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Redescription of *Mactra bonariensis* Philippi, 1893 and designation of a neotype

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During an ongoing revision of the Paraná Formation fauna of Argentina, the taxonomic status of *Mactra bonariensis* Philippi, 1893, was reassessed. The morphological characters of *M. bonariensis* provided in the original description and illustration do not allow clear delimitation of the species. The absence of type material of this species, coupled with difficulties in resampling the type locality due to urbanization, necessitates designation of a neotype. No records of this taxon were found in palaeontological and malacological collections. However, material collected from the Paraná Formation at 'La Juanita' (Entre Ríos, Argentina) comes from beds equivalent to those exposed at the locality from which Philippi described the original material. As this species may be confused with Quaternary and extant species from the region, a redescription is provided and a neotype designated.

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Key words: *Mactra*, taxonomy, morphology, Miocene, Entre Ríos, bivalves.

ANALYSIS of the Cenozoic molluscan faunas of Entre Ríos province has provided significant information about the palaeogeographic evolution of the region. The marine deposits of the Paraná Formation have been described under various names during the 20th century, e.g., the 'Entrerriense–Rionegrense,' 'Mesopotamiense,' 'Entre Ríos' and 'Entrerriana' formations. The age of these deposits has been intensively debated over the years. It has been regarded as middle Miocene (Aceñolaza 2000, Aceñolaza & Aceñolaza 2000, del Río 2000) or late Miocene (Camacho 1967b, Zabert 1978, Cione *et al.* 2000).

The earliest scientific accounts of the Entre Ríos area were carried out by d'Orbigny (1839, 1842) after his visit in 1827. During this visit he collected fossil

material at the locality then known as Bajada Grande (presently the city of Paraná). Charles Darwin, in 1833, collected marine fossils at the same locality, but he did not describe new species from the area and only made some geological observations on the basis of d'Orbigny's previous descriptions (Darwin 1846). Subsequent authors outlined the geology and palaeontology of Entre Ríos province in more detail (Bravard 1858, Philippi 1893, Borchert 1901, Ameghino 1906, Ihering 1907, Frenguelli 1920, 1947, Kantor 1925, Cordini 1949, Camacho 1967a, Yrigoyen 1969, Iriondo 1973, Aceñolaza 1976, 2000, 2004, Aceñolaza & Sayago 1980, del Río 1990, 1991, del Río & Martínez Chiappara 1998, Aceñolaza & Aceñolaza 2000, Cione *et al.* 2000, Muravchik *et al.* 2004, Pérez *et al.* 2010).

The cosmopolitan family Mactridae Lamarck, 1809 (Bivalvia: Heterodonta) is well

represented in modern South American seas. *Macra* Linnaeus, 1767 was recorded in the southwestern Atlantic Ocean by d'Orbigny (1846), when describing the fauna he collected during his '*Voyage dans l'Amérique Meridionale.*' He described four species, two of them from the Uruguayan coast (Maldonado bay) and two from the Argentinean coast (Río Negro province).

An ongoing revision of the Paraná Formation fauna revealed that a species of *Macra* was present in deposits referred to the Paraná Formation, a richly fossiliferous unit exposed along the eastern bank of the Paraná River in the Province of Entre Ríos. Assessment of the taxonomic status of this species suggested its inclusion in *Macra bonariensis* Philippi, 1893. However, a search for type material of this species was unsuccessful. Identification of the species of *Macra* collected in the Paraná Formation is difficult if based on Philippi's brief description and inadequate illustrations. The material could potentially be mistaken for other species of

Macra living presently along the coast of the South Atlantic adjacent to the mouth of the Río de la Plata. Exhaustive collecting at many localities of the Paraná Formation yielded only the specimens described herein, and it appears that this is the only species of the genus represented in this lithostratigraphic unit. Therefore, a re-description of this taxon and designation of a neotype will prevent taxonomic confusion of this species with any extant species, some of which have Quaternary representatives appearing in localities nowadays exposed upstream along the Paraná River, not far from the areas in which the Miocene unit is exposed.

The locality known as 'La Juanita' is very close to Aldea Brasileira in Diamante department (Entre Ríos province). Eight metres of the Paraná Formation are exposed at this locality along the lower part of the riverbank (Fig. 1A). The section begins alternating white to yellowish sands and green siltstones, strongly bioturbated by *Ophiomorpha* isp. separated by an erosional surface

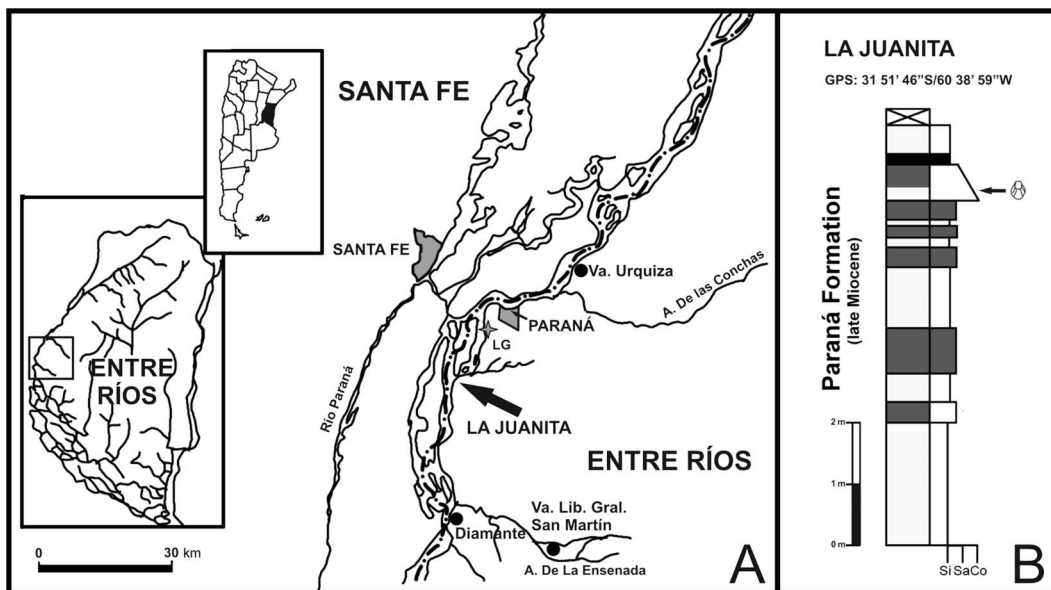


Fig. 1. A, Map of the study area showing the neotype locality of *Macra bonariensis* Philippi, 1893 'La Juanita' and 'Los Galpones' (LG locality). B, Geological section of the Paraná Formation at 'La Juanita'; the abbreviations are Si (siltstone) and Co (conglomerate); the arrow indicates the fossiliferous level (modified from Cione *et al.* 2008).

from the overlying shell bed. This shell bed is *ca* 50 cm thick (Fig. 1B, indicated by the arrow), with a lenticular geometry *ca* 100 m long. From a lower part rich in shells, the bed grades upwards into an almost exclusively sandy fraction at the top. Towards the middle part, the sandy matrix grains are strongly cemented by carbonate. Identified shells include *Erodona*, *Polymesoda*, *Mytilopsis*, *Chionopsis*, *Anadara* and *Maetra*. These taxa are associated with a rich fauna of other non-identified invertebrates and vertebrates. The base of the section is usually covered by debris fallen from the adjoining cliff, or else by the river during floods; the top is concealed by vegetation (Fig. 1B).

Material and methods

Following Stanley (1970), valve measurements were taken with a digital caliper (see Table 1). Dimensions are in millimetres. Abbreviations used are L=length; H=height; W=width. Specimens were examined under direct light with a hand lens and digital images were taken with a Nikon D100 camera with a 60 mm Nikkor macro lens. All the material comes from the same locality and level at the 'La Juanita' quarry (Cione *et al.* 2008) (31°52'46"S;

60°38'59"W). Examined materials are deposited in the following collections: Centro de Investigaciones Científicas y de Transferencia Tecnológica a la Producción (CICYTTP) CONICET, Diamante, Entre Ríos (DMT); Museo Argentino de Ciencias Naturales 'Bernardino Rivadavia' (MACN); Museo de Ciencias Naturales y Antropológicas 'Prof. Antonio Serrano,' Paraná, Entre Ríos (MAS); The Natural History Museum, London (NHMUK); Museo de La Plata (MLP); Museo Nacional de Historia Natural, Santiago, Chile (MNHNC).

Systematic palaeontology

Superfamily MACTROIDEA Lamarck, 1809

Family MACTRIDAE Lamarck, 1809

Maetra Linnaeus, 1767 [= *Trigonella* Da Costa, 1778, subsequent designation by Winckworth (1929); *Deikea* Mayer Eymar, 1872; *Colorimaetra* Iredale, 1929; *Telemacra* Iredale, 1929]

Type species. *Cardium stultorum* Linnaeus, 1758 [subsequent designation by Fleming (1818, p. 309)].

	Specimen number	L (mm)	H (mm)	W/2 (mm)
Neotype	MAS-Pi 067 (Rv)	25.53	19.25	7.16
Additional material	MAS-Pi 055 (Rv)	18.66	13.51	4.07
	MAS-Pi 068 (Rv)	18.53	13.53	4.47
	MAS-Pi 030 (Lv)	17.93	13.81	4.63
	MAS-Pi 033 (Lv)	22.37	16.76	5.21
	MAS-Pi 039 (Lv)	16.99	12.65	3.45
	DMT-Pi 027 (Rv)	14.43	11.35	3.35
	DMT-Pi 032 (Rv)	15.27	11.51	3.13
	DMT-Pi 037 (Rv)	14.04	10.76	2.96
	DMT-Pi 012 (Lv)	18.01	14.09	4.18
	DMT-Pi 013 (Lv)	23.84	18.09	6.42
	DMT-Pi 015 (Lv)	17.95	13.74	4.47

Table 1. Measurements of the new specimens of *Maetra bonariensis*.

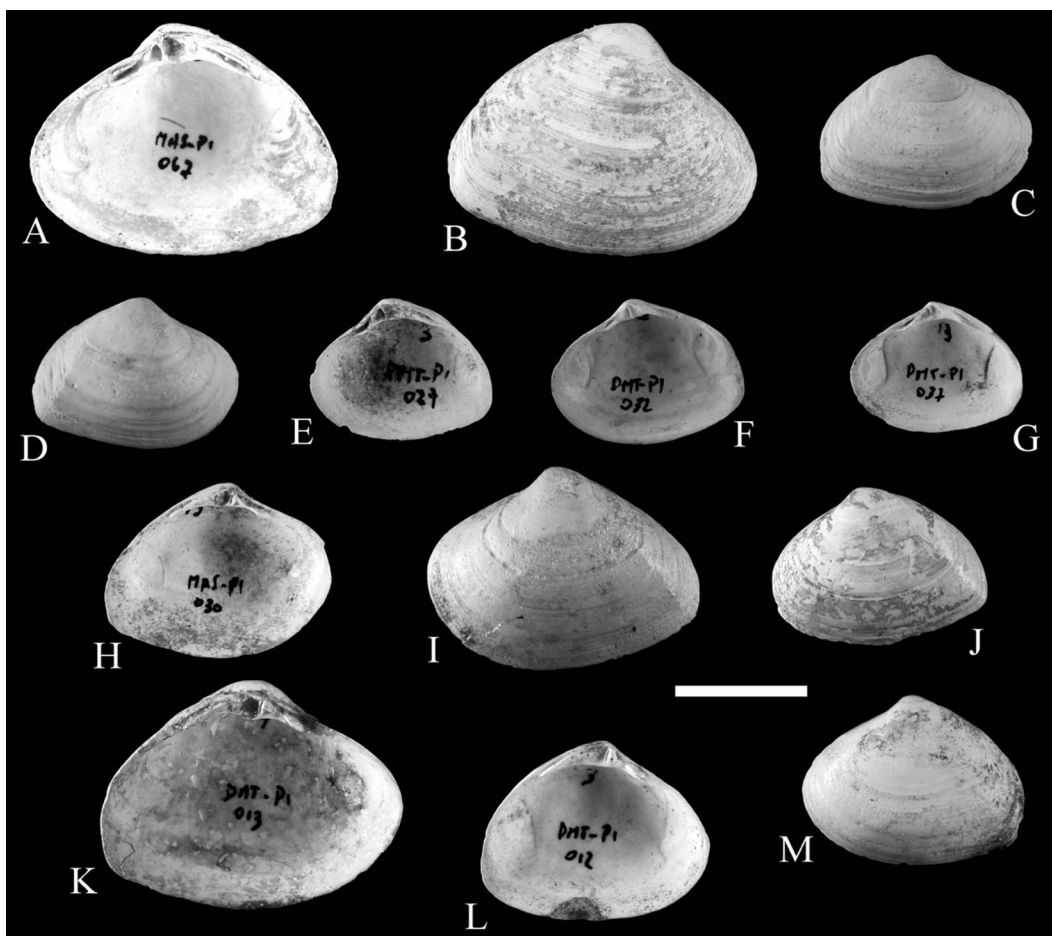


Fig. 2. *Mactra bonariensis*. A–B [neotype, MAS-Pi 067]; C [MAS-Pi 055]; D [MAS-Pi 068]; E [DMT-Pi 027]; F [DMT-Pi 032]; G [DMT-Pi 037] are right valves and H [MAS-Pi 030]; I [MAS-Pi 033]; J [MAS-Pi 039]; L [DMT-Pi 012]; K [DMT-Pi 013]; M [DMT-Pi 015] are left valves. Scale bar=10 mm.

***Mactra bonariensis* Philippi, 1893 (Fig. 2A–M)**

1893 *Mactra bonariensis* Philippi, p. 8, pl. 1, fig. 5.

1998 *Mactra (Mactra) janeiroensis* Smith, 1915; del Río & Martínez Chiappara, pp. 68–69, pl. 13, figs 13–15 [non *Mactra (Mactra) janeiroensis* Smith, 1915].

Diagnosis. Shell trigonal, elliptical, medium sized (up to 26 mm long), anterior and posterior end rounded and low; ventral margin curved to straight in the posterior part; external surface smooth with dorso-

posterior area defined by a very weak keel running from the umbo to the posterior ventral end; pallial sinus short, horizontal and rounded; muscle scars subcircular and equal in size and shape; right hinge with two elongate and fragile posterior lateral teeth, anterior lateral teeth short and close to the free cardinal tooth; left hinge with the V-shaped cardinal tooth flanked by a shelly lamella on the posterior side.

Description. Shell trigonal, elliptical, sub-equilateral, strong, averaging about 20 mm long and 15 mm high; clearly prosogyrous

umbos, inflated, not in contact; external surface smooth with irregular growth lines from umbo to ventral margin; posterior dorsal margin curved, delimited by a weak keel running from umbo to posterior ventral end and defining a slightly convex area; anterior dorsal margin not curved and weakly defined on shell surface; radial or concentric ornamentation poorly developed; anterior and posterior ends rounded; ventral margin convex to straight in the posterior part; right valve hinge with two cardinal teeth (3a and 3b), small and fragile; two anterior parallel lateral teeth (AI and AIII) very close to cardinals; AI and AIII elongate and similar in size and shape; two posterior lateral teeth (PI and PIII), more elongate than the anterior laterals; left valve with typical V-shaped cardinal tooth composed of two divergent simple cardinal teeth (2a, 2b); accessory lamella (4b) flanking cardinal tooth on posterior side; one anterior (AII) and one posterior (PII) lateral tooth; chondrophore well developed ventrally, triangular, placed at posterior side of cardinal teeth; external ligament groove rudimentary; pallial sinus deep, horizontal and rounded, about one-third of shell length (Fig. 2A–B).

Type material. Specimen MAS-Pi 067 (a right valve) is herein designated neotype of *Mactra bonariensis* Philippi, 1893, according to ICZN (1999, Article 75).

Neotype justification. Material belonging to *Mactra* and collected from the Paraná Formation has been referred to two different species. *Mactra bonariensis* Philippi, 1893 (pp. 8–9, pl. 1, fig. 5), was collected by Bravard from ‘La Bajada’ (an unidentified location presently within the limits of the city of Paraná). The available material to Philippi, and upon which he based the taxon, is currently missing from the collections, as revealed by exhaustive searches of the MACN and the Philippi Collection housed

in the MNHM, Santiago. Borchert (1901, p. 210, pl. 8, fig. 28) described and illustrated a specimen he called *Mactra patagonica* d’Orbigny, 1846. This is an extant species living along the coast between Río Negro and San Blas. Borchert included *Mactra bonariensis* Philippi, 1893, as a synonym of *Mactra patagonica*. The material upon which he based his description could not be located in the MACN, despite the fact that other specimens described by him are present in these collections. *Mactra patagonica* d’Orbigny *sensu* Borchert is, however, a different species and can not be identified with *Mactra bonariensis*. It appears to be different also from *Mactra patagonica* d’Orbigny, a fact that only further research may help to elucidate. According to Borchert, his (rare) specimens came from Paraná (Paraná Stufe). Careful collection at many outcrops of this unit in Entre Ríos yielded only the specimens described herein and no material clearly referable to *Mactra patagonica* d’Orbigny *sensu* Borchert was recovered. It must be noted, however, that the original localities now lie under urbanized areas. Thus, further collection at the type locality of *Mactra bonariensis* or at the locality from which Borchert’s specimens came seems, at least, unlikely. Philippi’s specimens seem to have been poorly preserved and the drawings he provided are inadequate for clear identification. In addition, the hinges were not illustrated. Nevertheless, the overall shape and sizes of the shells agree with our material. In order to avoid confusion with either *Mactra patagonica* d’Orbigny or *Mactra patagonica* d’Orbigny *sensu* Borchert, we deem it necessary to fix the name *Mactra bonariensis* and thus to designate a neotype.

Additional material. MLP-Pi 1819 (Frenquelli Collection), ‘Los Galpones,’ six right valves and three left valves; MAS-Pi 055, MAS-Pi 068, DMT-Pi 027, DMT-Pi 032, DMT-Pi 037, five right valves, and MAS-Pi 030, MAS-Pi 033, MAS-Pi 039, DMT-Pi

012, DMT-Pi 013, DMT-Pi 015, six left valves, all from 'La Juanita.'

Type locality. 'La Juanita' (31°52'46"S; 60°38'59"W), Entre Rios. The neotype comes from a level of conglomerates and coarse sand within the Paraná Formation (late Miocene), lying 6 m above the base of the stratigraphic column at the river water-line.

Occurrence. All other specimens were collected at 'La Juanita' and 'Los Galpones' (see Fig. 1A, 'LG'), Paraná Formation.

Remarks. The material upon which *Mactra bonariensis* Philippi, 1893 (pp. 8–9, pl. 1, fig. 5) was based, was collected at Paraná by Bravard and sent to Philippi by Burmeister. The right valve described and illustrated by Philippi (Fig. 3D) was not located in the collections at the Museo Nacional de Historia Natural in Santiago (Chile), de-

spite the exhaustive search carried out. According to Philippi (1893), this specimen was contained within a ferruginous matrix and it could be distinguished by the very thin shell, orthogyrous umbo and very prominent, rounded posterior margin lower than the anterior one, and also by carina marked only near the umbo (cf. Philippi 1893). *Mactra bonariensis* was only mentioned by Ihering (1897) in a list of species from Entre Rios province. Later, Borchert (1901, p. 210, pl. 8, figs 27, 28), identified a specimen from the Paraná Formation (*sensu* Bravard) as *M. patagonica* d'Orbigny, 1846 (p. 509, pl. 77, figs 27, 28) (Fig. 3E). At the same time he stated that *M. bonariensis* Philippi was a synonym of *M. patagonica*. However, Ameghino (1902, p. 243) pointed out that the material sent to Steinmann in Freiburg, and described by Borchert, included several cabinets. According to Ameghino, part of them came from the Paraná Formation and part

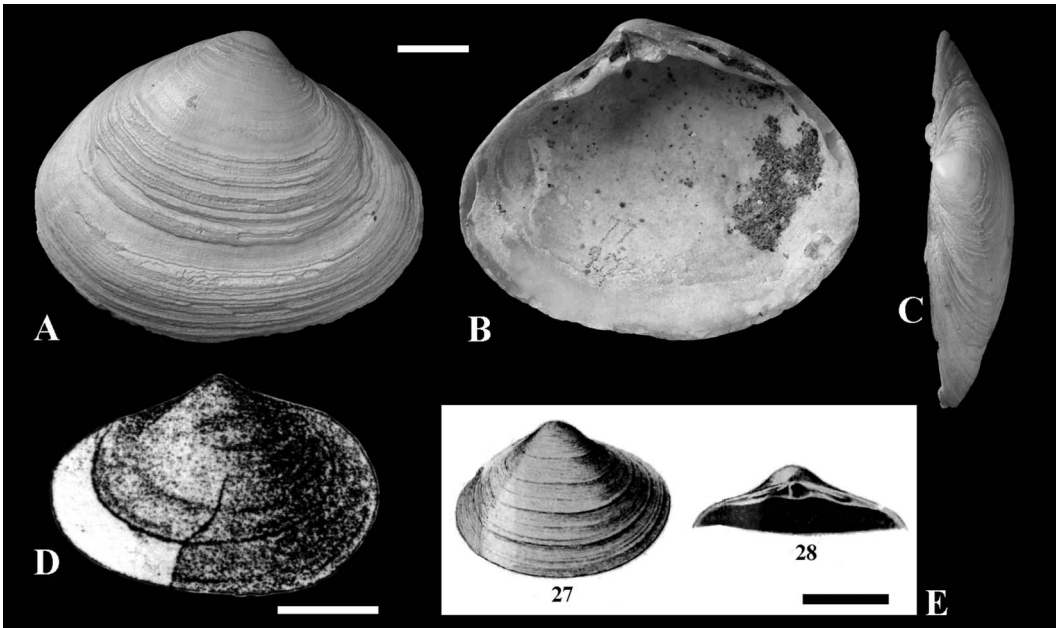


Fig. 3. A–C, *Mactra patagonica* d'Orbigny, 1846. [Holotype, NHMUK 1854.12.4.668]; D, original illustration of *Mactra bonariensis* Philippi, 1893; E, original illustration of *Mactra patagonica* Borchert (*non* d'Orbigny, 1846). Scale bar=10 mm.

from younger geologic deposits, as a consequence of misplacement of the material during the years in which no curator was in charge at the Museo Nacional in Buenos Aires. Ihering (1907) reviewed the material and recognized differences between *M. bonariensis* and *M. patagonica* stressing that the first had a thinner shell and a well-marked thin sharp line running from the umbo towards the posterior end, a higher and more inflated umbo, and the posterior end of the valve in a more ventral position. Ihering (1907) mentioned *M. bonariensis* as a valid species and *M. patagonica* Borchert, 1901 (*non* d'Orbigny 1846) as its synonym. However, after analyzing the original artwork, we concluded that the morphological characters illustrated by Borchert (1901) are very different from those reported by Philippi (1893). Ihering (1914, p. 59) indicated the existence of cotypes of *Mactra bonariensis* from the Bravard Collection. The only specimens referred to this species from the Paraná Formation in the Ihering Collection include the poorly preserved specimens collectively numbered MACN-Pi 493, which have a very damaged condition. However,

none of them is the specimen illustrated by Philippi.

Several publications have mentioned *Mactra bonariensis*, but none has included new material or illustrations (Ihering 1907, del Río 1990, 1991, del Río & Martínez Chiappara, 1998). In all cases the authors reproduced the rudimentary original illustration of Philippi (1893, p. 8, pl. 1, fig. 5). De Medina (1962) mentioned *Mactra bonariensis* specimens collected from a drill core in Chuy, Uruguay. After analysis of the illustration (De Medina, 1962, p. 209, figs 11, 12), we conclude that the specimens should be assigned to *Mactra isabelleana* d'Orbigny, 1846 (Fig. 4A, B).

The specimens collected at 'La Juanita,' including the neotype, differ morphologically from *Mactra patagonica* d'Orbigny, 1846 (Fig. 3A–C) in being less strong, larger and lacking a postumbonal keel defined by a line on the external surface. Del Río & Martínez Chiappara (1998) misidentified specimens of *M. bonariensis* as *Mactra (Mactra) janeiroensis* (MLP-Pi 1819). The typical concentric ornamentation of the external surface in Smith's species is not

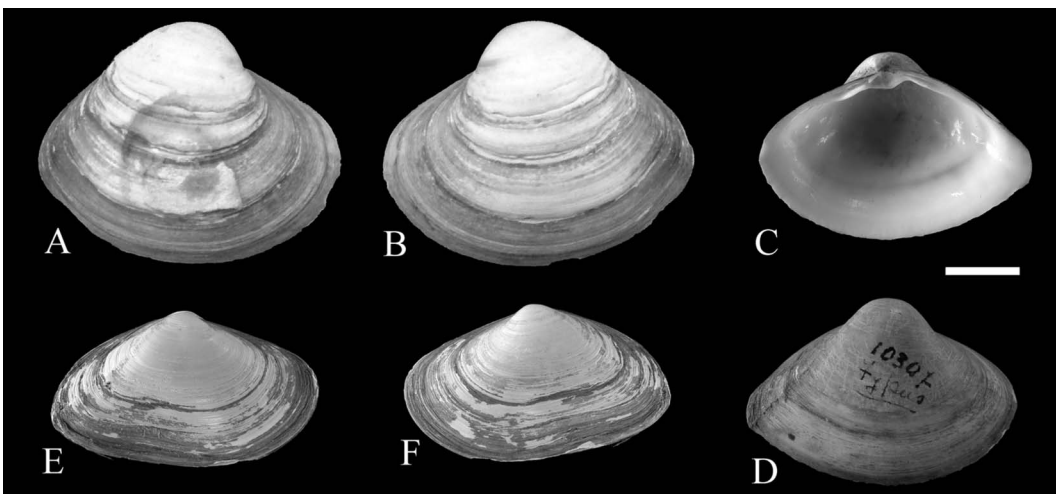


Fig. 4. Recent mactrids from the southwestern Atlantic. A–B, *Mactra isabelleana* d'Orbigny, 1846 [Lectotype, NHMUK Reg. No. 1854.12.4.667/1]; C–D, *Mactra marplatensis* Doello Jurado, 1949 [Holotype, MACN-IN 10307]; E–F, *Mactra guidoi* Signorelli & Scarabino, 2010 [Holotype, MNHNM 15526]. Scale bar=10 mm.

evident in the specimens collected at 'Los Galpones' (MLP-Pi 1819). The neotype of *M. bonariensis* also differs from other Cenozoic mastrids recorded from Patagonia. *Mactra garretti* Ortmann, 1902 (p. 150, pl. 29, fig. 9a–d) is known from the early Miocene Monte León Formation. It is undoubtedly more circular and the ventral margin is completely rounded. Also from the Monte León Formation, *Mactra darwinii* Sowerby, 1846 (p. 249, pl. 2, fig. 9) and *Mactra indistincta* Ihering, 1897 (p. 262, fig. 3), are presently considered to be *nomina dubia* (Signorelli, 2010). The type material of these two species is missing and additional material was not found at the type localities. However, the original illustrations suggest that both species differ from *Mactra bonariensis* in the external morphology of the shell. *Mactra darwinii* is more clearly circular and also more fragile. *Mactra indistincta* is more elongate with prominent orthogyrous umbones. *Mactra steinmanni* (Ihering, 1909, p. 36), recorded from the Eocene Rio Turbio Formation, Santa Cruz province, is very elongate, oval and compressed when compared with *M. bonariensis*. *Mactra longa* (del Río, 1994, p. 108, pl. 1, figs 1, 2) was collected in the purportedly late Miocene Puerto Madryn Formation. The shell in this species is thinner, more fragile, with a deeper pallial sinus, and the hinge carries more elongated lateral teeth.

Mactra bonariensis shows morphological differences to the three extant species inhabiting the region. The shell of *Mactra isabelleana* d'Orbigny, 1846 is more trigonal, stronger and the line that defines the posterior area is not evident (Fig. 4A, B). The sinuous ventral margin and the very elongate shell of *Mactra guidoi* Signorelli & Scarabino, 2010 (p. 34, figs 13–24) are two characters that permit the recent and fossil forms to be distinguished (Fig. 4E, F). Finally, the posterior and prominent keel of *Mactra marplatensis* Doello-Jurado, 1949 (p. 4, fig. 3) and its trigonal shell with sharp

anterior and posterior ends, clearly separate this species from *M. bonariensis* (Fig. 4C, D).

Designation of the neotype stabilizes *Mactra bonariensis* Philippi, 1893 as the only species of this genus known to occur in the late Miocene of the Paraná Formation.

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