

# A TERRESTRIAL GASTROPOD COMMUNITY FROM THE EARLY PLIOCENE (NEOGENE) OF MENDOZA, ARGENTINA, WITH DESCRIPTION OF A NEW SPECIES OF *RADIODISCUS* PILSBRY AND FERRISS, 1906 (MOLLUSCA: PULMONATA: CHAROPIDAE)



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**Abstract.** Numerous fossil gastropods have been recorded in an edaphic level of the middle section of the the Aisol Formation (Mendoza Province, Argentina). This stratigraphic section bears an association of fossil mammals suggesting an early Pliocene age (possible Montehermosan SALMA). Up to four taxa of gastropods have been identified, belonging in *Succinea* Draparnaud (Succineidae), *Gastrocopta* Wollaston (Vertiginidae), *Bostryx* Troschel (Bulimulidae), and a new species of *Radiodiscus* Pilsbry and Ferriss (Charopidae). The fossil record of terrestrial pulmonate mollusks in Argentina is scarce and mainly restricted to the Quaternary. Thus, the record of these taxa is of paramount importance because it constitutes the oldest record of *Gastrocopta* and *Succinea* in Argentina, the first record of *Bostryx* in Mendoza Province, and the first record of the family Charopidae (*Radiodiscus sanrafaelensis* nov. sp.) in Pliocene deposits of Argentina.

**Key words.** Gastropoda. Stylommatophora. Pliocene. Montehermosan SALMA. South America.

**Resumen.** UNA COMUNIDAD DE GASTROPODOS DEL PLIOCENO TEMPRANO (NEÓGENO) DE MENDOZA, ARGENTINA, CON DESCRIPCIÓN DE UNA NUEVA ESPECIE DE *RADIODISCUS* (MOLLUSCA: PULMONATA: CHAROPIDAE). Numerosos restos de gastrópodos fósiles han sido encontrados en niveles edafizados de la sección media de la Formación Aisol (Mendoza, Argentina). Esta sección estratigráfica es portadora de una asociación de mamíferos fósiles que sugiere una edad Plioceno temprano (posiblemente SALMA Montehermosense). Se han podido identificar al menos cuatro taxones: *Succinea* Draparnau (Succineidae), *Gastrocopta* Wollaston (Vertiginidae), *Bostryx* Troschel (Bostrycidae) y una especie nueva del género *Radiodiscus* Pilsbry y Ferriss (Charopidae). Los registros fósiles de moluscos pulmonados terrestres en Argentina son escasos y se restringen al Cuaternario. El hallazgo de estos taxones en la sección media de la Formación Aisol (Plioceno temprano) reviste gran importancia ya que constituye el registro más antiguo de los géneros *Gastrocopta* y *Succinea* para la Argentina, el primer registro del género *Bostryx* para la Provincia de Mendoza, y el primer registro de la familia Charopidae (*Radiodiscus sanrafaelensis* nov. sp.) en depósitos de edad Pliocena en Argentina.

**Palabras clave.** Gastropoda. Stylommatophora. Plioceno. SALMA Montehermosense. América del Sur.

CENOZOIC outcrops cover almost 80% of Mendoza Province (Yrigoyen, 1993). These deposits harbor a rich vertebrate fauna that has been the subject of numerous studies over the last 100 years and has contributed to the definition of several SALMAs (South America Land Mammal Age) that are used as a regional biostratigraphic tool; however, records of invertebrates from these units are few in the literature. Purportedly Cenozoic fossil invertebrates were found in several localities in southern Mendoza Province such as the Malargüe region, Mechanquil, Borde Alto del Payún, upstream the Liu Malal River, and at the Sierra de Chachahuén. All of them come from beds included in the Roca Formation (Danian). These

invertebrate associations were found to include primarily Cretaceous marine taxa with no elements that could indicate a Cenozoic age (Medina and Olivero, 1993). Therefore, the fossils are probably reworked from older deposits (*i.e.*, Jagüel Formation). The first record of a continental mollusk in the province is that of the freshwater bivalve *Corbicula elchaensis* Rusconi, 1949, from the late early Miocene Mariño Formation (Rusconi, 1949; Cerdeño, 2007); Cerdeño and Vucetich, 2007). A rich continental mollusk fauna was described from the late Pleistocene/Holocene El Zampal Formation (Zárate and Mehl, 2008); it includes the land snails *Succinea meridionalis* d'Orbigny, 1846, *Radiodiscus* sp. aff. *Radiodiscus quilla-*

*jicola* Vargas-Almonacid, 2000, and *Rotadiscus amancaezensis* (Hidalgo, 1869) (Miquel and Aguirre, 2011). The Holocene record in west-central Argentina is rich in continental gastropods, but the middle Holocene is generally sterile probably as the result of changes in climate conditions (de Francesco *et al.*, 2007; de Francesco, 2010). Continental fossil mollusks commonly occur in Quaternary alluvial successions of Argentina (de Francesco *et al.*, 2007; de Francesco, 2010); however, the Paleogene–Neogene record is scarce and restricted to a few localities (del Río *et al.*, 2007; Miquel and Bellosi,

2010). In this paper we present the oldest Cenozoic record of a terrestrial mollusk fauna from Mendoza Province. The fossil locality is located on the right bank of the Atuel River, southwest from the city of San Rafael (Mendoza Province, Argentina). The bearing sediments are referred to the lower levels in the middle section of the Aisol Formation (González Díaz, 1972; see Forasiepi *et al.*, 2011, 2012; Turazzini, 2013). The record of fossil taxa in this assemblage is very poor and restricted to the Quaternary, whereas their living representatives are not abundant in the region (Parodiz, 1961; Fernán-

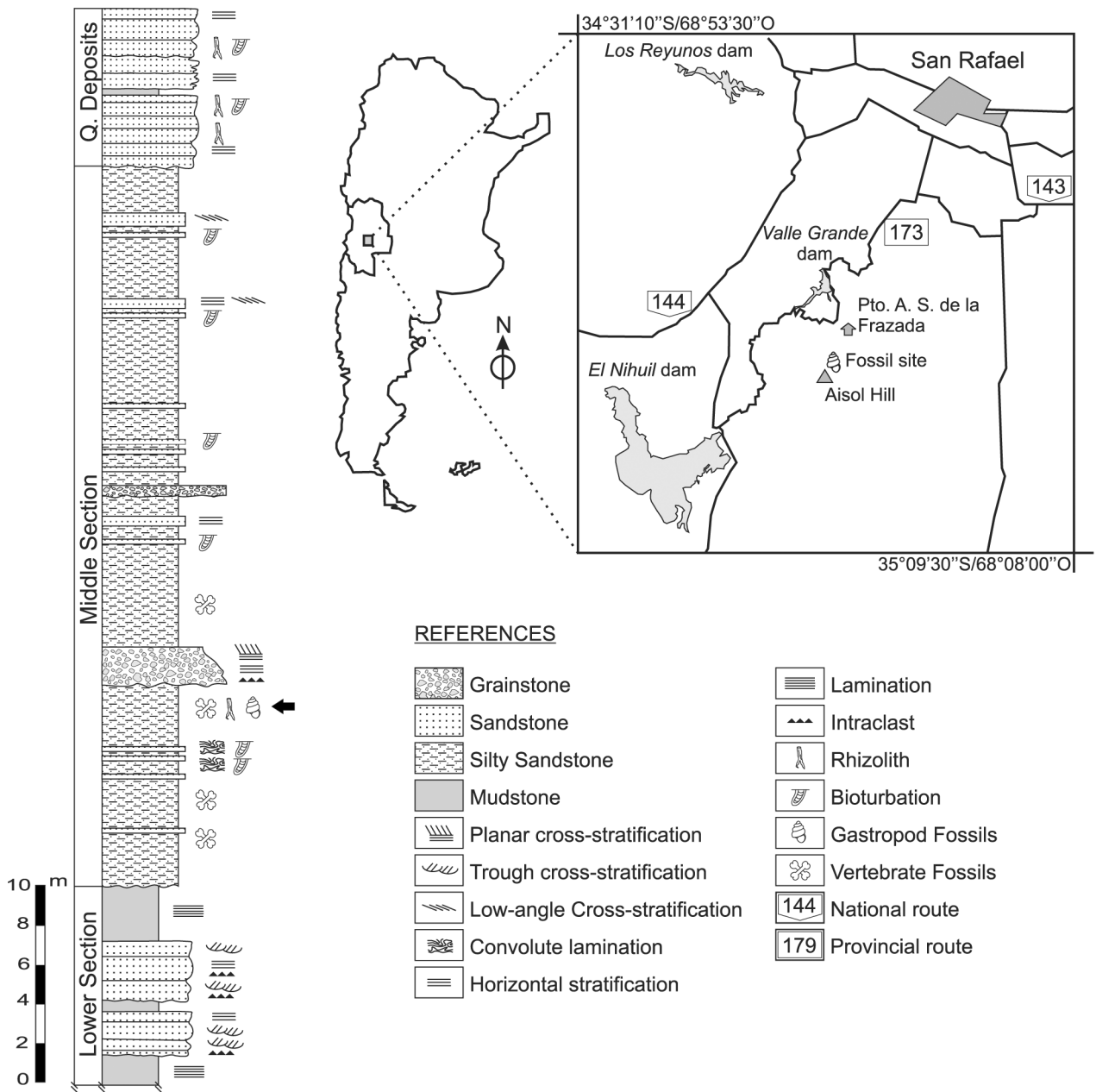


Figure 1. Location map (top right) and stratigraphic profile (left) of the fossiliferous site.

dez, 1973; Miquel, 1993, 1995). The Pliocene record of these taxa in Mendoza Province provides insights into the evolution of the terrestrial mollusk fauna in the region.

## MATERIAL AND METHODS

All the specimens studied are deposited in the Museo de Historia Natural de San Rafael, San Rafael city (Mendoza Province). Microphotographs of the metal-coated specimens were taken with a Scanning Electron Microscope (Philips XL 30 TMP) at the Servicio de Microscopía Electrónica de Barrido of the Museo Argentino de Ciencias Naturales “Bernardino Rivadavia”.

**Institutional abbreviations.** MHNSR, Museo de Historia Natural de San Rafael, San Rafael, Argentina.

**Abbreviations.** SEM, Scanning Electron Microscope (Philips XL 30 TMP); T.L., Total length; M.d., Major diameter.

## GEOLOGICAL SETTING

The San Rafael Block (Feruglio, 1946) is an orographic unit lying between 34°15'–36°15'S and 68°15'–69°00'W. During the Jurassic, Cretaceous and part of the Paleogene, the block acted as a positive area and was subject to a long-lasting interval of denudation, resulting in planation of the Neopaleozoic–Triassic bedrocks (Polansky, 1954, 1963; Criado Roque, 1972; Kozlowsky *et al.*, 1993; Ramos, 1999). The Neogene succession is dominantly composed of synorogenic, pyroclastic sediments, affected by tectonic deformation related to the different phases of the ongoing Andean orogeny (Dessanti, 1956; González Díaz, 1964, 1972; Yrigoyen, 1993).

The oldest Cenozoic unit in the San Rafael Block area is the Aisol Formation (Yrigoyen, 1993). It was described by González Díaz (1972) and considered to be middle Miocene (Soria, 1983). It thus defines a stratigraphic hiatus of ~230 Ma between the Early Mesozoic and middle Neogene deposits. Recent studies divided the Aisol Formation into three sections based on lithology and paleontological content (Forasiepi *et al.*, 2011, 2012; Turazzini, 2013). The analysis of the vertebrate fauna found in the lower and middle sections indicated that their age could be Colloncuran (middle Miocene) and possible Montehermosan (early Pliocene) respectively (Soria, 1983; Forasiepi *et al.*, 2009, 2011; Vucetich *et al.*, 2012; Turazzini, 2013). The stratigraphic identity of these sections is currently under revision. The middle section of the Aisol Formation outcrops between Puesto Arroyo

Seco de la Frazada (34°53'52"S, 68°30'56"W) and the Cerro Aisol (Aisol Hill) (34°56'22"S, 68°28'40"W). The locality with fossil gastropods is situated in the southernmost portion of these outcrops, near the Cerro Aisol (Aisol Hill), at 34°55'58.56"S, 68°30'38.70"W (Fig. 1). The middle section at this locality is ~45 m thick, and mainly composed of grayish pink (5R 8/2), fine to median-grain sized sandstones interpreted as floodplain deposits, and a few channeled grainstone deposits (Fig. 1). It seems to overlie the lower section unconformably, but in some sectors there is an obvious difference in the inclination angles of the two units (angular unconformity). The sandstones appear poorly stratified, with partial dissolution of grains and a high participation of carbonates. The gastropod-bearing level lies in the lower third of the section, nearly 1.5 m below a grainstone channel-deposit that is a very conspicuous landmark in the field. A petrographic analysis of the studied level showed that it consists of a fine-grained, feldspar lithic sandstone, composed mainly by mesosiliceous and acid volcanic and pyroclastic grains (39%), quartz (38%) and feldspar (mainly plagioclase, 19%), followed by intraformational fragments of gypsum (1%), iron-poor biotite (< 1%), altered amphiboles (< 1%) and other mafics (2%). It has floating texture and the cement is mainly composed of micrite and secondarily by microsparite. The microsparite is found filling holes and vacuities. Pedotubules constitute a complex net of channels that render an important secondary porosity to the rock. The presence of pedotubules, holes and vacuities, floating fabric, and macroscopic rhizocretions *s.s.* (*sensu* Klappa, 1980) suggest an advanced degree of pedogenesis. Carbonates not only participate as cement and coating of vacuities, but are also found filling the internal casts of the gastropods and replacing their shells, as revealed by thin sections.

## SYSTEMATIC PALEONTOLOGY

- Phylum MOLLUSCA Linné, 1758
- Class GASTROPODA Cuvier, 1797
- Subclass PULMONATA Cuvier, 1817
- Order STYLOMMATOPHORA Schmidt, 1855
- Superfamily PUPILLOIDEA Turton, 1831
- Family VERTIGINIDAE Fitzinger, 1833
- Genus **Gastrocopta** Wollaston, 1878

**Type species.** *Pupa acarus* Benson, 1856, subsequent designation by Pilsbry (1916). Recent, Azores Islands.

**Gastrocopta** sp.

Figure 2.1

**Referred material.** MHNSR-INV 3081. Eight internal casts with parts of shell.

**Description of the shell.** Shell small, ovate-cylindric, spire well developed, with obtuse apex, and 5.5–6 convex whorls

with slow growth; the last whorl is less than half the total length; suture deep; aperture broken, with at least one internal parietal lamella; the teleoconch shows a slightly axial striation originated by growth lines.

**Measurements of illustrated specimen.** T.l.= 3.12 × M.d.= 1.43 mm. Other specimen: T.l.= 2.86 × M.d.= 1.43 mm.

**Remarks.** The specimens studied herein are bigger than the other fossil and living argentinian species of the genus. The lack of apertural teeth and the very fragmentary lamella in the specimens do not allow a specific identification with any of the known Argentinian species, *i.e.*, *Gastrocopta dicrodonta* (Doering, 1879), a recent species described from Mendoza, or *Gastrocopta nodosaria* (d'Orbigny, 1835) and *Gastrocopta oblonga* (Pfeiffer, 1853), living in northern and central Argentina (Miquel and Aguirre, 2011; Pilsbry, 1916).

Superfamily SUCCINEOIDEA Beck, 1837

Family SUCCINEIDAE Beck, 1837

Genus **Succinea** Draparnaud, 1801

**Type species.** *Succinea putris* (Linné, 1758), by Opinion 94 (ICZN) (Pilsbry, 1948). Recent, Sweden.

**Succinea** sp. aff. **Succinea meridionalis** d'Orbigny, 1846

Figure 2.2–2.3

**Referred material.** MHNSR-INV 3079. Thirty shells and 128 broken specimens.

**Description of the shell.** Shell oval-oblong, imperforate, with, at least, 3 convex whorls, the last whorl well developed (two thirds of total length); aperture very expanded and oblong; spire acute and short; surface with growth lines.

**Measurements of illustrated specimen.** T.l.= 7.15 × M.d.= 3.9 mm.

**Remarks.** Its general morphology is similar to *S. meridionalis* from northern Patagonia to tropical and temperate areas in Argentina (Miquel and Aguirre, 2011), but the specimens lack off diagnostic characters for an accurate specific identification.

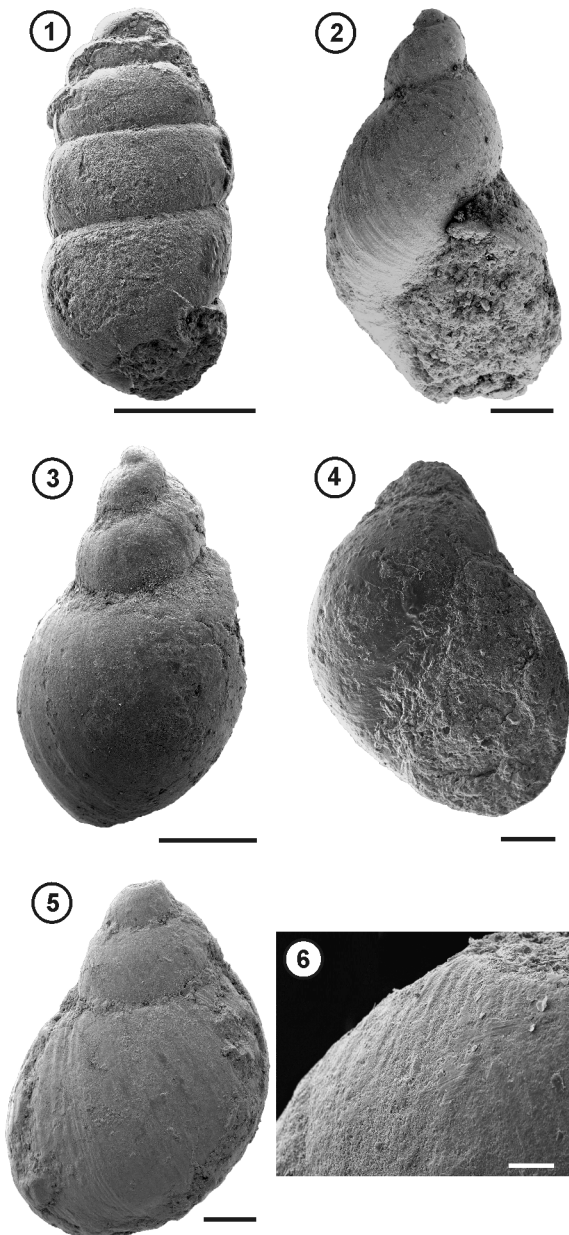
Superfamily ORTHALICOIDEA Albers-Martens, 1860

Family BULIMULIDAE Crosse and Fischer, 1873

Subfamily BOSTRYCINAE Breure and Romero, 2012

Genus **Bostryx** Troschel, 1847

**Type species.** *Bulimus (Bostryx) solutus* Troschel, 1847; by monotypy. Recent, Perú.



**Figure 2.** SEM microphotographs of the fossil gastropods. **1**, *Gastrocopta* sp., MHNSR-INV 3081, apertural view. **2–3**, *Succinea* sp. aff. *S. meridionalis*, MHNSR-INV 3079, apertural/abapertural view. **4–6**, *Bostryx* sp., MHNSR-INV 2080, apertural/abapertural view, and detail of protoconch sculpture. Scale bar in figures 2.1–2.5= 1000 µm, scale bar in figure 2.6= 100 µm.

**Bostryx** sp.

Figure 2.4–2.6

**Referred material.** MHNSR-INV 2080. Four shells.

**Description of the shell.** Shell of medium length, ventricose, 6 to 6.5 convex whorls, spire small, apex obtuse, deep suture, the protoconch with vestigial axial ribs and spiral incisures, the teleoconch with marked irregular axial growth lines.

**Measurements of illustrated specimen.** T.l.= 7.8 × M.d.= 5.46 mm.

**Remarks.** The specimens from the Eocene at Gran Salitral (La Pampa Province) (Melchor *et al.*, 2002) are bigger (T.l.= 27 × M.d.= 24 mm), and show a different general morphology, because they are lower and with a larger diameter, and show a large and perspectivus umbilicus.

Superfamily PUNCTOIDEA Morse, 1864

Family CHAROPIDAE Hutton, 1884

Genus **Radiodiscus** Pilsbry and Ferriss, 1906

**Type species.** *Radiodiscus millecostatus* Pilsbry and Ferriss, 1906; by original designation. Recent, United States of America.

***Radiodiscus sanrafaelensis* nov. sp.**

Figure 3

**Derivation of name.** From San Rafael, Mendoza Province, Argentina, the area where the new species was found.

**Diagnosis.** Shell discoidal, with four whorls, regular growth; aperture semicircular, teleoconch with 180–190 axial ribs in the last whorl; protoconch of 1.75 whorls with 13–14 spiral costulae.

**Type series.** MHNSR-INV 3082. Holotype (MHNSR-INV 3082-A) and four paratypes (MHNSR-INV 3082-B).

**Measurements of holotype.** T.l.= 1.56 × M.d.= 0.78 mm.

**Measurements of paratypes.** T.l.= 1.82 × M.d.= 0.78 mm (illustrated in apertural view); T.l.= 1.69 × M.d.= 0.65 mm; T.l.= 1.56 × M.d.= 0.78 mm; T.l.= 1.3 × M.d.= 0.65 mm.

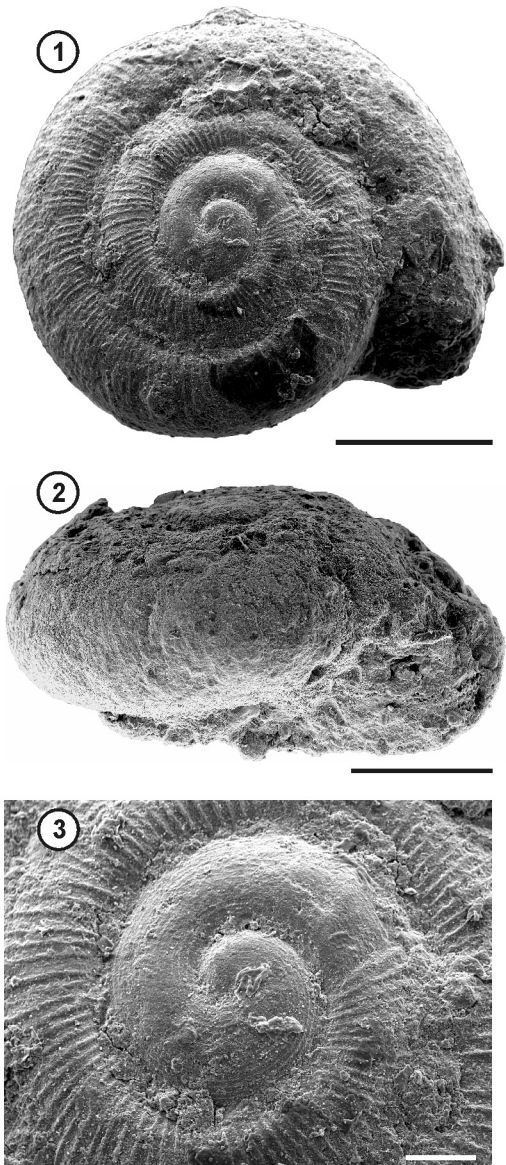
**Geographic occurrence.** 34°55'58.56"S, 68°30'38.70"W, southwest of San Rafael city, in San Rafael Department, Mendoza Province, Argentina.

**Stratigraphic occurrence.** Middle section of the Aisol Formation (early Pliocene).

**Description.** Shell small, discoidal, with four whorls, spire short, regular growth; aperture semicircular; suture deep; with different sculpture in proto- and teleoconch; adult shell of 2.25

convex whorls, with 180–190 axial ribs in the last whorl, and axial costulae between the ribs; protoconch of 1.75 whorls with 13–14 spiral costulae.

**Comparisons with related species.** Its morphology and sculpture are typical of Charopidae. The spiral costulae in the protoconch are characteristic of *Radiodiscus* (Miquel and Cádiz Lorca, 2008). The new species is compared with some Argentinian and Chilean species of *Radiodiscus* (Tab. 1). *Radiodiscus millecostatus*, the type species of the genus, inhabits



**Figure 3.** SEM microphotographs of *Radiodiscus sanrafaelensis* nov. sp.; **1**, apical view (holotype); **2**, apertural view (paratype); **3**, detail of protoconch sculpture (holotype). Scale bar in figures 3.1–3.2= 500 µm, scale bar in figure 3.3= 100 µm.

TABLE 1 – Comparative features of *Radiodiscus sanrafaelensis* nov. sp. and related species (average of the type series of the species).

Species	Measurements (total length × major diameter; mm)	Axial ribs of the teleoconch	Spiral costulae of the protoconch
<i>R. sanrafaelensis</i> nov. sp.	1.60 × 0.75	185	14
<i>R. millecostatus</i> Pilsbry and Ferriss, 1906	1.10 × 2.00	150	25
<i>R. lateumbilicatus</i> Weyrauch, 1965	1.00 × 1.70	780	—
<i>R. quillajicola</i> Vargas-Almonacid, 2000	1.00 × 1.70	90	17
<i>R. flammulatus</i> Hylton Scott, 1975	1.20 × 1.60	120	22
<i>R. compactus</i> (Suter, 1900)	0.60 × 1.15	155	25
<i>R. reticulatus</i> Fonseca and Thomé, 1995	1.00 × 1.70	120	20

North America. *Radiodiscus quillajicola* lives in central Chile and it was recorded in late Pleistocene deposits in Valle de Uco, Mendoza Province (de Francesco *et al.*, 2007). *Radiodiscus lateumbilicatus* Weyrauch, 1965, lives in Villavicencio (Mendoza Province). *Radiodiscus compactus* (see Miquel *et al.*, 2007) is from Brazil and northern Argentina, and *R. flammulatus* is from Patagonia. *Retidiscus reticulatus* from Brazil, was recorded in the Holocene of Buenos Aires Province (Argentina) (Miquel and Steffan, 2005). The genus *Retidiscus* Fonseca and Thomé, 1995, could be a junior synonym of *Radiodiscus* (Miquel and Aguirre, 2011). In comparison, *R. sanrafaelensis* nov. sp. has a greater total length and a smaller diameter; also, it is characterized by having fewer spiral costulae on the protoconch and more axial ribs on the teleoconch than any of the compared species. It also differs from *Radiodiscus* sp. cf. *R. riochicoensis* Crawford, 1939, from the Eocene at Gran Barranca (Chubut Province, Argentina) by its much smaller size albeit with the same number of whorls, although their general morphology and number of axial costulae is similar. However, these last traits are hard to establish because of poor preservation of the specimens.

## DISCUSSION

The fossil record of continental Cenozoic gastropods from Argentina is scarce from a geographic and temporal point of view (del Río *et al.*, 2007). In Mendoza Province there is no record of fossil continental gastropods older than Pleistocene (de Francesco *et al.*, 2007; de Francesco, 2010) and the

existing record is dominated by limnic taxa. In this context, the record of a continental terrestrial gastropod fauna in early Pliocene deposits from the San Rafael Block area is highly significant.

Specimens of *Gastrocopta* are numerous in limestone terrains, under stones or wood, or among leaves (Pilsbry, 1948). The genus has a short stratigraphic distribution in Argentina, *i.e.*, late Holocene–Recent (Tonni *et al.*, 2001; Aguirre *et al.*, 2011). It inhabits subtropical and temperate areas of the center and north of the country (Aguirre *et al.*, 2011; Miquel and Aguirre, 2011). The material presented in this work is the oldest record of the genus in Argentina.

The genus *Succinea* is distributed worldwide and its stratigraphic range extends from the Paleocene to the Recent. It was mentioned by Doering (1884, p. 22) from the “Tertiary” of Argentina, but so far, the oldest record of the genus in the country is from the late Pliocene–early Pleistocene (Ensenadan SALMA; Frenguelli, 1957). The new record from the Aisol Formation deposits is the oldest accurate record of the genus for Argentina.

The fossil record of the Orthalicoidea is scarce. In South America, the oldest record of the family comes from the Paleocene Itaborai Basin (Maury, 1935; Salvador and de Simone, 2013). In Argentina, the oldest record of the family Bulimulidae is from the Eocene Casamayor and Musters formations in Chubut Province (Parodiz, 1969; Miquel and Bellosi, 2010). Another Eocene record is from La Pampa Province (Genise *et al.*, 2010). In the Santa María Valley (Tu-

cumán Province), *Bulimulus* sp. was recorded from the San José Formation (late Miocene–Pliocene; Bossi and Palma, 1982; Morton, 2000). The genus *Bostryx sensu lato* is a ground-dwelling gastropod that inhabits leaf litter or shrubs in the Neotropical Region of South America (Venezuela, northern Argentina, Bolivia, Chile, Peru, and Ecuador) (Breure, 1979). Recent analyses revealed that this genus may be polyphyletic, with its species placed into two of the three subfamilies: some species of *Bostryx sensu lato* (Breure, 1979) are included in Bulimulinae while the rest of the species (*Bostryx sensu stricto*) are grouped together in the subfamily Bostrycinae (Breure and Romero, 2012). The materials here presented have no particular synapomorphies enabling identification at a specific level. Thus they are assigned to *Bostryx sensu lato*. In Argentina, this genus lives in central and tropical areas (Miquel, 1993, 1995).

The current distribution of *Radiodiscus* is from Tierra del Fuego Province (Argentina) to the United States of America (Pilsbry, 1948). The oldest accurate record of *Radiodiscus* in Argentina is *Radiodiscus* sp. aff. *R. magellanicus* (Smith, 1881) from the Eocene of Chubut Province (Miquel and Bellosi, 2010). The new material represents the first record of *Radiodiscus* in the early Pliocene and the first record of a fossil species of this genus in Mendoza Province.

The poor lateral development and thickness of the channel deposits, their scarce representation in the sequence, and the dominant gravel composition suggest that they were generated by poorly developed ephemeral fluvial systems. The presence of numerous macroscopic rhizocretions *s.s.*, and the petrographic observation of floating texture, paedotubules, holes and vacuities filled with carbonates, rhizoliths, and the micritic cement, are evidences of the development of paedocal type paleosols, characterized by high levels of carbonate accumulation (Wright and Tucker, 1991). This type of soils is usually formed under arid and semiarid climate conditions, in zones with grass or bushy vegetation (Alonso-Zarza, 1999). This agrees with the evidence of root traces and the microvertebrate fossil ensemble characteristic of arid and semiarid regions (Turazzini, 2013). In this context, the presence of a terrestrial gastropod community seems rare, but the extant related taxa of this fossil association inhabit a wide spectrum of environments. *Bostryx* lives usually on the ground in leaf litter, in shrubs, and on rock-faces, and its vertical distribution is 0–3600 m (Breure, 1979). *Gastrocopta* may be found

in microhabitats of moderate and low humidity all over the country (except Patagonia). *Succinea* and *Radiodiscus* prefer areas of middle to high humidity, with species in cold, temperate and tropical climates inhabiting diverse environments (Miquel and Aguirre, 2011). The gastropods found in the middle section of the Aisol Formation may have acted as opportunistic invaders, colonizing water-saturated soils right after sporadic flooding episodes, and finding refuge under the shade of spiny shrubs and grass vegetation when the general climate conditions of the region were rather dry.

## CONCLUSIONS

We report the occurrence of a fossil terrestrial pulmonate gastropod fauna from the early Pliocene of Mendoza Province. The specimens present in this ensemble constitute the first fossil record of the genus *Bostryx* in Mendoza Province, the most ancient record of *Gastrocopta* and *Succinea* in Argentina, and the first record of the family Charopidae (represented by *R. sanrafaelensis* nov. sp.) in the early Pliocene of Argentina. Regardless of the geological evidence and the microvertebrate ensemble that suggest arid to semiarid environmental conditions, the presence of this terrestrial gastropod community indicates that –at least sporadically– there were flooding episodes or water-saturated soils that favoured the occurrence of these humidsoil-dependant organisms.

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