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Xenarthra (Mammalia) from a new late Neogene fossiliferous locality in Northwestern Argentina

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A B S T R A C T

Northwestern Argentina contains one of the most complete continental late Neogene (ca. 9–2.58 Ma) fossiliferous sequences in South America, especially in the current territories of the Catamarca, Tucumán and Jujuy provinces. More precisely in Jujuy Province several localities bearing mainly fossil mammals have been reported at the Quebrada de Humahuaca in the Uquía, Maimará and Tilcara formations, in which the clade Xenarthra (Mammalia) is well-represented. In this scenario, the fossiliferous potential of other localities of Jujuy Province are less known, especially in those areas located at the northwest end of Argentina, bordering Bolivia in the Northern Puna. A new late Neogene fossiliferous locality near Calahoyo (3639 m.a.s.l), Jujuy Province, is here reported. The materials, belonging to Xenarthra, were exhumed from the base of the Tafna Formation which was deposited in a sedimentary basin by alluvial and/or fluvial currents, undergoing transitions of various lacustrine episodes. The taxa include the Tardigrada *Pyramiodontherium bergi* (Megatheriidae) and the Cingulata *Eosclerocalyptus* sp. (Glyptodontidae) and *Macrochorobates chapalmalensis* (Dasypodidae). From a biostratigraphic viewpoint, this assemblage suggests a Late Miocene-Pliocene age for the base of the Tafna Formation, and partially contradicts the supposed Plio-Pleistocene age of this unit. Finally, the new specimens here described indicate that Xenarthra were taxonomically and ecologically diverse during the late Neogene in the northwest end of Argentina, since they are represented by at least three main lineages (sloths, glyptodontids and armadillos).

1. Introduction

Neogene fossil mammals of Northwestern Argentina (NWA, currently the provinces of La Rioja, Santiago del Estero, Catamarca, Tucumán, Salta, and Jujuy) have been intensely studied since the XIX century and the first half of the XX century (see, among others, Moreno, 1882; F. Ameghino, 1891; Rovereto, 1914; C. Ameghino, 1919; De Carles, 1912; Castellanos, 1950; Marshall and Patterson, 1981; Esteban et al., 2014). Several continental sequences of this region represent almost the complete Late Neogene and earliest Pleistocene, ranging from 9 to 2 Ma (see Marshall et al., 1984; Reguero and Candela, 2011; Esteban et al., 2014). More precisely in the current territory of the Jujuy Province, several localities bearing fossil vertebrates (mainly mammals) at the Quebrada de Humahuaca, Cuenca de Humahuaca (23°–24°S), Eastern Cordillera (see Reguero et al., 2007; Reguero and Candela, 2008, 2011) have been reported. The most important are Uquía, Esquina Blanca, Chucalezna, San Roque, and Maimará, in which the Uquía (Plio-Pleistocene) and Maimará (late Miocene-early Pliocene) formations crop out with vertebrate-bearing horizons (see Salfity et al., 1984; Reguero et al., 2007; Reguero and Candela, 2008, 2011; Pujos et al., 2012; Pingel et al., 2012; Abello et al., 2015; Galli et al., 2016; Bonini et al., 2017). From a biostratigraphic viewpoint, some of them are especially important. Among them, the Uquía Formation allowed the recognition of the "Uquian Stage" (see Castellanos, 1923), which was the base for the "Uquian Land-Mammal Age" of Pascual et al. (1965; but see Cione and Tonni,

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2005).

According to the most recent evidence, the chronological distribution of these geological units (Uquía and Maimará formations) span from the late Miocene to the Pleistocene. A high diversity of vertebrates (mainly mammals) has been reported, being Xenarthrans (Mammalia) among the most conspicuous clades (Reguero and Candela, 2008, 2011; Pujos et al., 2012).

Although the late Neogene palaeofauna from the "Quebrada de Humahuaca" is relatively well known, the fossiliferous potential of other localities of Jujuy Province are less explored, especially in those areas located at the northwest end of Argentina, bordering Bolivia in the Northern Puna (Camacho et al., 2015). Recently, the first paleontological findings of mammals of the Tafna Formation (Turner, 1964; Pliocene-Pleistocene) were carried out in Calahoyo (northwest end of Jujuy Province; Fig. 1) with accurate stratigraphic control. Therefore, this paper aims to: a) report and describe the first records of a new late Neogene fossiliferous locality at the base of the Tafna Formation near Calahoyo; b) to discuss some biostratigraphic implications.

2. Materials and methods

Based upon the interpretation of aerial photographs, preliminary maps were made at 1:50.000 scale, with field survey of stratigraphy and tectonics. Profiles of the Tafna Formation were obtained in the area, with their associated textural analysis and determination of lithofacies, sedimentary structures, and fossil content. Mineralogical studies have been carried out by means of polarization microscopy. The chronological and biostratigraphic schemes used in this work are those proposed by Cione and Tonni (2005). Systematics partially follows Hoffstetter (1958), Paula Couto (1979), McKenna and Bell (1997), and Fernicola (2008). All the values are expressed in millimeters (mm), with an error range of 0.5 mm. Measurements smaller than 150 mm were taken with "vernier" calipers; measurements greater than this value were taken using an anthropometric spreading caliper. The description and terminology for osteoderms follow mainly Zurita (2007a) and Krmpotic et al. (2009).

2.1. Institutional abbreviations

PV-UNS, Colección Paleontológica de la Universidad Nacional del Sur, Bahía Blanca, Buenos Aires, Argentina; **MD-FM,** Museo Municipal de Ciencias Naturales "Carlos Darwin", Punta Alta, colección Farola Monte Hermoso, Buenos Aires, Argentina; **MMP,** Museo Municipal de Ciencias Naturales "Lorenzo Scaglia", Mar del Plata, Argentina; **MLP,** Museo de La Plata, Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, División Paleontología Vertebrados, La Plata, Buenos Aires; **MACN**, Museo Argentino de Ciencia Naturales "Bernardino Rivadavia", Buenos Aires, Argentina; **JUY-P**, Museo de Geología, Mineralogía y Paleontología, Instituto de Geología y Minería, Universidad Nacional de Jujuy, San Salvador de Jujuy, Argentina.

2.2. Anatomical abbreviations

Mf, upper molariform.

3. Geographic and geologic context

The Comarca of Calahoyo (22° 01′ 45.41″S-65° 50′ 51.54″W, 3639 m.a.s.l.) is located near the border between Argentina and Bolivia, in a depression north of the Bolson Laguna de Los Pozuelos (LLPB) (Fig. 1).

The area belongs to the Puna morphostructural unit. Puna is a large "altiplano", a high-altitude tableland, characteristic of the Central Andes. It is a biogeographical unit extending from Chile, Bolivia, Peru, and northwestern Argentina, and consists of plateaus between 3400 and 3800 m above sea level. A voluminous siliceous volcanism occurred between ca. 10–5 Ma. This volcanism, mainly composed of ignimbrites, settled over the San Juan de Oro surface. The most important periods of the crustal shortening and thickening of the Puna (the Quechua Phase) took place during the Middle to Late Miocene. After 5 Ma, following the Quechua Phase, sedimentary basins were formed (Gubbels et al., 1993). These basins were filled up with conglomerates, sandstones, mudstones, tuffs and tuffites of the Tafna Formation.

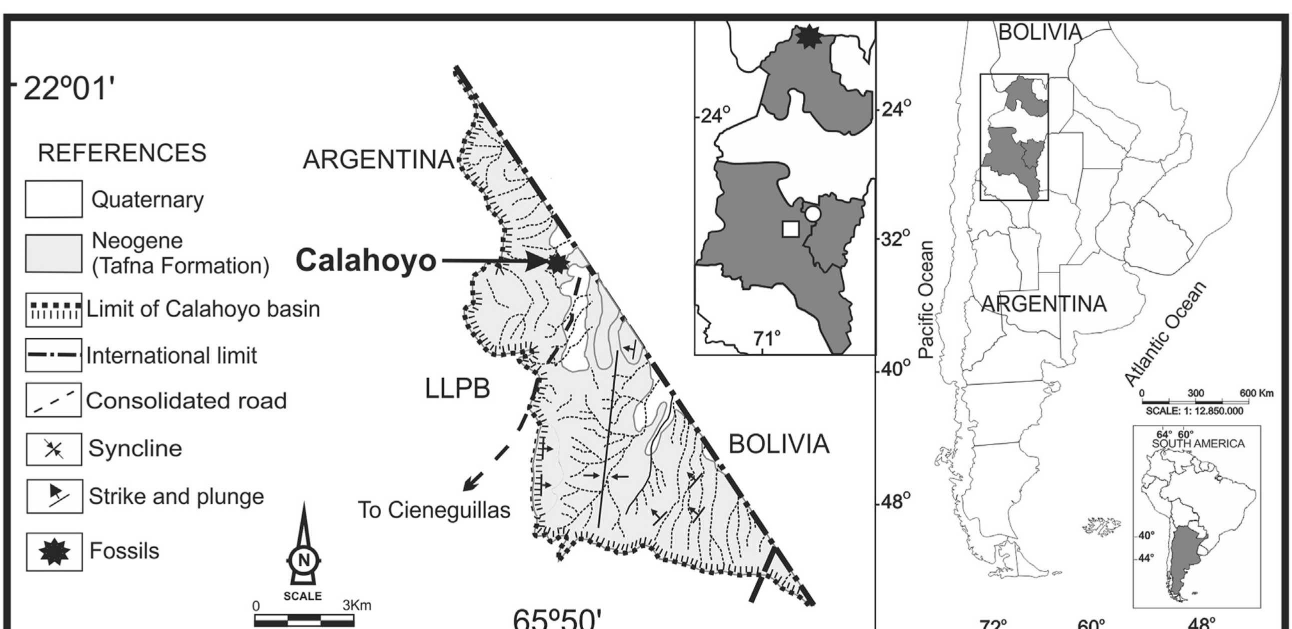

Fig. 1. Geological map of the Calahoyo basin including the studied locality and the outcropping area of the Tafna Formation. The circle indicates the locality of Tiopunco in Tucumán Province and the square the localities of Corral Quemado and Andalhuala in Catamarca Province.

As already mentioned, the geological units cropping out in the Calahoyo basin include the Tafna Formation (Pliocene-early Pleistocene, according to Turner, 1964) followed by an undifferentiated Quaternary (Fig. 1). Fossil xenarthrans were exhumed from the basal bed of the Tafna Formation. This unit was briefly described by Turner (1964), being similar to the Casira (or Kasira) Formation of Bolivia (see Claure, 1969). The age of the Casira Formation has never been well-established (Anaya et al., 1989). Cerdeño et al. (2012) suggested a Late Miocene age for the vertebrate-bearing horizons based on the presence of the Notoungulata Mesotheriidae *Plesiotypotherium casirense*.

3.1. Tafna Formation

This geological unit was originally studied by Turner (1964). Lithologically, it is mainly composed of gravels, sands, clays, tuffs, tuffites (sedimentary tuffs) emerging on the northern shore of the LLPB from underneath the Quaternary sediments, in the Calahoyo basin. The studied profile containing the fossil xenarthrans consists mainly of gravel and sand deposited in environments of alluvial fans, forming the basal member of the Tafna Formation. On the top of these strata, three levels of tuffs are interbedded with large dunes with cross-bedding (upper Member). The Tafna Formation is folded, forming a north-south syncline/anticline with a variable inclination, from 10° to 45° in the flanks. The sedimentary sequences and their fossil content are described in detail for the first time in the profile of the Tafna Formation (Fig. 2). This was obtained from the study area through the textural analysis, the determination of lithofacies, sedimentary structures, and the location of the fossils. Twelve facies were defined based en Miall 1987 (Fig. 2). The relief profile has a thickness of ~47 m and its base is covered (Fig. 2). It is exposed due to neotectonic adjustments of ~15 Ka and by the retrograde water erosion in the region of Calahoyo, in argentine-bolivian territory. The sediments accumulated in pluvial periods alternating with some eolian phases, showing thick cross (dunes) stratification, by alternating drier periods, and subjected to intense volcanism in the study area. The upper Member is ~31 m thick and it is constituted by the predominance of an association of facies of fine textures, sands and muds, with few thin debris flows, a level of limestone of eolian origin and three levels of tuffs. The basal Member is ~16 m thickness and is the carrier of the fossil mammals. It is composed of a predominance of associations facies thicker and to lesser extent sands, paleosol (P) and up to the present, a unique outcropping of tuffs (T) of very vitreous nature with few micrometric crystals. The fossil remains are located in the Gms Facies, constituted by massive, matrix-supported gravel; the matrix is fine-silt sand; with a variable thickness between 1.10 m and 1.50 m, grayish orange. Sedimentological evidence indicates that facies were deposited by mud flows slowly and viscous, at its distal end.

3.2. Inferred palaeoenvironment and age

All the materials were deposited on sedimentary basins by alluvial and/or fluvial currents, undergoing transitions of various lacustrine episodes. Volcanic ashes accumulated during these episodes, interbedded with eolian deposits (dunes). According to the palaeontological evidence, this basal member at Calahoyo could be Late Miocene- Pliocene in age. However, this age should be adjusted by future radiometric dating in tuffs.

4. Systematic paleontology

Xenarthra Cope, 1889.
Tardigrada Latham and Davies in Forster, 1795
Megatherioidea Gray, 1821.
Megatheriidae Gray, 1821.
Megatheriinae Gray, 1821.
Genus *Pyramiodontherium* Rovereto, 1914.
Type species. *Pyramiodontherium bergi* (Moreno and Mercerat, 1891).
Included species. The type species, *P. brevirostrum* Carlini et al., 2002, and *P. scillatoyanei* De Iuliis et al., 2004.
Pyramiodontherium bergi (Moreno and Mercerat, 1891)
Fig. 3 A–D

Referred Material. **JUY-P** 31, partial skull, preserving the right Mf1 and Mf5.

Stratigraphic and geographic distribution. Bajo de Andalhuala, Santa María Valley, Catamarca Province; although the stratigraphic provenance is unclear, the type material was exhumed from the Andalhuala Formation (see Brandoni and Carlini, 2009; Bonini and Brandoni, 2015); another record comes from the “Araucanian” (Late Miocene-Pliocene)” of Tiopunco, Tucumán Province (see Brandoni, 2006).

4.1. Description

The skull fragment (**JUY-P** 31) is approximately 320 mm long, low at the anterior third, with no evidence of skull sutures, which suggests it belongs to an adult individual. The skull has a slight lateral postmortem compression.

In anterior view (Fig. 3 A), the maxillary root of the zygomatic apophysis is low as in *Py. bergi* (Carlini et al., 2002, Fig. 1 E), whereas the shape of nasals and maxillaries is sub-trapezoidal in section.

In palatal view (Fig. 3 B), the rostrum is longer than wide, subquadrangular and straight as in *Py. bergi* (Carlini et al., 2002, Fig. 1. A); it has a constriction in front of Mf1, whereas the predentary region is expanded. The dental series, 150 mm long, are slightly convergent forward as in *Py. bergi* (Carlini et al., 2002, Fig. 1. A); they are lingually straight and labially convex. The Mf1 is trapezoidal in section, whereas the alveoli of Mf2, Mf3, and Mf4 are sub-trapezoidal, and the Mf5 trapezoidal as in *Py. bergi* (Carlini et al., 2002, Fig. 1. A).

In dorsal view (Fig. 3 C), the skull is relatively elongated and narrow, with a slight postorbital narrowing.

4.2. Comments

The specimen JUY-P 31 is assigned to *Pyramiodontherium bergi* on the basis of the following morphological characteristics: 1) the maxillary root of the zygomatic apophysis is low; 2) the rostrum is longer than wide, sub-quadrangular, and straight; 3) the dental series are slightly forwardly convergent; 4) the Mf1 is trapezoidal in section, whereas the alveoli of Mf2, Mf3 and Mf4 are sub-trapezoidal, and that of Mf5 is trapezoidal.

Cingulata Illiger, 1811.
Glyptodontoidea Gray, 1869.
Glyptodontidae Gray, 1869.
Genus *Eosclerocalyptus* C. Ameghino, 1919.
Included Species. *Eosclerocalyptus lineatus* Ameghino, *Eosclerocalyptus proximus* (Moreno and Mercerat, 1891) and *Eosclerocalyptus tapinocephalus* (Cabrera, 1939).
Eosclerocalyptus sp.
Fig. 3 E–I

Referred material. **JUY-P** 32, dorsal carapace, 11 osteoderms of the caudal rings, and complete caudal tube, of a single specimen.

Stratigraphic and geographic distribution. Huayquerian, Montehermosan and Chapadmalalan (Late Miocene-Pliocene) of

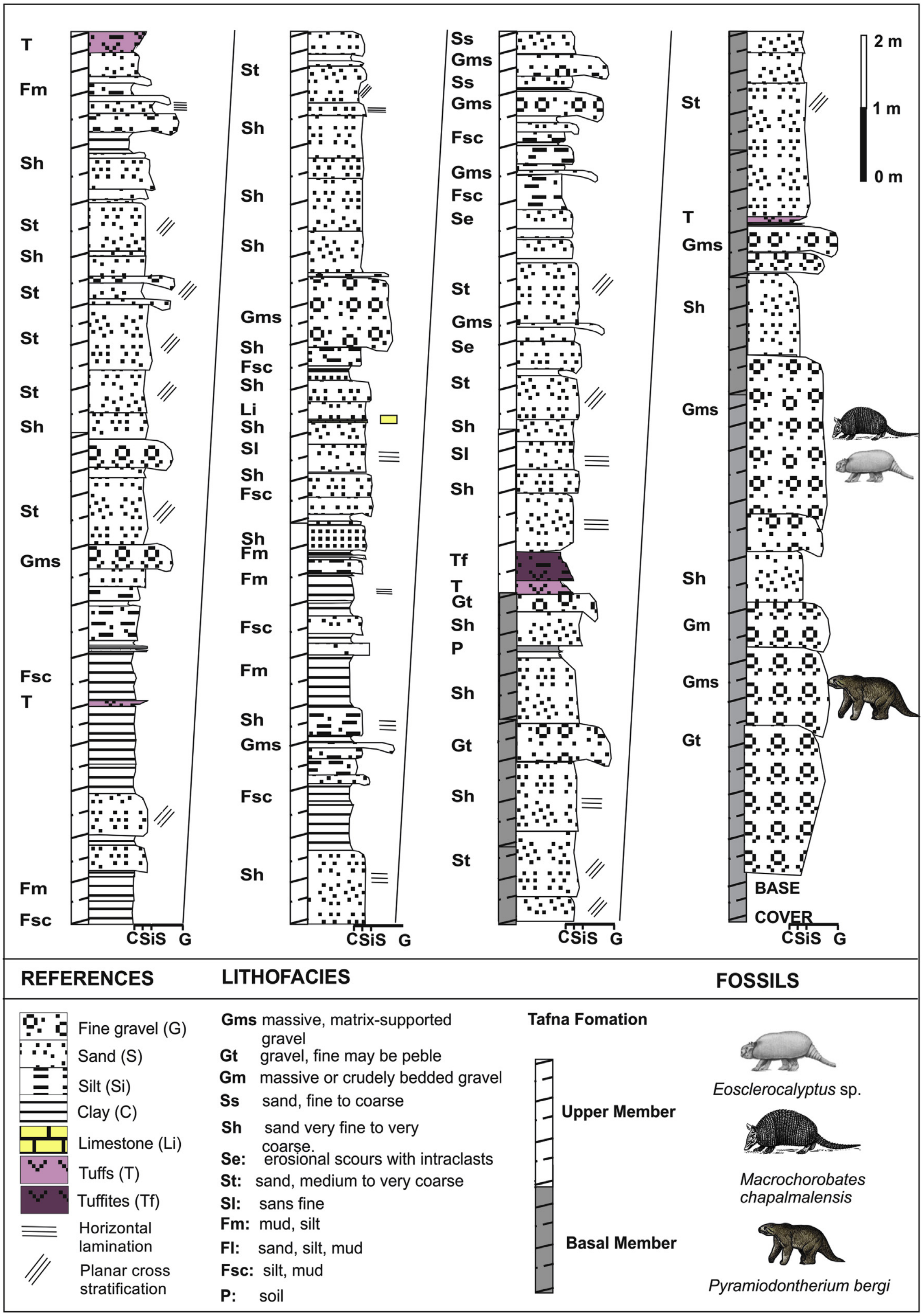

Fig. 2. Stratigraphic profile of the Tafna Formation showing the fossiliferous levels.

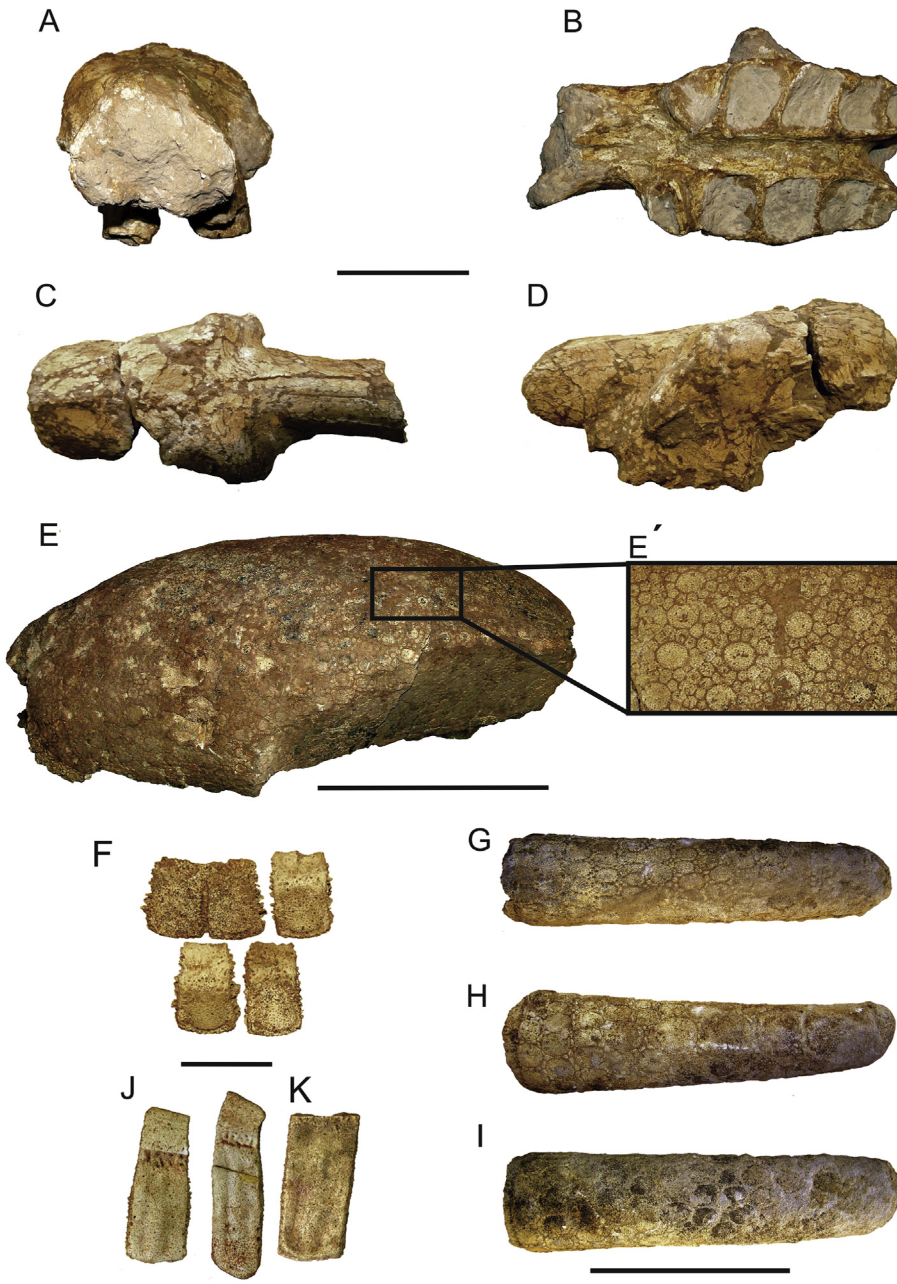

Fig. 3. *Pyramiodontherium bergi* (**JUY-P** 31), (**A-D**), skull in anterior, palatal, dorsal and lateral views. Scale bar equals 50 mm. *Eosclerocalyptus* (**JUY-P** 32), (**E**), dorsal carapace in lateral view, (**E′**), detail of the exposed surface of the osteoderm showing the "rosette" ornamentation pattern. Square bar equals 300 mm. (**F**), associated osteoderms of the caudal rings in dorsal view. Square bar equals 20 mm. (**G-I**), caudal tube in dorsal, lateral and ventral views. Square bar equals 150 mm. *Macrochorobates chapalmalensis* (**JUY-P** 33), (**J**), two complete and one **(K)** partial mobile osteoderms of the dorsal carapace in dorsal view. Scale bar equals 20 mm.

the Buenos Aires province; "Araucanian" (Late Miocene-Pliocene) of the Catamarca, Santiago del Estero and Tucumán provinces (Zurita and Tomassini, 2006; Zurita and Aramayo, 2007; Zurita, 2007b; Zurita et al., 2011; Tomassini et al., 2013).

4.3. Description

4.3.1. Dorsal carapace

The dorsal carapace is almost complete and well preserved, lacking the ventral-most osteoderms of both sides (Fig. 3 E). It is 880 mm in total length, whereas the antero-posterior diameter of the dorsal arc is 1000 mm. Compared to *E. lineatus* (MMP 4842) this specimen is approximately 25% smaller and 17% larger than the "Araucanian" species *E. proximus* (MACN 4853). The dorsal profile is somewhat convex, as observed in *E. lineatus* (MMP 4842 and MD-FM-05-266), *E. proximus* (MACN 4853) and *E. tapinocephalus* (PV-UNS 260), but different from the Pleistocene genus *Neo-sclerocalyptus* Paula Couto in which the dorsal profile is straight and parallel to the horizontal plane, giving the dorsal carapace an evident sub-cylindrical shape (Zurita et al., 2011). As in *Neo-sclerocalyptus* spp., *E. lineatus*, *E. tapinocephalus* (PV-UNS 260), and *E. proximus*, each osteoderm has an evident "rosette" pattern (ie, a subcircular central figure surrounded by a row of 8–12 polygonal peripheral figures; Fig. 3 E'). The general morphology of the osteoderms and their variability according to the different regions of the dorsal carapace follow the same pattern observed in

E. lineaus and *Neosclerocalyptus*. As in *E. lineatus* and cf. *Eosclerocalyptus lineatus* some accessories peripheral figures can be observed at the level of the caudal notch.

4.3.2. Caudal rings

11 osteoderms of one caudal ring are preserved (Fig. 3 F). Each osteoderm has a distal half with a large central figure occupying almost the entire surface, without peripheral figures. In turn, the proximal half is clearly depressed and represents the articular area to the next caudal ring, showing the typical morphology observed in Cingulata Glyptodontidae. The lateral margins show several well developed bony projections, as observed in some juvenile specimens of Glyptodontidae (see Zurita et al., 2016).

4.3.3. Caudal tube

The caudal tube is complete and presents an exceptional preservation. Its antero-posterior diameter is 420 mm. The dorsal surface shows a "rosette" pattern, although the peripheral figures are smaller compared to those of the dorsal carapace, and the central figures are somewhat convex (Fig. 3 G). The peripheral figures become even smaller at the proximal third, bearing some large foramina in the intersection of the central and radial sulci, showing some similarity with the genus *Palaehoplophorus* (González Ruiz et al., 2017). The ventral surface (Fig. 3 I) shows an evident reduction of the peripheral figures, as observed in some juvenile specimens of *Neosclerocalyptus* (see Zurita et al., 2016, Fig. 4 E). The right and left sides (Fig. 3 H) show five large figures being the largest the most distal one, as observed in *Neosclerocalyptus*, *E. tapinocephalus* and *E. proximus*. The lateral figures are separated by a row of very small peripheral figures, which are more evident on the right side. In summary, the general morphology shows no significant differences compared to *Eosclerocalyptus* spp.

4.4. Comments

The general morphology of the dorsal carapace and caudal tube allows its inclusion in the genus *Eosclerocalyptus,* whereas the convex dorsal profile of the carapace precludes its assignment to the genus *Neosclerocalyptus.* However, the species of *Eosclerocalyptus* are mainly characterized by skulls, since the morphology of the dorsal carapace and caudal tube are very conservative in the three species, *E. tapinocephalus*, *E. proximus* and *E. lineatus* (Zurita, 2007b; Zurita and Aramayo, 2007). The other Glyptodontidae having a similar "rosette" pattern and a similar development of the caudal tube are the Palaehoplophorini (Middle-Late Miocene; Scillato-Yané and Carlini, 1998; González Ruiz, 2010; Scillato-Yané et al., 2013; González Ruiz et al., 2017). This tribe shows different morphologies according to the different taxa e.g., osteoderms of some species may have a rough exposed-surface with grooves delimiting the central from the peripheral figures (González Ruiz, 2010); others have two or three rows of small peripheral figures and a depressed central figure (e.g., *Palaehoplophorus antiquus* Ameghino, 1883) (Scillato-Yané et al., 2013); and others show a series of clearly circular small peripheral figures (e.g., *Aspidocalyptus castroi* Cabrera, 1939). In summary, the absence of these characters in the studied material precludes its assignment to Palaehoplophorini.

Dasypodidae Bonaparte, 1838.
Euphractinae Pocock, 1924.
Eutatini Bordas, 1933.
Genus *Macrochorobates* Scillato-Yané, 1980
Type species. *Proeuphractus scalabrinii* Moreno and Mercerat, 1891.
Included species. *M. chapalmalensis* (Ameghino, 1908) and *M. scalabrinii* (Moreno and Mercerat, 1891).
Macrochorobates chapalmalensis (Ameghino, 1908)
Fig. 3 J–K

Referred material. **JUY-P** 33, two complete mobile osteoderms plus a fragmentary one.

Stratigraphic and geographic distribution. Cerro Azul Formation, Huayquerian (Late Miocene), La Pampa Province (Urrutia et al., 2008); Monte Hermoso and Chapadmalal formations, Montehermosan-Chapadmalalan (Pliocene), Buenos Aires Province; Uquía Formation, "Uquian" (Late Pliocene-Pleistocene), Jujuy Province (Scillato-Yané, 1982).

4.5. Description

The mobile osteoderms are slightly smaller than those of *Macrochorobates scalabrinii*. The region between the cranial portion (not exposed) and the exposed portion of the osteoderm is striated. The osteoderms have and elevated central figure with a sharpened carina at its proximal end, which widens and deflects laterally at its distal end. This central figure is less convex than the one observed in *M. scalabrinii*. The central figure is delimited by shallow grooves. Two lateral figures (one on each side of the central figure) are observed, undivided and little elevated. On the terminal margin there are numerous piliferous foramina that extend on the most distal lateral border (Fig. 3J–K).

4.6. Comments

Although the general ornamentation of the osteoderms of *Macrochorobates scalabrinii* and *M. chapalmalensis* is similar, the osteoderms of JUY-P 33 have a less convex central figure than that of *M. scalabrinii*, which allows its assignment to *M. chapalmalensis*. In addition, the size of the osteoderms also matches with those previously described for *M. chapalmalensis*.

5. Discussion

The new specimens here described indicate that during the late Neogene the taxonomic and ecologic diversity of the Xenarthra of the northwest end of Argentina, in the Northern Puna, was relatively high, similar to that observed in other Neogene units of NWA (e. g. Andalhuala, Corral Quemado, Maimará and Uquía formations) (see Reguero and Candela, 2011; Esteban et al., 2014). Fossil xenarthrans of Calahoyo are represented by at least three main lineages: sloths, glyptodontids and armadillos. Following the estimations of Reguero and Candela (2008) and Mac Fadden et al. (1994) for the Uquía and Inchasi formations of Eastern Cordillera (Pliocene), the area of Calahoyo could have been more than 2200 m.a.s.l. during the Pliocene, taking into account that the current elevation is *ca.* 3700 m.a.s.l. In this scenario, and as already stated by Reguero and Candela (2008), the environment must have been more humid than at present, taking into account that the cingulates *Eosclerocalyptus* and *Machrochorobates,* and the megatheriid *Pyramiodontherium* suggest the presence of forest and open areas (Scillato-Yané et al., 1995).

Pyramiodontherium is one of the best represented Megatheriidae of the late Neogene of Catamarca Province (Bonini and Brandoni, 2015). The species *Pyramiodontherium bergi*, reported for Calahoyo, was also identified in the late Neogene of Catamarca Province (Bajo de Andalhuala, Santa María Valley), in the Andalhuala Formation (Brandoni and Carlini, 2009; Bonini and Brandoni, 2015). Recently, the age of this unit was established by Esteban et al. (2014) in ca. 7.14–3.66 Ma. *Pyramiodontherium bergi* was also reported for the "Araucanian" of Tiopunco, (Tucumán Province) but without precise data of stratigraphic and geographic provenance (Brandoni, 2006). Specimens from the NWA assigned to *Py. brevirostrum*, the other species of the genus reported for the Neogene of Catamarca Province (Brandoni and Carlini, 2009), also lack precise stratigraphic control (see also Bonini and Brandoni, 2015). Kraglievich (1930) erected the species *Pyramiodontherium*? *carlesi*, which is poorly known, on the basis of materials found in the Neogene of the Jujuy Province (supposedly from Uquía). However, the stratigraphic provenance of this species is unknown and its assignment to this genus is also doubtful (Brandoni and Carlini, 2009). Recently, a specimen assigned to *Pyramiodontherium* sp. was described. This material was recovered from the upper levels of the Andalhuala Formation, exposed at San Fernando locality (Catamarca Province), with an estimated age of 4.91 Ma (Bonini and Brandoni, 2015). The latter specimen represents the first record of *Pyramyodontherium* of Catamarca with an accurate stratigraphy and age. Consequently, along with those from San Fernando locality and the Andalhuala Formation, the specimen of Calahoyo is one of the few records of *Pyramyodontherium* of the NWA with precise stratigraphic provenance, remarking its potential value from a biostratigraphic point of view. In addition, the specimen of *Pyramyodontherium bergi* of Calahoyo is the first unquestionable record of the genus in Jujuy Province, expanding its geographic distribution in the NWA.

Concerning glyptodonts, several specimens assigned to numerous taxa were recovered from different Neogene sequences of the NWA. However, the best known are those coming from the "Araucanian" (Late Miocene-Pliocene) of the provinces of Catamarca and Tucumán, which are taxonomically very different from the Mio-Pliocene Glyptodontidae from the Pampean region (see Cabrera, 1944; Zurita, 2007a; Zurita et al., 2016). In the "Araucanian" of NWA *E. proximus* is one of the most frequently recorded Glyptodontidae (Zurita, 2007b). In this scenario, most glyptodonts exhumed from the Uquía and Maimará formations were not revised, and lack precise stratigraphic provenance. Recently, new records (currently under study) were reported mainly from the base of the Uquía Formation. However, preliminary observations and published information indicate that *Eosclerocalyptus* could not be identified in the materials from the Uquía and Maimará formations. In these localities, the Glyptodontidae association is mainly composed of Doedicurinae and Glyptodontinae, plus some very doubtful taxa such as "*Urotherium* and "*Xiphuroides*" (see Reguero et al., 2007; Zurita et al., 2016). From a morphological viewpoint, the dorsal carapace of the specimen from Calahoyo is somewhat larger (*ca*. 17%) than *E. proximus* but smaller (*ca*. 25%) than *E. lineatus*. The absence of skull precludes a specific assignment; however, this is the northernmost record of *Eosclerocalyptus*, because there are no records of this genus in Pliocene localities of the Bolivian Eastern Cordillera (see Mac Fadden et al., 1994; Cione and Tonni, 1996).

Specimens of the Dasypodidae *Macrochorobates chapalmalensis* were reported from different late Neogene units of Argentina. This species is present in the Pliocene of Monte Hermoso (Montehermosan) and Chapadmalal (Chapadmalalan) formations in Buenos Aires Province (Scillato-Yané, 1982; Tomassini et al., 2013), and the Cerro Azul Formation (Huayquerian) in La Pampa Province (Urrutia et al., 2008). Outside the Pampean region, this taxon was also recorded in the Uquía Formation (Reguero and Candela, 2008).

6. Conclusions

The xenarthrans from the Tafna Formation represent the first mammals of the northwest end of Argentina in the Puna region with strict stratigraphic control. This highlights their potential biostratigraphic significance for temporal correlations with other Neogene stratigraphic units from the Jujuy Province, as those of the Cuenca de Humahuaca, and from other areas of the NWA. In addition, the fossil mammals of Calahoyo increase the knowledge of the Neogene mammalian diversity of the NWA, with precise stratigraphic and geographic control. This knowledge is crucial to evaluate the factors involved in establishing the composition of the extant mammalian fauna of the NWA and the acquisition of high altitude adaptations of the species that inhabit the Andean regions of Jujuy, which are still little explored. Finally, and from a biostratigraphic viewpoint, the recorded xenarthrans suggest a late Miocene-Pliocene age for the base of the Tafna Formation.

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