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New remains of Nothrotheriinae (Mammalia, Xenarthra) from Late Pleistocene fluvial deposits of Northern Pampa (Santa Fe Province, Argentina)

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Running header: *Nothrotherium* from Late Pleistocene fluvial deposits

Abstract

In this contribution the record of a Nothrotheriinae (Xenarthra, Tardigrada) ground sloth is reported from the Late Pleistocene of the Northern Pampa of Santa Fe Province, Argentina. The stratigraphic unit where the fossil was collected corresponds to fluvial-palustrine sediments of the Timbúes Formation, outcropping along the Carcarañá River valley. The relative stratigraphic position of this lithostratigraphic unit, observed in several sections mainly on the Paraná River cliffs near Carcarañá River distal area, suggests that it was deposited during the Last Interglacial Stage.The specimen (MPAHND-135), assigned to *Nothrotherium* cf. *torresi*, is represented by the proximal two-thirds of a left femur that shows a prominent lesser trochanter and no connection between the third trochanter and the ectepicondyle. The presence of *Nothrotherium* cf. *torresi* in sediments related to humid conditions supports the idea that Nothrotheriinae had great ecological tolerance and was capable of inhabiting climates ranging from cold and arid, as was previously proposed, to warm and humid.

Keywords. Folivora, Tardigrada *Nothrotherium*, interglacial conditions, Carcarañá River, environmental changes.

1. Introduction

The superorder Xenarthra, including fossil species, consists of two major clades: Cingulata (armadillos, pampatheres, and glyptodonts) and Pilosa, without dermal armor (except for some mylodonts that have dermal ossicles) but with a dense hair covering, which in turn comprise Vermilingua and Tardigrada. Tardigrada (sensu Latham and Davies 1795), or Phyllophaga or Folivora, constitute one of the characteristic mammalian groups for the Cenozoic of South America, and is represented by several lineages: Megatheriidae, Nothrotheriidae, Megalonychidae, and Mylodontidae (Gaudin, 2004), which were especially diversified during the Miocene to the Pleistocene (see Brandoni et al., 2016). Tardigrada was one of the most successful South American mammals participating in the Great American Biotic Interchange (GABI), given that members of Megatheriidae, Megalonychidae, Nothrotheriidae and Mylodontidae reached and diversified in North America (see McDonald et al., 2013; Carlini et al., 2018; Stinnesbeck et al., 2018, among others).

Among Nothrotheriidae, the subfamily Nothrotheriinae is known from the middle Miocene of Bolivia and Argentina to the Pleistocene of South, Central and North America (Brandoni, 2014; Brandoni and McDonald, 2015; De Iuliis et al., 2015). For the Quaternary, the group is mainly represented by two genera: *Nothrotherium* Lydekker, 1889, mainly recorded from the Pleistocene of Brazil (Hoffstetter, 1954; Paula Couto, 1971; Cartelle and Fonseca, 1983; Pujos, 2001), but also reported from the Pleistocene of Argentina and Uruguay (Kraglievich, 1926; Perea, 2007), and *Nothrotheriops* Hoffstetter, 1954, recorded from the Quaternary of the United States, Mexico, and Belize (McDonald, 1995; McDonald and Jefferson, 2008; Akersten and McDonald, 1991; Bell et al., 2004; De Iuliis et al., 2015). Remains of both genera are relatively common and many of their species [*e.g.*, *Nothrotherium maquinense* (Lund,

1839), *Nothrotheriops texanus* (Hay, 1916), *Nothrotheriops shastensis* (Sinclair, 1905)] are represented by large samples and in some cases by nearly complete specimens, along with mummified remains and dung. In addition, the genus *Nothropus* Burmeister, 1882 (represented by isolated mandibles of three nominal species) is also recorded from the Pleistocene of South America.

For the Pleistocene of Argentina, Nothrotheriinae is recorded in Buenos Aires Province (e.g., *Nothrotherium torresi* Kraglievich, 1926) and Santa Fe Province (see below); although, Hofreiter et al. (2003) reported dung from a sloth from Cuchillo Curá (Neuquén Province) which yielded DNA indicating it was a nothrotheriine but as no body fossils of a Nothrotheriinae are known from that region, assignment to a lower taxonomic level is not possible at this time. Regarding the Nothrotheriinae from the Pleistocene of the Santa Fe Province; the group is represented by *Nothropus carcaranensis* Bordas, 1942 and a Nothrotheriinae indet. from the cliffs of the Carcarañá River, nearly the village of La Ribera (Bordas, 1942; Brandoni and McDonald, 2015), *Nothropus priscus* Burmeister, 1882 and *Nothrotherium escrivanense* (Reinhardt, 1878) from the Carcarañá River (Schulthess, 1919), and *Nothrotherium roverei* Kraglievich, 1931, from the Setubal shallow lake, near Santa Fe city.

Several litostratigraphic units are recognized for the Pleistocene of the lower Carcarañá River catchment (e.g., Puerto San Martín Formation, Timbúes Formation, Carcarañá Formation, Tezanos Pinto Formation; Kröhling, 1999; Iriondo and Kröhling, 2009; Iriondo, 2010; Kröhling and Carignano, 2014). Some of these sequences range from late Middle to Late Pleistocene and are extremely fossiliferous with both aquatic and continental vertebrates (Frenguelli, 1928a; Brandoni and McDonald, 2015; Vezzosi, 2016; Vallone et al., 2017; Vezzosi et al., 2017, 2018).

Late Pleistocene units are recognized along the cut banks of the Carcarañá River; and include the Timbúes, Carcarañá and Tezanos Pinto Formations (Kröhling, 1999; and Carignano, 2014; Vezzosi, 2015), outcropping together with Holocene deposits (e.g., Lucio López/San Guillermo Formations; Kröhling, 1999; Iriondo, 2010, Kröhling and Carignano, 2014). The Timbúes Formation was described at the outlet of the Carcarañá River draining into the Paraná River (32°36'40.99"S – 60°45'34.28"W) (Iriondo and Kröhling, 2009), but preserves scare fossil mammal remains (Vezzosi and Kerber, 2018). It is noteworthy that the first fossil materials (i.e. Quaternary mammals) coming from the cliffs of the Carcarañá River were made by Darwin (1845, 1846), Burmeister (1879), and later by Frenguelli (1928a).

The aim of this contribution is to report and describe a new Nothrotheriinae remain recorded from the fluvial-palustrine paleoenviroments related to interglacial cycles, which is assigned to the Timbúes Formation in the Santa Fe Province. This record in stratigraphic context, allows us to discuss some paleoenvironmental and paleobiological aspects.

[Figure 1 near here]

2. Locality and stratigraphical provenance

The fossil was found on the right margin of the Carcarañá River, near the Carcarañá city, Santa Fe Province, Argentina (Figs. 1A–B, 2A). This deposit appears discontinuously in both banks of the river (32°55'2.28"S – 61°13' 29.64"W, roughly 40–50 m.a.s.l.) with an outcrop thickness of 2–4 m. The fossil material was recovered from the bottom section in the river cut banks (Fig 2A–B). Two different facies (facies 1, and

facies 2) can be identified in the bottom section at the localilty of the Espinillo natural reserve (Fig. 1B). Facies 1 consists of sandy silt that displays low-angle cross-stratification (Fig. 2A). This facies forms architectural elements that indicate down-stream accretion of bars built-up as banks. In addition, the high-angle cross-stratification indicates lateral accretion of bars that can be interpreted to be built-up as point bars grouped in banks inside sinuous channels (Fig. 2B). Facies 2, where the fossil was recovered, has poorly structured massive reddish brown sandy silt. This facies contains abundant iron oxide coatings. The high content of iron oxides macroscopically observed can be interpreted as evidence of intermittent flooded areas under humid and warm conditions. We interpret that this facies was deposited on a flood plain environment. The faintly stratified deposits show dispersed carbonate spread throughout the sediment. This post-sedimentological track indicates that drier climate cycles alternated diachronically with more humid periods. The facies association (facies 1 and 2) suggests an environment characterized by high availability of water under humid hydrological conditions.

While new outcrops are being studied and the systematic study of the regional stratigraphy is improving adding new geochronological data, we can assume some criteria to estimate the age of the sloth remains. Northern Pampa and Southern Mesopotamia present sedimentary successions and stratigraphic sequences that record the interglacial - glacial cycles typical of the Quaternary (Brunetto et al., 2015; Ferrero et al., 2017). In these latitudes, high-stand sea levels correlate with humid periods typical of interglacial cycles. The stages characterized by higher sea levels can be correlated with the periods of accumulation of the fluvial deposits recorded on terraces in the tributaries of the distal area of the continental fluvial system Paraná–Río de la Plata (Brunetto et al., 2015). That is due to the fact that the sea level is the base level of

the rivers in the distal area. This is a reasonable criterion for establishing a chronological correlation of the fluvial sediments that compose the terraces located inside the fluvial valleys, with the Marine Isotopic Stages (Jouzel et al., 2007; Rohling et al., 2008). There are OSL datings (120 ka - 95 ka) obtained from the higher fluvial terraces in neighbor areas, which indicate these levels were deposited over the Last Interglacial Stage (Brunetto et al., 2015; Ferrero et al., 2017).

In this work we assume that the well-defined fluvial deposits bearing the studied specimen correspond to the Timbúes Formation defined by Iriondo and Kröhling (2009), in the lower area of the Carcarañá River catchment. Despite not having geochronological data, the relative stratigraphic position of this lithostratigraphic unit, observed in several sections (Vezzosi, 2015) mainly on the Paraná River cliffs near Carcarañá River distal area (Timbúes and Campo de La Gloria sites, Fig. 1B), suggests that it was deposited during the Last Interglacial Stage.

[Figure 2 near here]

3. Materials and methods

In order to identify the specimen herein presented, the remain herein presented, several femora referred to species of Nothrotheriinae (e.g., *Nothroteriops shastensis*, *Nothrotherium torresi*, *Pronothrotherium typicum*) were studied (see below).

3.1 *Institutional abbreviations*

FMNH, Field Museum of Natural History, Chicago, USA; **LACM**, Natural History Museum of Los Angeles County; **LACM-HC**, Hancock Collection form Los Angeles County Museum, **MACN-Pv**, Museo Argentino de Ciencias Naturales “Bernardino

Rivadavia", CABA, Argentina; **MLP**, Museo de la Plata, La Plata, Buenos Aires, Argentina; **MPAHND**, Museo Particular de Antropología e Historia Natural "Los Desmochados", Casilda, Santa Fe, Argentina**; NSMLV-BLM**, Nevada State Museum, Las Vegas-Bureau of Land Management, Las Vegas, USA; **PIMUZ**, Paläontologisches Institut und Museum Universität Zürich, Zürich, Switzerland; **UF**, Florida Museum of Natural History, University of Florida, Gainesville, USA; **ZMK**, Zoological Museum University of Copenhagen, Copenhagen, Denmark.

3.2 *Abbreviations*

DH, diameter of femoral head; **masl**, meters above soil level; **p**, preserved measurement; **PW**, proximal width; **TML,** Total medial length.

3.3 *Species and specimens used for comparison*

Comparative femora specimens are listed below and come from different localities: *Nothrotherium maquinense* (ZMK 5711, Brazil), *Nothrotherium torresi* (MLP 4-50, Argentina), *Pronothrotherium typicum* (FMNH P14515, Argentina), *Nothrotheriops shastensis* (LACM 18919, LACM 21614, LACM 21620, LACM 21744, LACM-HC 428, NSMLV-BLM-P149, EEUU), *Nothrotheriops texanus* (UF 64350, UF 80038, UF 80211, UF 81362, UF 81500, UF 84931, UF 86355, UF 86733, UF 86734, UF 87012, EEUU), Nothrotheriinae indet. (MACN-Pv 14148, MACN-Pv 14149, Argentina). For chronological purposes, we follow the International Chronostratigraphic Chart (International Commission on Stratigraphic, 2018; Cohen et al., 2013).

4. Systematic paleontology

Class Mammalia Linneaus, 1758

Superorder Xenarthra Cope, 1889

Order Tardigrada Latham & Davies in Forster, 1975

Family Nothrotheriidae Ameghino, 1920

Subfamily Nothrotheriinae Ameghino, 1920

Genus *Nothrotherium* Lydekker, 1889

4.1. *Type species*

Nothrotherium maquinense (Lund, 1839: 220).

Nothrotherium cf. *torresi* Kraglievich, 1926

4.2. *Type specimen*

Nothrotherium torresi, MLP 4-50, a complete right femur.

4.3. *Referred material*

Proximal half of a left femur, MPAHND-135 (Figs. 3, A–C and 4).

4.4. *Locality and horizon*

Right bank of the Carcarañá River at the localilty of the Espinillo natural reserve (32°55'2.28"S – 61°13'29.64"W, 40 m.a.s.l.), near to the locality of Carcarañá, Santa Fe Province, Argentina (Fig. 1B, 2A). Flood plain facies of the Timbúes Formation (early Late Pleistocene, Vezzosi et al., 2018).

[Figure 3 near here]

5. Results

5.1 *Description and comparisons*

MPAHND-135 is represented by the proximal two-thirds of a left femur with the mid-shaft, but lacking the distal end and both condyles (Fig. 3A–C). As is characteristic of most femora of the late Pleistocene ground sloths (see Brandoni and McDonald, 2015), the mid-shaft is wide and antero-posteriorly flattened (Fig. 3A–B). Its general morphology and size is similar to that of other Quaternary Nothrotheriinae (i.e., *Nothrotheriops*, *Nothrotherium*; Table 1). As the type of *N. torresi* is a complete femur a direct comparison between the new specimen and the type was possible. The femur is unknown for *Nothropus*.

In MPAHND-135, the femoral head presents the same nearly spherical morphology (Fig. 3C) present in *Nothrotherium maquinense*, *Nothrotherium torresi* (Fig. 3F), *Nothrotheriops shastensis*, and *Nothrotheriops texanus*. The fovea ligamentum teres is a semi-oval and entirely enclosed isolated depression (not connected to the periphery by a sulcus) and it is located on the posteromedial part of the articular surface of the head (Fig. 4); the same condition is present in the type of *Nothrotherium torresi*, *N. maquinense*, *Nothrotheriops shastensis*, and *Nothrotheriops texanus*; whereas in MACN-Pv 14148 and MACN-Pv 14149 (referred as Nothrotheriinae indet. by Brandoni and McDonald, 2015) the fovea is semi-oval but it is connected to the periphery of the head by a shallow sulcus. In MPAHND-135, the long diameter of the fovea is 11.85 mm and the lesser diameter 6.30 mm; whereas in MACN-Pv 14148 and MACN-Pv 14149 both diameter of the fovea are larger (Brandoni and McDonadl, 2015: table 1).

As in *Nothrotherium torresi* (Fig. 3D,E), in MPAHND-135 the greater trochanter is prominent, its proximal margin nearly reaches the proximal margin of the head (Figs. 3A,B); in *Nothrotheriops* and MACN-Pv 14148 and MACN-Pv 14149 the

greater throchanter is more distally placed. In anterior view (Fig. 3A), in MPAHND-135 the crest between the head and the greater trochanter is straight, as occurs in *Nothrotheriops texanus*, *Nothrotherium maquinense* and *Nothrotherium torresi* (Fig. 3E).

In MPAHND-135, the third throchanter is prominent and it is more medially projected than in *Nothrotherium torresi* (Figs. 3B, 3D), and does not form a rugose surface medially projected as occur in *Nothrotheriops*. As occur in the species of *Nothrotherium*, the third trochanter is clearly distinct from the ectepicondyle (lateral epicondyle); whereas in *Nothrotheriops* and MACN-Pv 14148 and MACN-Pv 14149 the third throchanter is connected with the ectepicondyle.

Distally to the third and lesser trochanters, the shaft of the femur decreases in width as result of the concave medial margin and the absence of connection between the third throchanter and the ectepicondyle (Fig. 3). The latero-medial diameter of the shaft at the level of third trochanter is 136.42 mm.

[Table 1 near here]

[Figure 4 near here]

6. Discussion

As was mentioned, the Quaternary Nothrotheriinae is mainly represented by *Nothrotherium* recorded from South America and *Nothrotheriops* mainly recorded from North America. The morphological differences between both genera were discussed by Paula Couto (1971), De Iuliis et al (2011), among others; regarding the femur, the femur of *Nothrotherium* is more elongated, whereas in *Nothrotheriops* the femur is more

robust and distally broad; in addition, in *Nothrotherium* the third throchanter is well developed, is disconnected with the ectepicondyle, and clearly distinguishable, whereas in *Nothrotherium* the third throchanter is connected with the ectepicondyle forming an uniform structure (see Paula Couto, 1971: fig. 2).

Nothrotherium torresi was described by Kraglievich (1926) based on a nearly complete left femur (MLP 4-50, Figs. 3D–F). The general morphology and size of MPAHND-135 closely resembles the type of *Nothrotherium torresi* (Fig. 3); in addition, MPAHND-135 shares with MLP 4-50 the following features: 1) fovea ligamentum teres semi-oval in outline and entirely enclosed on the articular head; 2) greater trochanter prominent with its proximal edge close to the proximal margin of the head; 3) lesser trochanter prominent; 4) lack of connection between the third trochanter and the ectepicondyle. These similarities and the non-preservation of the distal portion in MPAHND-135, that precludes a better examination, allow us to refer this femur to *Nothrotherium* cf. *torresi*.

In South America, Quaternary Nothrotheriinae are known in Brazil, Uruguay and Argentina, (Roselli, 1976; Pujos, 2001; Ubilla, 2004; Brandoni and McDonald, 2015). Most of the records from South America correspond to those from Brazil (Lund, 1839; Paula Couto, 1971; Cartelle and Fonseca, 1983; Cartelle, 2000; Olivera et al., 2017), where at least two taxa from subtropical environments have been reported (*Nothrotherium maquinense* and *N. escrivanense*; Cartelle and Bohórquez, 1986; Pujos, 2001; Ghilardi et al., 2011). In addition Nothrotheriinae remains, with a set of features similar to those described by Brandoni & McDonald (2015), have recently reported from Serra da Bodoquena (Central Brazil; Olivera et al., 2017). In Uruguay, the records correspond to *Nothrotherium normarrosellii* Roselli, 1976 (based on a left femur with affinities with those referred to *Nothrotheriops*), which probably come from the Nueva

Palmira Formation (Perea, 1998) and *Nothrotherium* cf. *maquinense* from the Sopas Formation (Late Pleistocene; Ubilla et al., 2004; Perea, 2007; Ubilla and Martínez, 2016). In Argentina, *Nothrotherium* is represented by *N. torresi* which was recovered from the locality known as Playa del Barco, Buenos Aires Province. At this locality Pleistocene mammals (e.g., *Lestodon* Gervais, 1855, *Glossotherium* Owen, 1839, *Neochoerus* Hay, 1926 and Notoungulata taxa) were collected (Ameghino, 1908; Frenguelli, 1928b; Kraglievich, 1934; Manera de Bianco and Aramayo, 1998; Tomassini et al., 2010; among others).

Considering the record herein presented, for the Late Pleistocene of Santa Fe Province (Argentina) Nothrotheriinae comprises: *Nothropus carcaranensis*, *Nothropus. priscus*, *Nothrotherium escrivanense*, *Nothrotherium roverei*, a Nothrotheriinae indet. (Brandoni and McDonald, 2015) and *Nothrotherium* cf. *torresi*.

Although such diversity seems to be higher for the late Pleistocene of a small geographic area (Fig. 1), it is important to note that most of these taxa are based on isolated and no homologous bones (i.e. dentary, humerus, femur), and in several cases there are not precise stratigraphic and geographic information. This situation, and its systematics consequences, has already indicated by Brandoni and McDonald (2015) for the case of the femur referred as Nothrotheriinae indet. (see below).

The type specimen of *Nothropus carcaranensis* (a right dentary, MACN-Pv 11155) was collected by Osvaldo Coronel from the cliffs of the Carcarañá River, Santa Fe Province. Bordas (1942) studied the specimen and assigned it to the genus *Nothropus* despite the absence of the caniniform, the primary defining feature of the genus distinguishing it from *Nothrotherium*. An alternative hypothesis suggests that the dimensions of this dentary are similar in size to those of North American Pleistocene sloth *Nothrotheriops texanus* (see Brandoni and McDonald, 2015, fig. 5, tab. 2). Most

of the fossils remains collected by Osvaldo Coronel and his son (see Bordas, 1942) were found near the railway bridge over the Carcarañá River (32°38' 37.86"S – 60°49'32.93" W), at the village of La Ribera, Santa Fe Province, at approximately 25 m.a.s.l. (Fig. 1A–B). At this site, two formations, assigned to the Middle–Late Pleistocene, are present: the Puerto San Martín Formation and the Timbúes Formation overlying the former (Vezzosi and Kerber, 2018; Vezzosi et al., 2018). However, the exact stratigraphic provenance of (MACN-Pv 11555) is unknown.

Nothropus priscus is based on a dentary (MACN-Pv 975) of a juvenile individual that was collected from the Carcaraña River, F.C.A branch railway from Rosario to Córdoba that is parallel to the National Route Nº3, near the town Lucio López (32°42'38.39"S – 61°0'23.81"W, Fig. Fig. 1A–B; Vezzosi, 2015). Regarding its status, Quiñones et al. (2017) stated that it must be considered as *species inquirenda.*

The remains collected by Santiago Roth and referred to *Nothrotherium escrivanense* by Schulthess (1919) consists of several bones, including skull, vertebrae, humerus, and tibia (PIMUZ 0477), recovered from the Pleistocene of Santa Fe Province. Nevertheless, the exact geographic and stratigraphic provenance of these remains is unknown.

Nothrotherium roverei is based on a left humerus (MACN-Pv 11070) recovered from the Setúbal shallow lake (Setúbal–El Capón lacunar system; 31°35'14.99"S – 60°38'31.42"W), near the city of Santa Fe (Fig. 1A). The exact stratigraphic provenance of this specimen is unknown; however, remains of other Pleistocene ground sloths (e.g., *Megatherium americanum* Cuvier, 1796; *Glossotherium robustum* [Owen, 1842]) were also collected from the banks and bottom of this shallow lake (Frenguelli 1922; Kraglievich 1931; Ramonell, 2005).

As in the case of *Nothropus carcaranensis*, the femora referred as Nothrotheriinae indet. by Brandoni and McDonald (2015) was also collected by Osvaldo Coronel from the cliffs of the Carcarañá River, at the village of La Ribera, where the Timbúes and Puerto San Martin Formations crop out (Fig. 1B). Brandoni and McDonald (2015) proposed three possible taxonomic options for the femora: 1) the femora may be from *Nothropus* since the femur for that genus is unknown; 2) they may go with *Nothropus carcaranensis* which is not *Nothropus*; or 3) given the similarities of both femora with those of *Nothrotheriops*, they may in fact be from this genus and thus the first evidence for *Nothrotheriops* in South America.

Regarding *Nothrotherium* cf. *torresi*, the specimen MPAHND-135 was recovered from the Timbúes Formation at the Espinillo natural reserve (Fig. 1B), where the available sedimentary information suggests a fluvial sequence with humid conditions, probably over the Last Interglacial Stage in the Late Pleistocene period (Fig. 2A–D).

Within the overall context for the Pleistocene, the knowledge of the ecological tolerance and the environmental requirements of Quaternary Nothrotheriinae is limited. In general, species of Nothrotheriinae were considered as inhabitants of open environments, browsing on a variety of xerophytic vegetation (Thompson et al., 1980; Ghilardi et al., 2011). In this sense, McDonald and Jefferson (2008) considered that *Nothrotheriops* was probably better adapted to desert environments (with plants associated with more mesic and riparian habitats) than any of the other North American ground sloths. Green (2009), based on a dental microwear analysis, found a more abrasive diet for *Nothrotheriops*, which would be related to grass consumption. Although there is evidence that supports an opportunistic browsing or mixed feeding strategy for *Nothrotheriops shastensis* (Poinar et al., 1998; Hofreiter et al., 2000).

The analysis of the facies association of the Timbúes Fromation suggests a fluvial environment compatible with humid interglacial conditions. The location of sediments bearing fossils into a high fluvial terrace (Figs. 1C, 2A–D) suggests that the fluvial systems had a higher base level, typical of Quaternary humid periods characterized by higher averaged discharges and higher base levels (sea level). The sequence stratigraphy provides additional criteria that supports the interpretation of prevalence of humid environmental conditions.

The presence of *Nothrotherium* cf. *torresi* in sediments related to humid conditions does not necessary contradict previous opinions (Thompson et al., 1980; Ghilardi et al., 2011; McDonald and Jefferson, 2008), instead this record supports the idea that members of the Nothrotheriinae had great ecological tolerance and was capable of inhabiting climates ranging from cold and arid to warm and humid. In this sense, Brandoni et al. (2010) also suggested a great ecological tolerance for the Mylodontinae *Mylodon darwini* Owen, 1839 on the basis of the record of *M. darwini* from fluvial deposits of El Palmar Formation, Entre Ríos Province, Argentina.

Finally, the mammal assemblage recorded from the Timbúes/ Palo Negro Formations in the Northern Pampa consists of semiaquatic rodents (Hydrochoeridae and Myocastorinae), Toxodontidae and Gomphoteriidae ungulates, and a semiarboreal Erethizontidae with affinities to the Neotropical Pleistocene *Coendou* cf. *magnus* (Lund, 1839), which would suggest the presence of heterogeneous complex environments (Vezzosi, 2016; Vezzosi and Kerber, 2018; Vezzosi et al., 2018).

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Figure captions

Figure 1. A) Location map of the nothrotheriine records from Santa Fe Province: 1, *Nothrotheriium roverei* from Setubal shallow lake (Late Pleistocene; Vezzosi 2015); 2, Nothrotheriinae indet. from fluvial deposits from North's Salado River (early Late Pleistocene; Vezzosi, 2015); 3–4, Nothrotheriinae indet. from fluvial sequence outcropping in the Carcarañá River cut banks (Late Pleistocene; Brandoni and McDonald, 2015); 5, *Nothropus carcaranensis* from deposits of Carcarañá River (Late Pleistocene (Bordas, 1942); 6, *N. priscus* from deposits of Carcarañá River (Late Pleistocene; Burmeister, 1882); 7, *Nothrotherium* cf. *torresi* from fluvial deposits of Timbúes Fm. (early Late Pleistocene); B) Map of the lower area of the Carcarañá River catchment and relief obtained from a Digital Elevation Model (SRTM-NASA). The

683 provenance sites of the nothrotheriines records from Northerm Pampa (yellow dots) and
684 the sections where the stratigraphic succession has been described (brown dots) are
685 indicated on the map; C) Outcropping stratigraphic column representative through of a
686 longitudinal profile in the studty area.

687

688 Figure 2. A) Section of the Timbúes Formation: facies of stratified very fine sandy mud
689 at the bottom section; B) Section of the Timbúes Formation: facies of massive mud
690 overlying the stratified deposits (A); C) Section displaying a Holocene fluvial terrace
691 (the Lucio López Formation, sensu Kröhling, 1999). The Timbúes Formation appears at
692 the base of the fluvial bank cut. Holocene fluvial deposits overlies the Timbúes
693 Formation in erosive unconformity; D) lithostratigraphic units composed by fluvial
694 sediments have a geomorphological expression as terraces that indicate different
695 discharge magnitudes and/or base levels at the outlet. We interpret that these
696 morphogenetic surfaces correlate with interglacial periods.

697

698 Figure 3. Femora of *Nothrotherium* from Argentina. A–C, right femur of *Nothrotherium*
699 cf. *torresi* (MPAHND-135) in anterior, posterior and proximal view; D–E, right femur
700 of *Nothrotherium torresi* (MLP 4-50) in same views. Scale bar = 50 mm.

701

702 Figure 4. Detail of the femoral head of *Nothrotherium* cf. *torresi* (MPAHND-135). The
703 white arrow show the entirely enclosed fovea ligamentum teres. Scale bar = 50 mm.

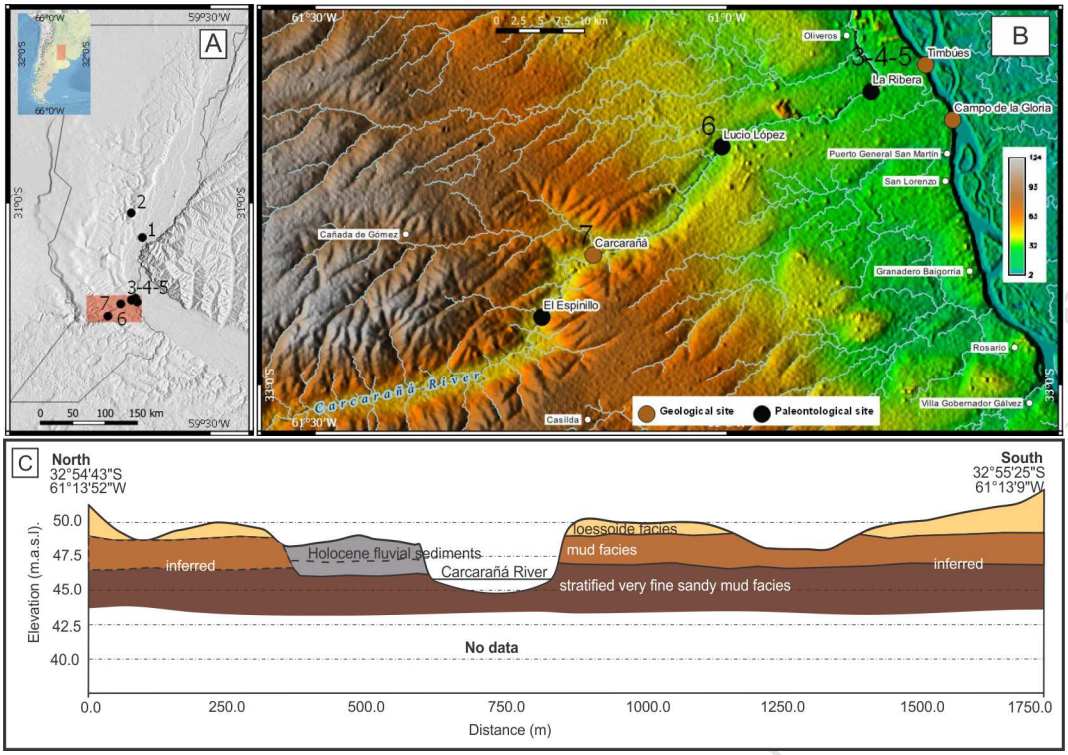
704

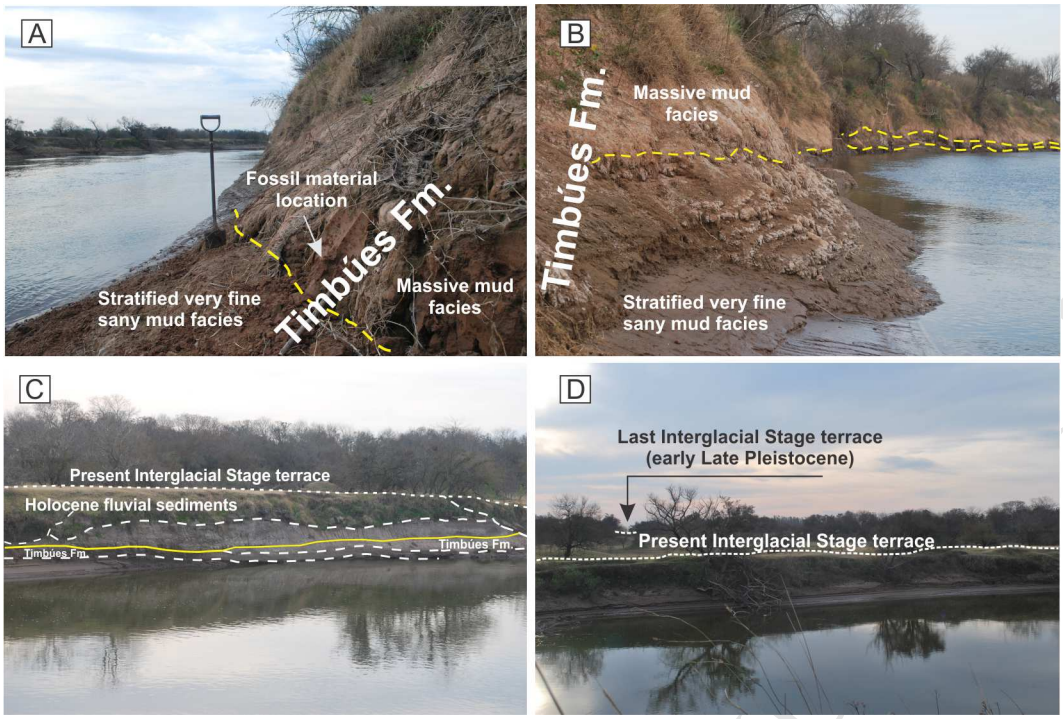
705 Table 1. Femora linear measurements (in mm) and anatomical abbreviations. DH,
706 diameter of femoral head; p, preserved measurement; PW, proximal width; TML**,** Total
707 medial length. Specimens of *Nothrotheriops shastensis* used in femoral measurements:

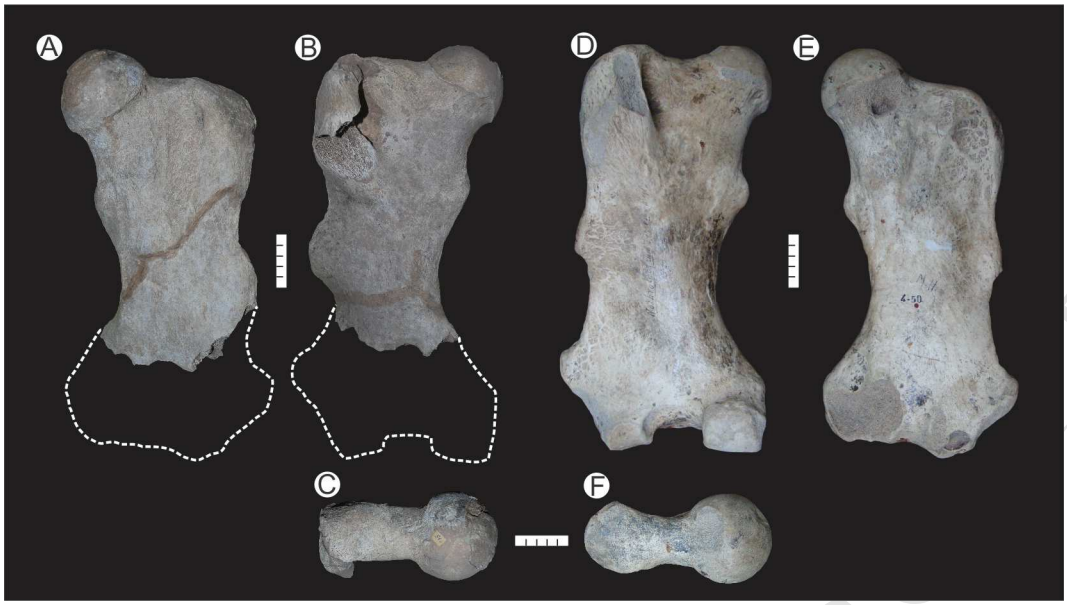
LACM 18919, LACM 21614, LACM 21620, LACM 21744, LACM-HC 428, NSMLV-BLM-P149. Specimens of *N. texanus* used in femoral measurements: UF 64350, UF 80038, UF 80211, UF 81362, UF 81500, UF 84931, UF 86355, UF 86733, UF 86734, UF 87012. In parenthesis is showed the sample number.

Table 1. Femora linear measurements (in mm) and anatomical abbreviations. DH, diameter of femoral head; p, preserved measurement; PW, proximal width; TML**,** Total medial length. Specimens of *Nothrotheriops shastensis* used in femoral measurements: LACM 18919, LACM 21614, LACM 21620, LACM 21744, LACM-HC 428, NSMLV-BLM-P149. Specimens of *N. texanus* used in femoral measurements: UF 64350, UF 80038, UF 80211, UF 81362, UF 81500, UF 84931, UF 86355, UF 86733, UF 86734, UF 87012. In parentesis is showed the sample number.

Taxon	Catalog Number	TML	DH	PW
Nothrotherium cf. *torresi*	MPAHND-135	286.82 *p*	89.08	179.81
N. torresi	MLP 4-50	410	88	194
N. maquinense	ZMUC 5711	243.5	50	94.7
Nothrotheriops shastensis	Range	347.6–398.1 (5)	77.5–86.2 (6)	145.6–182.1 (6)
N. texanus	Range	341–374 (9)	73.3–86 (10)	156.8–175.2 (9)
Pronothrotherium typicum	FMNH P14515	297	67	146.7
Nothrotheriinae indet.	MACN-Pv 14148	394	98	190
Nothrotheriinae indet.	MACN-Pv 14149	365	85	180







Highlights

- Fossil of Nothrotheriinae from fluvial deposits of Late Pleistocene of Argentina is presented.
- The stratigraphic sequence supports the existence of humid conditions in the Northern Pampa.
- This record supports the idea that Nothrotheriinae was capable of inhabiting climates ranging from cold and arid to warm and humid.
- Six taxa of Nothrotheriinae were recorded from the Late Pleistocene of Santa Fe Province, Argentina.