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

Raúl I. Vezzosi, Diego Brandoni, Enesto Brunetto, María Cecilia Zalazar

PII: S0895-9811(18)30389-4
DOI: https://doi.org/10.1016/j.jsames.2018.11.004
Reference: SAMES 2031

To appear in: Journal of South American Earth Sciences

Received Date: 21 September 2018
Revised Date: 1 November 2018
Accepted Date: 2 November 2018

Please cite this article as: Vezzosi, Raú.I., Brandoni, D., Brunetto, E., Zalazar, Mari.Cecilia., New remains of Nothrotheriinae (Mammalia, Xenarthra) from Late Pleistocene fluvial deposits of Northern Pampa (Santa Fe Province, Argentina), Journal of South American Earth Sciences (2018), doi: https://doi.org/10.1016/j.jsames.2018.11.004.

This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.
New remains of Nothrotheriinae (Mammalia, Xenarthra) from Late Pleistocene fluvial deposits of Northern Pampa (Santa Fe Province, Argentina)

Raúl I. Vezzosi¹², *, Diego Brandoni¹², Enesto Brunetto¹² and María Cecilia Zalazar³

¹Laboratorio de Paleontología de Vertebrados, Centro de Investigaciones Científicas y Transferencia de Tecnología a la Producción, Consejo Nacional de Investigaciones Científicas y Técnicas, Materia y España, E3105BWA Diamante, Argentina. E-mails: vezzosiraul@gmail.com, dbrandoni@cicyttp.org.ar, ernestobrunetto@cicyttp.org.ar

²Facultad de Ciencia y Tecnología, Universidad Autónoma de Entre Ríos, Entre Ríos, Argentina. Ruta Nacional 11 km 10,5, E3100XAD Oro Verde, Entre Ríos, Argentina.

³Universidad Nacional del Litoral, CC 217, 3000 Santa Fe, Argentina. E-mail: zalazarmariacecilia@gmail.com

*Corresponding author. Centro de Investigaciones Científicas y Transferencia de Tecnología a la Producción, Consejo Nacional de Investigaciones Científicas y Técnicas, Materia y España, E3105BWA Diamante, Argentina. Tel: +54 0343 4983086. E-mail: vezzosiraul@gmail.com.

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 (Schultess, 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 scarce 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 paleoenvironments 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 locality 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 downstream 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), Nothotheriinae 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 Xenartheta 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 Carcaraña River at the locality 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 Carcaraña, Santa Fe Province, Argentina (Fig. 1B, 2A). Flood plain facies of the Timbúes Formation (early Late Pleistocene, Vezzosi et al., 2018).

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 McDonaldl, 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 trochanter 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 trochanter 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 trochanter 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 trochanter 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 trochanter is well
developed, is disconnected with the ectepicondyle, and clearly distinguishable, whereas
in *Nothrotherium* the third trochanter 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) Nothrotleriinae comprises: Nothropus carcaranensis, Nothropus priscus, Nothrotherium escrivanense, Nothrotherium roverei, a Nothrotleriinae 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 Nothrotleriinae 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 Carcaraña 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 Formation 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 necessarily 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).

7. Acknowledgments

We thank to A. Kramarz (MACN), E. Aguirre (MPAHND), M. Reguero (MLP) for facilitating access to collections of their institutions. S. McLeod, J. Harris and Ch.
Shaw (LACM), S. Underwood (NSMLV), D. Webb. (UF), K. Aaris-Sorenson and K. Rosenlund (ZMUC), and B. Simpson (FMNH) facilitating access to collections or sent some photographs. We thank the reviewers for providing useful reviews. Contribution to PIP-CONICET-112-201101-01024, PICT-ANPCYT-2013-0491, PICT-ANPCYT-2017-0954.

8. Literature cited


Cuvier, G. 1796. Notice sur le squelette d'une très-grande espèce de quadrupède inconnue jusqu'à présent, trouvé au Paraquay, et déposé au cabinet d'histoire.
naturelle de Madrid. Magasin Encyclopédique: ou Journal des Sciences, des
Lettres et des Arts 1796(1), 303–310; 1796 (2), 227–228

Librería El Ateneo, 118 p. (Spanish translation of the second English edition),
Buenos Aires.

Darwin, C. 1846. Geological observations on South America, being the third part of the
geology of the voyage of the Beagle, under the command of Capt. Fitzroy, R.N.
during the years 1832-1836. Pags. vii + 1-279, lams. 1-5, 1 mapa. Smith, Elder
& Co., London.

De Iuliis, G., Gaudin, T.J. and Vicars, M.J. 2011. A new genus and species of
nothrotheriid sloth (Xenarthra, Tardigrada, Nothrottheriidae) from the Late
Miocene (Huayquerian) of Peru. Palaeontology 54: 171–205.

De Iuliis, G; McDonald, H.G.; Stanchly, N.; Spenard, J. and Powis, T.G. 2015.
Nothrotheriops shastensis (Sinclair) from Actun Lak: First record of
Nothrotheriidae (Mammalia, Xenarthra, Pilosa) from Belize. Ameghiniana 52:
153–171.

De Oliveira, A.M., Becker-Kerber, B., Cordeiro, L.M., Borghezan, R., Santos Avilla,
from central Brazil (Serra da Bodoquena, Mato Grosso do Sul) and comments on
paleobiogeography and paleoenvironments. Rev. bras. paleontol. 20(1), 31–44.
DOI: 10.4072/rbp.2017.1.03

assemblage from the Last Interglacial in southern South America (Entre Ríos,
Argentina). Biostratigraphy and paleoenvironment. Palaeogeography,


Kraglievich, L., 1934. La antigüedad pliocena de las faunas de Monte Hermoso y Chapadmalal, deducidas de su comparación con las que le precedieron y sucedieron. Imprenta “El Siglo Ilustrado”, Montevideo 136 pp.


Manera de Bianco, T., Aramayo, S., 1998. Presencia de *Neochoerus* sp. en el Pleistoceno tardío de Pehuen Co, provincia de Buenos Aires, Argentina. 7° Congreso Argentino de Paleontología y Bioestratigrafía (Bahía Blanca), Actas: 68.


Rohling, E.J., Grant, K., Hemleben, Ch., Siddall, M., Hoogakker, B.A.A., Bolshaw, M., Kucera, M., 2008. High rates of sea-level rise during the last interglacial period. Nature Geoscience 1, 38–42. DOI:10.1038/ngeo.2007.28


Schulthess, B., 1919. Beiträge zur Kenntniss der Xenarthra auf Grund der “Santiago Roth’schen Sammlung” des Zoologischen Museum der Universität Zürich, das Skelett der Hand und des Fusses der Xenarthra, etc. Mémoires de la Societe Paléontologique Suisse 44, 1–120.


Ubilla, M., Martínez, S., 2016. Geology and Paleontology of the Quaternary of Uruguay. Springer Briefs in Earth System Sciences, pp. 1-77. DOI: 10.1007/978-3-319-29303-5_1


Vezzosi, R.I.; Brunetto, E. and Flores, D. 2017. An intertropical Opossum (Mammalia, Marsupialia, Dilephidae) from the late Middle–Late Pleistocene of austral South America. Historical Biology: An International Journal of Paleobiology. DOI: 10.1080/08912963.2017.1354181


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

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

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

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

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 *Nothrotitheriops 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 parenthesis is showed the sample number.

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