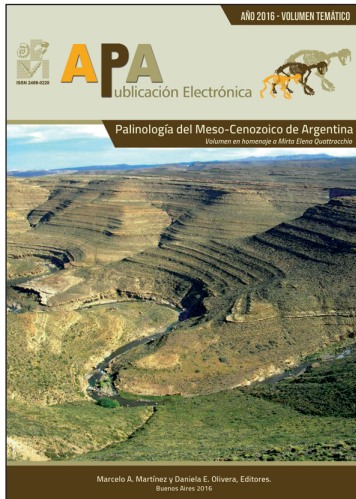




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## LATE CENOZOIC VERTEBRATES FROM THE SOUTHERNPAMPEAN REGION: SYSTEMATIC AND BIO-CHRONOSTRATIGRAPHIC UPDATE

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# LATE CENOZOIC VERTEBRATES FROM THE SOUTHERN PAMPEAN REGION: SYSTEMATIC AND BIO-CHRONOSTRATIGRAPHIC UPDATE

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**Abstract.** The knowledge of the vertebrate systematics and bio-chronostratigraphy of Late Cenozoic from the southwest of the Buenos Aires Province is updated. The study is focused on 12 localities that encompass the latest Miocene to the Holocene. Biostratigraphic units were identified and correlated to those of other areas of the Pampean Region. Farola Monte Hermoso, Bajo San José and Playa del Barco outstand because they yielded a large amount of fossil remains. In turn, the quarries near Grünbein allowed refining the age of “Huayquerian” faunas and their relationship with “Montehermosan” ones. The localities Cantera Seminario, Barrancas de Sarmiento, Cantera Vialidad, and Cantera Relleno Sanitario are assigned to the latest Miocene-earliest Pliocene; Farola Monte Hermoso and Las Oscuras, to the Early Pliocene; Bajo San José to the Middle Pleistocene; Puesto La Florida, Chacra Santo Domingo, and García del Río to the Late Pleistocene–Holocene; Playa del Barco to the Late Pleistocene; Pliocene *s.l.*, and Pleistocene–Holocene levels are exposed at Balneario Saldungaray.

**Key words.** Biostratigraphy. Mammals. Late Miocene–Holocene. Buenos Aires Province. Argentina.

**Resumen.** VERTEBRADOS DEL CENOZOICO TARDÍO DEL SUDOESTE DE LA REGIÓN PAMPEANA: ACTUALIZACIÓN SISTEMÁTICA Y BIO-CRONOESTRATIGRÁFICA. Se realiza una actualización del conocimiento de la sistemática de los vertebrados y la bio-cronoestratigrafía del Cenozoico tardío del sudoeste de la Provincia de Buenos Aires. El trabajo se enfoca en 12 localidades que abarcan desde el Mioceno más tardío hasta el Holoceno. En ellas se identificaron unidades bioestratigráficas que se correlacionan con otras áreas de la Región Pampeana. Se destacan Farola Monte Hermoso, Bajo San José y Playa del Barco como las localidades más fosilíferas. Por su parte, las canteras cercanas a la localidad de Grünbein se destacan por permitir la aproximación a las edades de faunas “huayquerienses” y su relación con las “montehermosenses”. Las localidades Cantera Seminario, Barrancas de Sarmiento, Cantera Vialidad y Cantera Relleno Sanitario se asignan al Mioceno más tardío–Plioceno más temprano; Farola Monte Hermoso y Las Oscuras al Plioceno Temprano; Bajo San José al Pleistoceno Medio; Puesto La Florida, Chacra Santo Domingo y García del Río al Pleistoceno Tardío–Holoceno; Playa del Barco al Pleistoceno Tardío; en Balneario Saldungaray afloran niveles asignados al Plioceno *s.l.* y al Pleistoceno–Holoceno.

**Palabras clave.** Bioestratigrafía. Mamíferos. Mioceno Tardío–Holoceno. Provincia de Buenos Aires. Argentina.

THE TEMPORAL scheme of the South American Cenozoic was established in the XIX Century by Ameghino (*e.g.*, Ameghino, 1889, 1898) on the basis of mammal assemblages of Patagonia and central Argentina. Pascual *et al.* (1965) introduced the first scheme of South American land-mammal ages (SALMAs), following the proposal of Ameghino, which was not substantially modified. The temporal calibration of the continental Late Miocene–Holocene is based mostly on mammal faunas from central Argentina. This interval includes the Chasican, Huayquerian, Montehermosan, Cha-

padmalalan, Marplatan, Ensenadan, Bonaerian, Lujanian and Platan SALMAs and Stages/Ages (Cione and Tonni, 1995, and references therein).

The southwestern Buenos Aires Province represents an outstanding area to study the biochronology and biostratigraphy of this interval based on the analysis of mammals because it has several outcrops bearing remains of at least the last 10 My. Some of them were already well known in the paleontological literature, for example Farola Monte Hermoso (Darwin, 1846; Bravard, 1857; Ameghino, 1887,

1889; Frenguelli, 1928, 1950; J.L. Kraglievich, 1946; Leanza, 1948; Bonaparte, 1960; more recently Tonni *et al.*, 1992, among others), Punta Alta (Darwin, 1846), Playa del Barco (Ameghino, 1908; L. Kraglievich, 1926, 1934; Frenguelli, 1928; Cabrera, 1929; J.L. Kraglievich, 1946; Parodi Bustos, 1962; more recently Aramayo and Manera de Bianco, 1989; Tomassini *et al.*, 2010). However, the idea to undertake investigations with a multidisciplinary approach began in the 1980s with the initiative of Dr. Mirta Quattrocchio by forming a team to conduct geo-paleontological researches.

The Laboratory of Palynology of the Universidad Nacional del Sur headed by Dr. Quattrocchio was already well known for the palynological studies in Argentina and abroad. By those times the staff began to study the profiles exposed along rivers, creeks, roads and railways cuts in the area of Bahía Blanca in which Late Cenozoic sediments were represented. We joined the field work together with palynologists, sedimentologists and specialists in microinvertebrates that were already part of the team, with the aim of

making our contribution from the point of view of vertebrate paleontology. The common idea was to make the reconstruction of the geological and paleoenvironmental evolution of the area.

During field work, several exposures appropriate for multidisciplinary study were found. In some of them the vertebrate record was scarce, but anyway they were significant when making the correlation with other localities. In this way, a wider span of time and geographic area could be studied.

The first results were limited to specific localities (*e.g.*, Quattrocchio *et al.*, 1988; Deschamps and Borrromei, 1992; Deschamps and Tonni, 1992; Verzi and Deschamps, 1996; Deschamps *et al.*, 1998), but with time, data were used to make bio-chronostratigraphic proposals (Deschamps, 2003, 2005), which were refined in subsequent papers (*e.g.*, Verzi *et al.*, 2004a, 2008; Deschamps *et al.*, 2012, 2013; Tomassini, 2012; Tomassini and Montalvo, 2013; Tomassini *et al.*, 2013a) even making inferences about environmental conditions suggested by the recorded taxa. In this sense, rodents were particularly important among mammals (Verzi *et al.*, 2004a; Quattrocchio *et al.*, 2008; Deschamps *et al.*, 2009, 2012, 2013; Tomassini *et al.*, 2013a; Vucetich *et al.*, 2014a,b, 2015).

The purpose of the present contribution is to provide an update of both the stratigraphic proposal, and the mammal systematics on which it is based, for the Late Miocene–Holocene interval, within an area of the southwest of the Buenos Aires Province between 38° 20′–39° S, and 61° 35′–62° 10′ W (Fig. 1). In this way, we wish to acknowledge Dr. Mirta Quattrocchio and to offer this work as a tribute for the influence she has had on the development of our careers.

### GEOLOGICAL SETTING

The oldest sediments bearing vertebrate remains in this area correspond to the Late Miocene interval and form the regional substrate above which the present relief was elaborated (Zárate, 2005). These are massive to coarsely stratified, brownish red to yellowish sandy silts ending with a massive carbonate level, known as “Pampean sediments”. The exposures are generally isolated along the banks of drainage systems. Different lithostratigraphic units were named for these sediments (some of them without the re-



Figure 1. Location map showing the studied localities. Grunbein represents three quarries very close to each other: canteras Seminario, Vialidad and Relleno Sanitario.

quirements of the stratigraphic Argentinean code CAE, 1992), e.g., Arroyo Chasicó (Pascual, 1961), Epecuén (Pascual, 1961), Pampiano (Fidalgo *et al.*, 1973), La Norma (De Francesco, 1992), Irene (Reig, 1955), Saldungaray and La Toma (Furque, 1967) formations. Folguera and Zárate (2009, 2011) gathered them as the Cerro Azul Formation and interpreted that they represent distal sinorogenic facies that document the Andean tectonic dynamic. Folguera and Zárate (2009) and Montalvo *et al.* (2012) proposed an evolutionary, regional geological model to explain the geographical distribution and antiquity of the faunal emblems found in the Cerro Azul Formation (see Verzi, 1999). According to the fossil content it includes deposits of the Chasicooan and Huayquerian ages (Fig. 2). The accumulation of these sediments began after the regression of the Paranense sea, identified in northeastern Argentina as Paraná and Entre Ríos formations (*sensu* Chebli *et al.*, 1999), and Barranca Final Formation in northeastern Patagonia (Colorado Basin; Zambrano, 1972). The establishment of these diverse groups of environments that favored the development of continental vertebrates was called Edad de las Planicies Australes (the age of the austral plains) by Pascual and Bondesio (1982). According to Zárate (2005) there was a progressive trend towards cooling and aridization, with alternating wetter and warmer conditions. In most sections sedimentation was related to fluvial agents or water bodies; eolian facies were subordinated, although through time they became dominant.

Pliocene sediments were grouped together with those Late Miocene ones as the “Araucanense”. They include the Montehermosan and Chapadmalalan ages. Several exposures, mainly represented by cliffs located in the Atlantic coast, yielded abundant mammal remains, being the most significant those of Farola Monte Hermoso and the area of Mar del Plata-Miramar, which are mostly related to fluvial environments.

The sedimentary record of the latest Pliocene–Pleistocene is represented by fluvial and aeolian sequences which are subject of several stratigraphic proposals in different areas of the Buenos Aires Province (see Zárate, 2005). Landscape reactivation occurs with the development of valleys carved in the Mio–Pliocene substrate. The fluvial Late Pleistocene–Holocene units are the equivalents to the Luján Formation

of northeastern Buenos Aires Province (Fidalgo *et al.*, 1973): Agua Blanca Formation (De Francesco, 1992, and modifications of Rabassa, 1989, and Zavala and Quattrocchio, 2001) or part of the San José Sequence and Agua Blanca Sequence (Zavala and Quattrocchio, 2001), as well as the Chacra La Blanqueada Formation (Rabassa, 1989), the youngest fluvial unit, corresponding to overflow sediments. The eolian sediments of this interval are included in the Saavedra Formation (De Francesco, 1992), equivalent to the La Postrera Formation of eastern Buenos Aires Province (Fidalgo *et al.*, 1973), and Matadero Saldungaray Formation (Rabassa, 1989), which represents the youngest eolian sediments of historical times.

Zavala and Quattrocchio (2001) produced a chronostratigraphic chart in which they proposed the relationships

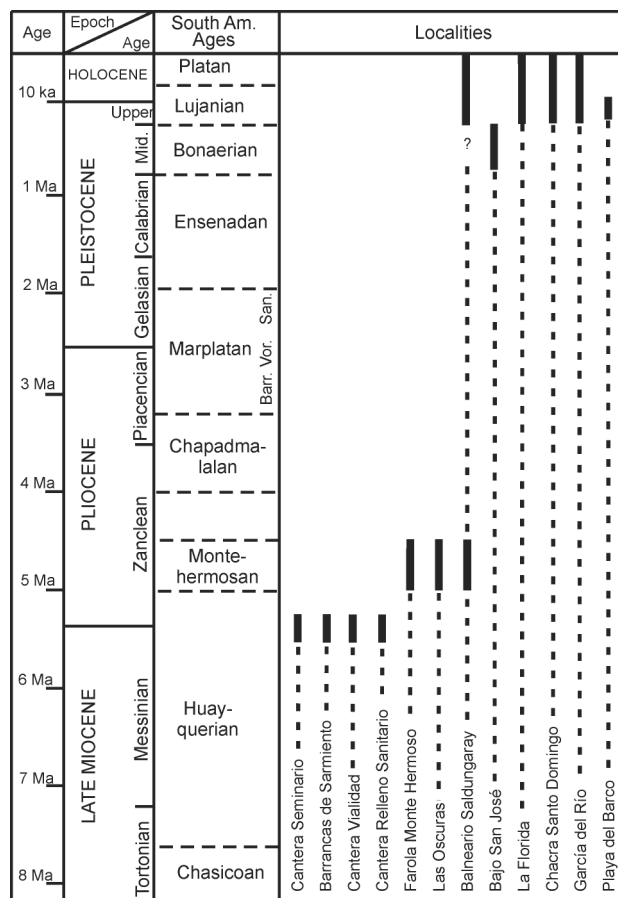


Figure 2. Stratigraphic chart showing the levels exposed at the studied localities correlated with International and South American ages.

among the lithostratigraphic units of the Late Cenozoic. The finding of mammals in many of them (Verzi *et al.*, 2004a, 2008; Deschamps, 2005; Tomassini *et al.*, 2010, 2013a; Deschamps *et al.*, 2012, 2013) together with numerical ages (*e.g.*, Aramayo, 1997; Schultz *et al.*, 2006) allowed improving their temporal assignment.

## STUDIED LOCALITIES

The localities representing the Late Miocene–Holocene interval selected for this contribution will be listed according to the age of the exposed sediments from oldest to youngest. See complete list of taxa in Appendix 1.

### Late Miocene–Pliocene

This interval was studied in quarries near Bahía Blanca and cliffs of the Sauce Grande River and the Atlantic coast.

#### 1) Cantera Seminario

*Location:* 38° 44' 08" S, 62° 12' 19" W; 58–68 m height (see Grünbein in Figs. 1, 3.1).

*Bearing unit:* Cerro Azul Formation (*sensu* Folguera and Zárate, 2009). The section is 11 m thick and was divided into five levels. Fossils were found in the upper part of level 2, below the calcrete crust.

*Biostratigraphic units recognized in the sequence:* type section of the *Xenodotomys ellipticus* Zone (Verzi *et al.*, 2008).

*Age:* Late Huayquerian (Late Miocene–earliest Pliocene; late Messinian–early Zanclean; see below; Deschamps *et al.*, 2013).

*Fossil content:* the octodontid rodents *Xenodotomys ellipticus* and *Phtoramys* cf. *P. hidalguense* are important biostratigraphic indicators (see Deschamps *et al.*, 1998; Deschamps, 2005; Verzi *et al.*, 2008 for details). Other taxa include: *Doellotatus* cf. *D. inornatus*, *D.* cf. *D. praecursor*, *Chorobates* sp., *Paedotherium* cf. *P. minor*, *Tremacyllus* cf. *T. impressus*, *Orthomyctera* sp., cf. *Palaeocavia* and *Lagostomus* sp. (we follow Rasia, 2016 for the validity of "*Lagostomopsis*") (Fig. 4).

#### 2) Barrancas de Sarmiento

*Location:* 38° 42' 05" S, 62° 15' 51" W; 50 m height (Figs. 1, 3.2).

*Bearing unit:* Cerro Azul Formation (*sensu* Folguera and Zárate, 2009).

*Biostratigraphic units recognized in the sequence:* *Xenodotomys ellipticus* Zone (Verzi *et al.*, 2008).

*Age:* Late Huayquerian (Late Miocene–earliest Pliocene; late Messinian–early Zanclean; see below; Deschamps *et al.*, 2013).

*Fossil content:* *Xenodotomys ellipticus* is an important biostratigraphic indicator (see Verzi and Deschamps, 1996; Deschamps, 2005; Verzi *et al.*, 2008 for details). Other taxa: *Paedotherium bonaerense*, *Lagostomus* sp., ?*Palaeocavia*, and *Eutatini* indet. (Fig. 5)

#### 3) Cantera Vialidad

*Location:* 38° 45' 19.89" S, 62° 09' 39.75" W; 51–64 m height (see Grünbein in Fig. 1, 3.3).

*Bearing unit:* Cerro Azul Formation (*sensu* Folguera and Zárate, 2009).

*Biostratigraphic units recognized in the sequence:* *Xenodotomys ellipticus* Zone (Verzi *et al.*, 2008).

*Age:* Late Huayquerian (Late Miocene–earliest Pliocene; late Messinian–early Zanclean; see below; Deschamps *et al.*, 2013). This deposit has a numerical dating of 5.28±0.04 Ma (Schultz *et al.*, 2006).

*Fossil content:* *Xenodotomys ellipticus* is an important biostratigraphic indicator which allows correlations with Barrancas de Sarmiento and Cantera Seminario. Remains of this rodent were found in the same level of the dating, and also in overlying levels (Deschamps *et al.*, 2013; Deschamps and Tomassini, personal observations). Other unpublished taxa include *Paedotherium* sp., and *Chorobates villosissimus*.

#### 4) Cantera Relleno Sanitario

*Location:* 38° 46' 24" S, 62° 09' 25" W; 12–24 m height (see Grünbein in Figs. 1, 3.4.)

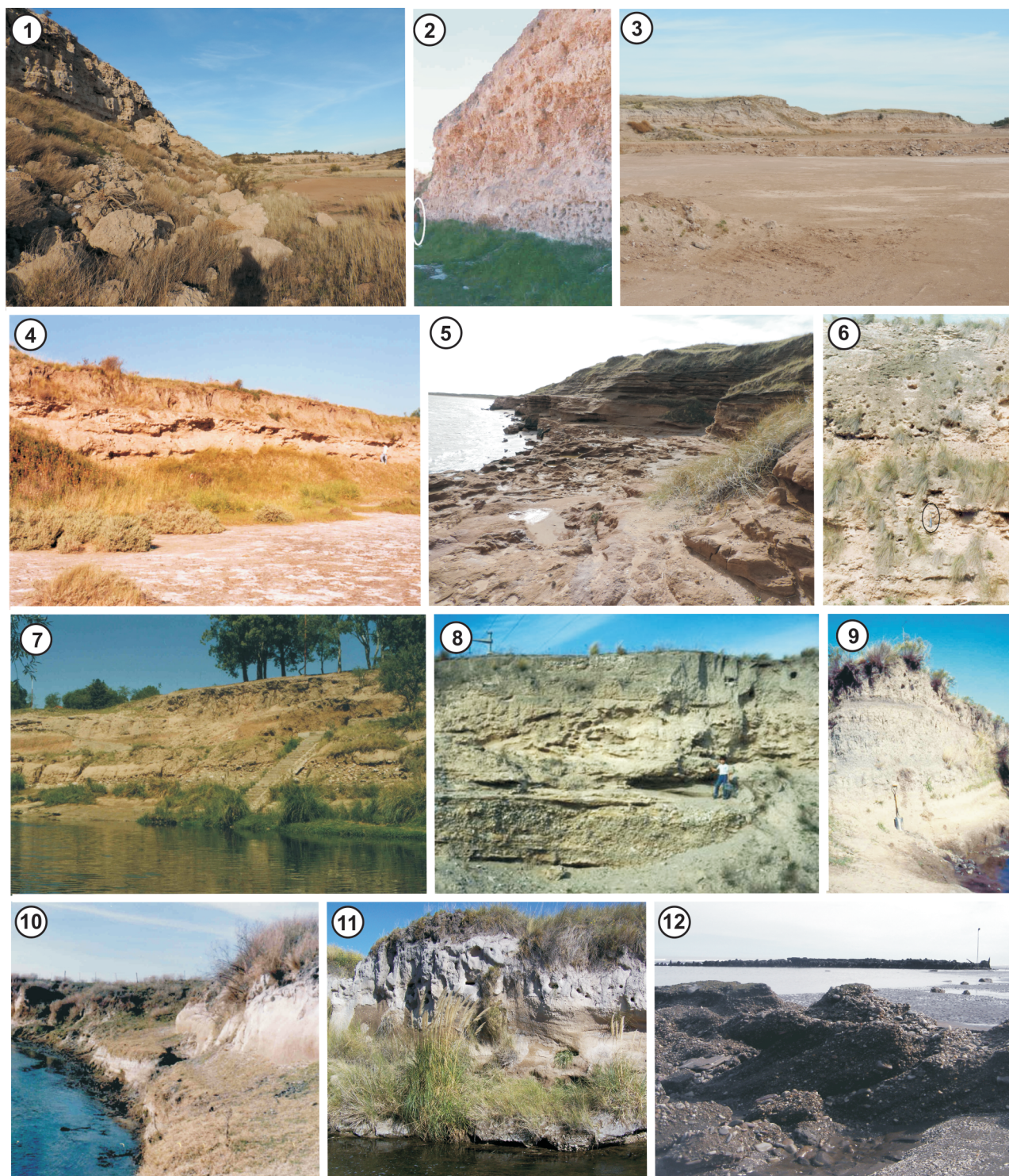
*Bearing unit:* Cerro Azul Formation (*sensu* Folguera and Zárate, 2009). This section has 8 m mean thickness divided into five levels on the basis of calcrete crusts and paleosoils. Materials were recovered from two levels at the middle of the exposure.

*Biostratigraphic units recognized in the sequence:* *Xenodotomys ellipticus* Zone (Verzi *et al.*, 2008) because of the presence of *Phtoramys* cf. *P. hidalguense*.

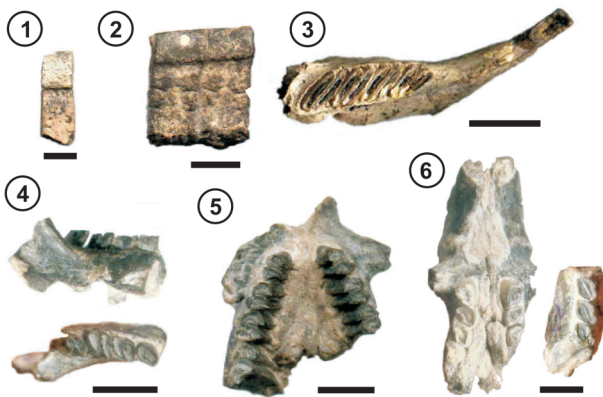
*Age:* Late Huayquerian (Late Miocene–earliest Pliocene; late Messinian–early Zanclean; see below; Deschamps *et al.*, 2013).

*Fossil content:* From the lower Level 1 (paleosoil): cf. *Borhyaenidium Phtoramys* cf. *P. hidalguense*, *Macrochorobates* sp., *Promacrauchenia* sp.; Level 2 (calcrete level overlying the pa-

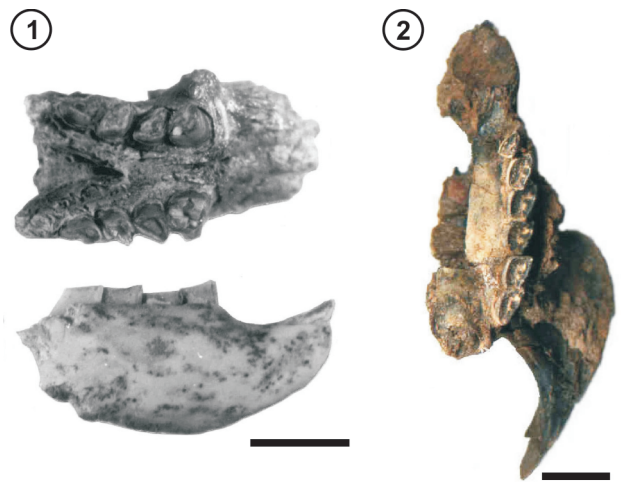
leosoil): *Chasicotatus* cf. *C. peiranoi*, *Chorobates villosissimus*, *Berthawyleria*, *Paedotherium* cf. *P. minor*, *Tremacyllus* cf. *T. impresus*, and *Promacrauchenia* sp. (Fig. 6).



**Figure 3.** View of the exposures at the studied localities. 1, Cantera Seminario; 2, Barrancas de Sarmiento; 3, Cantera Vialidad; 4, Cantera Relleno Sanitario; 5, Farola Monte Hermoso; 6, Las Oscuras; 7, Balneario Saldungaray; 8, Bajo San José; 9, Puesto La Florida; 10, Chacra Santo Domingo; 11, García del Río; 12, Playa del Barco.



**Figure 4.** Mammals found in Cantera Seminario. 1, osteoderm of *Doellotatus* cf. *D. inornatus*; 2, two osteoderms of *Doellotatus* cf. *D. praecursor*; 3, fragment of left mandible of *Lagostomus* sp.; 4, fragment of right mandible of *Pthoramyx* cf. *P. hidalguense*; 5, skull fragment of *Orthomyxtera* sp.; 6, skull and left mandible fragments of *Xenodontomys ellipticus*. Anterior to the right (3,4) and to top (5,6). Scale = 1 cm (1, 2), 5 cm (3), 5 mm (4–6).



**Figure 5.** Mammals found in Barrancas de Sarmiento. 1, skull fragment and right mandible of *Xenodontomys ellipticus*; 2, skull fragment of *Paedotherium bonaerense*. Anterior to the right (1) and to top (2). Scales = 4 mm (1) and 1 cm (2).

5) Farola Monte Hermoso

*Location:* 38° 58' 01" S, 61° 41' 43" W; 0–10 m height (Figs. 1, 3,5).

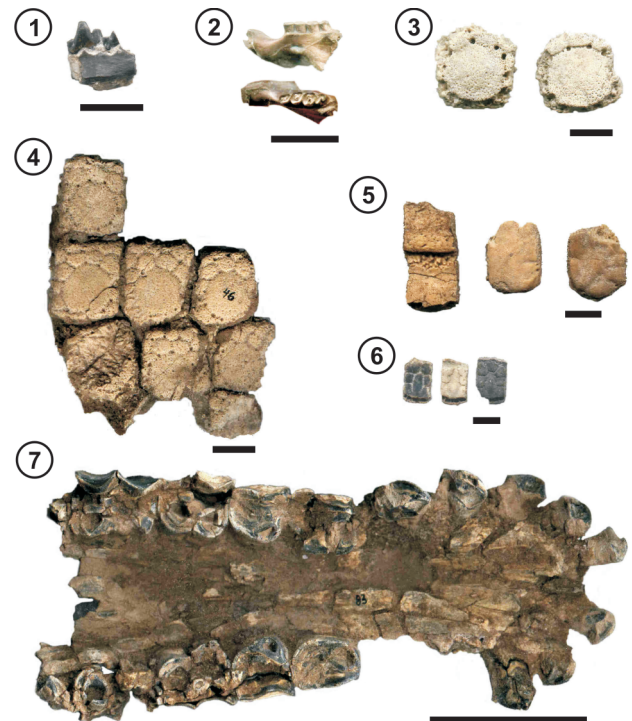
*Bearing unit:* Monte Hermoso Formation (Zavala, 1993).

*Biostratigraphic units recognized in the sequence:* type section of the *Eumysops laeviplicatus* Range Zone (Tomassini *et al.*, 2013a).

*Age:* Montehermosan (Early Pliocene; Zanclean; Tomassini *et al.*, 2013a).

*Fossil content:* *Eumysops laeviplicatus*, *Eumysops formosus*, *Eucelophorus cabrerai*, *Pithanotomys columnaris*, *Phugatherium cataclisticum* are important biostratigraphic indicators (Deschamps *et al.*, 2012, 2013; Tomassini *et al.*, 2013a). Other frequent taxa include *Actenomys priscus*, *Paramyocastor diligens* (see Verzi *et al.*, 2002), *Paedotherium bonaerense*, *Paedotherium typicum*, *Tremacyllus impressus*, *Doellotatus inornatus*, *Eoauchenia primitiva*, *Pseudotypootherium* sp. and *Plohophorus figuratus* (Fig. 7). See complete list in Appendix 1.

Recently, the knowledge of this fauna has been greatly increased with systematic, taphonomic, paleoenvironmental and paleobiogeographic contributions (*e.g.*, Zurita and Tomassini, 2006; Albino *et al.*, 2009; Tomassini and Montalvo, 2010, 2013; Miño-Boilini *et al.*, 2011; Tomassini *et al.*, 2011, 2014a; Agnolin and Tomassini, 2012; Agnolin *et al.*, 2014).



**Figure 6.** Some of the specimens found in Cantera Relleno Sanitario. 1, mandible fragment of cf. *Borhyaenidium*; 2, mandible fragment of *Pthoramyx* cf. *P. hidalguense*; 3, osteoderms of *Aspidocalyptus* sp.; 4, carapace fragment of cf. *Berthawylexia*; 5, osteoderms of *Macroephractus* cf. *M. morenoi*; 6, osteoderms of *Chasicotatus* sp.; 7, palate fragment of *Promacrauchenia* sp. Anterior to left (2) and to the right (7). Scales = 1 cm (1–6), 5 cm (7).

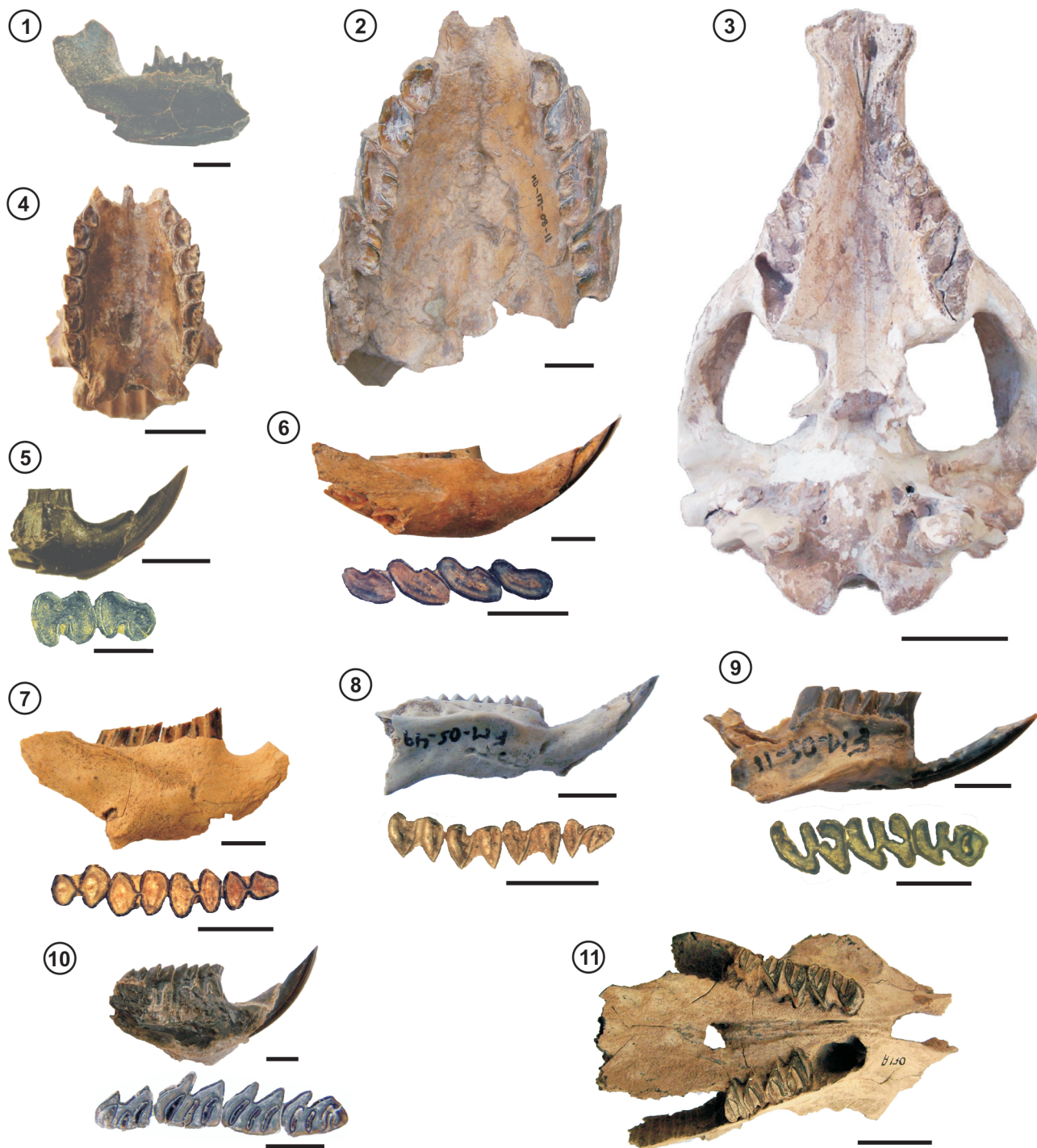


Figure 7. Some of the mammals found in Farola Monte Hermoso. 1, left mandible fragment of *Hyperdidelphys inexpectata* (inverted); 2, skull fragment in ventral view of *Pseudotypotherium* sp.; 3, skull in ventral view of *Toxodon chapalmalensis*; 4, skull fragment in ventral view of *Paedotherium bonaerense*; 5-9, right mandible fragments and detail of dental series in occlusal view of: 5, *Neophanomys* sp.; 6, *Actenomys priscus*; 7, *Pithanotomys columnaris*; 8, *Palaeocavia* sp.; 9, *Eumysops laeviplicatus*; 10, left mandible fragment and detail of dental series in occlusal view (inverted) of *Paramyocastor diligens*; 11, skull fragment of *Phugatherium cataclisticum*. Anterior to right (1, 5-11) and to top (2-4). Scales= 5 mm (A, E-J), 1 cm (B, D), 10 cm (C), and 2 cm (K).



According to Tomassini *et al.* (2013a) this biostratigraphic unit represents a brief lapse, included within a temporal range whose approximate boundaries are <5.28 Ma and 4.5/5.0 Ma.

#### 6) Las Oscuras

*Location:* 38° 44' 48.55" S, 61° 44' 01.04" W; 82 m height (Fig. 1, 3.6).

*Bearing unit:* Saldungaray-La Toma formations (*sensu* Deschamps, 2005); Cerro Azul Formation (*sensu* Folguera and Zárate, 2009).

*Biostratigraphic units recognized in the sequence:* *Actenomys priscus*-*Plohophorus cuneiformis* Zone (Deschamps, 2005). This unit may correspond to the *Eumysops laeviplicatus* Range Zone defined in Farola Monte Hermoso (see discussion in Tomassini *et al.*, 2013a).

*Age:* Montehermosan (Early Pliocene; Zanclean; *sensu* Deschamps, 2005).

*Fossil content:* *Actenomys priscus*, *Plohophorus cuneiformis*, *Pseudotypotherium* sp., *Lagostomus* sp., *Orthomyzter* sp., *Dolicavia* sp., and *Epitherium laternarium* (Deschamps *et al.*, 1989; Deschamps, 2005).

The record of *Actenomys priscus*, with similar characteristics to the specimens recovered from Farola Monte Hermoso, plus the absence of the different species of *Xenodontomys*, support the proposed age.

#### Pleistocene–Holocene

This interval was studied in the banks of the Sauce Grande River and Napostá Grande Creek.

#### 7) Sauce Grande River valley

##### a-Balneario Saldungaray

*Location:* 38° 11' 52.30" S, 61° 46' 11.39" W; 20 m height (Figs. 1, 3.7).

*Bearing unit:* The sequence begins with deposits of the Saldungaray Formation at the water level. This unit is overlain by coarse conglomerates and sands of the lower and upper sections of the San José Sequence (Zavala and Quattrocchio, 2001). Rabassa (1989) assigned these two latter units to the Agua Blanca Formation on the basis of two radiocarbon datings (32,300 +/- 1,800 RCYBP; Figini *et al.*, 1989; 27,500 +/- 670 RCYBP; Figini *et al.*, 1989; Rabassa, 1989) but geomorphology and stratigraphic position suggest an older age for these units. The profile ends with eolian deposits of the

Matadero Saldungaray Formation.

*Biostratigraphic units recognized in the sequence:* The recorded taxa were insufficient to recognize any unit.

*Age:* Pliocene *s.l.* (Saldungaray Formation), Middle Pleistocene (San José Sequence according to Zavala and Quattrocchio, 2001 and Deschamps, 2005), or Late Pleistocene Agua Blanca Formation (according to Rabassa, 1989), Historical times–Present (Matadero Saldungaray Formation).

*Fossil content:* Mammal remains were very scarce. Saldungaray Formation: *Paedotherium bonaerense*; San José Sequence, lower section: *Glossotherium* sp. and *Lama* sp.; upper section *Lagostomus* sp.; Matadero Saldungaray Formation: *Ctenomys talarum* and *Lepus europaeus*.

##### b-Bajo San José

*Location:* 38° 29' 12.10" S, 61° 46' 59.60" W; 125 m height (Figs. 1, 3.8).

*Bearing unit:* San José Sequence (Zavala and Quattrocchio, 2001), especially a sandy lens up to 1 m thick of the lower section that yielded most of the small vertebrates, 2 m from the base of the profile.

*Biostratigraphic units recognized in the sequence:* type section of the *Ctenomys kraglievichi* Zone (Verzi *et al.*, 2004a). The zone was also recognized at Las Grutas-Punta Negra in Necochea (southeastern Buenos Aires Province), as well as in Camet and Constitución, in the cliffs north of Mar del Plata.

*Age:* Bonaerian (Middle Pleistocene; Verzi *et al.*, 2004a)

*Fossil content:* the ctenomyid rodent *Ctenomys kraglievichi* as well as the dasypodid *Tolypeutes* sp. nov. (Scillato-Yané in Deschamps, 2005) are important biostratigraphic indicators, exclusive of the Bonaerian. Other taxa include: Pisces (*Pimelodella* aff. *P. laticeps*, *Callichthys callichthys*, *Percichthys* sp., *Corydoras* cf. *C. paleatus*), turtles (*Hydromedusa tectifera*), birds (*Rhea* sp., *Chloephaga* sp. 1, *Chloephaga* sp. 2, *Porphyrio* sp., cf. *Pseudoseisura cursor*-*Pseudoseisuropsis nehuen*, Motacillinae indet.), marsupials (*Lestodelphys* sp.), dasypodids (*Chaetophractus villosus*, *Zaedyus pichiy*, *Eutatus seguini*, *Propraopus* sp.), glyptodontids (*Glyptodon clavipes*, *Doedicurus* sp., *Panochthus tuberculatus*, *Sclerocalyptus* cf. *S. ornatus*), sloths (*Scelidotherium* cf. *S. leptcephalum*, *Glossotherium* sp., *Lestodon armatus*, *Megatherium americanum*), litopterns (?*Macrauchenioopsis ensenadensis*), notoungulates (*Toxodon* sp.), cricetid rodents (*Akodon* cf. *A. azarae*, *Akodon* cf. *A. inisca-*

*tus*, *Oxymycterus* sp., *Reithrodon auritus*, *Phyllotis* sp., *Lundomys* sp.), caviomorph rodents (*Microcavia* sp., *Galea* sp., *Lagostomus* sp., *Neochoerus* cf. *N. tarijensis*, *Myocastor columnaris*), Gomphotheriidae indet., artiodactyls (*Tayassuinae* indet., *Lama* sp., Cervidae indet.), perissodactyls (*Hippidion principale*), and carnivores (*Pseudalopex* sp., cf. *Herpailurus*) (Fig. 8). See complete list in Appendix 1.

The oldest records of *Callichthys callichthys*, *Percichthys*, *Porphyrio*, *Herpailurus*, *Lundomys*, *Oxymycterus*, *Phyllotis*, and *Tayassuinae* (Cione and López Arbarello, 1995; Pardiñas and Deschamps, 1996; Prevosti, 2006; Pardiñas and Teta, 2011; Gasparini, 2013) come from this site.

Some taxa are significant from a biogeographic point of view. Among Osteichthyes, the pimelodid siluriformes *Pimelodella*, *Callichthys* and *Corydoras*, and the Percichthyidae *Percichthys* are not sympatric today. The southern border of the geographic distribution of *Callichthys* is currently farther north within the Buenos Aires Province, and on the contrary, *Percichthys* inhabits today the Austral Subregion (Cione and López Arbarello, 1995). This is the southernmost record of the turtle *Hydromedusa tectifera* which today inhabits the Neotropical Region up to northern Argentina (de la Fuente, 1992, 1999).

As well, other taxa are important in view of their paleo-environmental meaning (for details see Pardiñas and Deschamps, 1996; Deschamps, 1998; Deschamps *et al.*, 2000; Verzi *et al.*, 2004a; Deschamps, 2005; Prevosti, 2006; Pardiñas and Teta, 2011; Gasparini, 2013).

The birds record is outstanding because three orders are represented, Anseriformes, Gruiformes and Passeriformes (Tonni and Deschamps, 2001). Anseriformes, Family Anatidae, include several remains of small indeterminate anatids and *Chloephaga*. This genus would be represented by two new species. Gruiformes is represented by the Family Rallidae, genus *Porphyrio*. Passeriformes are recorded by a large furnariid similar to *Pseudoseisura cursor* and *Pseudoseisura nehuén* (both from the Ensenadan of the Buenos Aires Province; Tonni and Noriega, 2001) and an indeterminate passeriid of the Family Motacillinae. Modern *Pseudoseisura* are widely distributed in South America inhabiting arid environments, but both species of *Porphyrio* inhabit intertropical South America. This means that *Porphyrio* would join *Callichthys*, *Hydromedusa* and *Lundomys* in warm

and humid environments, and *Chloephaga* would join *Percichthys*, *Lestodelphys*, *Phyllotis* and *Akodon iniscatus* among the taxa adapted to more arid and/or colder environments. c-Puesto La Florida

*Location*: 38° 35' S, 61° 45' W; 108 m height. This site is located at the Sauce Grande River valley between Bajo San José and Las Oscuras localities (Fig. 1, 3.9).

*Bearing unit*: middle and upper sections of the Agua Blanca Sequence, Chacra La Blanqueada and Matadero Saldungaray formations (Zavala and Quattrocchio, 2001).

*Biostratigraphic units recognized in the sequence*: type section of the *Ozotoceros bezoarticus* Zone in the upper section of the Agua Blanca Sequence, and *Bos taurus-Ovis aries* Zone in upper levels of the Chacra La Blanqueada and Matadero Saldungaray formations (Deschamps, 2005).

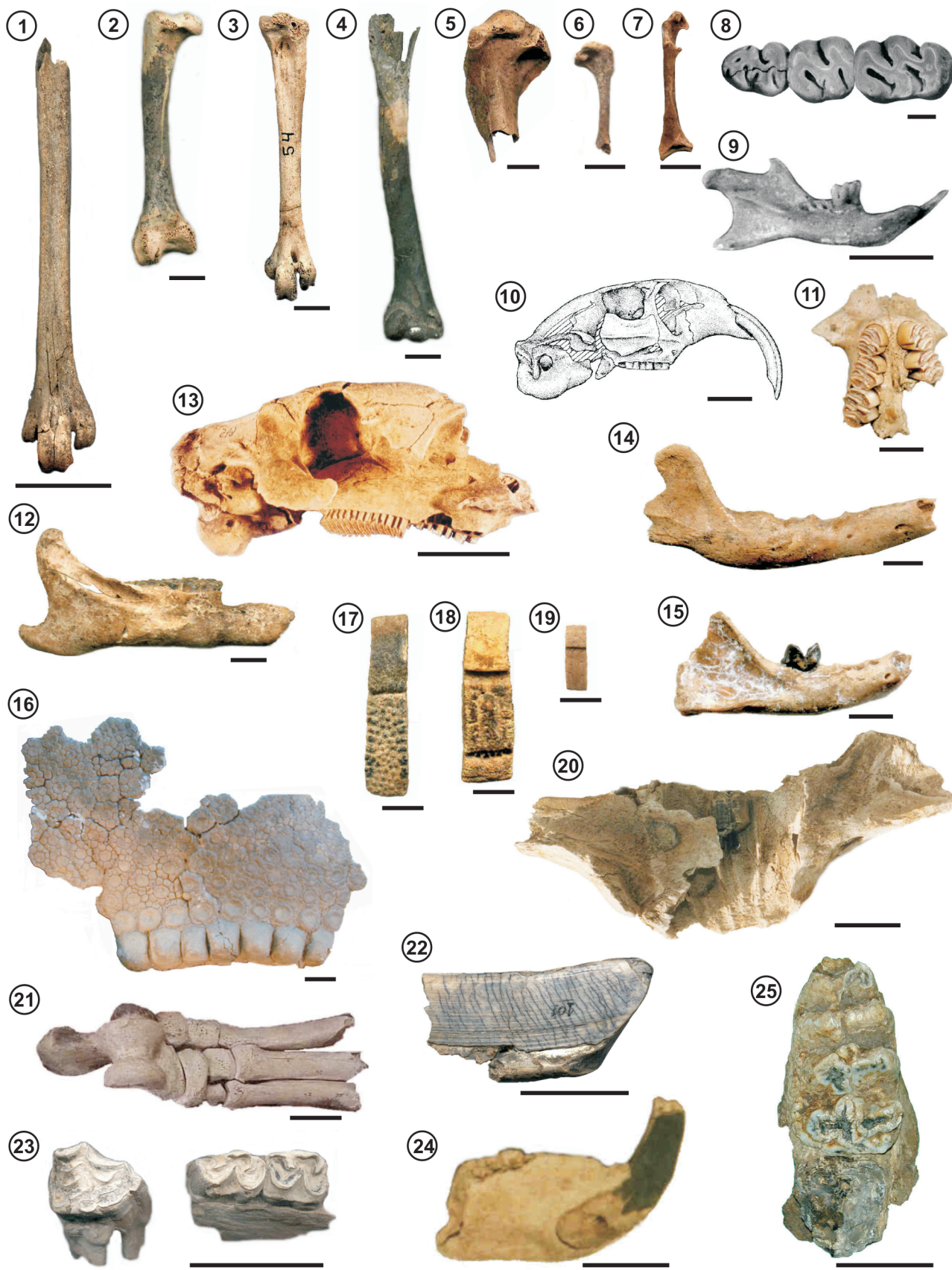
*Age*: Lujanian (Late Pleistocene–Early Holocene) for the Middle Section of the Agua Blanca Sequence; Platan (Late Holocene) for the Upper Section of the Agua Blanca Sequence; Platan (Late Holocene)–Present for the Chacra La Blanqueada Formation at this site; historical times–present for the Matadero Saldungaray Formation (Deschamps, 2005). In the cliffs of the Sauce Grande River near Bajo San José, Borromei (1995) reported radiocarbon datings for the upper section of the Agua Blanca Sequence (5010±120 years <sup>14</sup>C BP) and Chacra la Blanqueada Formation (2830±90 years <sup>14</sup>C BP) which restrict the age to the Middle and Late Holocene respectively. The Chacra La Blanqueada Formation was also dated on peat wood samples between 1570 ± 70 and 900±50 years <sup>14</sup>C BP at La Toma locality (Rabassa, 1989; Rabassa *et al.*, 1991).

*Fossil content*: Middle section of the Agua Blanca Sequence: *Lama guanicoe*. Upper section of the Agua Blanca Sequence: *Rhea americana*, cf. *Anas*, *Chaetophractus villosus*, *Zaedyus pichiy*, *Cavia aperea*, and *Ozotoceros bezoarticus*. Chacra La Blanqueada and Matadero Saldungaray formations: *Bos taurus*.

8) Napostá Grande Creek valley  
a-Chacra Santo Domingo

*Location*: 38° 33' 45.14" S, 62° 04' 17.27" W; 98 m height. This site is in the middle valley of the Napostá Grande Creek; access from Bahía Blanca City is through the road known as La Carrindanga (Figs. 1, 3.10).

*Bearing unit*: middle and upper sections of the Agua Blanca



Sequence, Chacra La Blanqueada and Matadero Saldungaray formations (Zavala and Quattrocchio, 2001).

*Biostratigraphic units recognized in the sequence:* type section of the *Equus (Amerhippus) neogaeus-Macrauchenia patachonica* Zone, in the middle section of the Agua Blanca Sequence (Deschamps, 2005), and type section of the *Bos taurus-Ovis aries* Zone in the Matadero Saldungaray Formation.

*Age:* Lujanian (Late Pleistocene–Early Holocene) for the Middle Section of the Agua Blanca Sequence; Platan (Late Holocene) for the Upper Section of the Agua Blanca Sequence (this unit yielded neospecies and a radiocarbon dating of  $1960 \pm 100$   $^{14}\text{C}$  years BP; see Deschamps and Tonni, 1992); Platan (Late Holocene) for the Chacra La Blanqueada Formation at this site; historical times for the Matadero Saldungaray Formation (Deschamps, 2005).

*Fossil content:* Middle Section of the Agua Blanca Sequence: scarce remains of Rheidae indet., *Chaetophractus villosus*, *Scelidotherium leptcephalum*, *Macrauchenia patachonica*, *Lama guanicoe*, Lamini indet., and *Equus (A.) neogaeus*. The Upper Section yielded abundant remains, especially the lower levels: Cyprinodontiformes indet., Anura indet., *Rhea* sp., *Nothura darwini*, Tinamidae indet., *Anas* cf. *A. platalea*, *Dendrocygna* sp., and Anatidae indet., *Lestodelphys halli*, *Thylamys* cf. *T. pusillus*, *Chaetophractus villosus*, *Zaedyus pichiy*, *Holochilus brasiliensis*, *Calomys* cf. *C. laucha-musculus*, *Reithrodon auritus*, *Ctenomys* sp., *Cavia aperea*, *Lama guanicoe*, *Ozotoceros bezoarticus*, and *Pseudalopex* aff. *P. gymnocercus*. Chacra La Blanqueada Formation: *Ctenomys talarum* and *Lama guanicoe*. Matadero Saldungaray Formation: *Lama guanicoe* and *Bos taurus* (Fig. 9).

b–García del Río

*Location:* 38° 21' 49.70" S, 62° 09' 05.32" W, 184 m height. Upstream of Napostá Grande village in the Napostá Grande Creek (Figs. 1, 3.11).

*Bearing units:* Middle and upper sections of the Agua Blanca Sequence, Chacra La Blanqueada and Matadero Saldungaray formations (Zavala and Quattrocchio, 2001).

*Biostratigraphic units recognized in the sequence:* the recorded taxa were insufficient to recognize any unit.

*Age:* the Upper Section of the Agua Blanca Sequence has a radiocarbon dating of  $2610 \pm 60$  years  $^{14}\text{C}$  BP (Quattrocchio et al., 1998), Late Holocene. Chacra La Blanqueada has a radiocarbon dating in this locality of  $2342 \pm 47$  years  $^{14}\text{C}$  BP (Tomassini et al., 2014b), Late Holocene.

*Fossil content:* *Lama guanicoe* was recorded in all units (Deschamps, 2005). Also, in Chacra La Blanqueada Formation *Ctenomys* cf. *C. talarum*, *Cavia aperea*, and *Chaetophractus villosus* were recovered (Tomassini et al., 2014b).

10) Playa del Barco

*Location:* 39° 00' 09" S, 61° 34' 52" W; 0–2 m height (Figs. 1, 3.12).

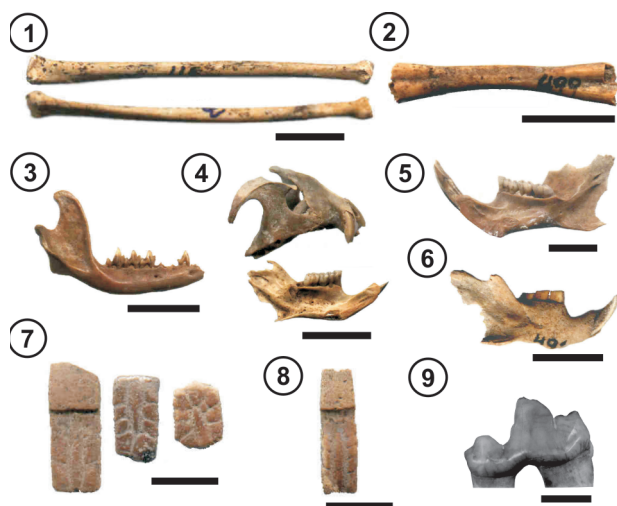
*Bearing unit:* San José Sequence (Zavala and Quattrocchio, 2001).

*Biostratigraphic units recognized in the sequence:* *Equus (Amerhippus) neogaeus-Macrauchenia patachonica* Zone (Deschamps, 2005).

*Age:* Lujanian (Late Pleistocene–Early Holocene). A radiocarbon dating yielded an age of  $16.440 \pm 320$   $^{14}\text{C}$  years BF (Aramayo, 1997). Some levels could include Bonaerian (Middle Pleistocene) fauna (see Zavala and Quattrocchio, 2001; Tomassini et al., 2010).

*Fossil content:* *Equus (Amerhippus) neogaeus*, *Macrauchenia patachonica*, *Glyptodon reticulatus*, *Doedicurus clavicaudatus*,

**Figure 8.** Some of the specimens found in Bajo San José. 1–7, Aves. 1, tarsus-metatarsus of *Rhea* sp.; 2–3, *Chloephaga* sp. 1; 2, left femur; 3, left tarsus-metatarsus; 4–5, *Chloephaga* sp. 2; 4, right humerus; 5, proximal fragment of left humerus; 6, right humerus of Motacillinae indet.; 7, left coracoid of cf. *Pseudoseisura-Pseudoseisuropsis*; 8–13, Rodentia. 8, upper molars of *Lundomys* sp.; 9, right mandible (inverted) of *Akodon* cf. *A. iniscatus*; 10, skull of *Ctenomys kraglievichi*; 11, palate fragment of *Myocastor columnaris*; 12, right mandible of *Lagostomus* sp.; 13, skull of *Neochoerus* cf. *N. tarijensis*; 14–15, mandibles of Carnivora. 14, *Pseudalopex* sp.; 15, cf. *Herpailurus*; 16–20, Edentata. 16, carapace fragment of *Glyptodon clavipes*; 17, osteoderm of *Tolypeutes* sp. nov.; 18, osteoderm of *Eutatus seguini*; 19, osteoderm of *Zaedyus pichiy*; 20, right mandible fragment of *Megatherium americanum*; 21, left posterior autopodium of ?*Macraucheniaopsiense*; 22, 3<sup>rd</sup> left lower incisor fragment of *Toxodon* sp.; 23, molariforms of *Hippidion principale*; 24, mandible fragment with incisor of Tayassuinae indet.; 25, molar of Gomphotheriidae indet. Anterior to the right (8–10, 12–15, 24), to top (11), and to the left (20). Scale= 1 cm (2–7, 10–12, 14–15, 17–19), 1 mm (8), 5 mm (9), 5 cm (1, 13, 21–23), 10 cm (16, 25).

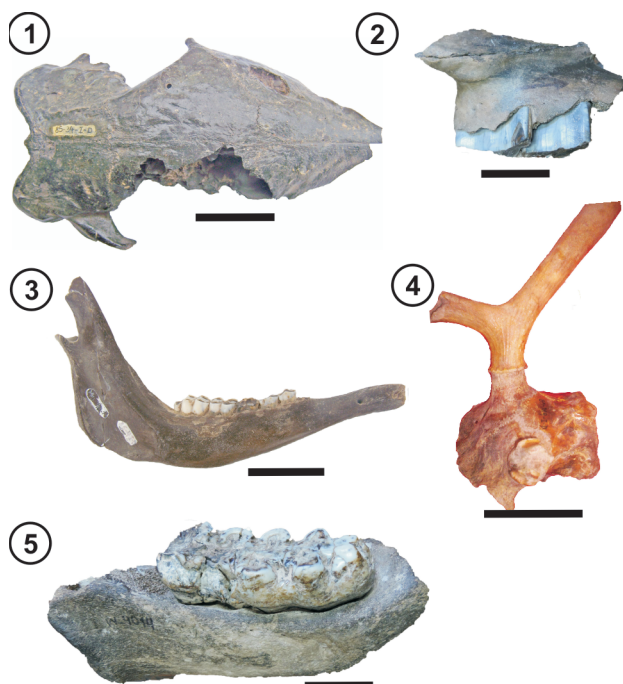


**Figure 9.** Some of the specimens found in Chacra Santo Domingo, Napostá Grande Creek. 1, Aves, right humerus of *Anas* cf. *A. platalea*; 2, tibia-fibula of Bufonidae indet.; 3, left mandible of *Lestodelphys halli*; 4, fragments of skull and mandible of *Reithrodon auritus*; 5, right mandible of *Holochilus brasiliensis* (inverted); 6, mandible of *Ctenomys* sp.; 7, osteoderms of *Chaetophractus villosus*; 8, osteoderm of *Zaedyus pichiy*; 9, p4 of *Pseudalopex* aff. *P. gymnocercus*. Anterior to the right (3–4, 6) and to the left (5). Scales= 1 cm (1–8) and 5 mm (9).

*Eutatus seguini*, *Scelidotherium leptocephalum*, *Lestodon armatus*, *Toxodon platensis*, *Notiomastodon platensis*, *Morenelaphus bonaerense*, *Hippidion* sp., *Smilodon populator*, *Nechoerus* cf. *N. tarijensis*, among others (Fig. 10; see complete list in Appendix 1).

#### SYSTEMATIC, BIOCHRONOSTRATIGRAPHIC AND PALEOENVIRONMENTAL COMMENTS

As mentioned above, since the idea of Mirta Quattrocchio of facing multidisciplinary studies, paleontologic survey in southwestern Buenos Aires Province was increased, and is still increasing today. This was reflected directly in enlarged collections which in turn allowed improving the knowledge of the vertebrate communities that inhabited the area during the last 10 My. In this context, those localities in which units formed by fluvial deposits are exposed (e.g., Farola Monte Hermoso, Bajo San José, Playa del Barco), yielded the largest amounts and diversity of bone remains. Together with pollen and ostracodes analyses, vertebrate taxa helped inferring paleoenvironmental, paleoclimatic and



**Figure 10.** Some of the specimens found in Playa del Barco. 1, skull of *Eutatus seguini*; 2, fragment of right maxilla of *Toxodon platensis*; 3, left hemimandible of Cervidae indet.; 4, fragment of skull of *Morenelaphus* sp.; 5, fragment of right hemimandible of *Notiomastodon* sp. Anterior to the right. Scales= 5 cm (1–3), 10 cm (4–5).

paleobiogeographic conditions both in the Mio–Pliocene and Quaternary.

The age of the late Cenozoic continental deposits and the included fauna is a major issue. Given the scarcity of numerical dating, the age has been almost always determined on the basis of fossil distribution, which makes boundaries and temporal extension of biostratigraphic units at least uncertain and controversial (see Cione and Tonni, 1995, 2005; Verzi *et al.*, 2008; Deschamps *et al.*, 2013). Multidisciplinary studies accomplished in the last years, including detailed fieldwork, paleontological prospection with precise data of stratigraphic provenance, systematics, sedimentological analyses, sequential stratigraphy, taphonomy, magnetostratigraphy, among others, resulted in an improvement of biochronostratigraphic schemes.

One of the main advances in this regard is the inference of the age of “Huayquerian” and “Montehermosan” faunas. Among mammal faunas, rodents are very useful as biostratigraphic tools because of their wide geographic distri-

bution, and high reproductive and rapid evolutionary rates (Vianey-Liaud *et al.*, 2011). The knowledge of the systematics and phylogeny of several groups of rodents recorded in these intervals has been largely improved in recent years (*e.g.*, Octodontidae, Ctenomyidae, Echimyidae, Hydrochoeridae). This turned out to be quite significant because many of them are good biostratigraphic indicators (Vucetich *et al.*, 2005; Verzi, 2008 and literature therein; Olivares 2009; Olivares *et al.*, 2012; Deschamps *et al.*, 2013 and literature therein).

In the study area, "Huayquerian" faunas were found in Cantera Seminario, Cantera Relleno Sanitario, Cantera Vialidad, and Barrancas de Sarmiento. These localities have in common the record of *Xenodontomys ellipticus* which is an octodontid rodent that pertains to the *Chasichimys-Xenodontomys* lineage. The polarity shown by their anagenetic evolutionary pattern led Verzi *et al.* (2004b) to propose that *X. ellipticus* is younger than *X. simpsoni* (from Los Salitrales Formation, Buenos Aires Province, and several localities of the Cerro Azul Formation in La Pampa Province) and older than *X. elongatus* (found in the Cerro Azul Formation cropping out at Caleufú, La Pampa Province). It is noteworthy that two other lineages of octodontid rodents (*Neophanomys* and *Reigechimys*; Verzi *et al.*, 2011; Sostillo *et al.*, 2014) support the scheme based on the lineage of *Xenodontomys*. The trend toward increasing hypsodonty observed in the lineage of *Xenodontomys* and in other caviomorph rodents is related to adaptations to open environments within the climatic deterioration of the Late Miocene (Verzi, 2001). Given that Cantera Vialidad yielded remains of *Xenodontomys ellipticus* in the same levels and above those which have a numerical dating of  $5.28 \pm 0.04$  Ma (Schultz *et al.*, 2006) it may be concluded that "Huayquerian" faunas in this area are latest Miocene–earliest Pliocene in age.

On the other hand, "Montehermosan" faunas were found in Farola Monte Hermoso and Las Oscuras. Deposits of the Monte Hermoso Formation in its type locality Farola Monte Hermoso were accumulated in a dynamic fluvial environment of high-sinuosity rivers ("muddy fine-grained rivers" in Miall, 1985). In these localities, none of the species of *Xenodontomys* has been recorded, being instead abundant *Actenomys priscus*, the most derived representative of the

lineage *Xenodontomys-Actenomys* (Verzi, 2008). In addition, when these specimens are compared to specimens of *A. priscus* found in levels assigned to the Chapadmalalan (from the area of Mar del Plata-Miramar), the latter display a more derived dental morphology (Deschamps, 2003; Tomassini *et al.*, 2013a). Preliminary observations (Tomassini, 2012) showed that the specimens of *Neophanomys* found in Farola Monte Hermoso are also more derived than the species recognized for the Huayquerian Stage/Age of La Pampa (*N. pristinus* and *N. recens*, Catamarca (*N. biplicatus*) and Mendoza (*N. biplicatus*). Hence the Montehermosan assemblages cannot be older than Early Pliocene because the evolutionary stage of these octodontids (and also other groups of mammals; see Tomassini, 2012; Deschamps *et al.*, 2012; Tomassini *et al.*, 2013a) supports the idea that the bearing sediments of the Monte Hermoso Formation are younger than those of the Cerro Azul Formation at Caleufú with "Huayquerian" fauna.

Another group of rodents found in the area that turned out to be very indicative from a biochronologic point of view are the giant capybaras. The study of the dental evolution of this family resulted in a new interpretation of their taxonomy and systematics which involved the ontogenetic change (Vucetich *et al.*, 2005, 2014a,b, 2015; Deschamps *et al.*, 2007, 2009, 2013). Currently, a single taxon is recognized for each level, and although they were not found in a single stratigraphic sequence to test the proposal, the accompanying fauna supports the different age inferred for each taxon. In "Huayquerian" assemblages only the genus *Cardiatherium*, with different species, is recorded (Vucetich *et al.*, 2005; 2014b). Instead in "Montehermosan" and "Chapadmalalan" assemblages, *Phugatherium* is recorded, with two species in the study area, *P. catacliticum* in Farola Monte Hermoso and *P. novum* in the area of Mar del Plata-Miramar (Deschamps *et al.*, 2012, 2013). Capybaras were one of the keys to suggest that a single biostratigraphic unit could be determined in the Monte Hermoso Formation at Farola Monte Hermoso, different from the one recognized in the area of Mar del Plata-Miramar. This is supported by other rodent lineages such as the different species of the echimyid rodent *Eumysops* (Olivares *et al.*, 2012) found in these localities (Deschamps *et al.*, 2012; Tomassini *et al.*, 2013a).

Concerning the age of the assemblages, the determination of the extension and the boundaries of the represented Stage/Age or SALMA has been long debated, especially those between Huayquerian and Montehermosan. A common use is to extend the boundaries of the different biostratigraphic units represented in a certain interval in order to obtain a continuous sequence, even without numerical dating or faunistic record that support these interpretations. In recent years, taphonomic and sedimentological studies carried out in several localities of the Pampean Region suggested that most assemblages actually represent a very short interval (e.g., Arroyo Chasicó, Laguna Chillhué, Calefú, Farola Monte Hermoso among others; Tomassini and Montalvo, 2013; Tomassini *et al.*, 2013a,b). We suggest restricting the assemblage duration to the represented interval, considering the existence of hiatuses between the following or previous assemblages instead of extending the duration up to the contiguous unit. In this sense, the assemblages would be like temporal windows in the stratigraphic column, which only show the moment of the assemblage, being the rest hidden. Their relative chronology, and partly the extension of the hiatuses between each other are given by the interpretation of taxonomic differences derived from the processes of anagenesis, extinction and migration (Montalvo *et al.*, 2012; Tomassini *et al.*, 2013b). This idea was somehow implicit when the non-contemporaneity of some “Huayquerian” assemblages was proposed (e.g., Verzi *et al.*, 2008; Deschamps *et al.*, 2013).

Taking a look at the time represented in the studied localities according to the mammal record (see Fig. 2), it is evident that the interval between the Montehermosan and Bonaerian (Chapadmalalan, Marplatan and Ensenadan, or following our scheme, the Late Pliocene–Early Pleistocene) is not represented in the area or has not been found yet. During this interval, even the sedimentological record is poor, because this area would have been affected by erosion processes and no deposition (Quattrocchio *et al.*, 2008). Certainly the regional geological model proposed to explain the geographical distribution and antiquity of the faunal associations will help in elucidating this issue.

The Bonaerian is represented at Bajo San José. The deposits of the San José Sequence in this locality were accumulated by a braided river (Borromei, 1990). The age of

the locality was inferred through the record of *Ctenomys kraglievichi*. This large and peculiar octodontid rodent was also found in Pleistocene localities of the Atlantic coast (Necochea, northern Mar del Plata, and also Uruguay; Verzi *et al.*, 2004a). No absolute dating is known so far for the levels bearing *Ctenomys kraglievichi*, but biochronological and paleomagnetic data suggest a relative dating of this unit. Among the first ones, the association with *Tolypeutes* sp. nov. and *Hippidion principale*, together with *Megatherium americanum*, *Glyptodon clavipes* and *Panochthus tuberculatus*, whose biochrons encompass the Bonaerian–Lujanian. Regarding paleomagnetic data, *Ctenomys kraglievichi* is recorded at least 2.2 m above the Bruhnes–Matuyama magnetostratigraphic boundary in northern Mar del Plata, which suggests a younger age than 0.78 Ma.

With respect to the paleoclimatic inferences, *C. kraglievichi* is associated in Bajo San José and the other localities, with other caviomorph rodents that represent an immigration event triggered by an important warm climatic pulse (Vucetich *et al.*, 1997; Vucetich and Verzi, 2002). The finding of the specimens of Necochea was quite significant. This rodent appears in a single sequence with other micromammal remains. The extinction of the taxa found in older levels is accompanied by the sudden appearance of *C. kraglievichi* associated with the single record of a post-Pliocene eumysopine echimyid rodent at this latitude, and the single dasypsectid recorded in the Pleistocene of Argentina. Both species and *C. kraglievichi* are clearly Brazilian immigrants to the southern-southeastern Buenos Aires Province. In Bajo San José, *C. kraglievichi* is associated with sigmodontine rodents (e.g., *Lundomys*; Pardiñas and Deschamps, 1996) and a tayassuine also suggesting a strong warm pulse. This warm pulse is in agreement with the relative high sea level proposed for the deposition of the San José Sequence through the analysis of sequence stratigraphy (Zavala and Quattrocchio, 2001). The climatic change identified in the *C. kraglievichi* Zone may correspond to the warm pulse at 0.4 Ma of the MIS 11 (see discussion in Verzi *et al.*, 2004a).

Mammal remains from the Late Pleistocene in the area are scarce, but suggest that it was a mostly arid period. After the influence of immigrant mammals entering through the Panamá corridor from Central and North America in the

set of events known as GABI (Great American Biotic Interchange), the composition of the mammal assemblages was already established. The major changes observed since the extinction of the megafauna are mostly due to responses to climatic-environmental change. The reaction is more evident in those populations that inhabit the extremes of the geographical distribution of the species (Millien *et al.*, 2006, and literature therein). Precisely, the southwest of the Buenos Aires Province is an ecotonal area between the Guayano-Brasileña and Andino-Patagónica Subregions (*sensu* Ringuelet, 1961), where the extremes of the geographical distribution of the species from both subregions are in close interaction.

This interval is recorded in Puesto La Florida, Chacra La Blanqueada, García del Río, Balneario Saldungaray, and Playa del Barco. The deposits are similar to those found in the banks of rivers and creeks of the east of the Buenos Aires Province (the Pampa Ondulada and Interserrana) with Lujanian deposits. They correspond mainly to channel deposits of plains rivers with differences related to the proximity of the ranges.

Holocene deposits are recorded in the same localities, overlying the Late Pleistocene levels. They are also similar to those of the Pampa Ondulada and Interserrana where the Platan was recognized. Most of the remains were found in the upper levels of the middle section of the Agua Blanca Sequence. In this sector of the profile, a conspicuous lamination is observed. The best represented locality of this interval is Chacra Santo Domingo, where a Brazilian and/or aquatic vertebrate fauna (fish, anurans, *Anas platylea*, *Dendrocygna*, *Holochilus brasiliensis* and *Cavia aperea*) agree with the hydrophytic communities found in pollen analyses. The southern expansion of Brazilian fauna coexisted with central and Patagonian elements (*Chaetophractus villosus*, *Zaedyus pichiy*, *Lama guanicoe*, *Reithrodon auritus*, *Pseudalopex gymnocercus*, among others) suggesting the amelioration of previous arid and semiarid conditions. As well, water bodies could have locally modified the arid conditions favoring the ingress of the Brazilian fauna, and the presence of endemic forms could have been favored by the influence of the nearby ranges (Quattrocchio *et al.*, 1988; Deschamps and Tonni, 1992).

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## APPENDIX 1. Systematic list. Record in the studied localities.

Taxa	Localities												
	CS	BSar	CV	CRS	FMH	LO	BaIS	BSJ	PLF	CSD	GdR	PdB	
Class Osteichthyes													
Order Siluriformes													
<i>Pimelodella</i> aff. <i>P. laticeps</i> Eigenmann, 1917													X
<i>Callichthys callichthys</i> Linné, 1758													X
<i>Corydoras</i> cf. <i>C. paleatus</i> (Jenyns, 1842)													X
<i>Siluriformes</i> indet.					X								
<i>Trichomycteridae</i> indet.					X								
Order Perciformes													
<i>Percichthys</i> sp.													X
<i>Plesiopercichthys dimartinoi</i> Agnolin et al., 2014					X								
Order Characiformes													
<i>Characidae</i> indet.					X								
Class Amphibia													
Order Anura													
<i>Rhinella</i> cf. <i>R. pisanoi</i> Casamiquela, 1967					X								
<i>Rhinella</i> cf. <i>R. schneideri</i> Werner, 1894					X								
<i>Ceratophrys ameghinorum</i> Fernicola, 2001					X								
<i>Lepidobatrachus australis</i> Nicoli, 2015					X								
<i>Leptodactylus</i> sp.					X								
Class Reptilia													
Order Chelonii													
<i>Chelonoidis australis</i> (Moreno, 1889)					X								
<i>Hydromedusa tectifera</i> (Cope, 1869)													X
Order Squamata													
<i>Tupinambis</i> sp.					X								
<i>Callopistes bicuspidatus</i> Chani, 1976					X								
<i>Colubridae</i> indet.					X								
aff. <i>Bothrops</i> Wagler, 1824					X								
<i>Boa</i> sp.					X								
Class Aves													
Order Anseriformes													
<i>Anas platalea</i> Vieillot, 1816													X
<i>Anas</i> sp.													X
<i>Chloephaga</i> sp. 1													X
<i>Chloephaga</i> sp. 2													X
<i>Dendrocygna</i> sp.													X
<i>Dendrocygninae</i> indet.					X								
<i>Anatidae</i> indet.													X
Order Tinamiformes													

Taxa	Localities												
	CS	BSar	CV	CRS	FMH	LO	BaIS	BSJ	PLF	CSD	GdR	PdB	
<i>Nothura parvula</i> Tambussi, 1989					X								
<i>Nothura darwini</i> Gray, 1840								X		X			
<i>Eudromia</i> cf. <i>E. elegans</i> Geoffroy St. Hillaire, 1832					X								
<i>Eudromia olsoni</i> Tambussi and Tonni, 1985					X								
<i>Tinamidae</i> indet.										X			
Order Rheiformes													
<i>Heterorhea dabbenei</i> Rovereto, 1914					X								
<i>Hinasuri nehuensis</i> Tambussi, 1995					X								
<i>Rhea americana</i> (Linné, 1758)									X				
<i>Rhea</i> sp.								X		X			
Order Ralliformes													
<i>Mesembriornis milneedwardsi</i> Moreno, 1889					X								
<i>Chunga incerta</i> Tonni, 1974					X								
Order Gruiformes													
<i>Porphyrio</i> sp.								X					
Order Ciconiiformes													
<i>Vultur gryphus</i> Linné, 1758					X								
<i>Dryornis pampeanus</i> Moreno and Mercerat, 1891					X								
Order Passeriformes													
<i>Pseudoseisura-Pseudoseisuropsis</i>								X					
<i>Motacillinae</i> indet.								X					
Class Mammalia													
Order Didelphimorphia													
<i>Thylatheridium pascuali</i> Reig, 1958					X								
<i>Thylamys contrerasi</i> Mones, 1980					X								
<i>Thylamys pusillus</i> (Desmarest, 1804)										X			
<i>Thylophorops</i> aff. <i>T. perplana</i> Ameghino, 1904					X								
<i>Lutreolina tracheia</i> Rovereto, 1914					X								
<i>Lutreolina biforata</i> Rovereto, 1914					X								
<i>Hyperdidelphys inexpectata</i> Ameghino, 1889					X								
<i>Hyperdidelphys parvula</i> Rovereto, 1914					X								
<i>Sparassocynus bahiai</i> Mercerat, 1899					X								
<i>Lestodelphys halli</i> (Thomas, 1921)										X			
<i>Lestodelphys</i> sp.								X					
Order Sparassodonta													
<i>Notocynus hermosicus</i> Mercerat, 1891					X								
<i>Achlysictis lelongi</i> Ameghino, 1891					X								
<i>Borhyaenidium</i> sp.				X									
Order Polydolopimorphia													
<i>Argyrolagus palmeri</i> Ameghino, 1904					X								
<i>Microtragulus argentinus</i> Ameghino, 1904					X								

Taxa	Localities												
	CS	BSar	CV	CRS	FMH	LO	BaIS	BSJ	PLF	CSD	GdR	PdB	
<i>Order Cingulata</i>													
<i>Euphractini sp. "a" nov. Scillato-Yané, 1982</i>					X								
<i>Holozaedyus laevisculptus Rovereto, 1914</i>					X								
<i>Zaedyus pichiy (Desmarest, 1804)</i>								X	X	X			
<i>Chaetophractus villosus (Desmarest, 1804)</i>								X	X	X	X		
<i>Tolypeutes matacus (Desmarest, 1804)</i>													
<i>Tolypeutes sp. nov. (Scillato Yané in Deschamps, 2005)</i>								X					
<i>Macrochorobates chapalmalensis Scillato-Yané 1980</i>					X								
<i>Macrochorobates sp.</i>				X									
<i>Chorobates villosissimus (Rovereto, 1914)</i>			X	X	X								
<i>Chorobates rescens (Ameghino, 1887)</i>					X								
<i>Chorobates sp.</i>	X												
<i>Macroeuphractus retusus Ameghino, 1887</i>					X								
<i>Macroeuphractus cf. M. morenoi (Lydekker, 1894)</i>				X									
<i>Propaopus sp.</i>								X					
<i>Eutatus seguini Gervais, 1867</i>			X				X						
<i>"Eutatus" praepampaeus Ameghino, 1904</i>					X								
<i>Doellotatus inornatus (Rovereto, 1914)</i>	X				X								
<i>Doellotatus cf. D. praecursor (Rovereto, 1914)</i>	X												
<i>Doellotatus chapadmalensis Bordas, 1933</i>					X								
<i>Ringueletia simpsoni (Bordas, 1933)</i>					X								
<i>Chasicotatus cf. C. peiranoi Esteban and Nasif, 1996</i>				X									
<i>Plaina cf. P. intermedia (Ameghino, 1888)</i>					X								
<i>Pampatherium sp.</i>					X								
<i>Eosclerocalyptus lineatus Ameghino, 1888</i>					X								
<i>Sclerocalyptus ornatus (Owen, 1845)</i>			X										
<i>Neosclerocalyptus sp.</i>													X
<i>Berthawyleeria sp.</i>				X									
<i>Aspidocalyptus sp.</i>				X									
<i>Trachycalyptus sp. nov. Scillato-Yané et al., 1995</i>					X								
<i>Panochthus tuberculatus (Owen, 1839)</i>								X					
<i>Panochthus sp.</i>													X
<i>Doedicurus sp.</i>								X					
<i>Doedicurus clavicaudatus (Owen, 1847)</i>													X
<i>Glyptodon clavipes Owen, 1839</i>								X					X
<i>Glyptodon reticulatus Owen, 1845</i>													X
<i>Nopactus cabrerai Zamorano et al., 2011</i>					X								
<i>Plohophorus figuratus Ameghino, 1887</i>					X								
<i>Plohophorus cuneiformis Ameghino, 1904</i>					X	X							
<i>Plohophoroides sp.</i>					X								
<i>cf. Hoplophorus</i>							X						

Taxa	Localities												
	CS	BSar	CV	CRS	FMH	LO	BaIS	BSJ	PLF	CSD	GdR	PdB	
<i>Phlyctaenopyga trouessarti</i> (Moreno, 1888)					X								
<i>Eleutherocercus antiquus</i> (Ameghino, 1887)					X								
<i>Palaeodaedicurus antiquus</i> Ameghino, 1889					X								
<i>Order Tardigrada</i>													
<i>Proscelidodon patrius</i> Ameghino, 1889					X								
<i>Scelidotherium leptocephalum</i> Owen, 1839								X		X		X	
<i>Scelidotherium</i> cf. <i>S. tarijense</i> Gervais and Ameghino, 1880												X	
<i>Glossotherium</i> sp.							X	X				X	
<i>Lestodon armatus</i> Gervais, 1855								X				X	
<i>Lestodon</i> sp.					X								
<i>Megatherium americanum</i> Cuvier, 1796				X			X						
<i>Myrmecophaga caroloameghinoi</i> Kraglievich, 1934					X								
<i>Order Rodentia</i>													
<i>Phtoramys</i> cf. <i>P. hidalguense</i> Pascual, Pisano and Ortega, 1965	X			X									
<i>Phtoramys homogenidens</i> Ameghino, 1887					X								
aff. <i>Neophanomys biplicatus</i> Rovereto, 1914					X								
<i>Neophanomys</i> sp.					X								
<i>Pithanotomys columnaris</i> Ameghino, 1887					X								
<i>Pithanotomys macer</i> Ameghino, 1888					X								
<i>Pseudoplateaomys formosus</i> Kraglievich, 1934					X								
<i>Eucelophorus cabrerai</i> Kraglievich, 1927					X								
<i>Xenodontomys ellipticus</i> Kraglievich, 1927	X	X	X										
<i>Actenomys priscus</i> (Owen, 1840)					X	X							
<i>Eumysops laeviplicatus</i> Ameghino, 1888					X								
<i>Eumysops formosus</i> Ameghino, 1906					X								
<i>Ctenomys talarum</i> Thomas, 1898							X			X	X		
<i>Ctenomys</i> sp.										X			
<i>Ctenomys kraglievichi</i> (Rusconi, 1930)								X					
<i>Myocastor columnaris</i> Rusconi, 1929								X					
<i>Paramyocastor diligens</i> (Ameghino, 1888)					X								
<i>Lagostomus incisus</i> (Ameghino, 1888)					X								
<i>Lagostomus</i> sp.	X	X				X	X	X					
<i>Lagostomus maximus</i> (Desmarest, 1817)													
<i>Palaeocavia</i> sp.	X	X			X								
<i>Neocavia depressidens</i> Parodi and Kraglievich, 1948					X								
<i>Neocavia</i> sp.					X								
<i>Dolicavia</i> sp.						X							
<i>Galea</i> sp.			X										
<i>Microcavia</i> sp.					X			X					
<i>Cavia aperea</i> Erxleben, 1777				X	X	X							
<i>Orthomyctera</i> sp.	X				X	X							

Taxa	Localities												
	CS	BSar	CV	CRS	FMH	LO	BaIS	BSJ	PLF	CSD	GdR	PdB	
<i>Prodolichotis sp.</i>					X								
<i>Caviodon australis</i> (Ameghino, 1888)					X								
<i>Cardiomya sp.</i>					X								
<i>Phugatherium catacliticum</i> Ameghino, 1889					X								
<i>Neochoeus cf. N. tarijensis</i> (Ameghino, 1902)								X				X	
<i>Telicomya giganteus</i> Ameghino, 1904					X								
<i>Phyllotini gen. et sp. nov.</i> Bond et al., 1998					X								
<i>Necomys bonapartei</i> (Reig, 1978)					X								
<i>Auliscomys formosus</i> Reig, 1978					X								
<i>Reithrodon auritus</i> (Fischer, 1814)					X			X		X			
<i>Lundomys sp.</i>								X					
<i>Holochilus brasiliensis</i> (Desmarest, 1819)										X			
<i>Akodon azarae</i> (Fischer, 1829)								X					
<i>Akodon iniscatus</i> Thomas, 1919								X					
<i>Oxymycterus sp.</i>								X					
<i>Calomys laucha</i> (Fischer, 1814) - <i>C. musculus</i> (Thomas, 1913)										X			
<i>Phyllotis sp.</i>								X					
<i>Order Lagomorpha</i>													
<i>Lepus europaeus</i> Linné, 1758								X					
<i>Order Notoungulata</i>													
<i>Paedotherium bonaerense</i> Ameghino, 1887		X			X		X						
<i>Paedotherium typicum</i> Ameghino, 1887					X								
<i>Paedotherium cf. P. minor</i> Cabrera, 1937	X			X									
<i>Paedotherium sp.</i>			X										
<i>Tremacyllus impressus</i> Ameghino, 1888	X				X								
<i>Tremacyllus cf. T. impressus</i>				X									
<i>Hemihegetotherium sp.</i>													
<i>Pseudotypotherium sp.</i>					X	X							
<i>Toxodon chapalmalensis</i> Ameghino, 1908					X								
<i>Toxodon platensis</i> Owen, 1837			X				X						
<i>Alitoxodon vetustum</i> Rovereto, 1914					X								
<i>Trigodon gaudryi</i> Ameghino, 1882					X								
<i>Trigodon minor</i> Rovereto, 1914					X								
<i>Xotodon prominens</i> Ameghino, 1889					X								
<i>Xotodon ambrosetti</i> Rovereto, 1914					X								
<i>Xotodon sp.</i>					X								
<i>Order Litopterna</i>													
<i>Eoauchenia primitiva</i> Ameghino, 1887					X								
<i>Epitherium laternarium</i> Ameghino, 1888					X	X							
<i>Diplasiotherium robustum</i> Rovereto, 1914					X								
<i>Promacrauchenia antiqua</i> Ameghino, 1889					X								



Taxa	Localities												
	CS	BSar	CV	CRS	FMH	LO	BaIS	BSJ	PLF	CSD	GdR	PdB	
<i>Promacrauchenia kraglievichi</i> Parodi, 1931					X								
<i>Promacrauchenia</i> sp.				X									
<i>Macrauchenioptis ensenadensis</i> (Ameghino, 1888)								X					
<i>Macrauchenia patachonica</i> Owen, 1838										X		X	
<i>Order Proboscidea</i>													
<i>Notiomastodon platensis</i> (Ameghino, 1888)												X	
<i>Gomphotheriidae</i> indet.								X					
<i>Order Artiodactyla</i>													
<i>Tayassuinae</i> indet.								X					
<i>Lama</i> sp.								X					
<i>Lama guanicoe</i> (Müller, 1776)							X			X	X		
<i>Ozotoceros bezoarticus</i> (Linné, 1758)									X	X			
<i>Morenelaphus bonaerense</i> Carette, 1922												X	
<i>Ovis aries</i> Linné, 1758									X	X			
<i>Bos taurus</i> Linné, 1758									X	X			
<i>Order Perissodactyla</i>													
<i>Equus (Amerhippus) neogaeus</i> Lund, 1840										X		X	
<i>Hippidion principale</i> (Lund, 1846)								X					
<i>Hippidion</i> sp.												X	
<i>Order Carnivora</i>													
<i>Parahyaenodon argentinus</i> Ameghino, 1904					X								
<i>Tetraprothomo argentinus</i> Ameghino, 1908					X								
<i>Cyonasua clausa</i> Ameghino, 1904					X								
<i>Smilodon populator</i> Lund, 1842												X	
<i>Pseudalopex</i> sp.								X					
<i>Pseudalopex gymnocercus</i> (Fischer, 1814)										X			
<i>cf. Herpailurus</i>								X					

BaIS, Balneario Saldungaray; BSar, Barrancas de Sarmiento; BSJ, Bajo San José; CSD, Chacra Santo Domingo; CRS, Cantera Relleno Sanitario; CS, Cantera Seminario; CV, Cantera Vialidad; FMH, Farola Monte Hermoso; GDR, García del Río; LO, Las Oscuras; PdB, Playa del Barco; PLF, Puesto La Florida.