I. THE CLASSIFICATION OF THE GENUS DROSOPHILA, WITH DESCRIPTIONS OF NINE NEW SPECIES

A. H. STURTEVANT

William G. Kerckhoff Laboratories of the Biological Sciences
California Institute of Technology,
Pasadena, California

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INTRODUCTION

The present account represents an attempt to bring up to date the work on the classification of Drosophila. It cannot be considered final—for certainly more species remain to be discovered in the Nearctic region, and our knowledge of most other parts of the world is very inadequate. Even among the known species, much remains to be done on the structure, cytology, behavior, and geographical distribution—and the data in these fields will undoubtedly lead to modification of many of the tentative conclusions here outlined.

Discussion of Characters

The present section contains an account of each of the characters most commonly studied in the genus. In each case the distribution throughout

the genus is indicated, together with methods and difficulties of determination and description. Most of the characters recorded as ratios show some intraspecific variation; in each case what has been attempted is to give an approximate average value.

Branches of arista.

I formerly distinguished between branches above and below the main axis. As Duda has often pointed out, however, the main axis is usually forked at its apex, and this makes for ambiguity; accordingly what is here usually recorded is the total number of branches, including the terminal fork as two.

This number is variable within a species; what has been attempted is to determine an approximate average value. The range of averages is from 7 (Pholadoris victoria, several of the obscura species-group of Sophophora, Phloridosa floricola, and most members of the following species-groups of Drosophila: melanica, repleta, pinicola, and carbonaria) to 12 (Drosophila tripunctata). The willistoni species-group of Sophophora and the quinaria, guttifera, and funebris groups of Drosophila also have numerous (10 or 11) branches.

Shape and hairiness of third antennal segment.

The third antennal segment is unusually large and is clothed with very long hairs in the subgenus Hirtodrosophila. The length of these hairs varies considerably in the rest of the genus; in Drosophila guttifera they are as long as in some species of Hirtodrosophila.

Structure of front.

The size, shape and distinctness of outline of the orbital lines and ocellar triangle, and of the velvety frontal lines, shows much variation from species to species, but so far no attempt has been made to describe them accurately.

In Pholadoris victoria there is a conspicuous V-shaped bristle-bearing shining mark on the front that has not been observed elsewhere in the family—though what appears to be the same structure is found in related families, being especially marked in the Milichiid Desmometopa.

Orbital bristles.

The orbitals are regularly three in number—two reclinate and one proclinate. The anterior reclinate, lying usually between the other two, is called the middle orbital, even when (as sometimes happens) it is situated at the same level as the proclinate one or even slightly anterior to it. The relative sizes of these bristles are of importance in classification; the middle one is regularly the shortest, and is $\frac{1}{6}$ to $\frac{1}{3}$ the length

of the anterior one in most groups. It is in general slightly longer in the obscura group, and in guttifera, pinicola, and carbonaria.

Oral bristles.

The anterior oral bristle, or vibrissa, is always conspicuous; the bristle just behind it may be nearly as long, or much smaller. If the species are divided into those where the second oral is greater or less than ½ the length of the first, it is found that the group with a short second oral includes the subgenera Hirtodrosophila, Pholadoris, and Phloridosa, the obscura group of Sophophora, and the melanica, repleta, robusta, pinicola, and polychaeta groups of Drosophila.

Carina.

The carina is narrow, and low near the clypeal margin of the face, in Hirtodrosophila and in the affinis sub-group of species. In general it is narrower in Sophophora than in Drosophila; perhaps the narrowest one in the latter subgenus is found in pinicola. Pholadoris, Dorsilopha, and Phloridosa all have it rather broad.

Cheeks.

The "greatest width of cheek" is to be taken as the perpendicular from the lower rear corner of the head to the margin of the eye, this distance to be taken as a projection when the head is placed with its sagittal plane at right angles to the line of vision. It is often more convenient to use the width in a perpendicular axis—i.e., from the lowest point of the eye. In general, the cheeks are narrow in Pholadoris, Hirtodrosophila, Sophophora, and in a few species of Drosophila (e.g., cardini, testacea, robusta, carbonaria).

Hairs below carina.

A few minute hairs are found just above the clypeal margin in the gray sub-group of the saltans relatives—i.e., saltans, biopaca, earlei, sellata, and rectangularis. So far as known this character does not occur elsewhere in the genus.

Acrostichal hairs.

The number of rows of acrostichal hairs often increases anteriorly; it is described on the basis of counts taken just anterior to the anterior dorsocentrals. Even with this precaution it is often not a very reliable character, as it is variable in some species and difficult to determine in others. It has been the rule to key any species known to be subject to such difficulties both ways.

The character is, in general, of little importance in delimiting groups of species. The two sub-groups represented by obscura and affinis differ

in that the first has 8 rows, the second 6; the melanica group has 6, as does also the quinaria group; the repleta group usually has 8, though a few show only 6. No numbers of rows other than 6 or 8 are certainly known as normally characteristic for any species of the genus.

Acrostichal bristles (including prescutellars).

Differentiated acrostichal bristles occur in the genus either as a presutural pair (in the testacea group—subgenus Acrodrosophila of Duda), or as a pair just in front of the scutellum—the prescutellars. These latter are characteristic of the subgenus Pholadoris, and occur in several other poorly understood forms (e.g., sigmoides and florae). There are occasional indications of enlarged hairs in this position in some of the larger species of the repleta group, but in none of these are such hairs as distinct as in the species named. Duda recognizes this as a definite subgeneric character, using it as the sole stated basis for separating his Paradrosophila. The type of this subgenus, Drosophila pictipennis Kertesz, is an East Indian species that is not obviously related to any American form.

Color and pattern of thorax.

The ground color of the thorax—with which is closely correlated that of the head and abdomen—may be roughly described as yellowish or blackish, with a somewhat intermediate reddish brown type that occurs in the funebris and polychaeta groups. The yellowish series includes some rather dark brownish forms, and some that are but little darker than these have been classed as blackish; in other words, there is not a very sharp line between the two types, and yet the distinction remains in general a convenient one.

The yellow species sometimes show a more or less distinct pattern of longitudinal mesonotal or pleural dark stripes (the mesonotal ones best developed in Dorsilopha and in guttifera, the pleural ones in Dorsilopha and in Hirtodrosophila), but do not usually have a pollinose mesonotum. This general color is found in most Hirtodrosophila, in Dorsilopha, in the willistoni and melanogaster groups of Sophophora, and in the quinaria, guttifera, testacea, tripunctata, cardini, and immigrans groups of Drosophila.

The remaining groups are all more or less blackish, often with strong pollinosity. The pollinose areas are in many forms limited, to give a pattern. In the repleta group this is a spotted pattern, each hair and bristle arising from a non-pollinose area. In other groups (e.g., the pollinose subgroup of the saltans group, in the robusta and melanica groups, in Hirtodrosophila alabamensis, and elsewhere) this pattern is in the form of longitudinal stripes that are usually rather indefinite in outline and that are often broken at the suture or elsewhere.

Dorsocentral bristles.

There are regularly two pairs of dorsocentrals, both posterior to the suture. In several forms, such as funebris or virilis, it is not unusual to find somewhat enlarged hairs in the dorsocentral rows anterior to the dorsocentral bristles, and in almost any species occasional specimens have a well developed bristle in this position on one or both sides of the thorax. Only in the polychaeta group (polychaeta and illota) does the possession of three pairs appear to be the usual condition.

The distance between the anterior and posterior dorsocentrals varies from species to species; it is shortest—i.e., the anterior is inserted furthest to the rear—in the subgenus Phloridosa.

Anterior scutellars.

The anterior pair of scutellar bristles are convergent in some Hirtodrosophila (e.g., duncani), Dorsilopha, the melanogaster and obscura groups of Sophophora, the robusta, funebris, polychaeta, carbonaria, cardini, and immigrans groups and most of the melanica and repleta groups of Drosophila. They are divergent in some Hirtodrosophila, in Pholadoris, Phloridosa, the saltans and willistoni groups of Sophophora, and in the quinaria, guttifera, virilis, transversa, and tripunctata groups (and the species ritae and nigromelanica) of Drosophila.

Sternopleural bristles.

As pointed out by Kikkawa and Peng, the relative length of the anterior and posterior sternopleural bristles is a useful specific character. They use the term "sterno-index" to indicate the ratio, anterior divided by posterior. This ratio ranges from about .2 (Phloridosa) or .3 (Dorsilopha and the saltans and willistoni groups) to .8 or .9 (Pholadoris, polychaeta, and most of the virilis, repleta, melanica, and immigrans groups).

Tarsal ornaments of male.

The sex-combs on the basal tarsal segment of the first leg of the male of melanogaster and simulans are familiar. The males of the other members of the melanogaster group and of all the obscura group have such a comb, and a similar but somewhat smaller one also on the second tarsal segment. In the affinis subgroup this distal comb is reduced to a single tooth. In ananassae and takahashii both combs are much reduced in size; in bipectinata the proximal one is broken, to give in effect two parallel combs on the basal segment and a very small third one on the second segment; in montium, rufa, auraria, nipponica, and ficusphila both combs are very long and conspicuous. In montium and auraria, observations on the mating indicate that these combs are made use of in holding the female during copulation. Examination of all species indicates that there is a strong correlation between the number of teeth in a comb—i.e., its length —and the angle at which it is placed. The very long combs are parallel

to the axis of the tarsus, the very short ones are nearly at right angles to that axis, and the combs of intermediate length are at corresponding angles.

Other types of sexual differences are also found on the first tarsi. In immigrans the two basal segments are clothed with long dense hair in the male, and in several species (notably in hydei) there are fewer long hairs on these segments. In others these hairs are not so long, but are conspicuously recurved (e.g., occidentalis, virilis, funebris, or micromelanica). These long or recurved hairs (except those in immigrans) are, like the sex-combs, usually on the inner surface of the segment.

Preapical tibial bristles.

These bristles are small or absent on the first and second tibiae in most species of Hirtodrosophila, and in Dorsilopha; elsewhere they are distinctly evident on all three tibiae. In the obscura group and in ananassae those on the first tibiae are unusually long.

Abdominal bands.

The shape of the posterior dark areas on the abdominal tergites offers good specific differences, but is somewhat inconvenient to use. In pinned material the shrinkage of the abdomen often obscures the pattern hopelessly, and even in living material allowances have to be made for some darkening with the age of the specimen, for different superficial appearances due to the degree of distension of the abdomen, and for sexual differences.

There are two fairly distinct types of dark bands: some are broken or definitely narrower in the mid-dorsal region, whereas others are uniform in width or are broader in the median line. The narrowing is sometimes slight, and is in general most evident in newly emerged females; determinations on young live specimens will often be contradicted by observations on old dead ones. The rule is that the narrowing begins with the proximal band and extends posteriorly—i.e., if one band is narrowed or broken it is the anterior one, if two they are the two basal ones, etc. In general, no more than the anterior band (if any) is narrowed except in the subgenus Drosophila. In that subgenus from 3 to 5 bands are usually narrowed, though in such forms as micromelanica, virilis, or carbonaria the whole abdomen is so dark that the determination of the point becomes impracticable.

In some forms—especially in the quinaria and guttifera groups—there is a further breaking of the abdominal bands, to form rows of spots. In some members of the repleta group there is a lateral pale area on each tergite, the shape and extent of which is helpful in classifying that difficult group.

Sexual differences in abdominal color are most frequent in the posterior tergites, which often have more extensive black areas in males than in females—as in melanogaster, simulans, or funebris.

Opaque areas on abdominal tergites.

In the saltans group there are curious opaque heavily chitinized areas on the fifth abdominal tergites of the females, that have not been observed in any other forms. These areas are single and in the median line in all except biopaca, which has a pair of lateral ones. They are not usually easy to make out in pinned material. In live specimens they are conspicuous, and of a characteristic shape in each species; these shapes have been utilized in forming the specific names of the six members of the group here described as new. The histological nature of these areas and their function (if any) are not known.

Wing-vein indices.

The four indices appearing in the species descriptions are the following: costal index (length second section of costa/length third section); fourth vein index (length fourth—i.e., distal—section of fourth vein/length third section); 4c index (length third section of costa/length third section of fourth); 5x index (length distal section of fifth vein/length posterior crossvein). The first two of these are somewhat less variable and more useful as specific characters. All show interspecific variability, and the attempt has been to record average values.

The costal index ranges from about 1.2 in bipectinata to 4.4 in immigrans. It is in general 3.0 or less in Sophophora, and in this subgenus is highest in the obscura group. In Drosophila it is usually 3.0 or greater (2.2 in guttifera, 2.0 in polychaeta, 2.5 in carbonaria, 2.4 in arizonensis, 2.5 in peninsularis, 2.6 to 2.9 in several other forms). It is less than 2.0 in Pholadoris, varies from 1.9 to 3.8 in Hirtodrosophila, 3.1 in Dorsilopha, 2.1 to 3.6 in Phloridosa.

The fourth vein index shows a weak but definite negative correlation with the costal index—i.e., if the second vein ends near the wing tip (high costal index), the posterior crossvein is likely also to be distally placed (low fourth vein index). The extreme values observed for the fourth vein index are 1.0 in deflecta and 2.7 in auraria. Values as high as 2.0 are rare except in Sophophora, Pholadoris, and Dorsilopha.

Duda has described the venation extensively in terms of the curvature of the veins. This procedure is often helpful, especially in the case of the sinuate posterior crossvein of flexa, sigmoides, and some of the quinaria group. The gentle curves often found in the longitudinal veins are difficult to describe in words, but furnish useful diagnostic characters when pictures are available.

Bristles of Costa.

The costal margin has heavy though short bristles from the base of the wing to a point between the ends of the second and third veins. The point at which these bristles disappear is a satisfactory species character, but varies much as between closely related forms—i.e., it is not useful as

a group character. The extremes noted are in several members of the repleta group, where only the basal ¼ of the third costal section is bristled, and in guttifera (about ¾ of the third section bristled) and polychaeta (9/10 of the third section bristled).

At the tip of the first section of the costa there is usually one pair of these bristles that is longer than the others, one directed diagonally upwards, the other diagonally downwards. In most species these are approximately equal in size, but in immigrans, magnafumosa, chagrinensis, cardini, putrida, and floricola one of them is so little differentiated from the adjacent bristles that it is simplest to describe the situation by saying that only one bristle is present. Differences in the lengths of these two bristles are also recorded in grisea, spinofemora, and macrospina limpiensis; it is not certain whether these are more or less marked than the differences noted by other observers—since the last three records are due to Patterson and Wheeler, who may have been more precise in their descriptions of this character than some of the rest of us have been.

Wing color.

In many species the wings are uniformly transparent gray, with yellow to dark brown veins. In some forms (e.g., many members of the repleta group) the tip of the first costal section is black. In others there is a clouding of the wing blade along the veins; this appears first along the cross-veins and at the junctions of the longitudinal veins with the costa (e.g., various members of the quinaria, immigrans, and virilis groups). In guttifera there are also clouds around the sense-organs along the veins. In other forms there is a general darkening of the blade of the wing, especially as the specimens age. In such a form as robusta the darkening is most marked along the veins; in nebulosa it becomes intense over a still greater portion of the blade. More complex patterns occur in the family, but are unusual in the genus itself. Perhaps the commonest such pattern consists of a large well-defined very dark spot at the tip of the second vein (e.g., suzukii, several species of Scaptomyza, and numerous members of other acalypterate families). More complex types of banding occur (as in calloptera, many of the Hawaiian forms described by Grimshaw, etc.); but most of these cannot be assigned to any of the subgenera here recognized, and it may be doubted if they are properly to be included in the genus.

Malpighian tubes.

Two stalks arise from opposite sides of the gut near its posterior end; each branches a short distance from its base, and each branch bears a Malpighian tube. The two tubes arising from one stalk lie anterior to their bases, those from the other posterior.

The anterior pair are simple, unbranched, and yellowish with white tips, in all but two of the species dissected. In cardini there is a single tube,

forked only at its apex; in floricola there is no tube, the stalk being a blind sac that is much smaller than that of the posterior pair.

There are two posterior tubes in all forms dissected, but in many species their distal ends are fused to form a loop around the gut. In Pholadoris victoria, and in Drosophila cardini and robusta the ends are merely closely apposed, without the formation of a continuous lumen (the same condition occurs in Scaptomyza graminum). In Hirtodrosophila duncani and orbospiracula, Dorsilopha busckii, Phloridosa floricola, and in all species of the subgenus Drosophila examined (except cardini and robusta, just described), the fusion is complete and involves a continuous lumen. All the species of Sophophora examined have the distal ends free, and not apposed—which is the usual situation in the related families that I have studied.

Testes.

The testes show specific differences in color, but I have done little with this—partly because there is some effect of age on the character.

The shape of the testis is a good group character. The organ is more or less elliptical in Pholadoris (victoria, and coracina according to Kikkawa and Peng) and in the subgroup that includes obscura and pseudoobscura. It is somewhat longer and slightly curved (about the shape of a banana) in Hirtodrosophila duncani, and is much longer and spirally coiled in all other forms studied. There are differences in length of the spirally coiled types, but these are hard to estimate exactly; among the shorter ones are those found in the affinis subgroup and in the melanogaster group, whereas the organ is very long in most species of the subgenus Drosophila.

Ventral receptacle.

The length of this organ is very highly correlated with that of the testis. It is a simple short tube or pocket in corvina and in the obscura subgroup, longer and having about 3 irregular coils in duncani, still longer in the melanogaster group and affinis subgroup, and is a long fine tube in the other species examined. In the saltans group this tube is looped into a long coil, like a skein of wool, and the whole skein is then bent into the form of the letter M. In Phloridosa floricola and in most members of the subgenus Drosophila (micromelanica, putrida, and pinicola are exceptions) there is a "minor coiling" or kinkiness, such that the whole organ resembles a tangled spring.

Of the other Drosophilid genera, the species dissected show the following types: Amiota and Sinophthalmus, a simple recurved pocket, much like that of some of the obscura group; Gitona, slightly longer and folded, but shorter than duncani; Scaptomyza and Leucophenga, long, fine, not kinky; Stegana, long, fine, kinky. In Chymomyza and Mycodrosophila the organ is long and fine, but my notes do not indicate whether it is kinky or not.

Spermathecae.

There are two spermathecae in all members of the genus examined, though in some forms they are rudimentary. In auraria, montium, and floricola the organs are within the usual size-range, but are scarcely chitinized at all; in nigromelanica they are fully chitinized but very small; in micromelanica, polychaeta, hydei, mulleri, and several of the other members of the repleta group (see descriptions by Patterson and Wheeler) they are both small and weakly chitinized.

The spermathecae are telescoped at the base in all members of the genus that I have seen. They vary greatly in size and shape (see figures in Sturtevant 1921, pp. 36–37), but I have been unable to discover any useful group characters in these differences.

Eggs.

There are no filaments and no remains of follicle-cells in Phloridosa floricola. There are two blunt filaments in Sophophora, two tapering ones in the melanica group. In the saltans and willistoni groups and in ananassae and bipectinata the apical ⅓ to ½ of each filament is greatly expanded and flattened. In the quinaria and guttifera groups there are three filaments, of which the two anterior are tapering, and the posterior evidently represents a fusion of the posterior pair present in the rest of the subgenus. Four tapering filaments occur in Dorsilopha busckii and in all the subgenus Drosophila except the melanica, quinaria, and guttifera groups just mentioned; four are also present in Hirtodrosophila duncani and orbospiracula. In Pholadoris there are from 6 to 9 filaments.

Among the other genera in the family the following numbers of filaments have been observed: Amiota and Stegana, none; Scaptomyza, 2 (graminum) or 4 (adusta, terminalis); Mycodrosophila, 4; Chymomyza, 8 to 10.

Larvae.

There are a number of species—Pholadoris victoria (and P. coracina according to Kikkawa and Peng), the saltans group, and cardini, in which the larvae "skip," by the same mechanism as that which is well known in Piophila and a few other Acalypterae (Professor Patterson informs me that this habit is found also in the Drosophilid genus Gitona). The larva siezes its posterior end with its mouthhooks, and stretches. The hooks pull loose suddenly, the larva straightens with considerable force, and as a result is thrown several inches into the air. It seems clear that this curious habit—for which there is no obvious adaptive explanation—must have arisen several times independently. No structural peculiarity of the mouth-hooks or of the region that they grasp has been observed.

The larvae of Dorsilopha busckii have a series of fleshy dorsal processes, resembling those of certain Anthomyiidae, but not observed in any other Drosophilid.

It may be noted here that the larvae of Clastopteromyia inversa (found in the spittle-masses of Cercopidae on alder at Middleboro, Mass., and at Mendham, N.J.) have structures similar to those figured by Malloch and McAtee for Aulacigaster under the name of "pseudopodia." The ventral hooklets of the 6 anterior abdominal segments are aggregated into small rounded areas, one on each side of each segment. These button-like areas are on elevated leg-like processes, which the larva in fact uses in locomotion, in a manner strongly suggestive of the action of the abdominal "prop-legs" of a caterpillar.

Puparia.

The color, size, and texture of the puparium show much inter-specific variation, as does the angle between the posterior spiracles. However, I have paid attention only to the anterior spiracles in most cases. Here there are two useful characters: the number of branches of the spiracle, and the length of the "horn."

The number of branches per anterior spiracle ranges from an average of 4 (coracina, according to Kikkawa and Peng) to 23 (bifurca). It is in general low (10 or less) in Hirtodrosophila, Pholadoris, Dorsilopha, and Sophophora. It is about 11 in Phloridosa floricola, and in Drosophila is not often as low as 10 (though scattered species such as pinicola, micromelanica, and occidentalis have 7 to 8, and transversa has only 5).

The anterior spiracles are often on a definite stalk, and the length of this stalk (plus the spiracle) in relation to the length of the puparium itself has been recorded for many species. Each "horn" is 1/10 (or less) the length of the puparium in Hirtodrosophila, Pholadoris, and Sophophora (slightly longer in melanogaster and simulans); about $\frac{1}{5}$ the puparium in Dorsilopha and Phloridosa. In Drosophila the horns are rather short in the quinaria, guttifera, pinicola, virilis, testacea, tripunctata, funebris, melanica, polychaeta, and cardini groups—though in many of these they are longer than in most Sophophoras. In robusta the horns are $\frac{2}{5}$ the puparium, in immigrans they are about $\frac{1}{2}$, and in longicornis about $\frac{2}{3}$.

Chromosomes.

Sturtevant and Novitski (1941) have discussed the chromosome configurations of the genus on the basis of 6 "elements," represented by the 6 pairs of chromosomes of virilis or the six separate euchromatic elements of the salivary gland chromosomes of melanogaster or pseudoobscura. These typically consist of 5 rods and a dot.

The earlier cytological observations have been summarized by Kikkawa and Peng; the present discussion is based on their list, on the new data in the present publication, on the data given by Sturtevant (1940) and by Sturtevant and Novitski (1941), and on a few unpublished data from this laboratory.

The six elements are all separate and unmodified in their gross structure —i.e., the virilis configuration is found, in the following species: virilis, novamexicana, transversa, phalerata, tripunctata, macroptera, macrospina, repleta (also mulleri, ramsdeni, and about 10 other members of the repleta group here reported by Patterson and Wheeler), micromelanica, cardini, and similis—all belonging to the subgenus Drosophila; and in Sophophora subobscura.

Essentially the same arrangement is found also in funebris, histrio, longicornis, hamatofila, palustris, subpalustris, subquinaria, occidentalis, suboccidentalis, and hydei—all apparently with an extra amount of heterochromatin on the X. Hirtodrosophila orbospiracula is apparently also to be reckoned as a variant from this type.

A modification of this type is found in which one of the rod-shaped chromosomes has acquired a non-terminal centromere, becoming a J or small V. This occurs in montana, melanospila, and neorepleta (where the V is an autosome), and probably in Sophophora elliptica.

There is thus a total of over 35 known members of the subgenus Drosophila in which all 6 elements are separate, as opposed to two Sophophoras and one Hirtodrosophila.

In another series of species two of the rod-shaped elements are attached, to give a large V, with three rods and a dot remaining. This occurs in Sophophora pseudoobscura and miranda (where the large V is the X); in Drosophila texana (where the V is an autosome); and in calloptera (subgenus uncertain) and Scaptomyza adusta (where the X is not yet identified).

Subterminal or median centromeres are found in the rods associated with single large V's in several forms. There is one small V in melanica, nigromelanica, "melanissima" of Kikkawa and Peng, and in sordidula—all of the subgenus Drosophila. Two J's occur with a large V in Hirtodrosophila duncani and in all the members of the affinis subgroup of Sophophora that have been examined; and three small V's and a large one are recorded for Sophophora obscura. In all these cases the large V appears to be the X.

Two large V's result from fusion of 4 rods, leaving a rod and a dot. This is the familiar configuration of melanogaster, and is found in simulans and five other members of the melanogaster group—the rod being X wherever it has been identified. The same arrangement is recorded for Chymomyza amoena and Scaptomyza graminum—again with X as the rod. In several other forms the same configuration is recorded, with no identification of the X: Pholadoris coracina; Drosophila vibrissina, quinaria and munda; bromeliae and florae (subgenus uncertain); Chymomyza procnemis; Mycodrosophila dimidiata.

The single rod has acquired a subterminal centromere in Sophophora robusta, in which also X is a large V, not a separate element.

Still another modification from this type occurs in Sophophora ananassae, and probably also in bipectinata and montium, where part of the element A (X of melanogaster) has become attached to the dot. In ananassae and bipectinata the remaining portion of X has also acquired a median centromere. It is possible that fuliginea also belongs here, its metaphase configuration resembling that of montium.

In the other types that can be analyzed the dot has become attached to a rod, to give a J, the short arm of which is often overlooked. This seems not to have been observed except in cases where there has also been fusion of rods.

The type with one large V, 2 rods and a J is known in immigrans and in the related komaii in the subgenus Drosophila. Apparently this arrangement is present in Pholadoris victoria, with the added property that both rods have acquired subterminal centromeres.

The two rods of this type are fused, to give 2 large V's and a J, in the willistoni group and all the saltans group except elliptica, and in takahashii (according to observations of Mr. George T. Rudkin) of Sophophora; in Drosophila pinicola; and in Dorsilopha busckii. In takahashii and busckii the J is the X—i.e., its composition must be A–F; in all the other forms named the chromosome in question is autosomal.

There remain a number of configurations not yet correlated with the general scheme; they will need a determination of the distribution of heterochromatin, and perhaps genetical study as well. The following examples may be cited: polychaeta (Mr. Novitski's preparations show one large V, two somewhat smaller V's, one J, one rod, one dot); fulvalineata, with five rods and a small V; bizonata and Cladochaeta nebulosa (three nearly equal V's and a dot).

Mating habits.

The mating habits have been observed in more than 20 species since the summary previously given (Sturtevant 1921) was written. The most striking new types are the following:

Hirtodrosophila duncani. As first observed by Dr. W. P. Spencer, the female inflates her abdomen when sexually excited. The phenomenon is quite marked and unmistakable; it has not been observed elsewhere.

Drosophila polychaeta. No vibration, circling, or other preliminary movements seen. The male follows the female, touching her abdomen with his proboscis and fore tarsi. He then grasps the tips of her wings with his first and second pairs of legs, and doubles his abdomen underneath. If successful in mating he retains this same position, never mounting further, and the wings of the female are never spread. Ten copulations observed; each lasted about 30 seconds. Numerous unsuccessful attempts at mating.

In auraria and in montium it seems clear that the very large sex-combs assist the male in retaining his grasp on the abdomen of the female. In elliptica, emarginata, and cordata, the female gives a characteristic

"switching" reaction during copulation, as though attempting to remove the male.

Mounting precedes copulation in auraria, montium, carbonaria, polychaeta, and apparently in duncani, as well as in the previously described Chymomyza amoena and C. procnemis.

The female spreads her wings before the male mounts in nebulosa, funebris, hydei, repleta, and virilis (all previously reported), and also in rectangularis, mojavensis, micromelanica, carbonaria, and cardini.

The duration of copulation averages 5 minutes or less in Phloridosa lutzii; Sophophora nebulosa, affinis, and montium; Dorsilopha busckii; Drosophila robusta, virilis, polychaeta, hydei, linearepleta, repleta, and mojavensis. No member of the repleta group is known except the four last named above. The longest duration observed is in immigrans (average 53 minutes); next come cordata, macrospina, and carbonaria—all about 30 minutes.

In general the mating habits do not seem to furnish useful group characters. It is possible that more observations, both on additional species and more exact descriptions of those already observed, may change this situation. Two possible group characters are referred to above ("switching" in a saltans subgroup, and brief copulation in the repleta group).

Food habits.

Several more or less distinct kinds of feeding and breeding habits may be recognized among the species of Drosophila. Most species may be roughly characterized as general scavengers, fruit feeders, sap feeders, or fungus feeders.

The general scavengers feed on decaying vegetable matter (such as potatoes, cabbages, and sometimes manure), occasionally on animal matter (busckii and funebris are common about stale formalin-preserved material in laboratories), and are also often to be found on decaying fruit with the next group of species. In the temperate zone these species are all associated with man; with the possible exception of funebris (which has perhaps recently changed from a fungus diet) they are all introduced in the United States. Included here are busckii, funebris, repleta, hydei, and the tropical ananassae.

The fruit-feeders in the temperate zone are also introduced forms associated with man. Members of the sap-feeding group are likewise to be found about fruit; but during the early part of the summer there is in general no available native food-material for the fruit-feeders; it is accordingly not surprising that the species that are largely limited to fruit are of tropical origin. This group includes melanogaster, simulans, and immigrans.

The sap-feeders are to be found on many kinds of bleeding trees—both conifers and dicotyledons. Pinus, Quercus, Betula, and Populus are perhaps the most favored trees, but the largest populations I have seen

have been on Vitis. This feeding habit occurs in Pholadoris, in the obscura group of Sophophora, in the melanica, robusta, tripunctata, and pinicola groups of Drosophila, and in the species californica and occidentalis of Drosophila. All of these are attracted to fruit, and certainly breed on it when it is available.

The fungus-feeders are to be found around either Agarics or Boletus. They are absent in most of California, where the long dry summers prevent growth of fungi at times when the temperature is high enough for Drosophila to breed. This group includes transversa, the testacea group, guttifera, so far as is known all of the subgenus Hirtodrosophila, and the related genera Leucophenga and Mycodrosophila.

Another type of feeding habit is represented by quinaria, deflecta, palustris, and subpalustris. The first is common about tomato plants, even before the fruit is ripe, and I have taken it in early spring on water-cress. The remaining three species are associated with water-plants—especially Nymphaea and Sagittaria. Apparently these forms breed on moist decaying parts of such succulent plants. It should be noted that these species are closely related; they are also close to occidentalis (a sap-feeder), and to transversa and guttifera (fungus-feeders).

A similar feeding-habit is that of utilizing decaying parts of desert succulents, such as Cactaceae, Yucca, or Agave. This habit, found in mojavensis, is perhaps to be correlated with the fact that the related repleta and hydei are general scavengers.

Still another feeding habit is that of utilizing flowers. This is found in the tropical florae, lutzii, alfari, and tristani, and in the Californian floricola. Observations on the latter indicate that the chief larval food is pollen; this group alone seems therefore not to be dependent on yeast and bacteria, for it is clear that in all the other types the medium itself is not the chief direct food supply. Several kinds of flowers are used; both in California and in the tropics there are records for Malvaceae (Gossypium in Jamaica, Hibiscus in California), Datura, morning-glories, and melon. In both regions Datura is most frequently used.

CLASSIFICATION OF THE GENUS DROSOPHILA

General Account

As outlined previously (Sturtevant 1939), an attempt has been made to develop a classification that is as free of personal bias as I could make it. A table was made up, including 56 species of Drosophila and two of Scaptomyza. For each of these the condition of 33 characters was noted. These characters are mostly included in the summary given herewith; the table itself has not been reproduced, because it would give a false impression of accuracy. A number of the characters used do not permit exact classification in all species, and it would be misleading to record

the best estimate I have been able to make—which is what appears in the table.

Three criteria were adopted, and every character which satisfied all of these was entered in the table.

(a) Every species must be capable of classification for the character. Size of sex-combs, for example, was not included because some species have no sex-combs.

(b) At least two species must be included in a class. The dorsal processes of the busckii larvae occur only in this species, and therefore cannot give any information about the relationships of the species; they were not included.

(c) Two characters obviously likely to be closely related developmentally or in terms of natural selection were not both included. This criterion is not easy to apply, but seems a necessary one to keep in mind.

Some characters have been entered as "present" or "absent," others as numerical values. In the latter case, since there is usually some intraspecific variability, an arbitrary degree of difference has been set as significant.

From this primary table two new tables have been made up; these may be described and discussed separately.

The second table shows the total numbers of differences, with respect to the 33 chosen characters, between each pair of the 58 species. The values in this table run from 0 to 25. They may be taken as giving indexes of the degrees of difference between the species concerned; and it seems fair to assume that they will also serve to indicate something about closeness of relationship.

Since, as pointed out, some of the characters used are rather indefinite, it is certain that a complete reconstruction of the primary table would not give just the same values for the second table. There would also be differences if different characters were used, or if different arbitrary values were selected as significant ones. One test has been carried out to obtain some idea of the extent to which the values of the second table may be taken to indicate true degrees of divergence. A new primary table was made up, based on 20 of the species included in the first primary table, and utilizing 11 characters that are wholly independent of the original 33 (5 of these 11 concern the chromosomes and the mating habits, not included in the original table because neither is known for all 58 species). From this a new second table was constructed, showing numbers of differences (among the 11 characters) between all pairs among the 20 species. A correlation table was then made up, for corresponding values in the two separate second tables. The result obtained was not unexpected; for values up to about 12 differences in the large table or 4 in the smaller one, there is an unmistakable positive correlation; for values higher than this there is little or no correlation. In other words, considering only the larger table, numbers of differences less than about

12 indicate probable relationship, and it is likely that, below this level, the table gives an indication of relative *degrees* of relationship; differences greater than 12 in number are of little significance. Twelve to fifteen differences mean little more than do twenty or more; but 6 are probably indicative of closer relationship than are 8 to 10.

The third table, derived from the primary 58x33 one, shows the correlation between different characters. This represents an attempt at weighting the characters. Every taxonomist recognizes certain characters as "good" and others as "poor" for the delimitation of groups above the species level. "Good" in this sense may be taken, I think, as implying that the character serves as a useful index of the probable nature of other characters. If this be granted, the best characters are those that show the highest correlations with the maximum number of other characters. In other words, the purpose in making the third table is to determine which are the "best" characters, in the sense in which the term is ordinarily used, by a method that is as free of personal equation as I can make it.

Study of this third table shows at once that there is a single group of highly correlated characters, and that no other strong correlations are present (except in a few cases of characters limited to a few species). The three most satisfactory correlations are as follows (see below for significance of the numbers in parentheses):

	Ventral receptacle			Posterior Malpighian tubes		
Egg filaments	kinky	not kinky	Egg filaments	free	apposed	fused
0	1 (0)	0	0	0	0	1 (0)
2	2	25 (24)	2	23	1 (0)	3
3	6	0	3	0	0	6
4	18	5 (2)	4	0	2	21 (18)
8	0	1 (0)	8	0	1 (0)	0

Ventral receptacle	Posterior Malpighian Tubes		
	free	apposed	fused
kinky	0	2	25 (24)
not kinky	23	2 (0)	6 (3)

Examination of the exceptional classes in these, and in the tables showing definite correlations of other characters with these three, shows that several species are repeatedly to be found in the lists of exceptions. These include the two species of Scaptomyza, duncani, victoria, busckii, and floricola. If these 6 are removed, the values shown in parentheses in the table are obtained. The four named species of Drosophila have accordingly here been placed in separate subgenera (Hirtodrosophila, Pholadoris, Dorsilopha, and Phloridosa, respectively).

The remaining 52 species then fall easily into two distinct assemblages—recognized as the subgenera Drosophila and Sophophora.

Turning now to the second table, the ranges of numbers of differences within and between the subgenera (and the genus Scaptomyza) are as shown:

	Scapto-myza	Hirtodro-sophila	Phola-doris	Phlori-dosa	Dorsi-lopha	Droso-phila	Sopho-phora
Scaptomyza	8	10	12–16	15	13	5–21	8–20
Hirtodrosophila	10	—	15	17	15	8–20	9–19
Pholadoris	12–16	15	—	15	15	11–19	12–18
Phloridosa	15	17	15	—	11	9–18	13–22
Dorsilopha	13	15	15	11	—	9–15	10–18
Drosophila	5–21	8–20	11–19	9–18	9–15	1–18	9–25
Sophophora	8–20	9–19	12–18	13–22	10–18	9–25	0–18

With the exception of a single pair of species, Drosophila pinicola and Scaptomyza terminalis (5 differences) the minimum number of inter-subgeneric differences is 8. Further examination of the second table shows that, within the three groups that have more than one studied species (Scaptomyza, Drosophila, Sophophora), this value of 8 is, in each case, also the minimum by means of which it is possible to inter-relate the whole group by successive pairs—a circumstance that may be taken as confirming the validity of the subgeneric separations.

Within each of the two large subgenera there exist some correlations of characters that are not present when the whole genus is considered. This is quite marked in the case of Sophophora, and easily leads to the recognition of four distinct species-groups, two of which are again easily split into two subgroups. The characteristics and component species of these are listed elsewhere in this paper.

Correlations are less evident in the subgenus Drosophila, which in general seems more complex than does Sophophora. The 14 species-groups are less satisfactorily delimited, and in some cases less homogeneous, than are those of Sophophora. The quinaria group, for example, might easily be made either to exclude transversa or to include guttifera, rather than *vice versa* as is here done. The robusta group is not very clearly distinct from the repleta one—and in fact even the funebris and melanica groups might perhaps be united to the repleta one.

The relationships between the subgenera are difficult to evaluate. Perhaps the most interesting species here is Drosophila pinicola, which shows the following numbers of differences: from virilis 7, from carbonaria 8, from all other members of its own subgenus 9 or more; from Scaptomyza terminalis 5, from S. graminum 10; from Hirtodrosophila duncani 8, from Sophophora affinis, algonquin, athabasca, and azteca 9 each. If pinicola is disregarded, the minimum differences of the subgenus Drosophila become: from Hirtodrosophila 11, from Scaptomyza 10, from Sophophora 12—the only inter-group difference as low as 8 then remaining being that between Scaptomyza and Sophophora (graminum-athabasca).

It therefore seems reasonable to regard pinicola as a primitive type, and to suppose that the related obscura group is primitive in the subgenus Sophophora. Both Scaptomyza and Hirtodrosophila may also be supposed to be related to this common Drosophila-Sophophora stock.

Within Sophophora, the melanogastor and willistoni groups may be supposed to be derived directly from the obscura one, and the saltans one from the willistoni one (Sturtevant 1940). Any phylogeny of the subgenus Drosophila must be very speculative at present. Tentatively, one may surmise that the main developmental line is through the following species-groups: pinicola, virilis, tripunctata, funebris, repleta, robusta, immigrans—in that order. On this basis the quinaria group arose from the virilis-tripunctata region, and the guttifera and testacea groups from the quinaria one; the melanica group from the repleta one; polychaeta from the funebris-repleta region; carbonaria from the repleta-melanica region; and the cardini group from the robusta one.

Dorsilopha is most like virilis, testacea, and quinaria of the subgenus Drosophila (9 differences). D. busckii is one of the species included in the trial 20x11 table made to check the results of the primary 58x33 table. A table of total differences among the 44 possible ones has been made up for these 20 species—i.e., a new "second table." This table leads in general to the same conclusions as the standard second table; but in the case of busckii it fails to confirm the resemblance to virilis (no members of the testacea or quinaria groups are included), and in fact suggests that busckii, while remote from all the other 19 forms, is perhaps least different from the melanogaster group of Sophophora. Incomplete descriptions of species of Hirtodrosophila other than duncani suggest that some of these (orbospiracula, for example) may in fact be the closest relatives of busckii.

Phloridosa comes closest to the repleta group of Drosophila, with virilis nearly as similar; Pholadoris has only a suggestion of relationship to robusta and to polychaeta of the subgenus Drosophila.

The same general method has been adopted in an attempt to determine the probable relationships of certain other genera of Drosophilidae, for which rather less information is available, with the following results:

Zaprionus vittiger Coquillett. Alcoholic material from Dr. G. Eloff has yielded the following characters: sterno-index .4; abdominal dark bands slightly narrowed in mid-dorsal region; ventral receptacle moderately long and slender, not kinky; spermathecae well-developed, brown, chitinized; eggs with 4 long tapering filaments, each about .9 length of egg; puparial horn about ⅙ puparium; anterior spiracle with about 9 branches. The form appears to be about equally distant from Dorsilopha, Hirtodrosophila, and Drosophila (most like pinicola and cardini in this subgenus).

Clastopteromyia inversa (Walker). Dissection, and examination of larvae and puparia, have been made. The closest relatives appear to be

Dorsilopha, Drosophila (repleta, robusta, and quinaria groups), and Scaptomyza.

Chymomyza amoena (Loew) and procnemis (Williston). Nearest Drosophila (pinicola, quinaria, and guttifera groups).

Mycodrosophila dimidiata (Loew). Nearest Pholadoris.

Amiota leucostoma Loew. Nearest Pholadoris, Mycodrosophila, and perhaps Hirtodrosophila.

Sinophthalmus and Gitona appear to be rather close to each other, and to be related to Amiota. This is possibly the most primitive group of genera in the family. Stegana and Leucophenga, close to each other, resemble Chymomyza; they are perhaps also related to Amiota or to Hirtodrosophila.

Finally, an attempt has been made to estimate the position of the family Drosophilidae. A table was made up including 40 genera (Scatophaga, Conops, and 38 assorted Acalypterae) classified for 29 characters. The characters include six from Frey's (1921) account of the mouthparts (in some cases based on my own study of these organs), four from the female genitalia (Sturtevant 1925–1926), and 19 from the external structure of the imagines—including most of the characters commonly utilized in the delimitation of families and larger groups. The Drosophilid genera Drosophila, Stegana, Gitona, and Sinophthalmus were included, as were the following that have at various times been referred to the family: Periscelis, Trixoscelis, Diastata, Aulacigaster, and Leiomyza.

The following numbers of differences were minimal for the genera indicated:

Drosophila: 2 (Stegana, Gitona); 4 (Sinophthalmus); 8 (Anthomyza); 9 (Desmometopa, Periscelis, Leptocera).

Stegana: 2 (Drosophila, Sinophthalmus); 3 (Gitona); 8 (Anthomyza, Tethina, Phyllomyza); 9 (Periscelis, Desmometopa, Diastata, Leptocera, Leucopis, Sphaerocera).

Gitona: 2 (Drosophila, Sinophthalmus); 3 (Stegana); 7 (Anthomyza); 8 (Aulacigaster, Leptocera); 9 (Borborus, Desmometopa, Diastata, Tethina).

Sinophthalmus: 2 (Stegana, Gitona); 4 (Drosophila); 7 (Anthomyza); 8 (Borborus, Aulacigaster, Leucopis, Phyllomyza); 9 (Desmometopa, Leptocera, Periscelis, Sphaerocera, Tethina).

Anthomyza: 6 (Aulacigaster); 7 (Desmometopa, Gitona, Stegana); 8 (Drosophila, Stegana, Ochthiphila); 9 (Diastata, Leucopis, Psila, Sapromyza).

Aulacigaster: 6 (Anthomyza); 8 (Gitona, Sinophthalmus, Piophila); 9 (Desmometopa, Diastata, Leucopis, Ochthiphila).

Desmometopa: 4 (Phyllomyza); 7 (Anthomyza); 9 (Drosophila, Gitona, Sinophthalmus, Stegana, Aulacigaster, Diastata).

Phyllomyza: 4 (Desmometopa); 8 (Stegana, Sinophthalmus); 9 (Tethina).

The chief conclusions to be drawn here are negative. The Drosophilidae are not closely related to the Agromyzidae, Trypetidae, Lonchaeidae, Sepsidae, Helomyzidae, Ephydridae, Astiidae, Sapromyzidae, Sciomyzidae, or Chloropidae. The suggestion of relationship to the Milichiidae is unexpected; those to the Anthomyzidae and to Aulacigaster have often been pointed out before.

Incidentally, some other results of a study of this table may be indicated. The Ephydridae (Ephydra, Dichaeta, Hydrellia studied) are very remote from all other included forms. Canace and Tethina, which have been compared to them, do not come as close as does Diastata—but even this latter resemblance does not seem significant. Chlorops and Periscelis are also remote from any other of the forms studied, and from each other. The Trixoscelidae and Helomyzidae appear to be related to the Sapromyzidae; Coelopa perhaps also belongs near here. The Sepsidae, Piophilidae, Clusiidae, and Psilidae are related to each other; another group includes the Trypetidae, Lonchaeidae, and Ortalidae, from which the Calypterae, Agromyzidae, and Sciomyzidae appear to be not remote.

Species Referred to Separate Genera

The following species that were included in Drosophila in my former account now seem best referred to the genera indicated.

Zygothrica Wiedemann. Malloch and Duda both recognize as one of the most important characteristics here the large shining ocellar triangle, that reaches the anterior margin of the front. The genus should include Drosophila vittatifrons Williston and D. poeyi Sturtevant.

Microdrosophila Malloch (synonym, Incisurifrons Duda). Anterior dorsocentral placed nearly as far anterior to posterior one as distance between dorsocentral rows; fourth-vein index about 4.0. The type species is Drosophila quadrata Sturtevant.

Diathoneura Duda. Anal cell and anal vein absent; carina low or absent; no prescutellars; postverticals minute; dark species. Includes Drosophila splendida Williston, D. opaca Williston, D. dubia Sturtevant, D. metallica Sturtevant, D. superba Sturtevant, and a number of other tropical species described by Duda.

Clastopteromyia Malloch. Anal cell and anal vein absent; carina low; prescutellars present; yellowish species; wings strongly clouded. The type species is Drosophila inversa Walker; also includes D. paradoxa Lamb, C. foridana Malloch (Florida), and C. triseta Malloch (Costa Rica).

Subgenera and species groups of Drosophila, with included species

Subgenus **Hirtodrosophila** Duda. Type, longecrinita Duda (Formosa). (Synonym Dasydrosophila Duda, as change of name).

Third antennal segment large, covered with unusually long hairs. Carina narrow, short, practically absent on lower part of face. Arista usually

with one branch below in addition to terminal fork. Sterno-index .5 or less. So far as known, all are fungus-feeders.

Duda has referred to this subgenus a number of Oriental and Neotropical forms, and I have also included D. duncani Sturtevant from the eastern United States. An examination of Philippine specimens of the type-species in my collection led me later to question this reference (Sturtevant 1940); but it now seems most likely that the group is a valid one and should also include alabamensis Sturtevant prognatha Sturtevant (both, as well as duncani, already tentatively referred here by Duda), longala Patterson and Wheeler, orbospiracula Patterson and Wheeler, cinerea Patterson and Wheeler, grisea Patterson and Wheeler, and chagrinensis Stalker and Spencer. The seven Nearctic species are all rare—perhaps only because systematic collection of fungus-feeding forms has been somewhat neglected.

The only two species that I have had available in stocks—duncani and orbospiracula—are very distinct. Further study of the subgenus will undoubtedly permit the recognition of a number of species-groups.

Subgenus **Pholadoris,*** subg. nov. Type Drosophila victoria, sp. nov.

Shining dark species; prescutellars present; a V-shaped shining bristle-bearing area on front; egg-filaments 6 to 8; posterior Malpighian tubes apposed at distal ends; testis short, not coiled; ventral receptacle short, not coiled or kinky; skipping larvae.

Includes D. coracina Kikkawa and Peng (Japan) and a number of undescribed forms.

Subgenus **Dorsilopha,** subg. nov. Type, Drosophila busckii Coquillet.

Yellowish species, mesonotum longitudinally striped; preapicals not evident on second and third tibiae; larvae with dorsal processes; 4 egg-filaments; posterior Malpighian tubes fused; ventral receptacle not kinky; sterno-index about .3.

No other species known.

Subgenus **Phloridosa,** subg. nov. Type, Drosophila floricola, sp. nov.

Shining black or brown species; bristles and branches of arista short; sterno-index .3 or less; anterior Malpighian tubes absent; posterior Malpighian tubes fused to form a loop around the gut; testes long, spirally coiled; eggs without filaments or remains of follicle cells; flower-feeding species.

Includes D. lutzii Sturtevant, D. alfari Sturtevant, D. tristani Sturtevant. D. mauiensis Grimshaw, from Hawaii, perhaps also belongs here.

Subgenus **Sophophora** Sturtevant. Type D. melanogaster Meigen (D. fasciata auct.)

Eggs with 2 blunt filaments; ventral receptacle not kinky; posterior Malpighian tubes free at their distal ends; sterno-index .6 or less; anterior spiracle and its stalk not over ⅕ length of puparium; second to fifth abdominal tergites with posterior dark bands that are never broken or narrowed in mid-dorsal line; cheeks always relatively narrow.

*This and the next two subgeneric names are anagrams of Drosophila.

Four distinct species-groups may be recognized:

1. saltans group. Dark species; long fine ventral receptacle; long spiral testes; one or two opaque heavily chitinized areas on fifth abdominal tergite of female; skipping larvae; no sex-combs; filaments of eggs much expanded apically; sterno-index .3 to .4; anterior scutellars divergent; tropical America.

Two sub-groups. (a) grayish markings on mesonotum; minute hairs present below carina; saltans Sturtevant, biopaca Sturtevant, rectangularis Sturtevant, sellata Sturtevant, earliei Sturtevant, and presumably prosaltans Duda.

(b) No gray mesonotal pattern; no minute hairs below carina: cordata Sturtevant; ellipitica Sturtevant, emarginata Sturtevant.

2. willistoni group. Yellowish species; long fine ventral receptacle; medium long spiral testes; no opaque areas on tergites; larvae do not skip; no sex-combs; sterno-index .3; egg-filaments much expanded at apices; anterior scutellars divergent; tropical America.

Includes willistoni Sturtevant and nebulosa Sturtevant.

3. melanogaster group. Yellowish species; rather long ventral receptacle; medium long spiral testes; no opaque areas on tergites; larvae do not skip; sex-combs present; sterno-index .5 to .6; anterior scutellars convergent; apparently native to tropical and sub-tropical regions of Old World, but several now much more widely distributed.

Includes melanogaster Meigen, simulans Sturtevant, takahashii Sturtevant, ananassae Doleschall, bipectinata Duda, montium de Meijere, auraria Peng. Also, from rather less complete data, it seems safe to add to this list unipectinata Duda, miki Duda, rufa Kikkawa and Peng, nipponica Kikkawa and Peng, ficusphila Kikkawa and Peng, and lutea Kikkawa and Peng. Suzukii (Matsumura) is perhaps best placed here, but is in some respects more like the next species-group (see Sturtevant and Novitski 1941, p. 536).

4. obscura group. Dark species; no opaque areas on tergites; larvae do not skip; sex-combs present; preapicals on first tibiae unusually long; sterno-index about .6; anterior scutellars convergent; second oral small; middle orbital large; north temperate zone.

There are two subgroups here: (a) Several teeth in distal sex-comb; 8 acrostichal rows; ventral receptacle short; testes elliptical; carina broad, flat. Includes pseudoobscura Frolowa, miranda Dobzhansky, subobscura Collin, obscura Fallén, tristis Fallén, and several undescribed European species.

(b) One tooth in distal sex-comb; 6 acrostichal rows; ventral receptacle nearly as long as in group 3; testes rather short, but still spirally coiled; carina narrow, not flat; American species. Includes affinis Sturtevant, algonquin Sturtevant and Dobzhansky, athabasca Sturtevant and Dobzhansky, azteca Sturtevant and Dobzhansky, narragansett Sturtevant and Dobzhansky, seminole Sturtevant and Dobzhansky.

Subgenus **Drosophila** Fallén. Type Musca funebris Fabricus.

Three or four egg-filaments (two in the melanica group), at least anterior ones tapering; ventral receptacle long, fine, usually kinky; testes long, spiral; posterior Malpighian tubes forming a closed loop around the gut, their distal ends sometimes merely apposed but usually fused and with a continuous lumen; dark posterior bands on abdomen usually narrowed or broken in mid-dorsal line; sterno-index usually .5 or more; cheeks often wide; puparial "horns" often more than 1/5 length of puparium.

This is the largest and most complex of all the subgenera. It is difficult to arrange in subdivisions; there are a number of species that clearly belong to the subgenus, but that are not sufficiently well understood to be placed satisfactorily (e.g. melanderi Sturtevant, macroptera Patterson and Wheeler, rubrifrons Patterson and Wheeler, bizonata Kikkawa and Peng, lugubrina Duda, and vibrissina Duda).

The following species-groups may be recognized:

1. quinaria group. Yellowish species, shining; eggs with 3 filaments; cross-veins clouded; abdominal dark bands often broken into spots; arista with 9 to 11 branches.

Includes quinaria Loew, deflecta Malloch, palustris Spencer, subpalustris Spencer, occidentalis Spencer, suboccidentalis Spencer, munda Spencer, subquinaria Spencer, and transversa Fallén. Probably also to be included are phalerata Meigen and nigromaculata Kikkawa and Peng.

2. guttifera group. Yellowish, mesonotum striped; 3 egg-filaments; wings with numerous black spots; second oral large; third antennal segment with longish hairs; costal index about 2.2; sterno-index about .4; fungus-feeder.

Includes only guttifera Walker.

3. pinicola group. No minor coils in ventral receptacle; grayish brown species; carina narrow; middle orbital 1/4 other two; "horns" of puparium scarcely 1/10 length of puparium; sterno-index about .5.

Includes only pinicola Sturtevant.

4. virilis group. Blackish species; anterior scutellars divergent; posterior cross-vein clouded; sterno-index .8 to .9.

Includes virilis Sturtevant, and the species or subspecies americana Spencer, texana Patterson, Stone and Griffin, novamexicana Patterson, and montana Patterson and Wheeler.

5. testacea group (= subgenus Acrodrosophila Duda). Yellowish or brownish species; a pair of presutural acrostichal bristles; ventral receptacle with no minor coils; fungivorous.

Includes testacea von Roser and putrida Sturtevant.

6. tripunctata group. Yellow; third to fifth abdominal tergites each with a median black spot; arista with about 12 branches; costal index about 4.3.

Includes tripunctata Loew, and perhaps histrio Meigen.

7. funebris group. Reddish brown species; sterno-index about .7; "horn" about ⅕ length of puparium; arista with 10 to 11 branches; male abdomen largely shining black.

Includes funebris (Fabricius), macrospina Stalker and Spencer, and subfunebris Stalker and Spencer.

8. repleta group. Grayish mesonotum, each hair and bristle arising from a black or dark brown spot; 6 to 9 branches of arista; "horn" of puparium usually more than ¼ length of puparium; costal index from 2.5 to 3.5.

Includes repleta Wollaston, hydei Sturtevant, mulleri Sturtevant, melanopalpa Patterson and Wheeler, neorepleta Patterson and Wheeler, linearepleta Patterson and Wheeler, fuliginea Patterson and Wheeler, nigrospiracula Patterson and Wheeler, leonis Patterson and Wheeler, hydeoides Patterson and Wheeler, nigrohydei Patterson and Wheeler, bifurca Patterson and Wheeler, pachea Patterson and Wheeler, aldrichi Patterson and Crow, buzattii Patterson and Wheeler, mojavensis Patterson and Crow, meridiana Patterson and Wheeler, mercatorum Patterson and Wheeler, peninsularis Patterson and Wheeler, ritae Patterson and Wheeler, brevicarinata Patterson and Wheeler, longicornis Patterson and Wheeler, hamatofila Patterson and Wheeler, and (on the basis of less complete information) also fasciola Williston, ramsdeni Sturtevant, californica Sturtevant, and maculipennis Duda.

9. robusta group. Large blackish species; posterior Malpighian tubes apposed, not with a continuous lumen; costal index about 4.0; arista with about 9 branches; "horn" ⅖ length of puparium.

Includes robusta Sturtevant and probably also colorata Walker and sordidula Kikkawa and Peng.

10. melanica group. Blackish species; two egg-filaments, each about the same length as the egg; sterno-index .7 to .8; second oral not over half first; arista with 7 to 8 branches.

Includes melanica Sturtevant, micromelanica Patterson, nigromelanica Patterson and Wheeler, and (with less certainty) melanissima Sturtevant (also the distinct Japanese species described by Kikkawa and Peng under this name), and perhaps pseudomelanica Sturtevant.

11. polychaeta group. Large reddish brown species; three pairs of postsutural dorsocentrals; costal index about 2.0; fourth vein index 1.8 to 2.2.

Includes polychaeta Patterson and Wheeler, probably also illota Williston, and perhaps grandis Kikkawa and Peng.

12. carbonaria group. Very dark species; middle orbital almost as long as anterior; pupae with strongly roughened surface.

Includes only carbonaria Patterson and Wheeler.

13. cardini group. Reddish or yellowish brown, shining; larvae skip; posterior Malpighian tubes apposed but not with continuous lumen; cheeks narrow; sterno-index about .5; costal index about 3.9.

Includes cardini Sturtevant, perhaps also similis Williston, albirostris Sturtevant, and metzii Sturtevant.

14. immigrans group (subgenus Spinulophila Duda, = Acanthophila Duda). Dull yellowish; a row of short thick spines on first femur; costal index over 3.0; "horn" about half length of puparium.

Includes immigrans Sturtevant, spinofemora Patterson and Wheeler, and (with less data to go on) komaii Kikkawa and Peng, nasuta Lamb, monochaeta Sturtevant, balneorum Sturtevant, rubra Sturtevant, signata Duda, annulipes Duda, ruberrima de Meijere, subfasciata de Meijere, mediostriata Duda, and maculifrons Duda.

Species vs. Subspecies

The authors of the present series of papers do not agree on the status of some of the forms described (see also Dobzhansky, 1941). I feel that several of the types here described as species are better treated as subspecies, as follows:

D. mulleri, subsp. mojavensis
D. virilis, subspp. americana, texana, novamexicana, montana
D. occidentalis, subsp. suboccidentalis

It seems likely that some other forms should also be considered as subspecies (e.g., arizonensis a subspecies of mulleri, subfunebris a subspecies of macrospina) if more data were available.

Several criteria are involved here. They will not always agree, and in any case it is clear that an element of personal judgment must always be involved in settling this question. However, the following seem to me the most important elements:

(a) Distinct species must be separable on the basis of ordinary preserved material. This is in order to make it possible for a museum man to apply a name to his material. The necessity for such a provision seems to me to be obvious, since only in this way can effective use be made of the whole technique of taxonomy.

(b) Cross fertility between distinct species is in general absent or so slight as to make unlikely any transfer of genes from one to the other in nature. This criterion is difficult to apply, and seems to me of secondary value for that reason. Geneticists are likely to emphasize its importance, taxonomists to minimize it. It is clearly of first importance for evolutionary theory, but even in the best understood cases it is still difficult to judge how much actual transfer of genes occurs.[1]

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[1]If two forms produce a hybrid with some degree of fertility, the extent to which there is an exchange of genes will depend on the following factors:

a. The frequency with which the two forms cross under natural conditions.
b. The effective population size of each of the two parental forms.
c. The degree of fertility of the F_1, and the frequency of mating with other F_1's or with each of the parental forms.
d. The fertility of each of the various types of hybrids produced in later generations.
e. Ecological differences between the two forms, and the nature of the various hybrid types with respect to selection based on such differences.

Each of these is difficult to evaluate, so that one will practically always have to resort to indirect evidence, or in borderline cases to poorly founded guesses.

(c) Subspecies usually replace each other geographically, species may do so but are more likely to show extensively overlapping distribution areas. This criterion is one that taxonomists usually emphasize. It is clearly helpful, but can never be decisive (unless made so by artificial definition). Our knowledge of distribution areas of Drosophila is still too imperfect in most cases to make possible a rigorous use of this principle. It should also be pointed out that this criterion alone is not adequate. Drosophila pseudoobscura is gradually replaced by athabasca as one travels northward in British Columbia, and by affinis as one travels eastward in central Texas. Both replacement zones are typical of those recorded for subspecies; but they concern wholly distinct types, that are very different morphologically, are certainly wholly cross-sterile, and that have geographical forms within themselves that show much less sharp replacement zones.

Descriptions of New Species

Drosophila victoria, sp. nov. (subgenus Pholadoris).

External characters of imagines.

♂ ♀ Arista with about 7 branches. Antennae brown, third segment black. Front velvety, reddish; orbits and triangle shining black, as is also a V-shaped mark with its ends between anterior ocellus and posterior orbital and its apex at anterior edge of front; this V-shaped mark bears a row of about 6 mesially directed bristles on each of its arms. Middle orbital about 1/5 other two. Second oral about 1/2 first. Carina broad, flat; face dark brown; no hairs below carina. Cheeks dark brown, scarcely 1/6 greatest diameter of eye. Eyes with short, dark pile.

Acrostichal hairs in 6 rows; prescutellars small but clearly differentiated. Anterior scutellars divergent. Mesonotum and scutellum dark brown, almost black, subshining. Pleurae brown, somewhat pollinose. Legs brown, femora and basal halves of tibiae darker. Sterno-index about .7. Apical bristles on first and second tibiae, preapicals on all three.

Abdomen black, brownish at base.

Wings clear. Costal index about 1.9; 4th vein index about 2.4; 4c index about 1.3; 5x index about 1.4. Two bristles at apex first costal section. Heavy spines on basal 3/5 of third costal section.

Length body 2.0 mm.; wings 1.8 mm.

Internal characters of imagines.

Anterior Malpighian tubes two, simple; posterior with their distal ends apposed, but without a continuous lumen.

Testes oval, dark.

Spermathecae two, chitinized, dark, small, telescoped at base.

Ventral receptacle short, broad, curved.

Other characteristics, relationship, and distribution.

Eggs.—Eight tapering anterior filaments and a series of shorter apical processes. Each filament is about 7/10 the length of the egg.

Larvae.—The larvae skip.

Puparia.—Anterior spiracle with about 4 branches, it and its very short stalk scarcely 1/10 the length of puparium.

Mating habits.—Not studied.

Chromosomes.—Spermatogonial figures show one large and one small pair of V's and two pairs of J's (E. Novitski).

Relationships.—Near coracina Kikkawa and Peng, from Japan. There are also other (undescribed) relatives in North America.

Distribution.—About cottonwoods at several points along the edges of the deserts of southern California. The type material is from Andreas Canyon, near Palm Springs.

This species, or one very similar to it, has been taken by Drs. D. D. Miller and H. D. Stalker at Rochester, N.Y. It is probable that the record of a skipping larva of Drosophila from sap in Illinois (Malloch) refers to the same form.

Professor Patterson records what also appears to be the same form, though it usually has fewer egg-filaments and his description of the chromosomes differs slightly, from Las Cruces, Silver City, New Mexico; Tombstone Canyon, Mule Mountains, Cave Creek, Chiricahua Mountains, Arizona; Cottonwood Canyon, Utah; Magdalena, Hermosillo, State of Sonora, Mexico.

Habits.—This species, like its undescribed relatives, apparently feeds on sap, and is commonest around cottonwood trees (Populus spp.).

Drosophila cordata, sp. nov. (subgenus Sophophora).

External characters of imagines.

♂. Arista with about 8 branches. Antennae brown, third segment darker. Front reddish brown, velvety; orbits and triangle grayish pollinose. Middle orbital about 1/5 other two. Second oral nearly as long as first. Face brown; carina narrow; no minute hairs below carina. Cheeks brown; their greatest width about 1/6 diameter of eye. Eyes with short pile.

Acrostichal hairs in 6 rows. No prescutellars. Anterior scutellars divergent. Mesonotum and scutellum dark brown—almost black—slightly pollinose, no markings. Pleurae brown, paler below. Legs yellowish brown, femora darker. Sterno-index about .3. Apical bristles on first and second tibiae, preapicals on all three.

Abdomen dark brown, slightly paler toward base of each tergite.

Wings clear. Costal index about 2.3; 4th vein index about 2.5; 4c index about 1.3; 5x index about 1.0. Two bristles at apex first costal section. Third section of costa with heavy bristles on its basal 2/5.

Length body 1.7 mm.; wings 1.7 mm.

♀. Abdomen with more marked pale basal bands on tergites. A median opaque area on fifth tergite that is shaped like a conventionalized heart.

Internal characters of imagines.

Anterior Malpighian tubes two, unbranched, posterior Malpighian tubes not fused at their apices.

Testes in a spiral of about 4 gyres.

Ventral receptacle long, fine, not kinky; resembling a skein of wool folded as a whole into the shape of the letter M.

Spermathecae two, chitinized; spherical with a basal telescoping, and with an apical indentation that comes to a sharp point from which there is a pattern of radiating lines.

Other characteristics, relationship, and distribution.

Eggs.—Two filaments, broadly expanded on their apical halves, about ½ the length of the egg.

Larvae.—The larvae skip.

Puparia.—About 6 branches of anterior spiracle; these plus their short stalk scarcely 1/10 length of puparium.

Mating habits.—Relatively little wing movement during courtship. During copulation the female gives the "switching" reaction that was also seen in elliptica and emarginata, though it is less marked here. The only copulation timed lasted for 29 minutes.

Chromosomes.—Two pairs of V's and a pair of rods.

Relationships.—Closest to elliptica and emarginata, here described as new.

Distribution.—Quirigua, Guatemala (T. Dobzhansky).

Drosophila elliptica, sp. nov. (subgenus Sophophora).

External characters of imagines.

♂. Arista with about 8 branches. Antennae gray, third joint dark brown. Front dark brown, orbits and a narrow anterior median line polished. Middle orbital ⅕ other two. Second oral nearly as long as first. Carina narrow, not flattened or sulcate. Face dark brown. Cheeks dark brown; their greatest width scarcely ⅙ greatest diameter of eyes, width in vertical axis scarcely 1/10 diameter of eyes. Eyes with heavy dark pile. No minute hairs below carina.

Acrostichal hairs in 6 rows; no prescutellars. Anterior scutellars divergent. Whole thorax dark blackish brown, dull. Coxae and femora black, tibiae and tarsi brown. Sterno-index about .4. Apical bristles on 1st and 2nd tibiae, preapicals on all three; preapical on front leg not as long as diameter of tibia. Tarsi of front leg without sex-combs or other sexual characters.

Abdominal tergites shining black. Hypopygium large.

Wings slightly blackish. Costal index about 2.1; 4th vein index about 2.0; 5x index about 1.2; 4c index about 1.2. Two well-developed bristles at apex of first costal section; third costal section with heavy bristles on its basal 3/10.

Length body 2.0 mm. (in pinned specimen); wings 2.0 mm.

♀. Abdominal tergites, especially three apical ones, with yellowish basal bands. On the fifth tergite there is a large median opaque area, elliptical in shape, and including the whole width of the black band.

Length 2.25 mm.

Internal characters of imagines.

Anterior Malpighian tubes two, unbranched, short; posterior ones two, free.

Testes long, spiral (7–8 gyres).

Spermathecae heavily chitinized, strongly telescoped at base, no apical indentation, pear-shaped, with two thickened rings at the base.

Ventral receptacle long, thin, not kinky, arranged like a skein of wool that has been bent (as a whole) into the shape of the letter M.

Other characteristics, relationship, and distribution.

Eggs.—2 filaments, equal in length to the egg itself, their apical halves greatly expanded.

Larvae.—The larvae "skip," like those of saltans, cardini, and others.

Puparia.—Each anterior spiracle with about 6 branches; it plus its stalk about 1/10 the length of the puparium itself.

Mating habits.—Little wing movement; occasional "scissors" and "vibration" of both wings simultaneously by the male. Female does not spread her wings before male mounts. Usual method of mounting and final position. Female very restless, especially for the first few minutes of copulation, frequently giving a characteristic "switching" reaction (as in D. emarginata). In copula 16 minutes in only case timed.

Chromosomes.—Four pairs of rods, one pair of small V's, and one pair of small J's. (Dr. D. D. Miller).

Relationship.—Close to D. emarginata and D. cordata, here described as new.

Distribution.—Pachuca, Mexico (T. Dobzhansky).

Drosophila emarginata, sp. nov. (subgenus Sophophora).

External characters of imagines.

♂. Arista with about 8 branches. Antennae brown, third section darker. Front yellowish, blackish around ocelli. Middle orbital ¼ other two. Second oral ¾ first. Face yellowish brown; carina narrow; no minute hairs below carina. Cheeks yellowish; their greatest width ⅕ diameter of eye. Eye with rather long dense pile.

Acrostichal hairs in 6 rows. No prescutellars. Anterior scutellars divergent. Humeri, mesonotum, and scutellum yellowish brown, unmarked. Pleurae brown. Legs yellowish brown, femora darker.

Anterior sternopleural ⅓ length of posterior. Apical bristles on first and second tibiae, preapicals on all three.

Abdomen dull brownish black, each tergite with a rather poorly defined basal brown band.

Wings clear. Costal index about 2.1; 4th vein index about 1.8; 4c index about 1.1; 5x index about 1.6. Two bristles at apex first costal section. Third costal section with heavy bristles on its basal ⅓.

Length body 2.0 mm.; wings 2.0 mm.

♀. Fifth abdominal tergite with a large opaque elliptical area on its posterior border, this area distinctly emarginate anteriorly in the median dorsal line.

Internal characters of imagines.

Anterior Malpighian tubes two, unbranched.

Posterior Malpighian tubes separate, ends free.

Testes long, spiral.

Ventral receptacle long, fine, not kinky, in the M-shaped skein usual for the saltans group (see elliptica, etc.).

Spermathecae two, chitinized, pear-shaped, strongly telescoped at base, without apical indentation or basal collar.

Other characteristics, relationship, and distribution.

Eggs.—Two filaments, expanded on their apical ⅔, each slightly longer than the egg.

Larvae.—The larvae skip.

Puparia.—Anterior spiracle with about 7 branches; it and its short stalk scarcely 1/10 length of puparium.

Mating habits.—Circling; "scissors" movement; female does not spread her wings before male mounts. Here, as in elliptica and to a lesser extent cordata, the female gives a marked "switching" reaction, as though trying to dislodge the male, at intervals throughout copulation. Seven copulations timed; duration from 12 to 34 minutes, with an average of about 25 minutes.

Chromosomes.—Two pairs of V's and a pair of rods.

Relationships.—Nearest elliptica and cordata.

Distribution.—Quirigua, Guatemala (T. Dobzhansky).

Drosophila biopaca, sp. nov. (subgenus Sophophora).

External characters of imagines.

♂. Arista with about 8 branches. Antennae gray, third segment dark brown. Front gray, frontal lines reddish, broad. Middle orbital about ¼ other two. Second oral nearly as long as first. Carina narrow; face brown; a few small hairs below carina. Cheeks gray, their greatest width about ⅙ greatest diameter of eyes. Eyes with medium pile.

Acrostichal hairs in 6 rows; no prescutellars. Anterior scutellars divergent. Mesonotum dark brown, with a gray stripe between middle acrostichal rows, and a wider one including each dorsocentral row.

There is also a gray line lateral to the dorsocentral line (on each side), curving out from the posterior end of the dorsocentral stripe and rejoining it at the suture. Humeri gray. Scutellum dark brown, with grayish margin and central area. Pleurae brown, sutures gray. Legs brown. Sterno-index about .3. No sexual characters on front tarsi. Apical bristles on 1st and 2nd tarsi, preapicals on all three.

Abdomen gray, each tergite with a broad black posterior band that is broader in the mid-dorsal region; the fifth one covers nearly the whole tergite.

Wings clear. Costal index about 2.0; 4th vein index about 1.9; 4c index about 1.2; 5x index about 1.3. Two well-developed bristles at apex first costal section; third costal section with heavy bristles on its basal 4/10.

Length body 1.7 mm. (in pinned specimen); wing 1.8 mm.

♀. Fifth abdominal tergite with a better developed gray basal band; the dark apical band includes a pair of lateral opaque areas.

Internal characters of imagines.

Anterior Malpighian tubes two, unbranched.

Posterior Malpighian tubes not fused at distal ends.

Testes in a spiral of about 5 gyres.

Spermathecae weakly chitinized, ovoid, with a "collar" at base; envelop thin. Ventral receptacle very long, without "minor coils," resembling a skein of wool that has been bent, as a whole, into the shape of an M.

Other characteristics, relationship, and distribution.

Eggs.—Two filaments that are slightly longer than the egg and are greatly flattened and expanded on their apical halves.

Larvae.—The larvae skip.

Puparia.—Each anterior spiracle with about 7 branches; it and its short stalk less than 1/10 the length of the puparium.

Mating habits.—Vibration of one wing, occasional circling; usually mate with little preliminary courtship. Copulations observed to last from 3 to 18 minutes—averages about 10 minutes.

Chromosomes.—Two pairs of V's and a pair of rods.

Relationships.—Near to rectangularis and sellata, here described as new, and also to saltans Sturtevant and earlei Sturtevant.

Distribution.—Quirigua, Guatemala (type locality, T. Dobzhansky); Balboa, Panama Canal Zone (J. Schultz).

Drosophila rectangularis, sp. nov. (subgenus Sophophora).

External characters of imagines.

♂. Arista with about 9 branches. Antenna brown, third segment darker. Front reddish brown, orbits and triangle black, pollinose. Middle orbital about 1/5 other two. Second oral nearly as long as first. Carina narrow; face brown; a few minute hairs below carina. Cheeks brown; their greatest width about 1/5 greatest diameter of eye. Eyes with short pile.

Acrostichal hairs in 6 rows. No prescutellars. Anterior scutellars divergent. Mesonotum brownish black, with a narrow gray stripe between median acrostichal rows, one in each dorsocentral row, and a more lateral one connected with the dorsocentral one at the suture. Scutellum dark brown, margins slightly grayish. Humeri brown. Pleurae brown, sutures grayish. Legs yellowish brown, femora and bases of tibiae slightly darker. Anterior sternopleural ⅓ length of posterior. Apical bristles on first and second tibiae, preapicals on all three.

Abdomen black, each tergite with a narrow basal gray band.

Wings clear. Costal index about 2.3; 4th vein index about 2.1; 4c index about 1.3; 5x index about 1.3. Two bristles at apex first costal section. Third costal section with heavy bristles on its basal ⅓.

Length body 1.8 mm.; wings 1.8 mm.

♀. Fifth abdominal tergite with a rectangular opaque mark.

Internal characters of imagines.

Anterior Malpighian tubes two, unbranched; posterior free, not forming a loop.

Testes long, in a spiral of 7 to 8 gyres.

Ventral receptacle long, thin, in a single coil that is not bent into the M-shape found in sellata, biopaca, etc.

Spermathecae two, chitinized; pear-shaped, with no apical indentation; strongly telescoped at base; two basal collar-like ridges.

Other characteristics, relationship, and distribution.

Eggs.—Two filaments, much expanded on their apical ⅖; about ⅘ the length of the egg.

Larvae.—The larvae skip.

Puparia.—Anterior spiracles with about 6 branches; these and their short stalk scarcely 1/10 length of puparium.

Mating habits.—Vibration of one wing. Female spreads her wings before male mounts. No "switching" by female during copulation. Six timed copulations lasted from 12 to 19 minutes, average 17 minutes.

Chromosomes.—Two pairs of V's and a pair of rods.

Relationships.—Near biopaca, sellata, saltans, and earlei.

Distribution.—Orizaba, Mexico (T. Dobzhansky).

Drosophila sellata, sp. nov. (subgenus Sophophora).

External characters of imagines.

♂. Arista with about 8 branches. Antennae reddish brown, third segment blackish anteriorly. Front gray, frontal lines reddish brown. Middle orbital about ⅕ other two. Second oral nearly as long as first. Carina narrow; face brown; a few small hairs below carina. Cheeks gray; their greatest width about ⅕ diameter of eye. Eyes with short pile.

Acrostichal hairs in 6 rows; no prescutellars. Anterior scutellars divergent. Mesonotum gray, with the following brown markings: a

median spot just behind the suture; a pair of interrupted stripes inside the dorsocentral rows; three short stripes in a line just outside the dorsocentral rows. Scutellum gray. Pleurae gray, brownish ventrally. Legs brown, femora almost black. Anterior sternopleural ⅓ posterior. Apical bristles on first and second tibiae, preapicals on all three.

Abdomen black, four basal segments each with a grayish yellow basal band that is narrower in the median line and does not reach the lateral edge of its tergite.

Wings clear; a black spot at tip of first costal section. Costal index about 1.7; 4th vein index about 2.0; 4c index about 1.5; 5x index about 2.0. Two bristles at tip of first section of costa. Third section of costa with heavy spines on its basal ⅖.

Length body 1.7 mm.; wing 1.7 mm.

♀. A median dark opaque area on fifth abdominal tergite, that is elliptical and strongly narrowed in the median line to give a saddle-like shape.

Internal characters of imagines.

Posterior Malpighian tubes with distal ends free.

Testes long, spirally coiled.

Ventral receptacle long, fine, not kinky, resembling a skein of wool that is folded (as a whole) into the shape of an M.

Spermathecae 2, black, chitinized, spherical, telescoped at base.

Other characteristics, relationship, and distribution.

Eggs.—Two filaments, somewhat expanded on their apical halves, each about ⅘ the length of the egg.

Larvae.—The larvae skip.

Puparia.—Anterior spiracles with about 6 branches; they and their short stalks scarcely 1/10 the length of puparium.

Mating habits.—Vibration with one wing at a time, circling, rapid scissors movement; much excitement. The one copulation timed lasted for 15 minutes.

Chromosomes.—Two pairs of V's and a pair of rods.

Relationships.—Near biopaca and rectangularis, here described as new. It is also evidently much like prosaltans Duda, from Paraguay. The chief reason for not applying that name to it is the distribution, plus the fact that I have not seen Duda's material.

Distribution.—Antigua, Guatemala City (type locality), Guatemala; Chilpancingo, State of Guerrero, Mexico (all collections by T. Dobzhansky).

Drosophila pinicola, sp. nov. (subgenus Drosophila).

External characters of imagines.

♂. Arista with about 7 branches. Antennae gray, third segment dark brown. Front gray, dull; frontal lines broad, velvety, red. Middle orbital

¼ other two. Second oral less than ⅓ first. Carina high, narrow, flattened, slightly sulcate. Face grayish brown. Cheeks yellowish brown; their greatest width ⅕ greatest diameter of eyes. Eyes somewhat oblique, covered with medium pile. No minute hairs below carina.

Acrostichal hairs irregular, usually in 6 rows but may also be counted as 8; no prescutellars; anterior scutellars nearly parallel. Mesonotum dull grayish brown, with darker indistinct markings in dorsocentral rows, above humeri, and in transverse suture connecting these areas. Pleurae grayish brown. Coxae yellow; femora dark brown; tibiae brownish yellow, darker at base; tarsi brownish yellow, two terminal segments much darker. A few short fine slightly recurved hairs on anterior face of the tarsi. Sterno-index about .6. Apical bristles on 1st and 2nd tibiae, preapicals on all three. Preapicals on first nearly as long as diameter of tibia.

Abdominal tergites brown, with broad shining black apical bands that reach the posterior margin of the tergites on the sides of the abdomen. The basal black band is definitely narrowed in the mid-dorsal line; the 5th one covers nearly the whole tergite. Hypopygium large.

Wings clear except for a cloud on posterior crossvein. Veins dark brown. Costal index about 3.1; 4th vein index about 1.4; 5x index about 1.0; 4c index about 0.7. Two well-developed bristles at apex of first costal section; third costal section with heavy bristles on its basal 4/10.

Length body 2½ mm. (in pinned specimen); wings 2 mm.

♀. No fine recurved hairs on front tarsi. Second dark abdominal band slightly narrowed in mid-dorsal line.

Internal characters of imagines.

Anterior Malpighian tubes two, unbranched; posterior fused into a loop around the gut, lumen continuous.

Testes rather broad, in a spiral of about two gyres.

Spermathecae strongly chitinized, telescoped at base, indented at apex, slightly broader than long. Ventral receptacle long, fine, coiled, not kinky.

Other characteristics, relationship, and distribution.

Eggs.—Four tapering filaments, the two anterior ones more slender than the posterior, their length half that of the egg.

Larvae.—The larvae do not skip.

Puparia.—Each anterior spiracle with about 7 branches; anterior spiracle with scarcely any stalk, .1 the length of the puparium.

Mating habits.—Not studied.

Chromosomes.—Three pairs: X is J-shaped, Y is V-shaped, each arm about as long as the long arm of the X; there are two pairs of autosomes, a V and a rod, each of the three arms concerned being about the length of the short arm of the X (E. Novitski).

Relationships.—This species constitutes a special group in the subgenus Drosophila, its closest ally in the subgenus apparently being virilis. Pinicola is also closest to Scaptomyza and to the subgenus Sophophora

(obscura-affinis species group) among all the members of its subgenus yet studied. Its peculiar chromosome group is difficult to interpret; otherwise it appears to be a very primitive form.

Distribution.—Pacific Grove, Pinnacles National Monument, Sequoia National Park, Pasadena, San Gabriel Canyon, mountains north of Beaumont, slopes of Mt. San Jacinto (type locality), Andreas Canyon, California.

This species has been found usually in association with conifers. At Sequoia Park it was observed on moist spots on the trunks of Sequoia gigantea; it is probably a sap-feeder. In the laboratory it is difficult to breed, and can be kept in culture only at low temperature.

Drosophila floricola, sp. nov. (subgenus Phloridosa).

External characters of imagines.

♂. Arista with about 7 short branches. Antennae black. Front dark velvety brown, orbits and ocellar triangle shining black. Middle orbital ¼ other two. Second oral ¼ first. All bristles of entire animal short. Carina broad, flat, sharply angled. Face black. No hairs below carina. Cheeks dark brown, black posteriorly; their greatest width about ¼ greatest diameter of eye. Eyes with short pile.

Acrostichal hairs in 8 rows. No prescutellars. Anterior dorsocentrals less than half as far from posterior ones as the latter are from each other. Anterior scutellars divergent. Humeri, mesonotum, and scutellum somewhat shining brownish black, without markings or pollinosity. Pleurae black, slightly pollinose. Coxae and femora black, tibiae dark brown, tarsi lighter brown. Anterior sternopleural ⅕ posterior. Apicals on first and second tibiae, preapicals on all three.

Abdomen black, 5th tergite yellowish brown, 4th sometimes brown.

Wings clear. Costal index about 2.5; 4th vein index about 1.7; 4c index about 1.0; 5x index about 1.2. No conspicuous bristles at apex first costal section. Third costal section with heavy spines on its basal ⅗.

Length body 2 mm.; wings 2 mm.

♀. Fourth abdominal tergite paler than in ♂.

Internal characters of imagines.

Anterior Malpighian tubes absent; their common base present, smaller than that of posterior pair.

Posterior Malpighian tubes fused to form a loop around the gut.

Testes reddish orange, very long and slender, in a tight coil of many gyres.

Spermathecae two, weakly chitinized, strongly telescoped at base, elongate.

Ventral receptacle long, narrow, with marked "minor coils."

Other characteristics, relationship, and distribution.

Eggs.—Naked—i.e., without filaments or remains of follicle cells on their surfaces.

Larvae.—The larvae do not skip.

Puparia.—About 11 branches to anterior spiracle; it and its stalk about 1/5 length of puparium.

Mating habits and chromosomes.—Not studied.

Relationships.—Nearest to tristani Sturtevant, from Costa Rica; also close to the Neotropical lutzii Sturtevant and alfari Sturtevant.

Distribution.—Pasadena, Monrovia, Elsinore, Palm Canyon, all in southern California.

The larvae feed in flowers, apparently chiefly on pollen. The adults are to be found in the flowers, often in large numbers. They have been taken in Datura (probably the chief natural food-plant), Hibiscus, melon, morning-glory, and calla lily.

This form was not observed until October, 1941; a full season of collecting will probably extend its known geographical range and list of food-plants.

A few specimens have been reared in the laboratory on the usual cornmeal-molasses medium, but it has not so far been possible to maintain a strain through successive generations.

Key to North American Species of Drosophila

In the key that follows, no attempt has been made to include the numerous species described by Duda. The student who has to deal with Neotropical forms will need to use his full paper (Duda 1925).

Other keys that may be useful are to be found in the following papers:

Bryan, 1938—Hawaii.

Duda, 1924—Old World.

Kikkawa and Peng, 1938—Japan and neighboring regions.

Malloch, 1924, 1927—Australia.

Malloch, 1934—Samoa.

Malloch, 1935—Marquesas Islands.

Malloch and McAtee, 1924—American genera, species of the District of Columbia region.

Sturtevant, 1921—North America.

Sturtevant, 1927—Oriental region.

Additional notes are given by Sturtevant (1923) and by Stalker and Spencer (1939).

In the following key the virilis and repleta species-groups (couplets 61–63 and 93–117) have been written by Professor Patterson and Mr. Wheeler, and the quinaria group (couplets 26–36) by Professor Spencer, who has also contributed couplet 87.

1. Mesonotum yellow, with distinct black longitudinal stripes, the median one bifid posteriorly; preapical bristles evident only on third tibiae....*busckii* Coq.

Mesonotum gray, each hair and bristle arising from a black or dark brown spot, these spots sometimes largely fused; costal index 2.4 to 3.6; arista with 6 to 9 branches ..... *repleta group* 93

Mesonotum not as above, usually unmarked or with a rather indistinct pattern 2

2. A row of short stout bristles on lower apical part of each front femur, the row parallel to the axis of the femur; costal index about 4.4 ..... *immigrans* Sturt.

No row of femoral bristles 3

3. Prescutellar bristles small but distinct 4

No prescutellar bristles 8

4. Wings more or less clouded; posterior crossvein sinuate 5

Wings clear; posterior crossvein straight 6

5. Wings largely blackish, a clear spot between second and third veins and another between third and fourth; eastern United States ..... *sigmoides* Loew

Wings largely clear, clouded on crossveins and at tips of longitudinal veins; tropical ..... *flexa* Loew

6. Dull, yellowish or brownish; tropical 7

Shining, black or dark brown; United States ..... *victoria* Sturt.

7. Yellow species ..... *bromeliae* Sturt.

Brown species; found in flowers ..... *florae* Sturt.

8. A pair of presutural bristles, often small, but definitely larger than surrounding hairs; yellowish or brownish 9

No presutural acrostichal bristles 10

9. Presutural acrostichals about as long as anterior dorsocentrals, nearly erect ..... *testacea* v. Roser

Presutural acrostichals only slightly larger than surrounding hairs, little elevated from surface of thorax ..... *putrida* Sturt.

10. Acrostichal hairs in six rows 11

Acrostichal hairs in eight rows 70

11. Yellowish or reddish species 12

Blackish or dark brown species 37

12. Wings with about 13 black spots; mesonotum striped; first 2 to 4 oral bristles nearly equal ..... *guttifera* Walker

Wings strongly clouded, especially on anterior portion and along posterior crossvein 13

Wings clear, at most with crossveins and tips of longitudinal veins clouded 14

13. Carina only a knob above; second oral small; middle orbital about ¼ other two ..... *sororia* Williston

Carina broad; second oral ¾ first; middle orbital ½ other two ..... *nebulosa* Sturt.

14. Face white; carina large; tropical 15

Face yellow or brown 16

15. Front yellow; abdomen banded ..... *albirostris* Sturt.

Front brown; abdomen black ..... *metzii* Sturt.

16. Carina small, confined to upper part of face, usually narrow 17

Carina larger, reaching well below middle of face 20

17. Third antennal segment long, clothed with very long hairs 18

Third antennal segment as usual; small tropical species 19

18. Costal index about 3.8; 4th vein index about 1.4 ..... *duncani* Sturt.

Costal index about 1.9; 4th vein index about 2.0 ..... *prognatha* Sturt.

19. Costa and crossveins clouded; costal index about 2.0 ..... *sororia* Williston

Wings clear; costal index about 1.8 ..... *nana* Williston

20. Large yellow species (2.8 mm. pinned); middle orbital about half length of anterior; only one large oral bristle; wings clear ..... *ordinaria* Coq.

Not entirely as above 21

21. Anterior scutellars convergent 22

Anterior scutellars divergent 23

22. Only one large oral bristle; costal index about 3.0 ..... *melanderi* Sturt.
    Two nearly equal oral bristles; costal index about 3.9 ..... *cardini* Sturt.
23. Wings clear 24
    At least the posterior crossvein clouded 26
24. Costal index about 1.8; second oral nearly as long as first; small tropical species ..... *willistoni* Sturt.
    Costal index about 3.0; second oral minute 25
25. Mesonotum with median dark stripe ..... *magnafumosa* Stalker and Spencer
    Mesonotum with no markings ..... *orbospiracula* Patterson and Wheeler
26.[1] Costal index about 4.2 27
    Costal index 3.5 or less 28
27. Cheeks ⅓ diameter of eyes; abdomen with no median spots *macroptera* Patterson and Wheeler
    Cheeks ⅙ diameter of eyes; abdomen with median spots on 3rd, 4th, and 5th tergites ..... *tripunctata* Loew
28. Eggs with 4 filaments; tropical ..... *similis* Williston
    Eggs with 3 filaments; nearctic 29
29. Mesonotum with longitudinal stripes; posterior crossvein more or less sinuate 30
    Mesonotum not longitudinally striped; posterior crossvein straight 32
30. Abdominal tergites each with 4 (may be 2 on 5th) distinct black spots *deflecta* Malloch
    A broad median and two lateral yellowish stripes on abdomen 31
31. Posterior crossvein slightly sinuate; small dark clouds on crossveins and apices of L 2, 3, and 4 ..... *palustris* Spencer
    Posterior crossvein strongly sinuate; heavy black clouds on crossveins and apices of L 2, 3, 4, 5 ..... *subpalustris* Spencer
32. Abdomen with dark apical bands, broken in mid-dorsal line but not into spots 33
    Abdomen with distinctly spotted pattern 35
33. Wings with narrow black clouds on posterior crossveins ..... *munda* Spencer
    Wings with heavy black clouds on both crossveins 34
34. Medially directed recurved hairs on male fore-tarsus shorter than thickness of tarsus ..... *occidentalis* Spencer
    Medially directed recurved hairs on male fore-tarsus longer than thickness of tarsus ..... *suboccidentalis* Spencer
35. Wings clouded at apices of longitudinals as well as on crossveins; medially directed recurved hairs on male fore-tarsus longer than thickness of tarsus and humerous ..... *quinaria* Loew
    Wings not distinctly clouded at apices of longitudinals; medially recurved hairs on male fore-tarsus shorter than thickness of tarsus and scanty 36
36. Anterior and posterior crossveins with wide black clouds; Rocky Mountain region ..... *subquinaria* Spencer
    Anterior and posterior crossveins with narrow dark clouds; Eastern United States ..... *transversa* Fallén
37. "Middle" orbital placed below the proclinate one, over ½ its length; carina small, confined to upper part of face; third antennal segment large, oval ..... *alabamensis* Sturt.
    Not entirely as above 38
38. Anterior scutellar bristles convergent 39
    Anterior scutellar bristles divergent 51
39. Third antennal segment large; pleurae striped ..... *cinerea* Patterson and Wheeler
    Third antennal segment as usual 40

[1]Couplets 26–36 by W. P. Spencer.

40. Carina narrow; sex-combs present on male tarsi; preapical on first tibia longer than diameter of tibia 41
Carina broader; no sex-combs; first preapical shorter than diameter of tibia .. 46
41. Proximal sex-comb with 8 to 10 teeth, nearly parallel to axis of tarsus; species larger and more brownish than the five following ones *algonquin* Sturt. and Dobzh.
Proximal sex-comb with 4 to 6 teeth, more oblique 42
42. Front slightly pollinose when viewed laterally; sex-comb with short teeth 43
Front scarcely pollinose 44
43. Front not pollinose when viewed from vertex; mesonotum not uniformly pollinose, with longitudinal stripes ..... *seminole* Sturt. and Dobzh.
Front pollinose when viewed from vertex; mesonotum uniformly pollinose *narragansett* Sturt. and Dobzh.
44. Teeth of sex-comb distinctly longer than greatest diameter of tarsal segment ..... *affinis* Sturt.
Teeth of sex-comb scarcely longer than greatest diameter of tarsal segment .. 45
45. Mesonotum with four relatively distinct less pollinose longitudinal stripes (two inside and two outside the dorsocentral lines); Calif. to Central America ..... *azteca* Sturt. and Dobzh.
Mesonotum with two relatively less distinct longitudinal stripes (inside the dorsocentral lines); Alaska and Oregon to Maine and Tenn. *athabasca* Sturt. and Dobzh.
46. Second oral over half length of first 47
Second oral less than half length of first 48
47. Costal index about 4.0; middle orbital very small ..... *pseudomelanica* Sturt.
Costal index about 2.5; middle orbital nearly as long as anterior one *carbonaria* Patterson and Wheeler
48. Posterior crossvein clouded; first coxae black; costal index about 4.0 .. *robusta* Sturt.
Posterior crossvein clouded; first coxae yellowish; costal index about 3.1 *pinicola* Sturt.
Posterior crossvein not clouded, though whole vane of wing may be somewhat smoky 49
49. Costal index less than 3.0; first coxae black ..... *micromelanica* Patterson
Costal index more than 3.0; first coxae brown 50
50. Mesonotum blackish brown; cheek ⅙ diameter of eye ..... *melanica* Sturt.
Mesonotum brownish black; cheek ⅓ diameter of eye ..... *melanissima* Sturt.
51. Wings with conspicuous dark pattern; mesonotum and scutellum marked with velvety black; front and antennae pale yellow; tropical *calloptera* Schiner
Wings clear or with clouds on crossveins 52
52. Carina narrow below; third antennal segment large, clothed with long hairs .. 53
Carina broader below; third antennal segment as usual 55
53. Mesonotum brown, striped; 4th vein index about 1.6; a single bristle at distal costal break ..... *chagrinensis* Stalker and Spencer
Mesonotum gray, striped; two bristles at distal costal break 54
54. Cheeks ⅓ diameter of eyes; mesonotum with median dark stripe *grisea* Patterson and Wheeler
Cheek ¼ diameter of eye; no median dark mesonotal stripe *cinerea* Patterson and Wheeler
55. Costal index over 4.0; 4th vein index about 1.3; large species ..... *colorata* Walker
Costal index less than 4.0; 4th vein index over 1.3 56
56. Bristles small; brown species, no pollinosity; only one conspicuous oral bristle; tropical; found in flowers ..... *lutzii* Sturt.
Bristles larger; more or less pollinose; not found in flowers 57
57. Anterior sternopleural at least half as long as posterior 58
Anterior sternopleural less than half as long as posterior 64

58. Middle orbital ⅛ anterior; cheeks ⅛ diameter of eye ..... *pinicola* Sturt.
Middle orbital ¼ to ½ anterior; cheek ¼ to ⅓ diameter of eye 59
59. Third costal section with heavy bristles on its basal third; 2 egg-filaments; sterno-index about .7 ..... *nigromelanica* Patterson and Wheeler
Third costal section with heavy bristles on basal half or more; 4 egg-filaments; sterno-index .8 to .9 60
60. Posterior crossvein narrowly clouded ..... *virilis* Sturt.
Posterior crossvein broadly clouded 61
61.[2] Costal index 3.0 to 3.3; 4c index to .85; 5x index about 1.0; arista with about 7 branches; 3rd costal section with heavy bristles on its basal ½ to ⅔; wings long, usually about as long as body; mesonotum with two rather prominent stripes 62
Costal index 2.5 to 2.8; 4c index .95 to 1.0; 5x index about 1.2; arista with 8 to 9 branches; 3rd costal section with heavy bristles on its basal ¾; wings long, but usually shorter than the body length; mesonotum with but faint striping 63
62. Only one prominent oral bristle, the 2nd not more than ¼ length of first, usually less; terminal tarsal segments of fore legs black; 3rd costal section with heavy bristles on scarcely more than the basal ½; abdomen grayish brown ..... *montana* Patterson and Wheeler
Second oral bristle about ¾ length of first; terminal tarsal segments of fore legs scarcely darker than rest of leg; 3rd costal section with heavy bristles on its basal ⅔; abdomen dark gray to black ..... *novamexicana* Patterson
63. (The two following species cannot be separated morphologically, but can be distinguished cytologically as follows:)
Metaphase plate of ♀ and ♂ with 3 pairs of rods, one pair of V's and one pair of dots ..... *texana* Patterson, Stone and Griffen
Metaphase plate of ♀ with one pair of rods, 2 pairs of V's and one pair of dots; ♂ with 4 rods, 3 V's and one pair of dots ..... *americana* Spencer
64. Mesonotum without gray or pollinose pattern; no minute hairs below carina 65
Mesonotum with definite gray markings; minute hairs below carina 66
65. Legs yellowish brown, femora darker ..... *cordata* Sturt.
Coxae and femora dark brown, almost black ..... *elliptica* Sturt.
66. A median dark spot near center of mesonotum; femora dark brown. *sellata* Sturt.
No median dark area on mesonotum 67
67. Dark brown areas evident on femora and tibiae 68
Femora and tibiae scarcely darkened 69
68. Anterior dark stripes inside dorsocentral rows not reaching level of anterior dorsocentral ..... *saltans* Sturt.
Dark stripes between dorsocentral rows reaching level of posterior dorsocentral ..... *rectangularis* Sturt.
69. Median pale thoracic stripe as wide as adjacent dark stripes ..... *earlei* Sturt.
Median pale thoracic stripe scarcely half width of adjacent dark stripes *biopaca* Sturt.
70. Yellowish or pale brown species 71
Blackish or dark brown species 79
71. Crossveins clouded; costal index about 4.0 72
Wings clear 73
72. Abdominal bands broken into spots; width of cheek not over ¼ diameter of eye ..... *transversa* Fall.
Abdominal bands interrupted at most in median dorsal line; cheek about ⅓ diameter of eye ..... *rubrifrons* Patterson and Wheeler

[2]Couplets 61–63 by J. T. Patterson and M. R. Wheeler.

73. Three pairs of postsutural dorsocentrals; middle orbital ⅓ length of anterior; costal index 2.1; 4th vein index 1.8 ..... *illota* Williston
Two pairs of dorsocentrals 74
74. Anterior scutellars convergent 75
Anterior scutellars divergent 78
75. Pale yellowish, all hairs and bristles yellowish; tropical ..... *torrei* Sturt.
Not pale, hairs and bristles black or dark brown 76
76. Costal index about 3.9; mesonotum striped ..... *fulvalineata* Patterson and Wheeler
Costal index about 2.2; sex-comb on male tarsus 77
Costal index about 1.5 ..... *ananassae* Doleschall
77. Vertical diameter of eye about 5 times width of cheek in same axis; male genital arch with hook-like process ..... *melanogaster* Meigen
Vertical diameter of eye about 7 times width of cheek in same axis; male genital arch with clam-shell-like process ..... *simulans* Sturt.
78. Thorax without pattern; sterno-index about .4
orbospiracula Patterson and Wheeler
Thorax with four faint longitudinal stripes; sterno-index about .3
longala Patterson and Wheeler
79. Shining, not at all pollinose; bristles and branches of arista short; found in flowers 80
Bristles and branches of arista of usual length; not found in flowers 82
80. Costal index about 3.6; femora yellow ..... *alfari* Sturt.
Costal index about 2.8; femora black or dark brown 81
81. Abdomen and mesonotum black ..... *tristani* Sturt.
Mesonotum dark brown; abdomen dark brown basally, yellowish apically
floricola Sturt.
82. Fourth vein index 2.0 or more; 3 pairs of postsutural dorsocentrals
polychaeta Patterson and Wheeler
Fourth vein index less than 2.0; 2 pairs of dorsocentrals 83
83. Brown species; anterior scutellars convergent; costal index over 3.0 84
Blackish, more or less pollinose 86
84. Cheeks 1/7 greatest diameter of eyes ..... *macrospina* Stalker and Spencer
Cheeks ⅙ to ¼ greatest diameter of eyes 85
85. Heavy spines on male anal plate curved slightly upward; row of peg-like bristles on egg-guide does not extend to dorsal edge of terminal process
funebris Fabricius
Heavy spines on male anal plate curved slightly downward; bristles on egg-guide extend well onto dorsal edge of terminal process
subfunebris Stalker and Spencer
86. Costal index 4.0 or more 87
Costal index 3.0 or less 88
87. Carina broad, scarcely sulcate; mesonotum and scutellum dark brown, indistinctly marked, if at all ..... *robusta* Sturt.
Carina narrow, deeply sulcate; mesonotum and scutellum light brown, the former distinctly striped and mottled ..... *colorata* Walker
88. Sex-combs present on two basal segments of first tarsi of males; anterior scutellars convergent 89
No sex-combs; anterior scutellars divergent (coffeata and annularis not known for latter character) 90
89. Femora and tibiae yellowish brown, scarcely blackened; development at 25° C. requires 13 to 14 days, with less than a day's difference for males and females ..... *pseudoobscura* Frolowa
Femora and tibiae distinctly blackish; development period at 25° C about 15 days for females, about 17 for males ..... *miranda* Dobzhansky

90. No gray pattern on mesonotum ..... *emarginata* Sturt.
Definite gray pattern on mesonotum 91
91. Crossveins slightly clouded ..... *annularis* Sturt.
Crossveins not clouded 92
92. One prominent oral bristle; carina sulcate ..... *coffeata* Williston
Two large oral bristles; carina not sulcate ..... *earlei* Sturt.
93.[3] Costal index 3.0 or above 94
Costal index below 3.0 104
94. Cheeks over ½ diameter of eyes; palpi brown ..... *californica* Sturt.
Cheeks less than ½ diameter of eyes, usually about ⅓; palpi pale yellow 95
95. Long recurved hairs present on medial side of fore tarsi, at least in males 96
No long recurved hairs on fore tarsi 97
96. Apex of first costal section black; arista with about seven branches *nigrohydei* Patterson and Wheeler
Apex of first costal section not black; arista with about nine branches *bifurca* Patterson and Wheeler
97. Lateral areas of abdominal segments solid brown 99
Lateral regions of abdominal segments with pale or yellow central areas 98
98. Wings clear; apex of first costal section not blackened *hamatofila* Patterson and Wheeler
Crossveins moderately clouded; apex of first costal section black *longicornis* Patterson and Wheeler
99. Wings somewhat dusky; legs black; front sooty black *fuliginea* Patterson and Wheeler
Wings clear; legs brownish or yellowish; coxae sometimes darker; front brown 100
100. Sterno-index about .66; two indistinct longitudinal stripes in acrostichal region, especially in ♀ ..... *pachea* Patterson and Wheeler
Sterno-index .80 or greater; thorax not noticeably striped 101
101. Costal index about 3.0 102
Costal index 3.3 to 3.5 103
102. Arista with about 7 branches; cheeks ⅓ diameter of eyes; sterno-index about .80; legs brownish; lateral areas solid ..... *nigrospiracula* Patterson and Wheeler
Arista with about 8 branches; cheeks ¼ diameter of eyes; sterno-index about .90; legs yellowish brown, fore coxae darker brown; lateral region of abdominal segments with yellowish central area ..... *repleta* Wollaston
103. Legs pale yellowish brown, fore coxae yellowish, not darkened ..... *hydei* Sturt.
Legs tannish yellow, fore coxae and femora light brown *hydeoides* Patterson and Wheeler
104. Acrostichal hairs in 8 rows; costal index 2.4 or greater 105
Acrostichal hairs in 6 rows; costal index about 1.8; spots of thorax fusing to form a broad median stripe and a pair of narrow anterior stripes just inside dorsocentral rows; medium sized fly from West Indies *fasciola* Williston
105. Crossveins more or less clouded 106
Wings clear 108
106. Second oral about half length of first; sterno-index about .80; 5x index above 1.5; length body to 2.5 mm ..... *meridiana* Patterson and Wheeler
Second oral ¼ or ⅕ length of first; sterno-index about .70 to .75; 5x index below 1.5; length body to 3.4 mm 107
107. Posterior crossvein clouded, anterior slightly so; vane of wing clear; spots of thorax fusing into two long brown stripes in outside acrostichal rows; third costal section with heavy bristles on its basal ⅓ *linearepleta* Patterson and Wheeler

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[3]Couplets 93–117 by J. T. Patterson and M. R. Wheeler.

Anterior and posterior crossveins moderately clouded, a slight darkening at tip of second longitudinal vein; spots of thorax not forming stripes; third costal section with heavy bristles on its basal ¼
leonis Patterson and Wheeler

108. Carina short dorsoventrally, low dorsally, broad and high ventrally, very widely sulcate; one prominent oral bristle followed by an irregularly disposed series of hairs ..... *brevicarinata* Patterson and Wheeler

Carina normally broadened below, rounded or triangular, moderately sulcate; oral bristles normal 109

109. Carina triangular, flaring rather widely below, not rounded; recurved hairs on tibiae and some on tarsi; apex of first costal section not blackened
ritae Patterson and Wheeler

Carina evenly rounded below, not triangular or flaring; no recurved hairs on tibiae; apex of first costal section blackened 110

110. Palpi black or nearly so; front blackish ..... *melanopalpa* Patterson and Wheeler

Palpi pale yellow or clear; front yellow or light to dark brown, not blackish .. 111

111. Arista with about 6 branches; second oral about ¼ length of first
neorepleta Patterson and Wheeler

Arista with 7 or 8 branches; second oral at least ⅓, often ½, length of first 112

112. Spots between dorsocentral rows largely fused to form two irregular stripes; abdominal bands; without pale lateral areas ..... *ramsdeni* Sturt.

Numerous spots between dorsocentral rows, these not fusing to form stripes; pale lateral areas present on abdominal segments 113

113. Arista with about 8 branches; third costal section with heavy bristles on its basal ½ or nearly so; length often to or beyond 3.0 mm. 114

Arista with about 7 branches; third costal section with heavy bristles on its basal ⅓ or ¼; length usually less than 3.0 mm. 115

114. Body color rather dark brown, abdominal pattern distinct, bands dark, median interruption pronounced; abdomen clear, whitish ventrally, testes showing through distinctly, light yellow
peninsularis Patterson and Wheeler

Body color light brown with a washed-out appearance; abdominal pattern faded and indistinct, bands light, interruptions indistinct; abdomen yellowish ventrally, testes showing through very faintly, light in color
mercatorum Patterson and Wheeler

115. Abdomen very pale yellow, bands and other markings very faded and indistinct; exceedingly faint blackish bands near bases of tibiae of 2nd and 3rd legs; last tarsal segments brown; cheeks about ¼ diameter of eyes ..... *mojavensis* Patterson and Crow

Abdomen yellow, bands rather distinct to angle of tergites with small dark areas in their apical corners; dark bands on all tibiae and usually on distal ends of femora; tarsi pale; cheeks about ⅓ diameter of eyes 116

116. Costal index about 2.4; 4th vein index about 1.7; sterno-index about .80; antennae brown; third costal section with heavy bristles on its basal ⅓
arizonensis Patterson and Wheeler

Costal index 2.6 to 2.8; 4th vein index 1.9 to 2.2; sterno-index .65 to .75; antennae yellowish or tannish brown; third costal section with heavy bristles on its basal ¼ 117

117. Abdominal bands distinct, separated from the triangular area in the apical corner of the tergite; testes yellow, placed posteriorly; eyes red
mulleri Sturt.

Abdominal bands less distinct, those of the last one or two segments with a basal connection between the band and the triangular marginal area; testes deep orange, placed nearly in the middle of the adomen; eyes vermilion ..... *aldrichi* Patterson and Crow

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