

# PLEISTOCENE MAMMALS FROM URUGUAY: BIOSTRATIGRAPHIC, BIOGEOGRAPHIC AND ENVIRONMENTAL CONNOTATIONS

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## ABSTRACT

New paleontological information as case studies - some as ongoing works - from northern and southern selected Pleistocene outcrops and geographic localities are provided. From northern Uruguay (Sopas Formation, late Pleistocene), are commented the presence of cranial remains of the Pleistocene proterotheriid *Neolicaphrium* cf. *N. recens*; the skull of a possible new species of tapir (*Tapirus* sp.) and an ocelot-like (cf. *Leopardus pardalis*) postcranial bones. It is also provided the fossiliferous mammal content of three selected localities with radiocarbon and TL ages. From southern Uruguay (Dolores Formation, late Pleistocene; Libertad Formation), is described for the first time for Uruguay the occurrence of the armadillo-like *Pampatherium typum* and the rodent caviid *Dolichotis* cf. *D. patagonum*. It is commented the presence of a possible new species of the ground-sloth *Catonyx*. There are also considered from southern Uruguay the mammalian content of a bone-bed spelled the "La Paz Local Fauna" (late Pleistocene) and the mammalian assemblage for the El Caño locality (? late Pleistocene). It is discussed the biocronology, paleoclimate and paleoecological connotations of the mammals studied. Considerations about the current state of the art in order to emphasize the importance to perform regional comparative studies are also be done.

## INTRODUCTION

In last years the knowledge of Pleistocene mammals of Uruguay has been increased as a consequence of many taxonomic and fieldwork performed (Ubilla & Perea, 1999; Martínez & Ubilla, 2004; Ubilla *et al.*, 2004a and references therein).

The Sopas Formation, widely exposed in river, stream and creek sides of northern Uruguay in sections up to 12 to 15 m high, includes a panoply of vertebrates with mammals as the dominant group (Ubilla, 2004) (Figure 1A and C; Figure 2A). Many radiocarbon ages range up to >43,000 years BP (minimum ages), based on wood and fresh-water mollusc shell samples (Ubilla, 2001); some TL produced ages from 43,000 to 360,000 years BP (Martínez & Ubilla, 2004; Ubilla *et al.*, 2004a,b). The mammalian assemblage under study conveys biostratigraphic, climatic and environmental information. By one hand, it is biostratigraphically correlated to the Lujanian Stage/Age of the Buenos Aires Province (late Pleistocene - early Holocene, see Cione & Tonni, 2005) due to the presence of *Equus neogaens* along with others taxa restricted to this unit (Ubilla *et al.*, 2004a) (Table 1). By the other hand, Bombin (1976) correlated the northern sediments of Uruguay with the



Figure 1. Geographic locations of Pleistocene fossiliferous sites studied. Northern Uruguay: A, Artigas Department, several localities; B, Salto Department, several localities; C, Tacuarembó Department, Malo Creek. Southern Uruguay: D, Canelones Department, Santa Lucía River, several localities; E, Montevideo Department, Las Piedras Creek; F, Colonia Department, El Caño.

Touro Passo Formation of southwestern Brazil providing a radiocarbon age of 11,040 years BP. Later, Da-Rosa *et al.* (2000) and Oliveira (2007) referred radiocarbon and thermoluminescence ages from 10,810 to 42,600 years BP.

Mammals of the Sopas Formation are related to various habitats such as fluvial and lacustrine environments, riparian forest and also open woodland to savanna and grassland (Ubilla *et al.*, 2004a). Moreover, freshwater molluscs support the presence of lotic and lentic habitats (Martínez & Rojas, 2004). In some localities, earthworm trace fossils show the development of paleosols under seasonal climate (Verde *et al.*, 2007).

The presence of tropical to temperate mammals in this unit indicates an important difference with those of the Guerrero Member of the Luján Formation, which yields mammals related to cold and arid conditions of the last glacial maximum (Tonni *et al.*, 1999). It is likely that the mammals of the late Pleistocene of northern

Uruguay could be more related to those of the La Chumbiada Member of the Luján Formation, related to the last interstadial (Tonni *et al.*, 1999), or those that inhabited the Mesopotamian area of Argentina and south western Brazil but, more field work and comparative studies must be carry out in order to substantiate this hypothesis.

The Pleistocene strata of southern Uruguay, which are under study, are providing an increasingly diversity of mammals (Arribas *et al.*, 2001; Rego *et al.*, 2007; Ubilla *et al.*, 2007a) (Figure 1D-F; Figure 2B-F). In the Santa Lucía River basin are a large number of outcropping fossiliferous late Pleistocene sediments. In many cases, very well preserved specimens including articulated skeletons have been found (Figure 2C) (Ubilla, 2008).

There is available a set of radiocarbon ages ranging from 17,600 to 10,500 years BP based on woods and enamel samples for some of this southern deposits (Gutiérrez *et al.*, 2005; Ubilla, 2007). In the Dolores Formation mammalian assemblage there are taxa that suggest arid to semiarid environment and perhaps cold climatic conditions as *Microcavia*, *Dolichotis patagonum* and *Chaetophractus villosus*. They seem to be related to the fauna that inhabited the pampean region in last Pleistocene, particularly those of the Miembro Guerrero of the Luján Formation.

The purpose of this paper is to provide new paleontological information as case studies - some as ongoing works - from northern and southern selected Pleistocene outcrops and localities, and to comment the current state of the art in order to emphasize the importance to perform regional comparative studies.

**Abbreviations:** BRA, Colección Andrés Sánchez; MAMC, Museo Arqueológico Municipal de Canelones “Antonio Tadei”; MACN-S, Museo de Ciencias Naturales de Salto; FC-DPV, colección vertebrados fósiles, Facultad de Ciencias, Montevideo, Uruguay.

The taxonomic nomenclature of Caviidae is based on Woods & Kilpatrick (2005).

## CASE STUDIES, NEW REPORTS AND ONGOING WORKS

### Northern Uruguay

As stated above, the Sopas Formation includes an

Table 1. Mammalian taxa from selected localities with radiocarbon and TL ages of the Sopas Formation and their distribution within the pampean chronostratigraphic units (PCU). B, Bonaerian; E, Ensenadan; L, Lujanian; R, recent. Pointed lines indicate taxa absent in the pampean area. Based on Ubilla (2004 and references therein).

Mammals	Localities			PCU
	Malo Creek	Sopas Creek	Cuareim (Pintado-Urumbeba)	
<i>Dasypus</i> aff. <i>D. novemcinctus</i>		x		---
<i>Propraopus</i> sp.	x	x	x	E-L
<i>Pampatherium humboldti</i>	?		x	---
<i>Glyptodon clavipes</i>	x	x	x	B-L
<i>Neothoracophorus</i> sp.			x	E-L
<i>Neuryurus rudis</i>			x	E
<i>Panochthus tuberculatus</i>	x	x		B-L
<i>Megatherium americanum</i>	x			B-L
<i>Glossotherium robustum</i>		x	x	B-L
<i>Lestodon</i> cf. <i>L. armatus</i>			x	E-B
cf. <i>Scelidotherium</i>	x			E-L
<i>Felis concolor</i>			x	E-R
<i>Panthera</i> cf. <i>P. onca</i>	x	x		E-R
<i>Smilodon populator</i>	x		x	E-L
<i>Lycalopex gymnocercus</i>		x		E-R
<i>Lontra longicaudis</i>	x			E/L
Tremarctinae			?	E-R
<i>Reithrodon</i> sp.	x			E-R
cf. <i>Wilfredomys oenax</i>	x			---
<i>Lundomys monitor</i>	x		x	E-B
<i>Coendou magnus</i>	x		?	---
<i>Myocastor coypus</i>			x	---
<i>Cavia</i> sp.	x	x	x	E-R
<i>Galea</i> sp.	x			E-R
<i>Microcavia criolloensis</i>		x		---
<i>Dolichotis</i> sp.	x			E-L
<i>Hydrochoerus hydrochaeris</i>	x		x	---
<i>Nechoerus</i> cf. <i>N. aesopi</i>	x			L
<i>Macrauchenia patachonica</i>	x	x		B-L
<i>Neolicaphrium recens</i>	?	x		B
<i>Toxodon platensis</i>			x	B-L
Gomphotheriid indet.			x	E-L
<i>Tapirus terrestris</i>	x	?	x	---
<i>Tapirus</i> sp.	x			E-B
<i>Equus neogens</i>	x	x	x	L
<i>Hippidion principale</i>	x	x	x	B-L
<i>Tayassu</i> aff. <i>T. pecari</i>		x		B-L
<i>Catagonus</i> sp.		x	x	E-L
<i>Hemiauchenia paradoxa</i>	x	x	x	B-L
<i>Lama (Vicugna)</i> sp.	x	x	?	---
<i>Antifer ultra</i>		x	x	B
<i>Morenelaphus brachyceros</i>			x	B
<i>Morenelaphus lujanensis</i>			x	B-L
<i>Ozotoceros</i> aff. <i>O. bezoarticus</i>	x			L
<i>Paraceros fragilis</i>			x	B-L

important diversity of fossil mammals and even it is correlated with the Lujanian, there are differences with the lujanian mammal fauna of the fluvial Guerrero Member of the Luján Formation. The available ages of the Sopas Formation (>40,000 years BP) are older than those of the Guerrero Member of the Luján Formation

(21,000 to 10,000 years BP *sensu* Tonni *et al.*, 2003) which are related to the last glacial maximum. Moreover, it must be noted that there are some mammals in the Sopas Formation, which are indicative in the Buenos Aires Province of the Ensenadan and Bonaerian age (Table 1). This pattern could be

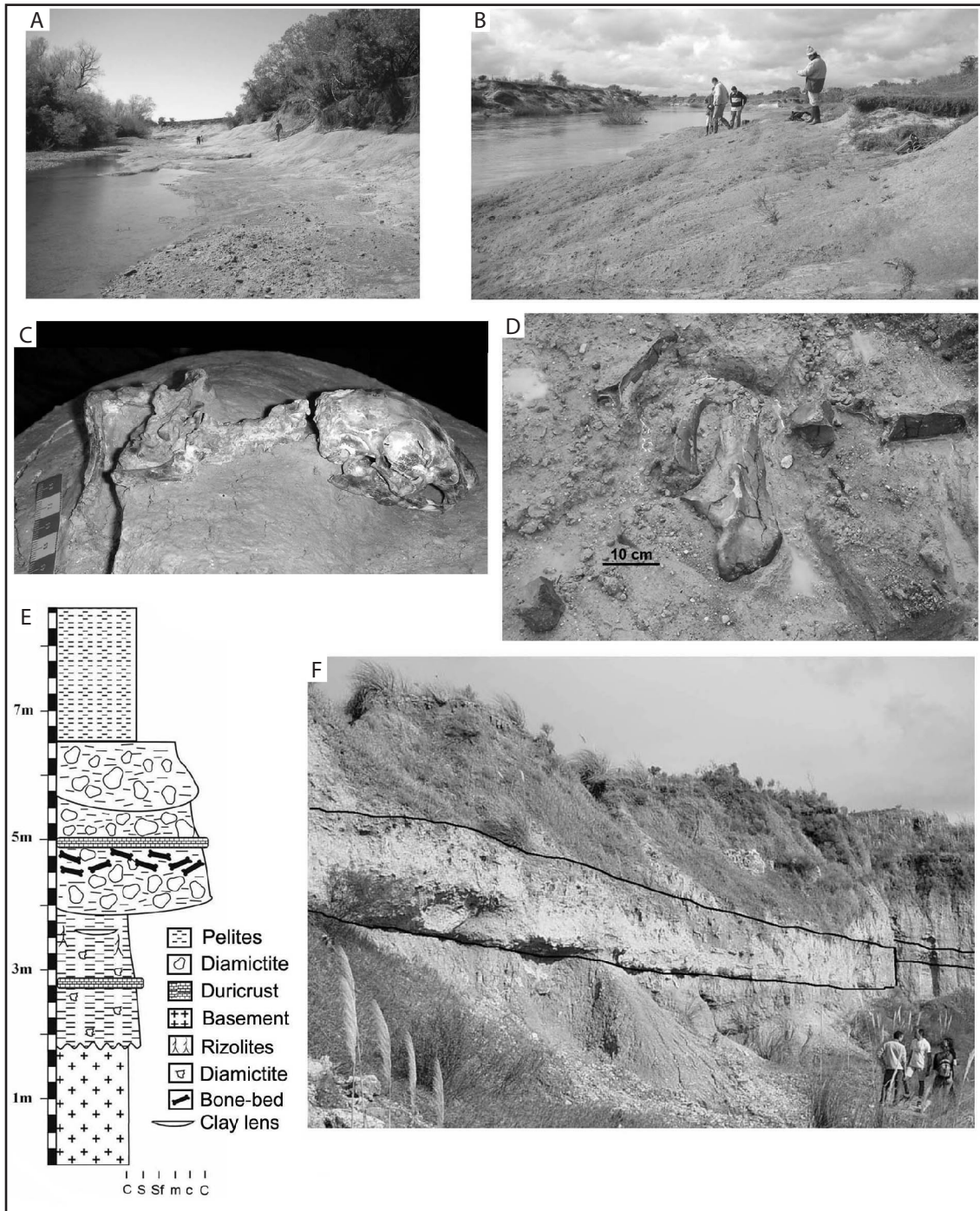


Figure 2. A, Sopas Formation (Sopas Creek, Salto Department); B, Dolores Formation (Veigas Creek, Canelones Department); C, articulated skeleton of *Microcavia criolloensis* in the Dolores Formation; D, disarticulated bones in the El Caño locality; E, stratigraphic profile (left) and the quarry with the "La Paz Local Fauna", Las Piedras Creek (right). Stratigraphic profile of the quarry including the "La Paz Local Fauna" was provided by C. Goso.



explained not only by temporal differences but also by ecological and climatic conditions. Due to the composition of the mammal assemblage of the Sopas Formation includes tropical to temperate taxa (*Tapirus*, *Hydrochoerus*, *Myocastor*, *Coendou*, etc.), it could be related to a warm interval of time such as the last interglacial or last interstadial (Ubilla *et al.*, 2004a). As in the Entre Ríos Province the faunal association of the Arroyo Feliciano Formation is related to warm and humid climate and referred to the last interglacial (Noriega *et al.*, 2004), a likely correlation with this fauna do not be discharged.

According to the Table 1, which includes three selected localities that possess radiocarbon and Tl ages, it is apparent that there are mammals more frequently found and are present in most of the localities studied. By the other hand, there are some mammals, which belong to only one locality, and in some cases the taxonomic resolution is still pending of revision and more and better materials. This type of taxonomic differences among localities could be constrained by temporal, ecological and sampling factors, which are difficult to be distinguishable. In this paper we will emphasize the following case studies:

#### Case-study 1

Litopterna (Protheriidae): *Neolicaphrium* cf. *N. recens*: an incomplete skull including dorsal surface, orbit, part of the rostrum, right incisor and part of both premolar and molar series (MACN-S-92) (Salto Department, Arapey River, Sopas Formation) (Ubilla *et al.*, 2007b).

The protheres were small to medium-sized cursorial litopterns. The group had an important diversity in the Tertiary (*ca.* 30 genera sensu Villafañe *et al.*, 2006) but the number of genera has dramatically been reduced in the Pleistocene to only one: *Neolicaphrium*. It was described by Frenguelli (1921) on the basis of mandibular remains from Argentina. Posteriorly, Bond *et al.* (2001) added new mandibular specimens (right and left mandibles of the same individual), from the Pleistocene of Uruguay and corroborated the persistence of the group in late Pleistocene. It is worthy of consideration the material described by Bond *et al.* (2001) from Uruguay (Salto Department), due to it belongs to the same litostratigraphic unit of the skull, which is under study. The skull here referred to *Neolicaphrium* cf. *N. recens* has

some remarkable characters: a comparatively long diastema with respect to the short P1-M3 series which suggest a relatively long snout; an anterolingual cingulum in molariforms such in *Thoatherium minusculum* and *Epitherium laternarium*; an orbit comparatively large as in *Eoauchenia primitiva*; the M3 located below the orbit, similar to *Eoauchenia primitiva* but differing to *Diadiaphorus* and *Epitherium* with the M3 located behind the posterior border of the orbit; the dorsal surface of the skull is quite parallel to the occlusal surface of molariforms differing from *Eoauchenia* with convergent dorsal surface. This material is important because it provides insights about the skull morphology of this extremely poorly known and last one Pleistocene protherothere.

#### Case-study 2

Perissodactyla (Tapiridae): *Tapirus* sp., an almost complete skull (FC-DPV-1822) (Malo Creek, Tacuarembó Department, Sopas Formation) not well preserved including rostral, dorsal and occipital regions, part of the zygomatic arch and the palatal region with almost eroded cheek-teeth. It is characterized by a short and wide rostral region, a short and low sagittal crest, a mastoid processes anteriorly projected and a lambdoid crest posteriorly oriented (Ubilla & Rinderknecht, 2006). Tapirs have just been described for the Sopas Formation from several localities (Table 1), and were referred to *Tapirus terrestris* or *Tapirus* sp. on the basis of mandibles or fragmented skull remains (Ubilla 1996). A preliminary comparison allows us to differentiate the skull under study from the living species of tapirs, but more studies have to be done including the extinct species of tapirs of South America with comparable characters. It could be the same species recently described by Ferrero & Noriega (2007), *Tapirus mesopotamicus*, or can be a different taxon not yet described. Then, it is necessary to test the hypothesis that the new finding implies that two species of tapir inhabited this area in the late Pleistocene or it was only one species and consequently, the material described as *T. terrestris* should be revised.

#### Case-study 3

Carnivora (Felidae): cf. *Leopardus pardalis*, part of

the articulated postcranial including most of the ribs, distal end of right humerus and femur, pelvis, right tibia, right calcaneum and part of the metacarpus (FC-DPV-1889) (Malo Creek, Tacuarembó Department, Sopas Formation). In the Sopas Formation have been found the large cats *Puma concolor* and *Panthera onca* (Table 1, Ubilla *et al.*, 2004a). The material under study, reveals the presence of a felid intermediate in size between the small and large South American cats, slightly more robust than *Leopardus pardalis*. A preliminary comparison with postcranial bones, particularly the calcaneum, shows that this specimen is quite similar in shape to the small cats (including the ocelot), differing from the large *Puma concolor* and *Panthera onca*.

The following alternative hypothesis will be analysed in an ongoing work: a) the material belongs to the ocelot *Leopardus pardalis* and perhaps represents an extinguished subspecies or b) it is a new taxon of felid different from the small and large cats (but quite similar in size and shape to the ocelot), and not yet described. The corroboration of the presence of the ocelot in the Sopas Formation is important in terms of ecological sense. In the Recent, this species has a tropical and temperate distribution and despite having a wide geographic distribution is strongly associated to areas of dense vegetation (Murray & Gardner, 1997). In this sense, it is congruent with the presence in the Sopas Formation of vertebrates, which suggest some forested areas (Ubilla *et al.*, 2004a; Tambussi *et al.*, 2005).

Southern Uruguay

In the last years intensive fieldworks were performed in order to increase the knowledge of several sedimentological units outcropping in southern Uruguay. Indeed, in the Santa Lucía River basin and also in the coastal cliffs on the Colonia Department, diverse Pleistocene strata yield many different mammalian associations (Ubilla *et al.*, 2007a).

The following case studies will be particularly highlighted in this paper:

Case-study 1

Xenarthra (Cingulata, Pampatheriidae): *Pampatherium typum* (Gervais & Ameghino, 1880), it is represented by

an almost complete anterior shoulder with fixed scutes and part of the first mobile band (BRA-4-724) (Figure 3A-B). It was found in the Pilatos Creek, a tributary of the Santa Lucía River, upstream to the San Ramón town, Department of Canelones (Figure 1D) in the Dolores Formation (late Pleistocene).

Scillato-Yané *et al.* (2005) made a taxonomic review of Pleistocene pampatheres of South America mostly based on the morphology of the fixed and mobile scutes. These authors recognized two genera of pampatheres: *Holmesina* with three species and *Pampatherium* with two species. The material here described for the first time for Uruguay shares the key diagnostic characters used to define *Pampatherium typum* by Scillato-Yané *et al.* (2005). Indeed, the scapular shoulder and the first mobile band of scutes belong to a small specimen, and the fixed and mobile scutes have even surfaces with a flat central area lacking a central figure as in *Pampatherium typum* (Figure 3A-B)(Table 2).

Until now, the geographical distribution of *Pampatherium typum* encompasses Bolivia (Tarija and Ñapua), Brazil (Santa Catarina), Paraguay (Asunción) and Argentina (pampean region, Formosa, Corrientes) (Scillato-Yané *et al.*, 2005). Therefore, it is increased its geographic distribution to the southern Uruguay.

Table 2: Measurements (in mm) of scutes of mobile and fixed bands of *Pampatherium typum* (BRA-4-724).

	First mobile band scute	Last fixed band scute
Lenght	72.2	30.4
Width	34.7	25.2

*P. typum* ranges from the Ensenadan to Lujanian age and was living in both warm and cold climates in the pampean region. According to De Iuliis *et al.* (2000), it was a grazer particularly adapted to feed on hard vegetables. Perhaps, a more flexible diet could be expected taken into account that this species inhabited in varied environment under warm and cold climates (Scillato-Yané *et al.*, 2005). The remains here described were recovered from the Dolores Formation, a late Pleistocene unit, usually considered related to cold and arid climatic conditions associated to the last glacial maximum.

Case-study 2

Rodentia (Caviidae): *Dolichotis* cf. *D. patagonum*,

fragmented skull lacking the dorsal surface with right and left basal portion of zygomatic arches and the palatal region bearing both cheek-teeth (BRA-1); incomplete skull lacking the dorsal surface, with rostrum, diastema, basal portion of the right zygomatic arch and both upper molar rows without M3 (BRA-3-672) (Figure 3C-D). Both skulls were found at

the Pilatos Creek upstream of the San Ramón town, Canelones Department (Dolores Formation).

The dolichotine caviids are represented by several taxa in the Miocene and Pliocene, which deserve taxonomic revision (Ubilla & Rinderknecht, 2003). In the Pleistocene the diversity of this group was apparently lower. The material here described is quite

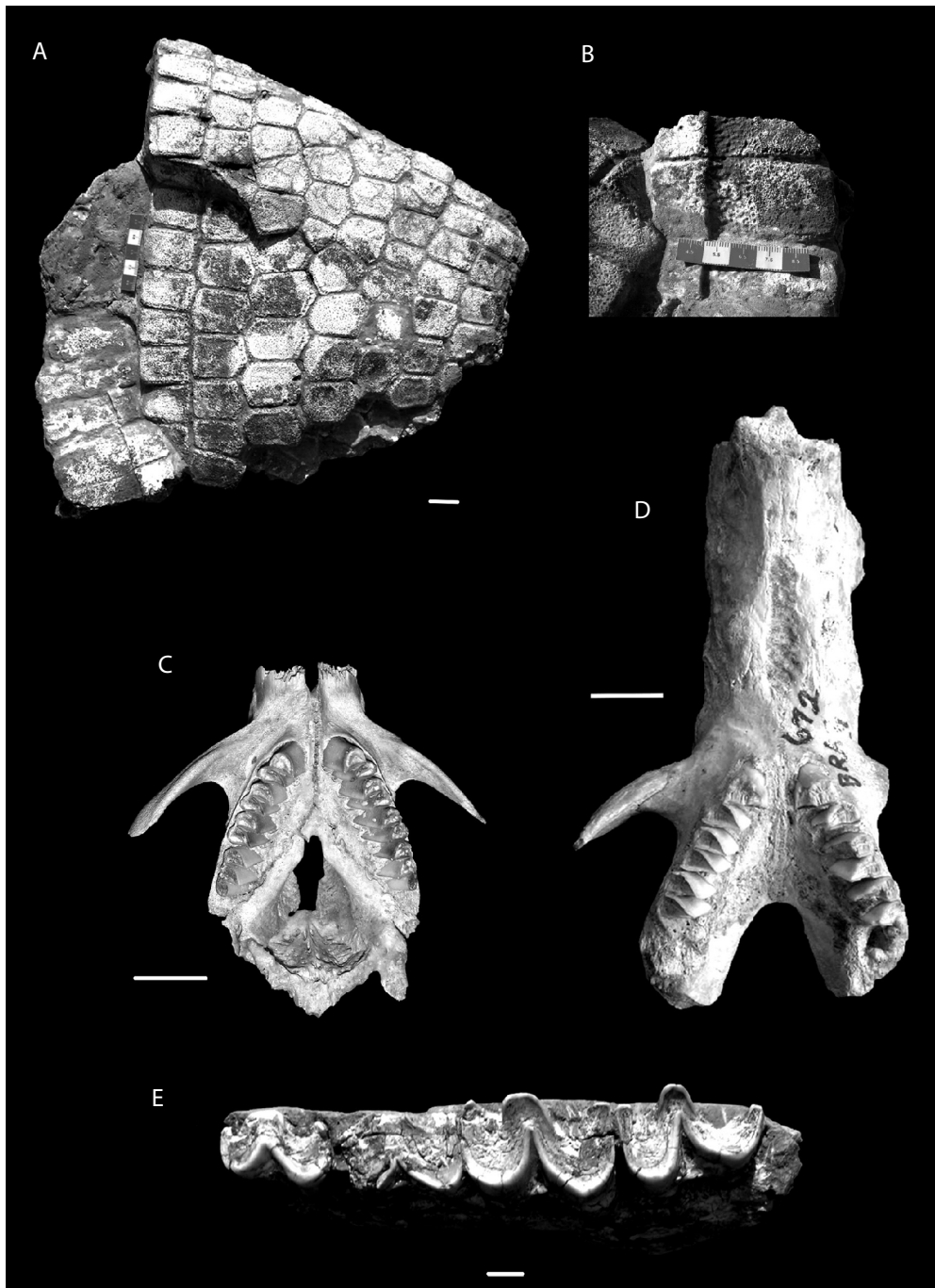


Figure 3. *Pampatherium typum*, BRA-4-724: A, anterior shoulder with fixed scutes; B, part of the first mobile band; *Dolichotis* cf. *D. patagonum*, fragmented skulls in palatal view: C, BRA-1 left; D, BRA-3-672 right; E, *Macrauchenia* cf. *M. patachonica*, BRA-380, left fragment mandible with p4-m3. Escalas: A, B = 2 cm, C-E = 1 cm.

Table 3. Measurements of the fossil dolichotines of the Dolores Formation determined as *Dolichotis* cf. *D. patagonum* and basic statistic of living species (taken from Ubilla & Rinderknecht, 2003); 1, palatal width; 2, diastema length; 3, P4-M3 length; 4, M3 length; 5, M3 width.

	<i>D. patagonum</i>					<i>D. salinicola</i>					Bra-1	Bra-3-672
	n	x	min	max	ds	n	x	min	max	ds		
1	41	33.6	25.8	38.2	2.35	28	20.4	16.4	22.6	1.47	27.9	34
2	41	41.4	31.8	46.6	3.27	27	24.4	18.8	29.2	2.82	-	38
3	41	25.6	20	30.1	2.34	23	16.5	13.1	19.3	1.68	20.3	-
4	37	9	6.9	10.5	0.92	24	5.9	3.9	7	0.93	6.3	-
5	37	5.4	3.9	8.9	0.82	23	3.3	2.1	4.4	0.62	3.7	-

similar in shape and size in cranial and dental measurements (palatal width, diastema length, P4-M3 length) with the living “mara” *Dolichotis patagonum*. Its living relative *Dolichotis salinicola* tends to be smaller and could be discharged (see Table 3 and Figure 4A-C). The preserved M3 has the same morphology of the two living species: the second internal fold is penetrating and possess cementum and the posterior border of the second prism and the anterior border of the additional posterior prism are parallels.

The mara lives today in southern cone of South America mostly adapted to arid and semiarid environments (desert, scrub, grasslands) and can tolerate cold climates (Mares & Ojeda, 1982; Campos *et al.*, 2001). But, it was living in the Buenos Aires region during the late Pleistocene (and also in the Holocene) providing an evidence that at least aridification predominates in this area in this time. Aridification would occurred in the pampean region as a consequence of the last glacial effect (Iriondo & Garcia, 1993; Tonni *et al.*, 1999). The presence of *Dolichotis patagonum* in the Dolores Formation indicates similar environmental conditions as is also suggested by the co-occurrence of *Microcavia* and *ChaetophRACTUS villosus* (Ubilla *et al.*, 2007a; Rego *et al.*, 2007). Its presence in southern Uruguay in the late Pleistocene could have been favoured by the fact that the Rio de La Plata estuary probable was extremely reduced due to a severe retraction of the sea level occurred during the last glacial maximum (Violante & Parker, 1999).

#### Case-study 3

Litopterna (Macrauchenidae): *Macrauchenia* cf. *M.*

*patachonica*: left fragment mandible with p4-m3 (BRA-780) (Table 4, Figure 3E) collected from the Dolores Formation at Aparicio Creek (Canelones Department) (Figure 1D). It is a characteristic Bonaerian-Lujanian ungulate mammal. The occlusal surface of molariforms and size are similar to *M. patachonica*. It is important to note that in the same strata were found several postcranial bones including femora, right tibia, atlas, axis and many vertebrae from a large macrauchenid quite similar to *M. patachonica*. In the Pleistocene strata of Uruguay, this peculiar ungulate is rare, a pattern that could be explained by the fact that its population might have been composed by a low number of individuals.

Table 4: Measurements of lower molariforms of *Macrauchenia* cf. *M. patachonica* (BRA-780).

	p4	m1	m2	m3
Length	32.4	33.7	40.6	39
Width	20.6	22.1	27.4	22.1

#### Case-study 4

Xenarthra (Mylodontidae): *Catonyx* sp. from Aparicio Creek, a tributary of the Santa Lucía River, 4 km downstream to the Town of San Ramón, Canelones Department (Dolores Formation) (Figure 1D). The skull and mandible (MAMC-18) are well preserved and almost complete. It was found closely associated to an articulated posterior body half of *Propaopus* sp. and remains of another mylodontid sloth, *Glossotherium* sp. This peculiar preservation is far from being explained due to the scarce evidence of the involved sedimentary processes.



This material represents the best specimen of a scelidotherine collected in Uruguay and could be a new species. Because of the porosity of some bones, and the well-marked bone sutures, the specimen seems to be a young adult.

It shows many features that characterize the genus *Catonyx*: inflated rostrum, very curved palate at the level of M2 (and consequent elevated mandibular symphysis), a stepped suture between premaxilla and maxilla, temporal ridges delimiting a concave surface on the parietals, and occipital condyles projecting ventrally (Perea *et al.*, 2006). Amazingly, it has three characters shared with *Scelidotherium* (sensu McDonald, 1987) which suggests an early separation of both genera and a revision of the diagnostic characters of both genera is necessary.

There are no species of *Catonyx* that matches with our material, but comparing it with the species *C. chiliensis* there is a superficial resemblance. The material is being in study by two of the authors (AC and DP).

#### Case-study 5

The “La Paz Local Fauna” (sensu Corona *et al.*, 2005; late Pleistocene): in the nearness of the Santa Lucía river (Las Piedras creek, Montevideo, southern Uruguay) (Figure 1E; 2E-F), the Libertad Formation (sensu Corona *et al.*, 2008) yields a peculiar assemblage of fossil vertebrates with mammals as predominant group.

The association includes mammals found in the late Pleistocene such as *Glyptodon* cf. *G. clavipes*, *Doedicurus* sp., *Panochthus* sp., *Neosclerocalyptus* sp., *Lestodon* sp., *Macrauchenia patachonica*, *Stegomastodon waringi*, *Toxodon platensis*, Pampatheriidae, *Ozotoceros* cf. *O. bezarticus*, *Hippidion* sp., Megatheriinae g. *et* sp. indet., *Myocastor* sp. (Marchesano *et al.*, 2002; Corona *et al.*, 2005). According to some taphonomic features it is likely that some kind of ecological mixture could be present in the fossiliferous assemblage. This fossil association, located in a quarry, is a bone-bed of lobular geometry of 50 m in horizontal length (Figure 2E-F). Most of the bones belong to large mammals and are disarticulated, fragmented and do not show a preferred orientation. In addition, some complete remains were also found as an skull of *Toxodon platensis*, and a mandible of *Stegomastodon waringi* described by Gutiérrez *et al.* (2005). This is the first record of this

species of gomphotheriid for Uruguay and implies a southern extension of its geographic distribution. It is available an AMS  $^{14}\text{C}$  of  $17,620 \pm 100$  years BP. made on enamel teeth of *Stegomastodon waringi* (Gutiérrez *et al.*, 2005).

It is quite intriguing that among the bone sample are frequently found large and huge bones particularly of *Lestodon* and *Glyptodon*, which are larger than the expected size for these taxa. The real cause of this pattern is still elusive.

Taphonomic attributes observed in all bones collected are under study such as orientation, disarticulation, abrasion, weathering, fragmentation

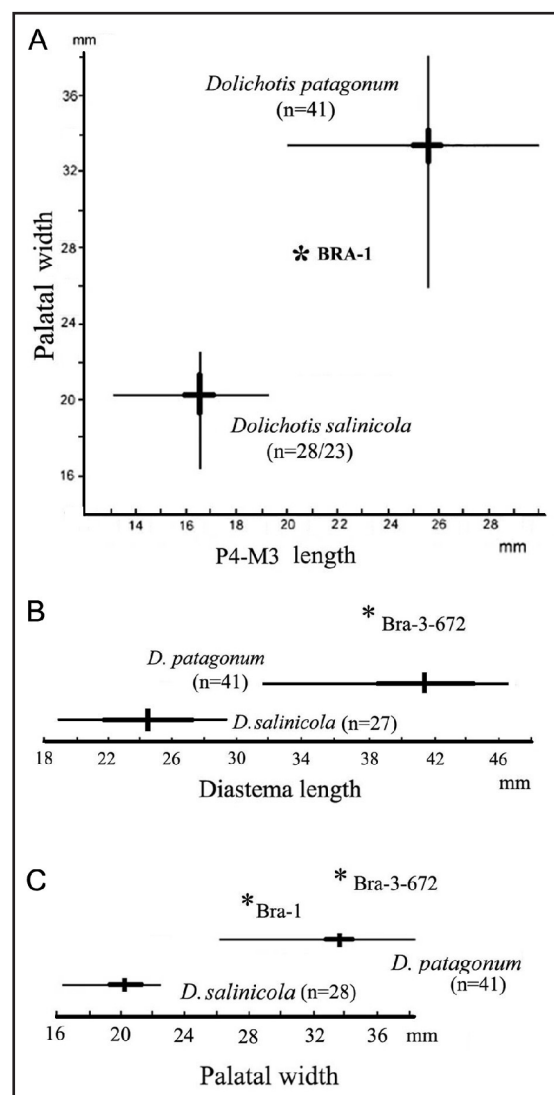


Figure 4. A, bivariate plot comparing palatal width and P4-M3 length for living dolichotines and the fossil material of the Dolores Formation; B,C, univariate diagrams comparing living dolichotines and the fossil material studied. Black bars represent the 95% confidence intervals around the mean.

and sorting (Corona *et al.*, 2007). The taphonomic information available, the sedimentological features observed and mineralogical studies performed suggest that the last depositional event had a high level of energy such a mud flow. Indeed, a high percentage of bones lost their osteological surface and a minor percentage lost their spongy bone, which suggest a relatively low time of subaerial exposition. The abrasion observed is very low and according to the Zingg diagram obtained the transport agent did no sort the bones. Moreover, the paraseftic nature of the sedimentary matrix (angulosity of clasts) indicates a high viscosity gravitational flux evidences by the contact between clasts and that the abrasive power of the flux was minimum. The smectita predominates on chlorite and sepiolite according to the X-ray diffraction performed on pelites which in addition to the presence of remobilization facies suggest different kind of sources such wind, weathering, etc.

#### Case-study 6

The “mammalian association of the El Caño locality”: the coastal cliffs (Libertad Formation?) of the El Caño are located 10 km westerly to Colonia city (Figure 1F), near to the homonymous creek and yield a rich pleistocene mammalian diversity. In the abrasion platform outcrop greenish mudstones, not well sorted with intercalation of sandy level and conglomerates. Skeletal remains show different preservational patterns since fragmented and complete bones usually disarticulated can be found (Figure 2D). A high energy fluvial depositional environment is suggested by some lithological features as coarse sandy levels and conglomerates along with taphonomic parameters such agglomeration of bones, broken and sandy abraded bones.

In the mammalian association predominates the large ground-sloth *Lestodon armatus* (60 to 70% of the total bones recovered). As it is represented by all the skeletal bones, with ribs and vertebrae the dominant bones, which could belong to many individuals, a minimum sorting effect is inferred. In addition, *Toxodon* sp., *Equus* (*A.*) sp. and the camelid *Hemiauchenia* sp. are well represented. There are also but less abundant glyptodonts as *Glyptodon clavipes*, *Panochthus*, *Doedicurus* and *Neuryurus*, armadillos as *Propraopus* sp., gomphotheriids as cf. *Stegomastodon* and

indetermined hystricognath rodents (Teisseire, 1928; Rinderknecht, 1999, 2006).

Overlaying this fossiliferous strata are brownish mudstones with calcium carbonates as duricrusts which yield the same mammalian taxa along with the litoptern *Macrauchenia* sp., a ground-sloth Scelidotheriinae indet., large carnivorans as *Felis* cf. *F. onca*, horses as *Hippidion* sp. and hystricognath rodents as *Lagostomus* sp., Ctenomyidae indet. and the extinct caviine *Galea ortodonta* (Calcaterra, 1972; Ubilla & Rinderknecht, 2001).

Even the mammalian fauna include some characteristic medium to late Pleistocene genera, it is necessary more fieldwork in order to increase the data set aside from geochronological information to better accurate the age of the bearing strata.

#### CONCLUDING REMARKS

The Sopas Formation widespread in northern Uruguay, particularly in the Artigas, Salto and Tacuarembó departments. It can be envisaged as a rich fossiliferous sedimentary unit according to the presence of several vertebrate groups (giant terrestrial turtles, lizards, some birds, terrestrial and fresh-water mammals), fresh-water and terrestrial molluscs, woods and continental ichnofossils (Ubilla, *et al.*, 2004a, Verde *et al.*, 2007).

This unit deserves more studies in terms of taxonomic and sedimentary analysis. It is necessary to be aware that the preservational pattern of its fossil content has differences among localities and could bring about preservational bias. As it was aforementioned, the Sopas Formation has been correlated with the Touro Passo Formation of southwestern Brazil. Nevertheless, the taxonomic correlation between both sedimentary units needs more detailed fieldwork in selected localities with more geochronological dates. A comprehensive analysis should be done taking in account not only the Touro Passo Formation but also another fossiliferous sedimentary strata of southern Brazil (see Ribeiro *et al.*, 2007 and references therein).

By the other hand, the knowledge of the fossil content of many lithological units of the Mesopotamian area of Argentina has been increased in last years (see Noriega & Ferrero, 2007; Tonni, 2007a, b). Though the mammalian association of the Sopas Formation is correlated to the Lujanian age of

the Buenos Aires Province, it yields some “brasílic” taxa, which differentiate it from those of the Guerrero Member of the Luján Formation. It is likely that the mammal assemblage of the Sopas Formation be more related to the mammals that inhabited the mesopotamian area or with those referred to the La Chumbiada Member of the Luján Formation. This hypothesis is far to be confirmed and it is necessary to perform a regional comparative analysis encompassing the southern brazilian and mesopotamic region.

In order to have a better comprehension of the paleoecological conditions it would be important to develop palynological analysis, ichnofacies and sedimentary studies as independent sources of data in the same fossiliferous outcrops.

The mammal assemblages of the Dolores Formation in southern Uruguay include some taxa mostly related with arid environments and that can tolerate cold climate, as occurred during the last glacial maximum at the pampean region. Some radiocarbonic ages obtained from selected localities of the Santa Lucía river basin range from 11,200 to 10,500 years BP. This information constitutes an important background to develop a more detailed faunistic analysis, in order to accurate the correlation with the typical lujanian mammal of the Guerrero Member of the Luján Formation of the Buenos Aires Province. Not less important is to take in account the oscillations of the Del Plata basin during the last glacial maximum, in order to explain the shared faunal occurrences between southern Uruguay and the pampean area.

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