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Late Cenozoic mammal bio-chronostratigraphy in southwestern Buenos Aires Province, Argentina

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Abstract. Fossil land mammals from ten localities of southern Buenos Aires Province, Argentina were studied. A new stratigraphic pattern based on materials with reliable stratigraphic provenance is proposed and compared to that of the central-east of the Pampean region. Correlation of fauna and calibration to the time scale suggest that the interval represented in the study area encompasses from the Late Miocene (Huayquerian Age) to the Present. Six biozones were defined for this lapse: *Xenodontomys ellipticus* Zone, *Plohophorus cuneiformis-Actenomys priscus* Zone, *Ctenomys kraglievichi* Zone, *Equus* (*A*.) *neogaeus-Macrauchenia patachonica* Zone, *Ozotoceros bezoarticus* Zone, and *Bos taurus-Ovis aries* Zone. They are correlated within a chronostratigraphic chart.

Resumen. BIO-CRONOESTRATIGRAFÍA DE MAMÍFEROS DEL CENOZOICO TARDÍO EN EL SUDOESTE DE LA PROVINCIA DE BUENOS AIRES, ARGENTINA. Se estudiaron diez localidades fosilíferas del sur de la provincia de Buenos Aires, Argentina. Sobre la base de los mamíferos fósiles se elaboró un esquema estratigráfico para el área y se comparó con el patrón del centro-este de la región pampeana. La correlación de la fauna y su calibración con la escala temporal sugieren que el intervalo representado en el área comprende desde el Mioceno Tardío (Edad Huayqueriense) hasta el presente. Se definieron seis biozonas para este lapso: Biozona de *Xenodontomys ellipticus*, Biozona de *Plohophorus cuneiformis-Actenomys priscus*, Biozona de *Ctenomys kraglievichi*, Biozona de *Equus* (*A*.) *neogaeus-Macrauchenia patachonica*, Biozona de *Ozotoceros bezoarticus* y Biozona de *Bos taurus-Ovis aries*. Estas biozonas se correlacionan dentro de una carta cronoestratigráfica.

Key words. Mammal biostratigraphy. Late Miocene-Recent. Argentina.

Palabras clave. Bioestratigrafía de mamíferos. Mioceno Tardío-Reciente. Argentina.

Introduction

Southwestern Buenos Aires Province in central-east Argentina is a favorable area to undertake a land-mammal biostratigraphic study of the Late Cenozoic, because sedimentary units crop out in a relatively small area (no more than 1250 km²; figure 1), bearing faunas representing at least the last 6 million years. Many of the exposures are composed of the so called "Sedimentos Pampeanos" (*sensu* Fidalgo *et al*., 1975). These sediments are well known for their strong lithologic uniformity and broad distribution throughout the Pampean region. Consequently, the study of their paleontological contents is quite important for stratigraphic correlation.

Papers on vertebrate paleontology with stratigraphic approach of the Late Cenozoic of Argentina have been accomplished mostly in eastern Buenos Aires Province (Tonni and Fidalgo, 1979; Cione and Tonni, 1999 and references therein). In southwestern Buenos Aires Province the studies of vertebrate paleontology had been so far restricted to well known outcrops of the Atlantic coast (Tonni *et al*., 1992 and references therein). Only isolated remains were known for the rest of the area until this study was accomplished. New collections in the area began in 1985 and yielded about 700 specimens with trustful information concerning stratigraphic provenance. Fossil prospecting was accompanied by detailed sedimentologic, palynologic, and microinvertebrates (ostracods) studies carried out by other researchers. In addition, absolute dating was used in correlation of Pleistocene deposits.

Zavala and Quattrocchio (2001) made a sequence stratigraphy analysis of the area characterizing the genesis of the deposits. Their proposal provided the geological frame for the biostratigraphic study and alerted about paleoenvironmental control and/or interpretation of the findings. The most significant profiles were selected to define biostratigraphic zones based on mammals, which were in turn chronostratigraphically correlated to each other and to other biozones of the Pampean area.

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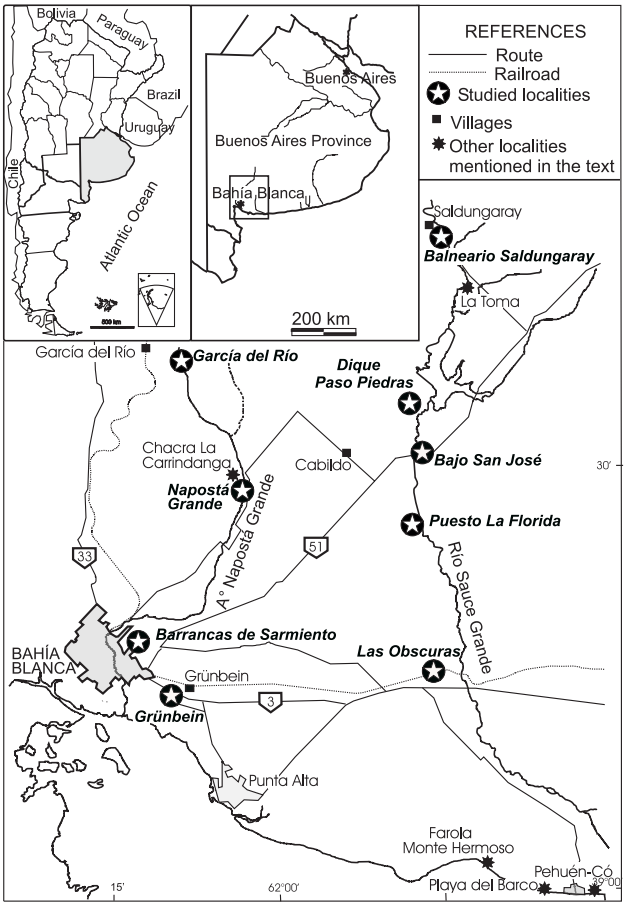

Figure 1. Location map / *Mapa de ubicación.*

All the new data and materials were studied and the results are the base of the biostratigraphic and chronostratigraphic proposal, which includes the biozonation of the area. The paleoclimatic and paleoenvironmental trends observed through the vertebrate fauna, as well as some faunal descriptions and systematic revisions will be developed in future papers.

Material and methods

Ten fossil localities were selected (figure 1) in view of their fossil content. The collection of fossil vertebrates was made according to current rules, accompanied by detailed profiles, reporting precise stratigraphic and geographic provenance. This task included sifting through 1 and 2 mm sieves to recover microvertebrates. Fossils collected are housed in the Cátedra de Geología Histórica from the Universidad Nacional del Sur, Bahía Blanca (repository UNSGH and BB). Appendix 1 shows the complete systematic list of the vertebrates found in all localities. For the biostratigraphic analysis, the taxa found in each locality were listed in the profile with their stratigraphic provenance (see figures 3-6). These records determined biostratigraphic units following the Argentine Code of Stratigraphy (Comité Argentino de Estratigrafía, 1992), and chronostratigraphic units, in order to enable the correlation among localities. The defined biozones were set down in a chronostratigraphic chart, which was modified from the one proposed by Zavala and Quattrocchio (2001) according to the new results. This allowed visualization of the space-time correlation of the events. Four Range Zones and two Association Zones were recognized. Biochrons of taxa were taken from literature (compilations of Alberdi *et al*., 1995; Cione *et al*., 1999 and literature therein), and are shown in Appendix 2. Some of the taxa biochrons had to be analyzed in light of the current knowledge of the geology of their type localities, in order to reduce misinterpretations of stratigraphic provenance. Available absolute dating was also taken into account, resulting in a reliable chronology for the local stratigraphic framework.

Geological setting

The study area is located in the southwest of Buenos Aires Province between 38°30′ S lat. and the Mar Argentino, and 61°20′-62°30′ W long. (figure 1). The main geographic features are the Sierras Australes and two watercourses, the Sauce Grande river and arroyo Napostá Grande. The regional substratum is formed by reddish-brownish, silty-loessic sediments, informally named "Sedimentos Pampeanos" ("Pampean Sediments") that crop out in quarries, riverbanks, and roads cuts. The "Pampean Sediments" are assigned in this area either to the Monte Hermoso Formation (Lower to Middle Pliocene, Zavala, 1993; Marshall *et al*., 1983: 37 and literature therein) or to the Saldungaray-La Toma Formations (Late Pliocene-Early Pleistocene, Furque, 1967; see also Marshall *et al*., 1983) depending on the locality. The lithological uniformity of the "Pampean Sediments" makes them very difficult to correlate even between geographically nearby localities. They span from the Late Miocene to the Middle Pleistocene, from southwest to northeast of the Buenos Aires Province (Fidalgo *et al*., 1975; Marshall *et al*., 1983). The Sauce Grande river and arroyo Napostá Grande have cut the regional substratum and deposited the fluvial sediments which form the La Delta, San José and Agua Blanca Sequences (assigned to the Early Pleistocene, Early-Middle Pleistocene, and Middle Pleistocene-Holocene respectively (Zavala and Quattrocchio, 2001), and the Chacra La Blanqueada Formation (Late Holocene-Historical Times (Rabassa, 1989; Rabassa *et al*., 1991). The eolian sediments are named as the Saavedra and Matadero

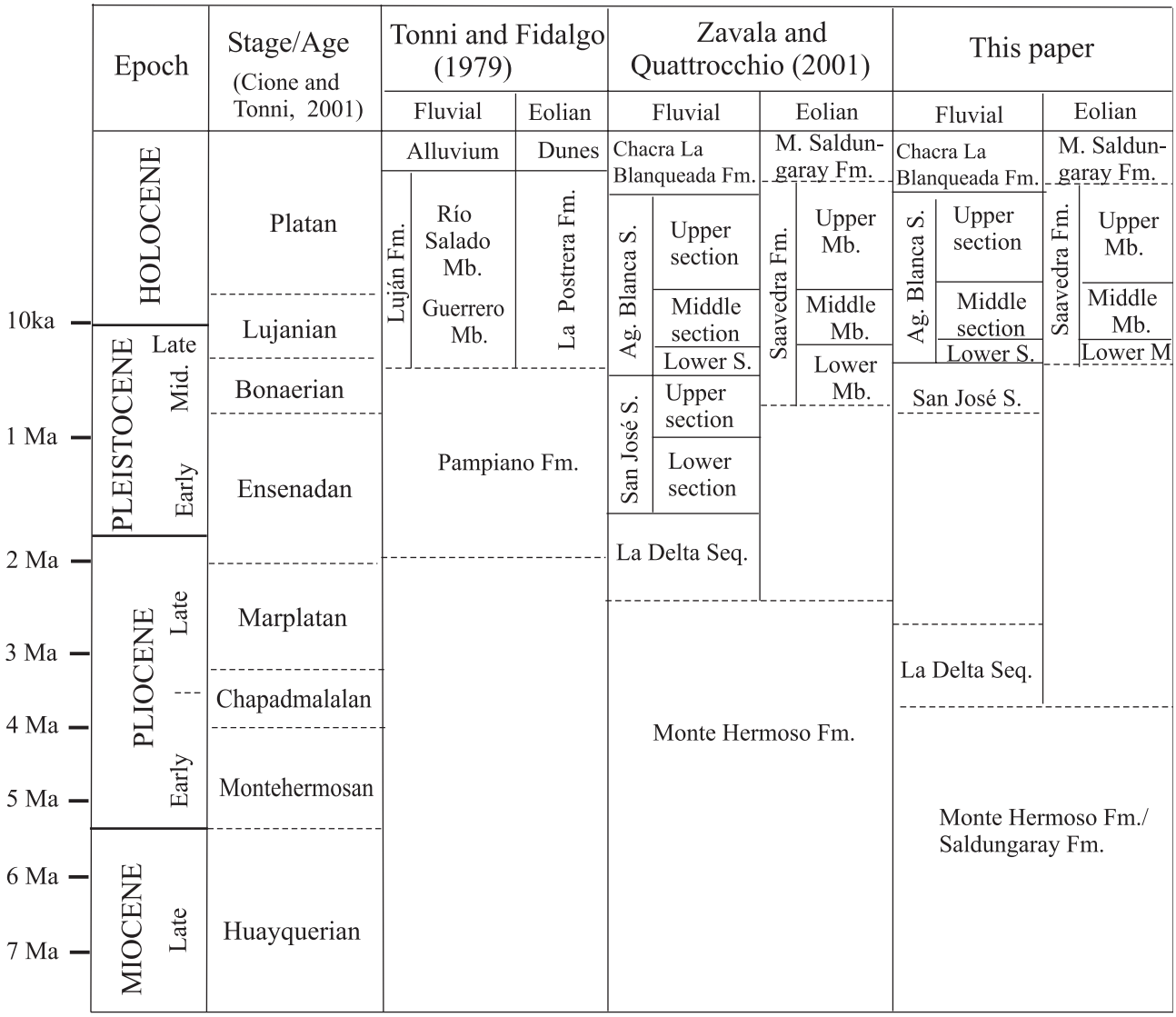

Figure 2. Correlation of the lithostratigraphic units according to different authors, and the new proposal / *Carta de correlación entre las unidades litoestratigráficas propuestas por diferentes autores y la nueva propuesta.*

Saldungaray Formations assigned to the Late Pleistocene-Holocene and Late Holocene- Historical Times respectively (De Francesco, 1970; Rabassa, 1989) (figure 2).

Zavala and Quattrocchio (2001) made the facies and sequence-stratigraphic analysis of the area. They described the depositional sequences related to the valley filling, and interpreted that the sequence was controlled by relative sea level changes, and that these changes were in turn, triggered mainly by paleoclimatic fluctuations, although the authors do not discard neotectonic influence.

Biostratigraphy

The biochron of each taxon was assessed (see Material and methods), as well as the association in which they were recorded (see Appendix 2 and Comments). The ten localities selected for this study encompass the whole lapse represented in the area: Cantera Seminario, Cantera Relleno Sanitario (both near Grünbein), Barrancas de Sarmiento, Las Obscuras, Dique Paso Piedras, Balneario Saldungaray, Bajo San José, Arroyo Napostá Grande, Puesto La Florida and García del Río (figure 1). The first four are formed exclusively by "Pampean Sediments". The other six include fluvial and eolian deposits.

Results

1 and 2. Grünbein. Two quarries near Grünbein village, approximately 5 km SE from Bahía Blanca city (38°46'S-62°11'W), were studied. In both quarries "Pampean Sediments" assigned to the Saldungaray

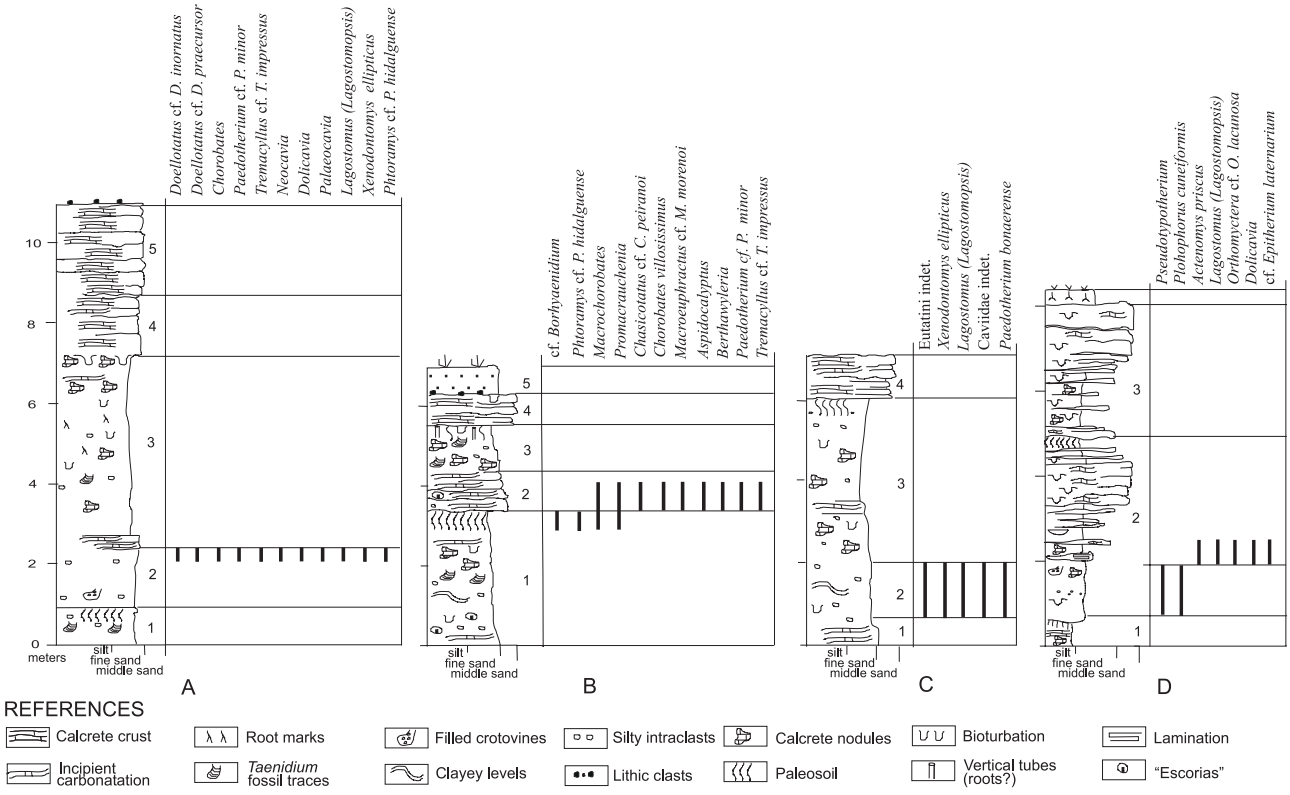

Figure 3. Biostratigraphy of the studied localities / *Bioestratigrafía de las localidades estudiadas.* **A,** Grünbein Cantera Seminario; **B,** Grünbein Cantera Relleno Sanitario; **C,** Barrancas de Sarmiento; **D,** Las Obscuras.

Formation crop out, with several intercalations of paleosoils, bioturbations, "escorias" (scoria) and crotovines (figures 3.A-B). Profiles and the list of recovered taxa were described by Deschamps *et al*. (1998).

1. *Cantera Seminario* (38°44'08''S-62°12'19''W) is 11 m thick and was divided into five levels mostly because of the presence of calcrete. Fossils were found in the upper part of level 2 below the calcrete crust (figure 3.A). They are isolated scutes of *Doellotatus* cf. *D. inornatus*, *D.* cf. *D. praecursor*, *Chorobates*, and skull and mandible fragments of *Paedotherium* cf. *P. minor*, *Tremacyllus* cf. *T. impressus*, *Dolicavia*, *Neocavia*, *Palaeocavia*, *Lagostomus* (*Lagostomopsis*), *Xenodontomys ellipticus*, and *Phtoramys* cf. *P. hidalguense* (see Appendix 1).

2. *Cantera Relleno Sanitario* (38°46'24''S-62°09'25''W) has 8 m mean thickness divided into five levels on the basis of calcrete crusts and paleosoils. The materials were recovered from two contiguous levels (figure 3.B). The lower one is a paleosoil that yielded mandible fragments of cf. *Borhyaenidium* and *Phtoramys* cf. *P. hidalguense*, scutes of *Macrochorobates*, and metapods of *Promacrauchenia*. Level 2 is the calcrete level overlying the paleosoil and yielded scutes of *Chasicotatus* cf. *C. peiranoi*, *Chorobates villosissimus*, *Macrochorobates*, *Macroeuphractus* cf. *M. morenoi*, *Aspidocalyptus*, and *Berthawyleria*, mandible fragments of *Paedotherium* cf. *P. minor*, *Tremacyllus* cf. *T. impressus*, and part of the skull of *Promacrauchenia*.

The age of both localities is here reinterpreted on the basis of the known biochrons (see Appendix 2 and Comments) and especially, on new studies of the rodent *Xenodontomys ellipticus* (Verzi *et al*., 2003, 2004c). A Late Huayquerian Age (Late Miocene) is proposed for these deposits.

3. Barrancas de Sarmiento. This locality is a cliff about 7 m high at Sarmiento Street in Bahía Blanca city (38°42'05''S-62°15'51''W). It is composed of brownish-reddish, sandy silts ("Pampean Sediments") assigned to the Saldungaray Formation, with levels of carbonates, ephemeral fluvial deposits and paleosoils intercalated (González, 1984; Verzi and Deschamps, 1996). Fossils were found at a single level (figure 3.C), at approximately 1 m from the base: one scute of Eutatini, one isolated cheek tooth of Caviidae indeterminate, a fragment of skull and isolated teeth of *Paedotherium bonaerense*, isolated teeth of *Lagostomus* (*Lagostomopsis*), and several fragments of skull and palate of *Xenodontomys ellipticus* (Verzi and Deschamps, 1996).

Recent studies of the enamel microstructure of *X. ellipticus* (Verzi *et al*., 2003; 2004c) suggested that the

specimens of this locality would be coeval with those of Cantera Seminario (Grünbein) and older than those found in sediments of the Quequén Salado river, approximately 2° farther east. Consequently the age proposed for this locality is Late Huayquerian (see Appendix 2, Comments, and Verzi *et al*., 2004a).

4. Las Obscuras. This site, on the right margin of the Sauce Grande river valley, was exposed during railway works, 2000 m from the bridge of national route N° 3 over the river (Deschamps *et al*., 1989). The whole sequence is formed by "Pampean Sediments" assigned to the Saldungaray-La Toma Formations, grayish sandy silts with compact levels of calcium carbonate (locally named as "tosca"), paleosoils, crotovines up to 1,5 m diameter, that have not been lithostratigraphically defined. It is divided into three units, of which only unit 2 yielded fossil mammals (figure 3.D). Specimens found were a caudal tube and part of the carapace of *Plohophorus cuneiformis*, associated upper and lower cheek teeth of *Pseudotypotherium*, a mandible of *Actenomys priscus*, maxilar and mandible of *Lagostomus* (*Lagostomopsis*), a mandible of *Orthomyctera* cf. *O. lacunosa*, a fragment of palate of *Dolicavia*, and one astragalus of cf. *Epitherium laternarium*.

The record of *Actenomys* (see Comments), plus the absence of *Xenodontomys*, and on the basis of *P. cuneiformis*, the fossiliferous level of this locality was assigned to a Montehermosan Age (Early Pliocene) (see Appendix 2 and Comments).

5. Dique Paso Piedras. This locality is placed near the Paso Piedras dam, 2 km from route 51. The exposure is 30 m thick of "Pampean Sediments" assigned to the Saldungaray Formation. A high terrace level formed by coarse conglomerates, partly carbonated, discontinuous along the Sauce Grande river valley, is known as La Delta Sequence (Zavala and Quattrocchio, 2001) (figure 4). Fossils were very scarce in both units. The Saldungaray Formation yielded a mandible fragment of Iguania indet., mandible fragments of *Paedotherium bonaerense*, aff. *Pithanotomys* and Caviidae indet. In La Delta Sequence, a scute of Plohophorini indet. and a mandible fragment of *Microcavia* were found.

The material of *Pithanotomys* of the Saldungaray Formation is not as derived as the materials from the Chapadmalal Formation in its type locality (3.3 Ma, Schultz *et al*., 1998) suggesting a Montehermosan Age, in agreement with *Paedotherium bonaerense*. The record of a Plohophorini (a tribe known from the Hauyquerian to the Early Marplatan) in the overlying La Delta Sequence (see Appendix 2) and the unconformity between both units (figure 4), constrains its age. The Saldungaray Formation would be Late Huayquerian to Montehermosan (Late Miocene-Early Pliocene) and the La Delta Sequence would be Chapadmalalan to Marplatan.

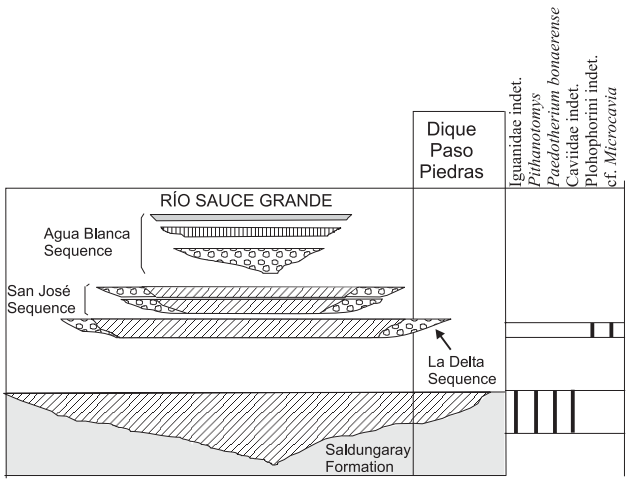

Figure 4. Biostratigraphy of the studied localities. Not in scale / *Bioestratigrafía de las localidades estudiadas. Sin escalas.* Chronostratigraphic chart of Dique Paso Piedras. References in figure 7 / *Carta cronoestratigráfica de Dique Paso Piedras. Referencias en figura 7.*

6. Balneario Saldungaray. This site is exposed at the left margin of the Sauce Grande river at the riverside of Saldungaray village. The sequence begins with "Pampean Sediments" at the water level, assigned to the Saldungaray Formation. This unit is overlain by coarse conglomerates and sands of the San José Sequence (figure 5.A). The profile ends with eolian sands of the Matadero Saldungaray Formation. The scarce mammal remains found in all these units do not constrain the age of the deposits but agree with the interpretation of Zavala and Quattrocchio (2001). A skull of *Paedotherium bonaerense* was found in the Saldungaray Formation, a complete pelvis of *Glossotherium* and another of *Lama*, in the lower section of the San José Sequence; a hind limb of *Lagostomus*, in the Upper Section of this sequence, and skulls of *Ctenomys talarum* and *Lepus europaeus*, in the Matadero Saldungaray Formation (see Appendix 2). These remains suggest a Montehermosan Age for the Saldungaray Formation (Early Pliocene), Pleistocene *sensu lato* for the San José Sequence, and Late Holocene-Historical Times for the Matadero Saldungaray Formation.

7. Bajo San José. This locality is placed near the bridge of route 51 over the Sauce Grande river. It is a terrace of conglomerates and coarse sand known as the San José Sequence exposed discontinuously along the valley, overlying the Saldungaray Formation and seldom covered by eolian units. The de-

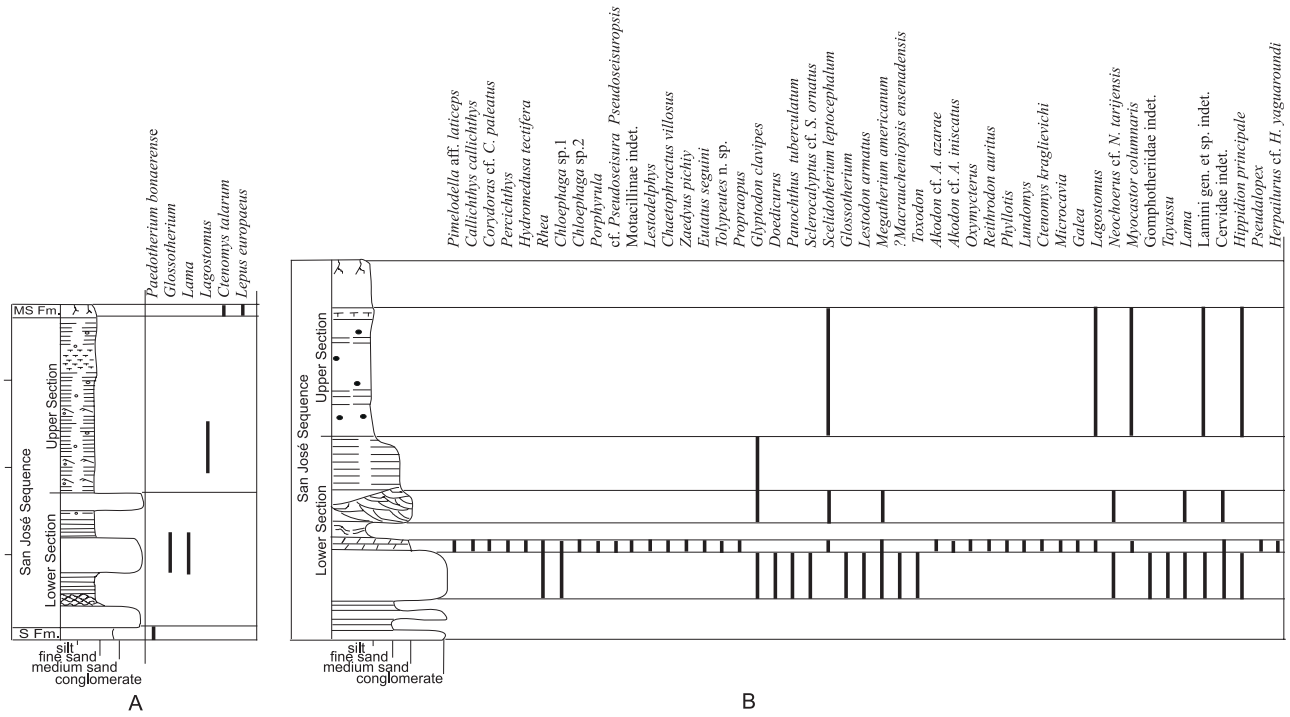

Figure 5. Biostratigraphy of the studied localities / *Bioestratigrafía de las localidades estudiadas.* **A,** Balneario Saldungaray; **B,** Bajo San José. References in figure 3 / *Referencias en figura 3.*

tailed sedimentological studies suggested that this deposit was formed by a braided fluvial system (Borromei, 1990). The San José Sequence yielded a rich vertebrate fauna (figure 5.B) listed in Deschamps and Borromei (1992) and also studied by Cione and López Arbarello (1995), Deschamps (1998), Deschamps *et al*. (2000), de la Fuente (1999), Pardiñas and Deschamps (1996), Tonni and Deschamps (2001) and Verzi *et al*. (2004b). The following taxa were collected in the Lower Section: *Pimelodella* aff. *P. laticeps*, *Callichthys callichthys*, *Percichthys*, *Corydoras* cf. *C. paleatus*, *Hydromedusa tectifera*, *Rhea*, *Chloephaga* sp. 1, *Chloephaga* sp. 2, *Porphyrula*, cf. *Pseudoseisura-Pseudoseisuropsis*, Motacillinae indet., *Lestodelphys*, *Chaetophractus villosus*, *Zaedyus pichiy*, *Eutatus seguini*, *Tolypeutes* n. sp., *Propraopus*, *Glyptodon clavipes*, *Doedicurus*, *Panochthus tuberculatus*, *Sclerocalyptus* cf. *S. ornatus*, *Scelidotherium* cf. *S. leptocephalum*, *Glossotherium*, *Lestodon armatus*, *Megatherium americanum*, ?*Macraucheniopsis ensenadensis*, *Toxodon*, *Akodon* cf. *A. azarae*, *Akodon* cf. *A. iniscatus*, *Oxymycterus*, *Reithrodon auritus*, *Phyllotis*, *Lundomys*, *Ctenomys kraglievichi*, *Microcavia*, *Galea*, *Lagostomus*, *Neochoerus* cf. *N. tarijensis*, *Myocastor*, Gomphotheriidae indet., *Tayassu*, *Lama*, Cervidae indet., *Hippidion principale*, *Pseudalopex*, and *Herpailurus* cf. *H. yaguaroundi*. In the Upper Section, only *Scelidotherium*, *Myocastor columnaris* and *Lagostomus*, were found.

Six detailed profiles were drawn, in which the collection level of each fossil could be identified. Then the taxa were joined in a schematic profile representative of the whole exposure (figure 5.B). The study of this fauna is in agreement with the geological interpretation, since the different abundance of materials among different sedimentological facies relies on taphonomy, the necessary energy for a quick burial, place of the facies within the depositional model, and preservation (Deschamps and Borromei, 1992).

The analysis of the vertebrate fauna found in Bajo San José required the revision of several taxa. Some taxa had their first record in this locality (*i.e*. the fishes *Pimelodella* aff. *P. laticeps*, *Callichtys callichthys* and *Percichthys*; the birds *Porphyrula* and Motacillinae; the Muridae *Oxymycterus*, *Lundomys* and *Phyllotis*, and the *Tayassuidae Tayassu*), and others were new taxa (*Chloephaga* sp. 1 and 2), consequently the analysis of their biochrons was difficult (see Comments). The Bonaerian Age is transitional between Ensenadan (Early Pleistocene) and Lujanian (Late Pleistocene) ages, and very few taxa are exclusive of this age. Accordingly, some authors have not recognized enough faunal differences to distinguish a separate age (see Marshall *et al*., 1984; Cione and Tonni, 1999). Cione and Tonni (1999) confirmed the original Ameghino's "Piso Bonaerense" and defined the *Megatherium americanum* Zone as the biostratigraphical base for this Age. The finding of the rodent *Ctenomys kraglievichi* (with short biochron) in Middle Pleistocene sediments of several localities of the Buenos Aires Province suggested their stratigraphic

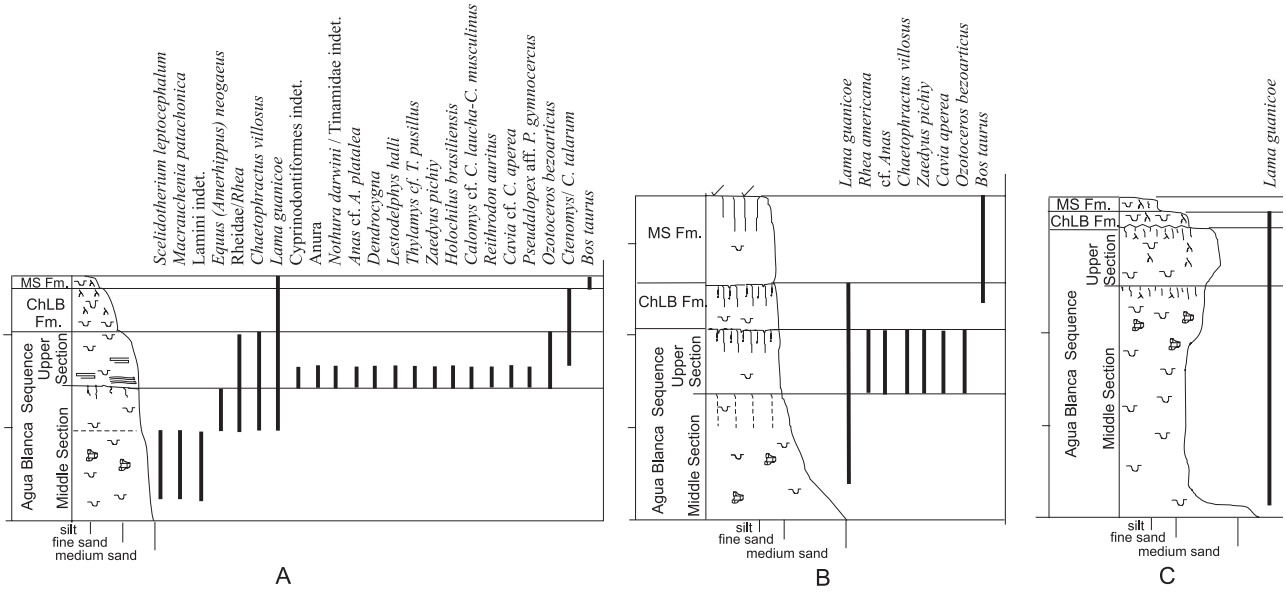

Figure 6. Biostratigraphy of the studied localities / *Bioestratigrafía de las localidades estudiadas.* **A,** Arroyo Napostá Grande; **B,** Puesto La Florida; **C,** García del Río. References in figure 3 / *Referencias en figura 3.*

correlation calibrated through magnetostratigraphic data (Verzi *et al*., 2004b). A Early Bonaerian Age (Middle Pleistocene) was proposed for the deposition of the Lower Section of the San José Sequence, correlated to the ISO 11, the most conspicuous warm pulse recorded for southern South America (Appendix 2, Comments, Deschamps, 2003, and Verzi *et al*., 2004b).

8. Napostá Grande. This site is in the middle valley of the arroyo Napostá Grande, 29 km north from Bahía Blanca city by the road to Cabildo village known as "La Carrindanga". Quattrocchio *et al.* (1988) and modifications made by Zavala and Quattrocchio (2001), recognized the Agua Blanca Sequence and the Chacra La Blanqueada and Matadero Saldungaray formations. The exposure begins with fine sands to silts of the Middle Section of the Agua Blanca Sequence at the water level. This unit is overlain by overflow deposits of the Chacra La Blanqueada Formation and eolian sediments of the Matadero Saldungaray Formation. Many vertebrate remains were found in every unit (Quattrocchio *et al*., 1988; Deschamps and Tonni, 1992) (figure 6.A). The palynological content and ostracods of this section were also studied (Quattrocchio *et al*., 1988; Bertels and Martínez, 1990; Grill, 1995; Martínez, 2002). In the Middle Section of the Agua Blanca Sequence scarce remains of the following taxa were found: Rheidae indet., *Chaetophractus villosus*, *Scelidotherium leptocephalum*, *Macrauchenia patachonica*, *Lama guanicoe*, Lamini indet. and *Equus* (*Amerhippus*) *neogaeus*. But in the Upper Section fossils were more abundant and varied, especially in the lower levels with lamination: scales of Cyprinodontiformes indet., postcranial bones of Anura indet., *Rhea*, *Nothura darwini*, and Tinamidae indet., mandibles of *Anas* cf. *A. platalea*, and *Dendrocygna*, Anatidae indet., mandibles and/or postcranial bones of *Lestodelphys halli*, *Thylamys* cf. *T. pusillus*, *Chaetophractus villosus*, *Zaedyus pichiy*, *Holochilus brasiliensis*, *Calomys* cf. *laucha- musculinus*, *Reithrodon auritus*, *Ctenomys*, *Cavia aperea*, *Lama guanicoe*, *Ozotoceros bezoarticus* and *Pseudalopex* aff. *P. gymnocercus*. In the Chacra La Blanqueada Formation *Ctenomys talarum* and *Lama guanicoe* were found, and in the Matadero Saldungaray Formation, *Lama guanicoe* and *Bos taurus*.

These data suggest a Lujanian Age (Late Pleistocene-Early Holocene) for the Middle Section of the Agua Blanca Sequence (Appendix 2). The Upper Section of this unit is regarded as Platan in age (Late Holocene) because of the absence of Pleistocene species, the record of neospecies, and a radiocarbon dating of 1960±100 ^{14}C years BP (Deschamps and Tonni, 1992). Although no remains of introduced fauna have been found in the Chacra La Blanqueada Formation at this site, they are common in others (Puesto La Florida, Rabassa, 1989; Rabassa *et al*., 1991), suggesting that this unit may have been deposited from the Late Holocene up to the present. The Matadero Saldungaray Formation would have been deposited at least partially after the arrival of the Europeans (17th century).

9. Puesto La Florida. This site is located at the Sauce Grande river valley between Bajo San José and Las Obscuras localities. The cliffs expose the lithostratigraphic units described for Arroyo Napostá Grande.

Only some postcranial bones of *Lama guanicoe* were found in the Middle Section of the Agua Blanca Sequence. In the Upper Section, the following materials were found: a tarsus-metatarsus of *Rhea americana*, ulnae of cf. *Anas*, postcranium and scutes of *Chaetophractus villosus*, scutes of *Zaedyus pichiy*, large part of the skeleton of *Cavia aperea*, and postcranium of *Ozotoceros bezoarticus*. Several postcranial bones of *Bos taurus* were found in the Chacra La Blanqueada and Matadero Saldungaray Formations (figure 6.B).

These findings suggest the same ages as for the previous locality for the lithostratigraphic units.

The Upper Agua Blanca Sequence has a radiocarbon dating in the cliffs of the Sauce Grande river near the Bajo San José locality that yielded 5010±120 years ^{14}C BP, restricting this unit within the middle Holocene (Borromei, 1995). The Chacra La Blanqueada Formation was dated in 2830±90 years ^{14}C BP, Late Holocene (Borromei, 1995) and between 1570 ± 70 and 900±50 years ^{14}C BP (5 wood samples and 1 basal peat sample) at the type section of this unit (Rabassa *et al*., 1991).

10. García del Río. This locality is placed upstream of the Napostá Grande locality in the arroyo Napostá Grande. The outcropping units are those described for Napostá Grande and Puesto La Florida localities. Only *Lama guanicoe* was recorded in all units (figure 6.C), which supplies no biostratigraphic information at this level. A radiocarbon dating of 2610±60 years ^{14}C BP (Quattrocchio *et al*., 1998) assigns the Upper Section of the Agua Blanca Sequence to the Platan Age, Late Holocene.

Bio-and chronostratigraphy (figure 7)

Exposures of the ten localities were correlated in a chronostratigraphic chart. In this context, lithological units are considered unconformity bounded units representing the events occurred in the basin, with temporal and genetic meaning. This is the first time that a paleovertebrate study is based on these units. The genesis of the deposits determined through previous facies and sequence-stratigraphy analysis alerted about paleoenvironmental control on the findings that must be taken in mind when analyzing presence and absence of taxa.

The resulting biostratigraphic scheme allows chronostratigraphic correlation with other areas of the Pampean region, and refinement of the previous pattern, especially with those units based on micromammals.

Since no fossils were found in the Lower Section of the Agua Blanca Sequence, its age could not be assessed. But as the previous Bajo San José Sequence was assigned to the Early Bonaerian, it cannot be older than Middle-Late Bonaerian (late Middle Pleistocene).

The new biostratigraphic scheme here proposed is composed of six biozones for the studied area. From oldest to youngest these units are:

1. Xenodontomys ellipticus Zone

Definition. Total range of this taxon.
Age. Late Huayquerian (the end of the Late Miocene).
Reference section. The type area is Cantera Seminario in Grünbein. The stratotype is Unit 2 (figure 3.A). This is the single fossiliferous level of the profile, 0,5 m thick, between 2 m from the base and a level of calcrete crust.
Characteristic assemblage. *Xenodontomys ellipticus*, *Phtoramys* cf. *P. hidalguense*, *Borhyaenidium*, *Aspidocalyptus*, *Berthawyleria*.
Remarks. This biozone corresponds to the *X. ellipticus* chron a Zone of Verzi *et al*. (2004a). It is also recognized in the other profile studied in the area of Grünbein (Cantera Relleno Sanitario), and in Barrancas de Sarmiento. The fossil fauna suggests a response to relatively arid conditions, open environments of grasslands and herbaceous or shrubby steppes with trees.

2. Actenomys priscus-Plohophorus cuneiformis Zone

Definition. Total range of these two taxa.
Age. Lower Montehermosan (Early Pliocene).
Reference section. The type area is Las Obscuras, with type profile in figure 3.D. The stratotype is the base of Unit 2, between 0.80 and 2.50 m from the base of the exposure.
Characteristic assemblage. *Actenomys priscus* and *Plohophorus cuneiformis* are frequently associated with *Promacrauchenia* and *Pseudotypotherium* which are not exclusive of this age.
Remarks. This biozone is chronostratigraphically correlative to the Saldungaray Formation outcropping at Balneario Saldungaray, and to part of the Montehermosan Stage based on the *Trigodon gaudry* Biozone, defined by Cione and Tonni (1999) in Farola Monte Hermoso. Although *Plohophorus* is not quite abundant, *Actenomys priscus* on the contrary is very abundant and well known. In addition, the lower boundary matches with the end of the record of the genus *Xenodontomys*.

3. Ctenomys kraglievichi Zone

Definition. Total range zone. Total extension of the rodent *Ctenomys kraglievichi*.
Age. Early Bonaerian (Middle Pleistocene).
Reference section. The type area is Bajo San José and the stratotype comprises the Lower Section of the San José Sequence 2 m from the base of the quarry (figure 5.B).
Characteristic assemblage. Other taxa exclusive from the Bonaerian Stage are *Tolypeutes* n. sp. (Scillato Yané, pers. com.) and *Hippidion principale*. *Megatherium americanum*, *Glyptodon clavipes* and *Panochthus tuberculatus* are all abundant taxa from the Bonaerian-Lujanian.
Remarks. This biozone was published by Verzi *et al.* (2004b) while this paper was under revision. This unit is also recognized in the Atlantic cliffs of Necochea and north of Mar del Plata city, Buenos Aires Province (Verzi *et al*., 2004b). It corresponds chronostratigraphically to the basal part of the Bonaerian Stage, which is based on the *Megatherium americanum* Biozone (Cione and Tonni, 1999) of the Pampean region, without formal stratotype. The recorded taxa suggest a complex environment with open areas with scattered forests, temperate-warm, locally associated with water bodies such as the braided fluvial system suggested by facies analysis (Deschamps and Borromei, 1992; Deschamps, 2003; Verzi *et al*., 2004b).

4. Equus (Amerhippus) neogaeus-Macrauchenia patachonica Zone

Definition. The association of the ranges of these two taxa.
Age. Lujanian (Late Pleistocene).
Reference section. The type area is Arroyo Napostá Grande (near Chacra Santo Domingo), the type section is shown in figure 6.A. The stratotype is the Middle Section of the Agua Blanca Sequence.
Characteristic assemblage. *Equus* (*A*.) *neogaeus*, *Macrauchenia patachonica*, *Scelidotherium lepto-*

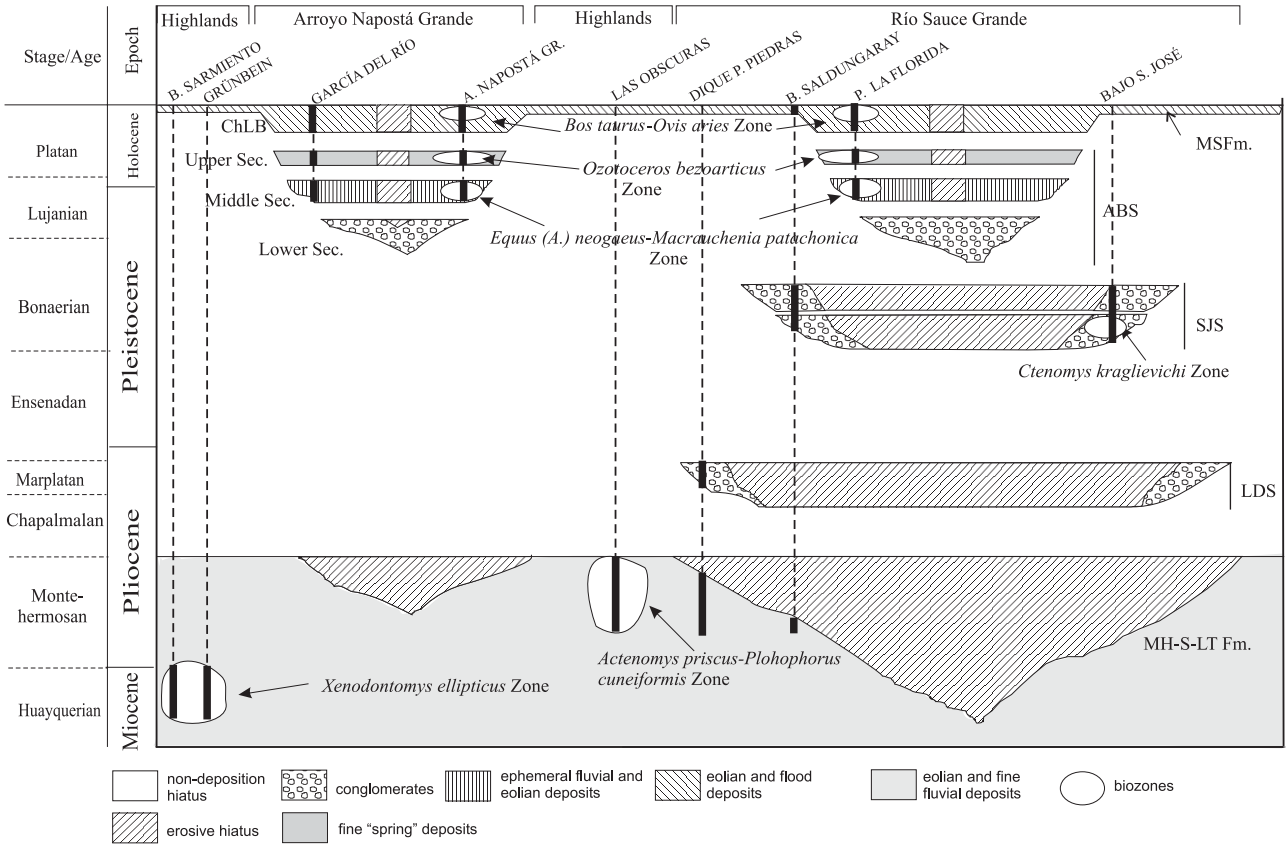

Figure 7. Chronostratigraphic chart of the area showing the relation time-space of the biostratigraphic units. Not in scale / *Carta cronoestratigráfica con la relación temporo-espacial de las unidades bioestratigráficas. Sin escalas.* **ABS,** Agua Blanca Sequence; **ChLB,** Chacra La Blanqueada Formation; **LDS,** La Delta Sequence; **MH-S-LT Fm,** Monte Hermoso-Saldungaray-La Toma Formations; **MSFm,** Matadero Saldungaray Formation; **SJS,** San José Sequence. Black line represents the time-event recorded in each locality / la línea negra representa los eventos registrados en cada localidad.

cephalum, *Megatherium americanum*, *Glossotherium*, *Lama guanicoe*.
Remarks. This biozone is also recognized in the Middle Section of the Agua Blanca Sequence cropping out at Puesto La Florida, and correlates chronostratigraphically with the Lujanian Stage, based on the *Equus* (*A.*) *neogeus* Biozone (Cione and Tonni, 1999). The environment suggested is open areas with grasslands and steppes.

5. Ozotoceros bezoarticus Zone

Definition. Total range of this taxon in the area.
Age. Platan (Late Holocene), determined on absolute dating and the record of fragments of indian pottery.
Reference section. The type area is Arroyo Napostá Grande (Chacra Santo Domingo). The stratotype is the Upper Section of the Agua Blanca Sequence (figure 6.A).
Characteristic assemblage. *Ozotoceros bezoarticus*, *Lama guanicoe*, *Lagostomus maximus*, *Cavia aperea*, *Ctenomys*.
Remarks. Although *O. bezoarticus* is an extant species, it is restricted to protected areas of San Luis and Buenos Aires Provinces. This biozone is also recognized in the Upper Section of the Agua Blanca Sequence exposed at Puesto La Florida. It may be chronostratigraphically correlated with part of the Platan Stage, based on the *Lagostomus maximus* Biozone defined for Paso Otero area, Buenos Aires province (Cione and Tonni, 2001).

6. Bos taurus-Ovis aries Zone

Definition. The first record of these living taxa introduced by the Europeans. The upper boundary cannot be defined.
Age. Historical times-present.
Reference section. The type area is Arroyo Napostá Grande (Chacra Santo Domingo), the stratotype is composed by the eolian sediments at the top of the profile assigned to the Matadero Saldungaray Formation (figure 6.A). In other sites of the area (i.e. Puesto La Florida) this biozone is also recognized in the upper levels of the Chacra La Blanqueada Formation.
Characteristic assemblage. *Bos taurus*, *Ovis aries*, *Lepus europaeus*, *Lagostomus maximus*.
Remarks. This is a special biozone composed of living species, which is not considered in the Comité Argentino de Estratigrafía (1992), but it is regarded here because it limits the top of the previous biozone and helps recognizing this important period in archaeological studies. Although *O. aries* was not recorded in this site, the species is also considered in the name of the biozone because many bones of this conspicuous representative of the introduced fauna were observed in the surroundings together with *Bos taurus*, in the upper levels of the Chacra La Blanqueada Formation and the Matadero Saldungaray Formation.

Conclusions

Six biozones ranging from the uppermost Miocene to historical times were recognized for southwest of the Buenos Aires Province, and correlated within a chronostratigraphic chart.

A Late Miocene age (Late Huayquerian) was assigned to the "Pampean Sediments" exposed at Grünbein and Barrancas de Sarmiento, and Early Pliocene Age (Montehermosan) to those exposed at Las Obscuras, Dique Paso Piedras and Balneario Saldungaray localities. La Delta Sequence was assigned to the end of the Early Pliocene (Chapadmalalan)-Late Pliocene (Marplatan), the San José Sequence to the Middle Pleistocene (Early Bonaerian), the Agua Blanca Sequence to the Late Pleistocene (Lujanian)-Holocene (Platan), and the Chacra La Blanqueada Formation and Matadero Saldungaray Formations partially to the Holocene (Platan) and partially to the Historical Times-present.

The aim of the study was the biostratigraphy of the southwestern Buenos Aires Province, but this entailed the systematic and chronological revision of the fauna on which the biozonation could be accurately determined. As a synthesis it may be said that two new taxa of the genus *Chloephaga* were found (see Appendices 1 and 2); the oldest records of the fish genera *Pimelodella* (*P.* aff. *laticeps*), *Callichthys* (*C. callichthys*) and *Percichthys*, the Muridae *Oxymycterus*, *Lundomys* and *Phyllotis*, and the Tayassuidae *Tayassu* are those of Bajo San José; the first record of *Berthawyleria* in Argentina is that of Grünbein. The genus *Actenomys* was preliminary reviewed. Some of the known biochrons of the taxa changed with the findings in this area. Some others were corrected reanalyzing the original papers in light of new studies of the geology of their type localities (see Appendix 2 and Comments).

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Appendix 1. Systematic list of the taxa found in the study area, up to the levels in which the new materials could be determined / *Lista sistemática de los taxones hallados en el área de estudio, hasta el nivel en que los nuevos materiales pudieron ser determinados.*

Class Osteichthyes Howes, 1894
Order Cyprinodontiformes Bertin, 1958
Cyprinodontiformes indet.
Order Siluriformes Fowler, 1951
Family Pimelodidae Eigenmann and Eigenmann, 1889
Genus ***Pimelodella*** Eigenmann, 1917
P. aff. ***laticeps*** (in Cione and López Arbarello, 1995)
Family Callichthyidae Gill, 1872
Genus ***Callichthys*** Linné, 1758
C. callichthys (in Cione and López Arbarello, 1995)
Genus ***Corydoras*** Lacépède, 1803
Corydoras cf. ***C. paleatus*** (Jenyns, 1842)
Order Perciformes Ludwig, 1883
Family Percichthyidae Jordan, 1923
Genus ***Percichthys*** Girard, 1854

Class Amphibia Linné, 1758
Order Anura Giebel, 1847
Anura indet.

Class Reptilia Laurenti, 1768
Order Chelonii Brongniart, 1800
Family Chelidae Gray, 1825
Genus ***Hydromedusa*** Wagler, 1830
H. tectifera (Cope, 1869)
Order Squamata Oppel, 1811
Family Iguanidae Gray, 1827
Iguanidae indet.
Class Aves Linné, 1758
Order Rheiformes Fürbringer, 1888
Family Rheidae Bonaparte, 1853
Genus ***Rhea*** Brisson, 1760
R. americana (Linné, 1758)
Order Tinaniformes (Huxley, 1872)
Family Tinamidae Gray, 1840
Genus ***Nothura*** Wagler, 1827
N. darwini Gray, 1867
Order Anseriformes Garrod, 1874
Family Anatidae Vigors, 1825
Genus ***Anas*** Linné, 1758
A. platalea Vieillot, 1816
Genus ***Chloephaga*** Eyton, 1838
Chloephaga sp. 1
Chloephaga sp. 2
Genus ***Dendrocygna*** Swinson, 1837
Order Gruiformes (Bonaparte, 1854)
Family Rallidae Vigors, 1825
Genus ***Porphyrula*** Linné, 1758
Order Passeriformes (Linné, 1758)
Suborder Tyranni Wetmore and Miller, 1926
Family Furnariidae (Gray, 1840)
Subfamily Philydorinae Sclater, 1890
Genus ***Pseudoseisura*** Reichenbach, 1853
Genus ***Pseudoseisuropsis*** Noriega, 1991
Suborder Passeres Linné, 1766
Family Passeridae (Illiger, 1811)
Subfamily Motacillinae Bonaparte, 1831

Class Mammalia Linné, 1758
Superorder Marsupialia Illiger, 1811
Order Sparassodonta (Ameghino, 1894)
Family Hathliacynidae Ameghino, 1894

Genus ***Borhyaenidium*** Pascual and Bocchino, 1963
Order DIDELPHIMORPHIA Gill, 1872
Family DIDELPHIDAE Gray, 1821
Subfamily MARMOSINAE Reig, 1981
Genus ***Lestodelphys*** Tate, 1934
Lestodelphys halli (Thomas, 1921)
Genus ***Thylamys*** Gray, 1843
T. pusillus (Desmarest, 1804)
Superorder XENARTHRA Cope, 1889
Order CINGULATA Illiger, 1811
Superfamily DASYPODOIDEA Gray, 1821
Family DASYPODIDAE Bonaparte, 1838
Subfamily DASYPODINAE Bonaparte, 1838
Tribe DASYPODINI Bonaparte, 1838
Genus ***Propraopus*** Ameghino, 1881
Subfamily EUPHRACTINAE Pocock, 1924
Tribe EUTATINI Bordas, 1933
Genus ***Doellotatus*** Bordas, 1932
Doellotatus inornatus (Rovereto, 1914)
Doellotatus praecursor (Rovereto, 1914)
Genus ***Chasicotatus*** Scillato Yané, 1979
Chasicotatus peiranoi Esteban and Nasif, 1996
Genus ***Eutatus*** Gervais, 1867
Eutatus seguini Gervais, 1867
Tribe EUPHRACTINI Pocock, 1924
Genus ***Chorobates*** Reig, 1959
Chorobates villosissimus (Rovereto, 1914)
Genus ***Macrochorobates*** Scillato Yané, 1980
Genus ***Macroeuphractus*** Ameghino, 1887
Macroeuphractus morenoi (Lydekker, 1894)
Genus ***Chaetophractus*** Fitzinger, 1871
Chaetophractus villosus (Desmarest, 1804)
Genus ***Zaedyus*** Ameghino, 1889
Zaedyus pichiy (Desmarest, 1804)
Subfamily TOLYPEUTINAE Gray, 1865
Tribe TOLYPEUTINI Gray, 1865
Genus ***Tolypeutes*** Illiger, 1811
Tolypeutes matacus (Desmarest, 1804)
Superfamily GLYPTODONTOIDEA Gray, 1869
Family GLYPTODONTIDAE Burmeister, 1879
Subfamily SCLEROCALYPTINAE Ameghino, 1895
Tribe SCLEROCALYPTINI Ameghino, 1895
Genus ***Sclerocalyptus*** Ameghino, 1891
Sclerocalyptus ornatus (Owen, 1845)
Genus ***Berthawyleria*** Castellanos, 1939
Tribe PALAEHOPLOPHORINI Hosffstetter, in Piveteau, 1958
Genus ***Aspidocalyptus*** Cabrera, 1939
Tribe LOMAPHORINI Hoffstetter, 1958
Tribe PLOHOPHORINI Castellanos, 1932
Genus ***Plohophorus*** Ameghino, 1887
Plohophorus cuneiformis Ameghino, 1904
Tribe PANOCHTHINI Castellanos, 1927
Genus ***Panochthus*** Burmeister, 1866
Panochthus tuberculatus (Owen, 1839)
Tribe NEURYURINI Hoffstetter, 1958
Subfamily DOEDICURINAE Ameghino, 1889
Genus ***Doedicurus*** Burmeister, 1874
Subfamily GLYPTODONTINAE Gray, 1869
Tribe GLYPTODONTINI Gray, 1869
Genus ***Glyptodon*** Owen, 1839
Glyptodon clavipes Owen, 1839
Order TARDIGRADA Lathan y Davies, 1795
Family MYLODONTIDAE Gill, 1872
Subfamily SCELIDOTHERIINAE Ameghino, 1889
Genus ***Scelidotherium*** Owen, 1839
Scelidotherium leptocephalum Owen, 1839
Subfamily MYLODONTINAE Gill, 1872
Genus ***Glossotherium*** Owen, 1839
Genus ***Lestodon*** Gervais, 1855
Lestodon armatus Gervais, 1855
Family MEGATHERIIDAE Owen, 1843
Genus ***Megatherium*** Cuvier, 1796
Megatherium americanum Cuvier, 1796
Order LITOPTERNA Ameghino, 1889
Family PROTEROTHERIIDAE Ameghino, 1887
Subfamily PROTEROTHERIINAE Ameghino, 1885
Genus ***Epitherium*** Ameghino, 1888
Epitherium laternarium Ameghino, 1888
Family MACRAUCHENIIDAE Gervais, 1855
Genus ***Promacrauchenia*** Ameghino, 1904
Genus ***Macrauchenia*** Owen, 1838
Macrauchenia patachonica Owen, 1838
Genus ***Macraucheniopsis*** Paula Couto, 1945
Macraucheniopsis ensenadensis (Ameghino, 1888)
Order NOTOUNGULATA Roth, 1903
Family TOXODONTIDAE Owen, 1845
Genus ***Toxodon*** Owen, 1837
Family MESOTHERIIDAE Alston, 1876
Subfamily MESOTHERIINAE Alston, 1876
Genus ***Pseudotypotherium*** Ameghino, 1904
Family HEGETOTHERIIDAE Ameghino, 1894
Subfamily PACHYRUKHINAE Kraglievich, 1934
Genus ***Paedotherium*** Burmeister (in C.V. Burmeister, 1888)
P. minor Cabrera, 1937
P. bonaerense (Ameghino, 1887)
Genus ***Tremacyllus*** Ameghino, 1891
T. impressus (Ameghino, 1887)
Subfamily HEGETOTHERIINAE Ameghino, 1894
Genus ***Hemihegetotherium*** Rovereto, 1914
Order LAGOMORPHA Brandt, 1855
Family LEPORIDAE Fischer, 1817
Genus ***Lepus*** Linné, 1758
L. europaeus Linné, 1758
Order RODENTIA Bowdich, 1821
Suborder MYOMOPHA Brandt, 1855
Superfamily MUROIDEA Illiger, 1811
Family MURIDAE Illiger, 1811
Subfamily SIGMODONTINAE Wagner, 1843
Tribe ORYZOMYINI Vorontzov, 1959
Genus ***Lundomys*** Voss and Carleton, 1993
Genus ***Holochilus*** Brandt, 1835
H. brasiliensis (Desmarest, 1819)
Tribe AKODONTINI Vorontzov, 1959
Genus ***Akodon*** Meyen, 1833
A. azarae (Fischer, 1829)
A. iniscatus Thomas, 1919
Genus ***Oxymycterus*** Waterhouse, 1837
Tribe PHYLLOTINI Vorontzov, 1959
Genus ***Calomys*** Waterhouse, 1837
C. laucha (Fischer, 1814)
C. musculinus (Thomas, 1913)
Genus ***Reithrodon*** Waterhouse, 1837
Reithrodon auritus (Fischer, 1814)
Genus ***Phyllotis*** Waterhouse, 1837
Suborder HYSTICOGNATHI, Tullberg, 1899
Infraorder CAVIOMORPHA Patterson and Wood in Wood, 1955
Family OCTODONTIDAE Waterhouse, 1839
Subfamily OCTODONTINAE Waterhouse, 1839
Genus ***Pithanotomys*** Ameghino, 1887
Genus ***Phtoramys*** Ameghino, 1887
P. hidalguense Pascual, Pisano and Ortega, 1965
Subfamily CTENOMYINAE Tate, 1935
Genus ***Xenodontomys*** Kraglievich, 1927
X. ellipticus Kraglievich, 1927
Genus ***Actenomys*** Burmeister (in C.V. Burmeister, 1888)
A. priscus (Owen, 1840)
Genus ***Ctenomys*** Blainville, 1826
C. kraglievichi (Rusconi, 1930)
C. talarum Thomas, 1898
Family CAVIIDAE Gray, 1821

Subfamily CAVIINAE Gray, 1821
Genus ***Palaeocavia*** Ameghino, 1889
Genus ***Neocavia*** Kraglievich, 1932
Genus ***Dolicavia*** C. Ameghino, 1916
Genus ***Galea*** Meyen, 1833
Genus ***Microcavia*** Gervais and Ameghino, 1880
Genus ***Cavia*** Pallas, 1766
C. aperea Erxleben, 1777
Subfamily DOLICHOTINAE Pocock, 1922
Genus ***Orthomyctera*** Ameghino, 1889
O. lacunosa (Ameghino, 1888)
Family CHINCHILLIDAE Bennett, 1833
Genus ***Lagostomus*** Brookes, 1828
L. maximus (Desmarest, 1817)
Subgenus LAGOSTOMUS (LAGOSTOMOPSIS) Kraglievich, 1926
Family MYOCASTORIDAE Miller and Gidley, 1918
Genus ***Myocastor*** Kerr, 1792
M. columnaris Rusconi, 1929
Family HYDROCHOERIIDAE Gill, 1872
Subfamily HYDROCHOERINAE (Gray, 1825), *sensu* Kraglievich, 1930
Genus ***Neochoerus*** Hay, 1926
N. tarijensis (Ameghino, 1902)
Order PROBOSCIDEA Illiger, 1811
Family GOMPHOTHERIIDAE Hay, 1922
Order ARTIODACTYLA Owen, 1848
Suborder SUIFORMES Jaeckel, 1911
Infraorder SUINA Gray, 1821
Family TAYASSUIDAE Palmer, 1897
Genus ***Tayassu*** Fischer, 1814
Suborder TYLOPODA Illiger, 1811
Family CAMELIDAE Gray, 1821
Tribe LAMINI Webb, 1974
Genus ***Lama*** Cuvier, 1800
L. guanicoe (Müller, 1776)
Suborder RUMINANTIA Scopoli, 1777
Family CERVIDAE Goldfuss, 1820
Subfamily ODOCOILEINAE Pocock, 1923
Genus ***Ozotoceros*** Ameghino, 1891
O. bezoarticus (Linné, 1758)
Family BOVIDAE Gray, 1821
Subfamily CAPRINAE Gray, 1821
Genus ***Ovis*** Linné, 1758
O. aries Linné, 1758
Subfamily BOVINAE Gray, 1821
Genus ***Bos*** Linné, 1758
B. taurus Linné, 1758
Order PERISSODACTYLA Owen, 1848
Family EQUIDAE Gray, 1821
Subfamily EQUINAE (Gray, 1821) Steinmann and Döderlein, 1890
Genus ***Equus*** Linné, 1758
Subgenus ***E.*** (***Amerhippus***) Hoffstetter, 1950
E. (A.) neogaeus (Lund, 1840)
Genus ***Hippidion*** Owen, 1869
H. principale (Lund, 1846)
Order CARNIVORA Bowdich, 1821
Family CANIDAE Fischer de Waldheim, 1817
Genus ***Pseudalopex*** Burmeister, 1856
P. gymnocercus (Fischer, 1814)*
Family FELIDAE Fischer de Waldheim, 1817
Subfamily FELINAE Fischer de Waldheim, 1817
Genus ***Herpailurus*** Severtzov, 1858
H. yaguaroundi (Lacépède, 1809)

*Galliari *et al*. (1996) assign the species of this genus to *Lycalopex* Burmeister, 1854 following Zunino *et al*. (1995).

Comments on Appendix 2

The oldest record of *Rhea* is that of *R. anchorenensis*, whose type and single specimen (currently lost) was found in the Ensenadan of Punta Anchorena, Buenos Aires Province.

The record of South American iguanians is discontinuous. It includes Cretaceous-Paleocene, Middle Miocene and Pleistocene taxa. They were not recorded so far in the Late Miocene-Pliocene. The fragment of Dique Paso Piedras is the first record for this lapse.

The holotype of *Doellotatus inornatus* is from Farola Monte Hermoso, without stratigraphic provenance (Rovereto, 1914). Other materials assigned to this species were found in the "Irenense" of the Quequén Salado river, Buenos Aires province, traditionally assigned to the Chapadmalalan (Goin *et al*., 1994) but certain levels of this locality must be considered older than this age (Verzi *et al*., 2003). Consequently, its biochron could be older.

Doellotatus praecursor is the most derived species of the genus (Deschamps *et al*., 1998). Although this species was recorded in the upper levels of the Río Negro Formation together with *Plohophorus* aff. *figuratus* (Aramayo, 1987), the holotype was found at the lower valley of the Río Negro without stratigraphic level (Rovereto, 1914). Other taxa considered typically Huayquerian were found in this area (see Aramayo, 1987). Hence the biochron of *D. praecursor* could be older than so far proposed.

Tolypeutes sp. is similar to the specimen found in the Río Salado near Belgrano, Buenos Aires Province, in Bonaerian sediments, that belongs to a new undescribed species (*Tolypeutes* n. sp., G. Scillato-Yané pers. com., 2003).

According to Cerdeño and Bond (1998), *Paedotherium bonaerense* is recorded from the Montehermosan to the Marplatan. The species of the genus *Paedotherium* are sometimes difficult to determine with isolated fragments because probably they follow an anagenetic evolutionary pattern (M. Bond pers. com., 2003). It may not be discarded that some specimens assigned to *P. minor* recorded in Epecuén and Arroyo Chasicó formations actually represent small/juvenile specimens of *P. bonaerense*. Consequently, the biochron of this taxon could have been longer.

The materials of *Oxymycterus* sp., *Lundomys* sp. and *Phyllotis* sp. cited in Alberdi *et al*. (eds.) 1995, for the Ensenadan are those found in Bajo San José (Pardiñas and Deschamps, 1996), which is considered here Bonaerian. Consequently, their biochron is Bonaerian-Recent.

The materials of *Pithanotomys* from Chapadmalal (3.3 Ma; Schultz *et al*., 1998) are more derived than that of Balneario Saldungaray (D. Verzi pers. com., 2003). Consequently, this latter could be older (*i.e*. Montehermosan).

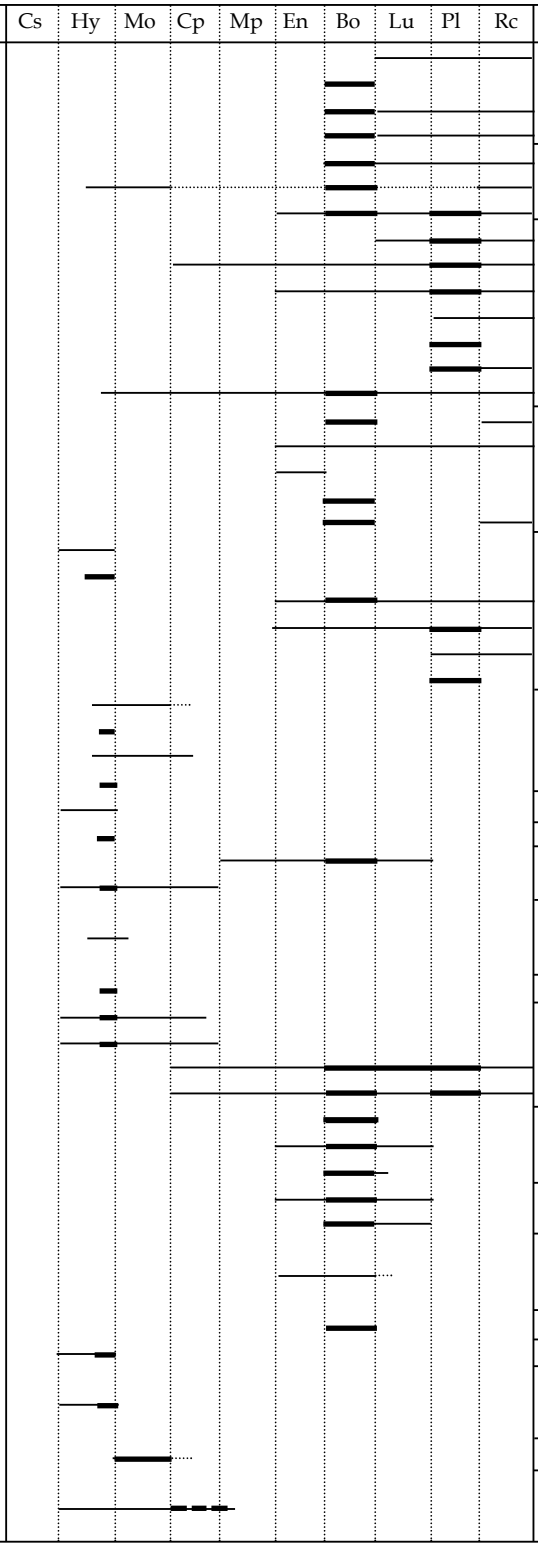
Actenomys is first and abundantly recorded in the Montehermosan in its type locality, and continues to the Chapadmalalan. The systematic of the several known species has not been revisited, but a preliminary revision showed that the specimen of Las Obscuras is similar to those of Farola Monte Hermoso determined as *A. priscus* (Owen, 1840), and different from those of Chapadmalal (Verzi and Deschamps, unpublished).

Caviids of the Late Miocene and Early Pliocene (*Neocavia*, *Paleocavia*, *Dolicavia*, *Orthomyctera*, *Lagostomus* (*Lagostomopsis*)) have to be reviewed, consequently they are not considered for biostratigraphic analyses. Anyway, those specimens of *Dolicavia* recorded in Grünbein, Cantera Seminario are not as derived as those of the Chapadmalalan (the third lobe of the p4 is smaller and the internal flexid not so deep as in *D. minuscula*).

Chinchillids show very low diversity and the only two taxa recognized from the Chasicoan to the Lujanian have not been revisited. Vucetich and Verzi (1995) think there is a single genus for the Plio-Pleistocene chinchillids because differences between *Lagostomopsis* and *Lagostomus* are only increasing size, with change in relative proportions of the skull and gradual thinning of cheek teeth. *Lagostomus* is recorded from the Chasicoan to the Upper Chapadmalalan.

Herpailurus yaguaroundi is not cited in the fossil record, but poorly studied materials of Felidae recorded since the Ensenadan are listed as *Felis* (Cione *et al*., 1999).

Appendix 2. Range chart of the taxa found in the study area compared to the biochron published in corresponding References. Thin straight line means the known biochron, dotted line means dubious record, and thick straight line means the record in the study area. An asterisk marks those taxa whose biochron is discussed in "Comments on Appendix 2." **Cs,** Chasicoan; **Hy,** Huayquerian; **Mo,** Montehermosan; **Cp,** Chapadmalalan; **En,** Ensenadan; **Bo,** Bonaerian; **Lu,** Lujanian; **Pl,** Platan; **Rc,** Recent / *Distribución estratigráfica de los taxones hallados en el área de estudio, comparados con los biocrones publicados en las referencias correspondientes. Líneas delgadas: biocrones conocidos; líneas punteadas: registros dudosos; líneas gruesas: registro en el área de estudio. Asterisco: taxones cuyo biocrón se discute en "Comentarios sobre el Apéndice 2".*



Taxa	References
Pimelodella laticeps	
Pimelodella aff. laticeps	"Deschamps and Borromei, 1992;
Callichthys callichthys	Alberdi *et al.* (eds.), 1995"
Corydoras paleatus	
Percichthys	Broin and de la Fuente, 1993
Hydromedusa tectifera	*
Rhea	
Rhea americana	
Nothura darwini	
Anas	
Anas platalea	Alberdi *et al.* (eds.), 1995
Anas cf. *platalea*	
Dendrocygna	
Chloephaga	
Porphyrula	
Pseudoseisura	
Pseudoseisuropsis	Tonni and Deschamps, 2001
cf. *Pseudoseisura-Pseudoseisuropsis*	
Motacilinae	
Borhyaenidium	
cf. *Borhyaenidium*	
Lestodelphys	Alberdi *et al.* (eds.), 1995
Lestodelphys halli	
Thylamys pusillus	
Thylamys cf. *T. pusillus*	
Doellotatus inornatus	*
Doellotatus cf. *D. inornatus*	
Doellotatus praecursor	*
Doellotatus cf. *D. praecursor*	
Chasicotatus peiranoi	Esteban and Nasif, 1996
Chasicotatus cf. *C. peiranoi*	
Eutatus seguini	Alberdi *et al.* (eds.), 1995
Macrochorobates	Scillato Yané, 1980
Macroeuphractus morenoi	"Alberdi *et al.* (eds.), 1995; Mones and Mehl, 1990"
Macroeuphractus cf. *M. morenoi*	
Chorobates villosissimus	
Chorobates	
Chaetophractus villosus	Alberdi *et al.* (eds.), 1995
Zaedyus pichiy	
Tolypeutes sp.	*
Propraopus	Cione *et al.*, 1999
Glyptodon clavipes	Tonni and Berman, 1988
Doedicurus	Cione *et al.*, 1999
Panochthus tuberculatus	
Sclerocalyptus ornatus	"Cione *et al.*, 1999; Treviño and Zurita, 2002"
Sclerocalyptus cf. *S. ornatus*	
Aspidocalyptus	Cabrera, 1939
Berthawyleria	"Castellanos, 1939; Marshall *et al.*, 1983"
Plohophorus cuneiformis	Ameghino, 1904
Tribu Plohophorini	"Scillato Yané and Carlini, In: Cione *et al.*, 2000; Alberdi *et al.* (eds.), 1995"

Appendix 2 (cont.)