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A new record of ground sloth in the Ribeira de Iguape valley, southeastern Brazil

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Abstract: In the early 1980s, an assemblage of extinct and extant vertebrates was collected from the Abismo Ponta de Flecha, a vertical cave in southern São Paulo, Brazil, for archaeological, geological, and paleontological analyses. While materials identified as ground sloths have been referenced in earlier publications, they have never been thoroughly described. In this study, we provide the first detailed description of a large, previously unidentified taxon found in Brazil, interpreted herein as belonging to the family Nothrotheriidae. Although direct dating of the specimen was not possible, other dated occurrences from the Ribeira de Iguape Valley suggest that it may have inhabited the region during the Late Pleistocene, coinciding with the local presence of a dense forest cover.

Keywords:

- Pleistocene;
- Quaternary;
- sloths;
- *Nothrotherium*;
- Xenarthra

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Résumé : ***Un nouveau cas de paresseux terrestre dans la vallée de la Ribeira de Iguape, sud-est du Brésil.-*** Au début des années 1980, une association de vertébrés éteints et d'autres toujours existants a été récoltée dans l'Abismo Ponta de Flecha, une grotte verticale au sud de São Paulo (Brésil), en vue d'analyses archéologique, géologique et paléontologique. Bien que les matériels identifiés comme étant des paresseux terrestres aient été mentionnés dans des publications antérieures, ils n'ont jamais été décrits adéquatement. Dans cette étude, nous fournissons la première description détaillée d'un grand taxon encore non identifié, découvert au Brésil, et interprété ici comme appartenant à la famille des Nothrotheriidae. Bien qu'il n'ait pas été possible de dater directement ce spécimen, d'autres découvertes datées de la vallée de la Ribeira de Iguape suggèrent qu'il aurait pu habiter la région à la fin du Pléistocène, ce qui coïncide avec la présence locale d'un couvert forestier dense.

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Mots-clefs :

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- Quaternaire ;
- paresseux ;
- *Notrotherium* ;
- Xenarthral

1. Introduction

Brazil was once inhabited by various species of extinct sloths (Xenarthra, Pilosa) that thrived in diverse environments. In the Quaternary faunas of Brazil, ten species from four different families have been identified, the latter being Megatheriidae, Mylodontidae, Megalonychidae, and Nothrotheriidae (Cartelle *et al.*, 2008, 2009, 2019). However, recent studies by Presslee *et al.* (2019) and Casali *et al.* (2022) elevated Scelidotheriidae and Megalocnidae (Caribbean ground sloths) to the family level, with the latter being reinterpreted as a superfamily (Megalocnoidea) by Delsuc *et al.* (2019).

The region of the Ribeira de Iguape Valley, in the southern state of São Paulo, features a system of caves developed in Precambrian carbonate rocks. Paleontological and archaeological research in this area commenced in the late 19th century, revealing that many of these caves preserve fossil remains of extinct ground sloths (Krone, 1898; Ameghino, 1907; Paula Couto, 1973). The Abismo Ponta de Flecha Cave, a complex vertical cave in the Ribeira de Iguape Valley (Fig. 1), has yielded a fossil assemblage of extinct and extant vertebrates (Chahud, 2022a; Chahud *et al.*, 2022, 2023a, 2023b). The first mention of sloths in this cave was by Barros Barreto *et al.* (1984). Subsequent references to the sloth material from Abismo Ponta de Flecha Cave were primarily found in the survey conducted by Ghilardi *et al.* (2011), who utilized previously published data. The present contribution aims to describe a femur belonging to a large Nothrotheriidae and provide paleoecological and paleoenvironmental insights.

2. Materials and methods

The Abismo Ponta de Flecha Cave is situated in Iporanga county, southern São Paulo state, Brazil (Fig. 1). The osteological material was collected between 1981 and 1982, and comprises 1386 elements, predominantly faunal remains, although a few archaeological remains have also been gathered (Barros Barreto *et al.*, 1984; Chahud, 2021, 2022b). The cave, whose geographic coordinates are 24° 33'38" S, 48° 41'08" W, is largely oriented 30-40° /70-80° SE in the region of Ribeira de Iguape Valley (Barros Barreto *et al.*, 1984). The deposits were excavated from galleries, known as '*jazidas*', and the position of each element collected was meticulously recorded. The subject of this study originated from *Jazida* 10 (J10), which preserves the greatest volume of sediments and osteological materials, primarily due to intense reworking by water (Barros Barreto *et al.*, 1984).

The material were analyzed using identified specimens from the Cuvieri Cave, curated at the Laboratory of Human Evolutionary Studies (LEEH) of the Biosciences Institute at the University of São Paulo (IB-USP). Additionally, the following references were consulted: Ameghino (1907), Kraglievich (1926), Lund (1950), Paula Couto (1954, 1979, 1980), Cartelle and Fonseca (1982), Cartelle and Bohórquez (1986), De Iuliis (1994), Toledo (1998), Pujos (2001), Cartelle *et al.* (2008, 2009), Ghilardi *et al.* (2011), Brandoni and Vezzosi (2019), Vezzosi *et al.* (2019), McDonald (2023), Pujos *et al.* (2023), and Varela *et al.* (2023a, 2023b).

The specimen described in this study is curated at the Laboratory of Systematic Paleontology within the Department of Sedimentary and Environmental Geology at the Institute of Geosciences of the University of São Paulo. The specimen has been assigned two numbers for the current study: the first, associated with field collection, bears the prefix "PF-", and the second is designated "GP/2C-", indicating its occurrence in the collection, IGc-USP.

3. Chronology

The Abismo Ponta de Flecha Cave presents a diverse array of macrovertebrates typical of the present-day fauna, with a few specimens attributed to extinct species of the Quaternary megafauna (Chahud, 2022a, 2022b; Chahud *et al.*, 2023b).

To date, only one such specimen has undergone dating. The initial dating, conducted by Baffa *et al.* (2000), employed electron spin resonance (ESR) to date a premolar of *Toxodon platensis* (PF-997/GP/2C-533E), resulting in an age of 6,700 ± 1,300 BP from dentine and 5,000 ± 1,600 BP from dental enamel. Later, a ^{14}C AMS date for the same specimen produced ages of 11,380 ± 40 BP (13,150-13,770 cal BP) and 11,090 ± 40 BP (12,900-13,180 cal BP). These ^{14}C data suggest that the specimen probably lived around the Pleistocene/Holocene boundary (Neves *et al.*, 2007). Other dates attributed to extinct Quaternary large mammals from the Ribeira de Iguape Valley are mostly less than 20,000 years, with specimens of *Catonyx cuvieri* and *Toxodon platensis* displaying ages younger than 14,000 years (Table 1).

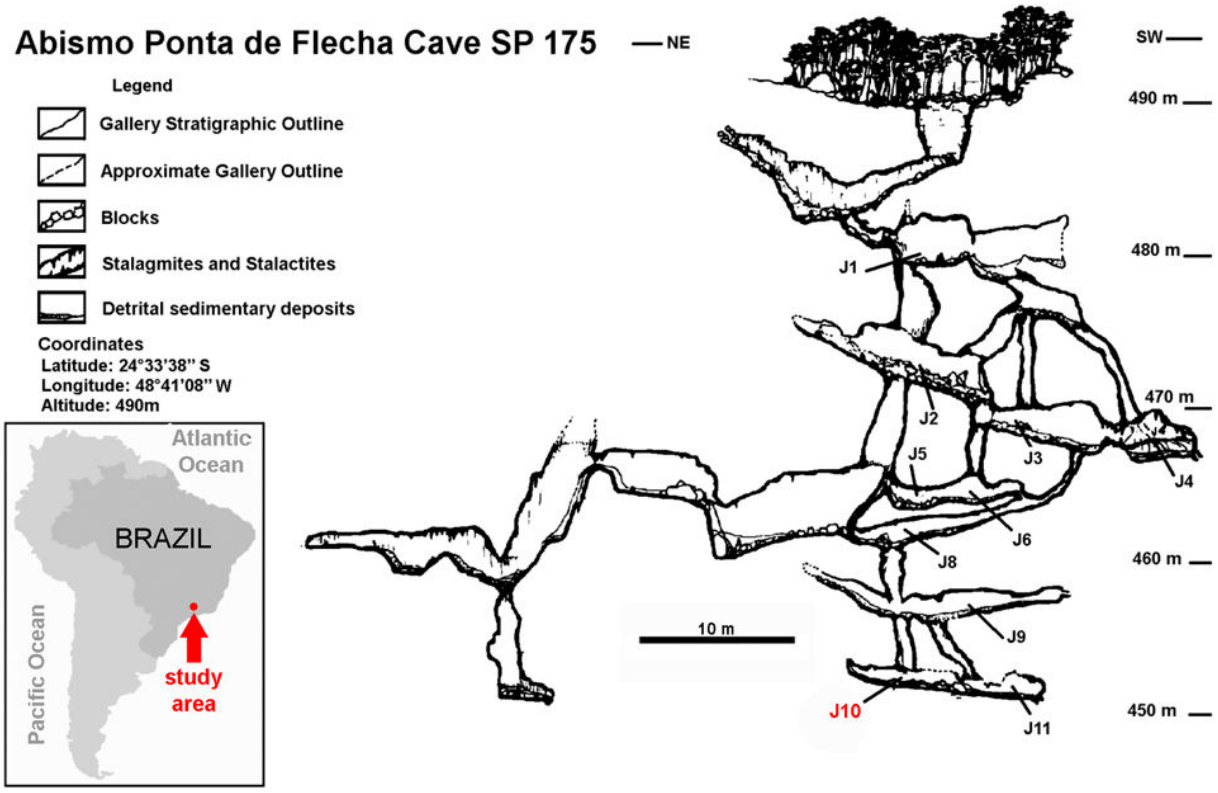

Figure 1: Schematic profile of the Abismo Ponta de Flecha Cave, SP 175. The location of the galleries (*Jazidas*, "J") preserving osteological material (J1-J11) is indicated (Barros Barreto *et al.*, 1984).

Table 1: Ages of specimens of the megafauna from the Ribeira de Iguape Valley (Neves *et al.*, 2007; Hubbe *et al.*, 2011, 2013). * curated in the Institute of Geosciences of the University of São Paulo, ** curated in the Museum of Zoology of the University of São Paulo.

Sample	Taxon	Cave name	Conventional age (^{14}C yr BP)	2σ calibration (cal yr BP)
PF-997/GP/2C-533E*	*Toxodon platensis*	Abismo Ponta de Flecha	11,380 ± 40	13,150-13,770
PF-997/GP/2C-533E*	*Toxodon platensis*	Abismo Ponta de Flecha	11,090 ± 40	12,900-13,180
GP/2E-706*	*Catonyx cuvieri*	Abismo Iguatemi	10,800±60	12,860-12,580
GP/2E-716*	*Smilodon populator*	Abismo Iguatemi	14,580±90	18,030-17,260
MZSP-PV454**	*Toxodon platensis*	Abismo do Fóssil	11,850±70	13,860-13,460
MZSP-PV610**	*Eremotherium laurillardi*	Abismo do Fóssil	12,550±60	15,130-14,240
MZSP-PV773**	Indeterminate Ground Sloth	Abismo do Fóssil	15,230±70	18,680-18,060
MZSP-PV642**	Scelidotheriinae	Abismo do Fóssil	15,780±80	19,310-18,710
MZSP-PV660**	*Glyptodon* sp.	Abismo do Fóssil	17,800 ± 70	20,680-21,370

4. Systematic paleontology

Superorder Xenarthra Cope, 1889

Order Pilosa Flower, 1883

Family Nothrotheriidae Ameghino, 1920

Subfamily Nothrotheriinae Ameghino, 1920

Genus *Nothrotherium* Lydekker, 1889

***Nothrotherium* sp.**

(Fig. 2)

Material and occurrence: The specimen is represented by a left femur, PF-990/GP/2C-559 (Fig. 2), which lacks the distal part; found in *Jazida* 10 of Abismo Ponta de Flecha cave.

Description: The specimen exhibits a fragmentary femoral head, with incrustations and several superficial fractures (Fig. 2). The greater trochanter region is elongated, is slightly inclined downward with respect to the femoral head, and exhibits a small natural cavity on the posterior face (trochanteric fossa). The third trochanter is not prominent, and a slight curvature exists between it and the greater trochanter. Distal to the femoral head, the lesser trochanter displays evidence of abrasion. The diaphysis is elongated, straight and flat, and decreases in width towards the distal region.

Measurements of the femur, as well as those of other specimens taken from the literature, are presented in Table 2.

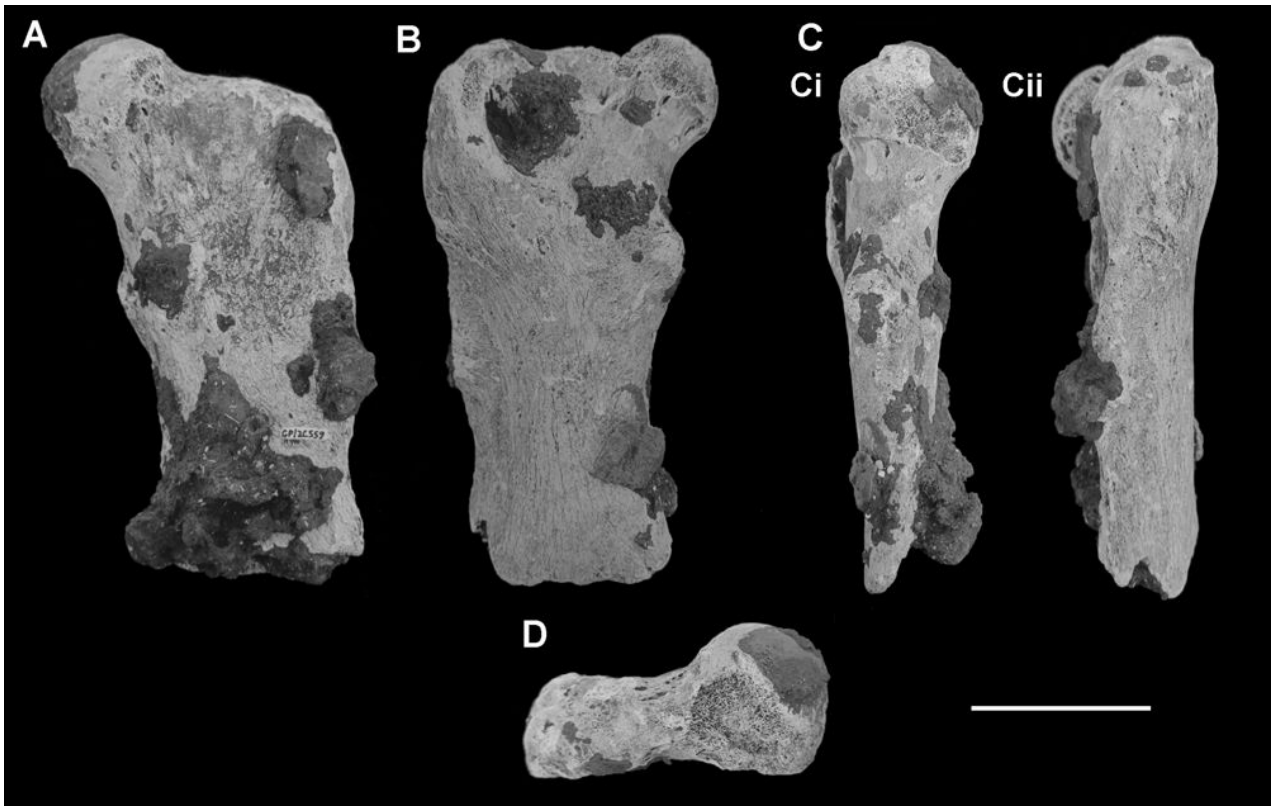

Figure 2: Femur of *Nothrotherium* sp. from the Abismo Ponta de Flecha Cave (PF-990/GP/2C-559). A) Anterior view, B) Posterior view, C, Ci and Cii) Lateral views, D) Proximal view. Scale bar = 100 mm.

Table 2: Measurements of proximal femora from species of Nothrotheriinae. Data taken from CARTELLE and FONSECA (1982), BRANDONI and VEZZOSI (2019), and VEZZOSI *et al.* (2019). The number of specimens used to estimate measurement is presented in parentheses.

Specimen	Maximum width of proximal part	Diameter of femoral head	Minimum width of diaphysis
PF 990/GP/2C-559	**150**	**~76.5**	**94.5**
Nothrotherium torresi	194	88	---
Nothrotherium cf. *torresi*	179.81	89.08	---
Nothrotheriops sp. MCRS 199	149	----	---
Nothrotheriops shastensis	145.6-182.1 (6)	77.5-86.2 (6)	112
Nothrotheriops texanus	156.8-175.2 (9)	73.3-86 (10)	---
Nothrotherium maquinense	87-105.4 (7)	50	54-55 (2)
Pronothrotherium typicum	146.7	67	---
Mionothropus cartellei	131	---	---
Nothrotheriinae indet. MACN Pv 14148	190	98	---
Nothrotheriinae indet. MACN Pv 14172	206	---	---
Nothrotheriinae indet. MACN Pv 14149	180	85	---

Discussion: The external morphology of the proximal part of the femur and the fully fused epiphysis precludethis specimen's being from to a young sloth of the Mylodontidea or Megatheriidae (CARTELLE & DE IULIIS, 1995; CARTELLE *et al.*, 2008, 2009). The angle formed by the greater trochanter and the femoral head differs from that observed in previously described Brazilian Megalonychidae (CARTELLE *et al.*, 2008). When compared to the known forms of Nothrotheriinae (Table 2), the specimen displays a maximum proximal femoral width greater than that of *Nothrotherium maquinense* and specimens of *Nothrotheriops texanus*, being similar in size to *Nothrotheriops shastensis*, while smaller than the femora attributed to *Nothrotherium torresi* and the indeterminate Nothrotheriinae studied by BRANDONI and MCDONALD (2015), BRANDONI and VEZZOSI (2019), and VEZZOSI *et al.* (2019). Although the femoral head is fragmented, it can be inferred that it was approximately the size of that of *Nothrotheriops texanus* and much larger than that of the only Nothrotheriinae ever described from the region, *Nothrotherium maquinense*.

We emphasize that the specimens of *N. maquinense* described from Brazil include subadults and young adults, with a previously reported instance of a young female with a fetus (CARTELLE, 1994; PUJOS *et al.*, 2023). The specimen discovered at the Abismo Ponta de Flecha cave is larger than previously described representatives of *N.*

maquinense (Cartelle & Fonseca, 1982; Brandoni & Vezzosi, 2019; Vezzosi *et al.*, 2019), and morphological differences in the proximal and medial part of the femur suggest that it represents a distinct species. While the external morphology of the specimen is indistinguishable from the femur of *Nothrotherium torresi* described by Kraglievich (1926), the measurements indicate that it represents a small individual. The key feature that makes this specimen similar to Kraglievich's (1926) is the slight curvature between the lesser third trochanter and the greater trochanter. In contrast, another specimen identified as *Nothrotherium* cf. *torresi* by Vezzosi *et al.* (2019) displays a much more robust greater trochanter and a prominent third trochanter.

The specimens of large Nothrotheriinae and *Nothrotheriops* studied by Brandoni and McDonald (2015) and Brandoni and Vezzosi (2019) are considerably more robust than the Abismo Ponta de Flecha Cave specimen. Additionally, a curvature is observed between the greater trochanter and the third trochanter.

Nothrotherium torresi was described on the basis of a single femur, a practice that may be considered dubious. Therefore, we have opted to designate the specimen studied herein as belonging to *Nothrotherium* sp. Multiple nothrotheres, including *N. torresi*, have been reported from the Upper Pleistocene of Argentina based on a few bones, and McDonald (2023) suggested that many of these taxa may eventually become junior synonyms. However, the systematic content of the genus *Nothrotherium* needs further clarification, as several of these specimens, such as those presented by Brandoni and McDonald (2015) and Vezzosi *et al.* (2019), display different dimensions and morphologies, necessitating a review of the genus.

Last but not least, we emphasize that the classification of our specimen within the genus *Nothrotherium* is based on its anatomical similarities with those described by Kraglievich (1926), Brandoni and McDonald (2015), and Vezzosi *et al.* (2019). It is important to note that the specimen from the Abismo Ponta de Flecha cave, along with those found in Argentina, also bears resemblance to some ancient species of Megalonichidae (Brandoni, 2009). Therefore, the family-level assignment of these materials remains an open question, and they may represent a yet-to-be-described genus.

5. Paleoecological comments

The paleoecology of several species of extinct sloths was examined by Dantas and Santos (2022) who suggested that *Nothrotherium maquinense* probably had a diet very imilar to that of extant sloths. Vezzosi *et al.* (2019) proposed that *Nothrotherium torresi* inhabited humid environments, and that the genus *Nothrotherium* tolerated a variety of environments, from cold and arid to warm and humid.

In the last 14,000 years, the region of Ribeira de Iguape Valley, where the Abismo Ponta de Flecha Cave is located, experienced very few environmental and paleoclimatic changes. It has been proposed that the modern forest was established after this period (Saia, 2006). Unfortunately, it has not been possible to date our specimen, and the absence of organized stratigraphy thwarted attemps to formulate a reliable chronological inference. Nevertheless, given (1) the presence of some megafaunal species after the proposed period of forest establishment (e.g., *Catonyx cuvieri*, recorded in the Ribeira Valley around the Pleistocene/Holocene boundary; Hubbe *et al.*, 2013) and (2) the likelihood that *Nothrotherium* inhabited humid environments (Vezzosi *et al.*, 2019), we cannot rule out the possibility that our specimen lived at a time when dense forest cover had already been established.

6. Conclusions

The presence of a large species of Nothrotheriinae has been observed for the first time in Brazil. Originating from the Abismo Ponta de Fecha Cave, the individual is known only from a femur and shares a similar shape with *Nothrotherium torresi* from Argentina. However, it differs from the latter species in its smaller size, leading us to classify it as belonging to *Nothrotherium* sp.

We believe that the classification of this species, along with other large Nothrotheriinae, would greatly benefit from a detailed systematic revision, which should include the study of better preserved specimens. It should then be possible to confirm the validity of several species that have been described within the group of large Nothrotheriinae.

While we lack specific dates for the specimen from Abismo Ponta de Flecha Cave, it is reasonable to suggest that it inhabited the region during the Late Pleistocene, if not the Early Holocene, corresponding to a period when the modern dense forest was expanding over the Ribeira de Iguape Valley region.

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