


Condylocardiidae (Bivalvia) from Namibia

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On the continental slope off Namibia three species of Condylocardiidae were found, including a new species: *Condylocardia damara* spec. nov. A comparison is made with morphologically similar *Condylocardia* species from the eastern Atlantic, the south-western Pacific and the southern Indian Ocean. Remarks and distribution notes are given for the two remaining species *C. angolensis* and *Carditella capensis*.

Key words: Mollusca, Bivalvia, Condylocardiidae, SE Atlantic Ocean, West Africa, Namibia.

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INTRODUCTION

The family Condylocardiidae (Bivalvia: Carditoidea) was introduced by Bernard (1896: 195-196) who described four species from St. Paul in the southern Indian Ocean and Stewart Island, New Zealand. All four species are very small (about 1 mm length), equivalve with internal ligament and with relatively large, exposed prodissoconchs. The original description was followed by a second paper (Bernard, 1897) with excellent detailed graphs and discussions on the shell, including the embryonic development. Subsequent publications on Condylocardiidae are scattered in time and geography and shall only be listed here as examples. Bartsch (1915) described one species of the family Condylocardiidae: *Condylocardia io* (now *Benthocardiella io*) and two species of the family Carditidae: *Carditella rugosa* (now *Carditopsis rugosa* belonging to Condylocardiidae) and *Carditopsis alfredensis* (now *Warana alfredensis* belonging to Carditidae) from Port Alfred in South Africa. Cotton (1930) described five new species

in *Condylocardia* from southern Australia, of which one was later moved to the genus *Austrocardiella* Middelfart, 2002 in the same family and one is currently placed in the family Carditidae, subfamily Cuninae. Salas & Rolán (1990) described four new species in *Condylocardia* from the Cape Verde Islands in the eastern Atlantic Ocean; all species were found in sand with shell fragments. Salas & Cosel (1991) described another three species in *Condylocardia* and one condylocardiid in *Carditopsis* E. A. Smith, 1881 from western Africa (Mauritania and Angola). The species were found on the upper shelf in sand with shell debris and in seagrass meadows with mud. The microstructures of the shells of two species (*C. boucheti* and *C. verdensis*) were later studied in additional detail (Rolán & Hernandez, 2004). Middelfart (2002) provided an extensive revision of nineteen condylocardiids from Australia. He introduced two new genera and eight new species, of which one is placed in *Condylocardia*. The Australian species occur from the littoral zone to upper bathyal depths. Coan (2003) described six new species in *Condylocardia* and two species in *Carditella* from the upper shelf on the western American continents and islands. Güller & Zelaya (2013) reviewed the Carditidae and Condylocardiidae from southern South America and illustrated syntypes of the type species in *Carditopsis* E. A. Smith, 1881 and *Carditella* E. A. Smith, 1881. Very recently Güller & Zelaya (2022) described two additional condylocardiid species of the genus *Benthocardiella* from sub-Antarctic waters.

The taxonomic status of the Condylocardiidae is controversial from today's perspective. Passos et al. (2021) detail the complications in the assignment of families and subfamilies in the Carditoidea. The miniaturisation, the limited anatomical information and the contradictory results of genetic studies lead to an open discussion about the status of the Condylocardiidae and Carditidae and subfamilies placed within them (e.g. Carditellinae, Cuninae, Condylocardiinae) (Passos, 2021 and references therein). As shown by González & Giribet (2015) and Combosch et al. (2017), Condylocardiidae are nested within Carditidae, and thus not representing a valid bivalve family. Despite these difficulties, we will leave it at the taxonomic classification

for the time being, which may possibly be improved in the future by supplementary genetic studies and is established in MolluscaBase.

Species in the family Condylardiidae live on upper continental or island slopes in temperate water in the Atlantic, Indian and Pacific Ocean (Bernard, 1896, 1897; Salas & Rolán, 1990; Salas & Cosel, 1991; Middelfart, 2002; Coan, 2003; Güller & Zelaya, 2013), mostly in sandy bottoms with shell debris (Salas & Rolán, 1990; Salas & Cosel, 1991; Middelfart, 2002; Coan, 2003). Brooding appears to be common in the family (Salas & Rolán, 1990; Salas & Cosel, 1991; Middelfart, 2002). Presently, 57 valid species are contained in eight genera (MolluscaBase, 2022). The genus *Condylocardia* contains 40% (23 taxa) of valid species in the family.

Knowledge about the Namibian bivalve fauna is very limited and mostly of a general nature. A few publications provide information on the occurrence or distribution of bivalve species. Of the species dealt with in the present study, only *Carditella capensis* is occasionally mentioned for territorial waters of Namibia (Barnard, 1964; Compton et al., 2002; Compton & Bergh, 2016; Bergh & Compton, 2020). Sometimes the similar South African species *Carditella similis* Jaeckel & Thiele, 1931 is also given for Namibia (Bremner, 1978; Edelman-Furstenberg, 2014), but this is most likely confusion with the previous species.

This study is part of an ongoing inventory of *Bivalvia* from offshore Namibia. Other studies recently reported on Namibian bivalve species are those of *Neocardia* G. B. Sowerby III, 1892 (Hoffman & Freiwald, 2019), *Galeomma-toidea* J. E. Gray, 1840, *Waisiuconcha* Beets, 1842, *Nuculana* Link, 1807, *Nucula* Lamarck, 1799 (Zettler & Hoffman, 2021a-c, 2022) and *Polittitapes* Chiamenti, 1900 (Zettler & Alf, 2021).

MATERIAL AND METHODS

Bivalve shells were taken by dredges and sediment samples from the sea bottom during cruises to offshore Namibia. Sediment samples were sieved on board, retaining the fractions greater than 1 mm. All mollusc material was hand-sorted under a low-magnification binocular and colour photographs were taken of selected samples at Leibniz Institute for Baltic Sea Research (IOW) using a microscope camera. High-resolution imaging was done on selected samples using the Scanning Electron Microscope (SEM) at Senckenberg am Meer, Wilhelmshaven (SaM) (Vega3-Tescan; incident electron energy 10 KeV, high-vacuum imaging using secondary electrons). The SEM samples were coated with gold to facilitate imaging.

The holotype and paratypes of the newly described species are retained in the Senckenberg Museum, Frankfurt

am Main (SMF). The remaining material is kept in the reference collections at the Leibniz Institute for Baltic Sea Research (IOW), Warnemünde, Germany and at Senckenberg am Meer, Wilhelmshaven, Germany.

In the descriptions of the hinge we use the numbering convention for the cardinal and lateral teeth introduced by Bernard (1897); this numbering was also used by Middelfart (2002: fig. 31 and in text) and Güller & Zelaya (2013).

The following abbreviations are used: AHAB = R/V Alexander von Humboldt; H = height of shell from dorsal to ventral margin; IOW = Leibniz Institute for Baltic Sea Research; L = length of shell from anterior to posterior margin; M = R/V Meteor; MSM = R/V Maria S. Merian; GeoB = Location reference system University of Bremen; SaM = Senckenberg am Meer, Wilhelmshaven; SMF = Senckenberg Museum, Frankfurt am Main; T = tumidity (thickness) of paired shell in umbonal view.

SYSTEMATICS

Class *Bivalvia* Linnaeus, 1758

Family *Condylardiidae* F. Bernard, 1896

Genus *Condylocardia* F. Bernard, 1896

Type species (designated by Bernard, 1897: 175): *Condylocardia sanctipauli* F. Bernard, 1896 (mentioned under the unjustified emended name *Condylocardia pauliana* F. Bernard, 1897).

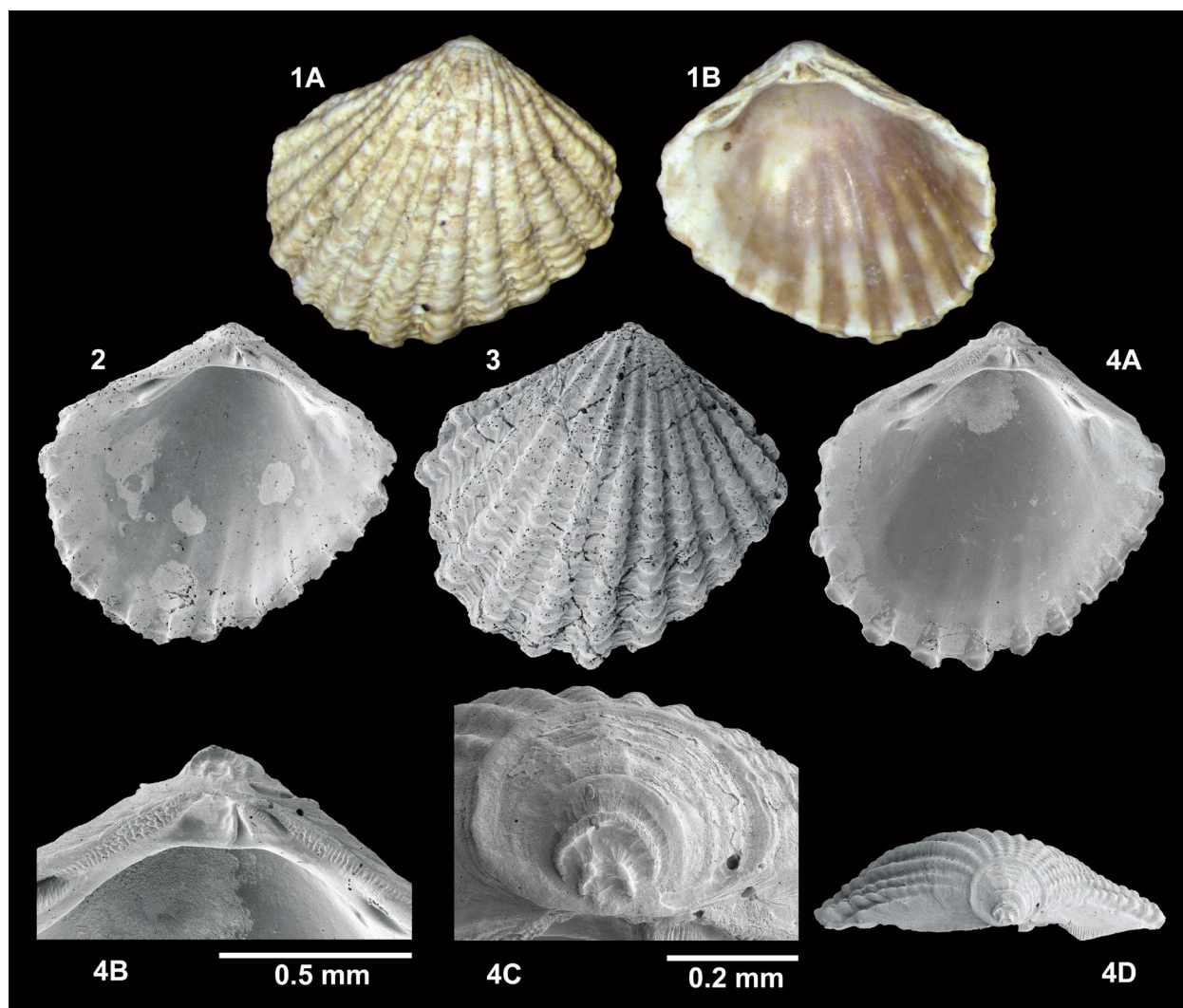
Condylocardia angolensis C. Salas & Cosel, 1991

Figs 1-4

Condylocardia angolensis C. Salas & Cosel, 1991: pp. 265-266, figs. 9-24. Type locality: Bay of Lucira (Bissonga), Namibe province, South Angola, 10-20 m, in maerl.

Material investigated. — **Namibia** • 3 valves, 18.000°S, 11.767°E; depth 56 m; MSM105-42; IOW. • 5 valves (Fig. 1), 18.000°S, 11.792°E; depth 20 m; MSM105-43; IOW. **Angola** • 4 valves (Figs 2-4), 15,096°S, 12.105°E; depth 62 m; MSM18-NA5; IOW.

Remarks. — Salas & Cosel (1991) reported the species from off Angola. The protoconch and dissoconch are strongly sculptured; its outline is angular and inequilateral. It belongs to a group of western African congeneric species with strongly ribbed dissoconchs and strongly sculptured and / or elevated prodissoconchs.



Figs 1-4. *Condylocardia angolensis* C. Salas & Cosel, 1991. 1. Namibia, MSM105-43, Right valve, H 4.0 mm, W 3.6 mm; 2-4. Angola, MSM18-NA5. 2. Left valve, H 2.3 mm, W 2.7 mm; 3. Right valve, H 2.2 mm, W 2.7 mm; 4. Left valve, H 1.9 mm, W 2.1 mm, T 0.6 mm, prodissoconch-1 W 0.22 mm, prodissoconch-2 W 0.47 mm.

***Condylocardia damara* spec. nov.**

Figs 5-8

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Type material. — Holotype (Fig. 5), 1 shell (paired valves); Namibia, New Year Mounds; 20.764°S, 12.833°E; depth 226 m; 1.i.2016; M122/GeoB20515; box core; silty mud with coral rubble; SMF359006. • paratype 1 (Fig. 6), 1 shell; same data as holotype; SMF359007. • paratype 2 (Fig. 7), 1 shell; same data as holotype; SMF359008. • paratype 3 (Fig. 8), 1 shell; same data as holotype; SMF359009. • paratypes 4; 100 shells; same data as holotype; SMF359010.

Other material investigated. — **Namibia** • 80 shells; 20.733°S, 12.818°E; depth 232 m; 01.i.2016; M122/GeoB20511; box core; silty mud with coral rubble; SaM85377. • 25 shells;

20.719°S, 12.817°E; depth 219 m; 01.i.2016; M122/GeoB20522; box core; silty mud with coral rubble; SaM85380. • 2 valves; 20.717°S, 12.867°E; depth 178 m; 01.i.2016; M122/GeoB20532; box core; silty mud with coral rubble; SaM85376. • 4 valves; 23.000°S, 13.499°E; depth 242 m; 25.viii.2019; M157/10; dredge; IOW. • 21 valves; 23.000°S, 13.683°E; depth 154 m; 26.viii.2019; M157/11, dredge; IOW. • 25 valves; 25.000°S, 13.917°E; depth 187 m; 07.ix.2019; M157/38; dredge; IOW. • 4 valves; 23.000°S, 14.133°E; depth 130 m, 16.i.2022; MSM105/18; corer; IOW. • 6 valves; 20.040°S, 12.280°E; depth 260 m, 24.i.2022; MSM105/46; multicore; IOW. • 2 valves; 25.000°S, 13.917°E; depth 186 m, 29.i.2022; MSM105/64; van Veen; IOW.

Etymology. — Damara refers to an ethnic group of people in Namibia.

Description. — Valves thick, moderately tumid, fan-

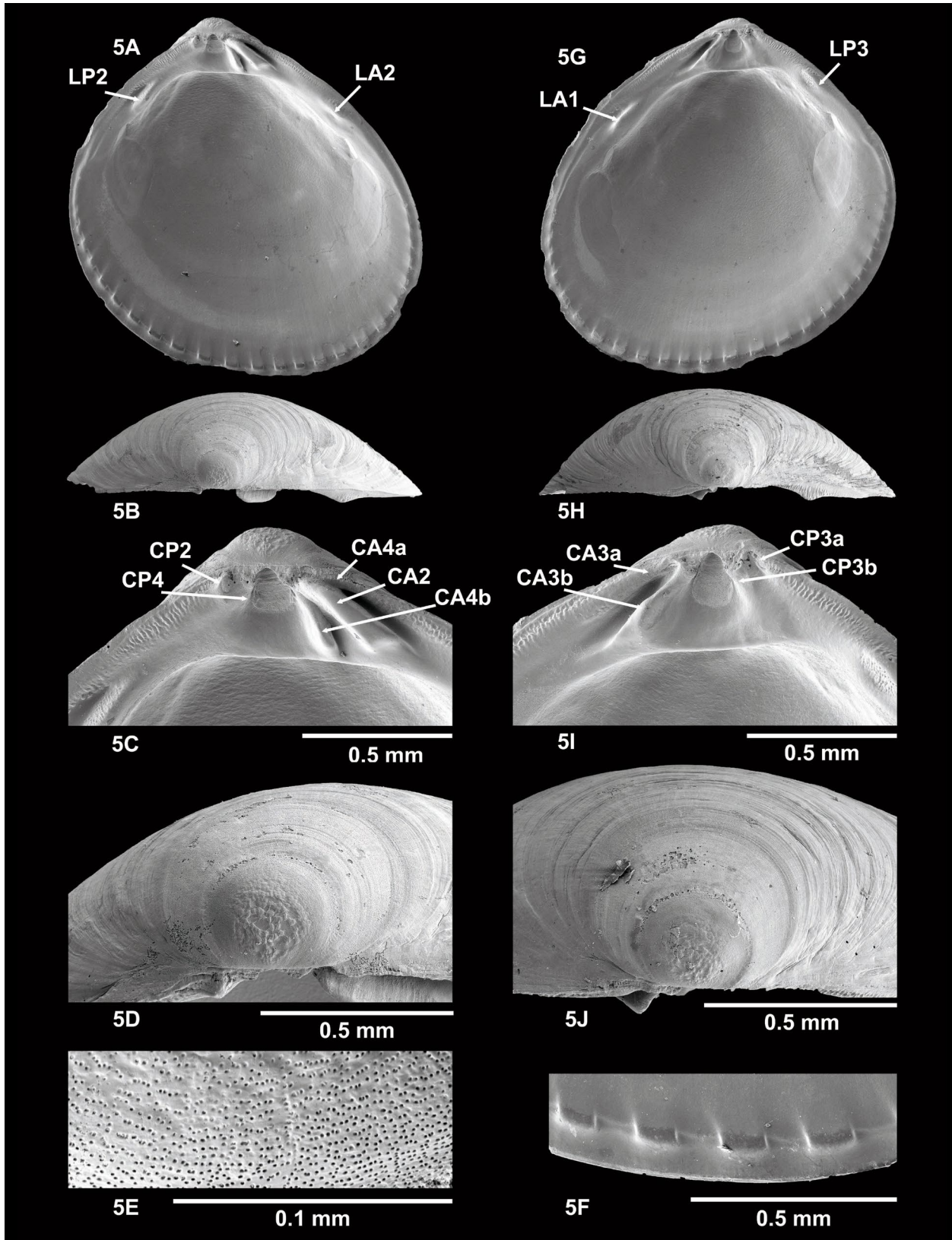
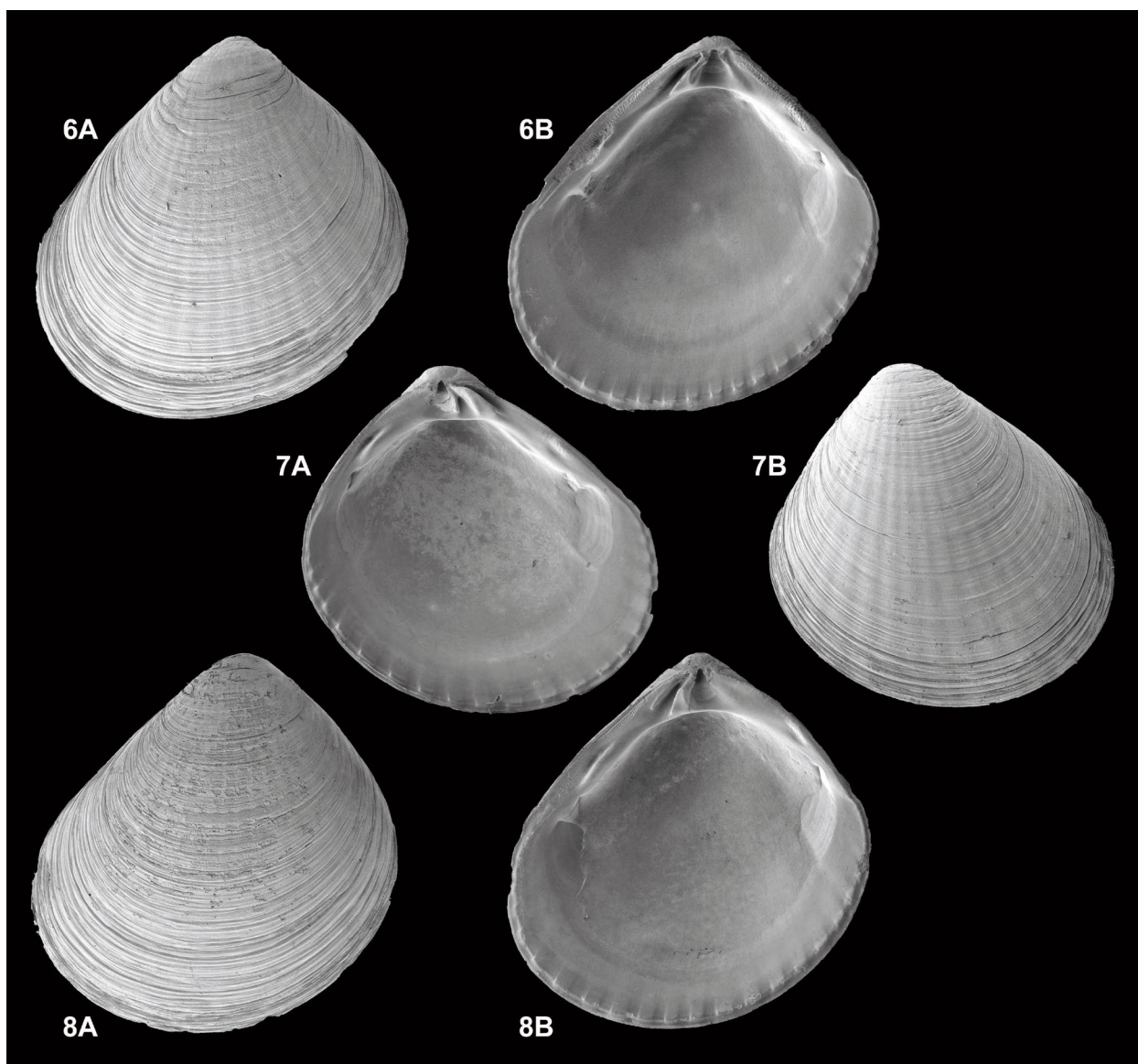


Fig. 5. *Condylocardia damara* spec. nov., holotype, Namibia, M122/GeoB20515. **5A-F.** Left valve. **5A.** Internal view, L 2.7 mm, H 2.8 mm. **5B.** Umbonal view, T 1.0 mm. **5C.** Cardinal teeth. **5D.** Prodissoconch L 0.37 mm, H 0.3 mm. **5E.** External micro-sculpture with tubulae, diameter 1 mm. **5F.** Internal ventral margin with crenulations. **5G-J.** Right valve. **5G.** Internal view. **5H.** Umbonal view. **5I.** Cardinal teeth. **5J.** Prodissoconch. Teeth numbering following Bernard (1897): C – cardinal tooth, L – lateral tooth, A – anterior tooth, P – posterior tooth. Left valve teeth: CA2, CA4a, CA4b, LA2, LP2. Right valve teeth: CA3a, CA3b, CP3a, CP3b, LA1, LP3.



Figs 6-8. *Condylocardia damara* spec. nov., paratypes, Namibia, M122/GeoB20515. **6A-B.** Paratype 1. **6A.** Left valve, external view, L 3.7 mm, H 3.8 mm. **6B.** Right valve, internal view. **7A-B.** Paratype 2. **7A.** Left valve internal view, L 4.1 mm, H 4.2 mm. **7B.** Right valve, external view. **8A-B.** Paratype 3. **8A.** Left valve, external view, L 4.4 mm, H 4.5 mm. **8B.** Right valve, internal view.

shaped shell with rounded protruding umbo, equivalve and subequilateral (Figs 5A-B, 5G-H); length maximum 4.5 mm (holotype 2.7 mm), height maximum 4.5 mm, tumidity of a valve 36% of length; colour white.

Prodissoconch with two stages (Figs 5B, 5D, 5H, 5J). First larval stage, flattened nearly circular disk, umbo straightly truncated; central sculpture rough, chaotic with smooth concave rim at margin; length 0.37 mm, height 0.30 mm. Second lecithotrophic stage smooth with fine commarginal growth lines, length 0.7 mm.

Dissoconch, external sculpture, initial (30% of height) dissoconch smooth, outer margin dissoconch with about 10-20 broadly rounded weak somewhat irregular radial

ribs with narrower interspaces, crossed by commarginal growth lines, irregular in strength and distance, dense near margin. Micro-sculpture of numerous commarginally aligned tubulae (Fig. 5E), diameter near 1 mm. Semi-circular smooth ventral margin. Internally smooth with weak microscopic ridges, width 5-10 mm; matt; the adductor muscle scars and ventral line clear (Figs 5A, 5G); posterior adductor scar oval; anterior scar kidney-shaped. Inner margin sharp, 20-25 cusps placed well inside of margin, rectangular towards margin (Figs 5A, 5F-G). Left valve hinge cardinal teeth (Fig. 5C); anteriorly, one very weak marginal tooth (CA4a), one strong obliquely elongated (CA2), one intermediate oblique elongated (CA4b) near internal liga-

ment; posteriorly inconspicuous near ligament (CP4) and weak (CP2) near margin. Right valve hinge cardinal teeth (Fig. 5I); anteriorly, one very weak marginal tooth (CA3a), one strong obliquely elongated (CA3b) near ligament; posteriorly inconspicuous near ligament (CP3b) and near margin (CP2). Left valve one anterior lateral tooth (LA2) and one posterior (LP2) (Fig. 5A). Right valve one anterior lateral tooth (LA1) and one posterior (LP3) (Fig. 5G). Angle of lateral hinge plates 90° (Figs 5A, 5G). On both anterior and posterior dorsal margins fine irregular flexuous ridges, perpendicular to margin (Figs 5C, 5I); ridges also present inside cavities for lateral teeth.

Differential diagnosis. — The type species *Condylocardia sanctipauli* F. Bernard, 1896 is only about 1.2 mm in length, it has a blunt umbo and a weak internal sculpture (Middelfart, 2002: syntype in fig. 2). Our species is up to 4.5 mm with a pointed umbo and it is internally smooth. *Condylocardia notoaustralis* Middelfart, 2002 from southern Australia is much smaller and its protoconch shows an auricle on the umbonal margin and a commarginal depression near its margin (Middelfart, 2002: fig. 6); our species lacks the auricle and the commarginal depression on the prodissoconch. *Condylocardia pectinata* Middelfart, 2002 from southern Australia is similar to the type species; an angular postero-ventral margin and its prodissoconch is smooth (Middelfart, 2002: fig. 10); our species is much larger with a more rounded outline and has a similar smooth prodissoconch. *Condylocardia geigeri* Coan, 2003 from the Galapagos Islands is similar to the type species, with a strong radial sculpture (Coan, 2003: fig. 28); our species has a weaker sculpture and is much larger. All congeneric species described from off NW Africa differ from our species; all are much smaller in size, often with concave dorsal margins that are pointed posteriorly and all prodissoconchs show a hat-like shape, a dimple at the elevated umbo with smooth steeply raised inner area and a depressed rim near the raised margin (Salas & Rolán, 1990; Salas & Cosel, 1991). The two species from Angola have very roughly sculptured prodissoconchs when compared to our species and the outline of the valves are more angular and inequivalve (Salas & Cosel, 1991).

Remarks. — Anatomic and molecular details are unknown; soft parts have not been studied. The latitudinal distribution range is 20°S–25°S; the bathymetric range is 130–242 m.

Genus *Carditella* E. A. Smith, 1881

Type species (designated by Dall, 1903: 1437) is *Carditella pallida* E. A. Smith, 1881, accepted as *Carditella tegulata* (Reeve, 1843) (see Güller & Zelaya, 2013).

Carditella capensis E. A. Smith, 1885

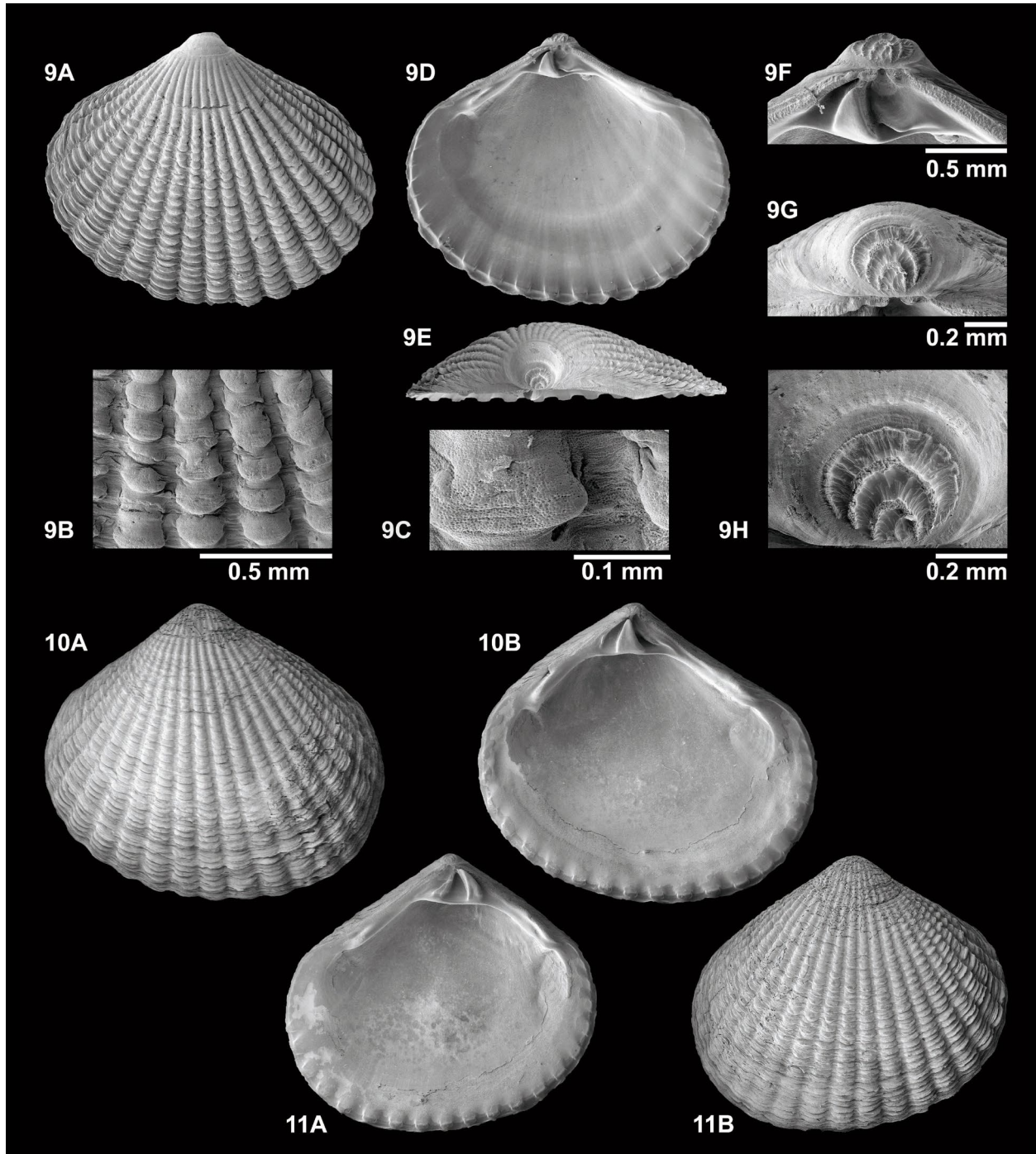
Figs 9–11

Carditella capensis E. A. Smith, 1885: pp. 12, 216, pl. 15, figs 7, 7c. Type locality: Simon's Bay, Cape of Good Hope, in 15 to 20 fathoms.

Material investigated. — **Namibia** • 1 valve; 18.385°S, 11.922°E; depth 42 m; 12.v.2004; AHAB8/BEI; van Veen grab; IOW. • 3 valves; 20.175°S, 12.710°E; depth 133 m; 24.viii.2011; MSM18/NAM004; dredge; IOW. • 5 valves; 22.499°S, 13.533°E; depth 156 m; 18.ix.2011; MSM18/NAM-BE21; dredge; IOW. • 20 shells; 20.733°S, 12.818°E; depth 232 m; 01.i.2016; M122/GeoB20511; box core; silty mud with coral rubble; SaM85372. • 133 shells, 20.764°S, 12.833°E; depth 226 m, M122/GeoB20515; boxcore; SaM85370. • 29 shells + 66 valves; 20.764°S, 12.831°E; depth 219 m, M122/GeoB20516; boxcore; SaM85373. • 33 shells (Figs 9–11), 20.719°S, 12.817°E; depth 219 m; 01.i.2016; M122/GeoB20522; boxcore; SaM85371. • 1 valve; 20.003°S, 12.417°E; depth 196 m; 05.xi.2016; M131/P6; van Veen grab; IOW. • 1 valve; 23.000°S, 13.499°E; depth 242 m; 25.viii.2019; M157/10; dredge; IOW. • 50 valves; 23.000°S, 13.683°E; depth 154 m; 26.viii.2019; M157/11; dredge; IOW. • 1 valve; 17.267°S, 11.724°E; depth 33 m; 31.viii.2019; M157/24; dredge; IOW. • 1 valve; 17.340°S, 11.602°E; depth 151 m; 01.ix.2019; M157/28; dredge; IOW. • 100 valves; 25.000°S, 13.917°E; depth 187 m; 07.ix.2019; M157/38; dredge; IOW. • 1 valve; 25.000°S, 14.103°E; depth 176 m; 10.ix.2019; M157/39; dredge; IOW. • 77 valves; 23.000°S, 13.500°E; depth 240 m, 14.i.2022; MSM105/13; dredge; IOW. • 10 valves; 23.000°S, 14.133°E; depth 130 m, 16.i.2022; MSM105/18; corer; IOW. • 100 valves; 25.000°S, 13.917°E; depth 186 m, 29.i.2022; MSM105/64; dredge; IOW. • 3 valves; 25.000°S, 14.100°E; depth 174 m, 29.i.2022; MSM105/66; van Veen grab; IOW. • 2 live collected specimens; 26.000°S, 14.897°E; depth 27 m, 01.ii.2022; MSM105/78; dredge; IOW. • 34 valves; 23.000°S, 13.500°E; depth 240 m, 14.i.2022; MSM105/13; van Veen; IOW. • 25 valves; 18.000°S, 11.517°E; depth 232 m, 22.i.2022; MSM105/38; dredge; IOW. • 2 valves; 20.040°S, 12.280°E; depth 260 m, 24.i.2022; MSM105/46; multicore; IOW. • 1 valve; 25.000°S, 13.733°E; depth 318 m, 28.i.2022; MSM105/62; dredge; IOW. • 1 valve; 27.000°S, 14.450°E; depth 339 m, 04.ii.2022; MSM105/90; van Veen; IOW. • 3 valves; 27.000°S, 14.817°E; depth 207 m, 04.ii.2022; MSM105/93; dredge; IOW. • 215 valves; 27.000°S, 15.150°E; depth 70 m, 05.ii.2022; MSM105/97; van Veen; IOW.

Remarks. — *C. capensis* is the most common of the condylocardiid species of Namibia. Nevertheless, it should be emphasised that in the vast majority of cases, only older and empty shells were found.

Currently *Carditella* is placed in the Family Carditidae (MolluscaBase 2022). Huber (2010), Güller & Zelaya (2013) and Valentich-Scott et al. (2020) place *Carditella* in Con-



Figs 9-11. *Carditella capensis* E. A. Smith, 1885, Namibia, M122/GeoB20522. **9A.** Left valve, external view, H 3.8 mm, W 4.5 mm, T 1.0 mm. **9B-C.** Right valve, external sculpture. **9D.** Right valve, internal view. **9E.** Right valve, umbonal view. **9F.** Right valve, cardinal teeth. **9G-H.** Right valve, prodissoconch-1 W 0.48 mm, prodissoconch-2 W 0.84 mm. **10A.** Left valve, external view, H 8.5 mm, W 9.6 mm; **10B.** Right valve, internal view. **11A.** Left valve, internal view, H 7.8 mm, W 8.7 mm. **11B.** Right valve, external view.

dylocardiidae. Also genetically *Carditella capensis* was assigned to Condylardiidae (Gonzales & Giribet, 2015, Combosch et al. 2016) but nested in the family Carditidae. Despite the ambiguity of the familial classification (see introduction), we also list *C. capensis* in the family Con-

dylocardiidae for the time being.

The prodissoconch of *Carditella capensis* has a similar rough sculpture (Figs 9E-H) encountered in Angolan species of *Condylardia* (Salas & Cosel, 1991; Cosel & Gofas, 2019). Similarly, *Carditella semen* (Reeve, 1843) from

Chile to Peru also has a strongly sculptured prodissoconch (Güller & Zelaya, 2013; figs 7L-O). A single lateral tooth is found on either side in each valve and the cardinal teeth are also similar to those in *Condylocardia*.

DISCUSSION

The Namibian *Condylocardia damara* spec. nov. belongs to a congeneric group similar to the type species. *Condylocardia geigeri* Coan, 2003 from the eastern Pacific and the Australian *Condylocardia pectinata* (Tate & May, 1900) (see Middelfart, 2002) also belong to this group. In Angola (Salas & Cosel, 1991) and Cape Verde (Salas & Rolán, 1990), the species in *Condylocardia* are quite variable and all are significantly different from the type species; these species show a strong external sculpture with straight or concave dorsal margins and angular anterior and posterior ends; their protoconchs are strongly elevated and / or strongly sculptured. Apart from *Condylocardia geigeri* Coan, 2003, all hitherto known eastern Pacific species are mostly similar to the eastern Atlantic species: they exhibit a strongly sculptured dissoconch and prodissoconch, and an angular outline (Coan, 2003). Many of the morphological characteristics of these species are found in the type species of *Carditella*: *Carditella tegulata*, see Güller & Zelaya (2013; fig. 5).

In summary, the morphological shell features of the type species of *Condylocardia* are persistently present in few species in the Indian-, Pacific- and the Atlantic Ocean. The genus *Condylocardia* is likely polyphyletic and in need of a revision preferably with molecular (DNA) data (see also González & Giribet, 2015; Combosch et al., 2016; Valentich-Scott et al., 2020). Unfortunately, the type species and many other species currently placed in *Condylocardia* are solely known from empty shells or single valves, which hamper a comprehensive study.

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