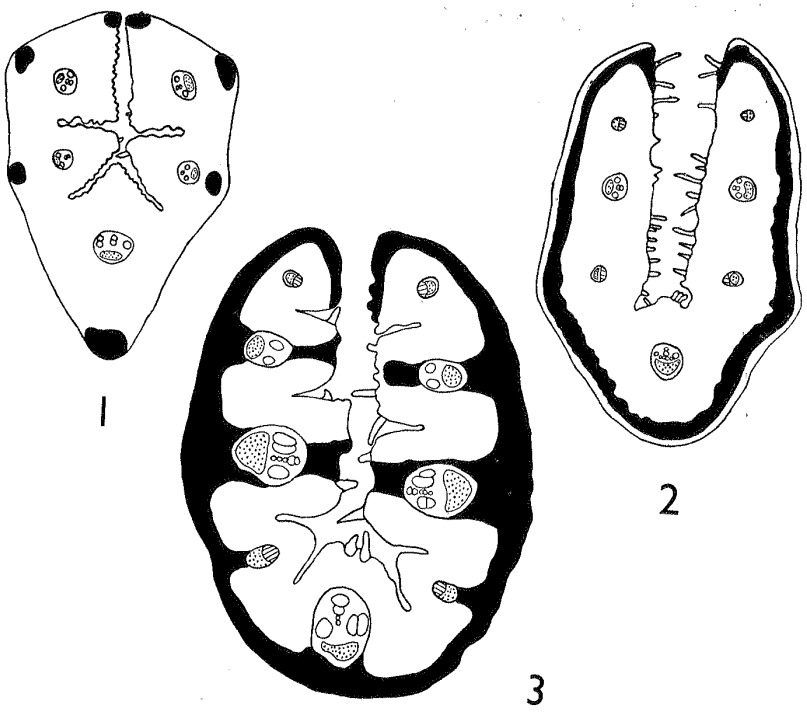


FIG. X

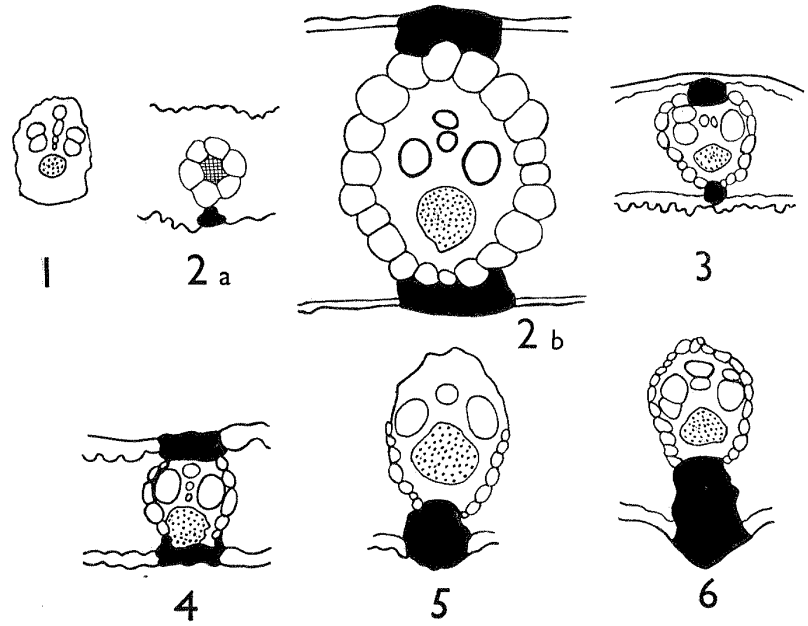


FIG. XI

FIG. X. DISTRIBUTION OF SCLERENCHYMA IN ACICULAR LEAVES

In transverse sections of acicular grass leaves the distribution of sclerenchyma is often of diagnostic value. Some of the types of sclerenchyma arrangement that have been observed are shown in Figs. 1–3

1. ***Festuca rubra L.* ssp. *rubra***
2. ***F. glauca.***
3. ***Stipa pennata.***

Sclerenchyma solid black. All × 200.

FIG. XI. BUNDLE-SHEATHS

Single types

1. ***Leptaspis cochleata.*** Midrib bundle, with no sheath.
2. (*a*) ***Buchloe dactyloides.*** Small bundle with complete sheath.
   (*b*) ***Arundo donax.*** Relatively large bundle with complete sheath.
3. ***Miscanthus condensatus.*** Sheath slightly interrupted abaxially and adaxially by sclerenchyma.
4. ***Euchlaena perennis.*** Sheath-cells clearly visible only to the left and right of the bundle; replaced by sclerenchyma adaxially and abaxially.
5. ***Miscanthus condensatus.*** Sheath-cells clearly visible only to the left and right at the phloem end of the bundle.
6. ***Miscanthus condensatus.*** Sheath interrupted by a large girder of sclerenchyma on the abaxial side.
   Leptaspis cochleata. See Fig. VIII, 3.

Sclerenchyma solid black. Phloem dotted. All × 200.

FIG. XII. BUNDLE-SHEATHS

Double types

1. ***Phalaris caerulescens.*** Two complete sheaths.
2. ***Brachypodium pinnatum.*** Outer sheath interrupted abaxially; inner sheath complete.
3. (*a*) ***Bromus carinatus.*** Outer sheath interrupted abaxially and adaxially; inner sheath complete.
   (*b*) ***Muhlenbergia racemosa.*** Similar to 3 (*a*) but smaller.
4. ***Cynodon dactylon.*** Midrib bundle. Outer sheath interrupted abaxially and with an adaxial extension of colourless cells connecting with the sclerenchyma; inner sheath complete.
5. ***Buchloe dactyloides.*** Both sheaths interrupted abaxially.
6. ***Sporobolus poiretii.*** Small bundle. Inner sheath, sometimes rather obscure, completed round phloem only; outer sheath complete and appearing triangular because provided with an adaxial extension of colourless cells.
7. ***Spartina townsendii.*** Large bundle. Inner sheath usually fairly well defined; outer sheath complete and provided with a wide, girder-like extension of colourless cells.

O.S. outer sheath. I.S. inner sheath. Sclerenchyma solid black. Phloem dotted. All × 200.

FIG. XIII. KEEL BUNDLES

The figures show the vascular bundles in transverse sections through the lamina taken about half way between its apex and base. In many grasses the keel is more clearly defined nearer the base of the lamina

1. ***Rhynchelytrum repens.*** Keel bundle solitary.
2. ***Bromus fibrosus.*** Three bundles in or near the keel. Intermediates between (1) and (2) sometimes occur.
3. ***Euchlaena perennis.*** Rounded keel containing numerous bundles of unequal size. Similar to (5) but smaller. In other grasses with similarly shaped keels the bundles are sometimes more uniform in size. Alternatively the median bundle may be much larger than the others.
4. ***Echinochloa crus-galli.*** Keel more or less triangular; containing numerous bundles of unequal size.
5. ***Saccharum bengalense.*** Similar to (3) but keel larger.
6. ***Zizania latifolia.*** A specialized type of keel with an unusual distribution of vascular bundles, and traversed longitudinally by intercellular air-spaces.

A.S. air-spaces. Sclerenchyma in solid black. Phloem dotted. All × 23.

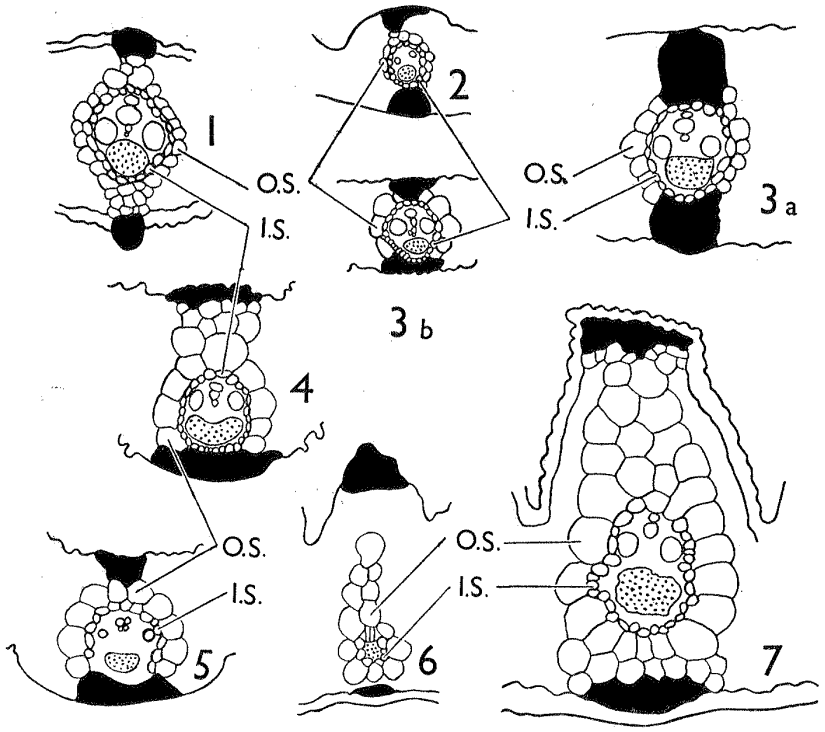


FIG. XII

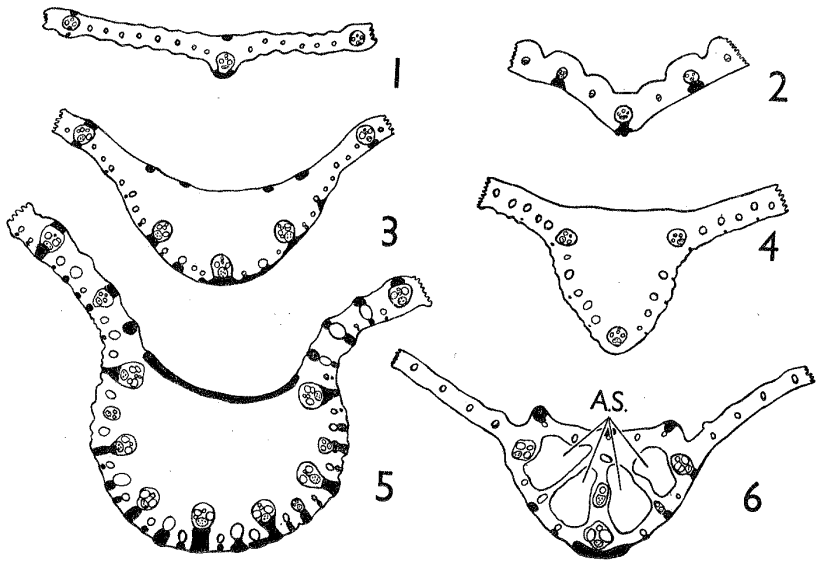


FIG. XIII

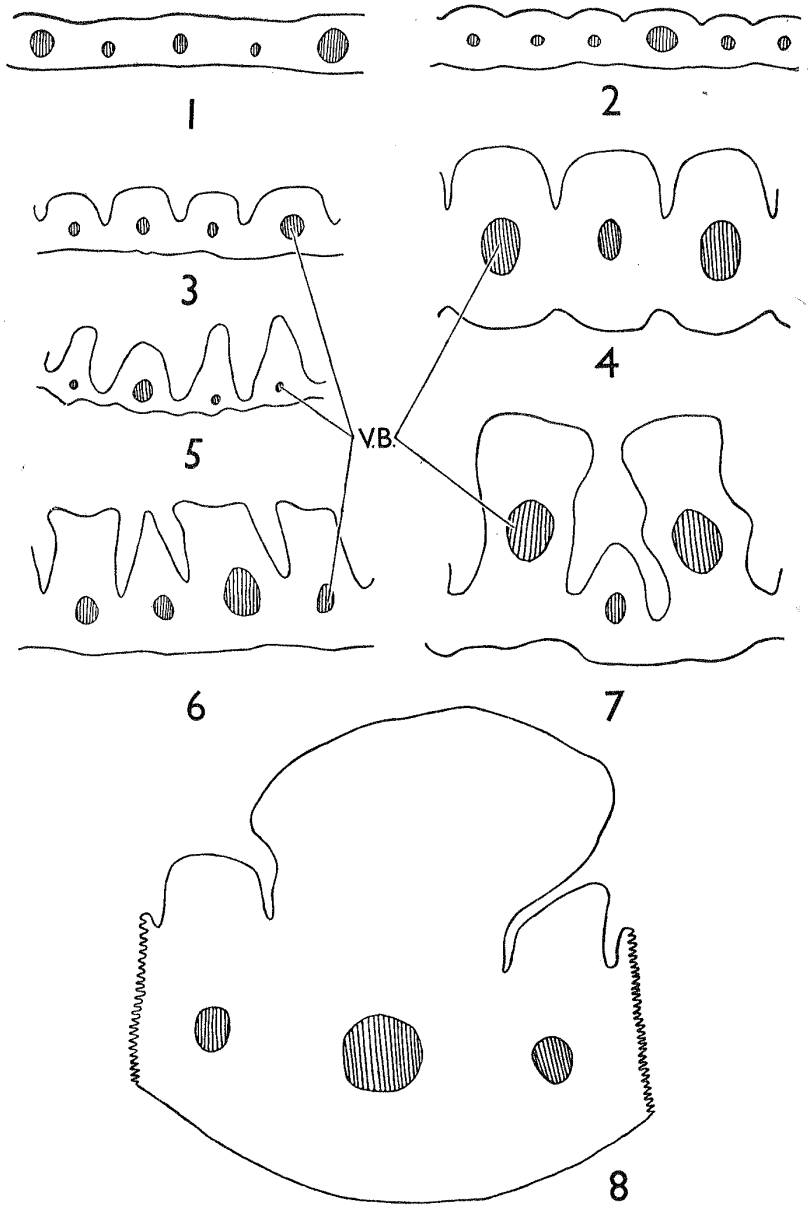


FIG. XIV

FIG. XIV. RIBS AND FURROWS ON THE ADAXIAL SURFACE

A series of diagrams to illustrate the various degrees to which ribs and furrows are developed on the adaxial surface

1. *Elymus canadensis.*
2. *Eleusine indica.*
3. *Melica ciliata.*
4. *Cortaderia selloana.*
5. *Alopecurus geniculatus.*
6. *Spartina townsendii.*
7. *Psammochloa villosa.*
8. *Cortaderia conspicua.*

V.B. vascular bundles. All × 55.

FIG. XV. BULLIFORM AND COLOURLESS CELLS

1. ***Bothriochloa caucasica.*** Bulliform cells in irregular groups.
2. ***Agropyron intermedium.*** Group of relatively uniform bulliform cells in regular groups. Similar but wider groups also occur.
3. ***Zea mays.*** Inflated bulliform cells very large, in regular groups—the *Zea* type.
4. ***Oryzopsis paradoxa.*** Bulliform cells in a fan-shaped group, the median cell in the group being appreciably larger than the remainder. Closely related to (6).
5. ***Cortaderia conspicua.*** Deep adaxial furrow partly lined by slightly enlarged bulliform cells—the *Ammophila* or *Elymus* type.
6. ***Agropyron elongatum.*** Adaxial furrow with a fan-shaped group of bulliform cells at the base. Not always appearing so thick-walled as in this diagram. Not very different from (4).
7. ***Arundo donax.*** Bulliform and associated colourless cells in narrow groups penetrating deeply into the mesophyll—the *Arundo* type.
8. ***Sporobolus indicus.*** Bulliform and associated colourless cells in fan-shaped groups penetrating into the mesophyll—the *Sporobolus* type.
9. ***Eleusine coracana.*** Groups of bulliform cells very similar to those in (8).
10. ***Miscanthus condensatus.*** Group of bulliform and associated colourless cells appearing as an archway extending over the adaxial side of one of the smaller bundles, the vertical pillars of the arch extending to the abaxial epidermis on either side of the bundle.
11. ***Eustachys sp.*** Adaxial part of the mesophyll, from the bundle-sheath to the adaxial epidermis, consisting wholly of colourless cells—the *Chloris* type.
12. ***Aristida pungens.*** Group of colourless cells extending from the base of an adaxial furrow towards a vascular bundle—a specialized type found in xerophytes.
13. ***Bouteloua curtipendula.*** A girder consisting of a group of bulliform and associated colourless cells traversing the mesophyll. Girders of this type occur between adjacent vascular bundles throughout the width of the lamina.
14. ***Aristida ciliata*** var. ***capensis.*** A tall girder of colourless cells traversing the mesophyll from the base of an adaxial furrow to the abaxial epidermis.

A.F. adaxial furrow. O.S. outer bundle-sheath. All × 136.

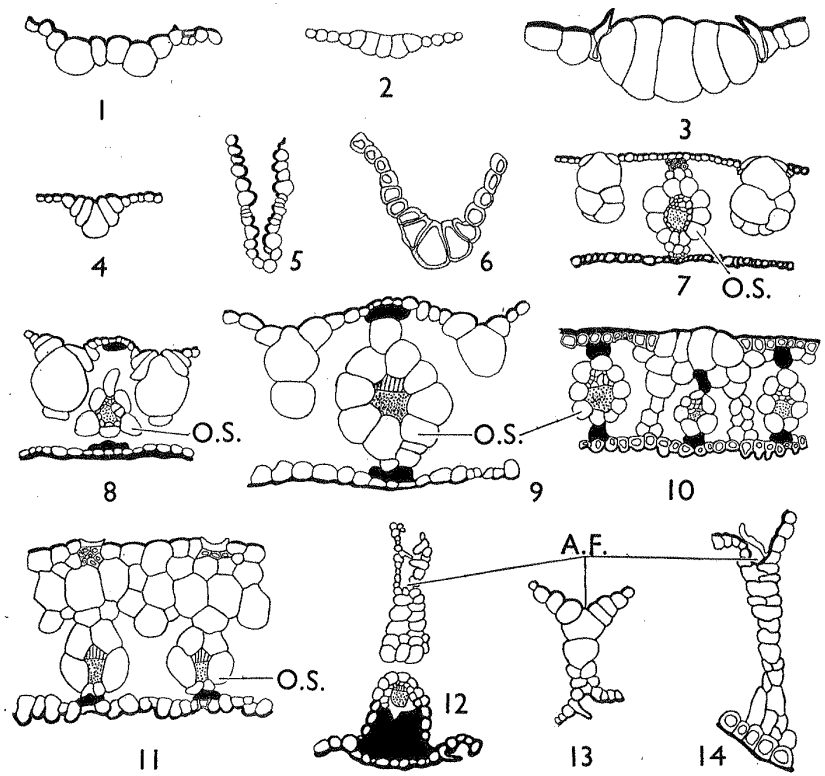


FIG. XV

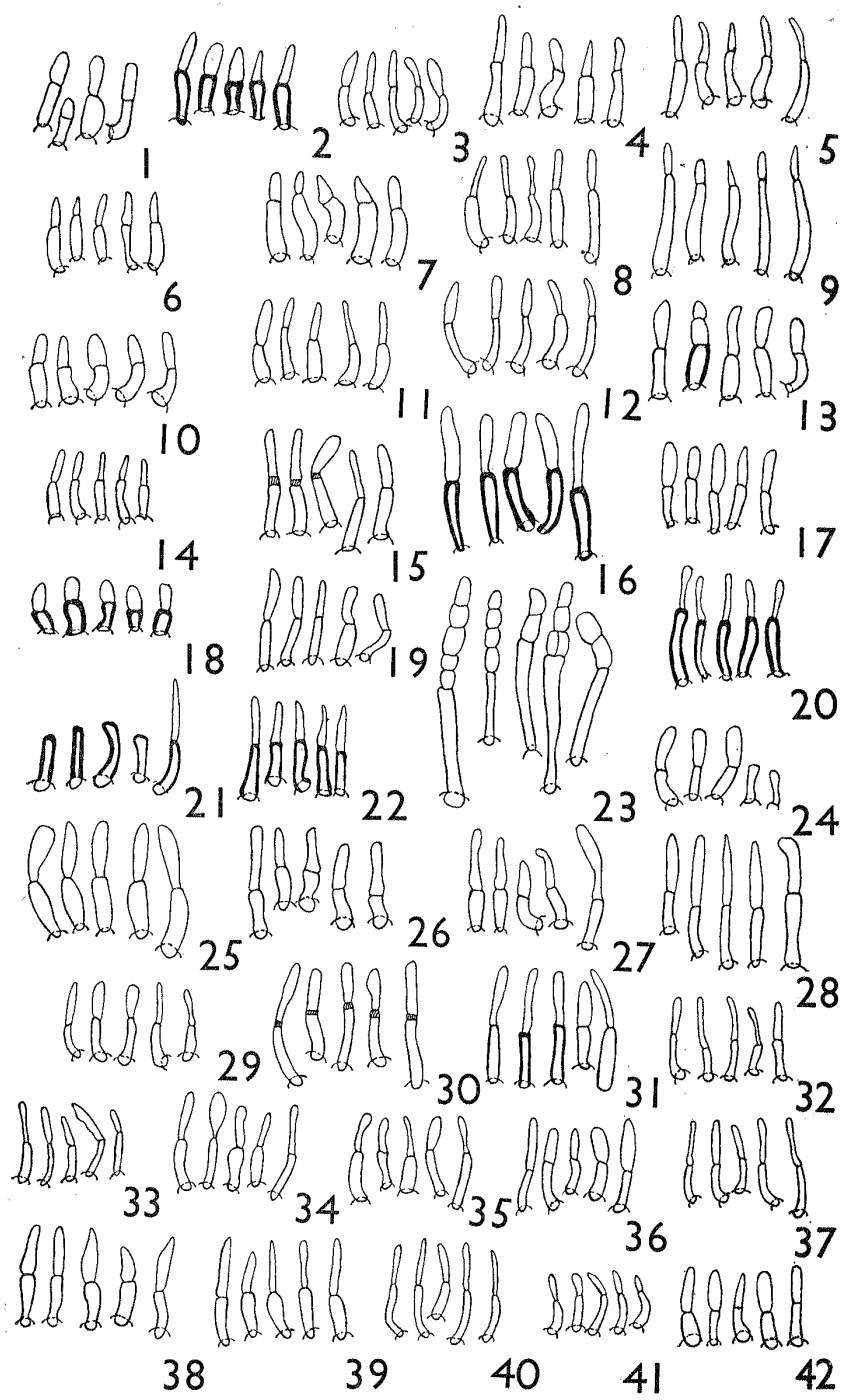


FIG. XVI

FIG. XVI. MICRO-HAIRS OF BAMBOOS

Nearly all of the bamboos that have been investigated have micro-hairs on the abaxial surfaces of the leaves. Fig. XVI shows the range of structure of these micro-hairs in forty-two spp. It will be noted that the morphology of the hairs varies from sp. to sp., and that the genera are not sharply demarcated. *Guaduella oblonga* (23) is exceptional in having uniseriate, or even partly biseriate, hairs. Hairs more than two cells long were also noted occasionally in *Arundinaria vagans* (13). The spp. represented are as follows

1. ***Arthrostylidium capillifolium.***
2. ***A. pubescens.***
3. ***Arundinaria (Semiarundinaria) fastuosa.***
4. ***A. variegata***
5. ***A. graminea.***
6. ***A. japonica.***
7. ***A. marmorea.***
8. ***A. murielae.***
9. ***A. nitida.***
10. ***A. pumila.***
11. ***A. simonii.***
12. ***A. ragamowskii***
13. ***A. vagans.***
14. ***Bambusa nana.***
15. ***B. vulgaris.***
16. ***Cephalostachyum capitatum.***
17. ***Chloothamnus elegantissimus.***
18. ***Chusquea tenella.***
19. ***Dendrocalamus giganteus.***
20. ***Dinochloa m'clellandii.***
21. ***Gigantochloa ligulata.***
22. ***Guadua paniculata.***
23. ***Guaduella oblonga.***
24. ***Melocalamus compactiflorus.***
25. ***Melocanna baccifera.***
26. ***Merostachys riedeliana.***
27. ***Nastus capitatus.***
28. ***N. elongatus.***
29. ***Ochlandra setigera.***
30. ***Oreobambus buchwaldii.***
31. ***Oxytenanthera abyssinica.***
32. ***Phyllostachys bambusoides.***
33. ***P. castillonis.***
34. ***P. heterocycla.***
35. ***P. nigra.***
36. ***P. reticulata.***
37. ***P. viridi-glaucescens.***
38. ***Pseudostachyum polymorphum.***
39. ***Schizostachyum gracile.***
40. ***Shibataea kumasasa.***
41. ***S. ruscifolia.***
42. ***Thyrsostachys oliveri.***

All × 220.

FIG. XVII. MIDRIBS OF BAMBOOS IN TRANSVERSE SECTION

1. (*a*)–(*c*) ***Dendrocalamus brandisii.*** T.S. midrib at three successively lower levels to show the range of structure in an individual le af (Type I, cf. (10)). × 60.
2. (*a*)–(*b*) ***Shibataea kumasasa.*** T.S. midrib at two successively lower levels to show the range of structure in a single leaf. At a higher level in the leaf than that illustrated in 2 (*a*), the midrib is marked by only a single vascular bundle.

3–11. T.S. midribs of bamboos cut in the position that was adopted as a standard for comparative purposes, i.e. about midway between the apex and base of the lamina. All × 60.

3. ***Arthrostylidium capillifolium*** (Type V).
4. ***Chusquea tenella*** (Type VIII).
5. ***Arundinaria murielae*** (Type VI).
6. ***Chusquea abietifolia*** (Type VII).
7. ***Atractocarpa olyraefolia*** (Type III).
8. ***Oxytenanthera abyssinica*** (Type II).
9. ***Phyllostachys bambusoides*** (Type IV, cf. (11)).
10. ***Gigantochloa ligulata.*** (*a*) × 12½; (*b*) a similar, but not identical section × 60 (Type I, large form, cf. (1)).
11. ***Phyllostachys viridi-glaucescens*** (Type IV, cf. (9)).

Solid black = sclerenchyma. Dotted areas = phloem. Vertical lines = xylem. The clusters of large cells in the adaxial epidermis are bulliform cells.

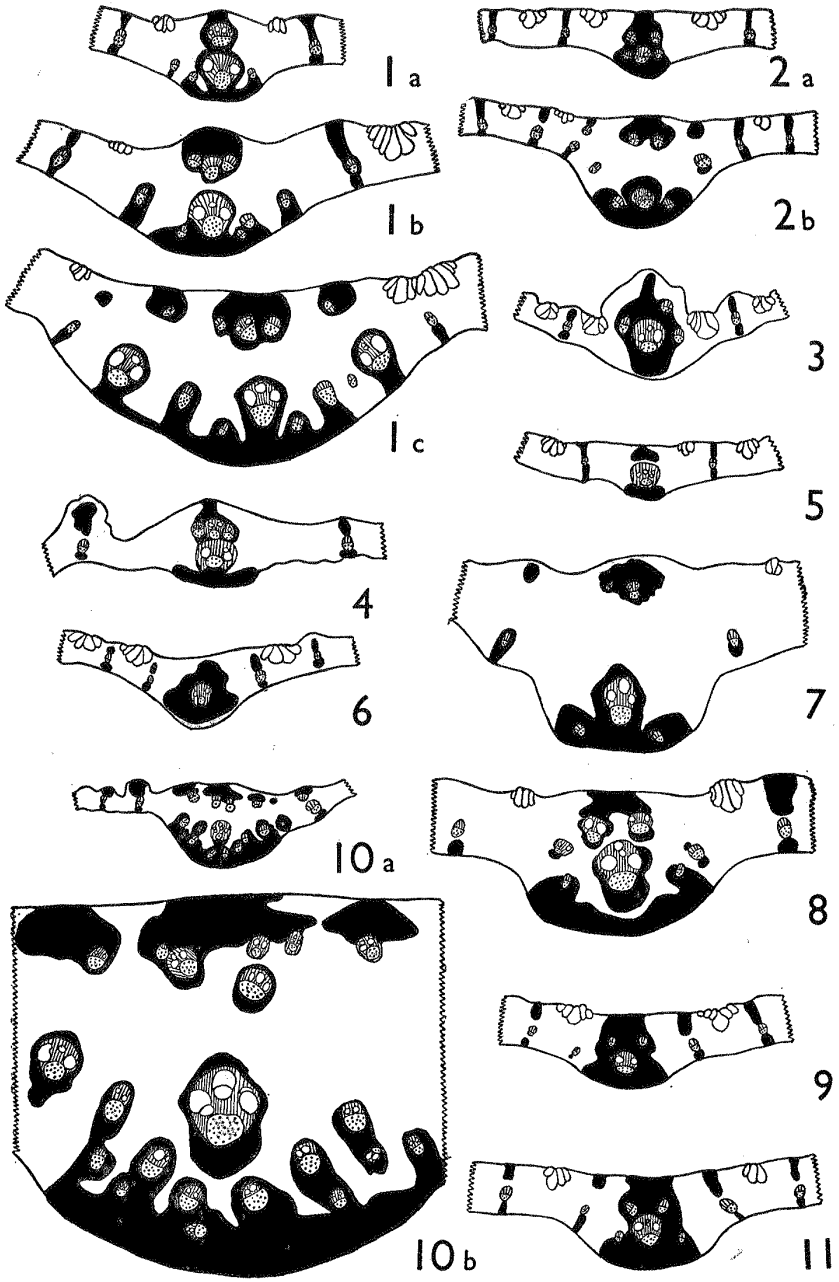


FIG. XVII

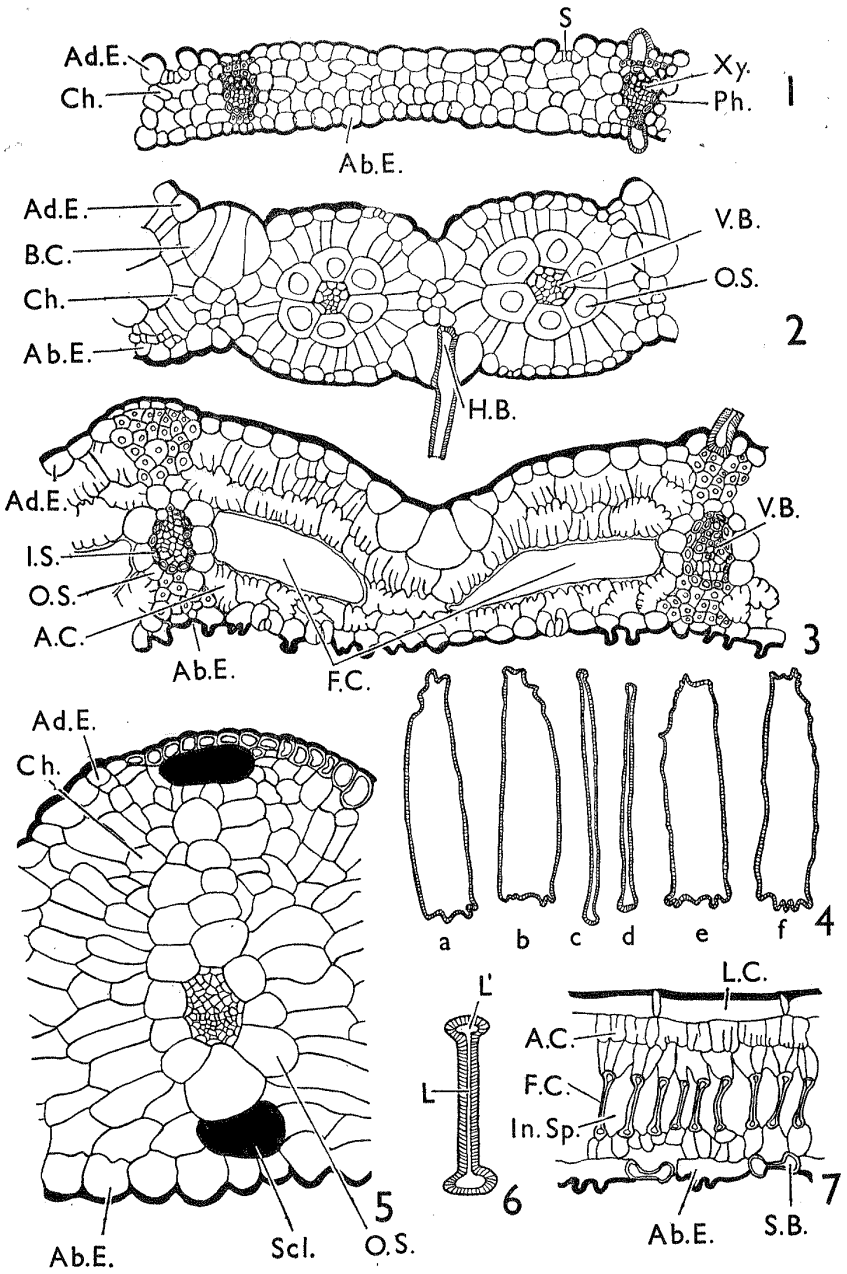


FIG. XVII

FIG. XVIII. MESOPHYLL STRUCTURE

1. ***Melica uniflora.*** T.S. lamina with festucoid mesophyll, the chlorenchyma not being arranged radiately around the vascular bundles. × 220.

2. ***Panicum capillare.*** T.S. lamina with panicoid mesophyll, the chlorenchyma being arranged radiately around the vascular bundles. × 220.

3. ***Arundinaria variegata.*** T.S. lamina showing the type of mesophyll characteristic of bamboos, with chlorenchyma composed of arm-cells and translucent fusoid-cells. × 220.

4. ***Dinochloa m'clellandii.*** (*a*), (*b*), (*e*), (*f*) Fusoid-cells from a macerated leaf lying on their sides, i.e. more or less as they appear in a T.S. of the leaf. (*c*), (*d*) Fusoid-cells from a macerated leaf standing on their edges, i.e. as they would appear in a paradermal section of the leaf. × 220.

5. ***Isachne kunthiana.*** T.S. of a small portion of the lamina passing through a vascular bundle, showing the chlorenchyma arranged in a more or less radiating manner around the vascular bundle. The assimilatory cells are often narrower and more elongated than those shown in the figure. This type of mesophyll, which is very spongy, and of which it is difficult to prepare sections, is highly characteristic of *Isachne* and allied genera. × 300.

6. ***Arundinaria variegata.*** Reconstruction of a fusoid-cell as seen in a T.S. of the lamina parallel with its long axis. These cells always appear to have contracted when observed in sections so that the narrow lumen is often invisible or is seen as a single line. The wider portion of the lumen at either end of the cell can sometimes be seen more clearly. Fusoid-cells are generally to be seen in a collapsed condition and this has led to difficulty in interpreting their structure.

7. ***Arundinaria variegata.*** T.S. lamina parallel to its long axis showing long-cells alternating with short-cells of the adaxial epidermis; chlorenchyma composed of arm-cells; a single row of fusoid-cells, separated from one another by intercellular spaces. Two dumb-bell shaped silica-bodies are to be seen in the abaxial epidermis. × 220.

Ab.E. abaxial epidermis. A.C. arm-cells. Ad.E. adaxial epidermis. B.C. bulliform cells. Ch. chlorenchyma. F.C. fusoid-cells. H.B. base of hair. I.S. inner bundle-sheath. In.Sp. intercellular space. L. lumen of cell. L′ wide lumen at end of cell. L.C. long-cell. O.S. outer bundle-sheath. Ph. phloem. S. stoma. S.B. silica-body. Scl. sclerenchyma. V.B. vascular bundle. Xy. xylem.

FIG. XIX. CULM STRUCTURE IN TRANSVERSE SECTION

1. ***Holcus lanatus.*** Culm T.S. × 30.
2. ***H. lanatus.*** Culm T.S. × approx. 7.
3. ***Anthoxanthum odoratum.*** Culm T.S. × approx. 7.
4. ***Agropyron intermedium.*** Culm T.S. × approx. 4.
5. ***Saccharum officinarum.*** Vascular bundle from the inner part of the culm. × 61.
6. ***S. officinarum.*** Culm T.S. × approx. 4.
7. ***Phyllostachys bambusoides.*** Vascular bundle from the inner part of the culm. × 30.
8. ***P. bambusoides.*** Culm T.S. ⅓ Nat. size.
9. ***Arundinaria variegata.*** Culm T.S. × approx. 4.
10. ***Phyllostachys bambusoides.*** Part of culm T.S. × 12.

A.T. assimilatory tissue (chlorenchyma). EP. epidermis. H.C. hollow centre of culm. SCL. sclerenchyma. V.B. vascular bundle.

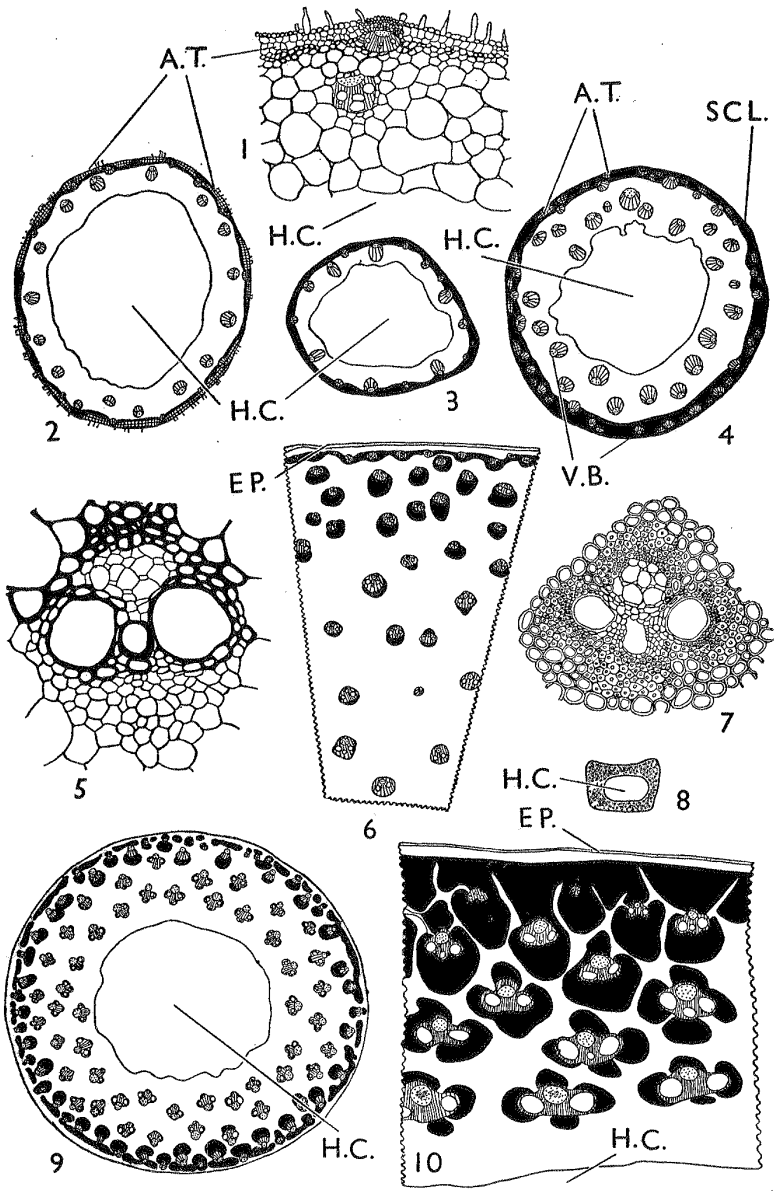


FIG. XIX

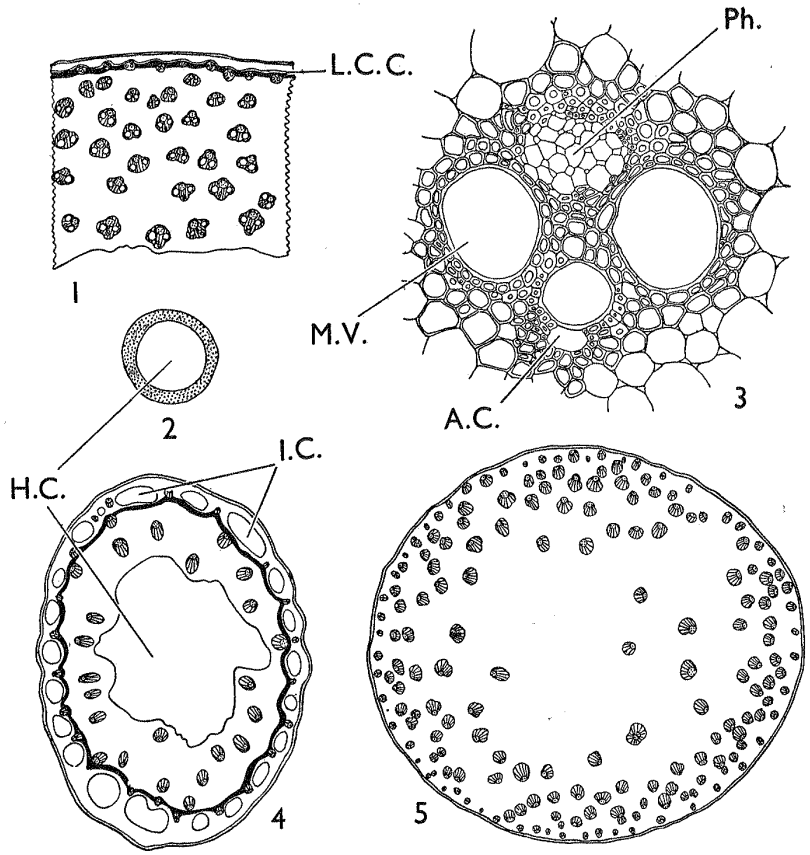


FIG. XX

FIG. XX. CULM STRUCTURE IN TRANSVERSE SECTION

1. ***Arundo donax.*** Culm T.S. × 13.
2. ***A. donax.*** Culm T.S. Nat. size.
3. ***A. donax.*** Vascular bundle of culm. × 183.
4. ***Paspalum commersonii.*** Culm T.S. × 20.
5. ***Miscanthus condensatus.*** Culm T.S. × 10.

A.C. air-canal formed by breakdown of the protoxylem. H.C. hollow centre of culm. I.C. intercellular cavity. L.C.C. layer of clear (translucent) cells. M.V. metaxylem vessel. Ph. phloem.

FIG. XXI. CULM STRUCTURE IN TRANSVERSE SECTION

1. ***Sacciolepis africana.*** Culm T.S. × 10.
2. ***S. africana.*** Culm T.S. × 36.
3. ***Oryza sativa*** var. ***violacea.*** Culm T.S. × 10.
4. ***Glyceria maxima.*** Portion of culm 12 mm. diameter T.S. × 20.
5. ***Leersia hexandra.*** Culm T.S. × 47.
6. ***L. hexandra.*** Culm T.S. × 17.
7. ***Glyceria maxima.*** Spongy tissue in culm. Spongy parenchyma of Fig. 4 more highly magnified. × 36.
8. ***Spartina townsendii.*** Culm T.S. × 20.
9. ***S. townsendii.*** Culm T.S. × 47.

H.C. hollow centre of culm. I.C. intercellular cavity. S.C. stellate cells. S.P. spongy parenchyma with abundant intercellular spaces.

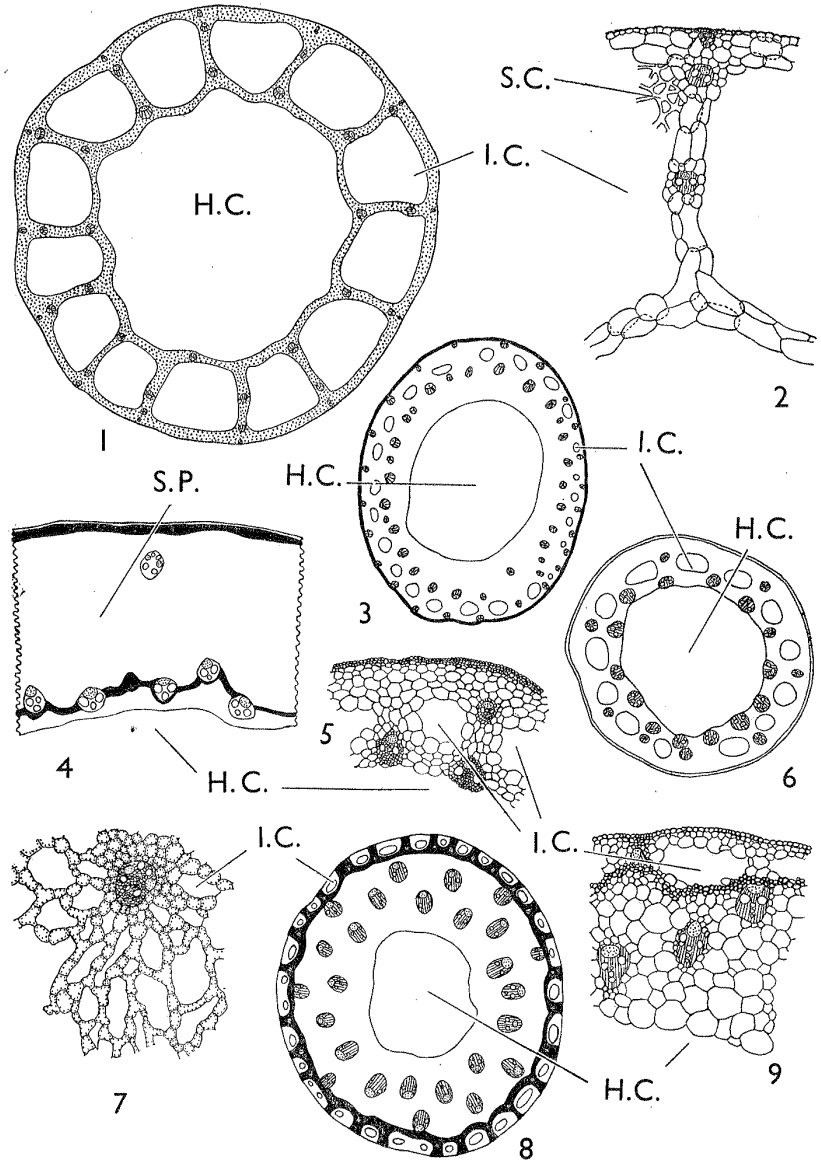


FIG. XXI

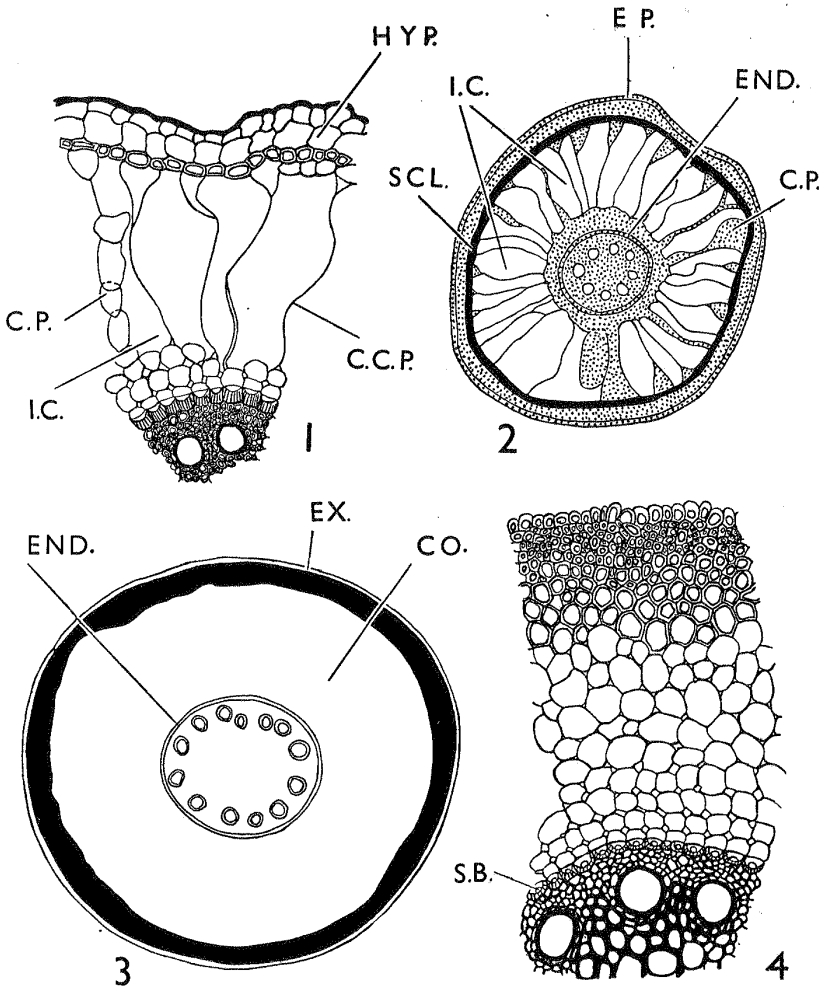


FIG. XXII

FIG. XXII. ROOT STRUCTURE IN TRANSVERSE SECTION

1. ***Paspalum commersonii.*** Portion of root T.S. × 65.
2. ***P. commersonii.*** Root T.S. × 26.
3. ***Cleistachne sorghoides.*** Root T.S. × approx. 15.
4. ***C. sorghoides.*** Root T.S. × 48.

CO. cortex. C.P. radiating plate of cortical parenchyma. C.C.P. radiating plate as C.P. but consisting of collapsed cells. END. endodermis. EP. epidermis. EX. exodermis. HYP. hypodermis. I.C. intercellular cavity. S.B. silica-body. SCL. sclerenchyma.

FIG. XXIII. LEAF EPIDERMIS OF *BROMUS*

Abaxial epidermis of the leaves of six spp. of *Bromus* to show inter-specific differences

1. ***B. carinatus.***
2. ***B. fibrosus.***
3. ***B. inermis.***
4. ***B. japonicus.***
5. ***B. tectorum.***
6. ***B. unioloides.***

H. base of macro-hairs. L.C. long-cells. S. stoma. S.C. short-cells. Broken horizontal lines mark cells over veins. Oblique continuous lines mark silica-bodies. Prickle-hairs shown with heavy black outlines. Figs. 1 and 4 × 220. Figs. 2, 3, 5, and 6 × 110.

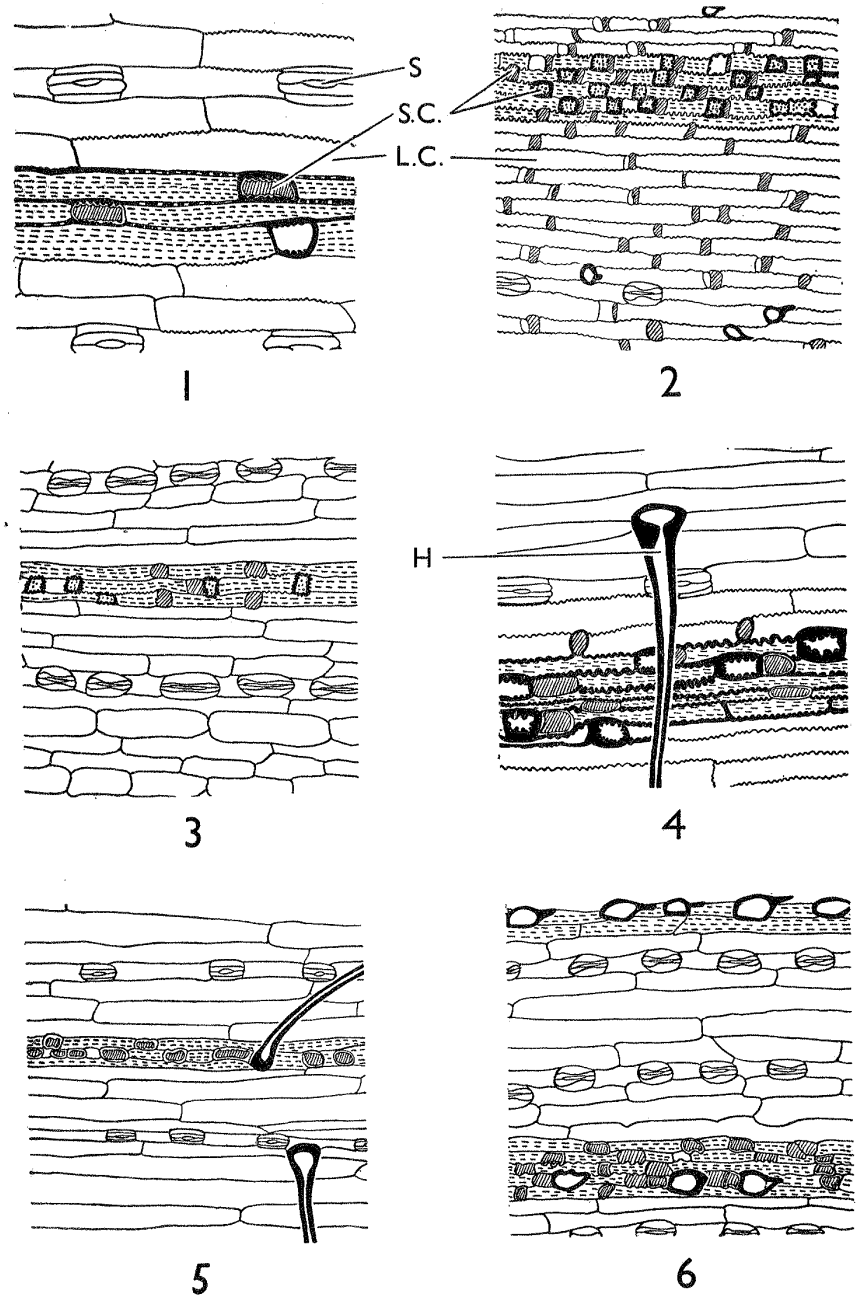


FIG. XXIII

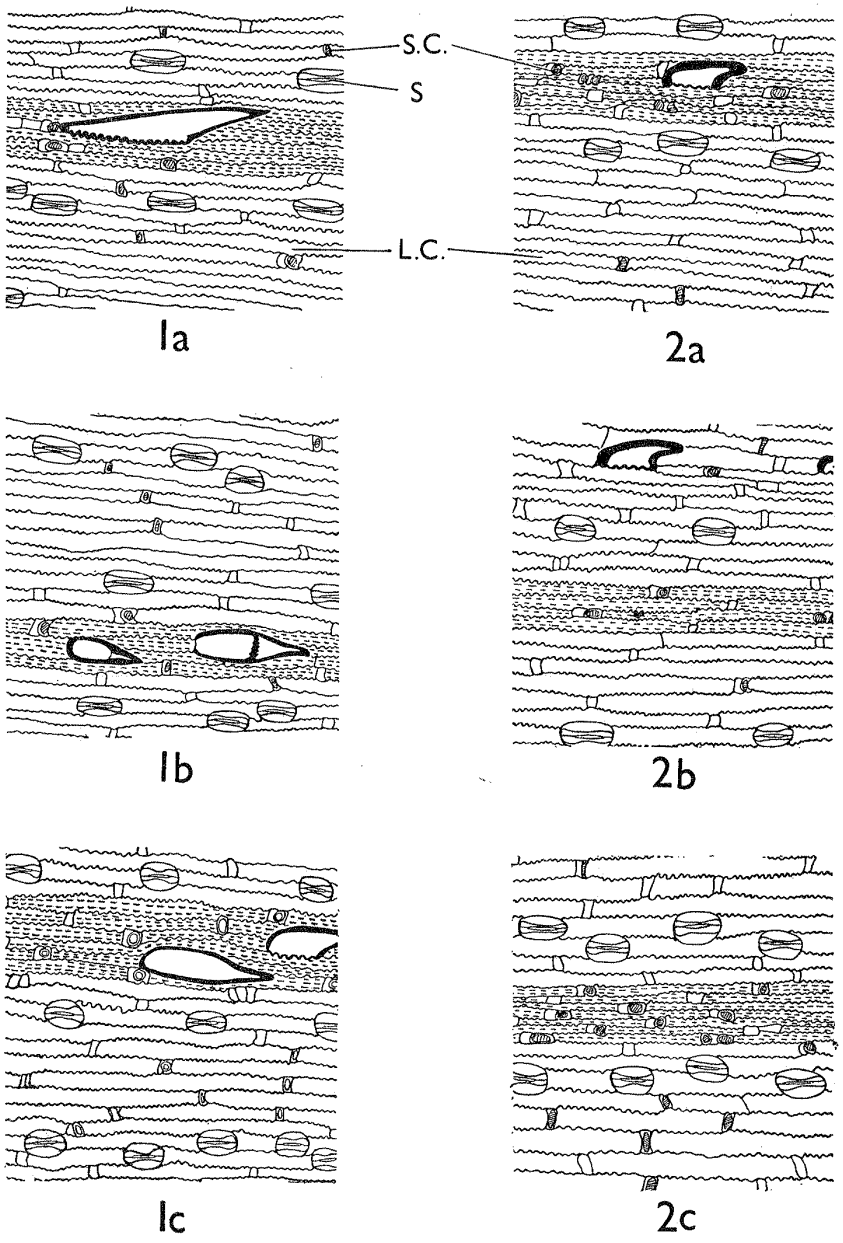


FIG. XXIV

FIG. XXIV. ABAXIAL LEAF EPIDERMIS OF *FESTUCA ARUNDINACEA*

1a–1c. Distal end, middle and base of a cauline leaf.

2a–2c. Distal end, middle and base of a basal leaf.

L.C. long-cells. S. stoma. S.C. short-cell. Broken horizontal lines mark cells over veins. Oblique lines mark silica-bodies. Prickle-hairs shown with heavy black outlines. All × 110.

FIG. XXV. ABAXIAL LEAF EPIDERMIS OF MISCELLANEOUS GRASSES

All preparations from midway between the apex and base of the lamina

1. ***Alopecurus geniculatus.***
2. ***Calamagrostis epigejos.***
3. ***Enneapogon cenchroides*** (only the bases of the glandular hairs (Fig. IIA, 8) are shown).
4. ***Eragrostis chloromelas.***
5. ***Brachypodium pinnatum.***
6. ***Leptaspis cochleata.***

H.B. hair base. L.C. long-cells. N. nucleus. P. papillae; P′ unpointed prickle. S. stoma. S.C. short-cell. Broken horizontal lines mark cells over veins. Oblique lines mark silica-bodies. Prickle-hairs shown with heavy black outlines. Fig. 1 × 110; remainder × 220.

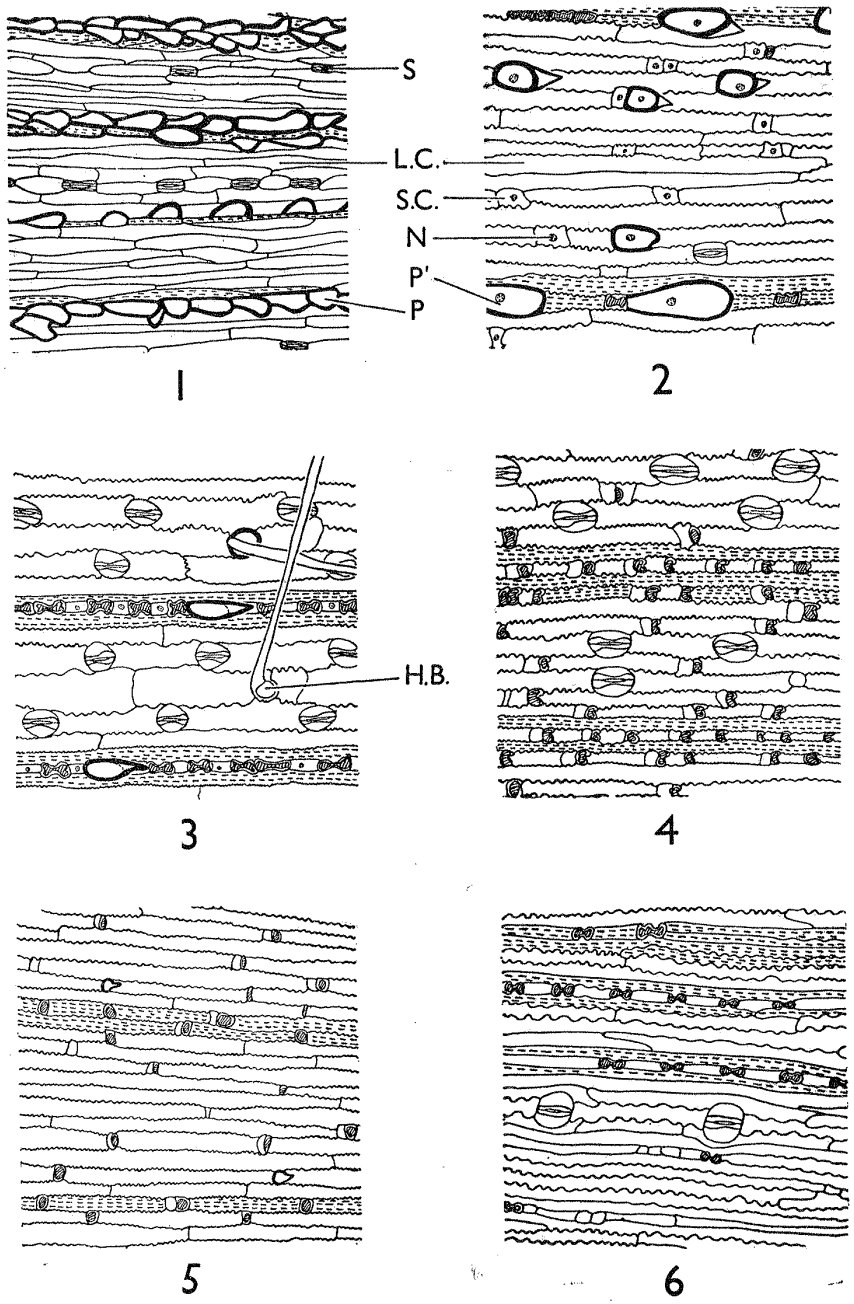


FIG. XXV

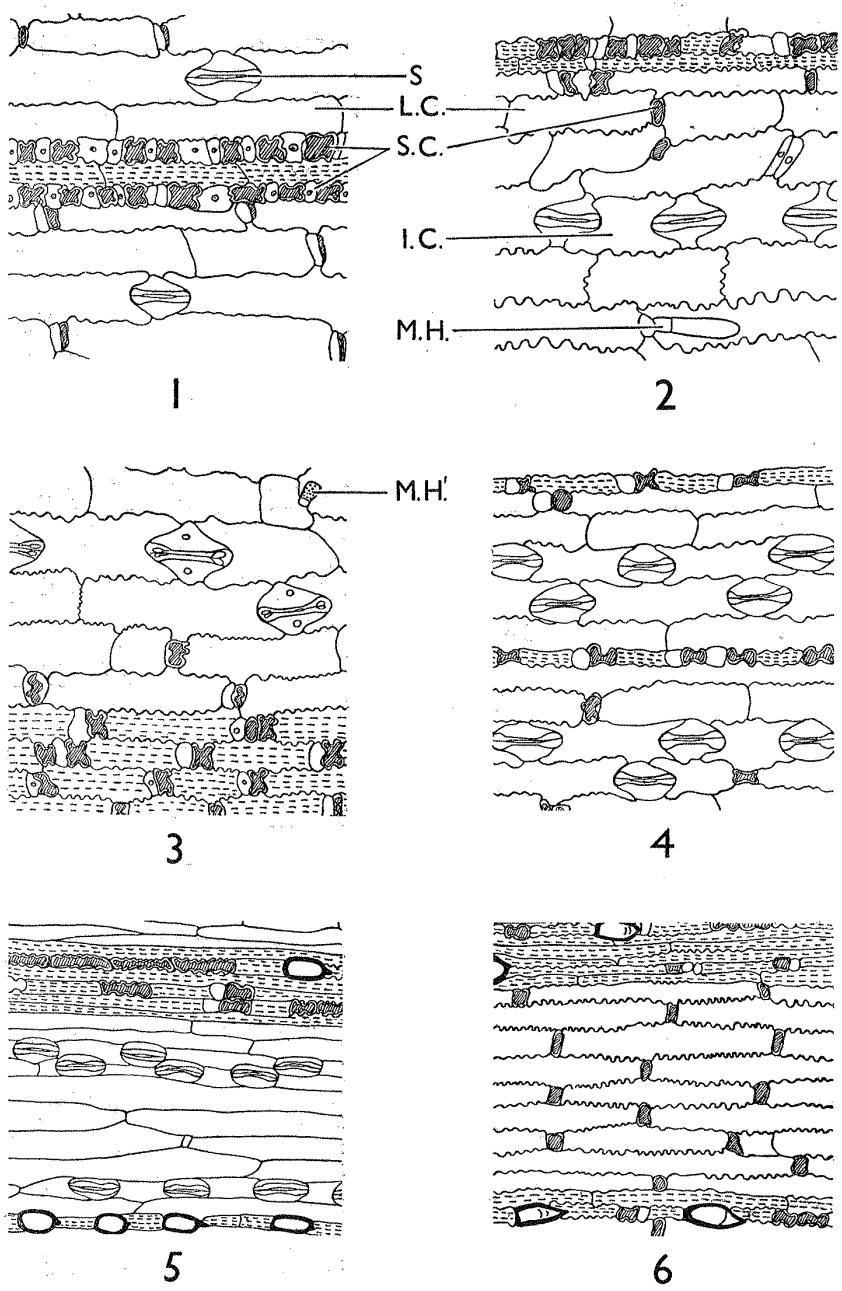


FIG. XXVI

FIG. XXVI. ABAXIAL LEAF EPIDERMIS OF MISCELLANEOUS GRASSES

All preparations from midway between the apex and base of the lamina

1. ***Euchlaena perennis.***
2. ***Euchlaezea mertonensis.***
3. ***Zea mays.***
4. ***Coix lacryma-jobi.***
5. ***Melica altissima.***
6. ***M. ciliata.***

I.C. interstomatal cell. L.C. long-cells. M.H. micro-hair. M.H.′ base of micro-hair. S. stoma. S.C. short-cells. Broken horizontal lines mark cells over the veins. Prickle-hairs shown with heavy black outlines.

FIG. XXVII. LEAF EPIDERMIS OF MISCELLANEOUS GRASSES

All preparations from midway between the apex and base of the lamina

1. ***Heteranthoecia guineensis*** (abaxial).
2. ***Cyrtococcum trigonum*** (adaxial).
3. ***Echinochloa crus-galli*** (abaxial).
4. ***Cymbopogon citratus*** (abaxial).
5. ***Cenchrus pauciflorus*** (adaxial).
6. ***C. pauciflorus*** (abaxial).

I.C. interstomatal cell. L.C. long-cells. M.H. micro-hairs. N. nucleus. P. papillae. S. stoma. S.C. short-cells. Broken horizontal lines mark cells over veins. Oblique lines mark silica-bodies. Prickle-hairs shown with solid black outlines. All × 220.

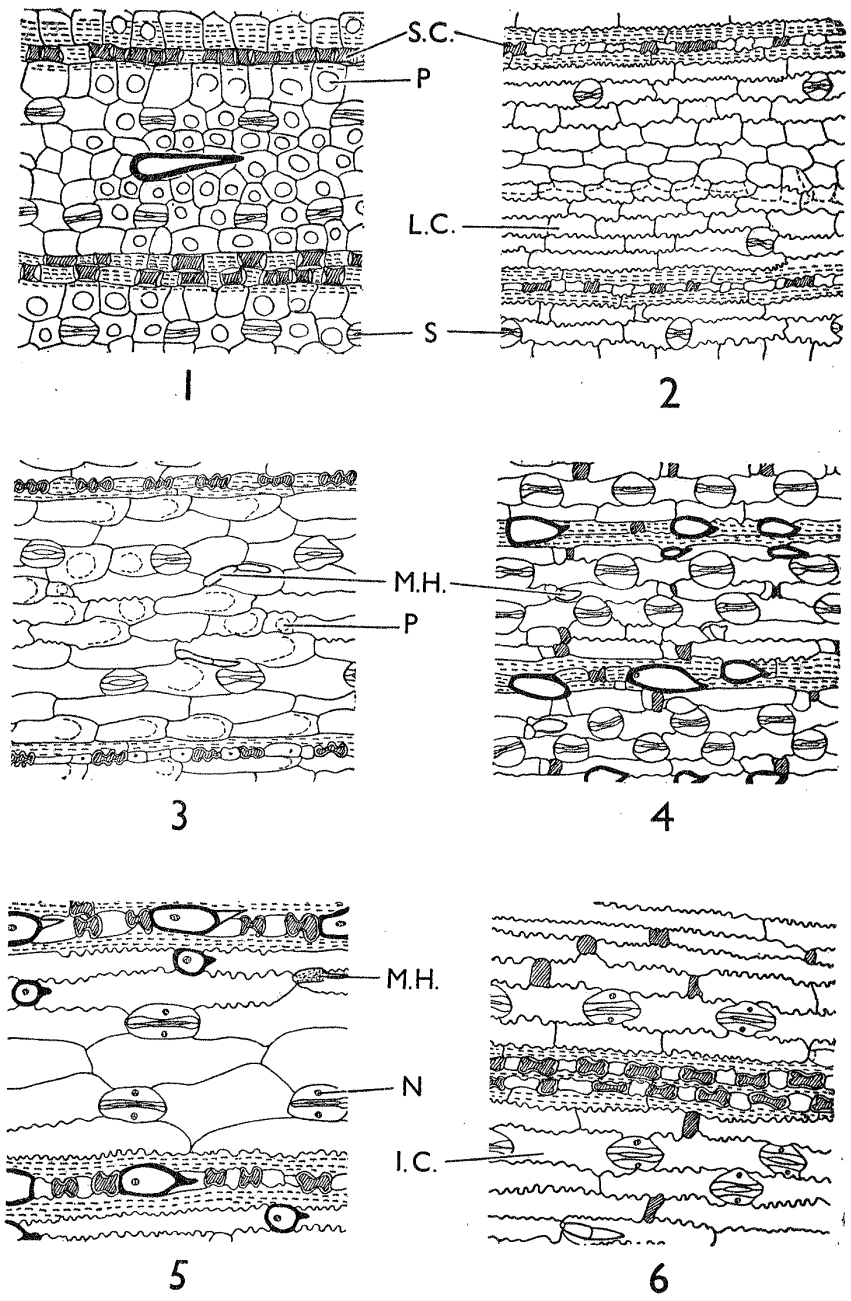


FIG. XXVII

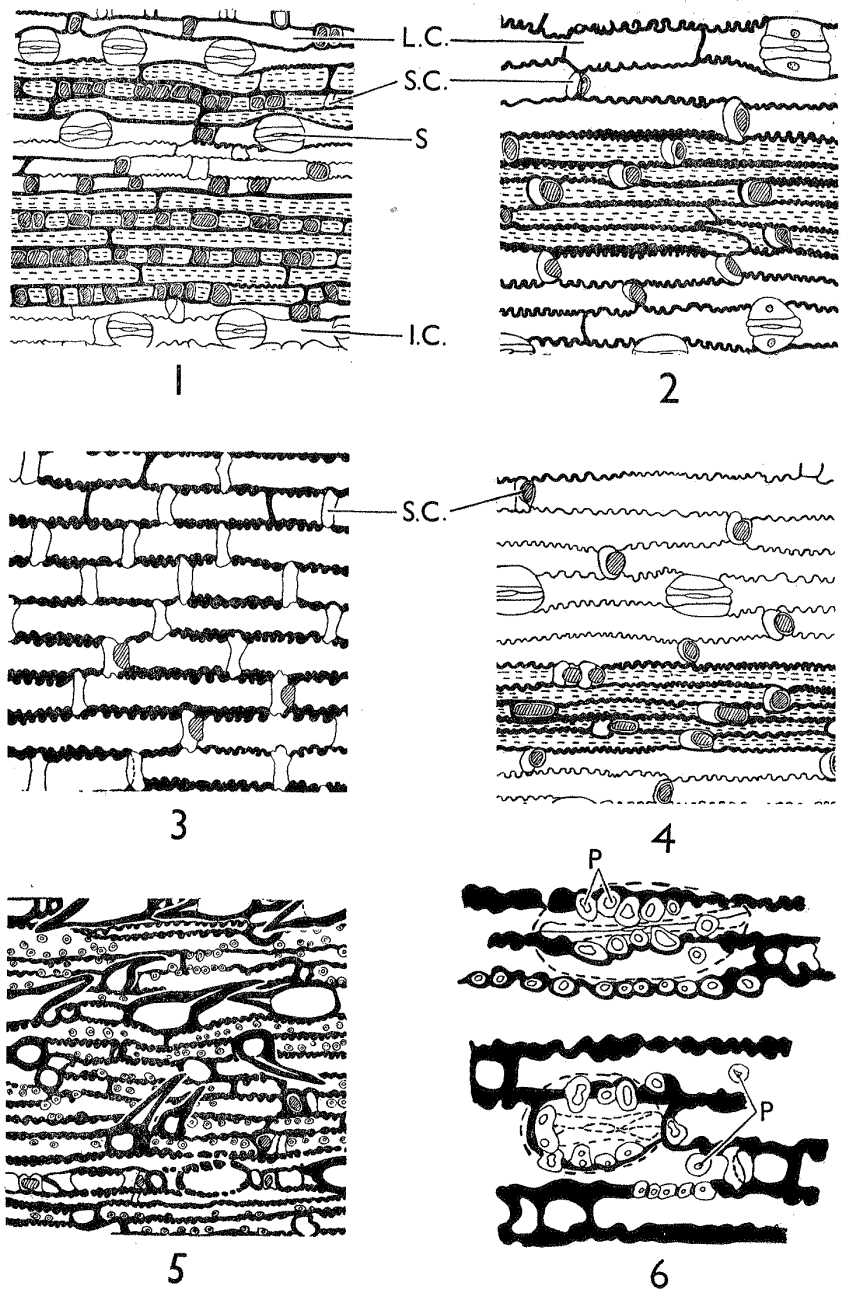


FIG. XXVIII

FIG. XXVIII. ABAXIAL LEAF EPIDERMIS OF MISCELLANEOUS GRASSES

All preparations from midway between the apex and base of the lamina

1. ***Festuca arundinacea* × *Lolium perenne*.**
2. ***F. arundinacea*.**
3. ***F. glauca*.**
4. ***Psammochloa villosa*.**
5. ***Trikeraia hookeri*.**
6. ***T. hookeri*.** Sunken stomata and surrounding epidermal cells and papillae more highly magnified.

I.C. interstomatal cell. L.C. long-cells. P. papillae. S. stoma; S.C. short-cells. Figs 1-5 × 220. Fig. 6 × 440.

FIG. XXIX. ABAXIAL LEAF EPIDERMIS OF MISCELLANEOUS GRASSES WITH INFREQUENT SILICA-BODIES

All preparations from midway between the apex and base of the lamina

1. ***Aegilops triaristata.***
2. ***Elymus condensatus.***
3. ***Cortaderia conspicua.***
4. ***C. selloana.***

In (3) and (4) most of the short-cells are silicified, but only a comparatively few of them contain silica-bodies.

H.B. base of macro-hair. L.C. long-cells. Pr. small prickle-hair. S. stomata. S.C. short-cells. Broken horizontal lines mark cells over the veins. Oblique lines mark silica-bodies. All × 110.

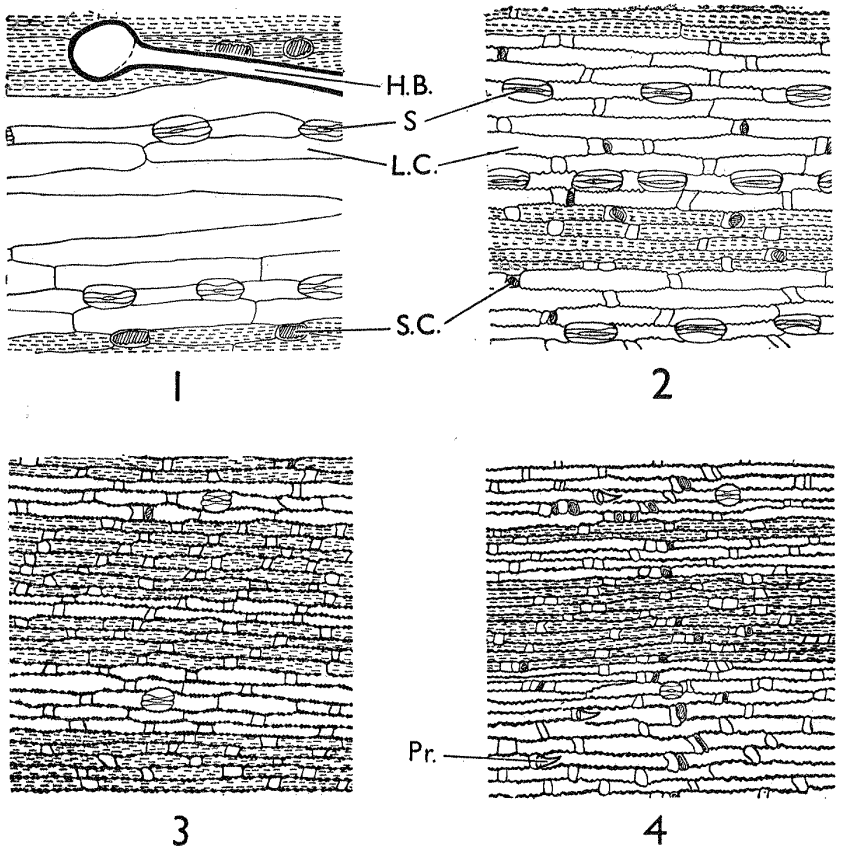
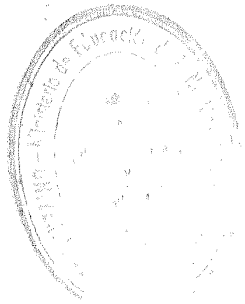


FIG. XXIX

NOTE FOR INDEX

Bold numbers indicate that the text contains author's original work.
Italic numbers are references to figures.



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