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Chronological implications of the nothrotheriid '*Xyophorus*' (Mammalia, Xenarthra) from the Collón Curá Formation (Miocene of Patagonia, Argentina)

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ABSTRACT

The specimen described herein and assigned to '*Xyophorus*' sp. (Mammalia, Xenarthra, Tardigrada) was collected in the locality Cerro Zeballos, northwestern Chubut Province, Argentina. The fossiliferous sediments bearing the specimen are correlated with Collón Curá Formation. The specimen has the features described for other members of '*Xyophorus*' (e.g. shape and size of the molariforms, relationship between diastema length, m1 and m2 length) and has a Diastema Length/Tooth Row Length index (DL/TRL index) of ca. 14, between that of '*X.*' *villarroeli* (12.07) from the Mauri Formation, Bolivia (ca. 10.3 Ma) and that of '*X.*' *bondesioi* (16.45) from Arroyo Chasicó Formation, Argentina (ca. 10–8.7 Ma). The relationship between DL/TRL index and age of the bearing sediments, would suggest a Tortonian age (late Miocene) for the deposits of Collón Curá Formation at Cerro Zeballos, which results in a 'younger age' compared to the middle Miocene age traditionally accepted for the Collón Curá Formation bearing the Colloncuran fauna *sensu stricto*. Although no absolute ages for Cerro Zeballos are available yet, the geographic proximity of Cerro Zeballos to Cushamen River (with levels dated at ca. 11.2 Ma) supports the tentative Tortonian age indicated by the presence of '*Xyophorus*' sp.

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Introduction

The clade Megatherioidea (Xenarthra, Tardigrada) includes the families Megalonychidae (e.g. *Eucholoeops* Ameghino 1887; *Megalonyx*, Harlan 1825), Nothrotheriidae (e.g. *Nothrotherium* Lydekker 1889; *Thalassocnus* Muizon and McDonald 1995), Megatheriidae (e.g. *Megatherium* Cuvier, 1796; *Planops* Ameghino 1887), and some genera recorded from the Miocene of Patagonia (Argentina) considered as basal Megatherioidea (e.g. *Schismotherium* Ameghino 1887; *Pelecyodon* Ameghino 1891; *Hapalops* Ameghino 1887) (Gaudin 2004).

Among Nothrotheriidae, Nothrotheriinae include several genera (e.g. *Nothropus* Burmeister 1882; *Nothrotherium*, *Pronothrotherium* Ameghino 1907; *Nothrotheriops* Hoffstetter 1954; *Mionothropus*, De Iuliis et al. 2011; *Lakukullus* Pujos et al. 2014, *Aymaratherium* Pujos et al. 2016) (see Burmeister 1882; Ameghino 1887, 1891, 1907; Lydekker 1889; Hoffstetter 1954; De Iuliis et al. 2011; Pujos et al. 2014, 2016), which are known from the middle Miocene of Bolivia and Argentina to the Pleistocene of South America, Central America and North America (Brandoni 2014; Brandoni and McDonald 2015; De Iuliis et al. 2015). Miocene taxa of this group are included in the genera *Pronothrotherium*, *Mionothropus*, and *Lakukullus*, and are primarily recorded from Argentina, Uruguay, Peru, and Bolivia. In addition, Brandoni (2014) considered that *Xyophorus* Ameghino 1887 (in the 'classical' sense) was biphyletic with: (1) a group of species with the generic name *Xyophorus* with affinities to basal Megatherioidea as *Hapalops*, and recorded from the early Miocene of the Santa Cruz Formation, Argentina (i.e. *Xyophorus rostratus* Ameghino 1887; *Xyophorus simus* Ameghino 1887; *Xyophorus andinus* Ameghino 1891; *Xyophorus atlanticus* Ameghino 1891; *Xyophorus sulcatus* Ameghino 1891; and *Xyophorus crassissimus* Ameghino 1894); and (2) the '*Xyophorus*' group (using quotation marks) represented by '*Xyophorus*' *bondesioi* Scillato-Yané 1978; '*Xyophorus*' *villarroelli* Saint-André 1996, and '*Xyophorus*' sp. which are recorded from the middle-late Miocene of Argentina and Bolivia, and are considered as members of Nothrotheridae-Nothrotheriinae.

For Argentine Patagonia the only accurate record of '*Xyophorus*' corresponds to '*Xyophorus*' sp. from the locality of El Petiso (middle Miocene of Chubut Province) (Brandoni 2014). However, there is also one mention of *Xyophorus* from the Collón Curá Formation (Miocene) at Pilcaniyeu Viejo (Río Negro Province) (Scillato-Yané 1978), but the author did not provide catalogue number and the specimen was never described nor figured. Also from the Collón Curá Formation, Scillato-Yané and Carlini (1998) described *Amphibradys guiomari* Scillato-Yané and Carlini 1998, based on a fragmentary skull, considered as a Nothrotheriidae-Nothrotheriinae by the authors.

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During the middle Miocene of Patagonia several main successive mammal faunas have been traditionally identified (Friasian, Colloncuran, Mayoan; see Flynn and Swisher 1995; and references therein). The Friasian fauna *sensu stricto* is recorded from the Río Frías Formation, Chile (de la Cruz and Cortés 2011; Bostelmann et al. 2012), the Colloncuran *sensu stricto* fauna from the Collón Curá Formation, Argentina (Madden et al. 1997; Ramos et al. 2015), and the Mayoan fauna from the El Portezuelo/Pedregoso and Río Mayo formations, Argentina (see González Ruiz et al. 2017; and references therein). In addition, a post-Colloncuran fauna from the locality of El Petiso was proposed (Villafañe et al. 2008). The operational use of these middle Miocene faunas as ages, South American Land Mammal Ages (SALMAS) or local faunas and the relations between them are still unclear, and has been debated by several authors (see Marshall and Salinas 1990; Vucetich et al. 1993; Flynn and Swisher 1995; Madden et al. 1997; Croft et al. 2009, 2016).

The objective of this contribution is the description of new remains of a fossil sloth assigned to '*Xyophorus*' sp., recorded at the locality of Cerro Zeballos. Although the sediments and the vertebrate association from Cerro Zeballos are under study, we follow Lage (1982) and Lizuaín et al. (1995) and consider these sediments as part of the Collón Curá Formation, and Martin and Tejedor (2007), who include this vertebrate association in the Colloncuran SALMA.

Institutional abbreviations: AMNH, American Museum of Natural History, New York, USA; FMNH: Field Museum of Natural History, Chicago, USA; LACM, Los Angeles County Museum of Natural History, Los Angeles, USA; LIEB PV, Laboratorio de Investigaciones en Evolución y Biodiversidad (-PV, Paleovertebrados), Esquel, Argentina; MACN A, Colección Ameghino, Museo Argentino de Ciencias Naturales 'Bernardino Rivadavia', Buenos Aires, Argentina; MACN Pv, Colección Paleontología Vertebrados, Museo Argentino de Ciencias Naturales 'Bernardino Rivadavia', Buenos Aires, Argentina; MLP, División Paleontología Vertebrados, Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, La Plata, Argentina; MNHN, Departamento de Paleontología de Vertebrados, Museo de Historia Natural de Bolivia, La Paz, Bolivia; MPEF-PV, Colección de Paleontología de Vertebrados del Museo Paleontológico Egidio Feruglio, Trelew, Argentina. UATF, Universidad Autónoma Tomás Frías, Potosí, Bolivia; UF, Florida Museum of Natural History, Gainesville, USA. YPM-PU, Yale Peabody Museum (Princeton University collection), New Haven, USA.

Materials and methods

Comparisons of the newly collected specimens were made with the following species (studied specimens between parentheses) assigned to Nothrotheriidae-Nothrotheriinae: '*Xyophorus*' *bondesioi* (MLP 32-V-20-1, Arroyo Chasicó Formation, Buenos Aires Province, Argentina); '*Xyophorus*' *villarroeli* (MNHN ACH 43, Mauri Formation, Member 6, Achiri, Bolivia); '*Xyophorus*' cf. '*X.*' *bondesioi* (UATF-V-000871, Cerdas, Bolivia; UF 26668, Quebrada Honda, Bolivia); '*Xyophorus*' sp. (MPEF-PV 3264, locality of El Petiso, Chubut Province, Argentina); *Mionothropus cartellei* De Iuliis et al. 2011 (LACM 4609/117533, Iñapari Formation, Acre River, Brazil and Peru); *Pronothrotherium typicum* Ameghino 1907 (MACN Pv 8140, 'Araucanense' of Catamarca Province, Argentina); *Nothropus carcaranensis* Bordas, 1942 (MACN Pv 11555, Pleistocene of Santa Fe Province, Argentina); and *Lakukullus anatirostratus* Pujos et al. 2014 (MNHN-Bol-V 006601, Quebrada Honda, Bolivia). In addition, other Megatherioidea were also compared: *Xyophorus andinus* Ameghino 1891 (MACN A 4634, Santa Cruz Formation, Argentina); *X. atlanticus* Ameghino 1891 (MACN A 4631, Santa Cruz Formation, Argentina); *X. crassissimus* (MACN A 6436; Santa Cruz Formation, Argentina); *Schismotherium fractum* Ameghino 1887 (MACN A 6446 –as part of MACN A 6445-70–, FMNH P13137, YMP PU 15361, YMP PU 15901; Santa Cruz Formation, Argentina); *Pelecyodon arcuatus* Ameghino 1891 (AMNH PV 9240, MACN A 4656; Santa Cruz Formation, Argentina); *Hapalops rectangularis* Ameghino 1887 (MACN A 2089-90; Santa Cruz Formation, Argentina); *H. longipalatus* Ameghino 1891 (MACN A 4513-16; Santa Cruz Formation, Argentina); *H. crassignathus* Ameghino 1891 (MACN A 4524; Santa Cruz Formation, Argentina); *H. minutus* Ameghino 1891 (MACN A 4527; Santa Cruz Formation, Argentina); *H. cylindricus* Ameghino 1891 (MACN A 4525; Santa Cruz Formation, Argentina); *Amphibradys guiomari* (MLP 91-IX-2-118, Collón Curá Formation, Argentina).

After a search at the MLP collection, the specimen assigned to *Xyophorus* by Scillato-Yané (1978) was not found. Eleven mandibular measurements (in mm) were taken, which included length and width of c, m1, m2, and m3 (see Table 1); the index Diastema Length/Tooth Row Length x 100; see

Table 1. Measurements (in mm) of '*Xyophorus*' sp, LIEB PV 5129, and other Megatherioidea considered for comparisons.

	c1L	c1 W	m1L	m1 W	m2L	m2 W	m3L	m3 W	DL	TRL	HRH	DL/TRL	HI
'*Xyophorus*' sp. (LIEB PV 5129)	c5	c3.5	7.5	10	7.8	11	9	10	6.1	43	31	14.18	0.72
'*Xyophorus*' sp. (MPEF-PV 3264)	4.2	3.1	5.9	6.9	6.3	7.1	6.7	5.5	3.8	32	25.6	11.87	0.8
'*X.*' cf. *bondesioi* (UF 26,668)	5.4	3.8	6.8	8.8	6.9	8.9	9.3	8.6	4.2	37	-	11.35	-
'*X.*' cf. *bondesioi* (UATF-V-000871)	5.5	4.1	7	9.1	6.6	9.6	8.6	7.5	3.5	37.5	-	9.33	-
'*X.*' *bondesioi* (MLP 32-V-20-1)	5.4	4.1	7.2	8.7	7.2	8.7	7.9	8.3	6.3	38.3	27.7	16.44	0.72
'*X.*' *villarroeli* (MNHN ACH 43)	6.6	3.8	8.7	10.3	8.2	10.3	9.5	9	5.3	43.9	-	12.07	-
X. atlanticus (MACN A 4631)	5.5	4	6.4	10.8	6	10.5	8	8.8	8	40.4	31	19.8	0.76
X. andinus (MACN A 4634)	7	4.7	6	10.7	6.2	10.5	7.7	8	8	40.5	32	19.75	0.79
X. crassissimus (MACN A 6436)	8.6	6.8	7.2	10.8	10	13.4	10.4	12	10.5	45	35	23.33	0.77
M. cartellei (LACM 4609/117533)	6.7	5.8	10.3	14.3	9.5	13.8	11.4	13.8	10.5	53.1	45.6	19.77	0.85
Pr. typicum (MACN Pv 8140)	5.8	5	8.5	10	9.5	12	10	11	12.5	56	36	22.32	0.64
L. anatirostratus (MNHN-Bol-V 006601)	6	8.1	10.3	14.3	10.2	15.5	13	13	9	60	48.2	15.00	0.8

Abbreviations, c, lower caniniform; D, diastema; HI, Hypsodonty Index; HRH, horizontal ramus height; L, length; m1–m3, lower molariform 1–3; TR, tooth row; W, width.

Brandoni 2014) corresponds to the percentage of the tooth row length represented by the diastema length. For chronological purposes we follow the International Chronostratigraphic Chart (Cohen et al. 2013; International Commission on Stratigraphic 2017).

Anatomical abbreviations: C/c, upper and lower caniniform respectively; D, diastema; HRH, horizontal ramus height; L, length; M1-M4, upper molariform 1–4; m1–m3, lower molariform 1–3; TR, tooth row; W, width.

Geological setting

The specimen described herein (LIEB-PV 5129) was collected in the locality Cerro Zeballos, northwestern Chubut Province, Argentina (42° 34′46.5″S, 70° 19′55″W) (Figure 1). According to Lage (1982) and Lizuaín et al. (1995), the fossiliferous sediments bearing the specimen are correlated with the Collón Curá Formation. They correspond to volcaniclastic sedimentits with a predominance of tuffs, chonites, and subordinate epiclastic sediments. The sequence is homoclinal with practically horizontal strata. Although at this locality the base of the sequence is covered (i.e. not exposed), in this area the Collón Curá Formation lies in discordance upon the Huitrera Formation (middle Eocene) (Lage 1982; Aragón and Mazzoni 1997).

The described profile (Figure 2) starts with a section of ca. 15 m of massive ocher or yellowish white tuffaceous sandstone, in general very friable and powdery, forming the typical badlands landscape. In all the profile, levels with concentrations of reddish concretions composed by tuffitic material frequently appears (Tf in Figure 2), and because they are more resistant to weathering they form steps in the profile. These levels with concretions and the presence of roots could indicate pedogenic processes. In all the section fossil vertebrates are abundant, even inside these concretions. Specimen LIEB PV 5129 was collected in the middle of this 15 m section. The profile continues, in paracomformity, with ca. 3 m of greenish tuffaceous mudstone with intercalated levels of ocher tuffaceous fine sandstones with massive structures (T in Figure 2). Above this, the profile continues with epiclastic deposits of claystone, mudstone, and grainstones, with some pyroclastic subordinated levels intercalated.

According to Bilmes et al. (2014) the Collón Curá Formation, near this area, is the result of the conformation of isolated depocenters in which ephemeral and deep lacustrine systems were developed. The described section has no structures that could indicate the deposition agent, although the tuffaceous material and the presence of roots suggests a shallow and low energy system of lagoons or lakes, and a floodplain with shallow and low energy fluvial courses, probably with periods of aerial exposure.

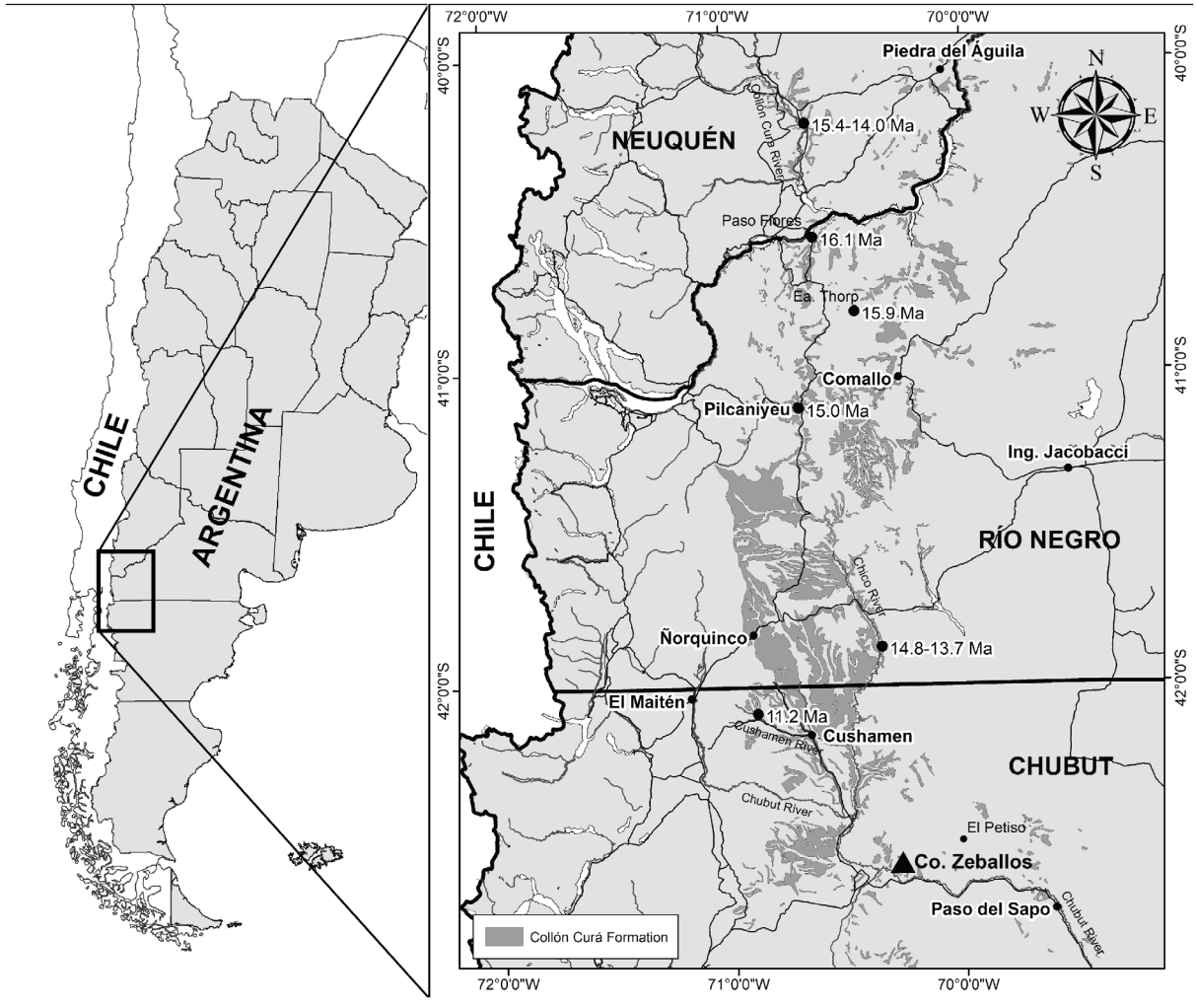

Figure 1. Location map of Collón Curá Formation with indication of Cerro Zeballos and the dated localities. Source: Authors

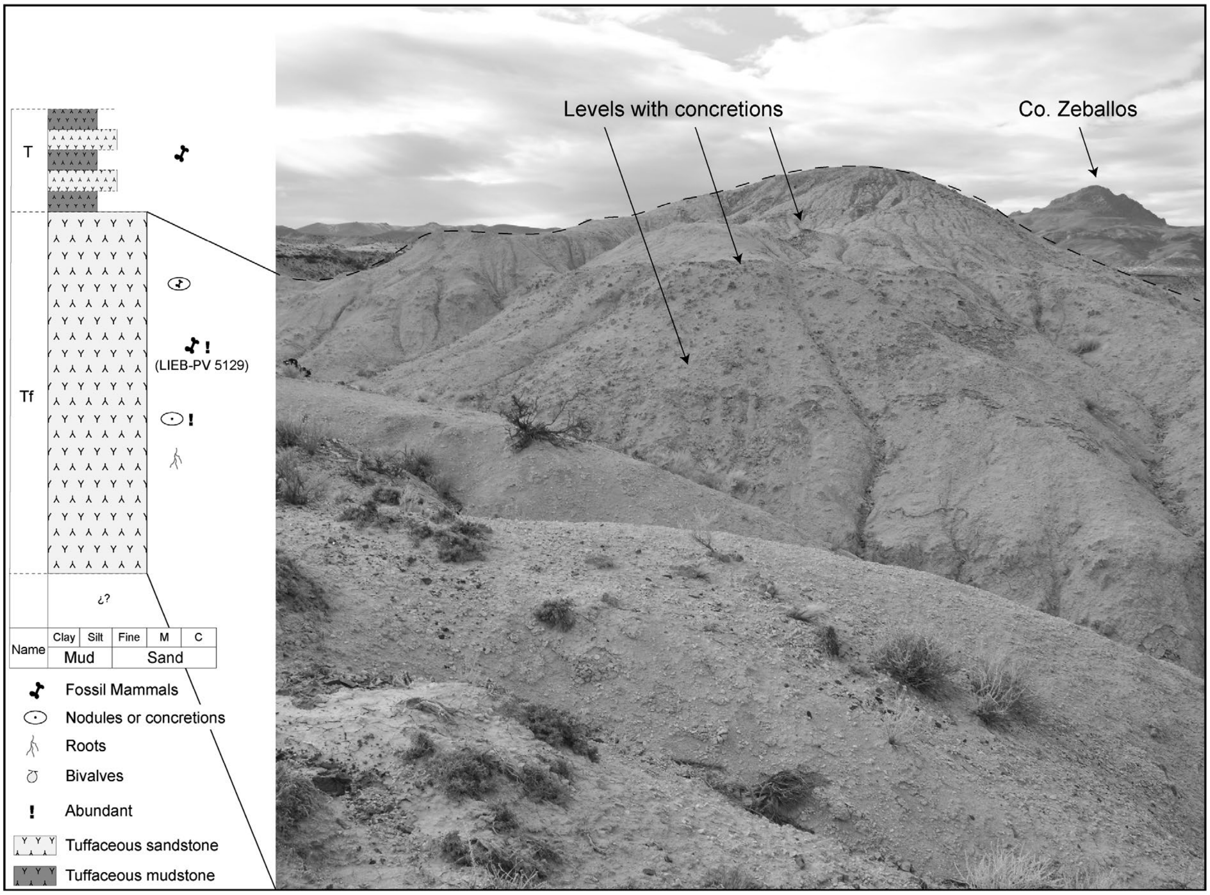

Figure 2. Stratigraphic section at Cerro Zeballos, Chubut Province, Argentina.

The age of the Collón Curá Formation, according to published absolute ages, spans from ca. 16 Ma to ca. 11 Ma (Burdigalian-Tortonian) (see Table 2). (Rabassa 1975; Marshall et al. 1977; González Diaz and Nullo 1980; Cazau et al. 1989; Mazzoni and Benvenuto 1990; Madden et al. 1997; Bilmes et al. 2013; Dunn et al. 2015; Ramos et al. 2015).

Table 2. Available geochronological information for the Collón Curá formation.

Locality	Province	Horizont of Collón Curá formation	Rock	Method	Age (Ma)	Error	Reference
Pilcaniyeu	Río Negro	Pilcaniyeu Ignimbritic Member	Biotite	$^{40}K/^{40}Ar$	15.0	?	Rabassa (1975)
Collón Curá River	Neuquén		Biotite		14.0	±0.3	Marshall et al. (1977)
					14.1		
			Plagioclase		14.4		
					15.4		
?	?	Piroclastic facies	?	?	11.0	±1	González Diaz and Nullo (1980)
?	?				15.0	?	
Quebrada Aguilucho	Río Negro	Tuff at the base of the formation	?	?	10.7	?	Cazau et al. (1989)
					11.5		
Paso Flores	Río Negro	Piroclastic facies	?	$^{40}K/^{40}Ar$	16.1	±2.6	Mazzoni and Benvenuto (1990)
Bajada Saavedra		Pilcaniyeu Ignimbritic Member			13.8	±0.9	
Thorp Farm		Piroclastic facies/Pilcaniyeu Ignimbritic Member			15.9	±3.1	
?	?	?	?	?	15.6 to 15.8	?	Scillato-Yané and Carlini (1998)
?	Río Negro/Neuquén	Pilcaniyeu Ignimbritic Member	?	$^{40}Ar/^{39}Ar$	15.7	?	Madden et al. (1997)
Chico River	Río Negro	Base of the middle section	Amphibole		14.86	±0.13	Bilmes et al. (2013)
Valley of Chico River	Río Negro	?	?	?	13.7	?	Dunn et al. (2015)
					13.9		
					14.0		
					14.6		
Bajada Sañeco	?				15.5		
					15.8		
?	?				15.7		
Cushamen River	Chubut	Upper section	Detrital zircons	U-Pb	11.2	±0.4	Ramos et al. (2015)

Systematic paleontology

Mammalia Linnaeus 1758

Tardigrada Latham and Davies in Forster, 1795

Nothrotheriidae Ameghino 1920

Nothrotheriinae Ameghino 1920

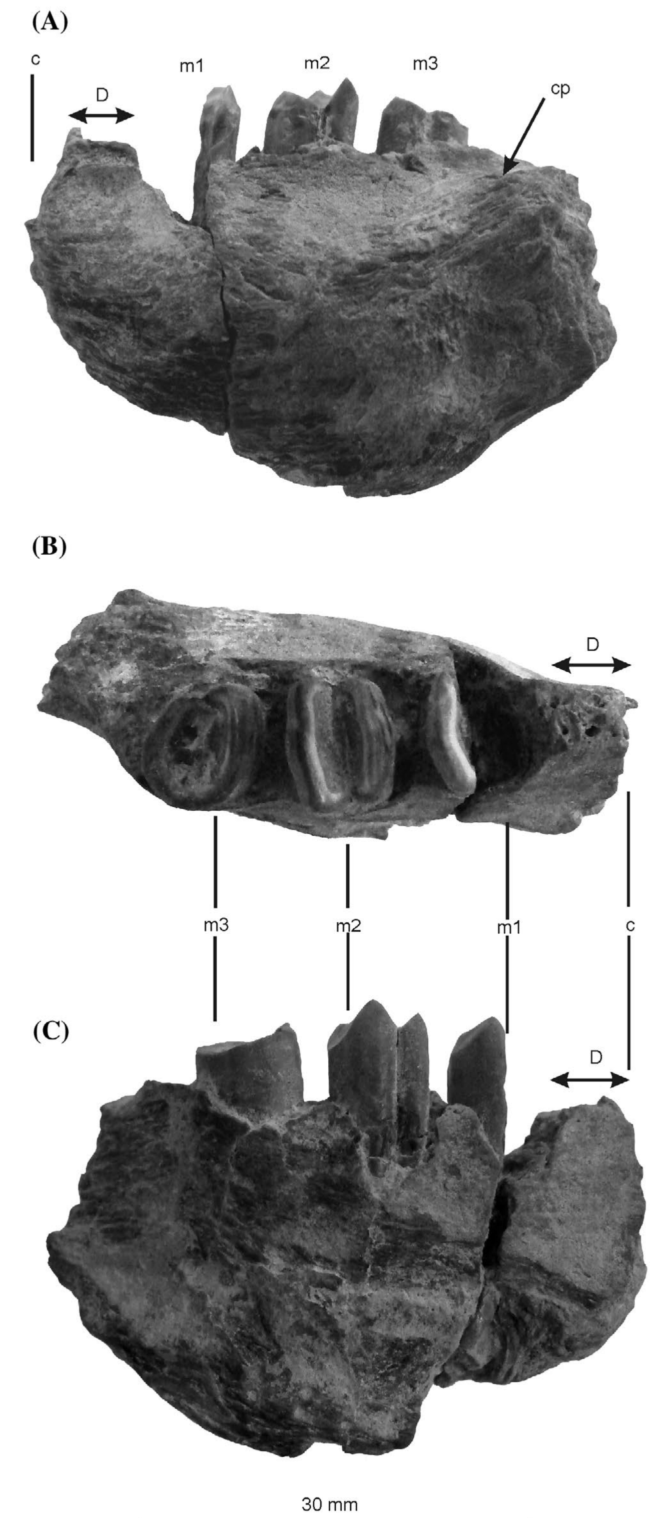

Figure 3. '*Xyophorus*' sp., LIEB PV 5129, from Collón Curá Formation. (A) lateral view. (B) occlusal view. (C) medial view.

Note: Abbreviations, c, lower caniniform; co, coronoid process; D, diastema; m1-m3, lower molariforms 1–3.

'*Xyophorus*' sp.

Figure 3

Referred material. LIEB PV 5129: Fragment of a left dentary lacking the anterior portion, the coronoid, angular and condyloid processes (Figure 3(A–C)); a maxillary fragment with three broken molariforms; and a metacarpal/metatarsal IV(?).

Geographic and stratigraphic provenance. Cerro Zeballos, Chubut Province, Argentina (42°34′46.5″S, 70°19′55″W, Figure 1). Collón Curá Formation.

Description. The present description mainly corresponds to a fragment of the left dentary. LIEB PV 5129 is similar in size to '*X.*' *bondesioi*, but especially to '*X.*' *villarroeli* (Table 1); whereas *Mionothropus cartellei*, *Pronothrotherium typicum*, *Nothropus carcaranesis*, *Lakukullus anatirostratus* are larger. As in '*X.*' *bondesioi*, '*Xyophorus*' sp. (MPEF-PV 3264), *M. cartellei*, *P. typicum* and *N. carcaranesis*, the ventral margin of the dentary is slightly convex (Figure 3A, C), whereas it is nearly horizontal in *L. anatirostratus*. The hypsodonty index (HI = mandibular height/ tooth row length) is 0.72; in '*X*' *bondesioi* the HI is also 0.72 and in '*Xyophorus*' sp. (MPEF-PV 3264) is 0.8. The anterior margin of the coronoid process is posterior to the posterior plane of m3, making this tooth well visible in lateral view (Figure 3(A–C)). A similar condition is present in '*Xyophorus*' sp. (MPEF-PV 3264), whereas in '*X.*' *bondesioi*, *M. cartellei*, *P. typicum*, and *N. carcaranesis* the anterior margin of the coronoid process is more anterior, obscuring the m3 in lateral view. The posterolateral opening of the mandibular canal is not preserved. In '*Xyophorus*' sp. (MPEF-PV 3264) it is on the lateral side of the coronoid process and near to the occlusal plane, whereas in '*X.*' *bondesioi*, *M. cartellei* and *N. carcaranesis* is more anterior, closer to the anterior margin of the coronoid process. As in '*Xyophorus*' sp. (MPEF-PV 3264), '*X.*' *bondesioi*, '*X.*' *villarroeli*, and *L. anatirostratus*, the diastema between c and the molariforms is short, shorter than the anteroposterior length of m1 and m2 (Figures 3and 4; Table 1). Contrary to this, in species of *Xyophorus* (e.g. *X. andinus*, *X. atlanticus*), *M. cartellei*, and *P. typicum* this diastema is longer than the anteroposterior length of m1 and m2 (Brandoni 2014; Brandoni and McDonald 2015). *Schismotherium* and *Pelecyodon*, with a dental formula of 5/4, do not have a diastema, but the first tooth is smaller than the others and also has a different morphology, so the terms caniniform and molariforms have been used for their dentition (see Brandoni et al. 2016). Although in LIEB PV 5129 the caniniform is broken, it is possible to describe its shape given the basal portion of the teeth and the posterior wall of the alveoli are preserved; the caniniform is suboval in outline, whereas it is oval in '*X.*' *villarroeli* and subcircular in '*Xyophorus*' sp. (MPEF-PV 3264) and '*X*' *bondesioi.* The caniniform is considered to be absent in *Nothrotherium* and *Nothrotheriops*. In *N. carcaranensis* a very small foramen appears in front of the anterior margin of m1, which was considered by Quiñones et al. (2017) to be the alveoli of the caniniform. The occlusal surface of the molariforms has mesial and distal lophids separated by an open transverse 'V' valley, and as in other Nothrotheriinae the molariforms (m1 and m2) have lingual and labial vertical grooves (Figure 3). In the studied species of *Xyophorus* (e.g. *X. andinus*, *X. atlanticus*), *Schismotherium*, *Pelecyodon*, and *Hapalops* (see Materials and Methods), as well as in the upper molariforms of *Amphibradys guiomari* (MLP 91-IX-2-118), the grooves are absent (Figure 5).

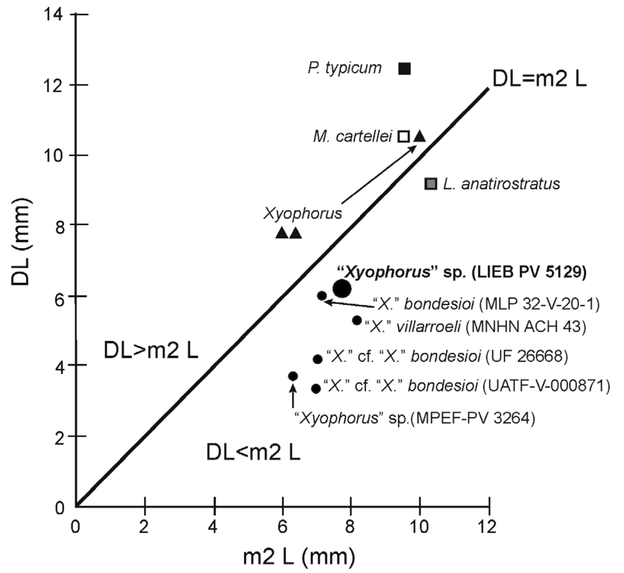

Figure 4. Biplot graph between diastema length (DL) and m2 length (m2 L).

The m1 is subtrapezoidal in outline, its mesial lophid is broken; the m2 is quadrangular in outline, and as was mentioned above, has lingual and labial vertical grooves; the m3 has its anterior face slightly convex and the posterior one semicircular in shape; whereas in *L. anatirostratus* the teeth are subquadrangular in outline. In addition to this and as in '*Xyophorus*' sp. (MPEF-PV 3264), '*X.*' *bondesioi*, and *L. anatirostratus*, the m3 has a groove only on the labial face, while the posterior lophid of m3 is semilunar semicircular (Figure 3(B)).

Discussion

Recently Brandoni (2014) described '*Xyophorus*' sp. (represented by MPEF-PV 3264) from the middle Miocene of Argentine Patagonia, and included *Xyophorus bondesioi*, *Xyophorus villarroeli*, in '*Xyophorus*', a series of forms different from typical *Xyophorus*. Brandoni (2014) considered that the species recorded from the Santa Cruz Formation (e.g. *Xyophorus andinus*, *Xyophorus atlanticus*) are similar to some species of *Hapalops* in having molariforms of oval to subquadrangular shape, with rounded edges and without vertical grooves. These forms differ from '*Xyophorus*' *bondesioi*, '*Xyophorus*' *villarroelli*, and '*Xyophorus*' sp. (MPEF-PV 3264), considered herein as members of Nothrotheriinae, by their trapezoidal or subcuadrangular molariforms, with mesial and distal lophids, and with vertical grooves on the labial and lingual faces (see De Iuliis et al. 2011 for a diagnosis of Nothrotheriidae and Nothrotheriinae). Specimen LIEB PV 5129 has the features described for other members of '*Xyophorus*' (e.g. shape and size of the molariforms, relationship between diastema length and m1 and m2 length; Figure 4), but a specific determination is not possible given the poorly preserved specimen; therefore assigning LIEB PV 5129 to '*Xyophorus*' sp. results justified.

Taking into account the considerations of Brandoni (2014), i.e. the anatomical differences between species included in *Xyophorus* and those located in the '*Xyophorus*' group, and the fact that '*Xyophorus*' differs (e.g. size, relationship between diastema length and m1or m2 length) from other genera of Nothrotheriinae that preserves the caniniform (e.g. *Pronothrotherium*, *Mionothropus*), the recognition of a new genus for '*Xyophorus*' *bondesioi*, '*Xyophorus*' *villarroelli*, and '*Xyophorus*' sp. (MPEF-PV 3264, LIEB PV 5129) would be justified. However, the scarcity of materials and their poor state of preservation prevents us from making a nearly complete diagnosis for a new genus. Regarding the use of quotation marks, Bengston (1988:244) indicated

> '...', i.e. quotation marks, around a genus-group name indicate that the species is thought to belong to a new genus (or subgenus) related to the named genus, but the material available is insufficient for the formal erection of a new genus.

Therefore, and until there is more and better material for the recognition of a new genus, '*Xyophorus*' corresponds to the generic name of '*Xyophorus*' *bondesioi*, '*Xyophorus*' *villarroeli*, and '*Xyophorus*' sp. (MPEF-PV 3264, LIEB PV 5129).

Regarding the geographic and chronologic distribution of the species of '*Xyophorus*', '*Xyophorus*' *bondesioi* is recorded from Arroyo Chasicó Formation (ca 10–8.7 Ma, Tortonian, late Miocene) of Buenos Aires Province, Argentina (Scillato-Yané 1978), and from localities of Cerdas (ca. 15.1 Ma, Langhian, middle Miocene) and Quebrada Honda (ca. 13–12.7 Ma,

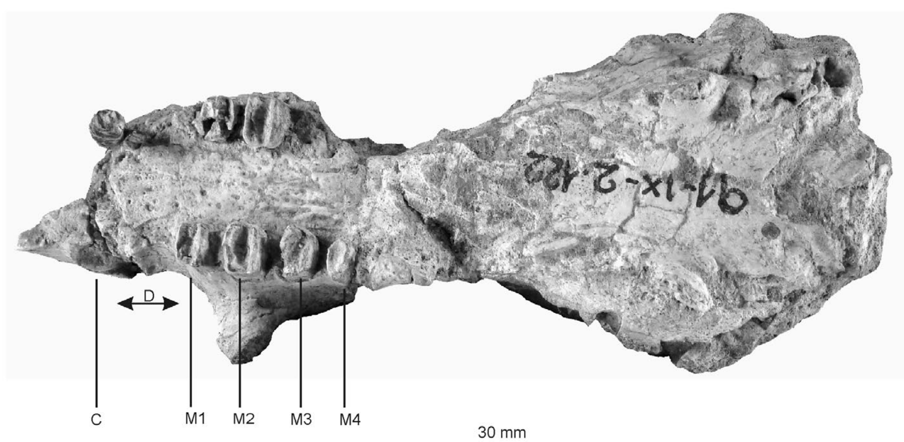

Figure 5. *Amphibradys guiomari* Scillato-Yané and Carlini 1998, MLP 91-IX-2–118, from Collón Curá Formation, in palatal view. Abbreviations: C, upper caniform; D, diastema; M1-M4, upper molariforms 1–4.

Serravallian age, middle Miocene) in Bolivia (Croft et al. 2009; Brandoni 2014). '*Xyophorus*' *villarroeli* is recorded from Member 6 of Mauri Formation (ca. 10.3 Ma, Tortonian, late Miocene) of Achiri, Bolivia (Saint-André 1996; Brandoni 2014), while '*Xyophorus*' sp. (MPEF-PV 3264) is recorded from the locality of El Petiso (Chubut Province, Patagonia, Argentina), which based on the faunal assemblage recorded is referred to the middle Miocene (see Villafañe et al. 2008). In this sense, Brandoni (2014) considered a Serravallian age (middle Miocene) as probable for these sediments, based on the morphology of MPEF-PV 3264 (e.g. relation between length of diastema and tooth-row length). In addition, Scillato-Yané (1978) mentioned the record of *Xyophorus* from the Collón Curá Formation at Pilcaniyeu Viejo (Río Negro Province, Patagonia), but he never provided a catalogue number and the specimen was never described nor figured. Therefore, it is not possible to know if the record corresponds to a species of *Xyophorus* or to a species of '*Xyophorus*' (as used herein). Regarding *Amphibradys guiomari* from the Collón Curá Formation, although Scillato-Yané and Carlini (1998) considered the species as a Nothrotheriidae-Nothrotheriinae, the absence of vertical grooves on the labial and lingual faces of the molariforms (Figure 5) suggests that *A. guiomari* would not be a Nothrotheriinae, and would correspond to a basal Megatherioidea. In this scenario, the record of '*Xyophorus*' sp. (LIEB PV 5129) corresponds to the first accurate record of a Nothrotheriinae from the Collón Curá Formation.

Regarding the Colloncuran fauna, Vucetich et al. (1993) defined the Colloncuran fauna *sensu stricto*, based on the presence of several rodent species (e.g. *Maruchito trilofodonte* Vucetich et al. 1993; *Neosteiromys*? *tordillense* Vucetich et al. 1993; *Protacaremys denisae* Vucetich et al. 1993; see Vucetich et al. 1993). The authors considered the Colloncuran fauna *sensu stricto* as the fauna from the fossil levels immediately below and above the Pilcaniyeu Ignimbrite (the middle section of the Collón Curá Formation cropping out at Neuquén and Río Negro provinces), and following Mazzoni and Benvenuto (1990), who suggested that their $^{40}K/^{40}Ar$ ages best fit ca. 14.1 Ma, they place the Collón Curá Formation in the middle Miocene. In addition, the latest $^{40}Ar/^{40}Ar$ of 15.7 Ma absolute age for the Ignimbrite indicates a Langhian age (middle Miocene) (Madden et al. 1997).

In the southern croppings of the Collón Curá Formation (e.g. Chico River, Chubut River, Cerro Zeballos; southwest of Río Negro and northwest of Chubut provinces), the guide level for the Collón Curá Formation (i.e., Pilcaniyeu Ignimbrite Member) is not deposited (Mazzoni 1993). Because of this, there is no available correlation with the fossil levels associated to the Ignimbrite, where the Colloncuran fauna *sensu stricto* came from (see Vucetich et al. 1993; Bilmes et al. 2013, 2014). In this area where southern croppings of Collón Curá Formation at Chico River (south of Río Negro Province) are exposed, the absolute $^{40}Ar/^{39}Ar$ ages obtained spans from 14.6 to 13.7 Ma (Bilmes et al. 2013; Dunn et al. 2015), while at Cushamen River (northwest of Chubut Province) there is one U-Pb absolute age of 11.2 ± 0.13 Ma (Ramos et al. 2015).

The new specimen presented here as '*Xyophorus*' sp. (LIEB PV 5129) has a DL/TRL index of ca. 14, this value being larger than the index for '*X.*' *villarroeli* (12.07) from the Mauri Formation (ca. 10.3 Ma), but smaller than the value for '*X.*' *bondesioi* (16.45) from Arroyo Chasicó Formation (ca. 10–8.7 Ma) (Table 1, Figure 6). Following the relationship between DL/TRL index and age proposed by Brandoni (2014), where the value of the index would decrease with the age of the bearing sediments, the DL/TRL index of ca. 14 for '*Xyophorus*' sp. (LIEB PV 5129) would suggest a Tortonian age (11.63–7.24 Ma) for the deposits of Collón Curá Formation at Cerro Zeballos (Figure 6), which results in a 'younger age' compared to the middle Miocene age traditionally accepted for the Collón Curá Formation with the Colloncuran fauna *sensu stricto*. Although no absolute ages for Cerro Zeballos are available yet, the geographic proximity of Cerro Zeballos to Cushamen River (with levels dated in ca. 11.2 Ma) supports the possibility that the sediments yielding specimen LIEB PV 5129 are younger than those from those associated to the ignimbrite that carry the Colloncuran fauna *sensu stricto*, so the tentative Tortonian age (late Miocene) indicated by the presence of '*Xyophorus*' sp (LIEB PV 5129).

The faunistic association from Cerro Zeballos is currently being studied, but some preliminary taxonomic results from the studies of marsupials (*Pseudonotictis chubutensis* Martin and Tejedor 2007; Palaeothentidae sp. nov. A and B, Argyrolagydae sp. nov., Hatlyiacinidae sp. nov.) (Martin and Tejedor 2007; Martin et al. 2016), glyptodonts (*Paraeucinepeltus raposeirasi* González Ruiz et al. 2011) (González Ruiz et al. 2011) and ungulates (Interatheriinae morphotipe A and B) (Vera et al. 2016), indicate that it could be different from the Colloncuran fauna *sensu stricto*. The information presented herein adds another fossil group (Nothrotheriidae-Nothrotheriinae) for the Collón Curá Formation; in addition, the different faunal associations (e.g. Cerro Zeballos, Colloncuran Fauna *sensu stricto*) recorded

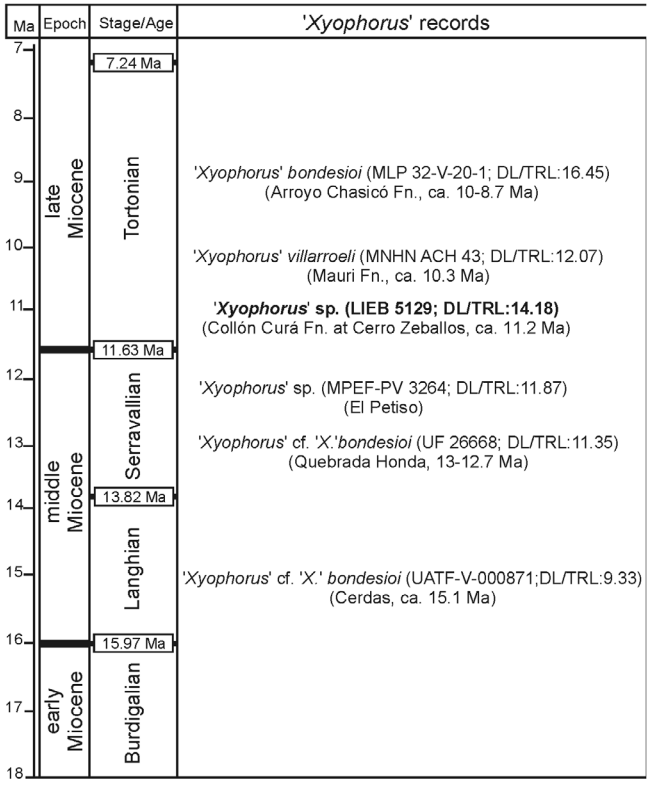

Figure 6. Geochronology for the Miocene.
Note: The chronologic provenance of the specimens referred to 'Xyophorus' and the DL/TRL index values are indicated.

from the Formation, and the different ages considered for it (spans from ca. 16 Ma to ca. 11 Ma, Burdigalian-Tortonian), results in a more complex situation of the Collón Curá Formation and their associated faunas.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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