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Eremotherium (*Xenarthra, Mammalia*) das coleções da Universidade Federal de Goiás, Brasil

Eremotherium (*Xenarthra, Mammalia*) from the collections of the Universidade Federal de Goiás, Brazil

Eremotherium (*Xenarthra, Mammalia*) de las colecciones de la Universidade Federal de Goiás, Brasil

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Resumo

Este estudo tem como objetivo realizar uma descrição detalhada dos materiaisde *Eremotherium* depositados em coleções paleontológicas da Universidade Federal de Goiás. Esses espécimes de preguiças gigantes incluem um conjunto de fragmentos associados de fêmur e vértebras, um fragmento de tíbia e dois fragmentos superiores esquerdo e direito. Este estudo foi realizado com base em levantamentos bibliográficos, descrições morfológicas e comparações de espécimes. Apesar de sua condição fragmentária, o tamanho e os aspectos morfológicos dos fósseis apresentam características diagnósticas que apóiam a identificação taxonômica como *Eremotherium*. Esses novos espécimes aqui descritos contribuem para aumentar e fortalecer a paleontologia do estado de Goiás, o que pode incentivar futuros investimentos em pesquisas em coleções, atividades de campo e pesquisa, aprimorando o conhecimento sobre mamíferos pleistocenos do Brasil Central.

Palavras chaves: Coleção paleontológica; Paleomastozoologia; *Eremotherium*; Goiás.

Abstract

This study aims to conduct an unprecedented detailed description of the *Eremotherium* materials housed at the paleontological collections of the Universidade Federal de Goiás. These giant sloth specimens include a set of associated femur and vertebrae fragments, one fragment of tibia, and two left and right maxillary fragments. This study was carried out based on bibliographic surveys, morphological descriptions, and specimens comparisons. Despite their fragmentary condition, the size and morphological aspects of the fossils show diagnostic characteristics that support taxonomic identification as *Eremotherium*. These new specimens described here contribute to increasing and strengthening the Goiás State paleontology, which

may encourage future research investments in collections, field activities, and research, enhancing the knowledge on Pleistocene mammals of Central Brazil.

Keywords: Paleontological collection; Paleomastozoology; *Eremotherium*; Goiás State.

Resumen

El objetivo de este estudio es realizar una descripción detallada sin precedentes de los materiales de *Eremotherium* alojados en las colecciones paleontologícas de la Universidade Federal de Goiás. Estas muestras de perezosos gigantes incluyen un conjunto de fragmentos asociados de fémur y vértebras, un fragmento de tibia y dos fragmentos maxilares izquierdo y derecho. Este estudio se realizó en base a encuestas bibliográficas, descripciones morfológicas y comparaciones de especímenes. A pesar de su condición fragmentaria, el tamaño y los aspectos morfológicos de los fósiles muestran características de diagnóstico que apoyan la identificación taxonómica como *Eremotherium*. Estos nuevos especímenes descritos aquí contribuyen a aumentar y fortalecer la paleontología del estado de Goiás, lo que puede alentar futuras inversiones en investigación en colecciones, actividades de campo e investigación, mejorando el conocimiento sobre los mamíferos del Pleistoceno del centro de Brasil.

Palabras clave: Colección paleontologíca; Paleomastozoología *Eremotherium*; Goiás.

1.Introduction

The Universidade Federal de Goiás (UFG) has two laboratories with paleontological collections: the Laboratório de Paleontologia e Evolução (Labpaleoevo) of the Geology Course at the Aparecida de Goiânia *Campus*, and the Laboratório de Geologia Aplicada (Labgeo), of the Geography Course, at the Instituto de Estudos Socioambientais at the Samambaia *Campus*. Both laboratories have been receiving fossil specimens found in field expeditions, especially in the Goiás State, which are curated, analyzed, and studied.

Goiás State has few mammal fossil records when compared to other Brazilian regions. The first *Eremotherium* record described to this region was in the 1960's (Moreira & Mello, 1969). A significant number of specimens identified as Megatheriidae were discovered in the Jaupaci municipality, Midwest Goiás State, but much of this material has not been formally described yet. Materials of *Eremotherium* and *Notiomastodon* (isolated teeth and bone fragments of mandible, maxilla, vertebrae, ribs, sacrum, humerus, femur, and ungueal phalanges) were found in the paleontological site known as Pau Ferrado (Jaupaci, Goiás State). Part of these specimens are housed at the Natural History Museum/Memorial do

Cerrado of the Instituto do Trópico Sub-Úmido of the Pontifícia Universidade Católica de Goiás, in Goiânia city (Paulo, 2014, p. 96).

In 2006, two fossil fragments (a rib and a femur) were found in the Jaupaci municipality, Goiás State, donated to Labgeo, and remained undescribed and unpublished. In 2017, the Labpaleoevo collection received fragments of a tibia and a left and right maxillary bones, found in the Piranhas municipality, dated to the Late Pleistocene by Oliveira (2018).

Considering the few studies and publications on fossil mammals from the Central Brazil, it is important to survey the Labgeo and Labpaleoevo collections, in order to increase the information on the mammalian fossil record of this region. In this way, this study aims to describe, for the first time, the giant sloth specimens housed at the Federal University of Goiás fossil Collections and to fill the regional gap for occurrence and geographic distribution of this extinct megamammal in Brazil.

2. The Giant Xenarthra: *Eremotherium* Spillman, 1948

Xenarthra is a Superorder of basal mammals with Neotropical distribution, comprising three living groups: Cingulata (armadillos), Vermilingua (anteaters), and Tardigrada (sloths) (Wetzel, 1985). The main synapomorphy of this Superorder is the presence of an accessory articulation in the lumbar vertebrae, called xenarthry, which names the Order. The Suborder Tardigrada (=Folivora) includes the families Bradypodidae, Megatheriidae, Mylodontidae, Megalonychidae, and Nothrotheriidae, and the genera *Bradypus* (“three-toed sloth”) and *Choloepus* (“two-toed sloth”) are its only living representatives. Despite the superficial similarities between these genera, which once led them to be assigned to the same Family (Webb, 1985), recent phylogenetic analysis suggest that Bradypodidae family diverged early in the Tardigrada evolution, at least 40 million years before present (Gaudin, 2004).

Among the extinct sloths, the genus *Eremotherium* stands out for the amount of records, especially in Brazil, as well as for its wide geographic distribution throughout the Americas (Cartelle & De Iuliis, 1995). According to Cartelle & De Iuliis (*op. cit.*), *Eremotherium* weighed approximately five tons, and could reach six meters in length and almost two meters of height in the quadrupedal position.

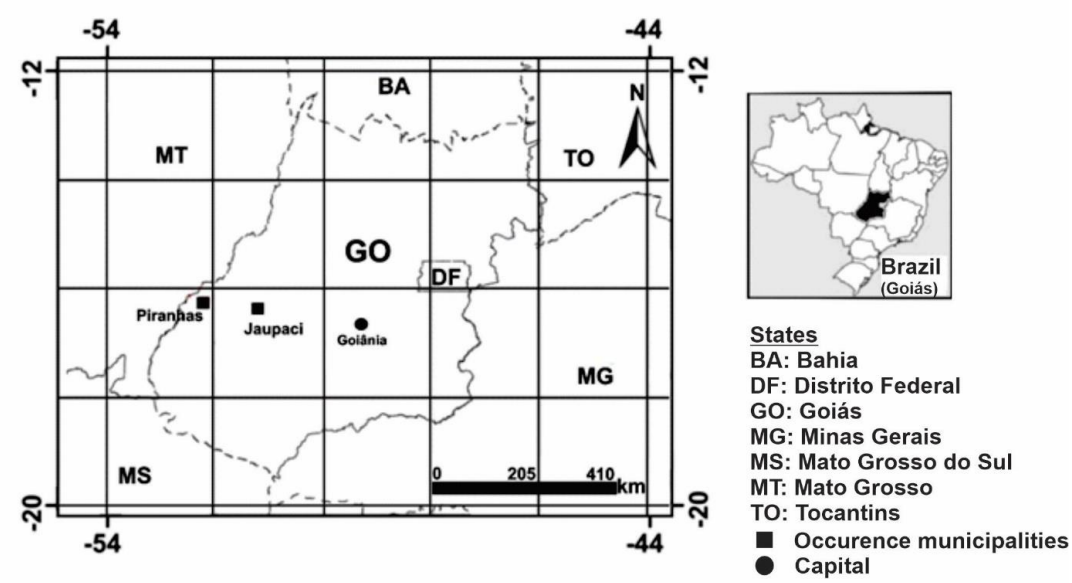
Silva (2015) performed a dental microwear analysis on *Eremotherium* specimens from Northeastern Brazil and found a different diet pattern from the one previously proposed to other Xenarthra. This genus had a feeding habit that equivalent to generalist

megaherbivores, i.e., a diet that included both C3 and C4 plants. CAM plants have been indicated as an occasional food resource for *Eremotherium laurillardi* in northeast Brazil (França *et al.*, 2014). However, data from dentine microwear of some extinct Xenarthra suggests that taphonomic alterations may be a limiting factor to interpret paleodiets (Haupt, 2012). Stable carbon isotope analysis show that *E. laurillardi* could live in both savannah and forest environments with intertropical distribution, tolerating different climate conditions (Ghilardi, 2011). The Goiás State is part of the paleozoogeographic region known as Brazilian Intertropical Region, which is interpreted as having a dry environment with open vegetation during the Pleistocene/Holocene (Oliveira *et al.*, 2017).

3. Locations and Geological Setting

The known fossil records of *Eremotherium* housed at the Labgeo collection are from the Jaupaci municipality, and the ones from the Labpaleoevo collection were found in the Piranhas municipality (Figure 1).

Figure 1. Geographical location of the municipalities of Jaupaci and Piranhas, Goiás State, where the *Eremotherium* specimens housed at LabGeo and Labpaleoevo were discovered.



Source: Authors.

Figure 1 shows the municipalities (squares marked on the map) of occurrences of *Eremotherium* reported so far for the state of Goiás. There are most important mammalian-bearing Pleistocene areas of the giant xenarthran of Central Brazil.

These areas were studied by researchers from Labpaleoevo e Labgeo da UFG and are potentially important for paleontological prospecting.

Within an area of approximately 527.2 km², the fossil site of Jaupaci is located at 269 km from the city of Goiânia, and 36 km from the municipality center. The fossiliferous locality is known as Localidade de Pau Ferrado, located on the left margin of the Claro River, on the lands of the Buriti Alto farm. According to Moreira (1973), the site consists of diamond gravels and poorly consolidated conglomerates that are usually associated with pebbles and blocks of various sizes. However, all specimens are from a relatively thin alluvial gravel riverbed layer, which difficults the presence of a columnar section. The material found in this locality corresponds to a femoral head and a disarticulated and fragmented rib with moderate abrasion marks, which indicate transportation. The aspect of the deposit suggests that the material suffered a low-energy transportation. The *Eremotherium* remains are the most abundant material in this locality (Moreira, 1973).

Although the Pau Ferrado fossiliferous deposit provided a significant amount of Pleistocene megafauna remains for the Goiás State, up to date, no detailed stratigraphic studies were performed in this region. This classic fossiliferous location constitutes the most prolific area for records of fossil mammal materials in the state of Goiás, mainly *Eremotherium*. It is made up of a river remobilization deposit that at times its flows remove fossil materials downstream from the main deposit.

Recently *Eremotherium* materials were donated to the Labpaleoevo/UFG by a farmer in the region of the municipality of Piranhas. These specimens are from Pleistocene unconsolidated sediments. According Moura (2007), its formation shows characteristics of immature sedimentation, and contains conglomerates, arkosites, lithics, sandstones, siltstones, shales, and claystones, as well as psamitic deposits with conglomerates at the border of the basin.

4. Material and Methods

A reseach is made with aim in bringing new knowledge to society as stated by Pereira et al. (2018). This study describes unpublished specimens of the Labgeo that were rediscovered during the organization of the collection. The materials were properly curated and housed in the Labgeo's collection. The only published study with specimens from the Labpaleoevo is a brief description made by Oliveira (2018).

An extensive bibliographic research was carried out on the works that approach the mammalian paleontology of the study areas, retrieving the information in order to organize, in an objective and updated way, the state of knowledge about the mammalian of the state of Goiás. Articles with specific morphological data or of relevance to the study are being raised to provide a basis for anatomical comparisons and correct identification of materials. After the osteological descriptions, the specimens and their diagnostic features were photographed with High Resolution digital camera.

The fossils studied here include a vertebral body, a left femoral head, left and right fragments of a skull, and fragments of the distal epiphysis of the tibia; all which are part of the collection of two laboratories of the UFG. The vertebral body and the left femoral head are part of the collection of the Labgeo of the Geography course of the Instituto de Estudos Socioambientais (IESA) (Paleo-IESA/V-012 Paleontologia - Instituto Socioambientais / Vertebrados), while the right (Paleo-UFG / V0029) and left (Paleo-UFG / V0030) skull fragments, and the distal epiphysis of the tibia (Paleo-UFG/V0031) are housed at the Labpaleoevo of the Geology course.

The fossil specimens are partially preserved is not fixed to the rock matrix, but inserted few fine sediments in small parts and needs restoration after mechanical cleaning. Mechanical preparation of specimens was made using a dental scaler and carver, brushes of different sizes and reinforced needles for abrasion, and thus removal of the fine sediments. A magnifying glass was also used to better observe the edges and contact points between the fossil and its matrix. Once the matrix was removed, the fragile specimens were treated with a 10% paraloid solution to confer greater resistance. After these procedures, portions of the specimen were glued together, but two fragments. The binding was made with cyanoacrylate glue (C5H5NO2). One more application of 10% paraloid solution was made to finalize the material preparation. Only then the material was able to be handled for obsevations.

5. Results

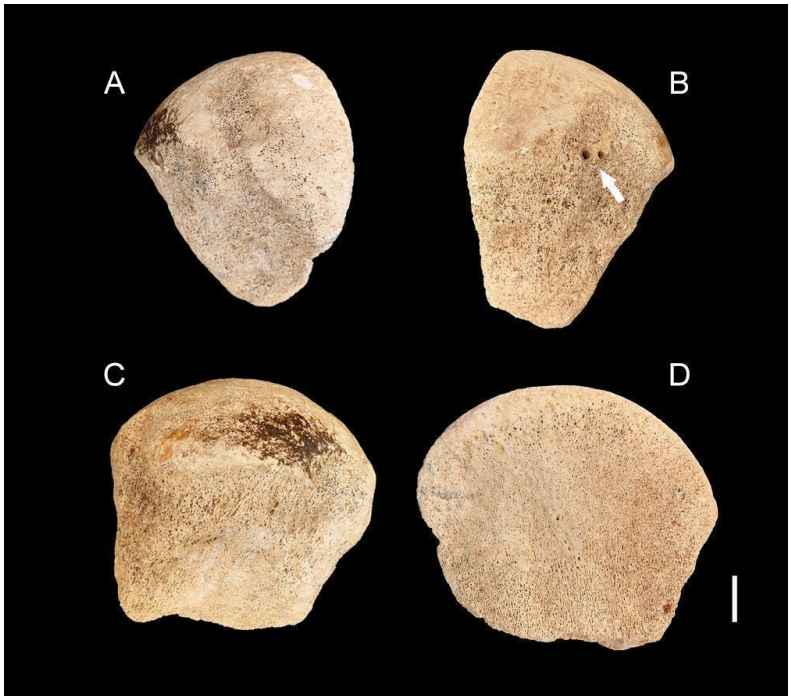
The following is a description of the *Eremotherium* specimens housed at UFG from Jaupaci and Piranhas municipalities.

Paleontological Systematics
Superorder Xenarthra Cope, 1889
Order Pilosa Flower, 1883
Suborder Tardigrada Latham & Davis, 1795

Superfamily Megatherioidea Gray, 1821
Family Megatheriidae Gray, 1821
Subfamily Megatheriinae Gill, 1842
Eremotherium Spillman, 1948

Paleo-IESA/V-0010 (Figure 2) corresponds to a fragment of the proximal epiphysis of a left femur. The proximal articular surface has semi-spherical shape and smooth texture. There are two fractures: an irregular one at the region where it articulates with the femoral neck, and a right-angled transverse fracture in the sagittal axis of the femoral head, where it articulates with the acetabulum. The cancellous bone is exposed on the fractured region, and presents a trabecular structure nearly oriented along the proximal-distal axis, towards the articular surface. It is possible to observe the femoral fovea at the postero-medial portion of the femoral head, where there are two foramina for the passage of ligaments and blood vessels, possibly respective to a branch of the obturator artery.

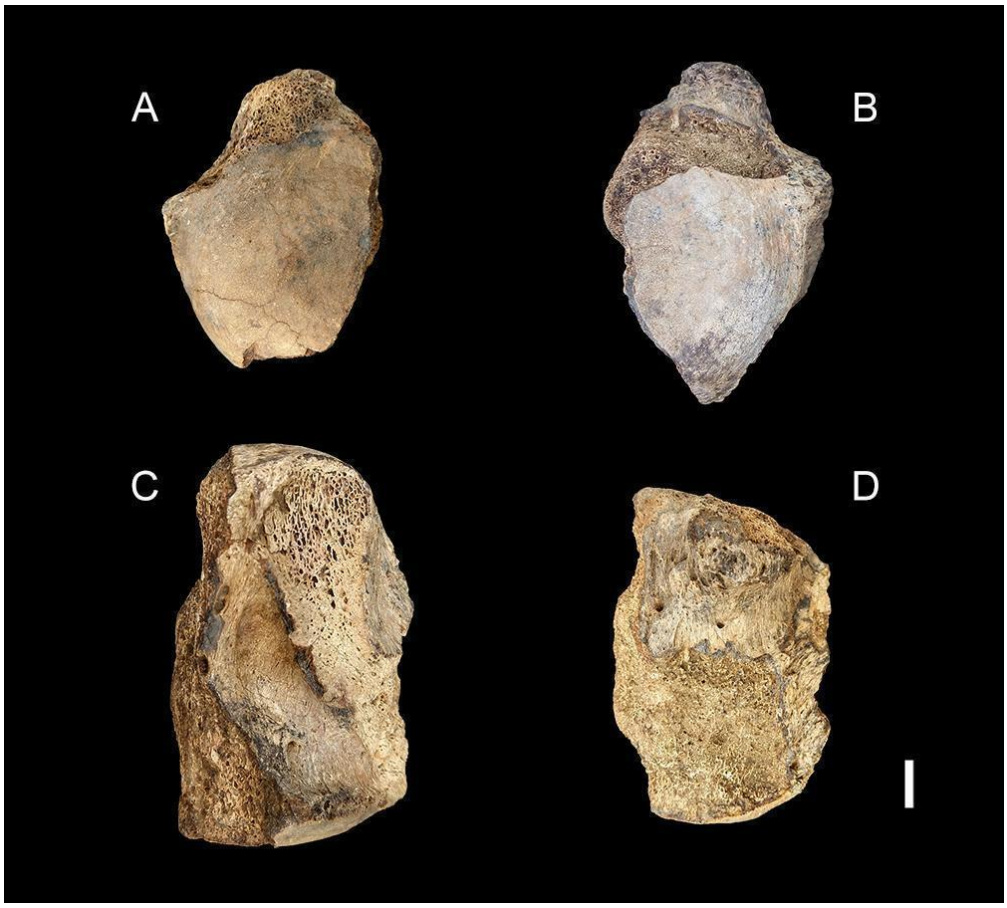
Figure 2: *Eremotherium* specimen Paleo-IESA/V-0012, a fragment of the proximal epiphysis of the left femur. A. Anterior view. B. Posterior view; the arrow shows the fovea. C. Medial view. D. Lateral view. Scale bar: 20 mm.



Source: Authors.

Paleo-IESA/V-0013 (Figure 3) is a vertebral body fragment of an acoelous vertebra with some remnants of the bone processes (which are not preserved).

Figure 3: *Eremotherium* specimen Paleo-IESA/V-0013, a vertebral body fragment. A. Anterior view. B. Posterior view. C. Ventral view. D. Dorsal view. Scale bar: 10 mm.



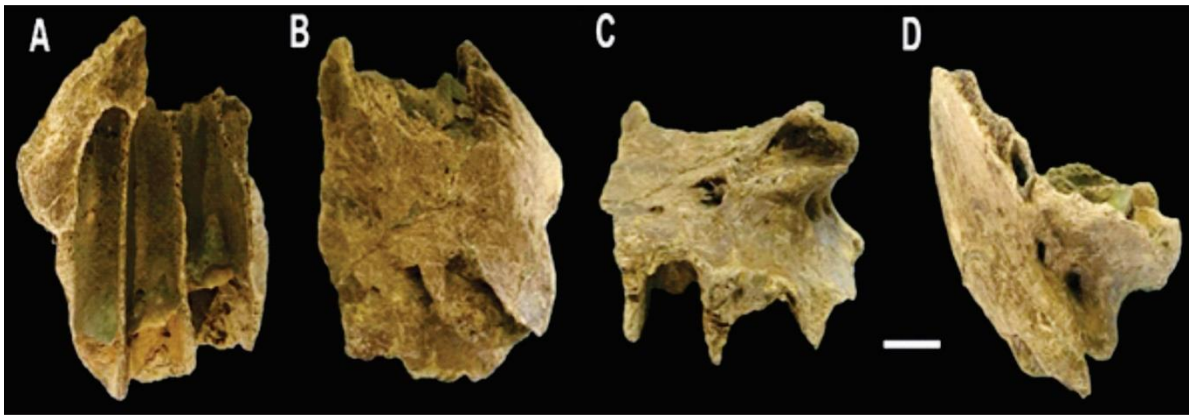
Source: Authors.

On its cranial aspect, there is a prominence that could be the base of the left pre-zygapophysis, with the articular surface only half preserved. The material has 9 cm of dorso-ventral length, 6.8 cm of lateral length, and 10.8 cm of craniocaudal thickness.

Paleo-UFG/V0029 is a cranial fragment corresponding to part of the right maxilla, the lacrimal bone, and part of the zygomatic bone (Figure 4). The lateral view of the maxilla shows the junction of the articular facet with the zygomatic bone.

The maxilla has two foramina at the region of the infraorbital foramen, in contrast with the single foramen usually seen in the taxon. In medial view, the interior of the alveoli are observable, but the lingual portion is not preserved. In the ventral view, it is possible to observe the M1-3 alveoli; however, all teeth are absent.

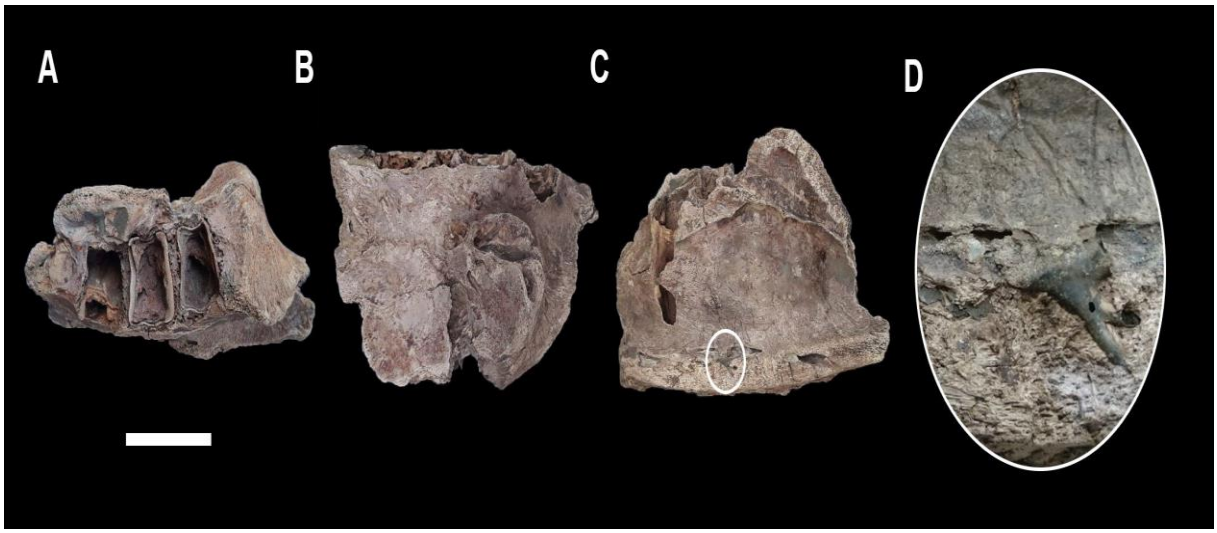
Figure 4: *Eremotherium*. Paleo-UFG/V0029. A. Lingual view. B. Lateral view. C. Occlusal view. D. Area of the infraorbital foramen in detail. Scale bar: 20 mm.



Source: Authors.

Paleo-UFG/V0030 is a cranial fragment with an incomplete left maxilla and zygomatic bone, and the palatine and lacrimal bones (Figure 5). In lateral view, the articular surface of the zygomatic bone can be seen. There is only one infraorbital foramen in the maxilla. In ventral view, the first and the second molar teeth are present, but their occlusal surfaces show signs of wear and, thus, are absent. The third molar is absent and its alveolus is filled with sediment. The palatine bone can be seen in the medial view and shows preserved vascular channels.

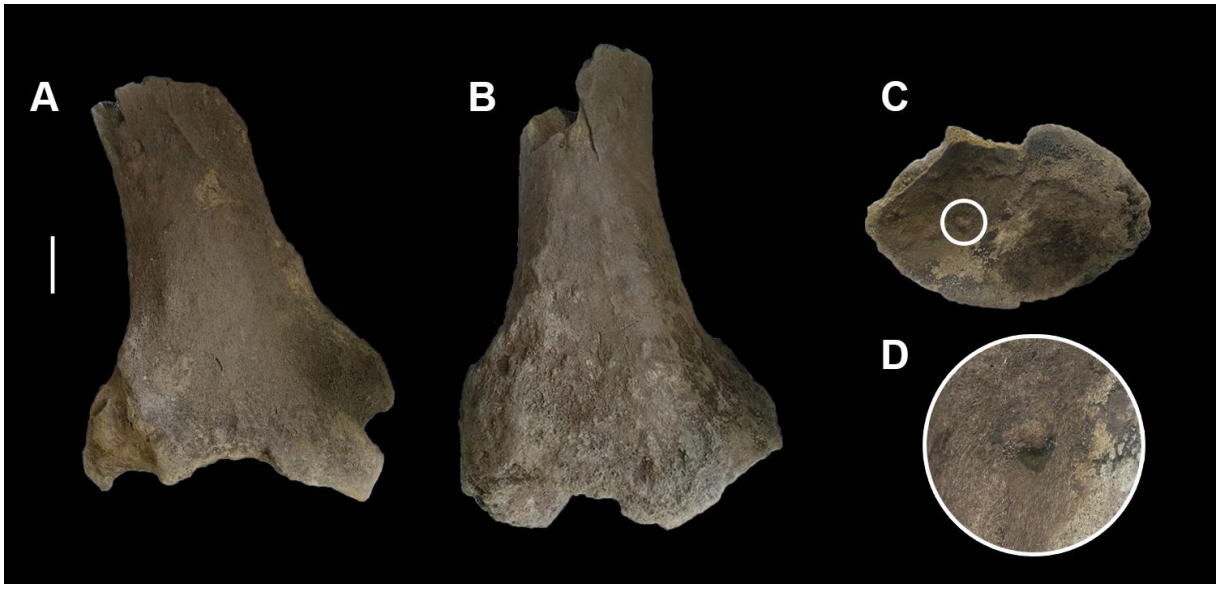
Figure 5: *Eremotherium*. Paleo-UFG/V0030. A. Occlusal view. B. Lateral view. C. Lingual view. D. In detail, structures that resemble blood vessels. Scale bar: 50 mm.



Source: Authors.

Paleo-UFG/V0031is an incomplete tibia (Figure 6) presenting the diaphysis and the distal epiphysis.

Figure 6: *Eremotherium* specimen Paleo-UFG/V0031, an incomplete tibia. A. Anterior view. B. Posterior view. C. Inferior view. D. In detail, a structure that has characteristics of an osseous disease. Scale bar: 2 mm.



Source: Authors.

In the proximal view, it is possible to observe the inner portion of the compact bone and the medullary channel. In the distal view, there is the articular surface where the astragalus articulates. This area also presents rounded button-shaped protuberances, possibly of pathological origin (Fig.6C-D). The fibular incisure and the malleolar groove are well preserved.

6. Discussion

The comparisons of the left and right skull fragments of the Labpaleoevo with the study of Cartelle & De Iuliis (2006) indicated that the material described here is compatible with the genus *Eremotherium.* Even though the specimen is not fully preserved, we analyzed the size, morphology, and number of teeth and alveoli present in the maxilla. *Eremotherium* has homodont dentition with 5 upper molars (M1-M5) of prismatic shape.

In both cranial fragments, only the base of the zygomatic bone is preserved with the infraorbital foramen (*sensu* Cartelle & De Iuliis, 2006), but there is variation between

specimens. The left cranial fragment shows a single foramen, while the right fragment has two foramina – a bigger and a smaller one. Variations in the morphology of this foramen, as well as the presence of an accessory foramen, are widely reported in humans (Aggarwal et al, 2015).

In the tibia, an irregular cross-section is seen in the proximal portion of the diaphysis. Due to the characteristics of the broken surface, it is possible that this fracture occurred before the burial event (Fernandez-Jalvo & Andrews, 2016). Rounded bone growths are also present on the distal articular surface of the tibia. These structures are characteristic of bone disease (Martin, 2008), but additional investigation is needed in order to confirm the nature of this paleopathology.

When analyzing the preservation state of the cranial fragments, both specimens show many fractures throughout its length. These aspects indicate that weathering processes occurred prior to fossilization, at stage 3. The surface fragmentation was caused by bone shrinkage, possibly due to loss of water or organic matter (Fernandez-Jalvo & Andrews, 2016).

Additional studies were conducted inside the Labpaleoevo (Oliveira, 2018) and included radiocarbon dating and Carbon isotope analysis on the second molar of the left cranial fragment (Paleo-UFG/V0030). The radiocarbon dating results yielded an age of 32.390 years BP (Late Pleistocene). The carbon isotope analysis indicates that this animal had a mixed feeding diet that included C3 and C4 plants, which is in accordance with the feeding habits previously suggested by other authors (Beltrão & Locks,1989; Costa *et al*. 2017; Oliveira *et al* 2017)

According to Oliveira (2018), the three specimens housed at Labpaleoevo collection (UFG) were found isolated, next to the superficial layer of the deposit composed by coarse gravel, rounded rocks, and sandstone quartz, with a total thickness of approximately three meters. These characteristics indicate that the material suffered short distance transportation.

The size of the fragmented vertebra is compatible with only two of the large-sized taxa that occurred in the region: *Eremotherium* and *Notiomastodon*. The cranio-caudal thickness of the vertebral body is 10.8 cm. This characteristic is similar to what is observed in *Eremotherium* (see Faria *et al*. 2013).

The size and morphology of the femur fragment are also compatible with the genera *Eremotherium* and *Notiomastodon*. However, it is possible to observe in this material the positioning of the femoral fovea as well as the preferential orientation of the trabecular bone.

The morphology and position of the *fovea capitis femoris* correlates with the femur-acetabulum joint fitting, which indicates the anatomical femoral posture (Jenkins & Camazine, 1977). This feature is usually used as a parameter to demonstrate the posture and life habit of vertebrates and supports distinction between taxa (e.g. Anemone, 1990; Stern, 2000; Marivaux *et al*, 2008), proving to be an informative character.

By observing the orientation of the trabecular bone, it was possible to estimate the direction of its longitudinal axis and to define the relative position of the fovea in relation to the transverse plane of the femoral head, as proposed by Jenkins & Camazine (1977). According to these authors, the observed angle suggests a more abducted position of the femur. This type of posture is equivalent to other *Eremotherium* specimens, and is distant from the graviportal posture infered to *Notiomastodon* (Ferretti, 2008).

The set of characteristics of the material suggests that it belongs to the genus *Eremotherium*, and its comparison with descriptions of other similar materials corroborates this inference (Tito, 2008; Barbosa *et. al*, 2014).

In addition to this morphological congruence, it is worth mentioning the abundance of this taxon in the Brazilian Intertropical Region (*sensu* Cartelle, 1999) and the fact that, until now, the records of ground sloths in the Goiás State as well as in the surrounding regions are exclusively assigned to *Eremotherium.* Therefore, it is reasonable to presume that the specimens described here belong to this taxon.

7. Conclusions

The fossil recovery works in non-formalized paleontological collections conducted by the team of the Labpaleoevo /Geology Course/UFG have been revealing several specimens which, despite their fragmentary nature, provide information about the fauna that inhabited the Cenozoic of the Goiás State. These new findings are not diagnostic to less inclusive levels, but represent an important sample of the materials assigned to *Eremotherium* in the Goiás State. Despite the common occurrence of this genus in many fossil sites and its wide distribution in the Brazilian Intertropical Region, these new specimens show the fossiliferous potential (fossil collections and fossiliferous localities) of that State, which contributes to the understanding of the evolution of the Brazilian and South American paleoenvironments since the end of the Cenozoic. New researches and surveys on the UFG's fossil collections are important as they will provide new discoveries and increase the scientific knowledge of regional paleontology.

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