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Redescription of Two Antarctic Species of *Cuspidaria: C. concentrica* Thiele, 1912 and *C. minima* (Egorova, 1993) (Bivalvia: Cuspidariidae)

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Abstract. *Cuspidaria concentrica* Thiele, 1912, frequently reported as a synonym of *Cuspidaria kerguelensis* Smith, 1885, is redescribed and revalidated following the study of new materials from the South Georgia Islands; this constitutes the first record of its presence in the Scotia Sea. The more elongated shell outline of *C. concentrica* and the smaller number of elevated lamellar concentric ridges clearly separate it from *C. kerguelensis*. *Cuspidaria minima* (Egorova, 1993), a species known from East Antarctica and the South Orkneys Islands, is redescribed based upon material from the Elephant Islands. *C. minima* is characterized by a small shell with a globose disk strikingly separated from the short rostrum and a shell surface with high, lamellated, upwardly bent commarginal ridges. Anatomical data, mainly from septal musculature of both species, are given. Type specimens of *Cuspidaria tenella* Smith, 1907, *Cuspidaria plicata* Thiele, 1912, and *Cuspidaria infelix* Thiele, 1912, are refigured and the reports on the presence of *C. kerguelensis* in the Scotia Arc Islands are discussed.

INTRODUCTION

The first record of *Cuspidaria* Nardo, 1840 in sub-Antarctic waters was provided by Smith (1885) who described *C. kerguelensis* from the Kerguelen Islands. Later, Smith (1907) described *C. tenella* from the Coulman Islands; Thiele (1912) described *C. concentrica, C. plicata* and *C. infelix*, all from Gauss Station, Antarctica (89°E). Egorova (1993) reviewed the Antarctic Cuspidariidae, and described *Cuspidaria multicostata* from off the South Sandwich Islands and *Cuspidaria minima* from the South Orkney Islands and East Antarctica, the latter, under *Subcuspidaria*, a genus proposed in the same paper (type species *Neaera kerguelensis* Smith, 1885).

A number of recent contributions (Soot-Ryen, 1951; Dell, 1964, 1990; Mühlenhard-Siegel, 1989; Hain, 1990; Narchi et al., 2002) reported the above mentioned species as present also in West Antarctica and the Scotia Sea. However, rather poor original descriptions of all species (all based on a single valve and lacking in details) led to confusion and erroneous identifications and synonymies. In this regard, Soot-Ryen (1951) reported *C. concentrica* as synonymous with *C. kerguelensis*, a criterion also accepted by Egorova (1993) but not by Dell (1990), who considered that *C. concentrica* differs from *C. kerguelensis* in having a fairly sparse sculpture. Dell (1964, 1990), Egorova (1993), and Poutiers & Bernard (1995) considered *C. plicata* as synonymous with *C. tenella*. Nicol (1966), on the basis of similarities on shell sculpture, considered *C. plicata* and, surprisingly for the same reasons, *C. concentrica* as synonymous with *C. tenella*. Hain (1990) also included *C. concentrica* and *C. plicata* in the synonymy of *C. tenella*. Dell (1964) suggested that *C. infelix* could be regarded as an extreme variation of *C. tenella*; however, Dell (1990) considered the former as a valid species. As pointed out by Dell (1990), "elucidation of the Antarctic species of *Cuspidaria* is still difficult".

In the present paper *Cuspidaria concentrica* and *C. minima* are redescribed upon materials from the Scotia Arc Islands. Other species of *Cuspidaria* previously reported from the Scotia Arc Islands are also figured and compared with the species here studied in an attempt to clarify their identity.

MATERIAL AND METHODS

The material from the Scotia Arc Islands was collected during the 2002 Latin American Polarstern Studies (LAMPOS) aboard the *R/V Polarstern* and the 1996 summer cruise to the South Georgia Islands by the *R/V Eduardo Holmberg* (voucher specimens in the collections of Museo Argentino de Ciencias Naturales "Bernardino Rivadavia" (MACN) and Museo de La Plata (MLP)). Specimens were fixed in a 10% formalin solution, sorted from the sediment under a stereoscopic microscope and preserved in 80% ethanol.

Shell morphology was studied and figured by scanning electron microscopy (SEM). Shell measurements were taken according to the following criteria: shell length (L), maximum anteroposterior distance; shell height (H), maximum dorsoventral distance, perpendicular to length; and shell width (W), maximum distance across valves. Morphometric ratios H/L and W/H were calculated. The number of specimens measured (n) and values of mean and

standard deviation are given. Gross anatomy was studied under a stereomicroscope. Soft-part terminology of septal musculature follows Yonge (1928) and Allen & Morgan (1981).

Several specimens for histological study were decalcified by a 12-hr rinsing in a 10% formalin solution added with 2% acetic acid, embedded in Paraplast®, sectioned at 7 μm thickness, and stained with Meyer's hematoxilin-eosin (Gabe, 1968).

Type specimens of *C. concentrica, C. plicata,* and *C. infelix* (Museum für Naturkunde (ZMB), Berlin) and photographs of the holotype of *C. tenella* (The Natural History Museum (BMNH), London) were studied for comparative purposes. The type of *Neaera kerguelensis* (BMNH) is presently badly damaged by Byne's Disease (K. Way, *in. lit.*), and not photographable. Additional specimens of *Cuspidaria plicata* and *C. infelix* collected by the BANZARE Expedition from the South Australian Museum, Adelaide (SAM) were examined. Study of the types of *Subcuspidaria minima* (probably in the Zoological Institute, Russian Academy of Sciences, St. Petersburg) was not possible.

SYSTEMATICS

Cuspidaria concentrica Thiele, 1912 (Figures 1–15)

Cuspidaria concentrica Thiele, 1912:233, pl. 18, fig. 29

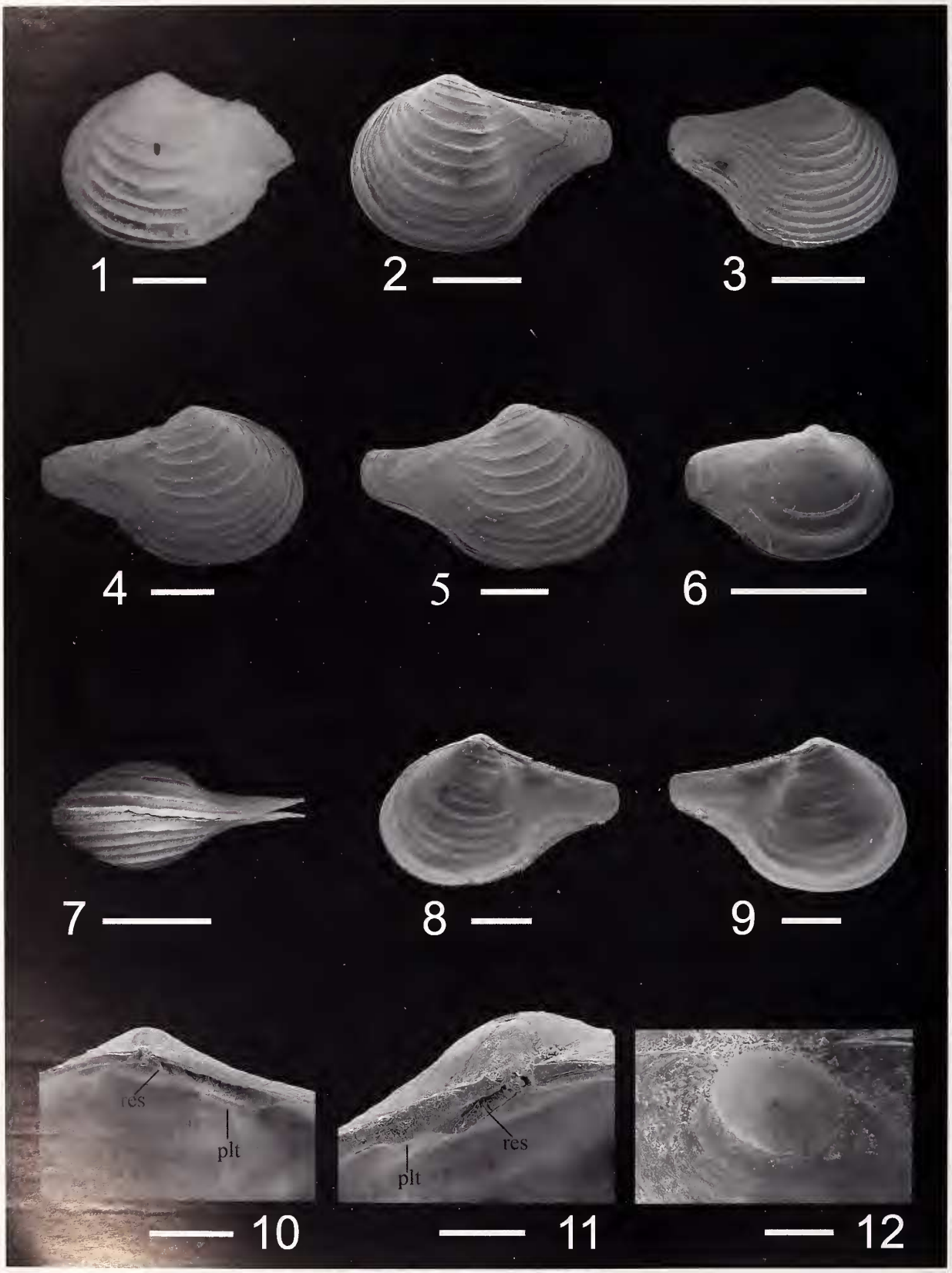
Diagnosis: *Cuspidaria concentrica* is characterized by its small size, the disk (i.e., the shell anterior to the rostrum) expanded anteriorly, and the shell surface with up to 16 lamellated commarginal ribs in larger specimens; a well-developed right-posterior lateral tooth, an inconspicuous left-posterior lateral tooth, and the anterior portion of the left-anterior septal muscle divided into three fascicles are also diagnostic.

Description: Shell small (maximum L = 5.4 mm), ovate (H/L = 0.63 ± 0.02, n = 15), somewhat globose (W/H = 0.75 ± 0.03, n = 15), inequilateral, slightly inequivalve (in ventral view, left valve overlaps right one) (Figures 1–9). Anterior margin somewhat expanded into a wide curve, particularly evident in right valve; ventral margin evenly rounded at the anterior half, sinuous at posterior one. Anterior dorsal margin short, connected insensibly with anterior margin, which slopes gently; posterior dorsal margin nearly straight in left valve, slightly curved in the right one (Figures 1–6, 8, 9). A weakly marked angle at the point of union of dorsal and anterior margins sometimes present (Figures 3, 6). Rostrum moderately projected, triangular in outline, dorsal and ventral margins not parallel, widely connected with disk. Transition between disk and rostrum moderately demarcated. Two rostral ridges running from beaks to posterior end of rostrum delimit a triangular area where shell sculpture fades (Figures 2, 4–6). Beaks wide, subcentral, directed posteriorly, low but well visible above dorsal margin. Hinge: right valve has only a posterior lateral tooth present, being an elongated plate with low, central, or posteriorly displaced cusp (Figures 8, 10); left valve has only posterior lateral tooth represented by a thickening of dorsal margin, forming a weak articular relief (Figures 9, 11). Resilium elongated, posterior to beaks, inserted in a low, slender, resilial pit (Figures 10, 11). Shell surface sculptured with a variable number of regularly spaced commarginal ribs: 9 to 12 in small specimens (3.5–4 mm L), 13–16 in larger ones (4.5–5.4 mm L). Ribs are lamellated, high in profile, anteriorly recurved, with rounded edges (Figure 13); interspaces much wider than ribs. Periostracum thin, forming weak, irregular, commarginal, and radial wrinkles particularly noticeable between ribs. Prodissoconch well discernible from dissoconch, about 195 μm in maximum diameter, finely granular (Figure 12). Dissoconch microsculpture formed by granules of two different sizes randomly distributed (Figure 14).

Soft parts: Anterior half of left anterior septal muscle clearly divided into a few, usually three, bundles of fibers; inner septal muscle well developed, joining the anterior septal muscle slightly before the insertion; at this point, part of the fibers of both muscles merge in a single insertion area (Figure 15). Lateral septal muscle formed by a continuous series of fibers, not arranged in bundles. Incurrent and excurrent siphons surrounded by seven short tentacles: three in middorsal and dorsolateral positions, and four in lateral and ventrolateral positions; each tentacle ending in an enlarged, rounded tip.

Examined material: Holotype (ZMB 63120); 187 specimens, 54°18′S, 35°30′W, South Georgia Islands, 94 m (MLP 5655, MACN-In 36377); 32 specimens, 53°59′S, 37°38′W, 158–159 m, South Georgia (MLP 7352, MACN-In 36378), 7 specimens, 54°30′S, 56°08′W, Burdwood Bank, 286 m (MLP 6873).

Remarks: *Cuspidaria concentrica* resembles *Cuspidaria minima* (Figures 16–26) and *Cuspidaria kerguelensis* (Figure 28) in general shell shape, but consistently differs in having a disk more anteriorly expanded (particularly evident in the right valve), the rostrum less markedly differentiated from the disk, and a smaller number of higher lamellated ribs. *C. concentrica* also differs from *C. minima* in having a weaker right-posterior lateral tooth and an inconspicuous posterior lateral tooth in the left valve. *Cuspidaria plicata* (Figure 29) differs from *C. concentrica* in having a more elongated disc and nonlamellated commarginal ribs. The shell sculpture of *Cuspidaria tenella* (Figure 30) and *Cuspidaria infelix* (Figure 31) with irregular and fine commarginal striae differs strikingly from that present in *C. concentrica.*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Figures 13–14. *Cuspidaria concentrica* from South Georgia Islands (MLP 5655): shell sculpture. Figure 13. Detail of shell sculpture. Figure 14. Detail of shell microsculpture. Scale bars: Fig. 13 = 140 μm; Fig. 14 = 50 μm.

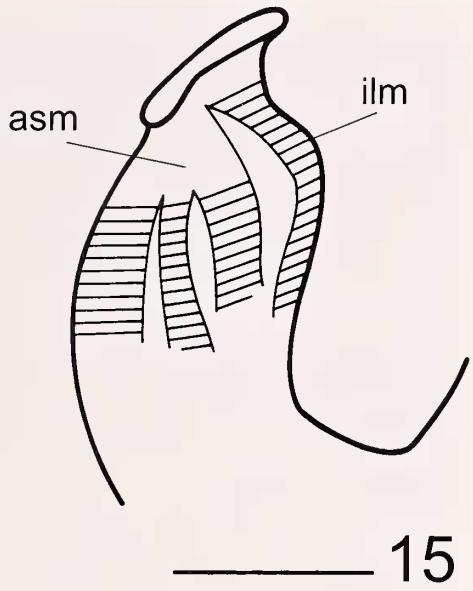

Figure 15. *Cuspidaria concentrica:* diagrammatic detail of anterior septal musculature. Scale bar = 500 μm. (asm = anterior septal muscle, ilm = inner longitudinal muscle).

Cuspidaria minima (Egorova, 1993)
Figures 16–27

Subcuspidaria minima Egorova, 1993:164–165, pl. 3, figs. 2, 3.

Diagnosis: *Cuspidaria minima* is characterized by its small size, short anterior end, and rounded, rather globose disk, strikingly demarcated from the rostrum. The shell surface with up to 15 lamellated commarginal ribs, the hinge with a robust right-posterior tooth, and a stout mamelliform left-posterior lateral tooth, as well as the anterior portion of the left-anterior septal muscle usually divided into several fascicles, are diagnostic features.

Description: Shell solid, whitish, small (maximum L = 4 mm), ovate (H/L: 0.63 ± 0.02, n = 13), inequilateral, slightly inequivalve (ventrally, left valve overlaps the right one) (Figures 16–19); disc and rostrum well-separated. Disk globose (W/H: 0.81 ± 0.04, n = 13), circular in right valve, tending toward trigonal in left one; transition between disk and rostrum strikingly demarcated by a depression of shell surface (particularly pronounced in left valve) (Figures 16–21); rostrum moderately projecting, handlike; a well-marked rostral ridge running from beaks to posterior end; a second, less pronounced rostral ridge running closer to posterodorsal margin (Figures 16–18). Beaks wide, subcentral, directed posteriorly, low but well-visible above dorsal margin. Anterior margin short, evenly, and widely rounded in right valve, sloping markedly in left one; ventral margin evenly rounded anteriorly, steeply curved posteriorly. Anterior dorsal margin very short, insensibly connected with the anterior margin; posterior dorsal margin slightly curved (Figures 16–21).

Shell surface sculptured with lamellated commarginal ribs (13 to 15 in specimens of 3.5–4 mm L), regularly separated; rib edge rounded; spaces between ribs wider

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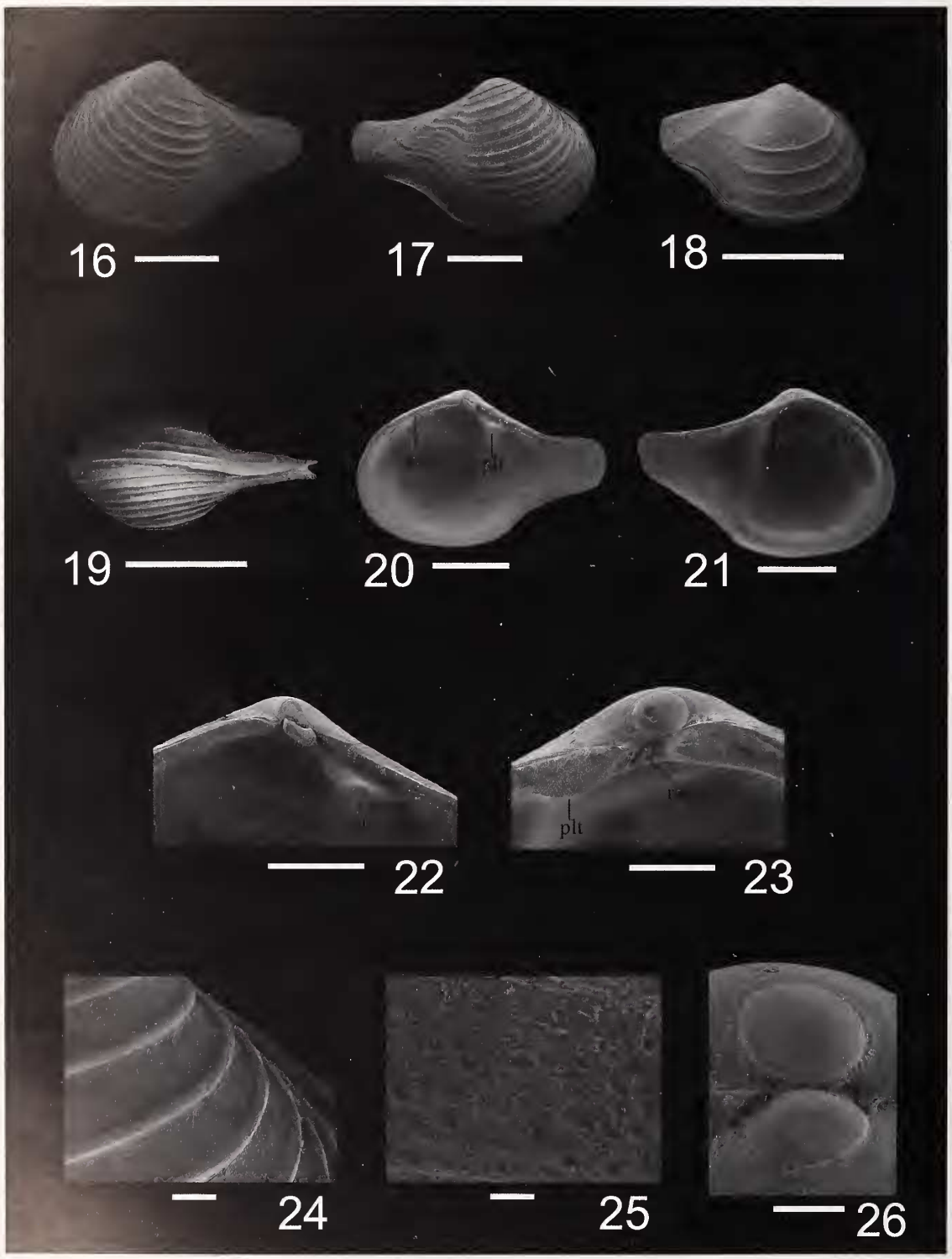
Figures 1–12. *Cuspidaria concentrica:* Figure 1. Holotype (ZMB 63120). Figures 2, 4–12 Specimens from South Georgia Islands (MLP 5655). Figure 2. Left valve. Figure 3. Right valve of a specimen from Burdwood Bank (MLP 6873). Figures 4, 5. Right valve; Figure 6. Juvenile specimen; Figure 7. Ventral view; Figure 8. Inner view of right valve. Figure 9. Inner view of left valve; Figures 10, 11. Detail of hinge. Figure 10. Right valve. Figure 11. Left valve. Figure 12. Prodissococonch. Scale bars: Figs. 1–9 = 1 mm; Figs. 10, 11 = 250 μm; Fig. 12 = 100 μm. (plt = posterior lateral tooth, r = resilium)



Figures 16–26. *Cuspidaria minima* from Elephant Islands (MLP 6881). Figure 16. Left valve. Figure 17. Right valve. Figure 18. Juvenile. Figure 19. Ventral view. Figure 20. Inner view of right valve. Figure 21. Inner view of left valve. Figure 22. Right valve detail of hinge. Figure 23. Left valve detail of hinge. Figure 24. Detail of shell sculpture. Figure 25. Detail of shell microsculpture. Figure 26. Prodissoconch. Scale bars: Figs. 16–21 = 1 mm; Fig. 22 = 500 μm; Fig. 23 = 250 μm; Figs. 24, 26 = 100 μm; Fig. 25 = 25 μm. (aar = anterior articular relief, plt = posterior lateral tooth, r = resilium).

Figure 27. *Cuspidaria minima:* diagrammatic detail of septal musculature. Scale bar = 500 μm. (asm = anterior septal muscle, ilm = inner longitudinal muscle, psm = posterior septal muscle).

than ribs (Figure 24). Commarginal ribs not extending dorsal to ventralmost rostral ridge. Periostracum forming weak, irregular, commarginal, and radial wrinkles (Figure 24). Prodissoconch well-discernible from dissoconch, about 175 μm of maximum diameter, finely granulated (Figure 26). The entire surface of dissoconch covered by low, circular depressions, variable in size, and microscopic granules (Figure 25). Hinge: a triangular, recurved, robust posterior lateral tooth in right valve, cusp rounded, displaced posteriorly (Figures 20, 22); a blunt mamelliform posterior-lateral tooth in left valve (Figures 21, 23). Articular reliefs anterior to beaks (anterior lateral teeth?), as shallow depressions and low protuberances, present in both right and left valves (Figures 20, 21). Resilium elongated, posterior to beaks, attached to a low and slender resilifer (Figures 22, 23).

Soft parts: The anterior portion of left-anterior septal muscle divided into several (usually six or seven) well-discernible, slender bundles of fibers (Figure 27). The insertion area of the left anterior septal muscle is well-differentiated from the one that corresponds to the inner longitudinal muscle. Incurrent and excurrent siphons surrounded by seven somewhat short tentacles: three in middorsal and dorsolateral positions and four in lateral and ventrolateral positions; tentacles ending in enlarged, rounded tips.

Examined material: 69 specimens, 61°23′S, 55°26′W, Elephant Islands, 285 m (MLP 6881).

Remarks: *Cuspidaria minima* is most similar to *Cuspidaria kerguelensis* (Figure 28) in shell shape; judging from the figure in the original description of *C. kerguelensis, C. minima* differs in having a smaller number of commarginal ribs; the spaces between the ribs are nearly equal to the rib width in *C. kerguelensis,* while in *C. minima* spaces are up to 3 times the rib width; in *C. minima* commarginal ribs fade above the rostral ridge while in the figure of *C. kerguelensis,* ribs extend onto the entire surface of the rostrum.

The shorter anterior half of the disk in *Cuspidaria minima,* as well as the presence of a strong posterior-lateral tooth in the right valve and a larger number of muscular bundles in the anterior half of the left-anterior septal muscle, clearly separate *C. minima* from *C. concentrica.* The posterior curvature of the ventral margin in *C. minima* changes more abruptly than in *C. concentrica,* and as a consequence, the disk and rostrum appear strikingly differentiated. Also, *C. minima* has, within the same range of size, a larger number of commarginal ribs than *C. concentrica.*

Figures 28–31. Other Antarctic species of *Cuspidaria.* Figure 28. *C. kerguelensis:* figure from the original description. Figure 29. *C. plicata:* holotype (ZMB 63121). Figure 30. *C. tenella:* holotype (BMNN 1905.9.25.11). Figure 31. *C. infelix:* holotype (ZMB 63119). Scale bars: Fig. 28 = 1 mm; Fig. 29 = 5 mm; Figs. 30, 31 = 10 mm.

Cuspidaria minima differs from the Antarctic species *C. tenella* (Figure 30) and *C. infelix* (Figure 31) in shell sculpture: the two latter species do not have lamellated ribs but rather irregular commarginal striae and periostracal folds. *C. tenella* also differs in having a larger shell and a proportionally smaller rostrum (Figure 30); *C. infelix* differs in being more expanded anteriorly, with the disk widely connected with the rostrum (Figure 31).

Cuspidaria plicata (Figure 29), another Antarctic species, differs from *C. minima* in having a smaller number of low, nonlamellated commarginal ribs.

Cuspidaria minima was originally described under *Subcuspidaria,* a genus proposed by Egorova (1993). *Subcuspidaria* was defined in the restricted context of a revision of Antarctic species of *Cuspidaria,* without considering the wide variability known for the genus. Hence, the value of the set of characters proposed by Egorova (1993) as diagnostic at genus level needs to be reevaluated in a wider context. So far, we prefer to use *Cuspidaria* for all the Antarctic species here studied. This is consistent with the catalogue of the Recent Anomalodesmata by Poutiers & Bernard (1995).

DISCUSSION

The new data given in this paper represent a contribution towards a better definition of two of the most common Antarctic species of *Cuspidaria.*

There is considerable confusion of the systematics of the sub-Antarctic and Antarctic species of *Cuspidaria* and, consequently, their actual geographical distributions are uncertain. Much of this confusion arises from the poor information on each taxon based on the small number of specimens studied; this has led to misinterpretations and erroneous synonymies. Such is the case, for example, for Dell (1990) who, based on "the small [shell] size, the strong but sparse commarginal sculpture and the whole aspect of Thiele's original figure," considered that *Cuspidaria concentrica* was described from a juvenile specimen (the type is 3.6 mm length). Our histological data showed that ripe eggs were present in females of *C. concentrica* of about 4 mm length, a fact that clearly indicates the adulthood of these "small sized" specimens. The same was observed in *Cuspidaria minima,* in which specimens of less than 4 mm length showed ripe ova and sperm.

Another source of misleading information is the fact that authors often have not considered the differences in shell outline and general shell shape existing between right and left valves: while the anterior half of the disk in the right valve is generally evenly rounded and more expanded anteriorly, in the left valve, the anterior end of the disk is shorter and slopes more abruptly. In this regard, it should be noted that a large number of the Antarctic species of *Cuspidaria* were described based on only one valve, and consequently, subsequent comparisons seeking similarities or differences could be biased.

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