

Late Pleistocene vertebrates from Touro Passo Creek (Touro Passo Formation), southern Brazil: a review

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² In memoriam.

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ABSTRACT

Touro Passo Creek is one of the most important fossiliferous late Pleistocene localities from southern Brazil. Although fossil vertebrates collected from this locality have been studied since the 1970s, several questions remain open. This paper provides a review of the knowledge on this subject accumulated since the original proposition of the Touro Passo Formation in 1976. The fossil assemblages of Touro Passo Creek show a predominance of mammals, and among them, artiodactyls and cingulates are the most diverse. The available absolute ages indicate that the fine-grained lithological levels (at least) were deposited during humid conditions of the Last Glacial Maximum, within oxygen isotope stages 3 and 2. The mammal assemblages contain a mixture of intertropical and pampean taxa. The large span of time that encompasses the deposition of the Touro Passo Creek beds could have contributed to this faunal mixture.

Key words: mammals; middle latitudes; *Tayassu pecari*; Quaternary; Rio Grande do Sul; Brazil.

RESUMEN

El Arroyo Touro Passo es una de las más importantes localidades con fósiles pleistocénicos del sur de Brasil. Aunque los vertebrados colectados en esta localidad han sido estudiados desde la década de 1970, varias preguntas siguen abiertas. En este trabajo se presenta una revisión del conocimiento acumulado desde la proposición original de la Formación Touro Passo en 1976. Las asociaciones fosilíferas contienen una predominancia de fósiles de mamíferos, y entre estos, los artiodáctilos y cingulados son los más diversos. Las edades absolutas muestran que los niveles litológicos de grano fino (por lo menos) se depositaron durante condiciones más húmedas, en los estadios isotópicos 3 y 2. Los vertebrados muestran una mezcla de afinidades entre taxones de afinidad pampeana e intertropical. El largo intervalo de tiempo en que se depositaron los

estratos del Arroyo Touro Passo pudo haber contribuido a esta mezcla de fauna.

*Palabras clave: mamíferos; latitudes medias; *Tayassu pecari*; Pleistoceno tardío; Cuaternario; Rio Grande do Sul; Brasil.*

INTRODUCTION

The study of the fossil vertebrates from Touro Passo Creek (TPC) (western region of the State of Rio Grande do Sul, southern Brazil) is very recent when compared with other late Pleistocene localities from South America. The historical background of this research is marked by two periods: the first, during the 1970s and the second during the 1990s up to the present day, when new fieldwork efforts began.

The first fieldwork trips to TPC had financial support from the Smithsonian Institute, USA, and FAPERGS-RS, Brazil, during the "Paleo-Indian Research Project," headed by the archeologist Eurico Theófilo Miller, who conducted several expeditions into the western region of the State of Rio Grande do Sul (see Milder, 2000) with the objective of collecting archaeological evidence of the oldest human populations from southern Brazil. The fossils collected on these expeditions were studied by the paleontologist Miguel Bombin with assistance of Carlos de Paula Couto and first mentioned in Bombin (1976), which formally defined the Touro Passo Formation. In that paper, the author presented only a checklist, without additional studies of these fossils (e.g., collection number, morphological descriptions, taxonomic and systematic relationships, and stratigraphic provenance). The main goal of Bombin (1976) was to propose geological and paleoenvironmental interpretations for the Touro Passo Formation.

After this first approach, the knowledge about the vertebrate fauna of TPC did not advance until the early 1990s when a study conducted by Oliveira (1992) summarized the research on the fossiliferous localities of the TPC. Subsequently, several papers have been published on the fossil vertebrates collected along this creek (e.g., Oliveira, 1996, 1999;

Oliveira *et al.*, 1999; Martins and Oliveira, 2003; Pitana and Ribeiro, 2007; Scherer *et al.*, 2007, 2009; Hsiou, 2007, 2009; Kerber and Oliveira, 2008a,b; Oliveira and Kerber, 2009; Gasparini *et al.*, 2009; Ribeiro and Scherer, 2009; Pitana, 2011; Kerber and Ribeiro, 2011; Kerber *et al.* 2011a, 2011b, in press; Pitana *et al.*, 2013).

It has been proposed that the southern Brazilian (South American middle-latitude) late Pleistocene fauna is from a transitional area with intertropical (*sensu* Cartelle, 1999) and pampean (Cione and Tonni, 1999) paleobiogeographic influences (*e.g.*, Oliveira, 1999 among several others). Hence, the correct identification of the material is very important for the understanding of these paleobiogeographic patterns. Today, almost 40 years after the original description of this formation in 1976 by Miguel Bombin, we provide a historical review of the fossil vertebrates from this geologic unit, including new remains, and a discussion about the paleobiogeographic and paleoenvironmental patterns.

INSTITUTIONAL ABBREVIATIONS

MCN-PV, paleovertebrates collection, Museu de Ciências Naturais da Fundação Zoobotânica do Rio Grande do Sul, Porto Alegre; MCPU-PV, paleovertebrates collection, Museu de Ciências da Pontifícia Universidade Católica do Rio Grande do Sul, Uruguaiana; MCP, paleo-

vertebrates collection, Museu de Ciências da Pontifícia Universidade Católica do Rio Grande do Sul, Porto Alegre; UFSM, paleovertebrates collection, Universidade Federal de Santa Maria, Santa Maria.

GEOLOGICAL SETTING

The Touro Passo Creek is located in Uruguaiana, State of Rio Grande do Sul, southern Brazil, near to the border with Uruguay and Argentina (Figure 1). This creek is a tributary of the Uruguay River basin and late Pleistocene lithologies are exposed along its margins. Most of the late Pleistocene strata are currently covered by vegetation, so the fossiliferous levels are only exposed in some areas. To date, we are studying six localities where the fossils are more abundant (Figure 1, Appendix A).

The lithofacies are represented by conglomeratic facies overlapped by silt and sand levels, both deposited on the basalts of the Serra Geral Formation (Figure 2). Carbonate nodules that represent post-depositional pedogenesis (Bombin, 1976) are found within the sandy and silty strata, but it is not clear yet when they were formed.

The available radiometric dates obtained by thermoluminescence (TL) (sediments), ^{14}C (charcoal), accelerator mass spectrometry (AMS) (mollusks) and electron spin resonance (ESR) (fossil teeth) range from ~42 to ~10 ka BP (Bombin, 1976; Miller, 1987; Milder, 2000; Da-Rosa,

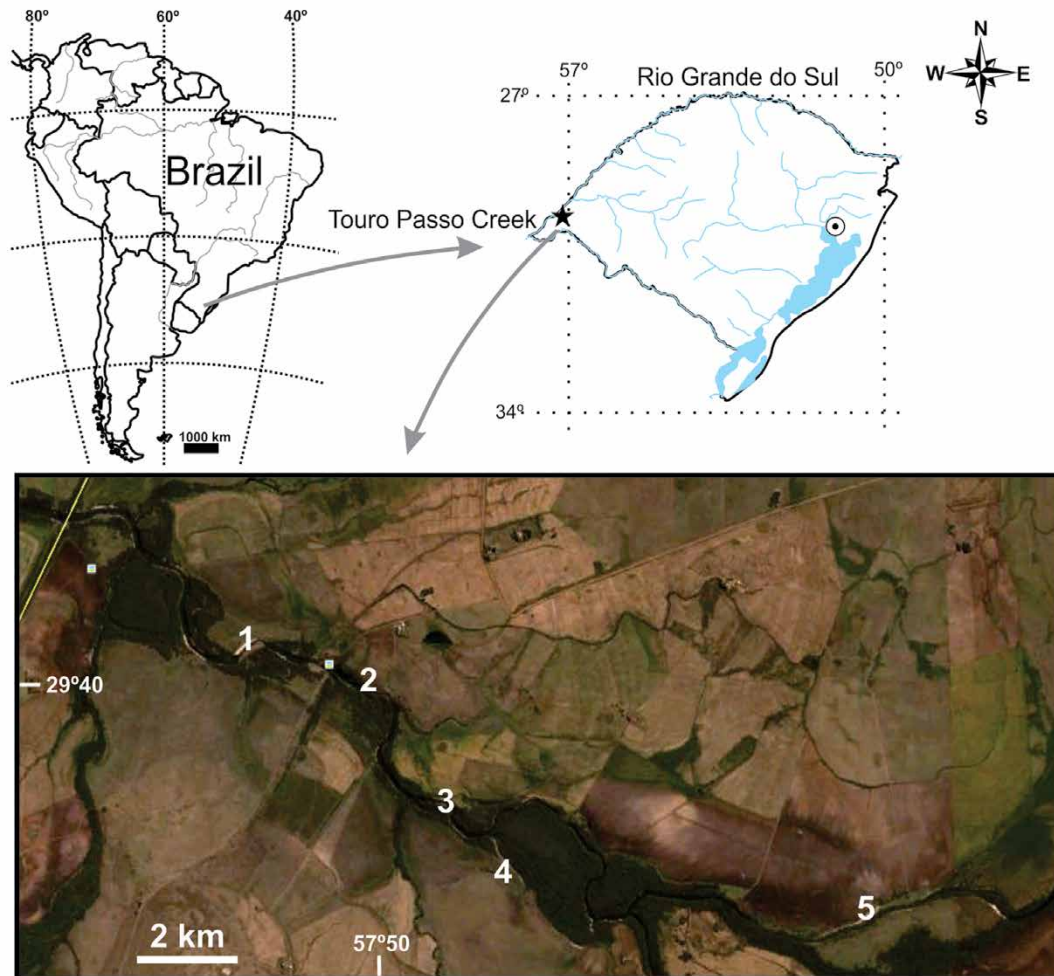


Figure 1. Location of Touro Passo Creek and the studied sites: 1. Ponte Velha II; 2. Ponte Velha I; 3. Milton Almeida; 4. Barranca Grande; 5. *Myocastor*. Source of the satellite image: Google Earth, March, 11, 2013.

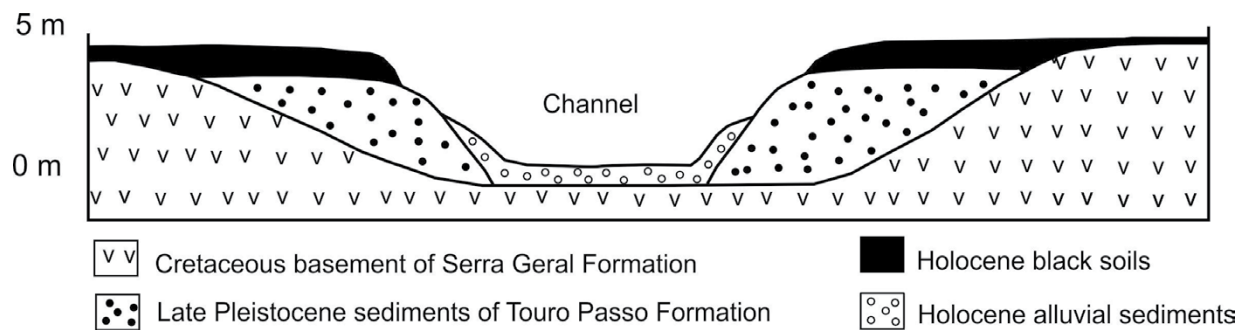


Figure 2. Schematic transversal section of Touro Passo Creek. See stratigraphic profiles in Oliveira and Kerber (2009) and Kerber and Ribeiro (2011).

2003; Kotzian *et al.*, 2005, Kerber *et al.*, 2011b), and therefore indicate a latest Pleistocene age (Table 1). The first studies considered the Touro Passo Formation as late Pleistocene–Holocene (*e.g.*, Bombin, 1976; Oliveira, 1992), but with the increase in absolute ages from this unit, the Touro Passo Formation is now considered exclusively from the latest Pleistocene (Oliveira, 1999). Holocene sedimentary levels (including the so-called “black soils” with an age of ~5 ka; Da-Rosa, 2003) found in TPC (without vertebrate remains) should be considered as a different geologic unit, but this discussion is beyond the scope of this paper.

The fossil vertebrates from TPC are found isolated or semi-articulated in the silt and sand levels (rarely), with absence of features of time-averaging. These fossils show intense carbonate incrustation. These levels correspond to the Lamítico Member of Bombin (1976). Fossils collected from the conglomeratic levels (Rudaceo Member of Bombin, 1976), originated in channels or point bars, are very fragmented, with features of reworking (abrasion and flat surfaces), and without carbonate incrustation.

SYSTEMATIC PALEONTOLOGY

Mammalia Linnaeus, 1758
 Xenarthra Cope, 1889
 Folivora Delsuc *et al.*, 2001
 Mylodontidae Gill, 1872

Material. MCPU-PV 032, Kerber and Oliveira (2008a).

Remarks. Osteoderms of an indeterminate mylodontid were reported from the Barranca Grande locality (Kerber and Oliveira, 2008a). These remains were attributed tentatively to this taxon because they are smaller in size compared to the osteoderms of Megatheriidae (Cartelle and Bohórquez, 1986).

Glossotherium robustum (Owen, 1842)

Material. MCN-PV 1452, MCN-PV 1950, MCN-PV 1482, Pitana *et al.* (2013).

Remarks. Bombin (1976) reported *Glossotherium robustum* from the Touro Passo Formation in his checklist. Subsequently, Oliveira (1992) described the specimen MCN-PV 1482 (incomplete right tibia) and assigned it to Mylodontidae gen. et sp. indet., because it is morphologically similar to *Glossotherium* Owen, 1839a and *Myloodon* Owen, 1840. However, the same specimen was reviewed by Pitana (2011) and attributed to *Glossotherium* aff. *robustum*. The specimen MCN-PV 1950 (an incomplete dentary) was described by Pitana (2011) and also assigned to *Glossotherium* aff. *robustum*; and a further comparative study confirmed that this material belongs to *G. robustum* (Pitana

et al., 2013). Therefore, the presence of *G. robustum* in another late Pleistocene locality of southern Brazil is confirmed on the basis of mandibular and postcranial remains (Pitana *et al.*, 2013).

Megatheriidae Gray, 1821

Material. The only record of a megatheriid from TPC was proposed by Oliveira *et al.* (1999), on the basis of a tooth fragment that cannot be assigned to a genus or species. However, this material is currently lost.

Glyptodontidae Gray, 1869 *Glyptodon* Owen, 1839b

Material. MCPU-PV 101, MCPU-PV 158, MCPU-PV 056, Kerber and Oliveira (2008a); MCN-PV 1441, MCN-PV 1442, Oliveira (1992, 1996).

Remarks. Glyptodonts from TPC have been described mostly on the basis of isolated osteoderms. The most complete material of Glyptodontidae was a carapace collected by M. Bombin in the 1970s (Bombin, 1976); however, this material is currently lost. *Glyptodon* sp., *Glyptodon clavipes* Owen, 1839b, *Glyptodon* aff. *clavipes*, *Glyptodon* aff. *reticulatus* Owen 1845, and *Glyptodon* cf. *G. reticulatus* have been, to date, reported from TPC (Bombin, 1976; Oliveira, 1992, 1996; Kerber and Oliveira, 2008a). On the basis of a few osteoderms from the Barranca Grande locality, *Neothoracophorus* Ameghino, 1889 (MCPU-PV 224, MCPU-PV 136, MCN-PV 1485) was reported by Oliveira (1992) and subsequently by Kerber and Oliveira (2008a). However, the taxonomic validity of this genus was questioned by Zurita

Table 1. Radiometric dating of Touro Passo Creek, (TPC); ages in years BP, except for ESR ages (ka BP). TL: thermoluminescence; AMS: accelerator mass spectrometry; ESR: electron spin resonance.

Dating	Method	Sample	Reference
11,010 ± 190	¹⁴ C	wood	Bombin (1976)
10,810 ± 275	¹⁴ C	charcoal	Miller (1987)
42,600	TL	sediment	Milder (2000); Da-Rosa, (2003)
15,400	TL	sediment	Milder (2000); Da-Rosa, (2003)
16,327	TL	sediment	Milder (2000); Da-Rosa, (2003)
15,970 ± 90	AMS	mollusk	Kotzian <i>et al.</i> (2005)
16,650 ± 203	AMS	mollusk	Kotzian <i>et al.</i> (2005)
34 ± 6	ESR	mammal tooth	Kerber <i>et al.</i> (2011b)
19 ± 3	ESR	mammal tooth	Kerber <i>et al.</i> (2011b)
23 ± 5	ESR	mammal tooth	Kerber <i>et al.</i> (2011b)
28 ± 3	ESR	mammal tooth	Kerber <i>et al.</i> (2011b)

et al. (2009), because the first description of this taxon provided by Ameghino (1889) was based on the size of osteoderms (smaller than other glyptodonts, such as *Glyptodon* and *Panochthus* Burmeister, 1866), a flat surface and an elevated central figure, characters observed in juvenile specimens of *Glyptodon*. Hence, a review of the specimens referred to “*Neothoracophorus*” from TPC should be carried out.

As mentioned above, the taxonomic identification of glyptodonts from TPC is based exclusively on a few osteoderms (Figure 3a). Zurita *et al.* (2012) stated that most of the taxonomic assignments of *Glyptodon* specimens to the specific level were carried out on the basis of isolated or fragmentary remains of carapaces. These structures are quite variable and do not allow an accurate taxonomic identification. In addition, Oliveira *et al.* (2010) reviewed the material of *Glyptodon clavipes* from northern and northeastern regions of Brazil and concluded that these remains, in fact, belong to the genus *Glyptotherium* Osborn, 1913. Thus, to avoid major errors in paleobiogeographic, biochronologic and biostratigraphic interpretations, we are using *Glyptodon* sp. for the specimens previously reported until new material is collected.

Panochthus Burmeister, 1866

Material. MCN-PV 1443, Oliveira (1996); MCPU-PV 059, Kerber and Oliveira (2008a).

Remarks. The scarce material belonging to *Panochthus* sp. in TPC is represented by a few isolated osteoderms, which revealed external surface with several tubercles and absence of a central figure, typical morphology of *Panochthus* (Oliveira, 1996; Kerber and Oliveira, 2008a). *Panochthus tuberculatus* (Owen, 1845) was the only species reported from southern Brazilian Pleistocene beds (*e.g.*, Paula Couto, 1943; Paula Couto and Souza Cunha, 1965; Bombin, 1976; Ribeiro and Scherer, 2009). However, recently Santos (2014) reported the presence of *Panochthus* cf. *P. greslebini* Castellanos, 1942 for the continental shelf of southern Brazil. *Panochthus greslebini* was also reported for the late Pleistocene of northern Argentina, at similar latitude to that of Rio Grande do Sul (Chimento and Agnolin, 2011)

Pampatheriidae Paula Couto, 1954

Pampatherium Ameghino, 1875 and *Holmesina* Simpson, 1930

Material. *Holmesina paulacoutoi*: MCPU-PV 036, Kerber and Oliveira (2008a); *P. typum*: MCPU-PV 080; MCPU-PV 157, MCPU-PV 1461 1-6, Kerber and Oliveira (2008a); *Pampatherium* sp.: MCN-PV 1444, MCN-PV 1445, MCN-PV 1446, MCN-PV 1447, MCN-PV 1467, MCN-PV 1480, Oliveira (1996).

Remarks. *Pampatherium* was first reported by Oliveira (1996) and subsequently Kerber and Oliveira (2008a) reported *Pampatherium typum* (Gervais and Ameghino, 1880) (Figure 3b) and *Holmesina paulacoutoi* (Cartelle and Bohórquez, 1984). Both taxa were identified on the basis of isolated osteoderms.

Dasypodidae Gray, 1821

Propraopus sulcatus (Lund, 1842)

Material. *Propraopus* sp.: MCPU-PV 230, Kerber and Oliveira (2008a); *Propraopus grandis*: MCN-PV 147, Pitana and Ribeiro (2007); *Propraopus* aff. *sulcatus*: MCPU-PV 024; MCPU-PV 135, Oliveira and Pereira (2009).

Remarks. *Propraopus grandis* was reported by Oliveira (1996) and Pitana and Ribeiro (2007). Subsequently, Oliveira and Pereira (2009) described osteoderms as *P.* aff. *sulcatus*, which, however, were previously assigned to *P. grandis*. Recently, *P. grandis* was considered a synonym of *P. sulcatus* by Castro *et al.* (2013).

Carnivora Bowdich 1821

Material. MCPU-PV 138 (Canidae indet.); MCPU-PV 141 (Coprolite), Kerber and Oliveira (2008a).

Remarks. Carnivores from TPC are very scarce, with few fossils represented by a fragmented tooth assigned to Canidae indet. and a coprolite tentatively attributed to a large carnivore by Kerber and Oliveira (2008a).

Cetartiodactyla Montgelard, Catzeflis and Douzery, 1997

Tayassuidae Palmer, 1897

Catagonus stenocephalus (Lund in Reinhardt, 1880) and

Tayassu pecari (Link, 1795)

Material. *Catagonus stenocephalus*: MCPU-PV 029, Gasparini *et al.* (2009); *Tayassu* sp.: MCN-PV 1425, Oliveira (1992); *Tayassu pecari*: MCN-PV 30107.

New remains. New remains of semi-articulated tayassuid were collected during an expedition in 2009 (Figure 4, Table 2). These remains are represented by a left dentary, with the p2–m3 series plus the canine, a left humerus, a scapula, the head of a femur, two articulated lumbar vertebrae, a sacral vertebra, a fragment of pelvic girdle and other fragmented bones. The specimen is a senile individual, because the occlusal surface of the cheek teeth shows advanced wear and extrusion signs are seen in labial view. These remains were assigned to *Tayassu pecari* on the basis of a p2 with reduced anterocingulum and p4 with subrectangular outline (Gasparini and Zurita, 2005; Gasparini *et al.*, 2011).

Remarks. Three genera of tayassuids are reported from South America: *Platygonus* Le Conte, 1848, *Catagonus* Ameghino, 1904 and *Tayassu* Fisher, 1814; only the last two genera have extant species (Gasparini, 2011). The new material confirms the presence of *T. pecari* in TPC, previously reported by Bombin (1976). In addition to this record, Oliveira (1992) reported a fragment of a dentary of *Tayassu* sp. (Figure 3d). Another interesting specimen of a tayassuid was previously attributed to the “*Catagonus* group” and subsequently to *Tayassu* sp. (Martins and Oliveira, 2003; Oliveira, 1999). Recently, Gasparini *et al.* (2009) attributed it to *Catagonus stenocephalus* (Figure 3c). Noteworthy, Gasparini *et al.* (2012) reported the presence of *Catagonus wagneri* (Rusconi, 1930) in sediments of the Sopas Formation, northern Uruguay.

Camelidae Gray, 1821

Hemiauchenia paradoxa Gervais and Ameghino, 1880,

Lama (*Vicugna*) aff. *L. (V.) gracilis* (Gervais and Ameghino, 1880)

Lama guanicoe (Müller, 1776)

Material. *paradoxa*: MCN-PV 1465, MCN-PV 1471, MCN-PV 1474 Oliveira (1992); MCN-PV 1471, MCN-PV 2077, MCN-PV 6946, MCN-PV 1465, MCN-PV 1474b, MCN-PV 1474a, MCN-PV 2159, 6947, MCN-PV 2164a–d, MCN-PV 7927, MCN-PV 1973, MCN-PV 2088, MCN-PV 3334, MCN-PV 1975b, 2082b, MCN-PV 3359, UFSM 11325, MCN-PV 2258a–f, MCN-PV 1975a, 2082a, MCN-PV 3278, MCN-PV 2258g, MCN-PV 1975c, MCN-PV 3309, MCN-PV 1975d, MCN-PV 2079, Scherer *et al.* (2007); MCPU-PV 039, MCPU-PV 155, Kerber and Oliveira (2008a).

Remarks. Camelid remains are the most common fossils from TPC. Recent reviews reported the presence of *Hemiauchenia paradoxa*, *Lama guanicoe* and *Lama* (*Vicugna*) aff. *L. (V.) gracilis* (Gervais and Ameghino, 1880) in several late Pleistocene localities from Rio Grande do Sul, including the TPC deposits (Scherer, 2006; Scherer *et al.*, 2007). The material attributed to these taxa is composed of dental and postcranial remains. In addition, Kerber and Oliveira (2008a) reported a palatal region with the cheek teeth and a dentary attributed to *H. paradoxa* (Figures 3e, 3f).

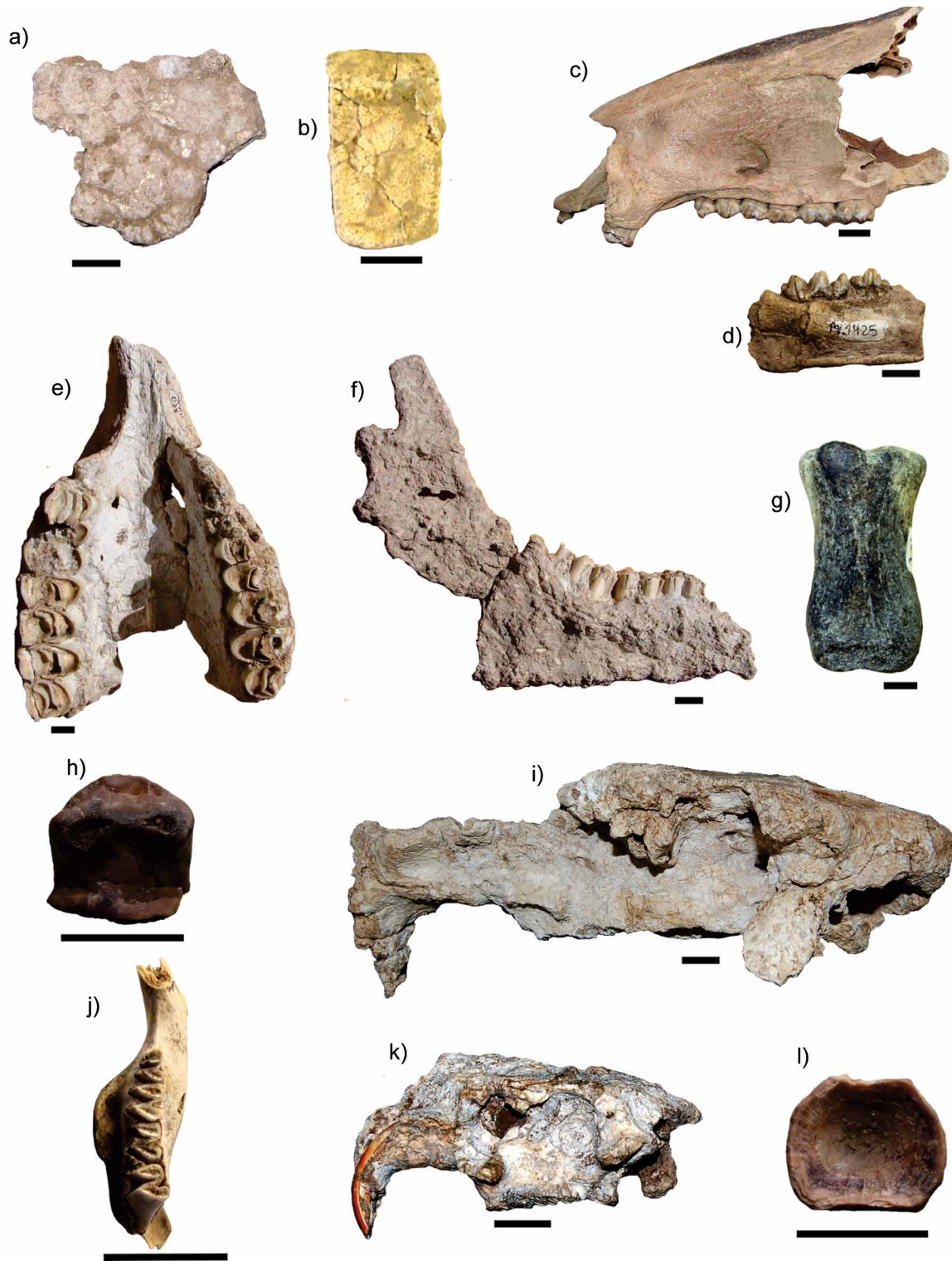


Figure 3. Fossil vertebrates from Touro Passo Creek. a) Osteoderm of *Glyptodon* sp. (without number), in external view; b) osteoderm of *Pampatherium typum* (MCPU-PV 1461-3), in external view; c) skull of *Catagonus stenocephalus* (MCPU-PV 029), in lateral view; d) left dentary of *Tayassu* sp. (MCN-PV 1425), in medial view; e) palatal portion of *Hemiauchenia paradoxa* (MCPU-PV 039), in palatal view; f) right dentary of *Hemiauchenia paradoxa* (MCPU-PV 155), in lateral view; g) first phalange of *Equus* (A.) *neogaeus* (MCPU-PV 208), in anterior view; h) fragment of lower tooth of *Tapirus* sp. (MCPU-PV 222) in occlusal view; i) skull of *Hydrochoerus hydrochaeris* (MCPU-PV 047), in lateral view; j) left dentary of *Galea* sp. (MCPU-PV 221), in occlusal view; k) skull of *Myocastor coypus* (MCN-PV 9712), in lateral view; l) vertebra of *Osteichthyes* indet. (MCPU-PV 160). Scale bars: 10 mm. Sources: Kerber and Oliveira (2008a, 2008b); Gasparini et al. (2009); Kerber et al. (2011a, in press).

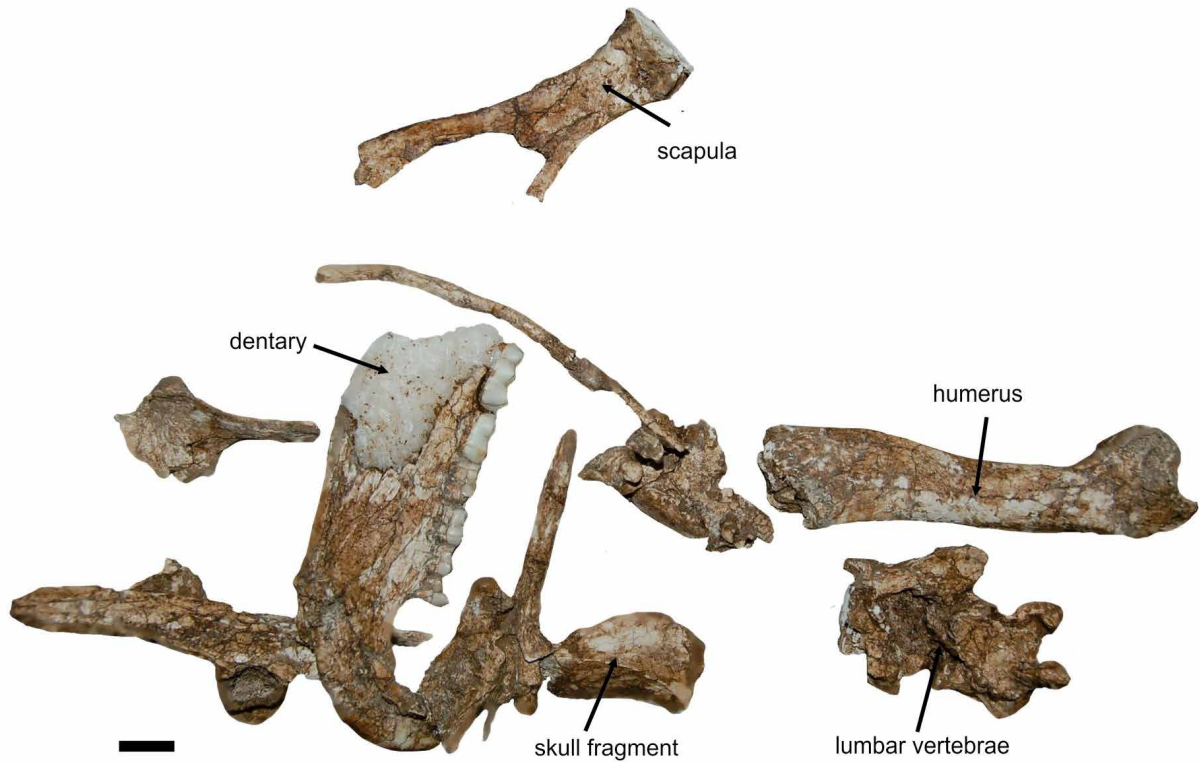


Figure 4. Remains of *Tayassu pecari* (MCN-PV 30107) from Touro Passo Creek as they were collected at the *Myocastor* locality. Scale bar: 20 mm.

Cervidae Gray, 1821

Antifer Ameghino, 1889 and *Morenelaphus* Carette, 1922

Material. *Antifer* sp.: MCPU-PV 212, MCPU-PV 223, Kerber and Oliveira, (2008a); MCN-PV 1458, Oliveira (1992); MCN-PV 943, MCN-PV 944, Ribeiro and Scherer (2009); *Morenelaphus* sp.: MCPU-PV 059, Kerber and Oliveira (2008a).

Remarks. Bombin (1976) mentioned the presence of *Blastocerus dichotomus* Illiger, 1815, *Mazama gouazoupira* Fischer, 1814, *Ozotoceros bezoarticus* Linnaeus, 1758 and *Morenelaphus brachyceros* (Ameghino, 1888). With the exception of *Morenelaphus*, the presence of the other taxa was not confirmed. Oliveira (1992) reported *Blastocerus* sp., however, Scherer *et al.* (2007) assigned to *Antifer* sp. the specimen referred by Oliveira (1992). Subsequently, Kerber and Oliveira (2008a) reported new remains of *Morenelaphus* sp. and *Antifer* sp. The more complete material is a cranial portion with both horns preserved assigned to *Antifer* sp. (see fig. 2A in Ribeiro and Scherer, 2009).

Perissodactyla Owen, 1848

Equidae Gray, 1821

Equus (*A.*) *neogaeus* Lund, 1841 and *Hippidion* Owen, 1869

Material. *E. (A.) neogaeus*: MCPU-PV 208, MCPU-PV 213, Kerber and Oliveira (2008a); MCN-PV 1461, MCN-PV 1463, MCN-PV 2052, MCN-PV 2053, Ribeiro and Scherer (2009). *Hippidion* sp.: MCN-PV 1460, Oliveira (1992); MCPU-PV 054, Kerber and Oliveira (2008a).

Remarks. The specimens of equids from TPC were mentioned by Oliveira (1992), who reported a molariform of *Hippidion* sp. Subsequently, Kerber and Oliveira (2008a) reported a tarsal and a first phalange (Figure 3g) attributed to *E. (A.) neogaeus* and a distal pha-

lange assigned to *Hippidion* sp. Ribeiro and Scherer (2009) mentioned three teeth of *E. (A.) neogaeus* (see fig. 2D, 2E and 2F in Ribeiro and Scherer, 2009).

Tapiridae Gray, 1821

Tapirus Brisson, 1762

Tapirus sp.

Material. MCPU-PV 222, Kerber and Oliveira (2008b).

Remarks. Bombin (1976) mentioned *T. terrestris* (Linnaeus, 1758). Subsequently, Kerber and Oliveira (2008b) described a single fragment of a lower tooth assigned to *Tapirus* sp. These authors suggested that this tooth may display a more plesiomorphic pattern than that of the living *Tapirus terrestris*. However, due to the fragmentary state of this material, there are no satisfactory arguments for this interpretation.

Notoungulata Roth, 1903

Toxodontidae Owen, 1845

Toxodon Owen, 1837

Toxodon sp.

Material. MCPU-PV 040, Kerber and Oliveira (2008a).

Remarks. The published information on *Toxodon* from TPC is scarce. Bombin (1976) listed *Toxodon platensis* Owen, 1837 and subsequently Kerber and Oliveira (2008a) reported an isolated tooth from the Ponte Velha I locality assigned to *Toxodon* sp. The only toxodontid reported for southern Brazil is *T. platensis* (Paula Couto, 1943; Lopes *et al.*, 2001); but in geographic areas next to Rio Grande do Sul, such as the Mesopotamian region and northern Argentina, *T. gracilis* Gervais and Ameghino, 1880 is also recorded (Miño-Boilini *et al.*, 2006; Ferrero, 2009; Ferrero and Noriega, 2009).

Litopterna, Ameghino, 1889
 Macraucheniiidae Gervais, 1855
Macrauchenia patachonica Owen, 1837

Material. MCN-PV 2160, Scherer et al. (2009).

Remarks. Material assigned to *M. patachonica*, represented by a single thoracic vertebra, was recently reported by Scherer et al. (2009). Specimens from Rio Grande do Sul are the only material assigned to *M. patachonica* in Brazil. Macraucheniiids from the intertropical region are assigned to *Xenorhinotherium bahiense* Cartelle and Lessa, 1988, which is probably closely related to *Macrauchenioipsis* Paula Couto, 1945 from Argentina (Cartelle and Lessa, 1988).

Proboscidea Illiger, 1811
 Gomphotheriidae indet.

Remarks. Bombin (1976) referred to the presence of *Notiomastodon platensis* (Ameghino, 1888) in TPC; however, in the review of southern Brazilian proboscideans, Marcon (2008) did not recognize its presence in TPC. Nevertheless, Kerber et al. (2011a) used some teeth fragments of indeterminate Gomphotheriidae in an ESR analysis. Paula Couto (1943) mentioned fossils of mastodonts from Uruguaiana Municipality; however, the exact provenance of this material was not given.

Rodentia Bowdich, 1821
 Hydrochoeridae (Gray, 1825) Gill, 1872
Hydrochoerus hydrochaeris (Linnaeus, 1766)

Material. MCPU-PV 047, MCPU-PV 043, MCN-PV 2072, MCN-PV 9572, MCN-PV 9573, MCN-PV 9574, MCN-PV 1978, MCN-PV 2088, Kerber and Ribeiro (2011); MCP-3076 V, Oliveira (1992).

Remarks. This taxon was first referred by Bombin (1976). Later, Oliveira (1992) reported a palatal portion attributed to this taxon. Kerber and Ribeiro (2011) described two skulls (Figure 3i), a dentary, isolated teeth and a fragment of a femur.

Caviidae Fischer de Waldheim, 1817
Galea Meyen, 1832
Galea sp.

Material. MCPU-PV 221, Kerber et al. (2011a).

Remarks. Material of this taxon, described by Kerber et al. (2011a), is represented by a single dentary with complete cheek teeth (Figure 3 j).

Table 2. Measurements of the lower cheek teeth of *Tayassu pecari* (MCN-PV 30107) from Touro Passo Creek. MD: mesiodistal length. LL: linguolabial width.

Measurement	MCN-PV 30107
MD p2	8.52
LWp2	4.88
MD p3	10.30
LW p3	6.34
MD p4	12.19
LW p4	9.46
MD m1	14.81
LW m1	-----
MD m2	16.96
LW m2	-----
MD m3	24.07
LW m3	14.13

Echimyidae Gray, 1825
Myocastor Kerr, 1792
Myocastor coypus (Molina, 1782)

Material. MCN-PV 9712, Kerber et al. (in press).

Remarks. This taxon is represented by a skull recently collected from the “*Myocastor*” locality (Kerber et al., in press) (Figure K).

Squamata Opper, 1811,
 Teiioidea Estes, de Queiroz and Gauthier, 1988
 Teiidae Gray, 1827
 Tupinambinae Presch, 1974
Tupinambis uruguaiensis Hsiou, 2007

Material. MCN-PV 2184 (holotype), Hsiou (2007).

Remarks. This lizard was the first extinct squamate described from the late Pleistocene of southern Brazil (Hsiou, 2007). According to Hsiou (2007), *Tupinambis uruguaiensis* is distinguished from other species of *Tupinambis* in having an articular bone with a deeply concave ventral margin, an angular process more rounded, proportionally larger and projecting beyond the ventral and posterior adjacent limits, and a very prominent adductor crest, so that the articular bone surface is lateroventrally directed. Recently, Scanferla et al. (2009) questioned the validity of this extinct teiid lizard because *T. uruguaiensis* shows several similarities to the extant lizards *T. merianae* Linnaeus, 1758 and *T. rufescens* (Günther, 1871). Thus, Brizuela (2010) conducted a phylogenetic analysis of South American teiids and suggested a review of the taxonomic and systematic affinities of *T. uruguaiensis*, testing the possibility that this lizard from the Touro Passo Formation represents a large *Tupinambis merianae*.

Pleurodira Cope, 1864
 Eupleurodira Gaffney and Meylan, 1988 (sensu
 Gaffney, Tong and Meylan, 2006)
 Cheloides Gray, 1825
 Chelidae Gray, 1825
Hydromedusa Wagler, 1830
Hydromedusa tectifera Cope, 1869

Material. MCN-PV 1847, MCN-PV 1848, Hsiou (2009).

Remarks. First reported by Bombin (1976), the material of *Hydromedusa tectifera* from TPC was not described or included in a comparative study. However, according to Maciel et al. (1996) and Hsiou (2009), these specimens can be attributed to this taxon.

Aves Linnaeus, 1758
 Ciconiiformes Bonaparte, 1854
 Ciconiidae Sundevall, 1836
Mycteria Linnaeus, 1758
Mycteria cf. *M. americana* Linnaeus, 1758

Material. MCN-PV 1845, Ribeiro et al. (1995).

Remarks. This material was first reported by Ribeiro et al. (1995) and subsequently described by Hsiou (2009). According to Hsiou (2009), the general morphology indicates that the tarsometatarsus (MCN-PV 1845) is that of a ciconiid bird closely related to the extant species *Mycteria americana*.

Osteichthyes Huxley, 1880

Material. MCPU-PV 160.

Remarks. Until now, the record of fishes is represented only by some

isolated vertebrae from the conglomerate level of the Ponte Velha I locality (Figure 3).

DISCUSSION

The available palynological data for southern Brazil indicates the predominance of open areas during the latest Pleistocene (Behling and Lichte, 1997; Behling, 2002; Bauermann *et al.*, 2009 and references therein), which is in agreement with the presence of some caviomorph rodents (Kerber *et al.*, 2012) and large mammals, such as ground sloths, glyptodonts, ungulates and proboscideans. However, some taxa recorded in TPC, such as *Tapirus* and *Tayassu pecari*, indicate the presence of some forested areas in western Rio Grande do Sul, although, the latter has also been recorded from aeolian sediments of the Tezanos Pinto Formation, Santa Fe Province, Argentina (Gasparini *et al.*, 2011). It is noteworthy that remains of Doedicurini and Sclerocalyptini glyptodonts, which were adapted to arid and cold conditions, are scarce in the Mesopotamian region of Argentina (Noriega *et al.*, 2004; Carlini *et al.*, 2004). The same pattern is valid for the TPC deposits, where there are no records of these glyptodontids.

Bombin (1975, 1976) suggested the presence of a mosaic environment during the latest Pleistocene of the western region of the State of Rio Grande do Sul, with gallery forests, permanent water bodies and open areas, accompanied by expansions and retractions of each component in response to the climatic oscillations of the late Quaternary. The available TL ages indicate that the Lamitico Member of Bombin (1976) (at least) was deposited during more humid conditions within the oxygen isotope stages 3 and 2. Oliveira (1999) stated that the assemblage found in the Barranca Grande locality (*Hydrochoerus hydrochaeris*, *Mycteria*, *Tupinambis* among others) suggests a wet climate. A new absolute age of about ~36 ka for these sediments (our unpublished information), corresponding to the isotopic stage 3, corroborates that this association is prior to the Last Glacial Maximum (LGM).

The first studies on vertebrates from western Rio Grande do Sul showed that the TPC has similar faunistic content to that observed in the Luján and Sopas formations, Buenos Aires Province and Uruguay, respectively (Bombin, 1975, 1976). Additional studies have shown a closer similarity between western Rio Grande do Sul and the Sopas Formation, and marked differences between TPC and the Luján Formation, mainly due to the presence of intertropical (Brazilian) taxa in southern Brazil (*e.g.*, Oliveira, 1996, 1999), which are absent in the latest Pleistocene of the Buenos Aires Province. Taxa with Brazilian affinities were reported from the Touro Passo Formation, including *Hydrochoerus hydrochaeris*, *Holmesina paulacoutoi*, *Tapirus* sp. and *Tayassu pecari*, and endemic taxa from the southern South America: *Hemiauchenia paradoxa*, *Macrauchenia patachonica*, *Morenelaphus*, *Antifer* and *Pampatherium typum*. The same pattern is repeated in all well-known late Pleistocene localities of similar latitude, such as Chuí Creek (Rio Grande do Sul), the Sopas Formation (northern Uruguay) and Toropí/Yupoí Formation (Mesopotamia region of Argentina), among others (Ubilla *et al.*, 2004; Oliveira and Pereira, 2009; Pereira *et al.*, 2012; Francia *et al.*, 2012). Another example is in Santiago del Estero Province, Argentina, where Chimento and Agnolin (2011) recorded the presence of the intertropical taxa *Holmesina paulacoutoi* and *Panochthus greslebini*. According to Chimento and Agnolin (2011), this geographic area has a faunistic homogeneity with the Argentine Mesopotamia and is not a distinct paleobiogeographic area as suggested by Carlini *et al.* (2004). The mammalian paleofauna of the Toropí/Yupoí formations, located in Corrientes Province, Argentina, is quite similar to that of the TPC. To explain the biogeographic affinities of the fauna as whole, a complex scenario has been proposed,

with periods of more Chaco-Pampean influence and other periods with more intertropical/tropical influences, including cold and dry periods alternating with wetter climates (Francia *et al.*, 2012; Erra *et al.*, 2013). Oliveira and Pereira (2009) proposed three hypotheses to explain this pattern in Chuí Creek. One of them argued in favor of a large span of time encompassing the sedimentation in the Chuí Creek, which is now corroborated by recent new absolute ages (Lopes *et al.*, 2010, 2012). The available radiometric data indicate a relatively wide span of time for the deposition of the sedimentary beds exposed in the TCP, and thus the faunistic assemblage found in these packages could be artificial or “non-analog”.

A difficulty found in comparing the similarity of the late Pleistocene faunas of southern Brazil and intertropical regions is the lack of well-studied faunas between these geographic areas. The states of Santa Catarina, Paraná, São Paulo and southern Mato Grosso do Sul, which could supply important information, have been poorly studied. Recent efforts have shown interesting results. Guilardi *et al.* (2011) and Castro and Langer (2011) studied the Pleistocene mammals from the upper Vale do Ribeira karst area (State of São Paulo) and they concluded that the fauna has a more intertropical influence. In the State of Paraná, with the exception of *Protocyon troglodytes* (Lund, 1839), which has an intertropical affinity, the other reported taxa have a wide range (see Silva and Sedor, 2008; Silva *et al.*, 2012).

CONCLUSIONS

Since the 1970s, several papers have been published on the fossil vertebrates from TPC. In this review, we can conclude that the knowledge on this site still has several problems, mainly on the specific determination of the taxa. This can be attributed to the fragmentary state of the remains.

The checklist of Bombin (1976) has several taxa that were not confirmed in later studies: *Scelidotherrium leptcephalum* Owen, 1840, *Mazama gouazoupira*, *Blastocerus dichotomus*, *Ozotocerus bezoarticus* and *Notiomastodon platensis*. The material of Sigmodontinae aff. *Reithrodon* Waterhouse, 1837 reported by Oliveira *et al.* (1999) for the Ponte Velha I locality was not located; thus, we cannot confirm the presence of this taxon. For this reason, these taxa should be excluded from the faunistic list of TPC.

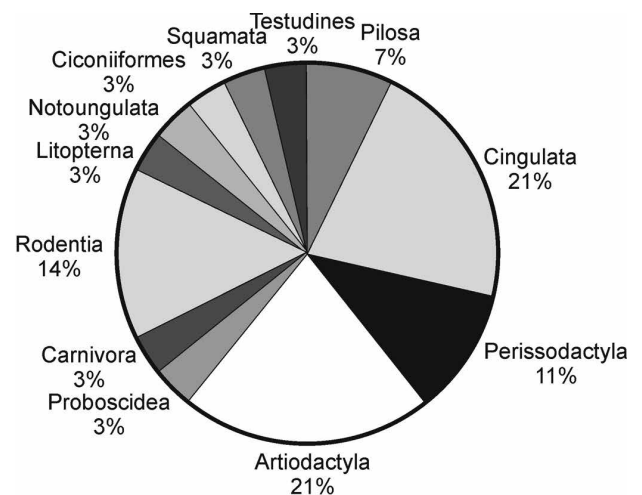


Figure 5. Diversity of tetrapod genera found in the Touro Passo Creek.

The fossil assemblages of TPC show a predominance of mammals. Among these, the Artiodactyla and Cingulata are the most diverse (Figure 5).

The available TL ages indicates that the Lamitico Member (at least) was deposited during humid conditions, within the isotopic stages 3 and 2.

The vertebrates show a mixture of Brazilian and Pampean taxa. The large span of time involved in the deposition of the TPC beds and the climatic oscillations could have contributed to this faunal mixture.

Although several points are still unclear, knowledge has been improved in the last few years. For future work, new fieldwork trips should be carried out with the objective of collecting fossils with precise stratigraphic control and absolute dating. This information will contribute to understanding the biostratigraphy and paleoenvironmental evolution during the late Quaternary of the western region of the State of Rio Grande do Sul.

ACKNOWLEDGEMENTS

We would like to express our gratitude to CNPq (Conselho Nacional de Pesquisa e Tecnologia) for financial support as a fellowship of Programa de Pós-Graduação em Geociências (UFRGS); and project PROSUL (490299/2008-3); Katarzyna Piper for the english review of the manuscript. Thanks also to Sabrina Negrão and Rafael Silveira da Rosa, who prepared the material of Tayassuidae; Francisco S. Buchmann, Renato P. Lopes and the editor, for their useful commentaries; A.S.H. thanks Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP Proc. No. 2011/14080-0).

APPENDIX A

Universal Transverse Mercator (UTM) coordinates of the studied localities in Touro Passo Creek. 1. Ponte Velha II (UTM 511591 m E and 671894 m S); 2. Ponte Velha I (UTM 512588 m E and 6718263 m S); 3. Milton Almeida (UTM 512889 m E and 6717556 m S); 4. Barranca Grande (UTM 513349 m E and 6717057 m S); 5. *Myocastor* (UTM 515538 m E and 6716615 m S).

ADDENDUM

The fossil vertebrates housed in the Pontifícia Universidade Católica do Rio Grande do Sul, campus Uruguiana (Uruguiana) (MCPU-PV) were transferred to the paleontologic collection of the Pontifícia Universidade Católica do Rio Grande do Sul, campus central (Porto Alegre) (MCP).

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Manuscript received: September 24, 2013

Corrected manuscript received: February 11, 2014

Manuscript accepted: February 15, 2014