

A new species of *Coelastarte* (Astartidae; Bivalvia) from the Early Jurassic of Chile and unusual ornamentation in eastern Pacific Jurassic bivalves

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Abstract. *Coelastarte fuersichi* (Bivalvia; Astartidae) is here described as a new, endemic species from the Early Jurassic (Pliensbachian) of northern Chile. Taphonomic evidence suggests that *C. fuersichi* was a shallow infaunal burrower with the posterior end directed upwards and projecting above the sea-floor. Its conspicuous tuberculate ornament, unique among Jurassic astartids, is thought to be adaptive in stabilising the specimen in a coarse-grained, shifting substrate. Carinate pteriods provide further examples of unusual ornamentation in Early Jurassic eastern Pacific bivalves. Possibly, high nutrient levels due to upwelling were an important factor by supplying the extra energy needed for the secretion of additional shell ornament.

■ *Mollusca, Bivalvia, Astartidae, new species, palaeoecology, Lower Jurassic, northern Chile, Southamerica*

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Introduction

The abundant and diverse Early Jurassic bivalve fauna from northern Chile is an important component in the analyses of the biodiversity and biogeography of Jurassic macrobenthos at variable scales. While most of the major bivalve clades were recently documented monographically (ABERHAN 1994, 2004, PÉREZ et al. in press), a thorough treatment of the subclass Heterodonta is still missing. Here I describe a new, endemic species of the astartid bivalve genus *Coelastarte*, which is characterised by an unusual, tuberculate ornament. Palaeoecological aspects are discussed, which also include the appearance of unusual ornamentation in other Early Jurassic bivalves

from the eastern Pacific margin. The studied material was collected by AXEL VON HILLEBRANDT in 1966 and is deposited in the Museum für Naturkunde, Humboldt-University, Berlin (MB.M.). Original field numbers are provided in the explanation of Plate 1. The specimens were prepared mechanically and coated with magnesium oxide prior to taking photographs. In the measurements, the following abbreviations are used: H = height; L = length; W = width (of single valve; in articulated specimens the total width is divided by 2); rv = right valve; 2v = double-valved; [] = estimated value. The notation of hinge teeth follows GARDNER & CAMPBELL (2002a).

Taxonomy

Class **Bivalvia** LINNÉ, 1758

Subclass **Heterodonta** NEUMAYR, 1884

Order **Veneroida** ADAMS & ADAMS, 1856

Superfamily **Crassatelloidea** FERUSSAC, 1822

Family **Astartidae** D'ORBIGNY, 1844

Subfamily **Astartinae** D'ORBIGNY, 1844

Genus *Coelastarte* BÖHM, 1893

Type species. *Astarte excavata* J. SOWERBY, 1819, Middle Jurassic (Bajocian), Great Britain.

Remarks. *Coelastarte* BÖHM was previously considered as a subgenus of *Neocrassina* (e.g. CHAVAN 1969). Following the opinions of FÜRSICH et al. (2000) and GARDNER & CAMPBELL (2002b), *Coelastarte* is classed as a separate genus herein.

Coelastarte fuersichi sp. nov.

Pl. 1, text-fig. 1

- 1981 Astartidae gen. et sp. indet – HILLEBRANDT & SCHMIDT-EFFING: 10.
 1992 Astartidae gen. et sp. nov. – ABERHAN: 152f.

Derivation of name. After FRANZ THEODOR FÜRSICH, in recognition of his outstanding contributions to the taxonomy and palaeoecology of Jurassic bivalves.

Type material. Holotype: Articulated specimen MB.M.5178.1, figured in Pl. 1, Fig. 5. Paratypes. MB.M.5178.2 (right valve, Pl. 1, Fig. 4), MB.M.5179.1 (right valve, Pl. 1, Fig. 2), MB.M.5179.2 (articulated specimen, Pl. 1, Fig. 6), MB.M.5179.3 (left valve, Pl. 1, Fig. 1), MB.M.5179.4 (left valve, Pl. 1, Fig. 3).

Type locality. All type specimens are from Quebrada Asientos, east of Potrerillos, northern Chile. The holotype, and paratype MB.M.5178.2 are from section 7 in HILLEBRANDT & SCHMIDT-EFFING (1981: 8-10, fig. 2) (26°27'S; 69°20'W). Paratypes MB.M.5179.1 to 5179.4 are from section 6 in HILLEBRANDT & SCHMIDT-EFFING (1981: 8-10, fig. 2).

Type horizon. The holotype is from a laterally extensive, ca. 50 cm thick, fossiliferous, bioturbated, sandy to conglomeratic packstone with bivalves, brachiopods, corals, gastropods and ammonoids (horizon 1 in HILLEBRANDT & SCHMIDT-EFFING 1981: 9, fig. 3); Pliensbachian (*Fanninocers fannini* Zone).

Additional material. 2 articulated specimens, 1 right valve and 1 left valve (MB.M.5178.3-6) from Quebrada Asientos, section 7 (HILLEBRANDT & SCHMIDT-EFFING 1981: fig. 2). 1 left valve and 1 right valve (MB.M.5179.5-6) from Quebrada Asientos, section 6 (HILLEBRANDT & SCHMIDT-EFFING 1981: fig. 2). 2 articulated specimens and 1 left valve (MB.M.5180.1-3) from Quebrada Asientos, section 3 (HILLEBRANDT & SCHMIDT-EFFING 1981: fig. 2). 1 left valve (MB.M.5181) from Quebrada Asientos, section 2 (ABERHAN 1992: fig. 3). All specimens, including the type specimens, are recrystallised. All material is from the Pliensbachian (*Fanninocers fannini* Zone).

Measurements (in mm).

Specimen	valve	H	L	W	L/H	L/W
Holotype						
MB.M.5178.1	2v	38.1	50.9	9.5	1.34	5.36
Paratype						
MB.M.5179.2	2v	40.2	56.5	10.5	1.41	5.38
Additional material						
MB.M.5178.3	2v	47.8	66.9	14.2	1.40	4.71
MB.M.5180.1	2v	38.7	59.6	[12]	1.54	[4.97]
MB.M.5180.2	2v	-	66.5	11.4	-	5.83
MB.M.5179.5	rv	50.1	66.3	[13]	1.32	[5.10]

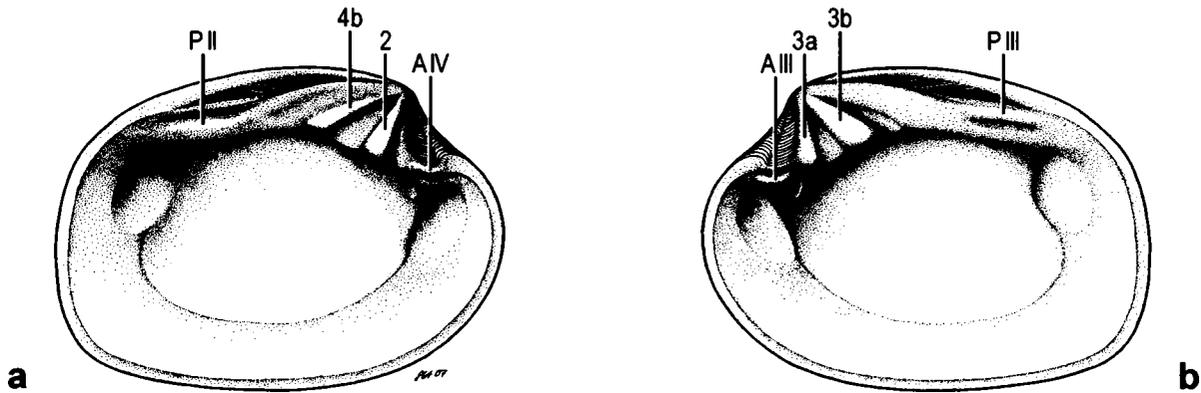
Diagnosis. Subtrapezoidal *Coelastarte* with surface ornament consisting of commarginal costae and variously arranged rows of tubercles.

Description. Shell medium-sized for the genus, thick-shelled, transversely subtrapezoidal in outline with length considerably exceeding height. Beaks small, pointed, not projecting above cardinal area, situated at about one-fifth of shell length from the anterior end. Umbones broad, prosogyrous. Inflation low (average L/W = 5.2). Antero-dorsal margin moderately concave, anterior margin well rounded, all other margins gently convex; postero-dorsal margin weakly projecting above umbo and running subparallel to ventral margin; posterior margin slightly truncated, oblique, merging with the postero-dorsal margin. Lunule and escutcheon well defined. Lunule elongated cordate, with deep concave depression, bordered by sharp crest. Escutcheon elongate, about two-thirds the width of the lunule, with deep wedge-shaped depression, smooth or with well defined growth lines, bordered by sharp escutcheon crest.

Postero-umbonal ridge broad, poorly defined, extending from umbo to postero-ventral corner of shell. Surface ornamentation consisting of evenly spaced, rounded commarginal costae obscured to various degrees by the development of irregular tubercles. Tubercles subcircular to transversely elongated; arranged (sub-) parallel to growth lines, or oblique and curved (Pl. 1, Fig. 1b), or indistinctly chevron-like (umbonal and central part of specimen figured in Pl. 1, Fig. 2a). Tuberculate ornament stronger on shell flank as compared with postero-dorsal area.

Adductor scars moderately large. Anterior adductor scar subovate, strongly deepening postero-dorsally, markedly impressed in ventral slope of hinge plate. Posterior adductor scar subquadrate, of roughly the same size as anterior adductor scar, but only moderately deepening antero-dorsally. Anterior pedal retractor scar subcircular, very well defined, placed immediately posterior to adductor scar, deeply impressed in ventral slope of hinge plate. Pallial line integripalliate, forming a shallow groove in anterior half of shell. Fine crenulations along internal side of anterior margin observed in one specimen only (Pl. 1, Fig. 4b).

Hinge plate thick. Hinge of left valve (Text-fig. 1a) with straight, narrow, prominent anterior cardinal tooth



Text-fig. 1. Reconstruction of *Coelastarte fuersichi* sp. nov.; a. Interior view of left valve. b. Interior view of right valve. Approximately x1.

(2); posterior cardinal tooth (4b) elongate, moderately thick, low; posterior lateral tooth (P II) coinciding with postero-ventral margin of hinge plate; anterior lateral tooth (A IV) short, located along antero-dorsal margin below lunule. Nymph moderately elongate, broad. Hinge of right valve (Text-fig. 1b) with strong, prominent, elongated subtrigonal posterior cardinal tooth (3b); anterior cardinal tooth (3a) narrow; posterior lateral tooth (P III) moderately thick, positioned in prolongation of nymph; anterior lateral tooth (A III) short, thick, positioned along ventral edge of anterior hinge area.

Comparisons. *Coelastarte fuersichi* is distinguished from all other known species of *Coelastarte* by the presence of a tuberculate ornament. The type specimen of *C. excavata* (J. SOWERBY 1821: 57, pl. 233), the type species of the genus, is shorter relative to shell height, and has a more anteriorly situated umbo and a more convex postero-dorsal margin. While these features are also evident in subsequent figures of *C. excavata* (e.g. MORRIS & LYCETT 1853: 85, pl. 9, figs. 18-19, PHILLIPS 1871: 165, pl. 9, fig. 7, DOUVILLÉ 1916: 50, pl. 6, fig. 5), other authors illustrated specimens of this species which correspond

quite well in shape with *C. fuersichi* (e.g. BOEHM 1883: 169, pl. 8, figs. 1-3, BENECKE 1898: 31, pl. 5, fig. 3, 1905: 225, pl. 16, fig. 17), including also specimens of *C. excavata* from the early Middle Jurassic of Argentina (GOTTSCHÉ 1878: 30, pl. 7, figs. 9a-c). A good agreement in shape also exists with *Coelastarte planoexcavata* RICHE (1904: 147, pl. 4, fig. 9) and its junior synonym *Coelastarte praelonga* ROLLIER (1912: 103, pl. 8, fig. 4) from the Middle Jurassic of Europe and India. However, all these specimens lack the tuberculate ornament typical of *C. fuersichi*. In addition to differences in ornamentation, *Coelastarte jurensis* (TORNQUIST) (DAMBORENEA et al. 1992: pl. 118, fig. 3) from the Bajocian of Argentina is much more elongated ($L/H = 1.8$) than *C. fuersichi* (average $L/H = 1.4$).

Remarks. Of the five available specimens showing interior shell margins, only one specimen is internally crenulated (Pl. 1, Fig. 4b). According to the discussion on fossil Astartinae in GARDNER & CAMPBELL (2000a) this may indicate sexual dimorphism, with the crenulated specimen representing a female, but clearly more material is needed to evaluate this possibility.

Palaeoecology of *Coelastarte fuersichi* and unusual ornamentation in eastern Pacific Jurassic bivalves

All occurrences of *Coelastarte fuersichi* are from sandy to conglomeratic, bioclastic limestones of Pliensbachian age. Despite the existence of suitable Lower Jurassic facies elsewhere in the Andean Basin, the new species is so far only known from the type locality.

As to the life habit, astartid bivalves are usually classi-

fied as shallow infaunal burrowers (STANLEY 1970). The right valve of an articulated specimen is intensely bored over the entire posterior third of the shell, whereas all other specimens lack signs of bioerosion. The borings are attributable to the ichnogenus *Entobia*. The distinct restriction of bioerosion to the posterior part of the shell

suggests that during lifetime the individual was buried in a posterior-up orientation with the posterior region of the shell projecting above the sediment-water interface. Bioerosion is not seen in the corresponding left valve, presumably due to strong silification of the shell.

The tuberculate ornament of *Coelastarte fuersichi* is reminiscent of the ornament of some trioniid bivalves, in particular that of *Quadratojaworskiella pustulata* REYES & PÉREZ (1980: 89, pl. 1, figs. 1-4, pl. 2, figs. 1-4). Interestingly, both endemic taxa co-occur in the same bed and so far are only known from Quebrada Asientos. In trioniid bivalves, the presence of rows of tubercles is interpreted as an adaptive character which served to aid in burrowing. Modelling experiments with robots indicate that the presence of regularly aligned, curved rows of tubercles, as present e.g. in *Myophorella* and *Yaadia*, increases the efficiency of burrowing in fine sand (STANLEY 1978, see also SAVAZZI 1991). However, this effect is not seen in medium sand, and the preference of *C. fuersichi* for coarse-grained sediments renders this functional explanation less likely. Moreover, compared with the highly aligned tuberculate costae of *Myophorella*, the tubercles of *C. fuersichi* are more evenly distributed across the flank. An alternative explanation is that the tuberculate ornament may have served to stabilise the specimen within a coarse, shifting substrate once burrowing had ceased (see also FRANCIS & HALLAM 2003).

Coelastarte fuersichi is the only known Jurassic astartid bivalve with a tuberculate ornament, but the presence of an unusual ornamentation is also evident in other groups of Early Jurassic bivalves along the eastern Pacific margin. A conspicuous example are several members of the bivalve family Bakevelliidae, which have developed distinct carinae on their valves. While *Gervillella araucana* is characterised by a single carina on its left valve, *Gervillaria pallas* exhibits a double carina on the left valve, whereas *Gervillella leesi* possesses a pair of carinae

on both valves (for the geographic and temporal distribution of these species see Table 1). Another Early Jurassic carinate pteroid bivalve is *Gervilleioperna* (*Gervilletia*) *turgida*, which has a double carina in the left valve (see Table 1). The presence of carinae is interpreted to increase adhesion of the valve to the sediment and to stabilise the shell (ABERHAN & MUSTER 1997). The development of additional shell ornament such as tubercles or carinae in genera, whose species otherwise do not show such features, shows that their genetic systems were flexible enough to allow for such modifications. An environmental stimulus to spend energy for the secretion of additional shell ornament may have been high nutrient levels. This is corroborated by palaeoceanographic and paleoclimatic modeling maps, which suggest coastal upwelling, and therefore nutrient-rich surface waters, in subtropical areas along the eastern palaeo-Pacific margin (e.g. PARRISH 1992, GOLONKA et al. 1994). This view is further supported by abundant and widespread occurrences in this region of large-sized Early Jurassic pectinoid bivalves, in particular various species of the genus *Weyla*, which are interpreted to reflect high productivity (ABERHAN et al. 2006).

	<i>Gervillaria pallas</i>	<i>Gervillella araucana</i>	<i>Gervillella leesi</i>	<i>Gervilleioperna turgida</i>
Stikinia	Plb	Sin	Sin	
Quesnellia	Plb			
Cadwallader			Het	
Wrangellia	Plb			
Antim. Terr.		Sin, Plb	Sin, Plb	
N. Chile	Sin, Plb	Sin, Plb		Sin, Plb
Neuquen B.	Plb, Toa	Plb		Plb

Table 1. Distribution of four Early Jurassic carinate pteroid bivalves along the eastern Pacific margin. The areas are roughly arranged from north (top) to south (bottom). For (palaeo-)geographic positions of the western Canadian terranes Cadwallader, Quesnellia, Stikinia and Wrangellia see ABERHAN (1998a, 1999). The Antimonio Terrane (Antim. Terr.) is situated in Sonora, Mexico, and the Neuquen Basin (Neuquen B.) in west-central Argentina. Het = Hettangian; Sin = Sinemurian; Plb = Pliensbachian; Toa = Toarcian. Data based on ABERHAN (1994, 1998b), DAMBORENEA (1987) and FLEISCHER et al. (in press).

EXPLANATION OF PLATE 1

Coelastarte fuersichi sp. nov.; Quebrada Asientos, east of Potrerillos, Pliensbachian, *Fanninoceras fannini* Zone. All specimens x1.

Fig. 1. MB.M.5179.3 (paratype) (HILLEBRANDT 660708/1); left valve. a. Internal view. b. Lateral view.

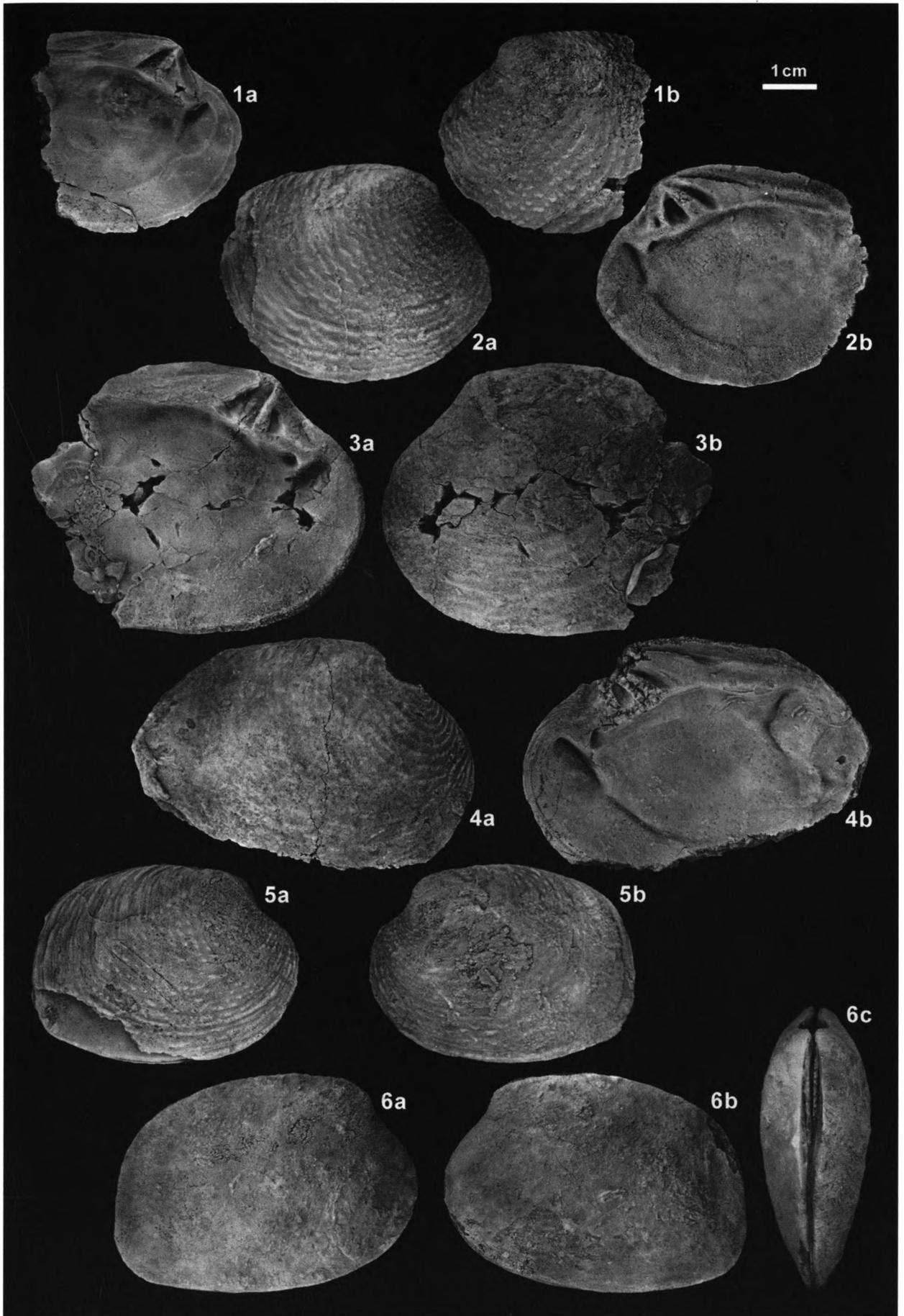
Fig. 2. MB.M.5179.1 (paratype) (HILLEBRANDT 660708/1); right valve. a. Lateral view. b. Internal view.

Fig. 3. MB.M.5179.4 (paratype) (HILLEBRANDT 660708/1); left valve. a. Internal view. b. Lateral view.

Fig. 4. MB.M.5178.2 (paratype) (HILLEBRANDT 660708/8); right valve. a. Lateral view. b. Internal view.

Fig. 5. MB.M.5178.1 (holotype) (HILLEBRANDT 660708/8); articulated specimen. a. Right valve view. b. Left valve view.

Fig. 6. MB.M.5179.2 (paratype) (HILLEBRANDT 660708/1); articulated specimen. a. Right valve view. b. Left valve view. c. Dorsal view.



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