

New remains and considerations on Nothrotheriidae from the late Pleistocene of La Ribera, Santa Fe, Argentina

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Abstract. The remains of Nothrotheriidae are very scarce in the fossil record of the Pleistocene of Argentina but the locality La Ribera (late Pleistocene) has an unexpected concentration of members of this family. In this work, an astragalus and a femur assignable to Nothrotheriidae from La Ribera are described as *Nothropus* cf. *carcaranensis* Bordas, 1942. Other material of this family of sloths from this locality, among which is the holotype of *Nothropus carcaranensis*, are reviewed with discussion about the intraspecific variation of the femora. The elements studied herein provide a better understanding of the diversity of the Nothrotheriidae in Argentina.

Keywords: anatomy • Ground Sloth • Pleistocene • Nothrotheriidae • Xenarthra

Resumen. Los restos de Nothrotheriidae son muy escasos en el registro fósil del Pleistoceno de Argentina aunque la localidad La Ribera (Pleistoceno tardío) muestra una inesperada concentración. En este trabajo se describen un nuevo astrágalo y un fémur de Nothrotheriidae de La Ribera como *Nothropus* cf. *carcaranensis* Bordas, 1942. Además se revisan los ejemplares de esta familia de perezosos hallados en esta localidad, entre los que se encuentra el holotipo de *Nothropus carcaranensis* y se discute sobre la variación intraespecífica de los fémures de Nothrotheriidae. El conjunto de elementos aquí reunidos permite avanzar hacia una mejor comprensión sobre la diversidad de Nothrotheriidae en Argentina.

Palabras clave: anatomía • perezosos terrestres • Pleistoceno • Nothrotheriidae • Xenarthra

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INTRODUCTION

Nothrotheriidae (Xenarthra, Folivora) is one of the main families of Pleistocene sloths in South and North America (Gaudin 2004, McDonald & Jefferson 2008, Rinderknecht et al. 2010), but its record from the Pleistocene of Argentina is particularly scarce, with specimens mainly found in the Santa Fe Province (Burmeister 1882, Schulthess 1919, Kraglievich 1931, Bordas 1942, Brandoni & McDonald 2015).

Most of the late Pleistocene nothrotheriid remains deposited in the Museo Argentino de Ciencias Naturales "Bernardino Rivadavia" (MACN) were collected by Osvaldo Coronel, in the town La Ribera, from the cliffs of the Carcarañá River, Santa Fe (Fig. 1). Mammal fossils from this locality were donated by Osvaldo Coronel to the MACN during the 1930s and 1940s, and today constitute an important part of the Pleistocene vertebrate collection of the Pampean region. Among these are the

remains of *Nothropus carcaranensis* Bordas, 1942 (MACN-Pv-11300, MACN-Pv-11555) which were found near the railway-bridge by O. Coronel, 100 meters far from the Provincial Route 11, where other nothrotheriid remains were also collected. In April 1942 he sent three femora of nothrotheriid sloths (MACN-Pv-14148, MACN-Pv-14149 and MACN-Pv-14172) followed by one more in November 1942 (MACN-Pv-14390). The four femora belong to four different adult individuals judging by the size and anatomical differences in the distal region. Together with the first three femora, an astragalus (MACN-Pv-14153) was collected from the same locality and is attributed by us to the Nothrotheriidae.

The purpose of this communication is to describe that astragalus and the femur (MACN-Pv-14390), as part of the original nothrotheriid material in the O. Coronel collection, which also includes the holotype of *Nothropus carcaranensis*. Finally, we discuss the diversity of the Nothrotheriidae from La Ribera.

MATERIAL AND METHODS

Femora: *N. cf. carcaranensis*: MACN-Pv-14148, 14149, 14172, 14390, MRS-199, PBQ2-3, 2-4. Astragalus: *N. cf. carcaranensis*: MACN-Pv-14153; *Nothrotherium maquinense* (Lund, 1839): MCL-1020/217, 2819/62, 22.030/01; *Aymaratherium jeani* Pujos et al., 2016: MNHN-BOL-V-012983; *Nothrotheriops shastensis* (Sinclair, 1905) right astragalus HC-1875-R-4.

The astragalus MACN-Pv-14153 was compared with that of *N. maquinense* (MCL-1020/217, 2819/62, 22.030/01), *A. jeani* MNHN-BOL-V-012983, and *N. shastensis* right astragalus HC-1875-R-4, using photographs or 3D-captures and photographs for the case of *N. shastensis*. The terminology adopted for description of astragalus follows Pujos et al. (2016). The femora were compared in anterior, posterior and distal views.

Institutional abbreviations: HC: Hancock collection of the Los Angeles County Museum of Natural History (USA); MACN-Pv: Museo Argentino de Ciencias Naturales "B. Rivadavia", colección paleovertebrados, Buenos Aires, Argentina; MAS: Museo de Ciencias Naturales y Antropológicas "Profesor Antonio Serrano", Paraná, Entre Ríos, Argentina; MCL: Museu de Ciências Naturais da Pontificia Universidade Católica de Minas Gerais, Belo Horizonte, Brasil.

SYSTEMATIC PALAEOLOGY

Superorder Xenarthra Cope, 1889

Order Pilosa Flower, 1883

Suborder Folivora Delsuc, Catzeflis, Stanhope & Douzery, 2001

Family Nothrotheriidae Ameghino, 1920
Subfamily Nothrotheriinae Ameghino, 1920
Genus *Nothropus* Burmeister, 1882

Type species: *Nothropus priscus* Burmeister, 1882.

***Nothropus cf. carcaranensis* Bordas, 1942**

Figs. 2A, C-F, I; 3D; 4D

Referred material. A well-preserved right astragalus (MACN-Pv-14153) and left femur (MACN-Pv-14390).

Geographic and stratigraphic provenance. The materials come from La Ribera near the bridge over Provincial Route 11 (Fig. 1). The stratigraphic position was not accurately recorded at the time of registration in the collection. However, the fossils could likely belong to the late Pleistocene Puerto San Martín Formation (Iriondo 1987) which is exposed in several sectors of the Río Carcarañá cliffs near la Ribera (Iriondo & Kröhling 2009).

Description. The astragalus is similar in size to the astragalus of *N. shastensis* and twice the size of *Nothrotherium maquinense* (Fig. 2). The odontoid process is well-developed, with a length comparable to the width of the discoid facet. This widens towards the base that contacts the discoid facet without reaching the width seen in *N. shastensis* near the discoid facet in its posterior portion. In anterior view the odontoid and discoid facet are at an angle close to 120°, which is greater than in *A. jeani* (90°) but a little smaller than in *N. shastensis* (130°). The perimeter of the discoid facet is rounded, as in *A. jeani*, *N. maquinense* and *N. shastensis*, and its radius is constant with respect to the odontoid process, as opposed to the irregular radius presented by mylodontines such as *Paramylodon harlani*

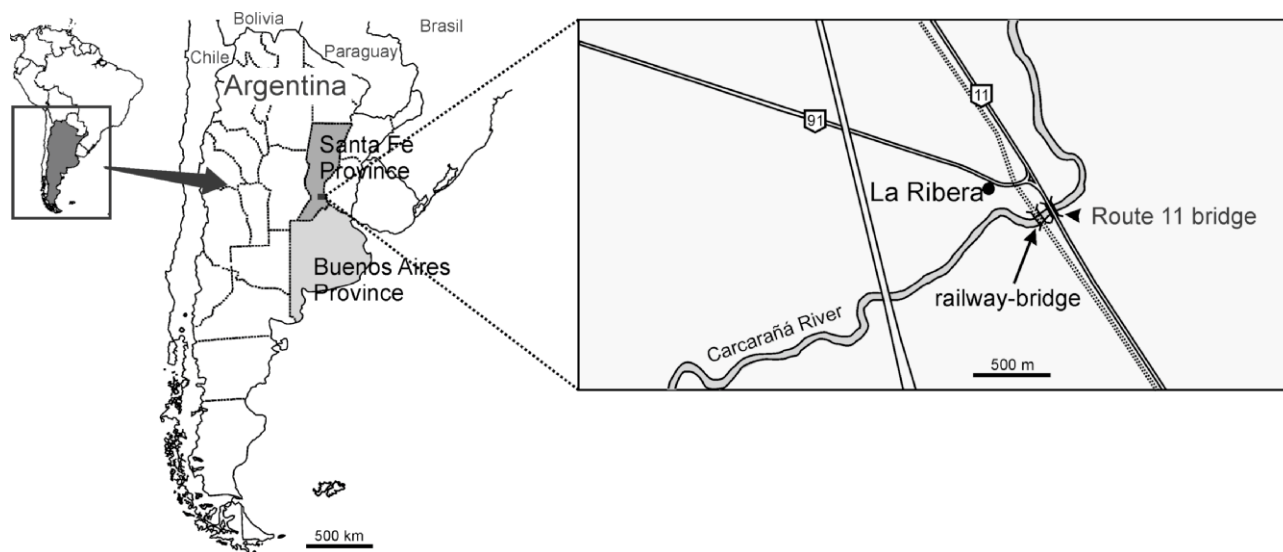


Figure 1. Geographic location of La Ribera in the Santa Fe Province.

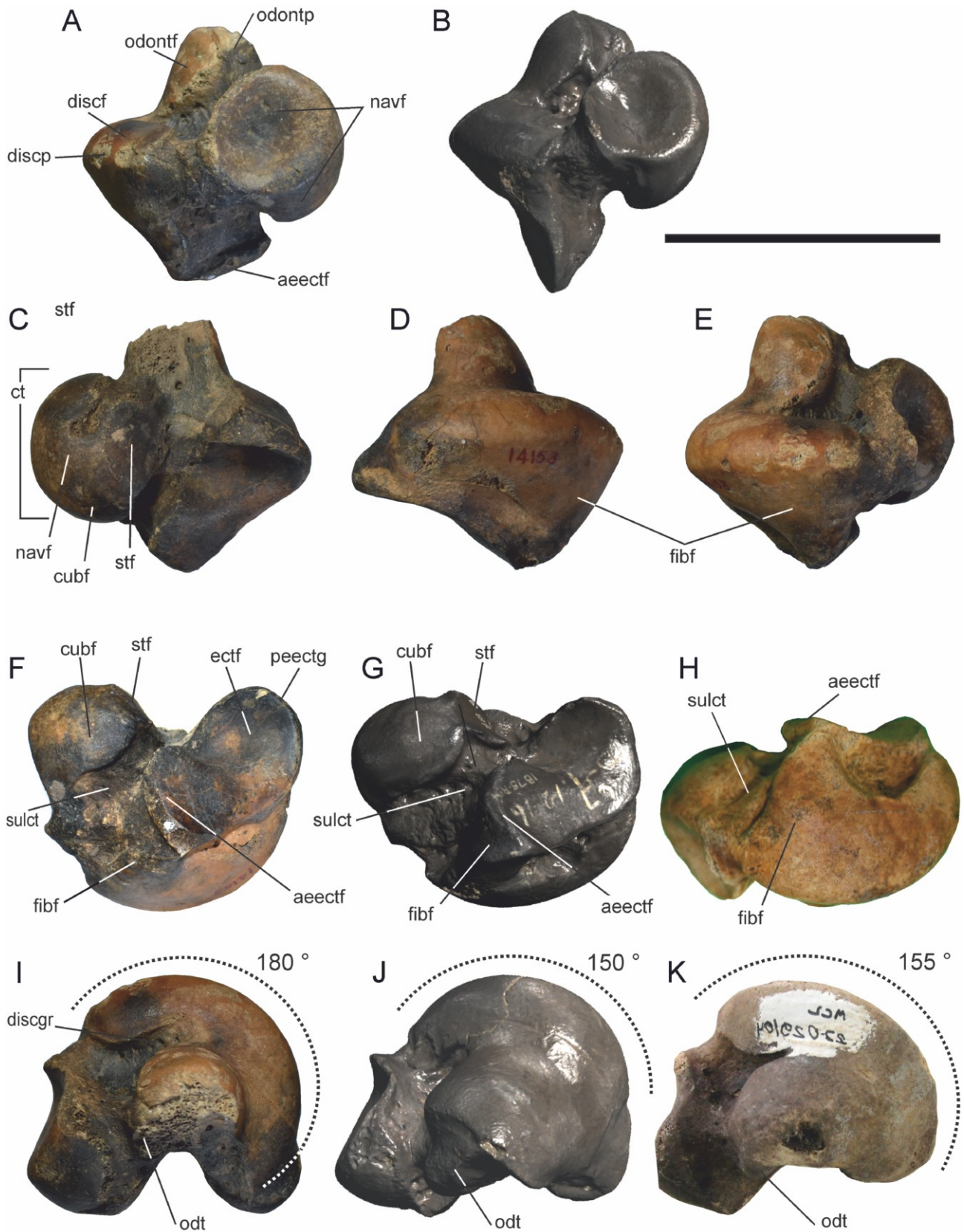


Figure 2. Astragali of Nothrotheriidae. **A, C-F, I:** *Nothropus cf. carcaranensis* (MACN-Pv-14153) from La Ribera (x0.5). **B, G, J:** *Nothropus shastensis* (HC-1875-R-4), from Los Angeles, U.S.A. (x0.5). **H, K:** *Nothropus maquinense* (MCL-22-029-04), from Bahia State, Brazil (x1). **A, B:** Distal views. **C:** Plantar view. **D:** Proximal view. **E:** Dorsal view. **F-H:** Lateroplantar views. **I-K:** Dorsomedial views. – Abbreviations: **aectf:** anterior edge of the ectal facet; **ct:** caput tali; **cubf:** cuboid facet; **discf:** discoid facet; **discgr:** discoid groove; **discp:** discoid process; **ectf:** ectal facet; **fibf:** fibular facet; **navf:** navicular facet; **odontf:** odontoid facet on odontoid process; **odontp:** odontoid process; **odt:** odontoid tuberosity; **peectf:** posterior edge of the ectal facet; **sulct:** sulcus tali; **stf:** sustentacular facet; **tibf:** tibial facet. The scale bar represents 100 mm for A-G, I; 50 mm for H, K.

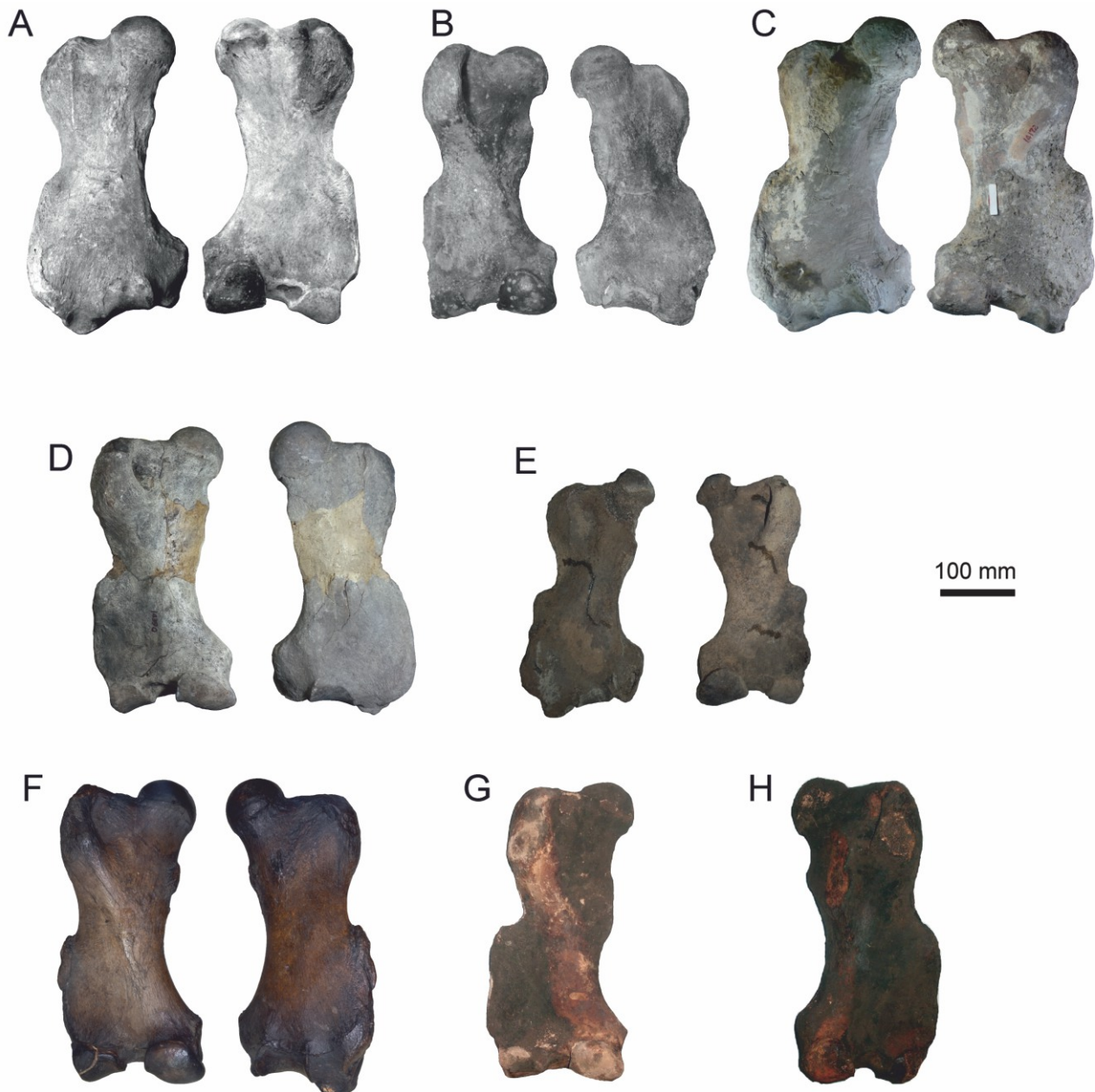


Figure 3. Anterior and posterior views of femurs of *Nothropus* cf. *carcaranensis*. **A:** MACN-Pv-14148, **B:** MACN-Pv-14149, both modified from Brandoni & McDonald (2015). **C:** MACN-Pv-14172. **D:** MACN-Pv-14390. **E:** MRS-199, Rio Salado, Santa Fe (modified from Brandoni & Vezzosi 2019). **F:** *Nothropus shastensis* (HC-418), Los Angeles, U.S.A. **G:** PBQ2-3 and **H:** PBQ2-4 from Serra da Bodoquena, Mato Grosso do Sul, Brazil, both modified from De Oliveira et al. (2017). - All figures scaled x0.11.

(Owen, 1839), *Glossotherium robustum* (Owen, 1842), and *Myiodon darwini* (Owen, 1839). The discoid facet extends 180° around the odontoid process as in some Megatheriinae such as *Pyramiodontherium* sp. (MAS-1392) and *Urumaquia robusta* (Carlini 2008), while in *N. shastensis* it reaches only 150° and 155° in *N. maquinense* (Fig. 2I-K). A discoid groove is characteristic of the astragalus of Nothrotheriidae, it extends over the discoid facet following the perimeter of the odontoid process (Fig. 2I-K, discgr). The discoid groove is covered by five foramina and it is

longer and wider in MACN-Pv-14153 than in *N. maquinense*, *N. shastensis*, and *A. jeani*.

The ectal facet is long and oriented obliquely with respect to the plane described by the discoid facet. It is concave along its entire major axis and flattened transversely at the anterior end whereas it is concave transversely at its posterior end. In dorsomedial view, the posterior edge of the ectal facet protrudes beyond the discoid facet (Fig. 2I), feature that it shares with *N. shastensis*. Therefore, the posterior edge of the ectal facet,

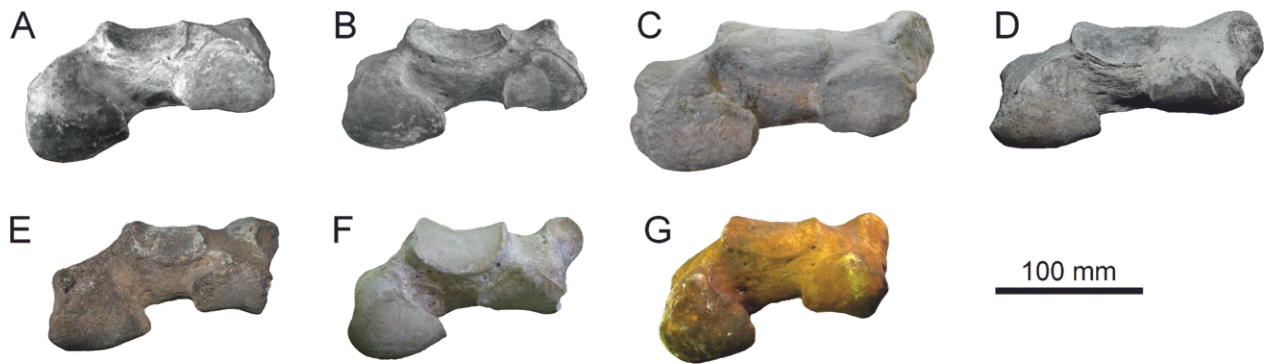


Figure 4. Distal views of femora of *Nothropus cf. carcaranensis*. **A:** MACN-Pv-14148, **B:** MACN-Pv-14149, both modified from Brandoni & McDonald (2015). **C:** MACN-Pv-14172. **D:** MACN-Pv-14390. **E:** MRS-199 from Rio Salado, Santa Fe, modified from Brandoni & Vezzosi (2019). **F:** *Nothropus shastensis* LACM-21618 from Los Angeles, U.S.A. (mirrored image), modified from Amson et al. (2015). **G:** *Nothropus maquinense* MCL21937 (double size) from Brazil, modified from Amson et al. (2015). - All figures scaled x0.20.

the odontoid process, and the caput tali describe an acute angle of about 50° (Fig. 2I).

Two thirds of the caput tali are located above the plane described by the discoid facet, the sulcus tali is broad and separates the caput tali from the ectal facet that is the joint for the calcaneum. An additional groove separates the anterior edge of the ectal facet from the fibula facet. The sulcus tali is also broad in *N. shastensis* whereas the ectal and fibular facets converge to form an acute angle, whereas in *N. maquinense* the sulcus tali is smaller in the astragalus MCL-1020/217 and MCL-2819/62, interrupted by a bridge that connects the cuboid facet and the ectal facet in the astragalus MCL-22.030/01.

The navicular facet closest to the discoid facet is concave while the most distal is convex as in *A. jeani* and *N. shastensis*. The navicular facet is located anteriorly and medially while the cuboid facet is plantar located. The fibular facet is composed of a wide and unique diffusely defined articular surface. A non-articular process called odontoid tuberosity is present on the plantar side of the odontoid process of *N. shastensis*, as in several Megatheriidae (Brandoni & Carlini 2009), while it is eroded and underdeveloped in the MACN-Pv-14153 astragalus, as in *N. maquinense*. The astragalus of *N. maquinense* (MCL-22-029-04) also has a subchondral erosion on the odontoid tuberosity (De S. Barbosa et al. 2016).

The MACN-Pv-14390 femur that remained unpublished shares the outstanding feature of all the Nothrotherid femora from La Ribera: the connection between the third trochanter and the ectepicondylar process. In anterior view, the medial border is deeply arched, which differentiates it from *N. shastensis* whose arch is less pronounced (Fig. 3F). The femoral head is prominent, rounded and the lesser trochanter is less prominent than in other specimens such as MACN-Pv-14149. In distal view, the distal end is very flattened, and the medial condyles are less projected to the posterior side than in *N. shastensis* and *N. maquinense* (Fig. 4). The patellar trochlea and medial and lateral condyles are separated in all specimens (Fig. 4A-D). The patellar trochlea is mediolaterally discrete as in MACN-Pv-14148, the lateral condyle is disconnected from

the trochlea in all specimens by a deep groove, while the medial condyle in MACN-Pv-14390 approaches the trochlea with a thin bone bridge that does not contact the patellar trochlea.

Remarks. The most abundant material of Nothrotheriinae from Santa Fe consists of femora, all of which share similar anatomy. The original collection of O. Coronel includes 4 femora, and a fifth one of similar shape was recently found by Marcelo Scioli (curator of the Salado River Museum) and described by Brandoni & Vezzosi (2019). The wide range of variation in the size of the femora is striking (Fig. 3C, 3E).

DISCUSSION

The astragalus described above shares some features with those of *N. shastensis* that are different in *N. maquinense*, such as the relatively large size and the relatively wide sulcus tali. However, it shares some features with the astragalus of *N. maquinense* that are absent in *N. shastensis*, such as the reduced odontoid tuberosity. On the other hand, the large angle described by the discoid facet seems a plesiomorphic character rather than that found in either *N. shastensis* or *N. maquinense*. This latter feature is consistent with a basal position also suggested for the juvenile of *N. carcaranensis* by the retention of the lower caniniform (Quiñones et al. 2017). On the contrary, the wide and long discoid groove appears as a unique feature; thus, the astragalus structure does not suggest closer relationships to *Nothrotheriops* than to any other nothrotheriine. Indeed, the similarities with *Nothrotheriops* in astragalus size may actually be of dubious significance since there is material assigned to *Nothrotherium* presenting a similar or even larger size than *Nothrotheriops*, at least from femoral measurements (Kraglievich 1926), and furthermore, the width of the sulcus tali is variable in Neogene nothrotheriids (Kraglievich 1928). The same can be said about similarities shared with *Nothrotherium*, such as the prominence of the odontoid tuberosity, given the variability found in Neogene

nothrotheriids (Kraglievich 1928, Pujos et al. 2016).

The femora have resemblance with the material of *N. shastensis* of North America; however, because of the presence of non-overlapping mandibular material assigned to *Nothropus carcaranensis* in La Ribera it is possible that they belong to this latter species (Brandoni & McDonald 2015). Two femoral characters, the confluence between third trochanter and ectepicondyle, and the low total length/distal width ratio, suggest the Salado River material would belong to *Nothrotheriops* (Brandoni and Vezzosi 2019), but the same features were considered as not allowing unequivocal reference to *Nothrotheriops* in femora from La Ribera (Brandoni & McDonald 2015).

Considering the morphological, geographical and likely stratigraphical closeness of the remains from Salado River and La Ribera, it seems possible that they would belong to the same species. Thus, it would be nearly as unsafe to refer them to *Nothrotheriops* as is referring the material from La Ribera to that taxon. Given the rarity of nothrotheres in the Pleistocene of Argentina and the low diversity in Nothrotheridae, it is tempting to refer all the nothrotheriid material from La Ribera, including the maxilla and mandible of *Nothropus carcaranensis*, the four femora, and the astragalus to a single species, in spite of the lack of accurate stratigraphic position and the isolated nature of these finds. This can only be definitively confirmed with additional study of the locality and the recovery of articulated or at least closely associated material. It is also likely that, given the similarity in morphology and provenance, the material from the Salado River belongs to the same species. Therefore, *Nothrotheriops* and *Nothropus* (the later being represented by material from La Ribera and the Salado River) can represent non-overlapping taxonomic entities which are however similar in femoral anatomy, likely because of close phylogenetic relationships.

The ancestor of *Nothrotheriops* could have expanded towards North America during the Great American Biotic Interchange (Pascual et al. 1985), while the South American ancestor of *Nothropus* could have given origin to the species found in Santa Fe as part of a South American lineage. Similar patterns have been suggested for the Mylodontidae, through species such as *P. harlani* (North America) and *M. darwini* or *G. robustum* (South America). Their astragalus and femora are quite similar due to relatively recent divergence, thus although they are clearly different taxonomic entities, *M. darwini* or *G. robustum* come from a lineage with a continuous evolutionary history in South America (Brambilla & Ibarra 2019).

The similarity between the femora from La Ribera and those from the Salado river in northern Santa Fe Province and the specimens from Serra da Bodoquena suggest a wide area of distribution of a nothrotheriid species (or group of closely related species), likely *Nothropus carcaranensis*, inhabiting latitudes lower than those of Buenos Aires Province, because no elements with similar anatomical characteristics to those from La Ribera and Santa Fe studied have been recorded from sediments of late Pleistocene age in the Buenos Aires Province. It is possible that the enigmatic *Nothropus carcaranensis* of La Ribera had already become extinct at least in these southern latitudes for the last part of the Pleistocene.

A wide intraspecific variation in size in ground sloths was previously documented by occipitals of mylodontines

(Brambilla & Ibarra 2018) and it is now clear that the femora from the Santa Fe Province studied here also have a wide variation in size in adult specimens (Fig. 3). This variation could be a response to environmental factors, differences in geographical location, or even the age of the specimens, and not only sexual dimorphism.

CONCLUSION

The original material studied here, the astragalus MACN-Pv-14153 and the femur MACN-Pv-14390, extend the knowledge about the anatomy of the Nothrotheriidae from the Santa Fe Province, and especially that group of specimens discovered by O. Coronel in the 40s. The astragalus presents clear similarities with that of *N. shastensis* although the differences observed with respect to the North American species could suggest a species of local origin not belonging to the genus *Nothrotheriops*. It is very possible that all the material from La Ribera and Salado River belong to a single species, namely *Nothropus carcaranensis*, although the available specimens are not enough for a definite determination.

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