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Marine Isotope Stage 3 in Southern South America, 60 ka B.P.–30 ka B.P.

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Continental Vertebrates During the Marine Isotope Stage 3 (MIS 3) in Argentina

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Abstract Paleontological sites in Argentina with continental vertebrates corresponding to the Marine Isotope Stage 3 (MIS 3) interval are scarce or poorly known. This situation is mainly due to the lack of absolute ages for Pleistocene fossil remains or their bearing sediments that would allow the verification of the chronology established for this interval. However, a few isolated evidences show that continental vertebrates responded to the abrupt temperature changes that characterized the MIS 3 (Heinrich colder events and Dansgaard–Oeschger warmer events). Up to date, continental vertebrate remains of this age have been found mainly in Buenos Aires province, but also in a few sites of northeastern Argentina (such as Entre Ríos, Corrientes, Formosa and Chaco provinces). In Buenos Aires province: (1) Paso Otero, in the Río Quequén Grande valley, evidence of warmer and more humid conditions were found in sediments dated in 37,800 ± 2300 radiocarbon years before present (RCYBP); (2) Mar del Sur, General Alvarado County, coastal marine sediments with continental mammals were dated in 25,700 ± 800 and 33,780 ± 1200 RCYBP; (3) Balneario Saldungaray, in the Río Sauce Grande valley, Tornquist County,

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gastropods associated with mammal remains were dated in 32,300 ± 1800 and 27,500 ± 670 RCYBP; (4) Los Pozos, Marcos Paz County, sediments dated between 29,000 and 33,000 RCYBP are associated with remains of mammals, birds, reptiles and amphibians; (5) San Pedro, San Pedro County, sediments bearing vertebrate fauna have two OSL datings of 37,626 ± 4198 and 41,554 ± 3756 years B.P. (YBP). In Entre Ríos province, Río Ensenada valley, Diamante Department, some levels of the Tezanos Pinto Formation with OSL datings between 9000 and 35,000 YBP yielded remains of grazer megamammals and other taxa characteristic of the modern Patagonian Domain. In the province of Corrientes, Arroyo Toropí, Bella Vista, vertebrate remains dated with OSL from 36,000 to 52,000 YBP show a clear taxonomic change in response to climatic fluctuations. In Formosa province, Río Bermejo, Villa Escolar sediments of the Fortín Tres Pozos Formation, bearing vertebrate fauna have an OSL age of 58,160 ± 4390 YBP. In the province of Chaco, Charata locality, gastropods associated with mammal remains were dated between 22,000 and 27,000 RCYBP. A larger amount of absolute datings of the bearing sediments and especially taxon dates are needed to determine more accurately the response of the fauna to the climate changes characteristic of MIS 3.

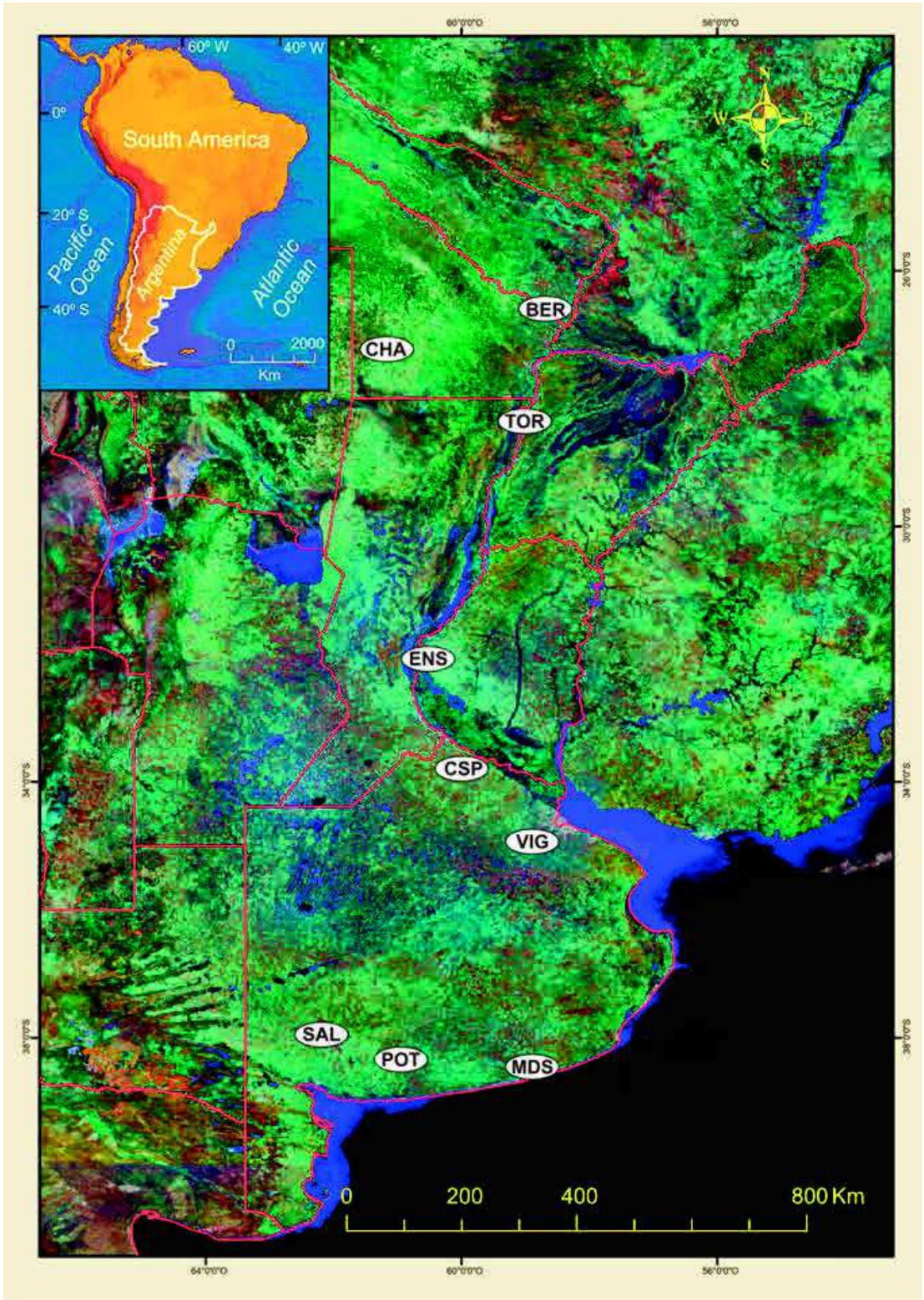
Keywords Chronology · Mammals · Paleontology · OSL · Paleoclimate · Late Pleistocene · Radiocarbon dating

1 Introduction

The Dansgaard/Oeschger (D/O; warmer events) and Heinrich (H; colder events) cycles are recorded in many marine and continental sites worldwide. However, the information is strongly biased to the Northern Hemisphere. The marine records are mainly from the North Atlantic, and the continental ones, from western North America, Europe, and China (Voelker 2002; Hessler et al. 2010; Kanner et al. 2012). Continental biological *proxies* are scarce and belong almost exclusively to palynological information about the then existing flora.

In Argentina, and especially in the Pampean Region, numerous sites with Pleistocene–Holocene vertebrates particularly of the last glacial period (110,000–12,000 YBP) are well known and have been extensively studied. However, due to the lack of numerical ages of Pleistocene fossil remains or their bearing sediments it is difficult to assign them the global chronology established for Marine Isotope Stage 3 (MIS 3). Thus, the sites that can be attributed to this interval with certainty are quite scarce or poorly known. Up to date, continental vertebrate remains of this age have been identified mainly in localities of the Buenos Aires province, but also in a few sites of northeastern Argentina such as Entre Ríos, Corrientes, Formosa, and Chaco provinces (Fig. 1).

Mammals in particular are especially sensitive to climate change and even more those populations that inhabit the extremes of the geographical distribution of the species (Millien et al. 2006, and literature therein). In this regard, Buenos Aires



◀ **Fig. 1** Geographic location of continental paleontological sites of Argentina, involved in the temporal lapse of MIS 3. *BER* Río Bermejo cliffs, near the Villa Escolar locality, Laishi Department (Formosa province); *CHA* Sitio 71, Charata locality (Chaco province); *CSP* Reserva Paleontológica Campo Spósito, Bajo del Tala, Río Baradero, San Pedro County (Buenos Aires province); *ENS* Río Ensenada, near the locality of Diamante, Diamante Department (Entre Ríos province); *MDS* Mar del Sur, General Alvarado County (Buenos Aires province); *POT* Paso Otero, in the Río Quequén Grande valley, Lobería County (Buenos Aires province); *SAL* Balneario Saldungaray in the Río Sauce Grande valley, Tornquist County (Buenos Aires province); *TOR* Arroyo (i.e., creek) Toropí, near Bella Vista locality, Bella Vista Department (Corrientes province); *VIG* Nicolás Vignona III Quarry, at the southern margin of the Río Matanza, Los Pozos locality, Marcos Paz County (Buenos Aires province)

province (included in the Pampean Region) is a good example of an ecotone between faunas of the Brazilian (in Argentina fossils have been recovered in Entre Ríos, Corrientes, Formosa and Chaco provinces) and Patagonian subregions (sensu Hershkovitz 1958; Cione et al. 2015), and consequently an interesting place to study the reaction of the fauna to environmental changes.

The composition of South American vertebrate assemblages was already established at the beginning of the Pleistocene (ca. 2.6 Ma), after the strong influence of legions of mammals entering through the Panama corridor during the major phase of the Great American Biotic Interchange (GABI) (see Cione et al. 2015; Vucetich et al. 2015). Thus, along the Pleistocene, the faunal changes were determined by their different reactions to climate change. On the one hand, the species often formed non-analog assemblages (the association of species that are today allopatric), typical of this period (Bell et al. 2004). On the other hand, megamammals and large carnivores became eventually extinct. A few isolated evidences suggest that continental vertebrates responded to the abrupt temperature changes, at millennia scale, that characterized the MIS 3 with H and D/O events.

In this contribution the faunal information of the Argentine continental paleontological sites involved in the MIS 3 interval has been gathered. The dynamics of the vertebrate fauna are also discussed here from the standpoint of the sudden changes in temperature.

1.1 Argentine Sites and Vertebrate Records During MIS 3

1. Buenos Aires province

1.a Balneario Saldungaray (SAL) in the Río Sauce Grande valley, Tornquist County, Sierras Australes (38° 12′ 15″S and 61°46′ 06″W; Figs. 1 and 2): Arenoso Medio Member of the Agua Blanca Formation (Rabassa 1989; =Upper section of the San José Sequence in Zavala and Quattrocchio 2001). A single vertebrate remains was found in this unit, which represents an indeterminate species of the chinchillid rodent *Lagostomus*.
The basal levels of this unit yielded abundant gastropods of the species *Plagiodontes patagonicus*, *Austroborus dorbignyi,* and *Discoleus aguirrei*,

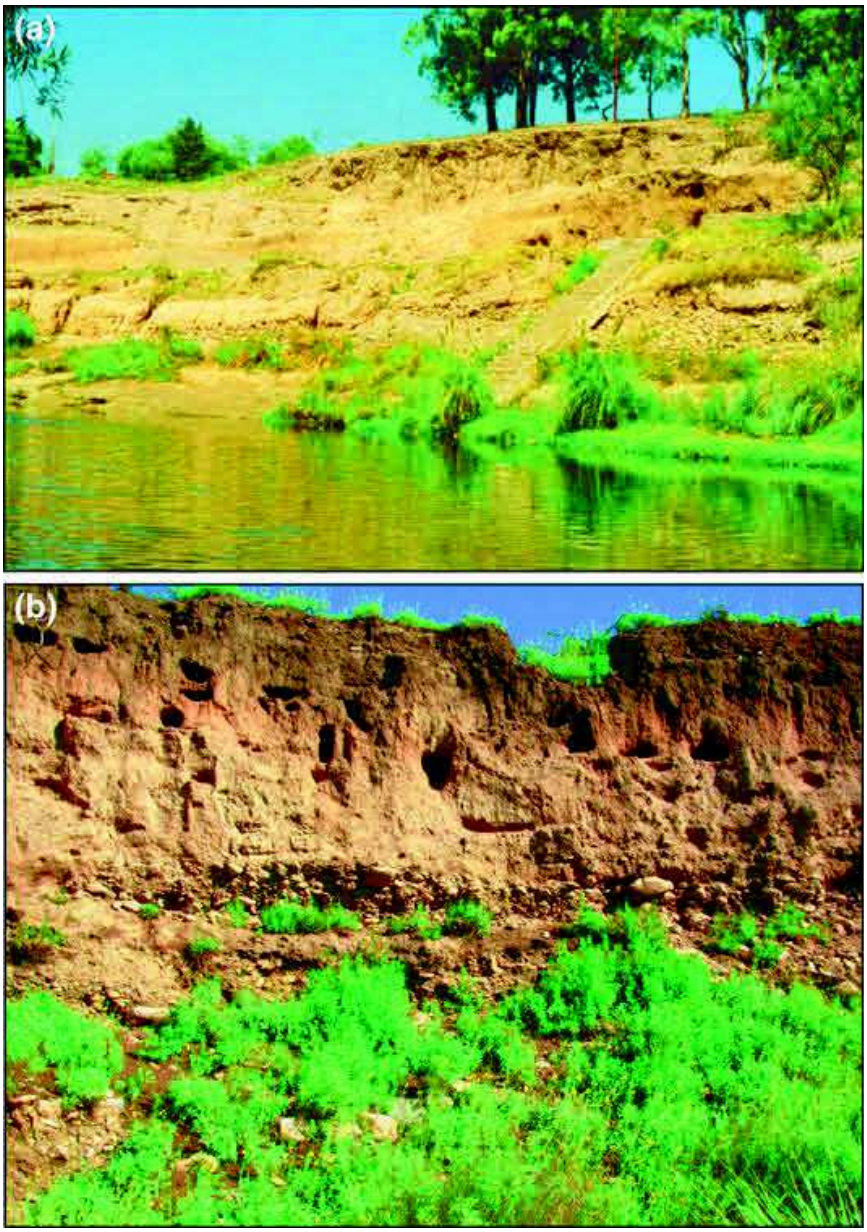


Fig. 2 Balneario Saldungaray (SAL) in the Río Sauce Grande valley, Tornquist County. **a** General view; **b** detail of the section 200 m downstream. Photograph by Cecilia M. Deschamps

being dominant *P. patagonicus*, followed by the other two. These three species currently inhabit the area and are usually associated, but the most frequent and dominant species is *D. aguirrei*, followed by *P. patagonicus* and *A. dorbigny.* One dating of 32,300 ± 1800 radiocarbon years before present (RCYBP; Figini et al. 1989; LP115) was obtained on valves of *P. patagonicus*. Another dating on the valves of the same species from the same lithostratigraphic unit in this locality yielded 27,500 ± 670 RCYBP (Figini et al. 1989; Rabassa 1989; LP2859) (see Table 1).

Table 1 Argentine sites with the OSL, TL and radiocarbon dates corresponding to the MIS 3 with vertebrate remains

Provinces	Paleontological site	Dates	References
Buenos Aires	Río Sauce Grande, Balneario Saldungaray, Tornquist County	27,500 ± 670 and 32,300 ± 1800 RCYBP	Figini et al. (1989), Rabassa (1989)
	Río Quequén Grande, Paso Otero, Lobería County	37,800 ± 2300 RCYBP	Prado et al. (1987), Pomi and Tonni (2011), Cenizo et al. (2015)
	Mar del Sur, General Alvarado County	25,700 ± 800 and 33,780 ± 1200 RCYBP	Tonni et al. (2010)
	"Nicolás Vignona III" Quarry, southern margin of Río Matanza, Los Pozos locality, Marcos Paz county	29,070 ± 1420/31,040 ± 740/31,950 ± 830/32,070 ± 1210/32,580 ± 1520 RCYBP	Gasparini et al. (2013), Beilinson et al. en preparation
	"Reserva Paleontológica Campo Spósito", Bajo Del Tala, Río Baradero, San Pedro County	OSL 37,626 ± 4198 and 41,554 ± 3756 years B.P.	Prado and Alberdi (2012), Aguilar (2013)
Entre Ríos	Río Ensenada, Diamante locality, Diamante Department	TL 35,890 ± 1030 and 31,690 ± 1620 years (Lower Member) B.P. TL 8150 ± 400 and 9390 ± 630 years (Upper Member) B.P. OSL 33,000 years B.P. (alluvial faces)	Kröhling (1999) Kröhling (1999) Ferrero (2013), Ferrero et al. (2015), Brunetto et al. (2015)
Corrientes	Arroyo Toropí, Bella Vista locality, Bella Vista Department	OSL 36,000 and 52,000 years B.P.	Tonni et al. (2005), Francia et al. (2012), Francia (2014)
Formosa	Río Bermejo cliffs, Villa Escolar locality, Laishi Department	OSL 58,160 ± 4390 years BP	Zurita et al. (2009)
Chaco	Sitio 71, Charata locality, Chacabuco Department	22,600 ± 380, 24,010 ± 430 and 26,630 ± 370 RCYBP	Gasparini et al. (2015)

This site was included in this paper because of the radiocarbon datings, but from the geomorphological point of view the unit bearing the dated valves was considered older, and was correlated with the Upper section of the San José Sequence assigned to the Middle Pleistocene (see details in Zavala and Quattrocchio 2001; Deschamps 2003, 2005; Verzi et al. 2004). The vertebrate remains so far found do not contribute to elucidate this issue.

Fig. 3 Paso Otero (POT), in the Río Quequén Grande valley, Lobería County. Photograph by Eduardo P. Tonni

1.b Paso Otero (POT), in the Río Quequén Grande valley, Lobería County (38° 11′ 48″S and 59° 06′ 56″W; Figs. 1 and 3): La Chumbiada Member of the Luján Formation.

According to Prado et al. (1987), the following mammals are recorded in the La Chumbiada Member (cited as "sector pardo" of the Guerrero Member). Xenarthrans: *Glyptodon* sp., *Doedicurus clavicaudatus*, *Panochthus* sp., *Eutatus seguini*; Perissodactyla: *Equus* (*A.*) *neogaeus*; Artiodactyla: *Lama guanicoe*, *L. gracilis*, Cervidae (Odocoileinae) indet.; Carnivora: *Dusicyon avus*, *Lycalopex gymnocercus*; Rodentia: *Lagostomus maximus*, *Dolichotis patagonum*, *Lundomys* sp.

Cenizo et al. (2015) described a bird assemblage from Paso Otero. This assemblage included 22 taxa of different avian families, associated with aquatic, semiacquatic and wading (i.e., Anatidae, Rallidae, Podicipedidae), and terrestrial habits (i.e., Tinamidae, Falconidae, Strigidae, Furnariidae).

Sediments of the La Chumbiada Member cropping out at Paso Otero are dated in 37,800 ± 2300 RCYBP (on the gastropod *Chilina fluminea*: LP1928; Pomi and Tonni 2011; Cenizo et al. 2015) (see Table 1).

Another locality, which unfortunately yielded no vertebrate remains, has two datings that helped to constrain the age of the end of the deposition of the La Chumbiada Member and the beginning of the Guerrero Member of the Luján Formation. This locality is Arroyo Tapalqué (Olavarría County, 36° 52′ 44″S–60° 18′ 38″W; Fig. 4). La Chumbiada Member is dated in 29,150 ± 800 RCYBB (LP 268), and the base of the Guerrero Member in 21,040 ±450 RCYBP (LP396), both on valves of the gastropod *Heleobia parchappei* (Figini et al. 1998).

Fig. 4 Arroyo Tapalqué, Olavarría County. The *red circle* indicates the place where the La Chumbiada and Guerrero members of the Luján Formation were dated. Photograph by Eduardo P. Tonni

1.c Mar del Sur (MDS), General Alvarado County (38° 20′ 55″S and 57° 59′ 28″W; Figs. 1 and 5).
Coastal marine sediments with continental mammals were dated in 25,700 ± 800 and 33,780 ± 1200 RCYBP (Tonni et al. 2010) (see Table 1).
This still unnamed stratigraphic unit, about 1 m thick, is composed of green yellowish silty-clayey sands, slightly compacted. It contains isolated osteoderms of the extinct megamammal *Glyptodon* sp. (Tonni et al. 2010) and shells in life position of *Tagelus plebeius,* a euhaline bivalve species which is a common inhabitant of estuaries and coastal lagoons of Argentina. The shells of *T. plebeius* are also associated with shells of *Heleobia australis*, a gastropod of wide range of salinity (mesohaline to euhaline, ca. 10–35 ‰).

1.d Nicolás Vignona III Quarry (VIG), at the southern margin of the Río Matanza, Los Pozos locality, Marcos Paz County (34° 54′ 40.4″S and 58° 42′ 11.9″W; Figs. 1 and 6).
The sedimentary succession starts with laminated siltstones and fine sandstones of a gray-greenish coloration and a high participation of *Helobia australis* and *Diplodon* sp. Shells of both species were dated in 32,070 ± 1210 and 31,040 ± 740 RCYBP (LP2602, LP2665). These deposits are overlain by brown sandstones with trough cross-stratification and paleosol development. They are associated with remains of mammals, birds, reptiles, and amphibians (see Table 1). Finally, the uppermost 2 m are composed of light brown sandy siltstones with abundant *Helobia australis* valves that yielded ages of 32,580 ± 1520 and 29,070 ± 1420 RCYBP.

Fig. 5 Mar del Sur (MDS), General Alvarado County. Photograph by Esteban Soibelzon

The fauna exhumed from VIG shows taxa mainly adapted to open or semiopen and arid or semiarid environments (e.g. *Panochthus*; *Doedicurus*; *Glyptodon*; *Eutatus*; *Megatherium*; *Lestodon*; *Notiomastodon*; *Macrauchenia*; *Lestodelphys* cf. *L. juga*; *Toxodon* and *Hippidion*). In addition, there are extant taxa at the same stratigraphic level (e.g., *Chaetophractus*, *Ctenomys*, *Dolichotis*, *Lagostomus*, *Lama*, and *Tayassu pecari*). The bearing level was dated on specimens of the bivalve *Ostrea* sp. (LP2729) giving an age of 31,950 ± 830 RCYBP.

Similarly to what happens in Balneario Saldungaray, the Nicolás Vignona III Quarry site was included in this paper because of the radiocarbon datings. From the sedimentological and geomorphological points of view, the deposits bearing the dated valves are considered older, and might be correlated with the MIS 5e transgression (Upper Pleistocene). The vertebrate remains so far found do not contribute to elucidate this issue.

1.e Reserva Paleontológica Campo Spósito (CSP), Bajo del Tala, Río Baradero, San Pedro County (33° 44′ 34″S and 59° 36′ 6″W; Figs. 1 and 7).

The vertebrate remains housed at the Museo Paleontológico "Fray Manuel de Torres" (San Pedro) include the following taxa: *Megatherium americanum*, *Notiomastodon platensis*, *Macrauchenia patachonica*, *Morenelaphus* sp.,

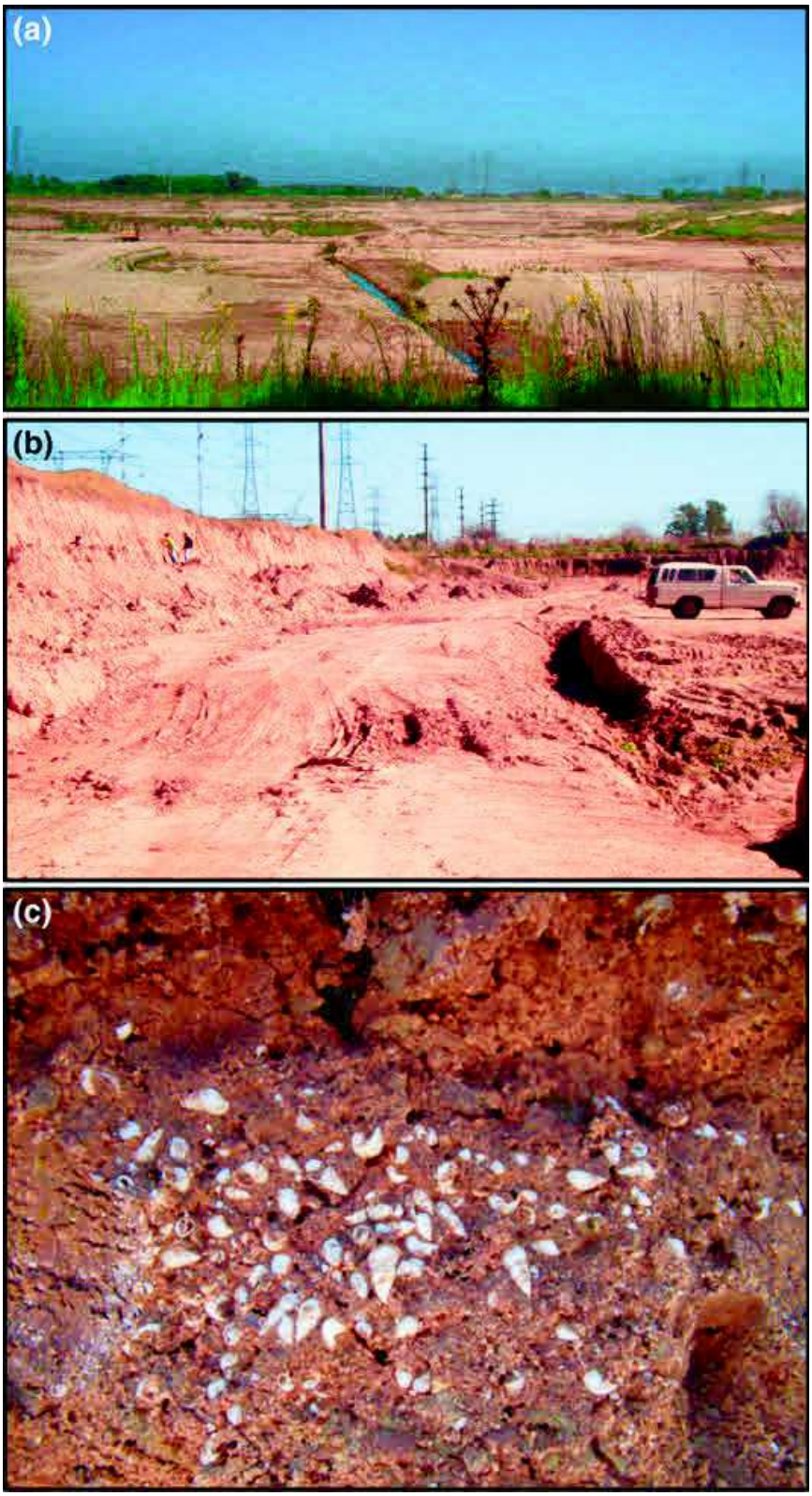


Fig. 6 **a–b** General views of the Nicolás Vignona III Quarry (VIG), at the southern margin of the Río Matanza, Los Pozos locality, Marcos Paz County. **c** detail of the level with *Helobia australis*. Photographs by Esteban Soibelzon

Antifer sp., *Toxodon platensis*, *Lestodon armatus*, *Panochthus tuberculatus*, *D. clavicaudatus*, *Glyptodon* sp., *Equus (A.) neogaeus*, *Hippidion principale* and *Hemiauchenia* sp. The same taxa at a generic level were recognized for this site by Aguilar (2013).

Sediments bearing this vertebrate fauna have two OSL datings of 37,626 ± 4,198 and 41,554 ± 3,756 years BP (Prado and Alberdi 2012) (see Table 1).

2. Entre Ríos province

Río Ensenada (ENS), near the locality of Diamante, Diamante Department (32° 04′ 10″S and 60° 38′ 17″W; Figs. 1 and 8).

The Tezanos Pinto Formation is the typical Late Pleistocene–Early Holocene loess unit of the northeastern Pampean Region. It includes two members, which are mainly developed at the divides. The Lower Member is dated by TL in 35,890 ± 1,030 and 31,690 ± 1,620 YBP (Kröhling 1999). The Upper Member yielded TL ages of 8,150 ± 400 and 9,390 ± 630 YBP (Kröhling

Fig. 7 Reserva Paleontológica Campo Spósito (CSP), Bajo del Tala, Río Baradero, San Pedro County. **a** View of access to the outcrop; **b** detail of the exposed units. Photographs by José Luis Aguilar

1999) (see Table 1). Within the valleys, the Tezanos Pinto Formation is represented by alluvial and fluvial facies. One OSL dating for the alluvial facies gave an age of 33,000 years (Ferrero 2009) and the fossil record is restricted to *Smilodon populator* (Ferrero 2013; Ferrero et al. 2015; Brunetto et al. 2015). For the valley of the Río Ensenada, Ferrero (2009) and Ferrero and Noriega (2009) described mammal taxa traditionally related to dry and cold climatic conditions, which are widely distributed in the Late Pleistocene of other areas of Argentina (Gasparini et al. 2011) as follows: *E. seguini*, *Glyptodon reticulatus*, *P. tuberculatus*, *L. gymnocercus* [cited as *Dusicyon gymnocercus*], *S. populator*,

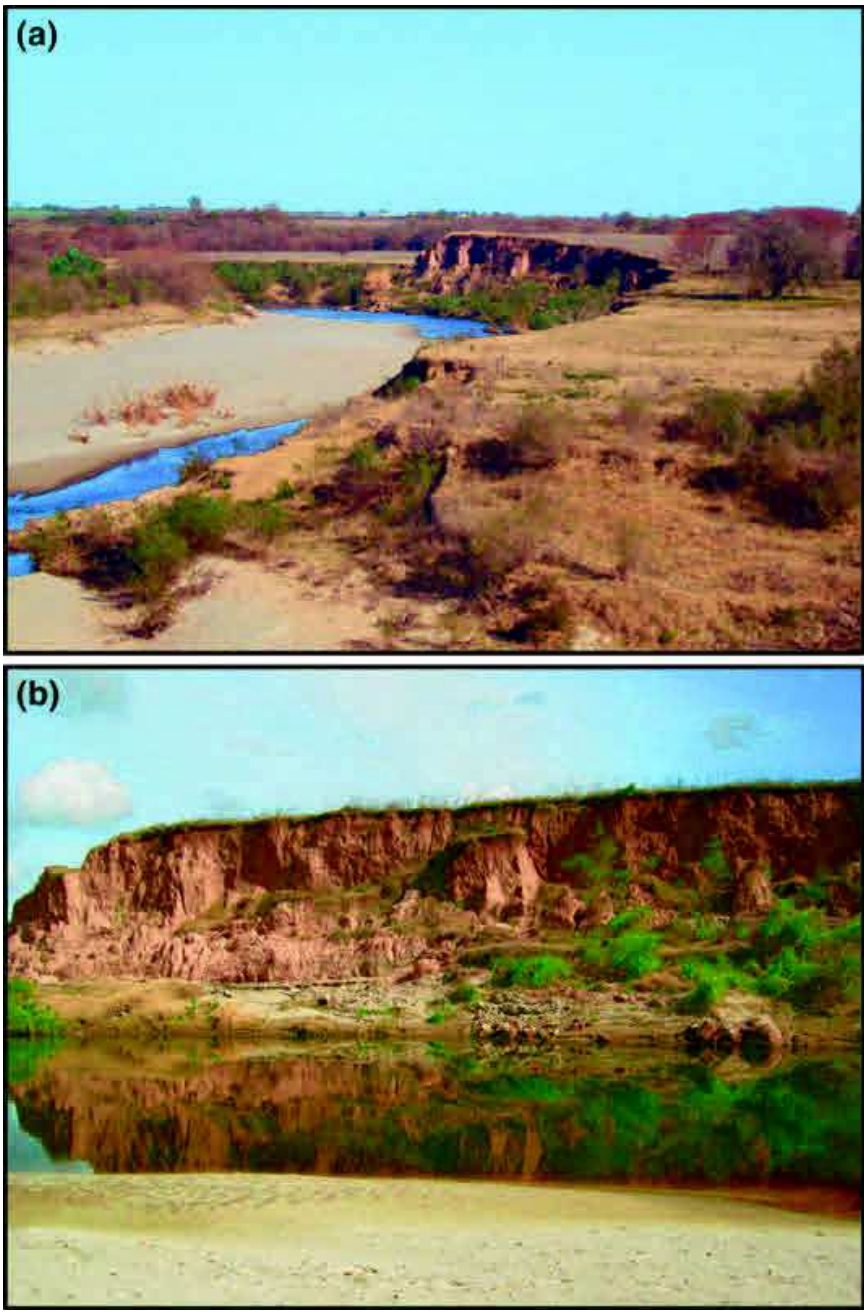


Fig. 8 Río Ensenada (ENS), Diamante Department. **a** General view of the locality; **b** detail of the main exposure. Photographs by Brenda Ferrero

M. patachonica, *T. platensis*, *Equus (A.) neogaeus*, *H. principale*, *Antifer ultra*, *Morenelaphus brachyceros*, *Hemiauchenia paradoxa*, *L. guanicoe*, and *L. gracilis*. However, they are found in the Salto Ander Egg Formation, in association with interglacial fauna (Ferrero 2013; Ferrero et al. 2015; Brunetto et al. 2015).

3. Corrientes province
   Arroyo (i.e., creek) Toropí (TOR), near Bella Vista locality, Bella Vista Department (28° 30′ 27″S and 59° 02′ 43″W; Figs. 1 and 9).
   The Toropí/Yupoí Formation includes an interesting assemblage of fossil vertebrates in which mammals are the most diverse and frequent, whereas reptiles are comparatively scarce. The bearing levels were dated by OSL yielding ages between ca. 52,000–36,000 YBP (Tonni et al. 2005; Francia et al. 2012) (see Table 1).
   Francia (2014) and Francia et al. (2015) reported the following vertebrates: Mammals: *N. platensis*, *Equus* (*A.*) cf. *E.* (*A.*) *neogaeus*, *Hippidion* sp., *Morenelaphus lujanensis*, *Hippocamelus sulcatus*, cf. *Mazama* sp., *T. pecari*, *Tayassu* sp., *Neolicaphrium recens*, *Hemiachenia paradoxa*, *T. platensis*, *Chaetophractus villosus*, *Euphractus* aff. *E. sexcinctus*, *Propraopus sulcatus*, *Holmesina paulacoutoi*, *Pampatherium typum*, *Neosclerocalyptus paskoensis*, *Neosclerocalyptus* sp., *P. tuberculatus*, *Glyptodon* sp., *Scelidotherium* sp., *Scelidodon* sp., *Galea* aff. *G. tixiensis*, *D. patagonum*, *S. populator*, and *Pantera onca*; Reptiles: *Chelonoidis lutzae*, and *Boa constrictor*.
4. Formosa province
   Río Bermejo cliffs (BER), near Villa Escolar locality, Laishi Department (26º 36′ S and 58º 40′ W; Figs. 1 and 10).
   The sediments cropping out at the Río Bermejo, can reach a thickness of 8-9 meters; the sediments bearing vertebrate fauna were considered by Zurita et al. (2009) as the Fortín Tres Pozos Formation. However, Iriondo (2010) assigned its lower portion to the Río Bermejo Formation and the upper one to the La Fidelidad Formation (Zurita et al. 2014).
   Zurita et al. (2009: 277) described the fauna as formed by "Pampean Patagonian elements". This fauna includes remains assigned to *Glyptodon* sp., *Neosclerocalyptus* cf. *N. paskoensis*, *P. typum*, *Pampatherium* sp., *Megatherium* sp., cf. *Morenelaphus*, cf. *H. paradoxa*, and *Toxodon* sp.
   At the lower third of the Río Bermejo Formation (sensu Iriondo 2010), sediments bearing vertebrate fauna have an OSL date that indicates an age of 58,160 ± 4,390 YBP (UIC2108BL; Zurita et al. 2009) (see Table 1). In addition, ^{14}C dating in the middle section of the Río Bermejo Formation indicated an approximate age of 9,500 YBP (Zurita et al. 2011, 2014).
5. Chaco province
   The paleontological site named as Sitio 71, Charata locality (CHA), Chacabuco Department (27° 11′ 60″ S and 61° 10′ 48″ W; Figs. 1 and 11) comprises alluvial sandy silts ("*grandes abanicos aluviales*", "large alluvial fans", sensu Iriondo et al., 2000) reworked by aeolian processes. Two paleosol levels were identified at the exposed profile, corresponding to stabilization moments of the landscape.

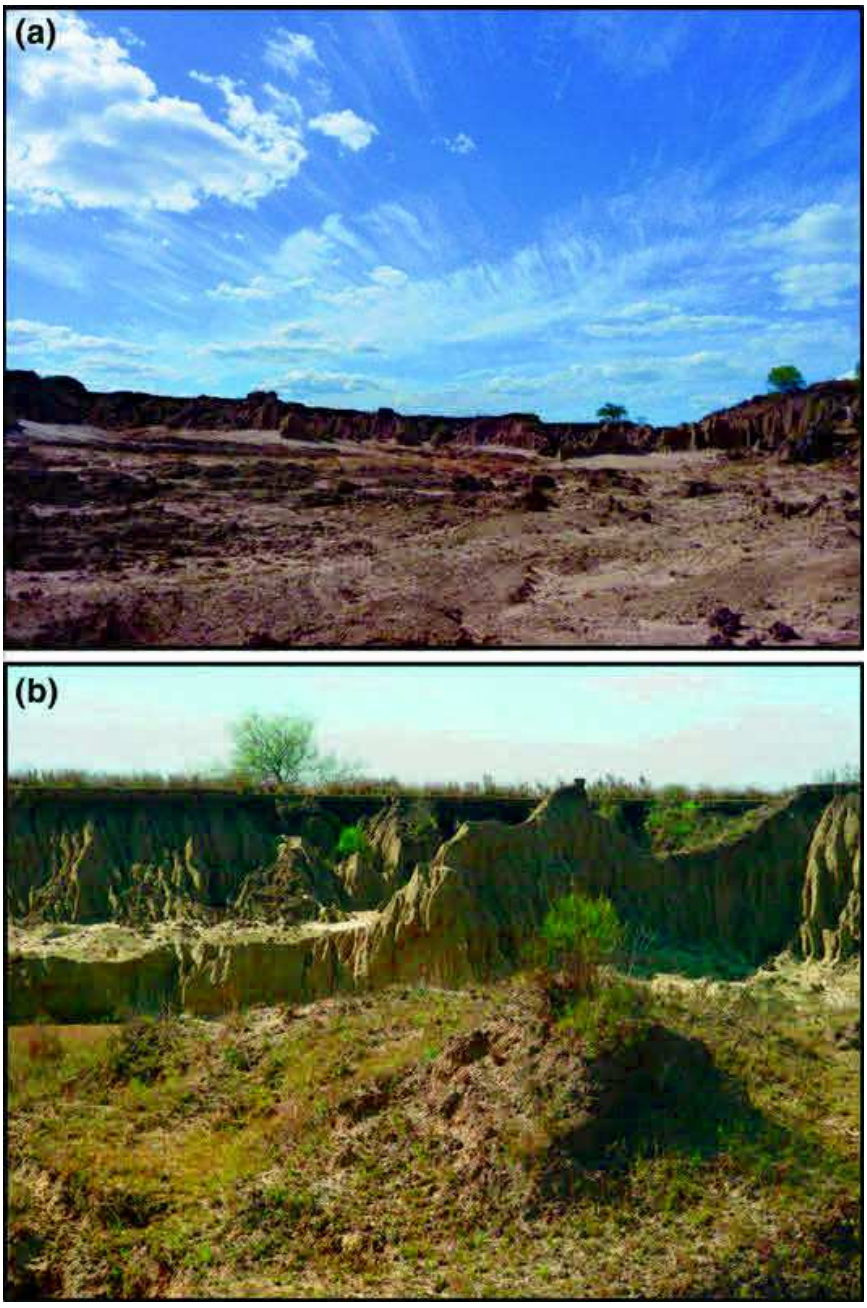


Fig. 9 Arroyo Toropí (TOR), Bella Vista Department. **a** General view of the locality; **b** detail of the exposed units. Photographs by Jorge Carrillo Briceño and Analía Francia

Sediments overlying the upper paleosol correspond to Level 1; Level 2 was deposited between both paleosols, and Level 3 is below the lower paleosol. Level 2 was dated in 22,600 ± 380 and 24,010 ± 430 RCYBP (*Pomacea* sp.: LP 3141 and LP 3188, respectively); a similar specimen of Level 3 was dated in 26,630 ± 370 RCYBP (LP 3142). The dates are stratigraphically consistent.

The faunal assemblage found at levels 2 and 3 correspond to *Glyptodon* sp., *Neosclerocalyptus* sp., *Equus* (*A.*) sp., and *Toxodon* sp. At level 3, a skull and mandible belonging to the tayassuid *Catagonus* sp. were recorded (Gasparini et al. 2015).

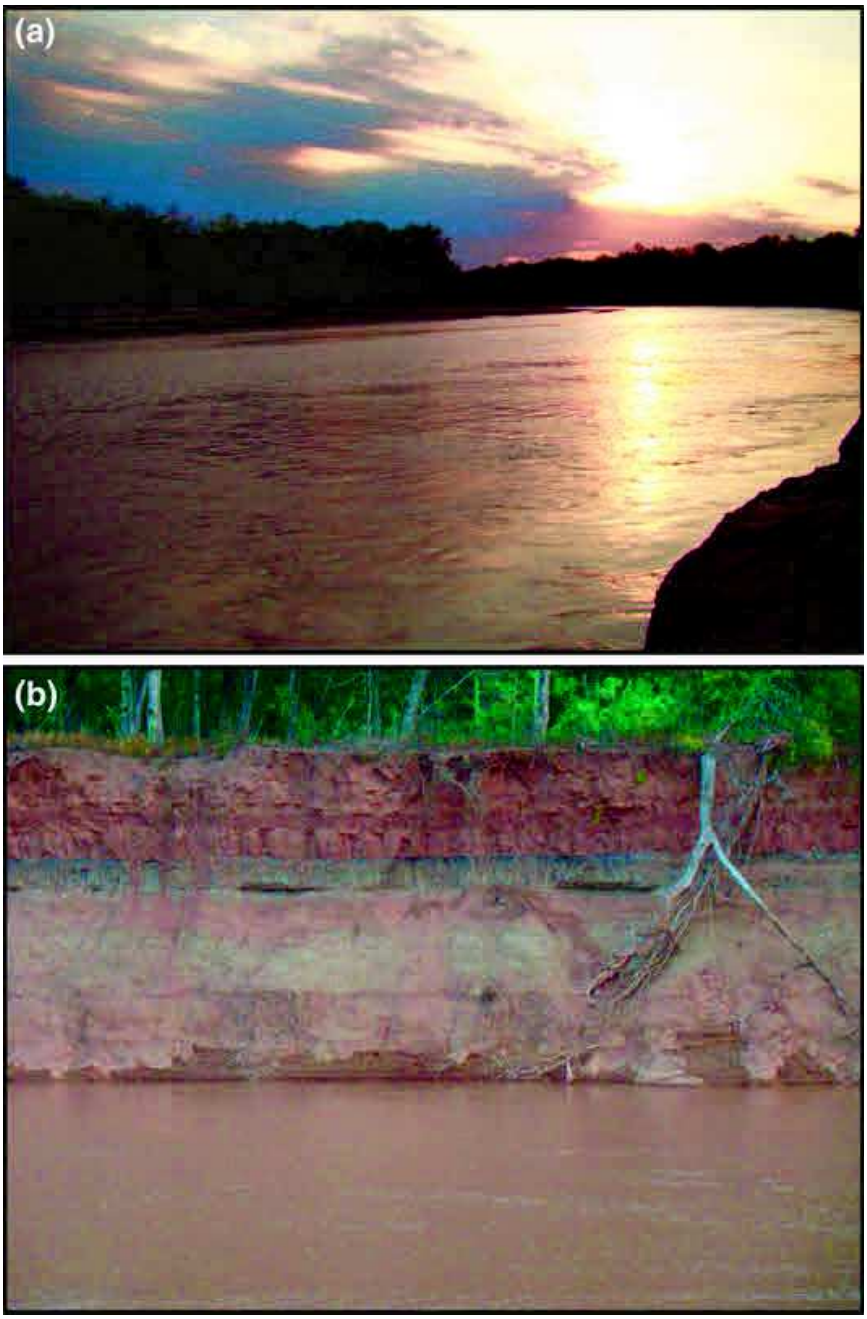


Fig. 10 Río Bermejo cliffs (BER), near Villa Escolar locality, Laishi Department. **a** View of the Río Bermejo; **b** detail of the cliffs. Photographs by Alfredo Zurita

Fig. 11 Paleontological site named as Sitio 71, Charata locality (CHA). Photograph by Guillermo Lamenza

2 Discussion

Data obtained from the studied sites allow some inferences to be made regarding paleoenvironments and paleoclimates prevailing in the interval corresponding to MIS 3, on the basis of the response of vertebrates to climate change and environmental requirements.

In Buenos Aires province, specifically in the assemblage at Paso Otero, the record of *Lundomys* sp. (Sigmodontinae, Mammalia) has been used by Teta and Pardiñas (2006; see also Pomi and Tonni 2011) to refer the bearing level to a warmer period. In addition, the signs of termite activity observed on the bones of this assemblage confirm such environmental conditions since termites are predominantly a tropical order of insects (Pomi and Tonni 2011). However, together with these evidences, xeric mammals such as *Lama gracilis* and *Lestodelphys* sp. were found. The association of species with different ecological requirements suggests that the deposit may represent an averaged time during which very rapid climate changes occurred.

According to Cenizo et al. (2015), the ecological requirements of the avian taxa reported for Paso Otero indicate the existence of open grasslands with the presence of freshwater and permanent ponds, similar to the environment found today in southeastern Buenos Aires province (e.g., "Area Interserrana Bonaerense"). Consequently, the high similarities in ecological requirements and species diversity of the assemblages of Paso Otero and the avifauna currently living in the area, suggest similar climatic conditions to the present ones.

In Mar del Sur, Tonni et al. (2010) provided new evidence about the abrupt warming that occurred during MIS 3. According to the geological data at this site, sea-level rise accompanied the climatic change.

Gasparini et al. (2013) described for Nicolás Vignogna III Quarry the first record of *T. pecari* in the central-northern region of Buenos Aires province. The genus was recorded in the Middle Pleistocene (Bonaerian) of southern Buenos Aires province (Río Sauce Grande, Bajo San José; Deschamps 2005) in sediments correlated with MIS 11, a very warm period although not necessarily wetter in this area (Verzi et al. 2004). During the Late Pleistocene, *T. pecari* was distributed southern to its current range, probably evidencing different paleoenvironmental conditions. The genus *Tayassu* by itself is insufficient to infer the prevailing environmental conditions, because of its wide current geographical distribution and broad ecological tolerance (Menegaz and Ortíz Jaureguizar 1995, Gasparini and Zurita 2005, Gasparini 2013). However, it has not been recorded together with faunas of cold climate. Besides, other recorded taxa which include living species such as *Lestodelphys*, *Chaetophractus*, *Ctenomys*, *Dolichotis*, *Lagostomus*, and *Lama* are characteristic of arid and semiarid areas. Today *T. pecari* is not sympatric with the species of *Dolichotis* and *Lestodelphys*.

In Entre Ríos province, Río Ensenada, the faunal assemblage is relevant because it includes taxa of Late Pleistocene megamammals typical of the Pampean Region and two species of Camelidae (one of them, extinct). The geographic distribution of living species (*L. guanicoe*) excludes the area of the Argentine Mesopotamia (Entre Ríos, Corrientes and Misiones provinces) being characteristic of arid and semiarid areas.

In Corrientes province, the faunal assemblage found in Arroyo Toropí is characterized by taxa with clearly different ecological requirements, to which it must be added the presence of taxa that are not currently present in this area; moreover, they live in distant geographical areas (Francia 2014). The record of climate-sensitive taxa such as *D. patagonum*, and *B. constrictor* suggests that the sequence was deposited under less humid environmental conditions than the present ones. In this sense, Scillato-Yané et al. (1998) inferred that the annual rainfall must have been lower than 700 mm, which strongly contrasts with the present situation with annual rainfall exceeding 1300 mm (Corrientes meteorological station, for decades 1941–1950 and 1981–990). However, the record of some elements with tropical or subtropical affinities, both extinct (e.g., *H. paulacoutoi*) and living ones (e.g., *P. onca*), suggests that some episodes of higher humidity also occurred during the deposition of the sequence.

In Formosa province, the mastofauna assemblage recorded at the Río Bermejo cliffs, near Villa Escolar (together with those previously known from the south and central eastern Chaco) includes taxa adapted to open and relatively cold environments (Zurita et al. 2009). This is in agreement with the conditions of deposition of the sediments that form the alluvial fan of the Río Bermejo. These authors also stated that *"esta paleofauna resulta, desde un punto de vista taxonómico, más afín a aquella registrada en el Pleistoceno tardío de la región Pampeana que a la conocida para la región Mesopotámica de Argentina, en donde se observa una "mezcla" de taxones típicamente pampeanos con otros de origen brasílico,*

indicadores de ambientes más húmedos y cálidos…" ("*this paleofauna is, from a taxonomic point of view, closer to that recorded in the Late Pleistocene of the Pampean Region than to that one known for the Mesopotamian Region in which there is a mix of typically Pampean taxa with Brazilian ones, indicators of more humid and warm environments*…") (Zurita et al. 2009: 285).

In Chaco province, the faunal assemblage of Sitio 71 was found at levels 2 and 3; the tayassuid *Catagonus* was found in the latter. This genus has a set of morphological features that suggests adaptations to cursorial habits on dry and relatively open environments. The bearing sediments and the particularities of the faunal assemblages, as well as the chronological data, allow confirming that in this area of Argentina, arid and semiarid conditions, with scarce or absent vegetation cover were developed during the last part of MIS 3 and part of MIS 2. These environmental conditions allowed the settlement of megamammals adapted to open environments.

Taking into account the above-mentioned, the assemblages of vertebrates of the few sites that can be attributed to the MIS 3 suggest that they responded to the sudden changes of temperature that characterized this interval. In this sense, Paso Otero, Nicolás Vignona III Quarry (taking into account the comments on its age), and Arroyo Toropí are particularly informative. In these localities, taxa with different ecological requirements were found within a single lithostratigraphic unit. These lithostratigraphic units represent an average sample in terms of geological time, and not a single paleoclimatic event. Thus, the vertebrate assemblages of these units represent successive biocenoses instead of a single one. In summary, this scenario could be explained as a taphocoenosis produced by the association of taxa with different ecological requirements that lived in different intervals of time, being their stratigraphic association the result of the averaged time represented in the deposit. These mixed-up vertebrate assemblages would also suggest that the climatic changes and the resulting climatic episodes would have been fast, intense, and short.

In consequence the "non-analogous or disharmonious assemblages" (see Semken 1974; Lundelius 1983; Graham 1985; Graham and Mead 1987; Bell et al. 2004; Morgan and Emslie 2010) could be the result of rapid faunal changes without resolution in the fossil record.

A larger amount of absolute datings of the bearing sediments and especially taxon dates are needed to determine more accurately the faunal response to climate change.

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