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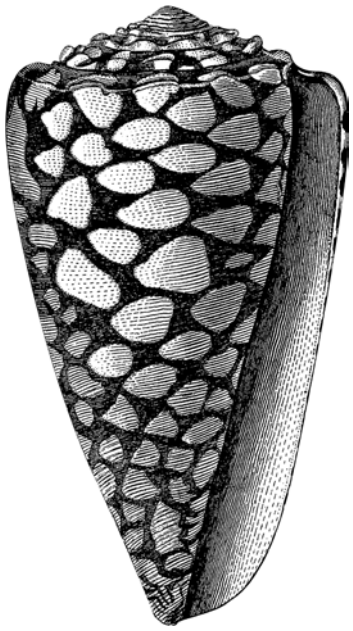

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A revision of the Australian Condylocardiinae (Bivalvia : Carditoidea : Condylocardiidae)

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Abstract

Nineteen species belong to the Condylocardiinae in Australia, eighteen of these are endemic. Six genera are recognised: *Benthocardiella* Powell with two new species, *B. burtonae* n. sp. and *B. darwinensis* n. sp.; *Condylocardia* Bernard with five species, one new (*C. cometa* n. sp.); *Condylocuna* Iredale with four species, three new (*C. annieae* n. sp., *C. jimbecki* n. sp., and *C. tricosa* n. sp.); *Cunanax* Iredale with four species; *Isodontocardia* n. gen. is monotypic, with one new species (*I. microcardia* n. sp.); and *Austrocardiella* n. gen. with three species, one new (*A. pouli* n. sp.).

Each species is illustrated and described from shell characters. Descriptions include full synonymy, subsequent references and habitat and distribution data. All type material relating to this revision is illustrated. The gross anatomy of *Condylocardia notoaustralis* Cotton is described.

Three species have been excluded from *Condylocardia* and the subfamily Condylocardiinae: *Condylocardia chapmani* is transferred to *Puyseguria*, ?Neoleptonidae; *Condylocardia ovata* is transferred to *Mysella*, Galeommatidae *sensu lato*; and *Condylocuna minuta* is transferred to Cuninae.

Introduction

The first records of species of Condylocardiinae stem from Bernard's (1896, 1897*a*) descriptions of species from Stewart Island (New Zealand) and St Paul Island (South Central Indian Ocean). Bernard provided an excellent starting point for the definition of this group, as he included a very detailed description of hinge teeth, not only of the adult but also of embryos and juveniles. The features shared by this group are their small size, narrow hinge with a strong curved, ventrally directed, anterior right valve cardinal (CA3, following hinge teeth terminology of Bernard 1897*a*: fig. 3, here reproduced as Fig. 1), single anterior and posterior lateral in each valve and the small, centrally located internal ligament in a triangular to circular resilifer.

Roger and Lefebvre (1944) regarded the hinge teeth, rather than external ornamentation, as the most valuable generic and familial characters on the basis that many species with radial ornamentation pass through a juvenile phase where the shell only possesses commarginal ribbing.

Major aspects of the biology of condylocardiines are unknown. Unconfirmed records indicate that they inhabit shallow water sandflats, where they may be abundant and possibly ecologically important (Slack-Smith 1998).

The anatomy of a condylocardiine has not previously been described, although the presence of brooded embryos has been reported from the first descriptions of the family (e.g. Bernard 1896, 1897*a*, 1898). Recently the same mode of reproduction was recorded for Atlantic species (Salas and Rolán 1990; Salas and von Cosel 1991). It has been noted that the prodissoconch is generally large, ornamented with radial ribs or with an elevated nucleus, and generally with a strong bulging rim.

The earliest named Australian condylocardiine is *Carditella subradiata* Tate, 1889 (Verco 1908*a*). The remainder were described after Bernard (1896) erected the family. Major contributions to the systematics of this group were by Cotton (1930), who described five new species, and Laseron (1953), who described seven. Lamprell and Healy (1998)

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illustrated all the species described up to 1998 with copies of the original illustrations. The number of valid species names equalled the number of available names (25 names) until the present revision, in which there are 19 valid species and 12 synonyms and two species are excluded from the subfamily.

The family has a worldwide distribution, with the greatest known diversity in Australia. New Zealand has five species and three subspecies in *Benthocardiella*, one species and one subspecies in *Condylocardia* and three species in *Condylocuna* (Spencer and Willan 1996). Eight species have recently been described from the Atlantic Ocean, four from the Cape Verde Islands (Salas and Rolán 1990) and four from West Africa (Salas and von Cosel 1991). Central American condylocardiines include: *Condylocardia hippopus* (Mörch, 1861, p. 200) [synonym: *Condylocardia panamensis* Olsson, 1942 (p. 34)]; and *Condylocardia digueti* Lamy, 1916 (p. 443). One species (*Condylocardia io* Bartsch, 1915) described from South Africa is probably a *Benthocardiella*.

The following genera belong in the confamilial Cuninae, which is being revised separately: *Americuna* Klappenbach, 1963; *Carditopsis* Smith, 1881; *Carditella* Smith, 1881; *Carditellona* Iredale, 1936; *Cuna* Hedley, 1902; *Hamacuna* Cotton, 1931; *Mesocuna* Laseron, 1953; *Micromeris* Conrad, 1866; *Ovacuna* Laseron, 1953; *Particondyla* Laseron, 1953; *Propecuna* Cotton, 1931; *Saltocuna* Iredale, 1936; *Volupicuna* Iredale, 1936; and *Warrana* Laseron, 1953.

Materials and methods

The material contained in the research collection at the Australian Museum, Sydney (AMS) was used as the basis for the revision. This collection proved to be particularly useful because Hedley, Iredale and Laseron, who all worked with the condylocardiines from Australia, had studied it. Additional material was borrowed from other museums. The abbreviations used are: AMS (Australian Museum, Sydney) (all numbers with the prefix C stem are from AMS); SAMA (South Australia Museum, Adelaide); TMH (Tasmanian Museum and Art Gallery, Hobart); NMV (Museum Victoria, Melbourne); WAM (Western Australia Museum, Perth); ANSP (Academy of Natural Sciences, Philadelphia); USNM (National Museum of Natural History Washington DC); NMNZ (Museum of New Zealand, Te Papa Tongarewa, Wellington); MNHN (Muséum National d'Histoire Naturelle, Paris); NTM (Northern Territory Museum and Art Gallery, Darwin); QM (Queensland Museum, Brisbane).

The small size of specimens in this group made it preferable to obtain scanning electron micrographs of the types. However, this was only done where the type material was syntypic and a lectotype could be selected for Scanning Electron Microscopy (SEM). No holotype or material from museums other than AMS was examined using SEM, but were photographed with a Pixera digital camera attached to a stereo microscope. Topotypic material was also used for SEM examination of the species. Where no material suitable for SEM was available from the type locality, specimens from the nearest possible locality were used. The shells were mounted on various sized stubs, gold coated, examined in a LEO SEM and digitally photographed.

Only one lot of wet material was available. The specimens were removed from their valves, cleared in glycerine and examined under a stereo microscope at 50–100× magnification.

A lectotype was selected and illustrated from syntype series throughout the manuscript. The lectotype selections are justified because they avoid future problems with defining the individual taxon name (e.g. caused by cryptic species) and illustrate the described species from multi-species type series.

Locality data (AMS and material from other museums) was exported from the collection database (TextPress) in Malacology, AMS, and plotted using ArcView. The abbreviations v and pr are used for valve and pair respectively and '+' indicates 'more than' the number indicated.

Shell characters (78) were defined and a data matrix created. Descriptions were generated using the DELTA program CONFOR (Dallwitz and Paine 1993).

The types and a few additional specimens were measured. The measurements were done with the aid of a graphics pad linked to a computer (see Ponder *et al*. 1989: 11). The length (SL) and height (SH) of the dissoconch, the length of the prodissoconch (PL) and the inflation of one valve (SI) were measured, and the inflation ratio (SL/SI×2) calculated.

Bernard and Munier-Chalmas (see Bernard 1898: 14; Cox *et al.* 1969: N52; Morton *et al.* 1998: 200–201; Middelfart 2000) proposed the most comprehensive hinge notation formula, which was based on

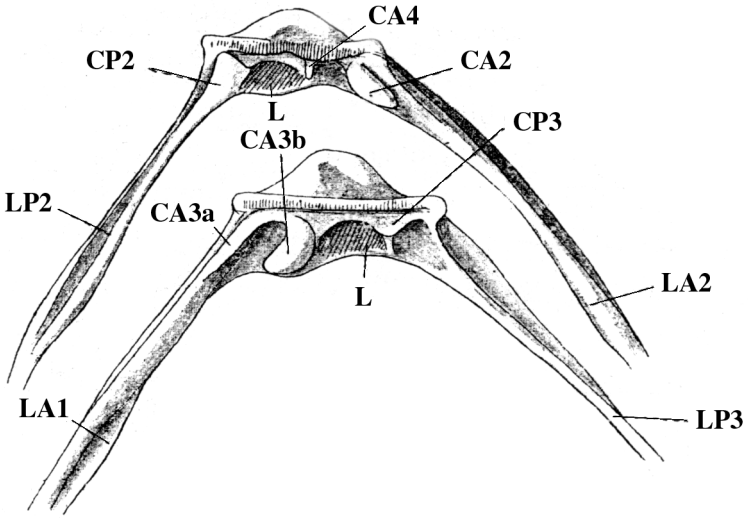

Fig. 1. The hinge teeth numbering system used by Bernard (1897*a*, reproduced from original publication). C, Cardinal; L in conjunction with letter and number, Lateral; L singularly, Ligament; A, Anterior; P, Posterior.

homologies of the lateral and cardinal teeth. As the formula is based on knowledge of the ontogeny of the hinge, ideally the ontogeny should be known for the formulation to be correctly applied. In the present revision, the work of Bernard (1896, 1897*a*) on Condylocardiidae is the basis for the formulae used. The detailed description provided by Bernard (1897*a*, fig. 3, p. 187) has been the foundation for descriptions provided herein. Bernard's figure is reproduced in Fig. 1, with an additional indicator for CA4. Since Bernard only worked with a few species from *Condylocardia* and *Condylocuna*, some extrapolation was necessary to cover the additional genera treated herein.

Key to species of Condylocardiinae

1. Shell small, under 10 mm, triangular with small cup-shaped, rarely sculptured prodissoconch. Hinge teeth with prominent triangular cardinal tooth in right valve. Left valve with one prominent triangular or two diverging cardinals . . . . . Cuninae
   Shell small, under 10 mm, triangular to oval, with large hat-shaped, smooth to sculptured prodissoconch. Right valve cardinal hook-shaped and merging with anterolateral, or with hinge teeth that appear similar in right and left valve (Condylocardiinae). 2
2. Shell with commarginal ribs only. 3
   Shell smooth, with radial ribs or with radial and commarginal ribs. 9
3. Inner ventral margin denticulate. 4
   Inner ventral margin smooth. 5
4. Prodissoconch about 40% of dissoconch length. Shell almost equilateral. . . . . *Condylocuna annieae* n. sp.
   Prodissoconch about 30% of dissoconch length. Shell inequilateral . . . . . *Condylocuna projecta*
5. Prodissoconch more than about 50% of dissoconch length with one central depression 6
   Prodissoconch less than 50% of dissoconch length with three radiating depressions 7
6. Prodissoconch with about six commarginal ribs . . . . . *Austrocardiella pouli* n. sp.
   Prodissoconch with about ten commarginal ribs . . . . . *Austrocardiella isosceles*
7. Cardinal hinge teeth not visible as distinct elements . . . . . *Condylocuna tricosa* n. sp.
   Cardinal hinge teeth visible and elaborate 8
8. Prodissoconch with radial ribs (three radial indentations) and about three commarginal ribs. . . . . *Austrocardiella trifoliata*
   Prodissoconch with small radial ribs, but no concentric ribs . . . . . *Condylocuna jimbecki* n. sp.

9. Shell smooth or with faint commarginal growth lines 10
Shell with distinct sculpture 11
10. Shell transparent with pink tinge when fresh. Prodissoconch length about 0.36 mm, inflation ratio between 1.56 and 2.17 . . . . . *Benthocardiella darwinensis* n. sp.
Shell clear when fresh. Prodissoconch length about 0.44 mm, inflation ratio between 1.27 and 1.70 . . . . . *Benthocardiella burtonae* n. sp.
11. Shell with 7–8 radial ribs . . . . . *Condylocardia cometa* n. sp.
Shell with more than eight radial ribs 12
12. Shell strongly convex anterodorsally and posterodorsally, looks shouldered in lateral aspect. Prodissoconch small, cup-shaped and with five indentations or four radial ribs . . . . . *Isodontocardia microcardia* n. sp.
Shell not strongly shouldered, generally triangular in outline. Prodissoconch large and conspicous in fresh shells 13
13. Prodissoconch D-shaped, central area raised and with two auricles (like a scallop). Right valve cardinal tooth anterior to ligament hook-like, curved ventrally 14
Prodissoconch more or less circular; if fresh commarginal ribs may be observed 17
14. Up to 12 radial ribs . . . . . *Condylocardia limaeformis*
More than 12 radial ribs 15
15. Shell inequilateral, displaced to halfway between posterior end and centre of shell . . . . . *Condylocardia pectinata*
Shell equilateral or slightly inequilateral 16
16. Shell with flat radial ribs and deep interspaces. Anterodorsal and posterodorsal margins straight or weakly convex . . . . . *Condylocardia rectangularis*
Shell with convex anterodorsal and posterodorsal margins, most prominent in larger specimens. Shells in some areas (south NSW coast) brown or mixture of brown and white . . . . . *Condylocardia notoaustralis*
17. Shell with strong concentric sculpture crossing radial ribs. Large shells (5–6.5 mm) very solid. Right valve with two large triangular cardinal teeth anterior and posterior to the central ligament. Left valve with one anterior and one posterior conspicuous cardinal, and two small lamellate cardinals proximal to ligament . . . . . *Cunanax pisum*
Concentric shell sculpture not conspicuous. Cardinal teeth either very long and diverging or small and similar looking in right and left valve 18
18. Cardinals small, right and left valve hinges similar. 12–16 radial ribs . . . . . *Cunanax subradiata*
Cardinals large and elongate. More than 20 radial ribs 19
19. Shell with wide hinge plate, cardinal teeth at less than 45 degrees to dorsoventral plane. Radial ribs between 20 and 24 . . . . . *Cunanax crassidentata*
Shell with narrow hinge plate, cardinal teeth at more than 45 degrees to the dorsoventral aspect. Max. 21 radial ribs . . . . . *Cunanax compressa*

Systematics

The present revision concerns the Australian genera of Condylocardiinae. The cunine genera *Micromeris* Conrad, 1866, *Mesocuna* Laseron, 1953 and *Particondyla* Laseron, 1953 were included in the Condylocardiinae by Chavan (1969), but they do not belong in this subfamily and are therefore excluded from this treatment (see Introduction).

Family **CONDYLOCARDIIDAE** Bernard, 1896

Diagnosis

Shells minute, generally under 2 mm, few up to 9 mm, trigonal to broadly ovate, commonly higher than long; radial ribs more or less marked, may be hidden by concentric sculpture or internal in shells. Ligament internal. Hinge teeth: CA3 dorsally curved into CA3a, CA3b, the latter being enlarged. Two laterals in each valve, each longer than half length of dorsal anterior and posterior slopes. Pallial line simple, adductor muscles isomyarian.

Remarks

The obliteration of the hinge tooth CA4 used in the diagnosis of Condylocardiidae by Chavan (1969) is not a consistent character for the whole family or either of the two subfamilies. Chavan's description of a CA5b to CA6b (5b–6b in text) as posterior to the ligament or CA4 is perplexing. The posterior cardinal in the left valve (here interpreted as CP3) is fused to the long posterior lateral, but has nothing to do with CA5b or CA6b.

Subfamily **CONDYLOCARDIINAE** Bernard, 1896

Diagnosis

Prodissoconch large, conspicuous and, in some species, sculptured. Hinge teeth: CA5 generally absent, if present directed anteroventrally. CA4b directed posteroventrally if not vestigial.

Remarks

The diagnosis by Chavan (1969) does not provide any solid distinction between the condylocardiines and the cunines. The prodissoconch size and shape is a very good character for the condylocardiines, despite one species having a small, slightly sculptured prodissoconch closely similar to the cunines. The CA5, characteristic of Cuninae, is found in one genus in the condylocardiines, but here directed anteroventrally, not posteroventrally as in the cunines. The cardinal CA4b is present in a few genera, but directed anteroventrally, not ventrally or posteroventrally as in the cunines. The difference between characters of the cunines and condylocardiines does not seem to call for separation at the family level.

Genus ***Condylocardia*** Bernard, 1896

Hippella Mörch, 1861: 199, invalid (*nomen oblitum*) ICZN opinion 872, 1969: 216. Type species (monotypy): *Hipella hippopus* Mörch, 1861: 200.

Condylocardia Bernard, 1896: 195. Type species: *Condylocardia santipauli* Munier-Chalmas in Bernard, 1896: 196, invalid emendation to *Condylocardia pauliana* by Bernard (1897*a*: 11). Moore's (1969) statement that the type selection was by subsequent designation of Cossmann (1902: 23) is in error, since Bernard (1897*a*: 11) unequivocally designates *Condylocardia pauliana* 'Espèce type de genre'.

Radiocondyla Iredale, 1936: 272. Type species (original designation): *Radiocondyla arizela* Iredale, 1936 (= *Condylocardia rectangularis* Cotton, 1930).

Diagnosis

A condylocardiine with shell less than 2.5 mm in length, triangular to oval; prodissoconch auricular, with central raised area and faint radial ribs. Dissoconch with radial ribs, ventral margin dentate. Hinge teeth: CA3 curved into CA3a,b; CA2 undivided and free.

Remarks

A syntype (no. 5) of *C. pauliana* from MNHN has been examined, and is here illustrated (Fig. 2). The specimen is slightly eroded but not so much as to obscure the generic characters. *Condylocardia pauliana* is very similar to *C. crassicosta* Bernard, 1896 from New Zealand and *C. limaeformis* Cotton, 1930 from Australia (see below). With only one syntype valve of *C. pauliana* available for comparison with *C. crassicosta* it is unclear whether they are conspecific.

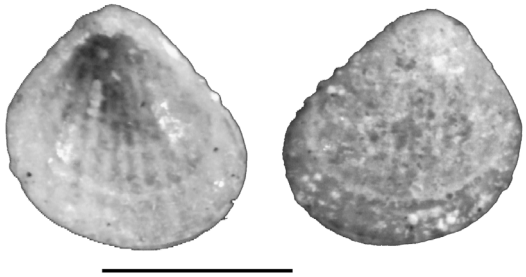

Fig. 2. *Condylocardia pauliana*. Syntype V, St Paul Island, South Indian Ocean. Scale bar: 1 mm.

Iredale (1936) used the closely set hinge teeth, flat radial ribs and larger size to distinguish *Radiocondyla* from *Condylocardia*, basing *Condylocardia* on *C. porrecta* (= *Cunanax subradiata*). These characters are, however, not sufficiently distinct from other members of *Condylocardia* to justify a separate genus.

Condylocardia cometa n. sp.

(Figs 3*a–e*, 5)

Material examined

Holotype. C379938 (1v) (Fig. 3*a*, *d*, *e*) SE of King Is., Bass Strait, Tasmania, 40°10.5′S 144°18.6′E, 51 m, 24 April 1973, coll. M. T. Sprightly.

Paratypes. C379940 (2v) (Fig. 3*b*, *c*) NW of Sandy Cape, Tasmania, 41°9.4′S 144°10.6′E, 132 m, 14 April 1973, coll. M. T. Sprightly.

Other material examined. **Tasmania**. W of Port Davey, 43°20.3′S 145°48.2′E, 82 m, 9 April 1973, C379939 (1v).

Description

Shell. Maximum length 1.35 mm, maximum height 1.34 mm, equilateral, orthogyrate, translucent or opaque white. Inflation ratio, 1.45–1.82.

Prodissoconch. Maximum length 390 µm, consisting of prodissoconch I and II. Prodissoconch I with one central indentation, prodissoconch II with slight radial pattern, rim sharp. Anterior and posterior prodissoconch auricles present.

Dissoconch. Lunule and escutcheon short, narrow with commarginal sculpture. Outline triangular, anterior and posterior end angled. Anterior and posterior dorsal slopes flat or very weakly convex, ventral margin concave. External sculpture of few major erratic and numerous fine growth lines, 7–8 strong radial ribs. Inner margin denticulate with 6–9 denticles. Hinge plate narrow and short. Two smooth lateral teeth in each valve. Right and left valve anterior lateral teeth (LAI, LAII) and posterior lateral (LPIII, LPII) long. Right valve anterior cardinal tooth (CA3) strongly arched, divided into anterior cardinal teeth elements CA3a,b. Posterior cardinal tooth (CP3) small, divided into elements CP3a,b. Left valve anterior cardinal teeth (CA2 and CA4) present, cardinal tooth CA4 divided dorsally into teeth elements CA4a,b. Posterior cardinal teeth (CP2 and CP4) present, CP2 the largest. Internal ligament 50 µm long, rounded, in resilium.

Dimensions. See Table 1.

Distribution

Western Tasmania; on continental shelf, 51–131 m. Habitat unknown. This species is only known from shells.

Table 1. Measurements of specimens of *Condylocardia cometa* n. sp.

	SL (mm)	SH (mm)	PL (mm)	SI (mm)	SL/SI×2
Condylocardia cometa, holotype, C379938	1.00	1.00	0.33	0.29	1.72
Condylocardia cometa, paratypes, C379940 (Fig. 3*b*)	1.19	1.17	0.32	0.37	1.61
(Fig. 3*c*)	1.13	1.01	0.34	0.31	1.82
C. cometa, C379939	1.33	1.34	0.39	0.46	1.45

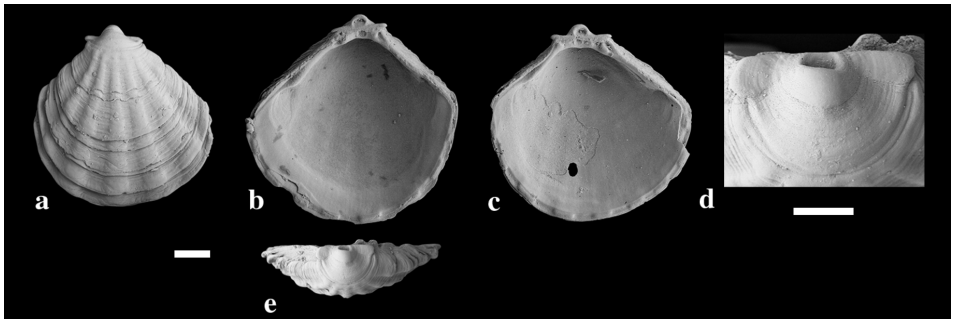

Fig. 3. *Condylocardia cometa* n. sp. Holotype C379938, SE of King Is., Bass Strait, Tasmania, *a*, *d*, *e*. Paratypes C379940, NW of Sandy Cape, Tasmania, *b*, *c*. Scale bars: *a–c*, *e*, 200 µm; *d*, 100 µm.

Remarks

Condylocardia limaeformis Cotton, 1930 is closely similar to this species. The fewer radial ribs (7–8 instead of 9–12), the angled anterior and posterior ends and the equilateral beaks separate shells of *C. cometa* from *C. limaeformis*.

Etymology

From Latin *cometa* meaning ‘a comet’.

Condylocardia limaeformis Cotton, 1930

(Figs 4*a–p*, 5)

Condylocardia crassicosta Bernard, 1897*a*. Verco, 1908*a*: 360. – Gatliff & Gabriel, 1909: 46; May, 1909: 54, pl. 6, fig. 6; May, 1921: 14; May, 1923: pl. 7, fig. 9; Macpherson & Gabriel, 1962: 321 (not Bernard, 1897*a*).

Condylocardia limaeformis Cotton, 1930: 238, fig. 12 (type locality: Cape Borda, South Australia, 113 m. Holotype, SAMA D.10112 (1v) (Fig. 4*a*)). – Lamprell & Healy, 1998: 168, fig. 472.

Condylocardia adelaideana Cotton & Godfrey, 1938: 194, fig. 195 (type locality: Backstairs Passage, South Australia, 40 m. Holotype, SAMA D.12609 (1v) (Fig. 4*b*), paratypes, SAMA D.12610 (3pr, 2v)). – Macpherson & Chapple, 1951: 17; Kershaw, 1955: 296.

Radiocondyla adelaideana (Cotton & Godfrey, 1938). Cotton, 1961: 207, fig. 201. – Lamprell & Healy, 1998: 172, fig. 498.

Condylocardia kunopia Laseron, 1953: 39, figs 10, 10a (type locality: Narrabeen Beach, Sydney, New South Wales, 33°42′S, 151°18′E, Pre 1951, coll. C. F. Laseron. Lectotype (here selected), C090557 (1v) (Fig. 4*c*), paralectotypes C388179 (2v)). – Iredale & McMichael, 1962: 17; Jansen, 1995: 101, fig. 423; Lamprell & Healy, 1998: 168, fig. 475.

Condylocardia sp. Laseron, 1953: 39, 12, 12a.

Other material examined. **New South Wales**. *Sydney area*: Off Chinaman's Beach, 33°48.97′S 151°14.87′E, 3.5–7.5 m, 1967, C379891 (1v); Balmoral Beach, 33°49.7′S 151°15.03′E, 1957, C366855, (1v); Little Coogee Bay, 33°55.25′S 151°15.7′E, 21 April 1895, C379901 (1pr); same locality, 19 July 1895, C379903 (1pr); Bate Bay, Cronulla Beach, 34°2.5′S 151°10′E, 1967, C379934 (13v); Gunnamatta Bay, 34°3.95′S 151°8.55′E, 4 Sep. 1926, C347816 (1v). Werri Beach, Gerringong, 34°44.3′S 150°50′E, beach, 1950, C366858 (4v). Sussex Inlet, Wreck Bay, 35°11′S 150°35′E, 1955, C366851 (1v). Pebbly Beach, 35°36.8′S 150°19.7′E, 1980, C366852 (3v). Batemans Bay, 35°43′S 150°12′E, shell sand on beach, 1950, C366853 (3v). Broulee, near Moruya, 35°51.5′S 150°10.5′E, 1985, C379890 (2v). Bermagui, Shelly Beach, 36°25′S 150°5′E, 1967, C366857 (28v). Eden Harbour, 37°4.45′S 149°54.5′E, 1955, C366856 (16v). Twofold Bay, 37°5′S 149°54′E, 27–46 m, 1953, C315615 (1v). Twofold Bay, 37°5′S 149°54′E, shore material, 1919, C366854 (4v). Boydtown, Twofold Bay, 37°6′S 149°53′E, beach, 1965, C379937 (1v). **Victoria**. Mallacoota, 37°34′S 149°56′E, 1918, C50489 (7v). Bass Strait, 44 km S of Marlo, 38°12′S 148°35′E, 146 m, flat outer shelf, 7 May, 1969, C379895 (2v). Between Eagle and Crawfish Rock, North West Arm, Western Port, 38°16′S 145°17′E, 3.6–5.5 m, 15 Feb. 1969, C379894 (1pr). Sandy Point, Western Port, just N of North Arm, 38°24.3′S 145°14.2′E, 7.5 m, sandy mud and shell, 28 Feb. 1977, C379896 (3v). Port Phillip, Frankston, 38°9′S 145°10′E, 1910, C30193 (2pr). Port Phillip Bay, Macrae, 38°20.9′S 144°55.5′E, 1967, C379902 (1v). Portarlington, Port Phillip Bay, 38°7′S 144°39′E, on *Galeolaria*, 22 March 1975, C379904 (1v). **Tasmania**. Blythe (Siding), near Burnie, 41°5′S 146°E, March 1956, C379905 (2v). Sulphur Creek, between Penguin and Burnie, 41°6′S 146°2′E, C379900 (28v). Goat Is., Ulverstone, 41°8′S 146°8′E, Rat-tailed *Caulerpa* in large rockpools, 20 Feb. 1984, C379893 (1v). Goat Is., W of Ulverstone, 41°8′S 146°8′E, short brown algae in pool, intertidal rocks, 18 March 1975, C379898 (1v). Maria Is., 4 km NE Beaching Bay, 42°27.5′S 148°12′E, 82.5 m, 25 March, 1970, C379914 (9v). Frederick Henry Bay, 42°53′S 147°34′E, 1908, C29421 (4v). Tinderbox Bay, S of Hobart, 43°3′S 147°20′E, 15 m, 1955, C379899 (14v). S of D'Entrecasteaux Channel, 43°40.4′S 146°50.4′E, 104 m, 2 April 1973, C379892 (20v). **South Australia**. Adelaide, Outer Harbour Beach, 34°49′S 138°29′E, 1957, C379911 (3v). Gulf St. Vincent, Largs Bay, 34°49′S 138°29′E, 1967, C379913 (2v). Bluff Beach, Yorke Peninsula, 34°44′S 137°29′E, rocks on intertidal limestone bench, 23 Feb. 1985, C379907 (2v). Spencer Gulf, Hardwicke Bay, 34°45′S 137°18′E, sand, 1902, C13447 (2v). Kangaroo Island, Stokes Bay, 35°37′S 137°12′E, stones on sheltered boulder shore, low tide, 4 March 1978, C379906 (4v). Spencer Gulf, Tumby Bay, 34°22′S 136°8′E, 1967, C379921 (28v). Fisherman Point, Cape Donnington, 34°45.5′S 135°59′E, stones in sheltered intertidal rocks, C379909 (2v) and in coralline turf on sheltered intertidal rocks, C379910 (1pr), 14 Feb. 1985. **Western Australia**. *Off Esperance*: 34°22.9′S 121°3.5′E, 85 m, coarse shell sand, Feb. 1981, C379919 (1v); 34°1.8′S 121°1.8′E, sand, 3 Feb. 1981, C379918 (3v). Two Mile Beach, Hopetoun, 33°57′S 120°7′E, 9 Jan. 1975, C379920 (1v). *Off Albany*: 35°14.4′S 118°20.5′E, 75 m, sand and shell, 12 March 1980, C379916 (1v); 35°6.4′S 118°10.6′E, 72 m, fine sand, 12 March 1980, C379915 (1v); 35°9.1′S 117°49′E, 64 m, coarse sand, 13 March 1980, C379917 (1v).

Description

Shell. Maximum length 1.43 mm, maximum height 1.49 mm, slightly inequilateral, orthogyrate, transparent to opaque white. Inflation ratio, 1.29–2.02.

Prodissoconch. Maximum length 360 μm, consisting of prodissoconch I and II. Prodissoconch I with one central indentation, prodissoconch II with slight radial pattern and sharp rim. Anterior and posterior prodissoconch auricles present.

Dissoconch. Lunule and escutcheon smooth, short and narrow. Outline triangular, anterior and posterior end angled. Anterior and posterior dorsal slopes straight or weekly convex. External sculpture of fine commarginal growth lines and 9–12 strong radial ribs. Inner margin denticulate, with 9–12 denticles. Hinge plate narrow and short. Two smooth lateral teeth present in each valve. Right and left valve anterior lateral tooth (LAI, LAII) and posterior lateral tooth (LPIII, LPII) long. Right valve anterior cardinal tooth (CA3) strongly arched, divided into anterior cardinal elements CA3a,b. Posterior cardinal tooth (CP3) present, divided into elements CP3a,b. Left valve anterior cardinal teeth (CA2 and CA4) present, CA4 divided into elements CA4a,b. Posterior cardinal teeth (CP2 and CP4) present, CP2 the largest. Internal ligament, 80 μm long, rounded, in resilium.

Dimensions. See Table 2.

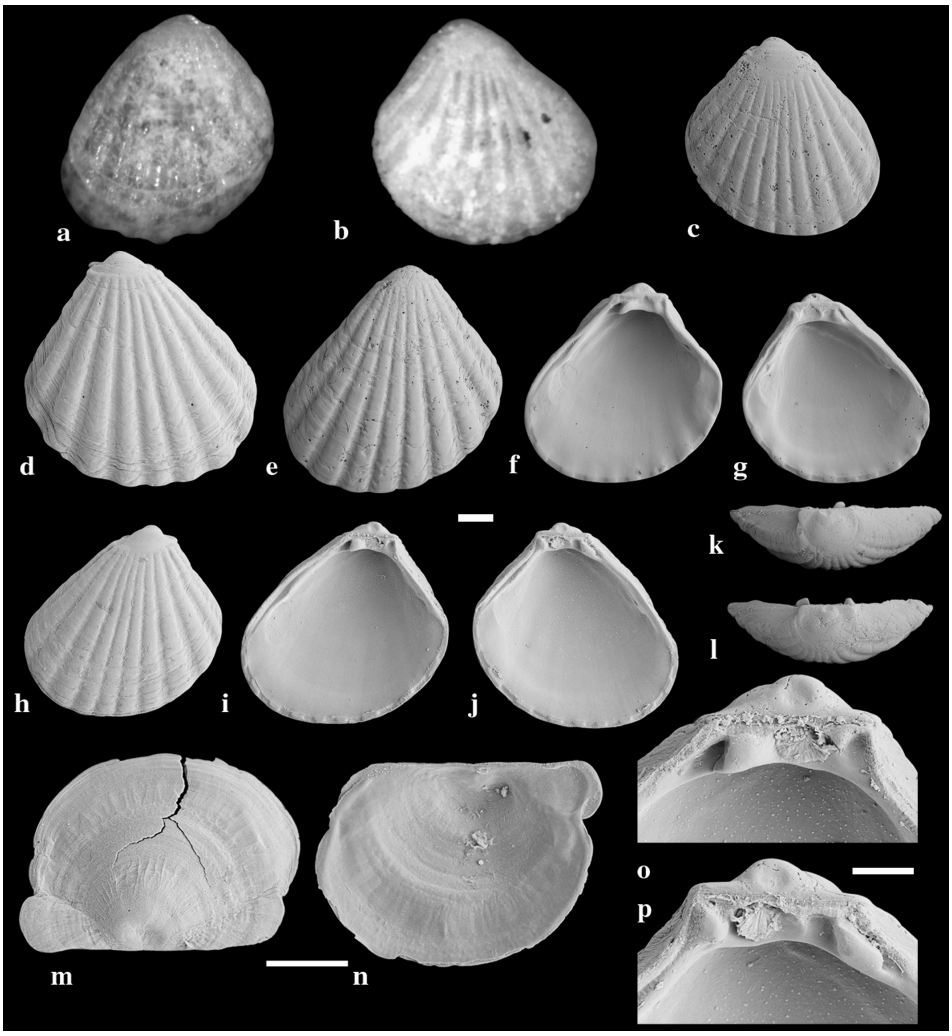

Fig. 4. *Condylocardia limaeformis*. *a*, *Condylocardia limaeformis* holotype SAMA D.10112, Cape Borda, South Australia. *b*, *Condylocardia adelaideana* holotype SAMA D.12609, Backstairs Passage, South Australia. *c*, *Condylocardia kunopia* lectotype C090557 Narrabeen Beach, Sydney, New South Wales. *d*, C379906, Kangaroo Island, South Australia. *e–g*, C379934, Cronulla, New, South Wales. *h–p*, C366856 Eden, New South Wales. Scale bars: *a–l*, 200 µm; *m–p*, 100 µm.

Reproduction

One embryo observed in each of two dried specimens.

Distribution

Mid New South Wales south to Victoria, Tasmania, South Australia and southwestern Western Australia; from intertidal rock pools to 146 metres. Shells have been collected intertidally in turfing algae, under stones, in sand or from shelly bottoms. This species is only known from shells.

Table 2. Measurements of specimens of *Condylocardia limaeformis* Cotton, 1930

	SL (mm)	SH (mm)	PL (mm)	SI (mm)	SL/SI×2
Condylocardia limaeformis, holotype, SAMA D.10112 (Fig. 4*a*)	1.29	1.37	0.28	0.50	1.29
Condylocardia adelaideana, holotype, SAMA D.12609 (Fig. 4*b*)	1.29	1.23	0.32	-	-
Condylocardia kunopia, lectotype, C090557 (Fig. 4*c*)	1.13	1.14	0.40	0.28	2.02
Condylocardia limaeformis, C379921	1.24	1.22	0.36	0.34	1.82
	1.29	1.29	0.35	0.44	1.47
	1.43	1.49	0.36	0.49	1.46
	1.20	1.15	0.33	0.41	1.46
	1.13	1.19	0.34	0.38	1.49

Remarks

The holotype of *C. limaeformis* is a very eroded valve but recognisable as belonging to this taxon. The lectotype of *C. kunopia* is quite inflated compared to other measured material, but this is merely an indication of the shape variation in *C. limaeformis*. *Condylocardia pauliana* from St Paul Island and *C. crassicosta* from Stewart Island, New Zealand are morphologically very similar to specimens of this species but available material of *C. crassicosta* seems slightly stouter and has heavier hinge teeth than *C. limaeformis*. It seems likely that these three taxa, ranging from St Paul Island to Australia and New Zealand, have a common ancestry and may even be geographically isolated populations of one species.

As the distribution indicates (Fig. 5), there are disjunct concentrations of records. This is probably due to differing sampling intensity but may also be due to lack of appropriate habitat exposure, or even the existence of cryptic species.

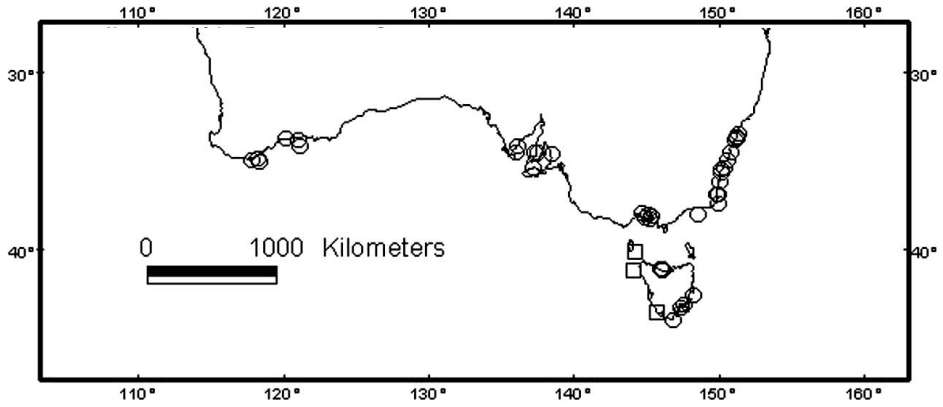

Fig. 5. Distribution of *Condylocardia limaeformis* (○) and *C. cometa* n. sp. (□).

Condylocardia notoaustralis Cotton, 1930

(Figs 6*a–p*, 7*A*, *B*, 8, 9)

Condylocardia australis Bernard, 1897*a.* – Verco, 1908*a*: 360; Gatliff & Gabriel, 1912*b*: 173; Macpherson & Chapple, 1951: 17 (not Bernard, 1897*a*).

Condylocardia notoaustralis Cotton, 1930: 239, fig. 13 (type locality: off Beachport, South Australia, 366 m. Holotype SAMA D.10109 (Fig. 6*a*) (1v)). – Cotton, 1961: 203, fig. 208; Lamprell & Healy, 1998: 168, fig. 471.

Condylocardia rotunda Laseron, 1953: 39, figs 11, 11a (type locality: Narrabeen Beach, Sydney, New South Wales. 33°42′S, 151°18′E. Pre 1951. coll. C. F. Laseron. Lectotype (here selected) (1v) (Fig. 6*b*) C090558. Paralectotypes, C388182(5v)). – Iredale & McMichael, 1962: 17; Jansen, 1995: 101, fig. 424; Lamprell & Healy, 1998: 168, 476.

Radiocondyla jacksonensis Laseron, 1953: 42, figs 19, 19a (type locality: off Sow and Pigs Reef, Western Channel, Sydney Harbour, 33°50.3′S 151°16.1′E, 11–16 m, 1948. Lectotype (here selected) (1v) (Fig. 6*c*) C090559. Many valves of paralectotypes C388183). – Iredale & McMichael, 1962: 17; Lamprell & Healy, 1998: 172, fig. 497.

Other material examined. **Queensland**. Off S end Fraser Is., 25°48′S 153°46′E, 73 m, soft corals, 10 Nov. 1976, C379856. Rainbow Beach, Wide Bay, S of Fraser Is., 25°54′S 153°5′E, 1955, C379271 (2v). ESE of Noosa Heads, 26°34′S 153°40′E, 128 m, 30 March 1969, C379266 (1v). Off Cape Moreton, 27°S 153°35′E, 128–183 m, 1967, C378963 (4v). **New South Wales**. E of Yamba, 29°30′S 153°26.3′E, 53 m, 21 Feb. 1972, C378921 (17v). 12 km E of Cakora Point, S of Yamba, 29°39.8′S 153°26.4′E, 55 m, 22 Feb. 1972, C379850 (19v). N of Coffs Harbour, 30°S 153°23′E, 61 m, 22 Feb. 1972, C379853. Off Laurieton, 31°40′S 152°50.4′E, 20 m, 25 Feb. 1972, C366806 (1v). Off Nelson Bay, Port Stephens, 32°43′S 152°15′E, 46–73 m, 1967, C366812 (18v) and C366814, (37v). Port Stephens, Fingal Bay, 32°45′S 152°10.5′E, beach, 1950, C366796 (5v). *Sydney area*: Off Patonga Beach, 33°33.6′S 151°16.8′E, 1959, C366801 (3v); Pittwater, 33°37′ 151°18′E, 1950, C347807 (4v); Narrabeen Beach, 33°42′S 151°18′E, 1951, C366824, (3v) and C90558 (6v); Narrabeen Lake (=Narrabeen Lagoon), 33°42.9′S 151°16.8′E, 1967, C347808 (1v); 33°43′S 151°40′E, 143 m, 5 Dec. 1978, C378922 (2v); Collaroy Beach, 33°43.7′S 151°18′E, shell sand, 1950, C366310 (20+v); 33°45.4′S 151°21.6′E, 40 m, 29 March 1972, C366805 (6v); Manly Beach, 33°48′S 151°17′E, 1950, C366803 (13v) and 1957, C366795, (18v); Middle Harbour, 33°48.1′S 151°14′E, 1913, C35724 (15v); Fairlight, 33°48.2S 151°16.4′E, 1970, C347814 (12v); off Fairlight Beach, 33°48.2′S 151°16.4′, 6–9 m, in shell rubble, 28 Feb. 1981, C366748 (1pr), same locality, 5 m, in shell rubble, 7 May 1982, C405392 (20+pr wet); North Harbour, 33°48.5′S 151°16.5′E, 4 m, with weed, 1950, C347813 (6v) and C347817, (20+v); Little Manly Beach, 33°48.5′S 151°17.2′E, 1950, C366820, (20+v); Little Manly Point, 33°48.6′S 151°17.15′E, 6 m, in rubble and brown algae washings, 1 Dec. 1982 C347810, (52+v dry, 9 pr wet) and 15 m, in rubble, 1 Dec. 1982, C366745 (3pr); Chinamans Beach, 33°48.97′S 151°14.87′E, 1950, C366822 (1v); same locality 4–11 m, 1967, C366802 (11v) and 3.5–7.5 m, 1967, C366826 (10v); Old Mans Hat Point, N Quarantine Station, 33°49.3′S 151°17.4′E, 15 m, 19 June 1884, C366787 (10v); Quarantine Bay, 33°49′S 151°17′E, 27 m, 1950, C347811 (19v) and 9–11 m, 9 March 1969 C366799, (1v); between Grotto and Dobroyd Pts, 275 m off Washaway Beach, 33°49′S 151°16′E, 14.5–18 m, 9 March 1969, C366747 (4v); off Balmoral, 33°49.5′S 151°15.4′E, 3.5–9 m, 1950, C379260 (20+v); between North and South Heads, near North Channel, 33°49.8′S 151°17′E, 9 March 1969, C366823 (1pr); 33°50′S 151°19′E, 46–73 m, 1967, C366779 (12v); 33°50′S 151°18′E, 46 m, associated with sponge, 5 Feb. 1973, C366797 (1pr); Western Channel, 33°50′S 151°16′E, 27 m, 1967, C366798 (15v); Western Channel, off Sow and Pigs Reef, 33°50.3′S 151°16.1′E, 1875, C366776, (5v), 9 Jan. 1879, C366782 (20+v) and 7 m, C378553 (27v); 14 May 1881, C366780 (82v), C366828, (23v), and 9 m, C366818 (15v); 11–14.5 m, 1950, C366817 (46v); 1976, C366794, (40+v); off Georges Head, 33°50.5′S 151°15.7′E, 1900, C366830 (1v); Watsons Bay, 33°50.7′S 151°16.7′E, 1888, C11595 (10v); Watsons Bay, off Green Point, 33°50.5′S 151°16.5′E, 6 m, 23 Feb. 1981, C379268 (4v) and 14.6 m, 1887, C47624 (37v); Nielson Park, Bottle and Glass Rocks, 33°50.94′S 151°16.13′E, 3.5–7.5 m, 1950, C366781 (30v), 9 m, 1878, C366784 (4pr), 11–17 m, 1950, C366811 (2pr); off Morts Dock, Balmain, 33°51.4′S 151°11′E, 7 m, 22 Oct. 1963, C347818 (1v); off E end Shark Is., 33°51.6′S 151°15.4′E, 9 m, 1873, C378554 (1pr) and 22 m, 18 Dec. 1879, C366808 (2pr); 2 km E of Minstral Point, 33°56.7′S 151°16.7′E, 38 m, 19 May 1972, C366792 (1v); 33°58′S 151°29′E, 150 m, 18 June 1962, C366775 (1v); Botany Bay, 1.6 km W of Kurnell, 34°0.3′S 151°11′E, 3.5–5.5 m, 17 May 1946, C378924 (1v); Kurnell, Botany Bay, 34°0.58′S 151°12.38′E, 1950, C366777 (6v); Bate Bay, Cronulla Beach, 34°2.5′S 151°10′E, 28 May 1939, C366827 (3v) and 1967, C366786 (20+v); Port Hacking, Gunnamatta Bay, 34°3.95′S 151°8.55′E, low tide, 1950, C347815 (1v); same locality, SW

end, 34°4.3′S 151°8.7′E, in channel, 1950, C347806 (20+v). Shellharbour, 34°35′S 150°52′E, 1994, C378927 (1pr). Werri Beach, Gerringong, 34°44.3′S 150°50′E, 1950, C366804 (15v). 36 km E of Ulladulla, 35°20.3′S 150°52.3′E, 179 m, 17 March 1972, C378928 (1v). Pebbly Beach, 35°36.8′S 150°19.7′E, 1980, C366833 (1v). Batemans Bay, 35°43′S 150°12′E, shell sand on beach, 1950, C366785 (9v). Broulee, near Moruya, 35°51.5′S 150°10.5′E, 1985, C378918 (10v). Bermagui, Shelly Beach, 36°25′S 150°5′E, 1967, C379852 (40+v). E of Bermagui, 36°27′S 150°19′E, 354–384 m, 22 July 1975, C378920 (2v). 32 km SE of Twofold Bay, 37°26′S 150°15′E, 149 m, 19 June 1962, C366837 (15v). 40 km E of Twofold Bay, 37°27′S 150°17′E, 294–304 m, 19 June 1962, C366815 (2v). **Victoria**. Bass Strait, *c.* 44 km SE of Cape Everard, 38°15′S 149°12′E, 165–274 m, 9 May 1914, C378964 (3v). 30 km SW of Cape Everard, 38°3.83′S 149°8.83′E, 119 m, brown sandy clay, flat outer shelf, 7 May 1969, C378960 (10v). Sandy Point, Western Port, just N of North Arm, 38°24.3′S 145°14.2′E, 7.5 m, sandy mud and shell, 28 Feb. 1977, C378961 (6v). Point Leo, Western Port, 38°26′S 145°5′E, Aug. 1956, C378962 (1v). S of Warrnambool, 38°43′S 142°29′E, 75 m, 24 June 1962, C378958, (1v). **Tasmania**. Murray Pass, Deal Is., Bass Strait, 39°28′S 147°18′E, 30–50 m, in red algae, 9 May 1974, C378948 (1v). East Cove, Deal Is., Bass Strait, 39°30′S 147°20′E, 6–15 m, 3 May 1974, C378937 (3pr). E of King Is., 40°S 144°38.5′E, 46 m, 30 April 1973, C378943 (2v). N of Three Hummock Is., 40°9.2′S 145°11.6′E, 51 m, 24 April 1973, C378953 (2v). SE of King Is., Bass Strait, 40°10.5′S 144°18.6′E, 51 m, 24 April 1973, C378945 (9v). S of King Is., 40°20′S 144°36.4′E, 55 m, 12 April 1973, C378944 (15v). Off Cape Naturaliste, 40°50.6′S 148°46.5′E, 399 m, silty sand and bryozoa, 26 March 1973, C379263 (3v). Off NE coast, 41°3′S 148°42′E, 125 m, 24 March 1931, C378955 (26v). S of West Point, 41°9.2′S 144°24.2′E, 88 m, 14 April 1973, C378940 (7v). NW of Sandy Cape, 41°9.4′S 144°10.6′E, 132 m, 14 April 1973, C378952, (39v). Bass Strait, Marrawah (Green Point), 41°10.82′S 144°52.79′E, 27 Dec. 1996, C378947 (7v). W of Sandy Cape, 41°39.6′S 144°28.7′E, 186 m, 15 April 1973, C378951 (31v). Off Long Point, N of Bicheno, 41°45.5′S 148°31′E, 113 m, 27 March 1973, C378931 (26v). Between Cape Sorell and Sandy Cape, 41°49.5′S 144°46′E, 86 m, 15 April 1973, C379860 (1v). N of Cape Lodi, 41°50′S 148°17.3′E, 33 m, fine-medium sand, 24 March 1973, C379262 (9v). S of Cape Lodi, 42°S 148°18′E, 28 m, sandy, 19 March 1973, C378933 (4v). SE of Cape Lodi, 42°S 148°35.5′E, 148 m, medium coarse sand and bryozoa, 19 March 1973, C378934 (2v). Off Cape Forestier, 42°10′S 148°34.7′E, 205 m, pale grey clayey sand and bryozoa, 19 March 1973, C378932 (10v). Great Oyster Bay, 42°10.2′S 148°6.2′E, 14 m, muddy sand, 18 March 1973, C379264 (3v), and 42°20′S 148°13′E, 45 m, yellow brown sandy mud, 18 March 1973, C378941 (5v). Green Cape, Maria Is., 42°43′S 148°1′E, 5.5 m, 26 March 1970, C379859 (2v). S of Maria Is., 42°51′S 148°20.4′E, 157 m, coarse bryozoan sand, 13 March 1973, C379861 (18v). Derwent Estuary, 42°55′S 147°23.5′E, 1970, C68681 (4pr). SW of Low Rocky Point, 42°58.2′S 145°26.6′E, 84 m, 10 April 1973, C378946 (30v). Off Eaglehawk Neck, 43°S 148°13.6′E, 122 m, coarse bryozoan sand, 13 March 1973, C378936 (3v). Tinderbox Bay, S of Hobart, 43°3′S 147°20′E, 15 m, 1955, C378954 (38v). Wedge Bay, off Nubeena, 43°6′S 147°44′E, 7 m, 1967, C378950 (1v). NE of Cape Pillar, 43°10′S 148°6.7′E, 113 m, medium sand and bryozoa, 13 March 1973, C378930 (3v). W of Port Davey, 43°20.3′S 145°48.2′E, 82 m, 9 April 1973, C379851. Off Port Davey, 43°22.5′S 145°44.5′E, 144 m, 9 April 1973, C379858 (10v). S of D'Entrecasteaux Channel, 43°40.4′S 146°50.4′E, 104 m, 2 April 1973, C378935 (20+v). S of Storm Bay, 43°47′S 147°48.5′E, 212 m, 30 March 1973, C379857 (20v). N of Macquarie Harbour, 44°19.8′S 144°51′E, 170 m, 16 April 1973, C378949 (13v). **South Australia**. Normanville, S of Adelaide, 35°26.8′S 138°18.5′E, 1967, C378965 (2v).

Description

Shell. Maximum length 1.62 mm, maximum height 1.67 mm, equilateral, orthogyrate, opaque, either white, brown or combination of the two. Inflation ratio, 1.11–1.65.

Prodissoconch. Maximum length 380 µm, consisting of prodissoconch I and II. Prodissoconch I with one central indentation, prodissoconch II with slight radial pattern and sharp rim. Anterior and posterior prodissoconch auricles present.

Dissoconch. Lunule and escutcheon short and narrow with commarginal sculpture. Outline oval to triangular, proximal dorsal anterior and posterior slopes strongly convex, distal slopes almost straight. External sculpture of commarginal ribs, fine growth lines and 13–19 strong radial ribs. Inner margin denticulate, with 13–19 denticles. Hinge plate narrow and short. Two sculptured lateral teeth in each valve. Right and left valve anterior lateral teeth (LAI, LAII) and posterior lateral teeth (LPIII, LPII) long. Right valve anterior cardinal tooth (CA3) proximally arched, divided into anterior cardinal teeth elements

CA3a,b. Posterior cardinal tooth (CP3) vestigial. Left valve with two anterior cardinal teeth (CA2 and CA4), CA4 dorsally bent into the cardinal teeth elements CA4a,b. Two posterior cardinal teeth (CP2 and CP4) present. Internal ligament 70 μm long, rounded and in resilium.

Anatomy

Material examined

C405392 (20+ specimens), C347810, (9 specimens).

Description

Mantle edge simple. Mantle margin with one posterior fusion between exhalant and inhalant openings. Inhalant opening (Fig. 7*A*, 1) extends from anterior end to posterior gill connection to the mantle edge. Exhalant siphon absent or very short, barely protruding beyond shell margin. Anus positioned just below posterior adductor muscle. Ctenidia with inner demibranch only, with about 17 filaments, sloping anteroventrally, length more than half shell length. Labial palps small, positioned at tip of most anterior gill filament, very close to anterior adductor muscle. Adductor muscles isomyarian. Small pedal retractor present anteriodorsally. Footh curved anteriorly, with longitudinal groove, sole. Byssus gland not observed.

Dimensions. See Table 3.

Reproduction

Up to 16 embryos and eggs in suprabranchial cavity. One specimen contained three large embryos and four smaller developing eggs, another contained three large embryos and five developing eggs. Embryos observed in specimens sampled in December (C347810).

Distribution

Southern Queensland, New South Wales, Victoria, Tasmania and South Australia. Shallow subtidal, continental shelf, and slope, 4–399 m (live specimens at 5–6 m depth, other depths shells only). Empty shells have been sorted from rubble, shell rubble, sand, bryozoan sand, clayey sand, clay, mud, sandy mud. Have been found live subtidally in rubble and brown algae washings (C405392, C347810).

Remarks

This taxon, as recognised here, is very variable in both colour and shape. The growth of the shell from juvenile to adult passes through a phase with convex anterior and posterior margins (see Fig. 6*c–e*) (like the type of *C. notoaustralis*), and a slightly elongated form (note the non-isometric pattern in Fig. 9). The convexity becomes less pronounced as the shell enlarges. The shells from New South Wales are the largest and, around Sydney, brown (like the type of *C. jacksonensis*). However, examination of specimens from throughout the range has failed to establish any character, colour or form that consistently separates these phenotypes. See Table 3 for shell measurements of these two forms.

This species is easily confused with juvenile *C. subradiata* but the smaller auricular prodissoconch (0.31±0.06 mm versus 0.66±0.11 mm (X±SD)) and the simpler hinge readily separate them.

Condylocardia notoaustralis may be separated from the closely similar species, *C. pectinata* by the consistently equilateral beaks.

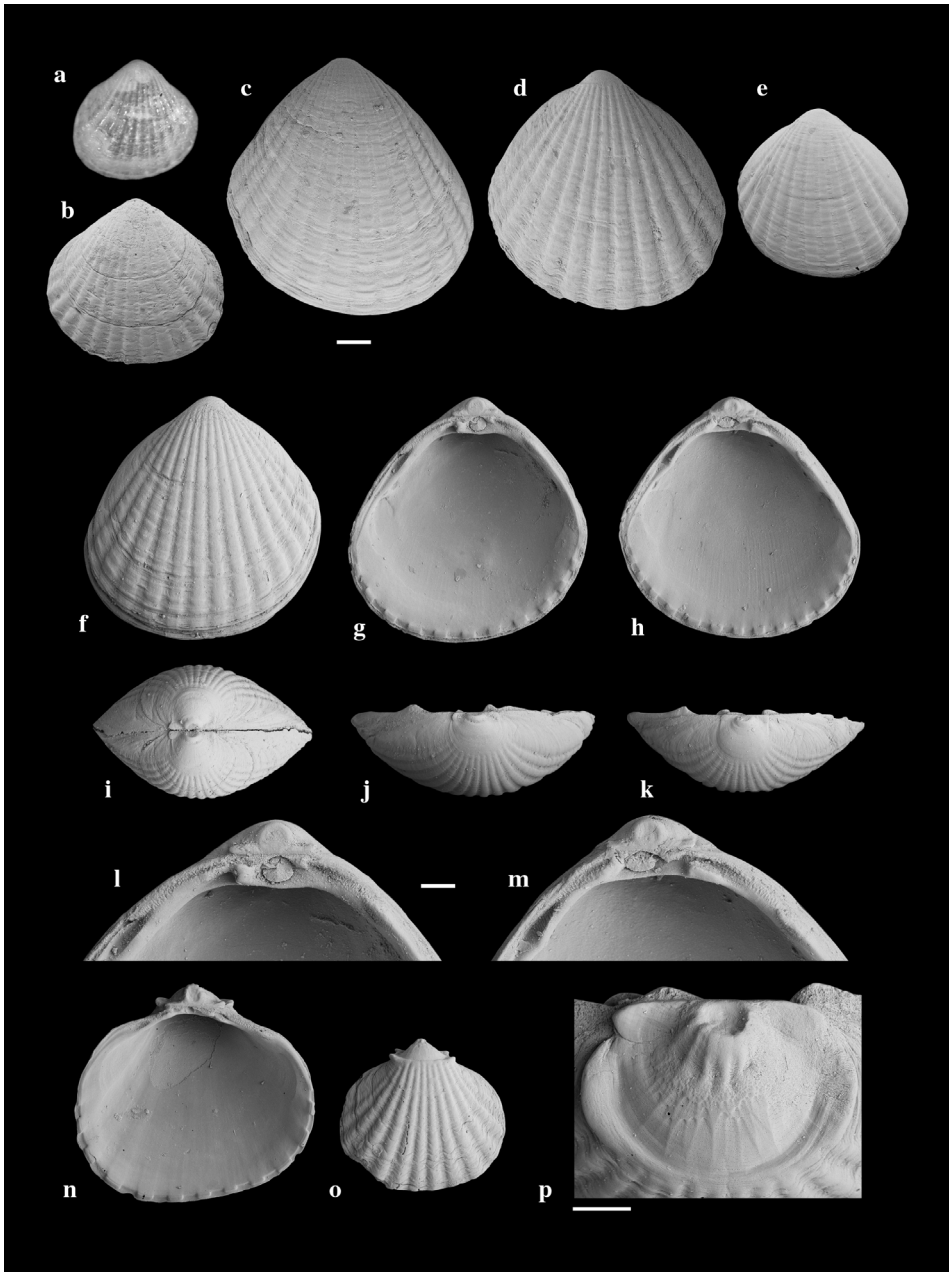

Fig. 6. *Condylocardia notoaustralis*. *a*, *Condylocardia notoaustralis* holotype SAMA D.10109, off Beachport, South Australia. *b*, *Condylocardia rotunda* lectotype C090559 Narrabeen Beach, Sydney, New South Wales. *c*, *Radiocondyla jacksonensis* lectotype C090559, off Sow and Pigs Reef, Sydney Harbour, New South Wales. *d*, *R. jacksonensis* paralectotype no. 3. *e*, *R. jacksonensis* paralectotype no. 4 (*d* and *e* both in lot C388183). *f–m*, C379265, off Sow and Pigs Reef, New South Wales. *g*, *j*, *l*, same valve. *h*, *k* ,*m*, same valve. *n–p*, C379851, W of Port Dovey, Tasmania. Scale bars: *a–k*, *n*, *o*, 200 µm; *l*, *m*, 100 µm; *p*, 100 µm.

Table 3. Measurements of specimens of *Condylocardia notoaustralis* Cotton, 1930

	SL (mm)	SH (mm)	PL (mm)	SI (mm)	SL/SI×2
Condylocardia notoaustralis, holotype, SAMA D.10109 (Fig. 6*a*)	0.73	0.80	0.19	0.33	1.11
Condylocardia rotunda, lectotype, C090558 (Fig. 6*b*)	1.03	0.97	0.32	0.38	1.36
Radiocondyla jacksonensis, lectotype, C090559 (Fig. 6*c*)	1.44	1.50	0.25	0.54	1.33
Condylocardia notoaustralis (brown northern phenotype), C366781	1.62	1.67	0.26	0.65	1.25
	1.45	1.47	0.31	0.49	1.48
	1.41	1.35	0.28	0.48	1.47
	1.22	1.09	0.32	0.37	1.65
	1.13	1.08	0.26	0.33	1.71
Condylocardia notoaustralis (white southern phenotype), C378951	1.33	1.26	0.37	0.57	1.17
	1.32	1.33	0.37	0.49	1.35
	1.36	1.34	0.35	0.53	1.28
	1.33	1.12	0.35	0.43	1.55
	1.30	1.18	0.38	0.46	1.41

The holotype of *C. notoaustralis* (Fig. 6*a*) does not match the original illustration well (Cotton 1930: p.238, fig. 13). The illustrated specimen has curved radial ribs, not straight central ribs as in the type specimen, and 12 instead of the 13 radial ribs mentioned in the text. The originally cited size is 1.5 mm × 1.4 mm (probably length × height). This is quite different from the actual measurements, 0.73 mm long, 0.80 mm high. Although the illustration of the type is very imprecise, the factor 2 measuring error may be due to calculation error. Although Cotton in his original description does not refer to a holotype but just 'type', he does list the type with holotype status in 1962: p. 263. Thus, no confusion should exist as to which specimen was measured and illustrated, unless the type has been switched between the description in 1930 and the subsequent reference to it in 1962.

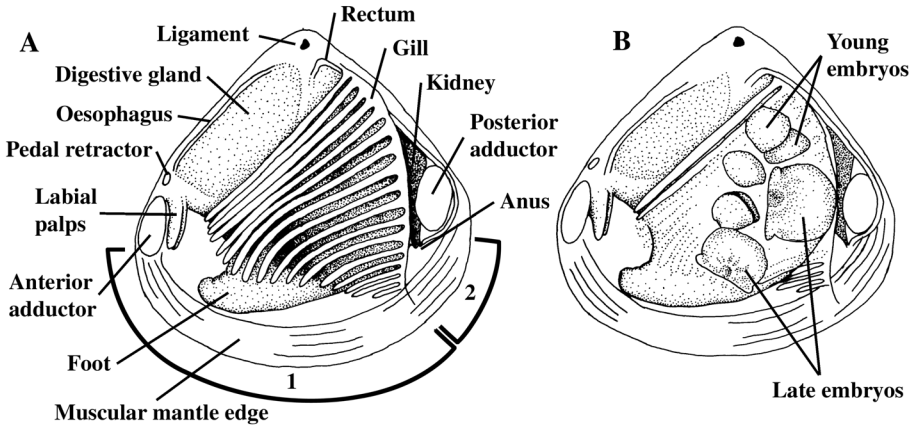

Fig. 7. *Condylocardia notoaustralis*. *A*, Animal with demibranch intact; 1, is the inhalant opening and 2, the exhalant opening. *B*, Animal with embryos of varying stages of development in the suprabranchial cavity.

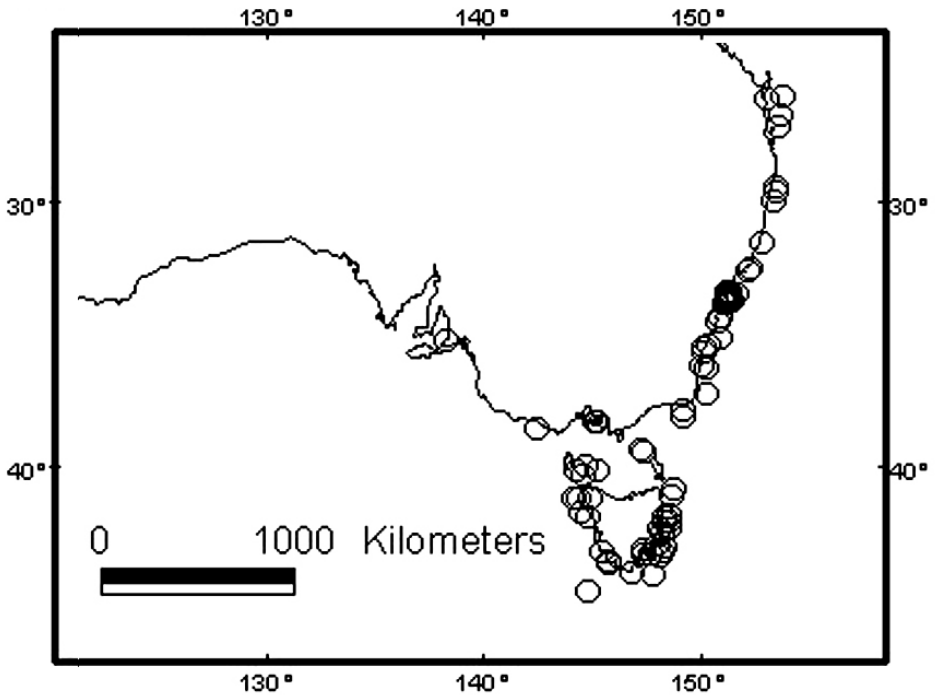

Fig. 8. Distribution of *Condylocardia notoaustralis*.

Condylocardia australis Bernard, 1896 from St Paul Island in the southern Indian Ocean is very similar to the oval, white specimens predominating in southern Australia. It seems unlikely that there has been a genetic exchange between these very isolated populations and

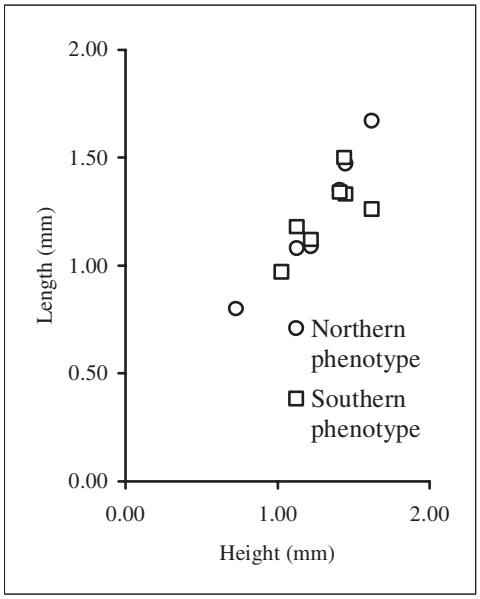

Fig. 9. *Condylocardia notoaustralis*. Height as a function of length in types, one southern and one northern population.

these taxa are maintained as distinct until more is known about *C. australis*. Three records of *C. australis* have been published from Australia (see synonymy). Cotton (1930) treated these records as misidentifications and described the Australian species as *C. notoaustralis*.

Successive stages from eggs to ready-to-hatch embryos have been found brooded in the suprabranchial cavity (Fig. 7*B*). This indicates either continuous brooding or an extended period in which reproduction takes place.

Condylocardia pectinata (Tate & May, 1900)

(Figs 10*a–i*, 12)

Carditella pectinata Tate & May, 1900: 103 (type locality: Derwent Estuary, Tasmania. Holotype (Fig. 10*a*) TMH 7512/E171 (2 valves presumably from same specimen)). – Tate & May, 1901: 435, pl. 27, figs 96, 97.

Condylocardia pectinata (Tate & May, 1900). Hedley, 1902: 318. – Pritchard & Gatliff, 1904: 231; Verco, 1908*a*: 359; Hedley, 1918: M17, 163; May, 1921: 17, no. 113; May, 1923: pl. 7, fig. 10; Macpherson & Chapple, 1951: 17.

Cuna pectinata (Tate & May, 1900). Hedley & May, 1908: 125, pl. 25, figs 43–45.

Condylocardia acuta Cotton, 1931: 353, fig. 18 (type locality: Cape Borda, South Australia. Holotype (Fig. 10*b*) SAMA D.10128).

Radiocondyla pectinata (Tate & May, 1900). Allan, 1950: 307, text fig. 11. – Kershaw, 1955: 296; Cotton, 1961: 207, fig. 212. Macpherson & Gabriel, 1962: 321; Lamprell & Healy, 1998: 172, fig. 499.

Radiocondyla acuta (Cotton, 1931). Cotton, 1961: 208, fig. 211. – Lamprell & Healy, 1998: 174, fig. 500.

Other material examined. **New South Wales**. 9–12 km NE of Cape Three Points, 33°32.5′S 151°31.4′E, 75–91 m, sticky mud and shell, 25 Feb. 1898, C16912 (2v). Sydney, Middle Harbour, 33°48.1′S 151°14′E, 1926, C345156 (23v). 26 km E of Wollongong, 34°25′S 151°15′E, 183 m, Aug. 1902, C18229 (20+). Broulee, near Moruya, 35°51.5′S 150°10.5′E, 1985, C380085 (1v). 40 km E of Twofold Bay, 37°27′S 150°17′E, 294–304 m, 19 June 1962, C366838 (2v). **Victoria**. Bass Canyon, 53 km S of Cape Conran, 38°18.33′S 148°39′E, 750 m, May 1969, C380088 (3v). Bass Strait, 44 km S of Marlo, 38°12′S 148°35′E, 146 m, flat outer shelf, 7 May 1969, C380090 (8v). **Tasmania**. Bass Strait, E of Grassy, King Is., 40°11′S 144°39′E, 58 m, 23 June 1962, C380078 (9v). Bass Strait, Marrawah (Green Point), 41°10.82′S 144°52.79′E, 27 Dec. 1996, C380087 (2v). Great Oyster Bay, 42°20′S 148°13′E, 45 m, yellow brown sandy mud, 18 March 1973, C380094 (5v). Green Cape, Maria Is., 42°43′S 148°1′E, 5.5 m, sublittoral algae, 26 March 1970, C380092 (3v). Derwent Estuary, 42°55′S 147°23.5′E, 1902, C10737 (7v). Eaglehawk Bay, Eaglehawk Neck, 43°1′S 147°55′E, 27 May 1903, C17718 (3v). Tinderbox Bay, S of Hobart, 43°3′S 147°20′E, 15 m, 1955, C380095 (43v). Wedge Bay, off Nubeena, 43°6′S 147°44′E, 7 m, 1967, C380076 (7v). Off Cape Pillar, 43°13′S 148°5′E, 183 m, 17 Dec. 1907, C29081 (3v). South Bruny Is., Great Taylor Bay, 43°27′S 147°10′E, 8 m, algae on sandy bottom, 14 Feb. 1973, C380093. **Western Australia**. Esperance, 33°52′S 121°54′E, 1968, C380096 (1v). Off Esperance, 34°7.4′S 121°12.7′E, fine sand, Feb. 1981, C380086 (5v) and 70–90 m, fine sand and shell, Feb. 1981, C380081 (1v). Off Albany: 34°54′S 118°50′E, 68 m, sand and broken shell, 21 March, 1980, C380083 (1pr); 35°14.4′S 118°20.5′E, 75 m, sand and shell, 12 March 1980, C380084 (1v); 35°9′S 117°46′E, 62 m, sand, 17 March 1980, C380082 (1v). Kilcarnup, N side of Margaret River, 33°57′S 114°59′E, 1 Jan. 1972, C380091 (1v).

Description

Shell. Maximum length 1.72 mm, maximum height 1.65 mm, inequilateral, orthogyrate, semitransparent and colourless or white to light brown. Inflation ratio, 1.32–1.62.

Prodissoconch. Maximum length 420 μm, consisting of prodissoconch I and II. Prodissoconch I with one central indentation and prodissoconch II with slight radial pattern and sharp rim. Anterior and posterior prodissoconch auricles present.

Dissoconch. Lunule and escutcheon short, narrow with commarginal sculpture. Outline oblique triangular, with extended anterior end and short, sharply angled posterior end. External sculpture of commarginal ribs and 16–17 strong radial ribs. Inner margin

denticulate, with 16–17 denticles. Hinge plate narrow and short. Two sculptured lateral teeth present in each valve. Right and left valve anterior lateral teeth (LAI, LAII) and posterior lateral teeth (LPIII, LPII) long. Right valve anterior cardinal tooth (CA3) ventrally arched, subdivided into anterior cardinal elements CA3a,b. Slender ventrally directed posterior cardinal tooth (CP3) present and divided into cardinal elements CP3a,b. Left valve anterior cardinal teeth (CA2 and CA4) present, CA4 divided into CA4a,b. Posterior cardinals (CP2 and CP4) present, CP4 vestigial. Internal ligament 120 μm long, rounded, in resilium.

Dimensions. See Table 4.

Distribution

Central New South Wales, south to southwestern Western Australia and Tasmania. Subtidal, down to continental slope, from 6 to 750 m depth. Shells found in mud, sand, shell sand or on algae in the subtidal zone. This species is only known from shells.

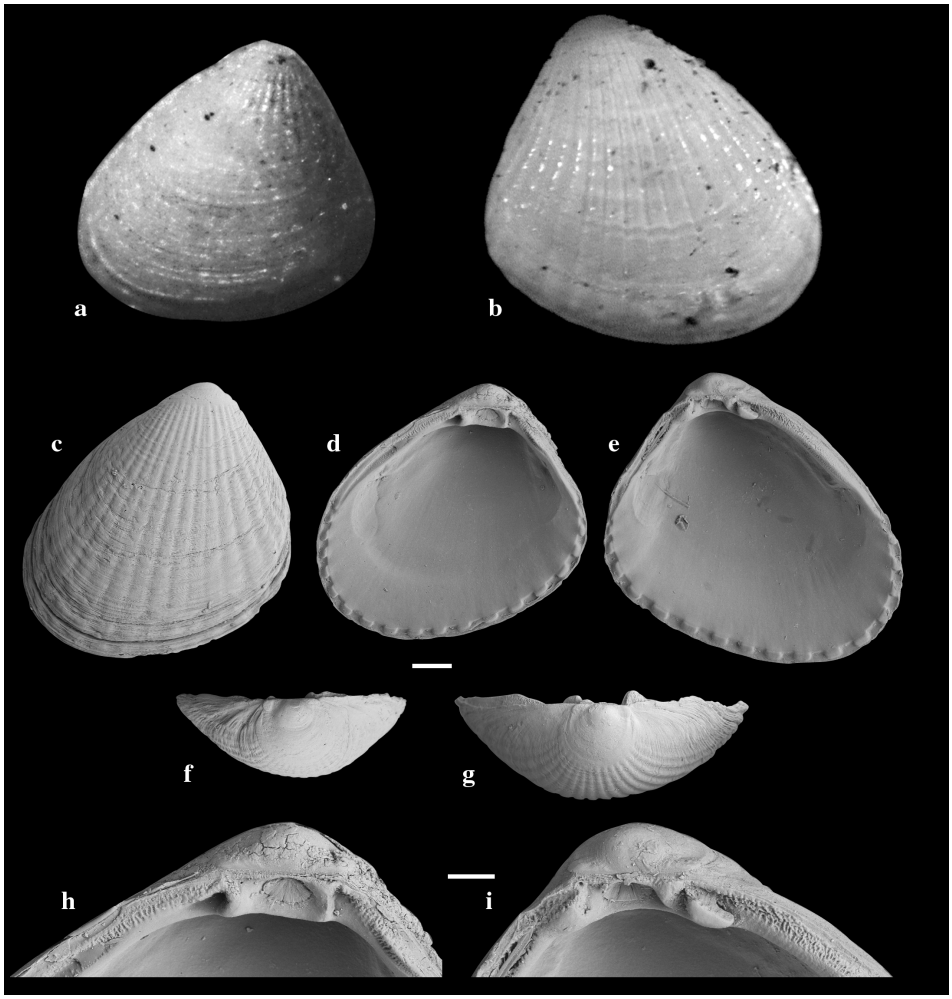

Fig. 10. *Condylocardia pectinata*. *a*, *Carditella pectinata* holotype TMH 7512/E171, Derwent Estuary, Tasmania. *b*, *Condylocardia acuta* holotype SAMA D.10128, Cape Borda, South Australia. *c–i*, C380076, Wedge Bay, Tasmania. Scale bars: *a–g*, 200 μm; *h*, *I*, 100 μm.

Table 4. Measurements of specimens of *Condylocardia pectinata* (Tate & May, 1900)

	SL (mm)	SH (mm)	PL (mm)	SI (mm)	SL/SI×2
Condylocardia pectinata, holotype (data from original description), TMH 7512/E171 (Fig. 10*a*)	1.50	1.50	-	-	-
Condylocardia acuta, holotype, SAMA D.10128 (Fig. 10*b*)	1.72	1.65	0.37	0.65	1.32
Condylocardia pectinata, C.380076	1.39	1.33	0.33	0.51	1.36
	1.62	1.53	0.37	0.51	1.59
	1.26	1.22	0.42	0.39	1.62
	1.39	1.29	0.39	0.43	1.62
	1.32	1.31	0.33	0.43	1.53

Remarks

This species is consistent in shape and sculpture and readily identifiable. Cotton (1931) distinguished *C. acuta* because it had fewer radial ribs than *C. pectinata*. However, this can hardly be valid as *C. acuta* has '18 ribs' and *C. pectinata* has '15 or more ribs' according to the original descriptions. Both radial rib numbers are within the range of the phenotypic variation of the species as interpreted herein (see description).

Condylocardia pectinata is most similar to *C. notoaustralis*, from which it can be separated by the inequilateral shell.

There appear to be large gaps in the distribution of *C. pectinata*, especially in South Australia and eastern Western Australia. It is unclear whether the gaps are due to the lack of sampling effort in these areas, true absence due to lack of suitable habitat, the existence of genuinely disjunct populations or cryptic species.

Condylocardia rectangularis Cotton, 1930

(Figs 11*a–k*, 12)

Condylocardia porrecta Hedley, 1906*b*. Hedley & May, 1908: 125, pl. 25, figs 41, 42 (not Hedley, 1906*b*).

Condylocardia rectangularis Cotton, 1930: 237, fig. 10 (type locality: off Beachport, South Australia, 73 m. Holotype SAMA D.14979 (ex. D.10113) (it is questionable whether the two valves belong to the same individual, see Table 5) (left valve illustrated Fig. 11*a*)). – Cotton, 1961: 203, fig. 205; Lamprell & Healy, 1998: 168, fig. 473.

Radiocondyla arizela Iredale, 1936: 272 (type locality: off Cape Pillar, Tasmania, 43°13′S 148°5′E, 183 m, 17 Dec. 1907. coll. and pres. C. Hedley and W. L. May. Lectotype (here selected) (1v) (Fig. 11*b*) C029082; Paralectotypes C388186, (Fig. 11*e–k*) (4v)). – Kershaw, 1955: 296 (sic *arezela*); Iredale & McMichael, 1962: 17; Lamprell & Healy, 1998: 172.

Other material examined. **Tasmania**. S of D'Entrecasteaux Channel, 40°39.5′S 147°20.5′E, 95 m, 1 April 1973, C379880 (31v) and 43°40.4′S 146°50.4′E, 104 m, 2 April 1973, C379883 (20+v). Off Cape Naturaliste, 40°50.6′S 148°46.5′E, 399 m, silty sand and bryozoa, 26 March 1973, C379885 (1v). SE of Cape Lodi, 42°S 148°35.5′E, 148 m, medium coarse sand and bryozoa, 19 March 1973, C379888 (1v). W of Port Davey, 43°20.3′S 145°48.2′E, 82 m, 9 April 1973, C379886 (4v). 3 km S Tasman Head, S Bruny Is., 43°33.75′S 147°19.35′E, 73 m, 24 March 1970, C379882 (16v). S of South East Cape, 43°42.2′S 146°18.6′E, 108 m, 4 April 1973, C379881 (14v). SE of Macquarie Harbour, 42°30′S 145°1′E, 104 m, 11 April 1973, C379889 (1v). SW of Sandy Cape, 41°39.5′S 144°37.1′E, 130 m, 15 April 1973, C379887 (6v). S of West Point, 41°9.2′S 144°24.2′E, 88 m, 14 April 1973, C379884 (4v). **South Australia**. SE of Kangaroo Is., 37°10′S 138°30′E, 155 m, 26 June 1962, C379879 (1v).

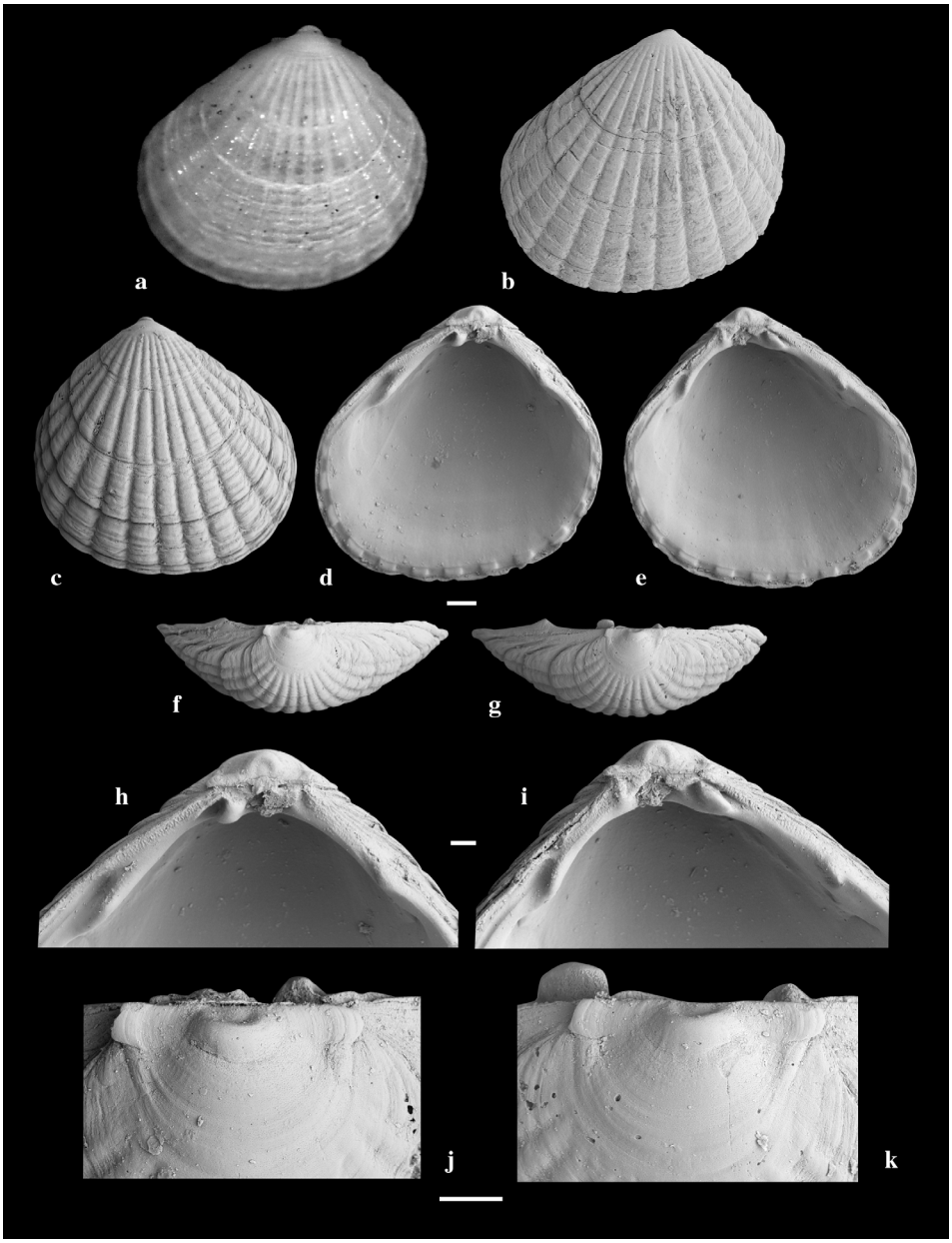

Fig. 11. *Condylocardia rectangularis*. *a*, *Condylocardia rectangularis* holotype SAMA D.14979, off Beachport, South Australia. *b*, *Radiocondyla arizela* lectotype C029082, off Cape Pillar, Tasmania. *c–k*, *Radiocondyla arizela* paralectotypes C388186, off Cape Pillar, Tasmania. Scale bars: *a–g*, 200 µm; *h*, *i*, *j*, *k*, 100 µm.

Description

Shell. Maximum length 2.21 mm, height 1.99 mm, slightly inequilateral, orthogyrate, translucent, white or light brown. Inflation ratio, 1.38–1.75.

Prodissoconch. Maximum length 480 μm, consisting of prodissoconch I and II. Prodissoconch I with one central indentation, prodissoconch II with slight radial pattern and sharp rim. Anterior and posterior prodissoconch auricles present.

Dissoconch. Lunule and escutcheon short, narrow, with commarginal sculpture. Outline triangular with anterior end slightly longer than posterior end. External sculpture of few major commarginal ribs, numerous commarginal growth lines and 13–14 flat but strong radial ribs. Inner margin denticulate with 13–14 denticles. Hinge plate narrow and short. Two sculptured lateral teeth in each valve. Lateral teeth of medium length (about half length of dorsal slopes), consisting of anterior LAI and posterior LPIII in right valve and anterior LAII and LPII in left valve. Right valve anterior cardinal tooth (CA3) strongly curved proximally, divided into anterior cardinal elements CA3a,b. Posterior cardinal CP3 visible, divided into CP3a,b. Left valve anterior cardinal teeth (CA2 and CA4) present, CA4 divided into CA4a,b. Posterior cardinal teeth (CP2 and CP4) present, CP2 the largest. Internal ligament 120 μm long, rounded, in resilium.

Dimensions. See Table 5.

Distribution

Tasmania and South Australia, from 9–399 m. Found in silty sand and sand with bryozoans. This species is only known from shells.

Table 5. Measurements of specimens of *Condylocardia rectangularis* Cotton, 1930

	SL (mm)	SH (mm)	PL (mm)	SI (mm)	SL/SI×2
Condylocardia rectangularis, holotype, SAMA D.14979 Left valve	2.21	1.96	0.48	0.63	1.75
Right valve, (Fig. 11*a*)	2.06	1.84	0.53	0.64	1.61
Radiocondyla arizela, lectotype, C029082 (Fig. 11*b*)	1.92	1.78	0.39	0.60	1.60
Condylocardia rectangularis, C379881	2.13	1.99	0.31	0.71	1.50
	1.69	1.91	0.35	0.52	1.63
	1.66	1.76	0.39	0.60	1.38
	1.78	1.93	0.40	0.62	1.44
	1.57	1.67	0.45	0.47	1.67

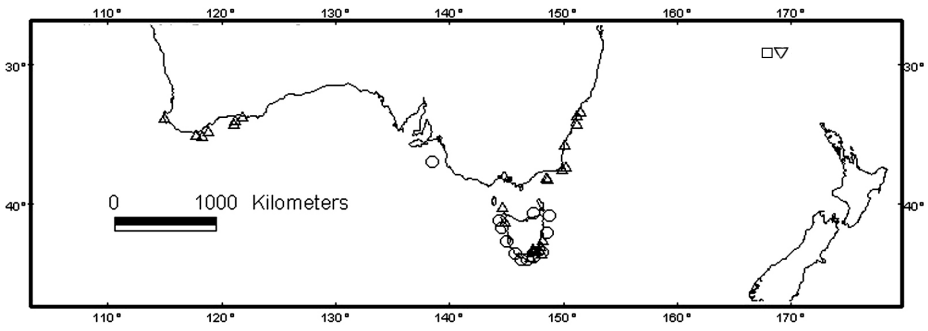

Fig. 12. Distribution of *Condylocardia rectangularis* (○), *C. pectinata* (Δ), *C. annieae* n. sp. (∇) and *Condylocuna jimbecki* (□).

Remarks

This species is very distinct, with wide, flat radiating ribs, inequilateral beaks and strongly hooked CA3. The prodissoconch readily separates *C. rectangularis* from *Cunanax subradiata*, the former having anterior and posterior prodissoconch auricles. It can be separated from *Condylocardia notoaustralis* by its flat, wide ribs, sharp anterior and posterior slopes and larger size and from *Condylocardia pectinata* by its narrow radiating ribs. *Condylocardia limaeformis* has fewer radials (up to 12 versus 13–14 in *C. rectangularis*).

Iredale (1936) renamed a shell, figured by Hedley and May (1908, pl. 25, figs 41, 42, as *Condylocardia porrecta*), *Radiocondyla arizela*, apparently unaware of Cotton's earlier description of the same taxon from South Australia. He also made it the type species of *Radiocondyla* Iredale, 1936. Despite being easily separable from the other members of *Condylocardia* revised herein, the taxon has no characters that would merit separation at the generic level (see also Remarks for the genus *Condylocardia*).

The disjunct distribution is possibly due to inadequate sampling in Victoria and South Australia.

Genus ***Austrocardiella*** n. gen.

Type species: *Condylocardia isosceles* Cotton, 1930.

Diagnosis

Very small condylocardiine, less than 1.5 mm long. Prodissoconch >40% length of adult, with commarginal pattern. Prodissoconch with single central or three radial indentations. Right valve anterior cardinal teeth consist of CA3 and CA5. Shell ovate, with weak commarginal ribs. Ventral margin smooth.

Remarks

One member of this group has been included in various genera (*Condylocardia*, *Condylocuna* and *Benthocardiella*) reflecting the non-typical morphology of the shell. The lack of radial ribs on the dissoconch seperates *Austrocardiella* from *Condylocardia*, while the sculptured prodissoconch distinguishes the genus from *Benthocardiella*. *Austrocardiella* can be destinguished from *Condylocuna* by the additional anterior cardinal hinge tooth CA5 (see Fig. 31) set on a large broad hinge plate and the weaker external commarginal sculpture.

The presence of one species in this group with a closely similar prodissoconch to species of *Condylocuna* suggests a close relationship between the two genera.

Etymology

Austro derived from Australia, *cardiella* meaning 'little heart'.

Austrocardiella isosceles (Cotton, 1930)

(Figs 13*a*–*g*, 16)

Condylocardia trifoliata Hedley, 1906*b*. Verco, 1907: 109. – Verco, 1908*a*: 359 (not of Hedley, 1906*b*).

Condylocardia isosceles Cotton, 1930: 238, fig. 11 (type locality: Backstairs Passage, South Australia. Holotype (Fig. 13*a*) SAMA D.10108.

Condylocuna isosceles (Cotton, 1930). Laseron, 1953: 40. – Cotton, 1961: 206, fig. 207.

Benthocardiella isosceles (Cotton, 1930). Lamprell & Healy, 1998:170, fig. 480.

Other material examined. **South Australia**. Off South Australian coast, deep water, 1907, C25988 (6v). **Western Australia**. Off Esperance, 34°2.75′S 121°0.6′E, coarse shell sand, 3 Feb. 1981, C382249 (2v). *Off Albany*: 34°44.9′S 118°50.5′E, 70 m, sand and shell, 21 March 1980, C382247 (1v); 35°6′S

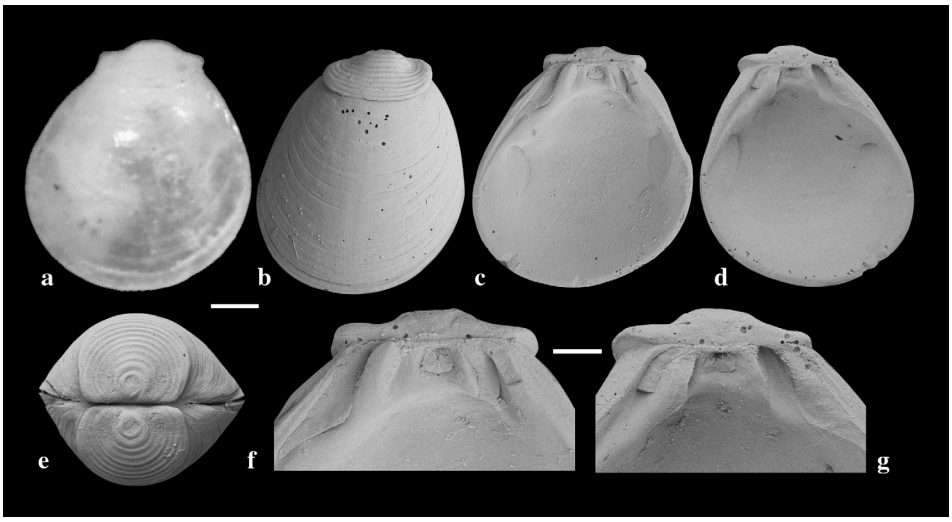

Fig. 13. *Austrocardiella isosceles*. *a*, *Condylocardia isosceles* holotype SAMA D.10108, Backstairs Passage, South Australia. *b–g*, C382307, off Albany, Western Australia. Scale bars: *a–e*, 200 µm; *f*, *g*, 100 µm.

118°39′E, 76 m, sand and broken shell, 20 March 1980, C382307 (13v); 35°8.5′S 118°20′E, 75 m, sand, 12 March 1980, C382245 (9v); 35°19′S 118°3.4′E, 80 m, fine sand and shell, 12 March 1980, C382244 (2prs). W of Green Head, 30°1′S 114°45′E, 52 m, Feb. 1982, C382248 (1v).

Description

Shell. Maximum length 0.97 mm, maximum height 1.1 mm, equilateral, orthogyrate, translucent or opaque white. Inflation ratio 1.10–1.27.

Prodissoconch. Maximum length 460 µm, consisting of prodissoconch I and II. Prodissoconch I with one central indentation, prodissoconch II with about ten commarginal ribs and thickened rim.

Dissoconch. Lunule and escutcheon absent. Outline oval, with anterior end slightly extended and broadly rounded, posterior end weakly angled. External sculpture of many weak rounded commarginal ribs. Inner margin smooth. Periostracum thin and smooth. Hinge plate wide. Two smooth lateral teeth in each valve. Right and left valve anterior lateral teeth (LAI, LAII) and posterior lateral teeth (LPIII, LPII) longer than half length of dorsal slopes. Right valve anterior cardinal teeth (CA3 and CA5) present, cardinal tooth CA3 most prominent, cardinal CA5 vestigial. Posterior cardinal tooth (CP3) arched, divided into CP3a,b. Left valve anterior cardinal tooth (CA4) arched, divided into cardinal elements CA4a,b. Posterior cardinal teeth (CP2 and CP4) present, CP4 very small. Internal ligament 75 µm long, rounded, in resilium.

Dimensions. See Table 6.

Distribution

Backstairs Passage, South Australia and from off Esperance to off Green Island, Western Australia, 52–80 m depth. Found in fine to coarse sand and shell sand. This species is only known from shells.

Remarks

Austrocardiella isosceles can be readily separated from *A. pouli* n. sp. by the number of commarginal ribs on the prodissoconch (*A. isosceles* about ten, *A. pouli* about six). Using

Table 6. Measurements of specimens of *Austrocardiella isosceles* (Cotton, 1930)

	SL (mm)	SH (mm)	PL (mm)	SI (mm)	SL/SI×2
Condylocardia isosceles, holotype, SAMA D.10108 (Fig. 13*a*)	0.94	1.02	0.45	0.37	1.27
Austrocardiella isosceles, C025988	0.97	1.00	0.45	0.42	1.15
	0.91	1.04	0.46	0.40	1.14
	0.93	1.05	0.46	0.41	1.13
	0.95	1.08	0.43	0.43	1.10
	0.94	1.10	0.44	0.46	1.02

SEM, other characters such as the features of the hinge can also be used to separate the taxa in this genus. *Austrocardiella isosceles* can be separated from *A. trifoliata* by the absence of three radiating indentations on prodissoconch I.

The large gap in distribution in the Great Australian Bight is probably due to the lack of adequate sampling in that area.

Austrocardiella pouli n. sp.

(Figs 14*a–i*, 19)

Material examined

Holotype. (Fig. 14*a* ,*h*, *i*). WAM S12719, off Albany, 35°6′S 118°39′E, 76 m, sand and broken shell, 20 March 1980, coll. HMAS Moresby.

Paratypes. C381978, (25v, Fig. 14*b–g*), C382308, (27v), off Albany, 35°6′S 118°39′E, 76 m, sand and broken shell, 20 March 1980, coll. HMAS Moresby; WAM S12720 (5v), off Albany, 35°14.8′S 118°30′E, 124 m, sand, 20 March 1980, coll. HMAS Moresby.

Other material examined. **Western Australia**. Great Australian Bight, 33°5′S 128°40′E, 75 m, 5 July 1962, C381993 (6v). *Off Esperance*: 34°12.85′ 121°6′E, 75 m, coarse sand and shell, Feb. 1981, C381990 (1v), 34°2′S 121°12.5′E, 76 m, coarse sand and shell, Feb. 1981, C381961 (5v), 34°21.6′S 121°9.6′E, 70–90 m, fine sand and shell, Feb. 1981, C381989 (1v), 34°11.2′S 121°7.7′E, sand, Feb. 1981, C381992 (1v), 34°22.9′S 121°3.5′E, 85 m, coarse shell sand, Feb. 1981 C381991 (8v). *Off Albany*: 34°44.9′S 118°50.5′E, 70 m, sand and shell, 21 March 1980; C381983 (1pr), 34°57′S 119°E, 73 m, sand and weed, 21 March 1980 C381977 (2v); 35°2.4′S 118°50′E, 73 m, sand and broken shell, 21 March 1980, C382246 (31v); 35°14.4′S 118°20.5'E, 75 m, sand and shell, 12 March 1980, C381975 (20+v); 35°8.5′S 118°20′E, 75 m, sand, 12 March 1980, C381972 (9v); 35°18′S 118°15′E, 62 m, 1930, C382252 (3v); 35°6.4′S 118°10.6′E, 72 m, fine sand, 12 March 1980, C381970 (1v); 35°14.7′S 118°10.4′E, 71 m, 12 March 1980, C381969 (1v); 35°19′S 118°3.4′E, 80 m, fine sand and shell, 12 March 1980, C381967 (20+v); 35°24.4′S 118°2.8′E, 150 m, sand, 12 March 1980, C381966 (21v); 35°10′S 117°52.7E, 57 m, sand, 13 March 1980, C381974 (8v); 35°9.1′S 117°49′E, 64 m, coarse sand, 13 March 1980, C381973 (7v); 35°9′S 117°46′E, 62 m, sand, 17 March 1980, C381981 (1v). *Off Rottnest Island*: 31°43.1′S 115°15′E, 100 m, broken shell and coral, Jan. 1981, C381964 (1v); 31°41.1′S 115°14′E, 98 m, broken shell and coral, Jan. 1981, C381997 (4v); Direction Bank, 31°45′S 115°16.4′E, 93 m, 12 Nov. 1980, C381988 (18v); Direction Bank, Stn 62, 31°43.4′S 115°13.8′E, 120 m, 12 Nov. 1980, C381984 (1v) and C381985 (5v); Direction Bank, 31°42.2′S 115°13.6′E, 105 m, 12 Nov. 1980, C381986 (7v); 31°37.8′S 115°10.7′E, 110 m, fine sand and broken shell, Jan. 1981, C381996 (20+v). SW of Mandurah, 32°41′S 114°51′E, 146–150 m, 17 March 1972, C381995 (2v). 24 km SW Dongara, 29°20′S 114°43′E, 40 m, 16 Feb. 1976, C381980 (2v). W of Green Head, 30°4.8′S 114°37.7′E, sand and broken shell, Feb. 1982, C381994 (1v). W of Cliff Head, 29°33.8′S 114°17′E, 137 m, 18 Feb. 1976, C381963 (1v).

Description

Shell. Maximum length 0.86 mm, maximum height 1.01 mm, equilateral, orthogyrate, translucent or opaque white. Inflation ratio, 1.16–1.31.

Prodissoconch. Maximum length 420 µm, consisting of prodissoconch I and II. Prodissoconch I with one central indentation, prodissoconch II with six commarginal ribs and thickened rim.

Dissoconch. Lunule and escutcheon absent. Outline oval or slightly triangular, with anterior end slightly extended and broadly rounded, posterior end weakly arched. External sculpture of up to 16 rounded commarginal ribs. Inner margin smooth. Hinge plate narrow centrally. Two smooth lateral teeth in each valve. Right and left valve anterior lateral teeth

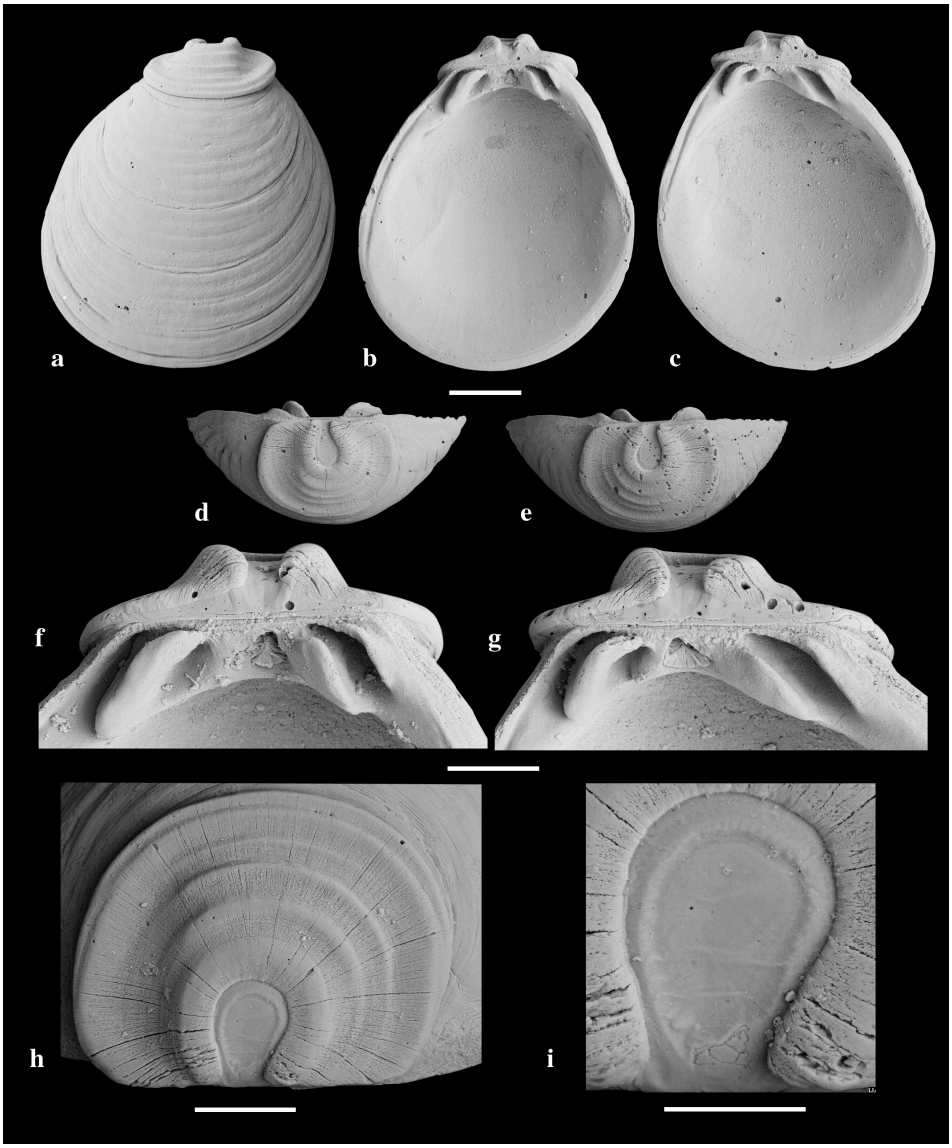

Fig. 14. *Austrocardiella pouli* n. sp. *a*, *h*, *i*, Holotype WAM S12719, off Albany, Western Australia. *b–g*, Paratypes C381978, off Albany, Western Australia. *b*, *d*, *f* and *c*, *e*, *g* same valves. Scale bars: *a–e*, 200 µm; *f*, *g* and *h*, 100 µm; *i*, 50 µm.

Table 7. Measurements of specimens of *Austrocardiella pouli* n. sp.

	SL (mm)	SH (mm)	PL (mm)	SI (mm)	SL/SI×2
Austrocardiella pouli, holotype, WAM S12719 (Fig. 14*a*, *h*, *i*)	0.81	0.92	0.37	-	-
Austrocardiella pouli, paratypes, C382308	0.75	0.90	0.39	0.31	1.21
	0.84	0.96	0.42	0.32	1.31
	0.80	1.01	0.35	0.34	1.18
	0.78	0.93	0.42	0.33	1.18
	0.86	1.01	0.39	0.37	1.16

(LAI, LAII) and posterior lateral teeth (LPIII, LPII) longer than half length of dorsal slopes. Right valve anterior cardinal teeth (CA3 and CA5) dorsally connected, CA5 about half size of CA3. Posterior cardinal tooth (CP3) arched, divided into two oblique cardinal elements (CP3a,b). Left valve anterior cardinal tooth (CA4) arched, divided into oblique cardinal elements (CA4a,b). Posterior cardinal teeth (CP2 and CP4) dorsally connected and cardinal tooth CP2 about twice size of cardinal tooth CP4. Internal ligament, 57 μm long, triangular, in resilium.

Dimensions. See Table 7.

Distribution

From the middle of the Great Australian Bight to west of Cliff Head, Western Australia, 40–150 m depth. Found in fine to coarse shell and calcareous sand derived from coral. This species is only known from shells.

Remarks

This species is endemic to the continental shelf off S–SW Western Australia, where it coexists with *A. isosceles*. *Austrocardiella pouli* may be readily separated from *A. isosceles* by the six commarginal ribs on the prodissoconch (see Remarks under *A. isosceles*). The single indentation on the prodissoconch separates it from *A. trifoliata*, which has three radiating indentations.

Etymology

Named in memory of the author's father, Poul Middelfart (1941–1998), always supportive and compassionate.

Austrocardiella trifoliata (Hedley, 1906*b*)

(Figs 15*a–l*, 16)

Condylocardia trifoliata Hedley, 1906*b*: 475, pl. 37, figs 20–23 (type locality: Masthead Is., Capricorn Group, Great Barrier Reef, Queensland, 23°32′S 151°45′E, 31–37 m, 25 Oct. 1904. Lectotype (here selected) (Fig. 15*a*, *b*) C019393 (1pr), paralectotypes C170779 (20+v, 1pr), paralectotypes in the Tomlin Collection, Department of Zoology, National Museum of Wales, Britain (Oliver, 1982), paralectotypes USNM 201429, (3pr), paralectotypes ANSP 94822, (3v, 4pr)). – Hedley, 1918: M17; Verco, 1907: 109, Verco, 1908*b*: 18.

Condylocuna trifoliata (Hedley, 1906*b*). Iredale, 1936: 272. – Lamprell & Healy, 1998: 170, fig. 485.

Condylocuna cambrica Iredale, 1936: 272. – Laseron, 1953: 41, fig. 13, 13a (type locality: Chinamans Beach, Middle Harbour, Sydney, New South Wales, 33°48.97′S, 151°14.87′E, pre 1906, pres. Ms.

L. Parkes, 1906. Lectotype (here selected) (Fig. 15*c*) C25120, (1v), paralectotypes C388177 (1v) (type material consisted of three valves of *Benthocardiella burtonae* n. sp. (now C388173), not illustrated or mentioned in original description, and two valves of *A. trifoliata*)); Iredale & McMichael, 1962: 17; Lamprell & Healy, 1998: 170, fig. 486 (not 484).

Benthocardiella vitrea Laseron, 1953: 41, figs 15a, b (type locality: Narrabeen Beach, Sydney, New South Wales. 33°42′S, 151°18′E, pre 1951, coll. C. F. Laseron. Lectotype (here selected) (Fig. 15*d*) C090566 (1v). Paralectotypes C388226 (1v) (original syntype lot contained specimens of two species, *viz*., two valves of *A. trifoliata* (here lectotype and paralectotype) and one valve of *Mysella ovata* now C388228 (juvenile, see excluded taxa below))). – Iredale & McMichael, 1962: 18; Lamprell & Healy, 1998: 168, fig. 479.

Other material examined. **Queensland**. NE of Rockhampton, 22°50′S 151°39′E, 64 m, 25 Sep. 1970, C381942 (47v). Great Barrier Reef, near Heron Is., 23°23.5′S 151°56.5′E, 40 m, 3 Oct. 1970, C381946 (1v). Noosa Heads, 26°23′S 153°6′E, 1963, C381950 (1v). NE of Cape Moreton light, 26°55.5′S 153°33.5′E, 115–119 m, 1968, C381948 (9v). **New South Wales**. Off Point Halliday, 32°4.5′S 152°33′E, 15–18 m, 1959, C367548 (1v). Off Crowdy Head, 32°38.15′S 153°0.13′E, 91 m, 16 Dec. 1957, C366875 (14v). Off Nelson Bay, Port Stephens, 32°43′S 152°15′E, 46–78 m, 1967, C366864 (3v). *Sydney area*: Patonga, Broken Bay, 33°33′S 151°16′E, 1960, C366877 (1pr) and 13 Aug. 1971, C366880 (4v); off Patonga Beach, 33°33.6′S 151°16.8′E, 1959, C366862 (8v); Narrabeen Beach, 33°42′S 151°18′E, 1951, C90566 (3v); 33°45.4′S 151°21.6′E, 40 m, 29 March 1972, C366866 (1v); Manly Beach, 33°48′S 151°17′E, 1950, C381951 (1pr), C366876 (1v), C381954 (1v); Chinamans Beach, 33°48.97′S 151°14.87′E, 1906, C25120 (2v), 4–11 m, 1967, C366865 (10v) and 3.5–7.5 m, 1967, C366868, (20+v); between Grotto and Dobroyd Pts, 275 m off Washaway Beach, 33°49′S 151°16′E, 14.5–18 m, 9 March 1969, C366863 (20+v); Quarantine Bay, 33°49′S 151°17′E, 27 m, 1950, C366878 (14v); off Balmoral, 33°49.5′S 151°15.4′E, 3.5–9 m, 1950, C381953 (17v); Balmoral Beach, 33°49.7′S 151°15.03′E, 1957, C366870 (1pr). Western Channel, off Sow and Pigs Reef: 9 Jan. 1879, C366859 (19pr); 9 m, 9 Jan. 1879, C366861 (15v); 7 m, 9 Jan. 1879, C381622 (4pr); 14 May 1881, C366881 (3pr); 7 m, 14 May 1881, C381623 (1pr); 33°50.3′S 151°16.1′E, 11–16 m, 1948, C315613 (17v); 30 Sep. 1976, C366860 (9v). Little Coogee Bay, 33°55.3′S 151°15.6′E, 19 July 1895, C366874 (1pr). **Tasmania**. S of D'Entrecasteaux Channel, 43°40.4′S 146°50.4′E, 104 m, 2 April 1973, C381955 (3v). E of King Is., 40°S 144°38.5′E, 46 m, 30 April 1973, C381957 (1pr). W of West Point, 41°S 144°7.5′E, 104 m, 14 April 1973, C381958 (1v). **South Australia**. Petrel Bay, N of St Francis Is., 32°29′S 133°18′E, 20–30 m, 28 Dec. 1973, C381959 (1v).

Description

Shell. Maximum length 1.46 mm, maximum height 1.29 mm, equilateral, orthogyrate, translucent or opaque white. Inflation ratio, 1.11–1.59.

Prodissoconch. Maximum length 460 μm, consisting of prodissoconch I and II. Prodissoconch I with three radiating indentations, prodissoconch II with three free commarginal ribs and thickened rim.

Dissoconch. Lunule and escutcheon absent. Outline triangular, with anterior end mostly more extended than posterior end. External sculpture of up to 17 commarginal ribs. Inner margin smooth. Hinge plate present. Two smooth lateral teeth in each valve. Right and left valve anterior lateral teeth (LAI, LAII) and posterior lateral teeth (LPIII, LPII) longer than half length of dorsal slopes. Right valve anterior cardinal teeth (CA3 and CA5) present, CA3 prominent and CA5 vestigial. Posterior cardinal tooth (CP3) strongly dorsally arched, divided into cardinal elements CP3a,b. Left valve anterior cardinal tooth (CA4) arched, divided into cardinal elements CA4a,b. Posterior cardinal teeth (CP2 and CP4) present, CP2 largest. Internal ligament 88 μm long, rounded, in resilium.

Dimensions. See Table 8.

Reproduction

A single embryo was observed in one dried specimen (C366859, Fig. 15*h*).

Distribution

From northeast of Rockhampton, Queensland south to Sydney, south and northeast Tasmania and off St Francis Island, South Australia, 4–119 m depth. Habitat unknown. This species is only known from shells.

Remarks

Austrocardiella trifoliata can be separated from *A. pouli* and *A. isosceles* by the three radiating indentations on the prodissoconch, as also seen in all species of *Condylocuna*.

Iredale (1936) erected *Condylocuna cambrica* based on the supposed difference in the shape of the northern and southern specimens. However, no significant and consistent difference in shape was found by examining the lectotype using SEM, and the type material is entirely comprised of small specimens.

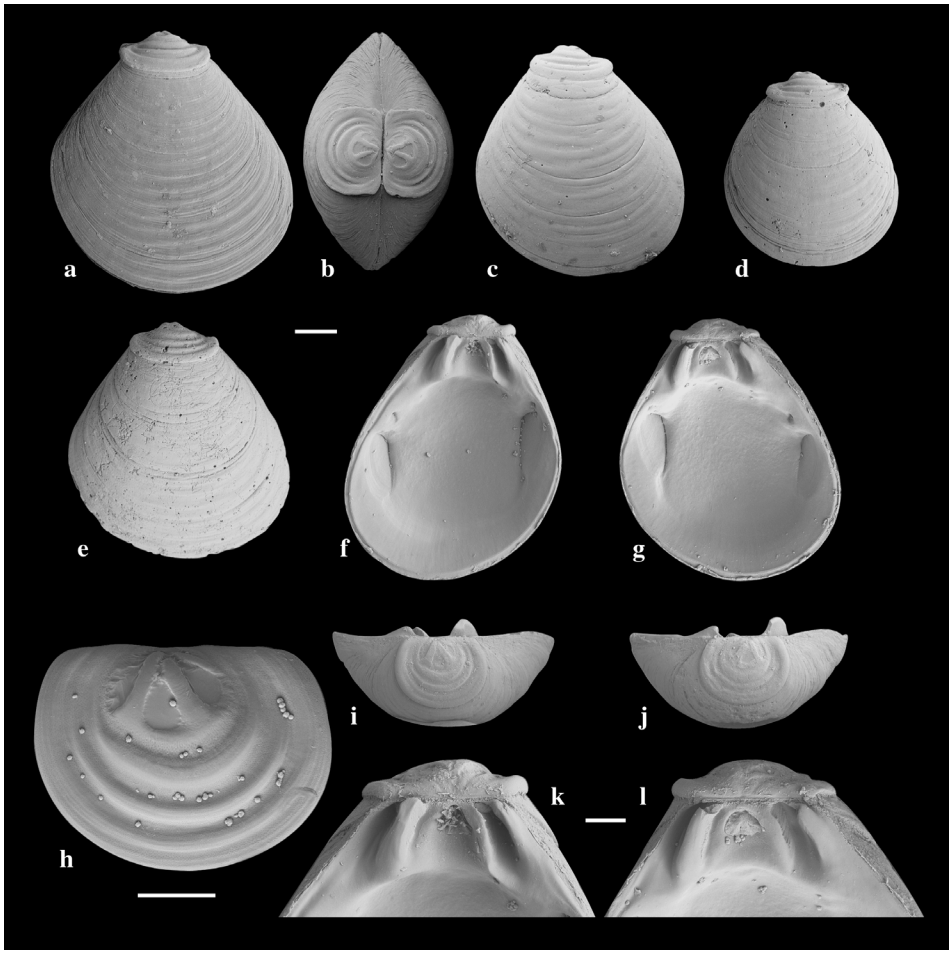

Fig. 15. *Austrocardiella trifoliata*. *a*, *b*, *Condylocardia trifoliata* lectotype C019393, Masthead Is., Queensland. *c*, *Condylocuna cambrica* lectotype C025120, Chinamans Beach, Sydney, New South Wales. *d*, *Benthocardiella vitrea* lectotype C090566, Narrabeen Beach, Sydney, New South Wales. *e–l*, C366859, off Sow and Pigs Reef, Sydney, New South Wales. Scale bars: *a–g*, *i*, *j*, 200 µm; *h*, *k*, *l*, 100 µm.

Table 8. Measurements of specimens of *Austrocardiella trifoliata* (Hedley, 1906*b*)

	SL (mm)	SH (mm)	PL (mm)	SI (mm)	SL/SI×2
Condylocardia trifoliata, lectotype, C019393 (Fig. 15*a*, *b*)	1.12	1.22	0.41	0.37	1.51
Benthocardiella vitrea, lectotype, C090566 (Fig. 15*d*)	0.80	0.90	0.38	0.36	1.11
Condylocardia cambrica, lectotype, C025120 (Fig. 15*c*)	0.90	1.07	0.39	0.39	1.15
Austrocardiella trifoliata, C381942	1.15	1.29	0.43	0.38	1.51
	1.13	1.26	0.44	0.38	1.49
	1.10	1.20	0.43	0.44	1.25
	0.96	0.97	0.42	0.31	1.55
	1.10	1.28	0.43	0.42	1.31
Austrocardiella trifoliata, C366868	1.04	1.17	0.48	0.39	1.33
	1.02	1.29	0.44	0.42	1.21
	1.46	1.28	0.43	0.46	1.59
	0.86	0.85	0.45	0.30	1.43
	0.86	0.94	0.43	0.29	1.48

Laseron (1953) described *Benthocardiella vitrea* as new with the note '...very close to *C. isosceles* Cotton, a South Australian species, but *C. isosceles* is practically equilateral and has a multifoliate prodissoconch rising to a peak'. *Austrocardiella isosceles* has been shown herein to have a single indentation in the prodissoconch, not three as mentioned by

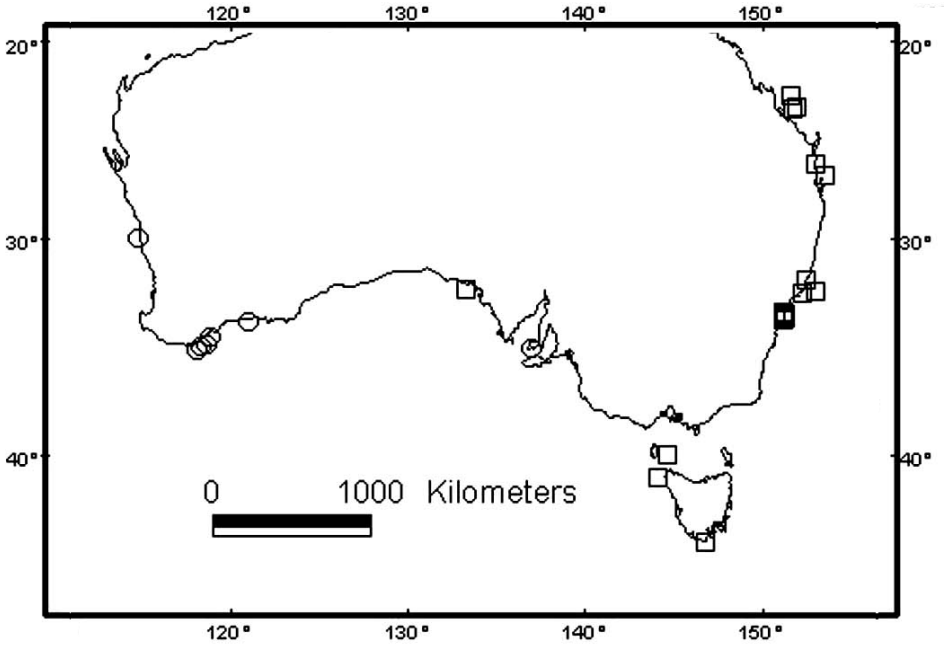

Fig. 16. Distribution of *Austrocardiella trifoliata* (□) and *A. isosceles* (○).

Laseron. Further, the shape of *A. trifoliata* is not inequilateral, but quite similar to *A. isosceles*. Two of the three specimens in the primary type lot for *B. vitrea* have a trifoliate prodissoconch, the third specimen is *Mysella ovata* (see below). The illustration for *B. vitrea* in Laseron's paper is unmistakenly *A. trifoliata*, and the description of two to three cardinals in the right valve is not consistent with *Mysella ovata*. For some reason Laseron did not observe the trifoliate pattern on the prodissoconch in these specimens, but did observe the commarginal ribs of the prodissoconch, a character never observed in the genus *Benthocardiella*.

The distribution gaps in southern New South Wales, Victoria and parts of South Australia may be a result of inadequate sampling of these tiny bivalves, or the South Australian record might be in error.

Genus ***Benthocardiella*** Powell, 1930

Benthocardiella Powell, 1930: 533. Type species (original designation): *Benthocardiella pusilla* Powell, 1930.

Diagnosis

Shell less than 1.5 mm, round to oval; prodissoconch smooth, with single, central elevation, rim with a heavy bulge. Hinge with cardinal CA3 curved, free standing and dorsally arched into CA3a,b; CA2 free. Hinge plate very narrow. Externally sculptured with commarginal growth lines, ventral margin smooth to dentate.

Remarks

Species of *Benthocardiella* are generally smooth, with a large, smooth, slightly elevated prodissoconch. The ventral margin may be dentate or smooth. The hinge consists of slightly detached cardinals CA3a,b well separated from the shell margin, except at the point where they join. Posteriorly, a small PC3 lies adjacent to the ligament. In the left valve, the anterior cardinal CA2 is detached. Dorsally (anteriorly and posteriorly to CA2) there is a dorsally divided small tooth that is possibly a CA4a,b. The posterior cardinal is obsolete in the left valve. There is both an anterior and a posterior lateral tooth in each valve. These characters are all concordant with the characters of *B. pusilla*, type species of *Benthocardiella*.

There is a superficial resemblance in hinge characters between the species here included in *Benthocardiella* and species of *Cyamiomactra* Bernard, 1897*b* and *Cyamium* Philippi, 1845 (Cyamiidae). In an early paper Hedley (1906*a*) placed *Cyamiomactra* (and *Cyamium*) in Crassatellidae. Thiele (1934) placed the Cyamiidae in a new superfamily Cyamiacea together with Neoleptonidae Thiele, 1934 and Sportellidae Dall, 1899, a classification followed by Chavan (1969). It is difficult to determine the difference between the hinge configuration of Cyamiidae and Neoleptonidae, except that they are transposed in relation to each other. Apparently the transposition of hinges can happen even within species (Moore, 1969, p. N57) and seems to be especially frequent in the Astartidae and Crassatellidae, both close relatives of the Condylocardiidae.

The two species described below are somewhat tentatively included in the Condylocardiinae, because the hinge teeth configuration matches that of other species in the family, especially *Condylocardia* and *Condylocuna* species. The prodissoconch is also very similar to other condylocardiines.

Benthocardiella burtonae n. sp.

(Figs 17*a–g*, 19)

Material examined

Holotype. (Fig.17*a*). (1v) C388190, Collaroy Beach, N of Sydney, New South Wales, 33°43.7′S 151°18′E, shell sand, 1950, coll. J. Voorwinde.

Paratypes. (Fig. 17*b–g*). (7v) C379873, Collaroy Beach, N of Sydney, New South Wales, 33°43.7′S 151°18′E, shell sand, 1950, coll. J. Voorwinde.

Other material examined. **New South Wales**. Off Port Stephens, off lighthouse, 32°42.5′S 152°15′E, 45–73 m, 1950, C379875 (7v). *Sydney area*: Manly, 33°48.2′S 151°17′E, 1926, C379876 (4v); Chinamans Beach, 33°48.97′S 151°14.87′E, 1950, C379874 (1v); off Balmoral 33°49.5′S 151°15.4′E, 3.5–9 m, 1950, C379870 (1v); Balmoral Beach, 33°49.7′S 151°15.03′E, 1957, C379869 (2v). Green Cape, S side of tip, 37°16′S 150°3′E, 2–4 m, mixed algae, exposed side, 13 Feb. 1973, C379871 (1v).

Description

Shell. Maximum length 1.42 mm, maximum height 1.42 mm, equilateral, orthogyrate, circular, translucent or opaque white. Inflation ratio, 1.27–1.70.

Prodissoconch. Maximum length 500 µm, consisting of prodissoconch I (discontinuity line between prodissoconch I and II not observed). Prodissoconch I smooth but slightly raised towards umbo, rim thickened.

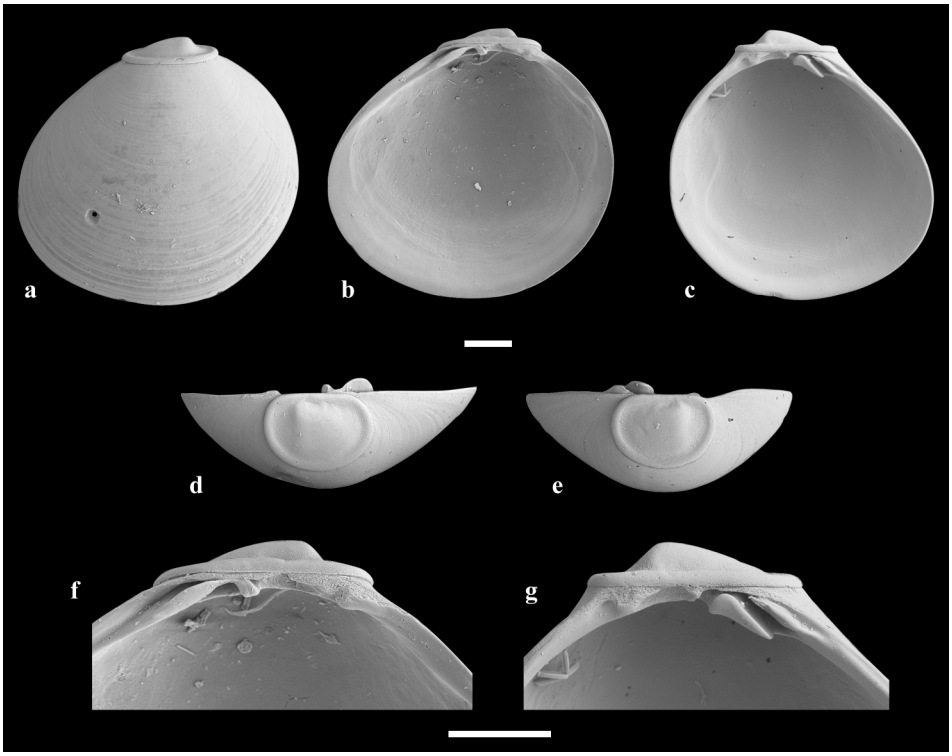

Fig. 17. *Benthocardiella burtonae* n. sp. *a*, Holotype C388190. *b*, *d*, *f* and *c*, *e*, *g*, same valves, paratypes C379873. All Collaroy Beach, Sydney, New South Wales. Scale bars: *a–e* (upper scale) and *f*, *g* (lower scale), 200 µm.

Table 9. Measurements of specimens of *Benthocardiella burtonae* n. sp.

	SL (mm)	SH (mm)	PL (mm)	SI (mm)	SL/SI×2
Benthocardiella burtonae holotype C388190 (Fig. 17*a*)	1.17	1.12	0.40	0.42	1.39
Benthocardiella burtonae, paratypes, C379873 (Fig. 17*b*)	1.20	1.13	0.44	0.37	1.62
(Fig. 17*c*)	1.09	1.12	0.43	0.41	1.33
	1.26	1.22	0.41	0.37	1.70
	1.38	1.42	0.50	0.49	1.41
	1.42	1.39	0.43	0.56	1.27

Dissoconch. Lunule and escutcheon absent. Sculpture consists of weak commarginal growth lines; inner margin smooth. Hinge plate narrow. Two smooth lateral teeth in each valve. Right valve anterior lateral (LAI) and posterior lateral (LPIII) long. Left valve anterior lateral (LAII) long and posterior lateral (LPII) short. Right valve anterior cardinal (CA3) arched, divided into anterior cardinal elements CA3a,b. Posterior cardinal (CP3) vestigial. Left valve anterior cardinals (CA2 and CA4) present, CA4 divided into anterior cardinal elements CA4a,b. Posterior cardinal (CP4) vestigial. Internal ligament 50 μm long, triangular, in resilium.

Dimensions. See Table 9.

Distribution

The few records of this species occur between Port Stephens and Green Cape, New South Wales, from shallow subtidal to 73 m. Habitat unknown. This species is only known from shells.

Remarks

Benthocardiella burtonae differs from *B. darwinensis* in being more inflated (see inflation ratio in Table 9), with a longer and less arched and detached CA3. The prodissoconch of *B. burtonae* is significantly larger than *B. darwinensis* (0.44±0.04 mm for *B. burtonae* versus 0.36±0.05 mm for *B. darwinensis* (X±SD, n=5; t-test, $p<0.01$)). The inner ventral margin is smooth in *B. burtonae* and denticulate in *B. darwinensis*.

Etymology

Named for Ms Pat Burton in appreciation of her years of sorting micro-bivalves as a volunteer in the Malacological section of the Australian Museum, Sydney.

Benthocardiella darwinensis n. sp.

(Figs 18*a–h*, 19)

Material examined

Holotype. C388191 (Fig. 18*a*) off Emery Point, Darwin, Northern Territory, 12°27′S 130°49′E, on sandbar, 25 Oct. 1969, coll. P. H. Colman.

Paratypes. C379877 (8v), off Emery Point, Darwin, Northern Territory, 12°27′S 130°49′E, on sandbar, 25 Oct. 1969, coll. P. H. Colman. C379878 (Fig. 18*c*, *e*, *g*) (4v); NTM P14470 (Fig. 18*b*, *d*, *f*, *h*) (1v), Sandbar No.1, Darwin, Northern Territory, 12°26′S 130°48′E, 14 Nov. 1970, coll. O. J. Cameron.

Description

Shell. Maximum length 1.21 mm, maximum height 1.04 mm, equilateral, orthogyrate, ovate, translucent and uniformly coloured, white to pink. Inflation ratio, 1.56–2.17.

Prodissoconch. Maximum length 370 μm, consisting of prodissoconch I (discontinuity segregating prodissoconch I and II not observed). Prodissoconch I smooth but slightly raised towards umbo, rim thickened.

Dissoconch. Lunule and escutcheon absent. External sculpture of commarginal growth lines only. Inner margin denticulate with 27 denticles (*n*=2). Hinge plate narrow. Two smooth laterals in each valve. Right valve anterior lateral (LAI) and posterior (LPIII) long. Left valve anterior lateral (LAII) long and posterior lateral (LPII) short. Right valve anterior cardinal (CA3) arched, subdivided into cardinal elements CA3a,b. Posterior cardinal (CP3) vestigial. Left valve with two anterior cardinals (CA2 and CA4), CA4 dorsally divided into anterior element CA4a and posterior element CA4b. Posterior cardinal (CP4) vestigial. Internal ligament 50 μm long, rounded, in resilium.

Dimensions. See Table 10.

Distribution

Off Darwin, Northern Territory. Found in sediment from sandbars. This species is only known from shells.

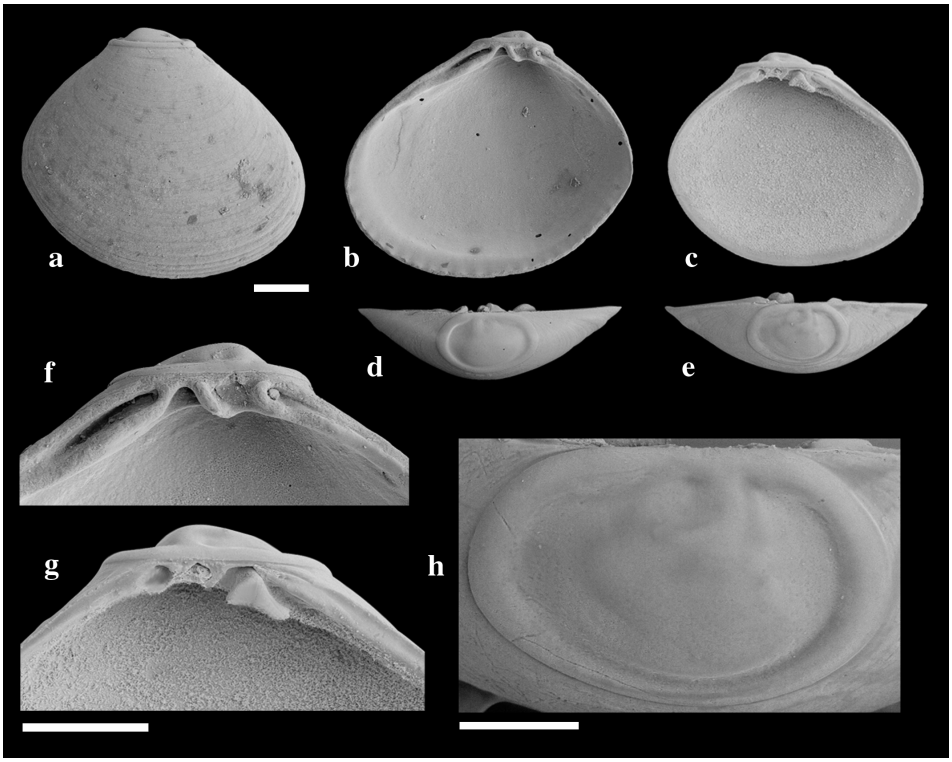

Fig. 18. *Benthocardiella darwinensis* n. sp. *a*, Holotype C388191, off Emery Point, Darwin, Northern Territory. *b*, *d*, *f*, *h*, Paratype NTM P14470, *c*, *e*, *g*, paratype, C379878, Sandbar No. 1, Darwin, Northern Territory. *b*, *d*, *f*, *h* and *c*, *e*, *g*, Same valves. Scale bars: *a–e* and *f*, *g*, 200 μm; *h*, 100 μm.

Table 10. Measurements of specimens of *Benthocardiella darwinensis* n. sp.

	SL (mm)	SH (mm)	PL (mm)	SI (mm)	SL/SI×2
Benthocardiella darwinensis, holotype C388191 (Fig. 18*a*)	1.03	0.91	0.32	0.33	1.56
Benthocardiella darwinensis, paratypes, C379878 (Fig. 18*b*, *d*, *f*, *h*)	1.04	0.89	0.30	0.24	2.17
	1.19	0.99	0.37	0.34	1.75
	1.21	1.04	0.37	0.30	2.02
	1.07	0.87	0.34	0.27	1.98

Remarks

*Benthocardiella darwinensis*is more elongate than *B. burtonae*, slightly more solid and with a dentate ventral margin. The cardinal CA3 is very similar to *B. burtonae* but more arched and attached to the dorsal part of the hinge plate. *Benthocardiella darwinensis* is pinkish coloured when fresh.

Etymology

Named after the type locality, Darwin.

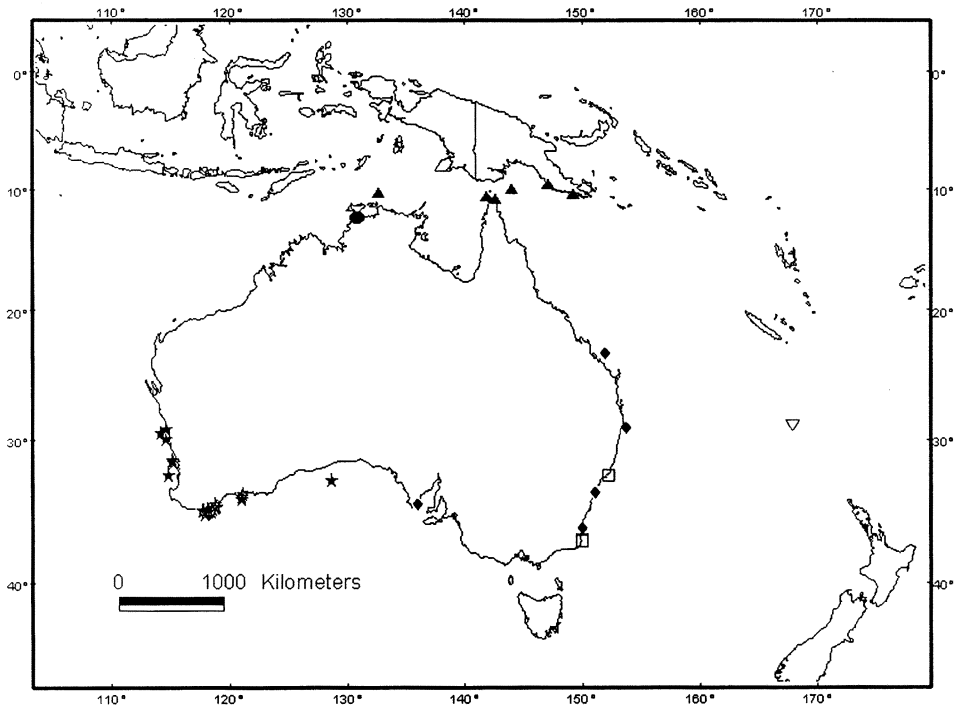

Fig. 19. Distribution of *Benthocardiella burtonae* n. sp. (□), *B. darwinensis* n. sp. (●), *Isodontocardia microcardia* n. sp. (▲), *Condylocuna tricosa* n. sp. (◆) and *Austrocardiella pouli* n. sp. (★).

Genus ***Condylocuna*** Iredale, 1936

Condylocuna Iredale, 1936: 272. Type species (original designation): *Condylocardia projecta* Hedley, 1902.

Diagnosis

Shell small (less than 1.5 mm). Prodissoconch with three radiating indentations, anterior and posterior end non-auriclar, rim bulging. External dissoconch structure commarginal ribs. Ventral margin denticulate. Hinge teeth more or less developed. Left valve anterior cardinal CA2 absent.

Remarks

Iredale (1936) erected this genus based on the difference in hinge teeth and commarginal ribbing from *Condylocardia*. He included *Condylocardia ovata* Hedley, 1906*a* (here included in *Mysella* Angas, 1877), *Condylocardia trifoliata* Hedley, 1906*b* (here included in *Austrocardiella*) and *Condylocuna projecta*, which he selected as type.

Although *Condylocuna minuta* Laseron, 1953: 41, figs 14, 14a has commarginal ribs, the hinge teeth configuration is very different from other species in *Condylocuna* and is better placed as a species of *Warrana* Laseron, 1953. The taxon is here excluded from the condylocardiines and will be dealt in a subsequent revision of the Australian Cuninae (Middelfart, unpublished data.).

Three species of *Condylocuna* occur in New Zealand (Spencer and Willan 1996).

Condylocuna projecta (Hedley, 1902)

(Figs 20*a–l*, 21)

Condylocardia projecta Hedley, 1902: 316, text fig. 57 (type locality: off Watsons Bay, Port Jackson, Sydney, New South Wales. 33°50.7′S, 151°16.7′E, pre 1902, coll. Australian Museum party. Holotype C013247 (Fig. 20*a*) 1 valve). – Pritchard & Gatliff, 1904: 231; May, 1909: 54; Hedley, 1918: M17, no. 165; May, 1921: 17; May, 1923: no. 12, pl. 7, fig. 12; Macpherson & Chapple, 1951: 17.

Condylocuna projecta (Hedley, 1902). Iredale, 1936: 272. – Laseron, 1953: 40, fig. 16; Kershaw, 1955: 296; Macpherson & Gabriel, 1962: 321; Jansen, 1995: 101, fig. 426; Lamprell & Healy, 1998: 170, fig. 481.

Other material examined. **Queensland**. *Great Barrier Reef*: Heron Is. 23°26′S 151°57′E: W side, 1950, C380307 (7v); 6 m, 1967, C380328 (3v); 8 m, 1967, C380298 (14v); off S side, 1–8 m, in coral rubble with algal layer off reef, 26 Dec. 1976, C380305 (2v); S side, rubble just below beach rock, low tide, 2 Jan. 1977, C380306 (9v); NW corner of reef, intestines of *Holothuria atra*, Aug. 1985, C380289 (11v). Wistari Reef, N side, 23°28′S 151°53′E, 4.5 m, in rubble and very short algae, over exposed edge, 28 Dec. 1976, C380294 (2v). **New South Wales**. 12 km E of Cakora Point, S of Yamba, 29°39.8′S 153°26.4′E, 55 m, 22 Feb. 1972, C380146 (3v). 15 km NE of Coffs Harbour, 30°15′S 153°19′E, 73–82 m, 1967, C380148 (1v). 14 km E of Coffs Harbour, 30°18.4′S 153°17.7′E, 76 m, 22 Feb. 1972, C380147 (1v). Off Crowdy Head, 32°38.9′S 153°0.8′E, 91 m, 16 Dec. 1957, C380302 (2v). North Fingal Bay, near Port Stephens, 32°44.75′S 152°10.5′E, 1950, C380150 (5v). 9–12 km NE of Cape Three Points, 33°32.5′S 151°31.4′E, 75–91 m, sticky mud and shell, 25 Feb. 1898, C16909 (2v). *Sydney area*: Narrabeen Beach, 33°42′S 151°18′E, 1951, C315605 (2pr); Collaroy Beach, 33°43.7′S 151°18′E, 1950, C366901 (2v) and C366905 (12v); Manly Beach, 33°47.7′S 151°17.19′E, 15 May, 1916, C366902 (1pr), beach shell sand, 1950, C380311 (12v), and 1957, C380143 (1v); Fairlight, 33°48.2′S 151°16.4′E, 4–7 m, 1955, C366912 (1v); off Fairlight Beach, 33°48.2′S 151°16.4′E, 6–9 m, in shell rubble, 28 Feb. 1981, C380303; 33°48.5′S 151°16.5′E, 1950, C366911 (3pr); Little Manly Beach, 33°48.5′S 151°17.2′E, 1950, C366904 (9v); North Harbour, 33°48.5′S 151°16.5′E, 4 m, weed, 1950, C380312 (2v); off Chinamans Beach, 33°48.97′S 151°14.87′E, 3.5–7.5 m, 1967, C366908 (19v), 4–8 m, 1967, C380145 (8v); Watsons Bay, off Green Point, 33°50.5′S 151°16.5′E, 14.5 m, 1873, C380142 (1pr); off Watsons Bay, 33°50.7′S 151°16.7′E, 1902, C13247 (4v); off Bottle and Glass Rocks, 33°50.94′S 151°16.13′E,

14 m, from sand in bottle, 22 May 1886, C366909 (2pr); South Coogee, 33°55.5′S 151°15.6′E, 10 m, algae, 12 Aug. 1979, C380317; 2 km SE of Long Bay, 33°58.43′S 151°16.32′E, 29 m, 27 Sep. 1972, C380308 (1pr); Bate Bay, Cronulla Beach, 34°2.5′S 151°10′E, 1967, C366907 (3v); Boat Harbour, N of Cronulla, 34°2.5′S 151°12′E, 2 m, rock and shell rubble in gully between rock platforms, 3 Nov. 1982, C366913 (1v); Gunnamatta Bay, Port Hacking, 34°3.95′S 151°8.55′E, 1951, C90588 (48v); Port Hacking, SW end of Gunnamatta Bay, 34°4.3′S 151°8.7′E, in channel, 1950, C366893 (3v). 26 km E off Wollongong, 34°25′S 151°15′E, 183 m, Aug. 1902, C18230. (5v). 8–13 km off Port Kembla, 34°27.9′S 151°4.5′E, 115–137 m, mud and pebbles, 18 March 1898, C13249 (4v). Werri Beach, Gerringong, 34°44.3′S 150°50′E, 1950, C380319 (3v). Pebbly Beach, 35°36.8′S 150°19.7′E, 1980, C366900 (1v). Bermagui, Shelly Beach, 36°25′S 150°5′E, 1967, C380151 (12v). Off Green Cape, 37°15.5′S 150°12′E, 110 m, muddy sand bottom, 1950, C366903 (1v). **Victoria**. Bass Strait, 36 km S of Cape Conran, 38°8.5′S 148°43.5′E, 107 m, May 1969, C380300 (1v). Bass Strait, 44 km S of Marlo, 38°12′S 148°35′E, 146 m, flat outer shelf, 7 May, 1969, C380310 (8v). Sandy Point, Western Port, just N of North Arm, 38°24.3′S 145°14.2′E, 7.5 m, sandy mud and shell, 28 Feb. 1977, C380321 (2prs). **Tasmania**. Bass Strait, Marrawah (Green Point), 41°10.82′S 144°52.79′E, 27 Dec. 1996, C380291 (1v). Off Bicheno, 41°50′S 148°17.3′E, 33 m, fine medium sand, 24 March 1973, C380301 (3v). Pirates Bay, Eaglehawk Neck, 43°1′S 147°56′E, under intertidal rocks, low tide, 30 March 1970, C366898 (1pr). W of Port Davey, 43°20.3′S 145°48.2′E, 82 m, 9 April 1973, C380314 (1v). S of D'Entrecasteaux Channel, 43°40.4′S 146°50.4′E, 104 m, 2 April 1973, C380290 (3v). **Western Australia**. *Off Albany*: 35°6.4′S 118°10.6′E, 72 m, fine sand, 12 March 1980, C380283 (1v); 35°22.6′S 118°10.2′E, 120 m, 12 March 1980, C380285 (1v); 35°4.1′S 118°6.4′E, 62 m, fine sand, 16 March 1980, C380286 (1v). Off North West Cape, 21°57.3′S 113°52′E, 88 m, fine sand and mud, Sep. 1981, C380293 (1v); off North West Cape, 22°58′S 113°41.2′E, 78 m, fine sand, Sep. 1981, C380292 (5v). **Coral Sea**. Middleton Reef, 29°27.6′S 159°6.7′E, 8 m, sand with algae in lagoon, 6 Dec. 1987, C380296 (1v). Elizabeth Reef, 29°55.4′S 159°2.7′E, rubble bank and sand flats, low water spring tide, 10 Dec. 1987, C380287 (22v). Elizabeth Reef, 29°56.2′S 159°2.4′E, 10 m, in dead coral on lagoon bommies, 12 Dec. 1987, C380295 (1v). Off NE side, 31°31′S 159°5′E, 27.5 m, 1912, C380327 (1v). Signal Point, 31°31.5′S 159°3.9′E, on short red algae on rocks, mean tide level, 21 April 1978, C380326 (2v). 31°32.5′S 159°4.7′E, 1912, C380299 (31v). S end of lagoon, 31°34′S 159°4.4′E, algae on outer reef crest, low tide, 23 April 1978, C380297 (1v).

Description

Shell. Maximum length 1.28 mm, maximum height 1.13 mm, inequilateral, with umbo equidistant from centre and end of shell, orthogyrate, translucent or opaque white. Inflation ratio, 1.54–2.00.

Prodissoconch. Maximum length 320 μm consisting of prodissoconch I and II. Prodissoconch I with three radiating indentations and prodissoconch II with commarginal pattern and thickened rim.

Dissoconch. Lunule and escutcheon short and broad, mostly smooth. Outline triangular, anterior end extended and dorsal anterior and posterior slope concave or straight, making the prodissoconch appear positioned on neck in a few specimens. Anterior end broadly rounded and posterior end sharply bent or slightly truncate. External sculpture of up to 21 commarginal ribs. Inner margin denticulate with 18 denticles. Hinge plate short but strong. Two smooth lateral teeth in each valve. Right and left valve anterior lateral teeth (LAI, LAII) and posterior lateral teeth (LPIII, LPII) longer than half dorsal slopes. Right valve anterior cardinal tooth (CA3) strong. Posterior cardinal tooth (CP3) strongly curved, subdivided into cardinal elements CP3a,b. Left valve anterior cardinal tooth (CA4) present, subdivided into cardinal elements CA4a,b. Posterior cardinal teeth (CP2 and CP4) present, CP2 much larger than CP4. Internal ligament 77 μm long, rounded, in resilium.

Dimensions. See Table 11.

Distribution

Queensland, New South Wales, Lord Howe Island, Victoria, Tasmania and Western Australia, low intertidal to 183 m depth. Found in algae washings, dead coral, rock, rubble, shell, sand, fine sand, muddy sand and mud. This species is only known from shells.

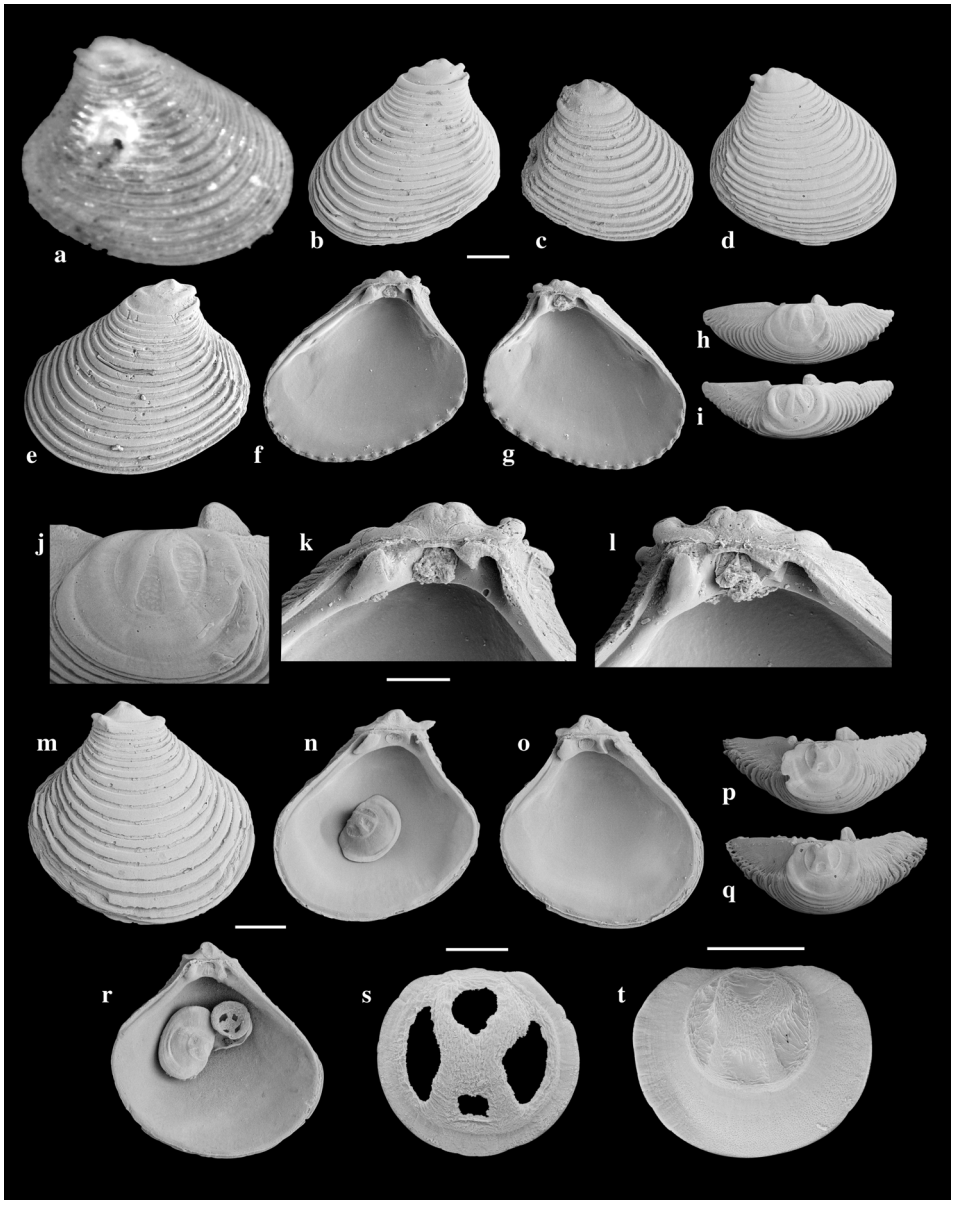

Fig. 20. *Condylocuna projecta* and *Condylocuna jimbecki* n. sp. *a*, *Condylocuna projecta* holotype C013247 off Watsons Bay, Sydney, New South Wales. *b*, C315605, Narrabeen, New South Wales. *c*, C380317, Coogee, New South Wales. *d*, *h–j*, C380151, Bermagui, New South Wales. *e–g*, *k*, *l*, C366908, Sydney Harbour, New South Wales. *m–t*, *Condylocuna jimbecki* n. sp. *m*, Holotype NMNZ M.273102, N of Norfolk Island. *n–t*, Paratypes C388215, N of Norfolk Island. Scale bars: *a–i* and *m–r*, 200 µm, *j–l* and *t*, 100 µm; *s*, 50 µm.

Remarks

Condylocuna concentrica (Bernard, 1896) from Stewart Island, New Zealand is closely similar to *C. projecta*. However, the prodissoconch is different and the commarginal ribs are closer and more numerous in *C. concentrica*. *Condylocuna annieae* may be readily

Table 11. Measurements of specimens of *Condylocuna projecta* (Hedley, 1902)

	SL (mm)	SH (mm)	PL (mm)	SI (mm)	SL/SI×2
Condylocuna projecta, holotype, C013247 (Fig. 20*a*)	1.28	1.13	0.29	0.32	2.00
Condylocuna projecta, C380145	1.04	0.99	0.32	0.27	1.93
	1.15	1.09	0.28	0.33	1.74
	1.09	1.01	0.32	0.35	1.56
	1.09	1.05	0.32	0.35	1.56
	1.11	1.10	0.28	0.36	1.54

distinguished from *C. projecta* by its much larger prodissoconch (see Remarks under *C. annieae*). *Condylocuna jimbecki* is also very similar to *C. projecta* (see Remarks under *C. jimbecki*).

The absence of records from South Australia and parts of Western Australia might be due to lack of sampling or may indicate the presence of cryptic taxa.

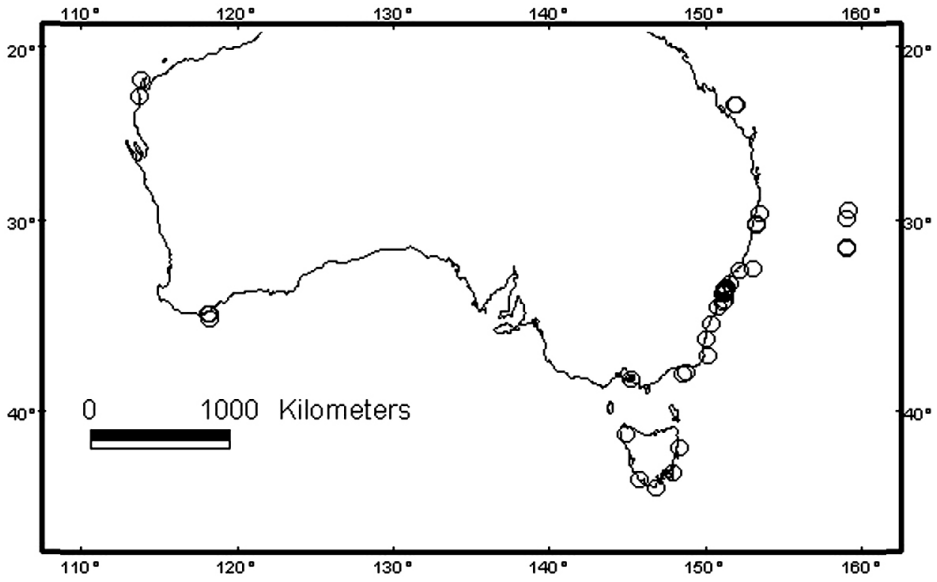

Fig. 21. Distribution of *Condylocuna projecta*.

Condylocuna annieae n. sp.

(Figs 12, 22*a–f*)

Material examined

Holotype. C388200 (Fig. 22*a*) (1v), Norfolk Island, 29°2′S 167°57′E, 1910, coll. R. Bell, ex. T. Iredale coll.

Paratypes. C380329 (Figs 22*b–f*) (31pr, 11v), NMNZ M.273096 (4v), Norfolk Island, 29°2′S 167°57′E, 1910, coll. R. Bell, ex. T. Iredale coll.

Other material examined. **Norfolk Island**. Off Duncombe Bay, 29°S 167°56′E, 31 m, 1940, C380330 (7v). 28°56′S 167°58′E, N of Norfolk Island, 38 m, 9 July, 1962, NMNZ M.224876 (20+ pr, v). 28°54′S 167°59′E, N of Norfolk Island, 33 m, 9 July 1962, NMNZ M.224580 and NMNZ M.225150 (20+ pr, v). 29°20′S 168°09′E, E of Norfolk Island, 201 m, 11 July 1962, NMNZ M.224790. 29°19′S 168°07′E, off Norfolk Island, 110 m, 11 July 1962, NMNZ M.225021 (9prs, 11v).

Description

Shell. Maximum length 1.15 mm, maximum height 1.21 mm, slightly inequilateral, orthogyrate, translucent or opaque white. Inflation ratio, 1.23–1.59.

Prodissoconch. Maximum length 520 μm, consisting of prodissoconch I and II. Prodissoconch I with three radial indentations, prodissoconch II with few commarginal rings and thickened rim.

Dissoconch. Lunule and escutcheon broad and very distinctly smooth. Outline slightly triangular, with slightly elongate, broadly rounded anterior and short, slightly angled posterior end. Dorsal slopes appear straight in exterior aspect. Exterior sculpture of up to 24 commarginal ribs. Inner margin denticulate with 16 denticles. Hinge plate present. Two smooth lateral teeth in each valve. Right and left valve anterior lateral teeth (LAI, LAII) and posterior lateral teeth (LPIII, LPII) longer than half dorsal slopes. Right valve anterior cardinal tooth (CA3) prominent and detached from anterior lateral tooth. Posterior cardinal tooth (CP3) dorsally recurved, divided into cardinal elements CP3a,b. Left valve anterior cardinal tooth (CA4) dorsally recurved, divided into CA4a,b. Posterior cardinal teeth (CP2 and CP4) present, CP2 much larger than CP4. Internal ligament 62 μm long, rounded, in resilium.

Dimensions. See Table 12.

Distribution

Norfolk Island, 31–201 m. Habitat unknown. This species is only known from shells.

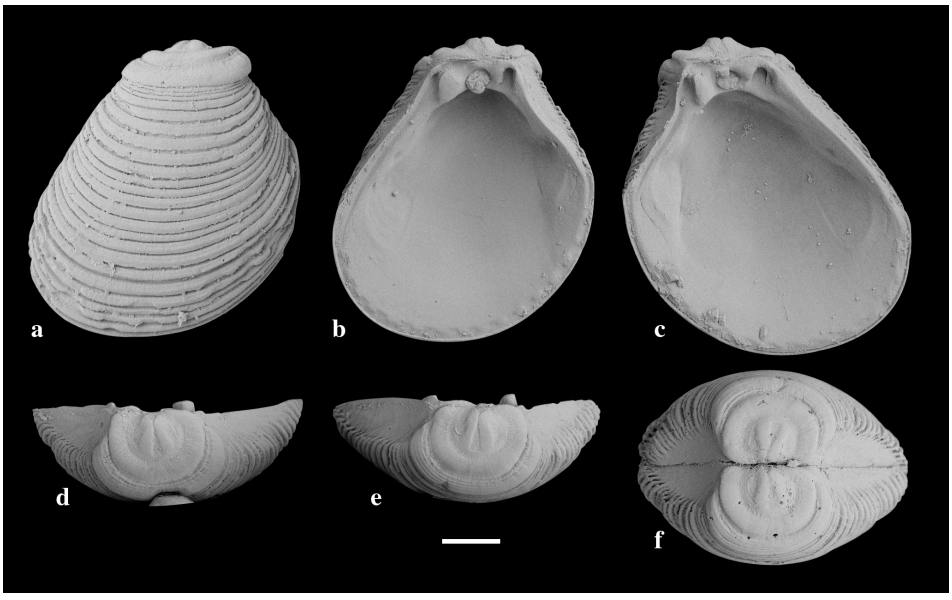

Fig. 22. *Condylocuna annieae*. *a*, Holotype C388200, Norfolk Island. *b–f*, Paratypes C380329, Norfolk Island. Scale bar: 200 μm.

Table 12. Measurements of specimens of *Condylocuna annieae* n. sp.

	SL (mm)	SH (mm)	PL (mm)	SI (mm)	SL/SI×2
Condylocuna annieae holotype, C388200 (Fig. 22*a*)	0.96	1.05	0.46	0.39	1.23
Condylocuna annieae, paratypes, C380329	1.15	1.16	0.51	0.43	1.34
	1.15	1.21	0.52	0.41	1.40
	1.05	1.08	0.47	0.37	1.42
	1.05	1.09	0.50	0.33	1.59
	1.05	1.13	0.49	0.36	1.46

Remarks

*Condylocuna annieae*can be readily distinguished from *C. projecta* by the significantly larger size of the prodissoconch (0.49±0.02 mm in *C. annieae* and 0.30±0.02 mm in *C. projecta*; X±SD, n=6; t-test, $p<0.01$). The species is slightly less inequilateral than *C. projecta*. The prodissoconch of *Condylocuna jimbecki* n. sp. is smaller.

Etymology

Named after the author's partner, Ms Annie Bowen, in recognition of her patience and help over the years.

Condylocuna jimbecki n. sp.

(Figs 12, 20*m–t*)

Material examined

Holotype. NMNZ M.273102 (Fig. 20*m*) 28°59′S 167°58′E, N of Norfolk Island, 38 m, Sep. 1962.

Paratypes. NMNZ M.273103 (22pr, 11v), C388215 (6prs, 5v and valves in Fig. 20*n–t*), 28°59′S 167°58′E, N of Norfolk Island, 38 m, Sep. 1962.

Other material examined. **Norfolk Island**. Off Duncombe Bay, 29°S 167°56′E, 31 m, 1940, C380324 (1v). 29°2′S 167°57′E, 1910, C380322 (8v). Emily Bay, Kingston, 29°4′S 167°58′E, short mixed algae from rock platform, 16 Sep. 1975, C380325 (2v). 28°56′S 167°58′E, 38 m, 9 June 1962, M.273101 (1pr, 1v). 28°54′S 167°59′E, 33 m, 9 June 1962, NMNZ M.273104 (4pr, 1v). 29°19′S 168°07′E, 110 m, 11 June 1962, NMNZ M.273105 (9pr, 8v). 29°20′S, 168°09′E, 201 m, 11 June 1962, NMNZ M.273106 (7pr).

Description

Shell. Maximum length 0.98 mm, maximum height 1.0 mm, equilateral, orthogyrate and white. Inflation ratio, 1.33–1.62.

Prodissoconch. Maximum length 320 µm, consisting of prodissoconch I and II. Prodissoconch I, with three radiating indentations, prodissoconch II smooth with sharp rim.

Dissoconch. Lunule and escutcheon large and conspicously smooth. Outline triangular, with anterior end very slightly extended and broadly rounded, posterior end is slightly recurved and angled. External sculpture consists of up to 18 strong commarginal ribs. Inner margin smooth. Hinge plate short and narrow. Two smooth lateral teeth in each valve. Right and left valve anterior lateral teeth (LAIII, LAII) and posterior lateral teeth (LPIII, LPII) longer than half length of dorsal slopes. Right valve anterior cardinal tooth (CA3) prominent but narrow and oblique. Both posterior cardinal tooth (CP3) and left valve anterior cardinal tooth (CA4) dorsally recurved, divided into cardinal elements (CP3a,b;

Table 13. Measurements of specimens of *Condylocuna jimbecki* n. sp.

	SL (mm)	SH (mm)	PL (mm)	SI (mm)	SL/SI×2
Condylocuna jimbecki, holotype, NMNZ M.273102 (Fig. 20*m*)	0.92	0.88	0.29	-	-
Condylocuna jimbecki, paratypes, C388215	0.84	0.82	0.32	0.26	1.62
	0.90	0.92	0.32	0.32	1.41
	0.96	1.00	0.28	0.36	1.33
	0.98	1.00	0.32	0.36	1.36
	0.96	1.00	0.32	0.34	1.41

CA4a,b). Posterior cardinal teeth (CP2 and CP4) present, CP2 most prominent. Internal ligament 70 µm long, in resilium.

Dimensions. See Table 13.

Reproduction

Two to six brooded embryos observed in dried specimens (e.g. C388215).

Distribution

Norfolk Island, found on the shelf from the intertidal zone (probably washed ashore) to 201 m depth. Habitat unknown. This species is only known from shells.

Remarks

Some embryos were discovered in dried specimens, which testifies to the development of the prodissoconchs of condylocardiines (Fig. 20*r*). These females contained embryos in the prodissoconch I (Fig. 20*s*) and II (Fig. 20*t*) stage. Since the animals were dried, all organic material had decomposed leaving only the calcified structures. The remaining structure in embryos with prodissoconch I consists of a circular shell with four 'holes' separated by an X-shaped bridge. These 'holes' are calcified in more developed embryos (Fig. 20*t*) and create the pattern seen in species of, for example, *Condylocuna*.

Prodissoconch I in *C. jimbecki* has a smaller ventral 'hole' to that of *C. projecta*. Prodissoconch I is also shorter (approximately 120 µm in *C. jimbecki* and 150 µm in *C. projecta*). Further, the anterior and posterior slopes of the dissoconch are concave, so that the prodissoconch appears to be sitting on a neck. The shell is also more equilateral than in *C. projecta*.

Etymology

Named after Mr Jim Beck in appreciation of the years of sorting assistance he has provided in Malacology at the Australian Museum.

Condylocuna tricosa n. sp.

(Figs 19, 23*a–h*)

Material examined

Holotype. C388198 (Fig. 23*a*, *d*) (1pr) W side Heron Is., Capricorn Group, Great Barrier Reef, Queensland, 23°26′S 151°57′E, tidemark, coll. J. Voorwinde, 1950–1960.

Paratypes. C380338 (Fig. 23*b*, *e–g*) (5v, 2 embryonic valves), QMMO68918 (Fig. 23*c*, *h*) (1v), W side Heron Is., Capricorn Group, Great Barrier Reef, Queensland, 23°26′S 151°57′E, tidemark, coll. J. Voorwinde, 1950–1960.

Other material examined. **New South Wales**. Off Ballina, 29°10′S 153°47′E, 103 m, 21 Feb. 1972, C366869 (1v). *Sydney area*: Balmoral Beach, 33°49.7′S 151°15.03′E, 1957, C366959 (1v); Maroubra Bay, 33°57′S 151°15.4′E, 8 July 1919, C380339 (1pr). Bermagui, New South Wales, 36°25′S 150°5′E, 1967, C380332 (1v). **South Australia**. Fisherman Point, Cape Donnington, 34°45.5′S 135°59′E, coralline turf on sheltered intertidal rocks, 14 Feb. 1985, C380337 (7v).

Description

Shell. Maximum length 0.88 mm, maximum height 0.8 mm, equilateral, orthogyrate, translucent or opaque white. Inflation ratio, 1.58–1.70.

Prodissoconch. Maximum length 400 μm, consisting of prodissoconch I and II. Prodissoconch I with three radiating indentations prodissoconch II smooth with sharp rim.

Dissoconch. Lunule and escutcheon long and broad, with remnants of commarginal ribs. Outline slightly triangular, anterior end extended and rounded distally, posterior end shorter and slightly angled. Exterior sculpture of up to 24 commarginal ribs. Inner margin smooth. Hinge plate not apparent. Two smooth lateral teeth in each valve. Right and left valves anterior lateral teeth (LAI, LAII) and posterior lateral teeth (LPIII, LPII) longer than half length of dorsal slopes. Right valve anterior cardinal tooth (CA3) prominent. Posterior cardinal tooth (CP2) prominent. Posterior cardinal teeth in right valve and anterior cardinal teeth in left valve undeveloped. Internal ligament 50 μm long, rounded, in resilium.

Dimensions. See Table 14.

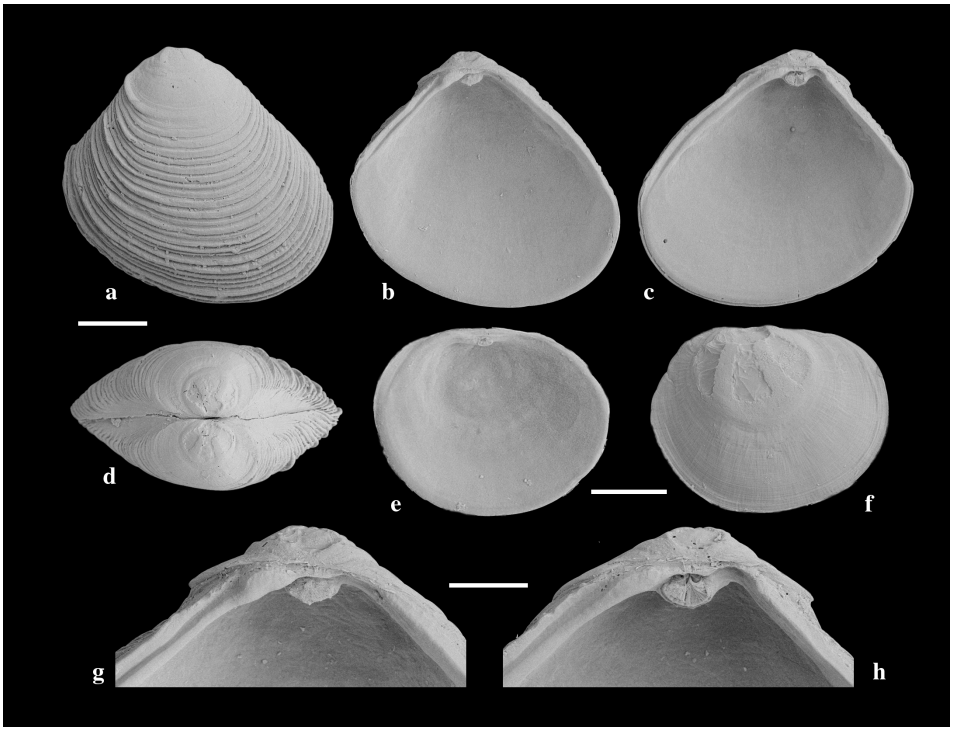

Fig. 23. *Condylocuna tricosa*. *a*, *d*, Holotype C388198. *b*, *e–g*, Paratypes C380338. *a*, *d*, and *b*, *g* and *c*, *h*, same valves. *c*, *h,* Paratype QMMO68918. All Heron Is., Queensland. Scale bars: *a–d*, 200 μm; *e*, *f* and *g*, *h*, 100 μm.

Table 14. Measurements of specimens of *Condylocuna tricosa* n. sp.

	SL (mm)	SH (mm)	PL (mm)	SI (mm)	SL/SI×2
Condylocuna tricosa, holotype, C388198 (Fig. 23*a*)	0.78	0.74	0.32	0.24	1.63
Condylocuna tricosa, paratypes, C380338	0.77	0.73	0.29	0.23	1.67
	0.88	0.80	0.40	0.27	1.63
	0.79	0.75	0.38	0.25	1.58
	0.78	0.78	0.34	0.23	1.70

Reproduction

One ready-to-emerge embryo found in a dry specimen (C380320, fig. 23e, f).

Distribution

Condylocuna tricosa has been recorded from Queensland, New South Wales and South Australia. Shells are recorded from intertidal and subtidal to 103 m depth. Found in coralline turf or in sand. This species is only known from shells.

Remarks

This species is congeneric and closely similar to '*Rochefortia*' *io* Bartsch, 1915 (p. 201, pl. 39, fig. 5; pl. 53, figs 5, 6; USNM 251043, syntypes (2 left valves, 1 right valve and 1 pair), Port Alfred, Cape Colony, South Africa. Note that *Condylocardia io* Bartsch, 1915 (p. 193, USNM 251066, 2 right valves, Port Alfred, Cape Colony, South Africa) is a different taxon, possibly a species of *Benthocardiella*. The lack of well-developed hinge teeth, general outline, commarginal ribbing and radiating indentations of prodissoconch I in *Condylocuna io* seem very similar to *C. tricosa*, but *C. io* is more posteriorly truncated, anteriorly elongated and has a yellow tinge. As well as the morphological differences mentioned, genetic exchange between the two species seems unlikely because of their highly disjunct distributions and the viviparous mode of reproduction in *C. io*.

Two records of similar looking species need further investigation. Two valves from Bairiki Island, Tarawa Atoll, 1°20′N 172°58′E (C380336) are congeneric and quite similar to the species described herein. Four valves and a whole specimen of an undescribed species from Waiwera, Northland, New Zealand (USNM 680015) are also congeneric and closely similar to *C. tricosa*.

While the Holocene record of one valve from Lake Baghdad, Rottnest Island, Western Australia (C380335) may indicate a larger area of distribution in the Holocene than today, it is equally likely that this record is based on a very similar taxon. Clearly, more material is required to resolve the distribution of the taxon.

The few collections and patchy distribution may be due to specimens being misplaced in collections because it is difficult to assign to a family without SEM images and can easily be misidentified as a juvenile bivalve because of the lack of elaborate hinge teeth.

Etymology

From '*tricosus*' meaning 'full of difficulties, perplexities or tricks', in relation to the difficulties faced in systematic placement of the species.

Genus ***Cunanax*** Iredale, 1936

Cunanax Iredale, 1936: 272. Type species (original designation): *Cuna pisum* Hedley, 1908.

Diagnosis

Prodissoconch large, non-pelagic type, with a knobbly or pitted prodissoconch I. Prodissoconch II smooth with slight radial structure. Dissoconch with faint radials and commarginal growth lines. Inner ventral margin denticulate. Wide hinge plate with short to very long cardinals. Posterior cardinal CP3 is divided into the cardinal elements CP3a,b. Left valve anterior cardinal CA2 absent, anterior cardinal CA4 dorsally divided into CA4a,b. Left valve posterior cardinals consisting of CP2 and CP4.

Remarks

The inclusion of three additional species, besides the type species, in this genus relies strongly on the prodissoconch and, to a certain extent, cardinal hinge teeth. The prodissoconch is large in *Cunanax*, reflecting a brooding and non-pelagic mode of development, and is sculptured with a central, raised, knobby nucleus and a few non-coherent commarginal structures. This prodissoconch type is not found in any other genus of condylocardiine.

The hinge teeth are generally very large and quite similar to those of the much smaller *Austrocardiella* and *Isodontocardia*, though these two genera have very distinctly different prodissoconchs.

Cunanax pisum (Hedley, 1908)

(Figs 24*a–i*, 27)

Cuna pisum Hedley, 1908: 476, pl. IX, figs 26, 2 (type locality: off Green Point, Watsons Bay, Sydney Harbour, New South Wales. 33°50.5′S, 151°16.5′E. 15 m, 1873, coll. J. Brazier, pres. C. Hedley, 1908. Holotype (Fig. 24*a*, *b*) C029114, 1 complete specimen). – Hedley, 1918: M.16.

Cunanax pisum (Hedley, 1908). Laseron, 1953: 37, figs 8–8b. – Iredale & McMichael, 1962: 17; Lamprell & Healy, 1998: 170, fig. 487.

Condylocuna moringa Laseron, 1953: 40, figs 18, 18a (type locality: off North Head, Sydney, New South Wales. 33°50′S, 151°18′E. 27 m, pre 1950, coll. C. F. Laseron. Holotype (Fig. 24*c*, *d*) C090555 (2v from very likely one specimen)). – Iredale & McMichael, 1962: 17; Lamprell & Healy, 1998: 170, fig. 483.

Other material examined. **Queensland**. Off S end Fraser Is., 25°48′S 153°46′E, 73 m, soft corals, 10 Nov. 1976, C381216 (1v). NNE of Cape Moreton, 26°52.5′S 153°36′E, 183 m, 1967, C381214 (7v). NE of Cape Moreton light, 26°55.5′S 153°33.5′E, 115–119 m, 1968, C366547 (1v). NE of Cape Moreton, 26°55.5′S 153°33.5′E, 115–124 m, 1967, C379868 (12v), and 27°S 153°35′E, 128–183 m, 1967, C381212 (14v). Off S end Fraser Is., 27°57.13′S 153°51.05′E, 201 m, sand, shell, brachiopods and bryozoans, 10 Nov. 1976, C381215 (23v). **New South Wales**. Off Tweed Heads, 28°17′S 153°44′E, 73 m, coarse sand and 'beach rock', 9 Nov. 1976, C366516 (2v). Off Ballina, 29°10.2′S 153°43.7′E, 86 m, 22 Feb. 1972, C366539 (2v). N of Coffs Harbour, 29°39.1′S 153°41.7′E, 95 m, 22 Feb. 1972, C366515 (1pr). 12 km E of Cakora Point, S of Yamba, 29°39.8′S 153°26.4′E, 55 m, 22 Feb. 1972, C366517 (17v). N of Coffs Harbour, 29°39.8′S 153°37.4′E, 82 m, 22 Feb. 1972, C366544 (12v), and 29°40.3′S 153°30.4′E, 71 m, 22 Feb. 1972, C381218 (1v). 15 km NE of Coffs Harbour, 30°15′S 153°19′E, 73–82 m, 1967, C366552 (2v). NE of Port Macquarie, 31°23′S 153°12′E, 183 m, 14 Oct. 1913, C37786 (3v). Port Stephens, 32°42′S 152°5′E, 1888, C47623 (1pr). Off Nelson Bay, Port Stephens, 32°43′S 152°15′E, 46–78 m, 1967, C366553 (2v). North Fingal Bay, near Port Stephens, 32°44.75′S 152°10.5′E, 1950, C366548 (2v). Off Newcastle, 33°2.2′S 152°23.7′E, 148 m, 3 March 1972, C381220 (5v). Off Tuggerah Lake, 33°20′S 151°39.4′E, 60 m, 11 March 1972, C366541 (2v). *Sydney area*: Collaroy Beach, 33°43.7′S 151°18′E, shell sand, 1950, C366549 (6v); S end of Collaroy Beach, 33°44′S 151°18′E, Aug. 1971, C366844 (1v); off Long Reef, 33°45′S 151°19′E, 26 m, 1950, C366540 (29v); off Chinamans Beach, 33°48.97′S 151°14.87′E, 3.5–7.5 m, 1967, C366264 (17v);

between Grotto and Dobroyd Pts, 275 m off Washaway Beach, 33°49′S 151°16′E, 14.5–18 m, 9 March 1969, C366545 (20+v); 33°49.5′S 151°21.6′E, 64–66 m, 27 Feb. 1973, C366513 (4v); off Balmoral, 33°49.5′S 151°15.4′E, 3.5–9 m, 1950, C381221 (7v); 33°50′S 151°18′E, 27 m, 1953, C315599 (19v); 33°51′S 151°15′E, 1900, C47622 (4v). Ulladulla, 35°21.5′S 150°28.5′E, in beach shell sand, 1950, C366543 (2v). **South Australia**. SE of Kangaroo Is., 37°10′S 138°30′E, 155 m, 26 June, 1962, C381217 (6v).

Description

Shell. Maximum length 6.33 mm, maximum height 6.65 mm, inequilateral, with umbo slightly displaced from middle, orthogyrate and white to bone coloured. Inflation ratio, 1.23–1.64.

Prodissoconch. Maximum length 1270 μm, consisting of prodissoconch I and II. Prodissoconch I pitted, prodissosconch II with slight radial pattern and sharp rim.

Dissoconch. Lunule and escutcheon long and broad with commarginal sculpture. Outline oval to triangular, with anterior end extended and broadly rounded, posterior end narrowly rounded, dorsal slopes straight of slightly concave. External sculpture of up to 36 sculpture raised commarginal ribs and 18–21 faint radial ribs. Inner margin denticulate with

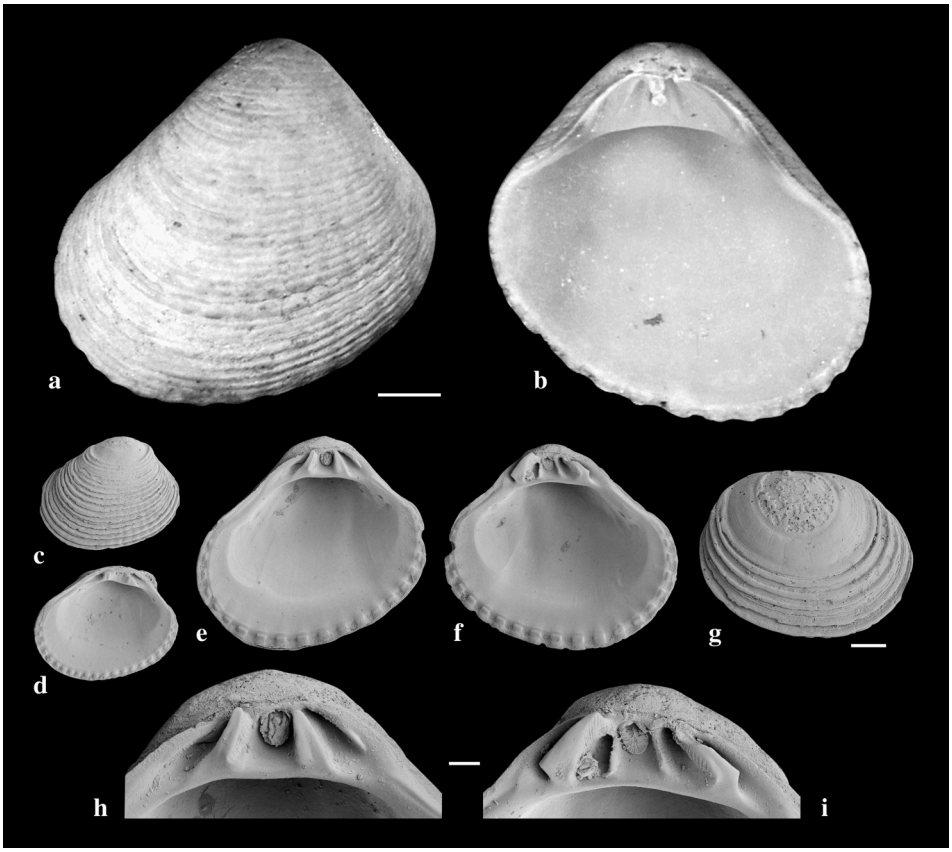

Fig. 24. *Cunanax pisum*. *a*, *b*, *Cuna pisum* holotype C029114, off Green Point, Sydney Harbour, New South Wales. *c*, *d*, *Condylocuna moringa* holotype, C090555, off North Head, Sydney, New South Wales. *e*, *f* and *h*, *i*, C366544, Sow and Pigs Reef, New South Wales. *g*, C366264, Sydney Harbour, New South Wales. *e*, *h* and *f*, *i*, same valves. Scale bars: *a–f*, 1 mm; *h*, *i*, 200 μm.

18–21 denticles. Hinge plate wide and long. Two smooth lateral teeth in each valve. Right and left valve anterior lateral teeth (LAI, LAII) and posterior lateral teeth (LPIII, LPII) longer than half the length of the dorsal slopes. Right valve anterior cardinal tooth (CA3) triangular and oblique. Posterior cardinal tooth (CP3) divided into small and marginal element CP3a and triangular and ventrally directed CP3b. Left valve anterior cardinal tooth (CA4) divided into dorsally interconnected large squat, marginal CA4a and slender, marginally directed CA4b. Posterior cardinal teeth (CP2, CP4) present and dorsally connected, CP2 being the largest, squat and marginally placed and CP4 being slender and ventrally directed. Internal ligament 200 μm long, rounded, in resilium.

Dimensions. See Table 15.

Distribution

From Fraser Island, Queensland, south to Ulladulla. The single record from South Australia is likely to be a locality error. Shells have been found from 4–201 m depth, in sand, shell sand and rubble, bryozoan sediment and among soft coral. This species is only known from shells.

Remarks

Laseron (1953) remarked that neither Hedley (1902), in describing this species, nor Iredale (1936), when including this species in *Cunanax*, actually commented on the hinge. Laseron (1953) further noted after examining the hinge that this species is probably not related to any of the recent condylocardiines.

The species *Condylocuna moringa* is based on a juvenile of *Cunanax pisum* and thus a synonym.

Bernard (1897*a*: p. 196) mentioned the primitive characters of the hinge of *Condylocardia*, which he considered of intermediate form between anisomyarian isodonts (Spondylidae) and heterodonts. The hinge of *C. pisum* could be considered even more plesiomorphic.

Table 15. Measurements of specimens of *Cunanax pisum* (Hedley, 1908)

	SL (mm)	SH (mm)	PL (mm)	SI (mm)	SL/SI×2
Cuna pisum, holotype, C029114 (Fig. 24*a*, *b*)	6.06	5.63	1.27	2.11	1.44
Condylocuna moringa, holotype, C090555 (Fig. 24*c*, *d*)	2.23	1.81	0.99	0.68	1.64
Cunanax pisum, C381217	4.90	4.84	1.01	1.77	1.38
	4.85	4.66	1.16	1.79	1.35
	6.33	6.24	1.27	2.22	1.43
	6.50	6.65	1.23	2.64	1.23
	4.02	3.66	1.04	1.33	1.51

Cunanax compressa (Hedley & May, 1908)

(Figs 25*a–g*, 27)

Cuna compressa Hedley & May, 1908: 124, pl. 24, figs 29–32 (type locality: off Cape Pillar, Tasmania, 43°13′S, 148°5′E. 183 m. 17–18 Dec. 1907. Lectotype (here selected) (Fig. 25*a*) C029080, (1v), paralectotypes C170793 (20+v)).

Condylocardia compressa (Hedley & May, 1908). Verco, 1908*a*: 359. – May 1921: 17; May, 1923: pl. 7, fig. 8; Kershaw, 1955: 296.

Volupicuna compressa (Hedley & May, 1908). Lamprell & Healy, 1998: 176, fig. 516.

Other material examined. **Tasmania**. Off Cape Naturaliste, 40°49.5′S 148°32.1′E, 62 m, yellow-orange coarse mud-sand, 26 March 1973, C378452 (1v), and 40°50.6′S 148°46.5′E, 399 m, silty sand and bryozoa, 26 March 1973, C378451 (7v). NE of Cape Pillar, 43°10′S 148°6.7′E, 113 m, medium sand and bryozoa, 13 March 1973, C378453 (1v), and 43°10′S 148°12′E, 172 m, fine–medium sand and bryozoa, 13 March 1973, C378454 (2v). 15 km NE of Tasman Is., 43°12.5′S 148°13.75′E, 570.5 m, 24 March 1970, C378464 (1v). 3 km S Tasman Head, S Bruny Is., 43°33.75′S 147°19.35′E, 73 m, 24 March 1970, C378471 (48v). S of Storm Bay, 43°35.5′S 147°32.3′E, 121 m, 30 March 1973, C378465 (7v). S of South East Cape, 43°42.2′S 146°18.6′E, 108 m, 4 April 1973, C378450 (8v). Between South East and South West Capes, 43°58.5′S 146°19.1′E, 168 m, 4 April 1973, C378473 (1v). S of D'Entrecasteaux Channel, 44°2.9′S 147°10′E, 168 m, 1 April 1973, C378472 (2v). SW of Low Rocky Point, 43°6.4′S 145°16.1′E, 154 m, 10 April 1973, C378457 (2v). SW of Low Rocky Point, 42°58.2′S 145°26.6′E, 84 m, 10 April 1973, C378458 (5v). SW of Low Rocky Point, 42°58.2′S 145°5′E, 188 m, 10 April 1973, C378456 (5v). NW of Low Rocky Point, 42°51.2′S 145°0.6′E, 146 m, 11 April 1973, C378459 (1v). S of Macquarie Hbr, 42°30′S 145°9.1′E, 88 m, 11 April 1973, C378470 (1v). SW of Sandy Cape, 41°39.5′S 144°37.1′E, 130 m, 15 April 1973, C378467 (7v). W of Sandy Cape, 41°29.5′S 144°24.4′E, 119 m, 15 April 1973, C379866 (15v). NW of Sandy Cape, 41°9.4′S 144°10.6′E, 132 m, 14 April 1973, C378469 (6v, 1pr). S of West Point, 41°9.2′S 144°24.2′E, 88 m, 14 April 1973, C378460 (8v). W of West Point, 41°1.2′S 144°21.5′E, 80 m, 14 April 1973, C378461 (3v). W of West Point, 41°S 143°55′E, 170 m, 14 April 1973, C378463 (3v). W of West Point, 41°S 144°7.5′E, 104 m, 14 April 1973, C378462 (3v). Bass Strait, E of Grassy, King Is., 40°11′S 144°39′E, 58 m, 23 June 1962, C378447 (2v). E of King Is., Bass Strait, 40°0.1′ 144°13.7′E, 33 m, 30 April 1973, C378455 (6v).

Description

Shell. Maximum length 9.01 mm, maximum height 8.91 mm, inequilateral, with umbo slightly displaced from middle, orthogyrate and white. Inflation ratio, 1.67–2.42.

Prodissoconch. Maximum length 1.38 mm, consisting of prodissoconch I and II. Prodissoconch I pitted, prodissoconch II with slight radial pattern and sharp rim.

Dissoconch. Lunule and escutcheon short and narrow, with commarginal pattern. Outline triangular, anterior end extended and broadly rounded, posterior end short and narrowly rounded. External sculpture of commarginal growth lines and 20–24 faint radial ribs. Inner margin denticulate with 20–24 denticles. Hinge plate very wide. Two smooth lateral teeth in each valve. Right and left valve anterior lateral teeth (LAI, LAII) and posterior lateral teeth (LPIII, LPII) longer than half length of dorsal slopes. Right valve anterior cardinal tooth (CA3) oblique, pointing anteriorly, longitudinally split into small segments. Posterior cardinal tooth (CP3) divided into large ventrally directed CP3a and marginal CP3b. Left valve anterior cardinal tooth (CA4) divided into narrow anterior marginal element CA4a and larger oblique CA4b. Posterior cardinal teeth CP2 and CP4 present, both dorsally connected, CP2 largest and marginally placed. Internal ligament 450 μm long, triangular, in resilium.

Dimensions. See Table 16.

Distribution

Tasmania. 33–570 m depth. Found in sand, mud or bryozoan substrate. This species is only known from shells.

Remarks

Cunanax compressa is hard to separate from *Cunanax crassidentata* but the smaller hinge plate, less dorsoventrally directed cardinals, larger prodissoconch (1.12±0.14 mm versus 0.91±0.18 mm in *C. crassidentata*; X±SD, n=6 in *C. compressa* and n=5 in *C. crassidentata*, t-test, $p<0.01$), more numerous radial ribs and the general shape are useful characters.

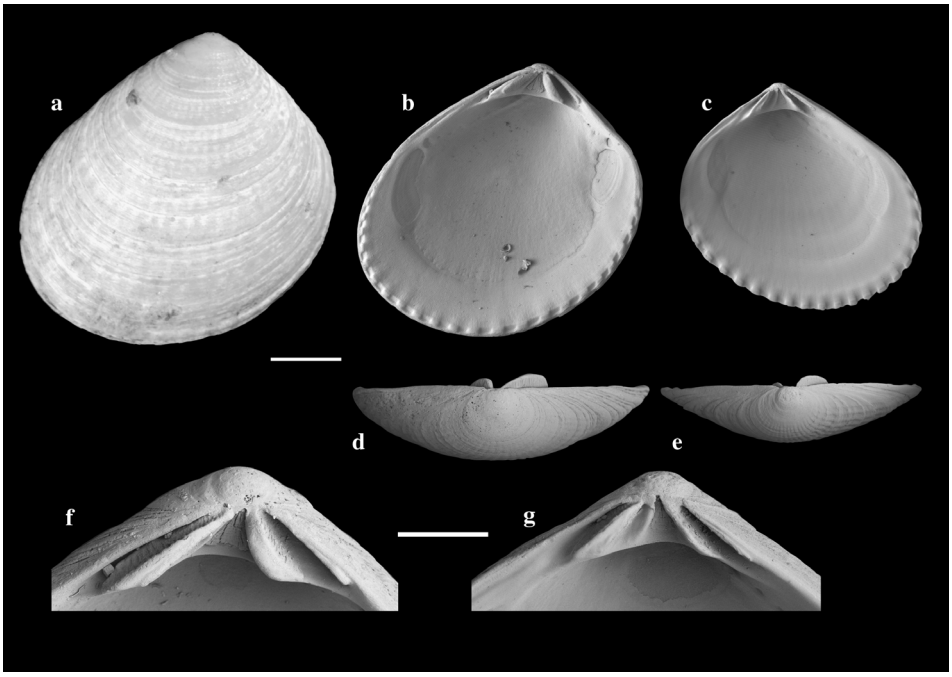

Fig. 25. *Cunanax compressa*. *a*, *Cuna compressa* lectotype C029080, off Cape Pillar, Tasmania. *b–g*, C378471, Tasman Head, Tasmania. Scale bars: *a–e*, 200 µm; *f*, *g*, 100 µm.

Table 16. Measurements of specimens of *Cunanax compressa* (Hedley & May, 1908)

	SL (mm)	SH (mm)	PL (mm)	SI (mm)	SL/SI×2
Cuna compressa, lectotype, C029080 (Fig. 25*a*)	9.01	8.91	1.00	2.56	1.76
Cunanax compressa, paralectotypes, C170793	8.00	8.10	1.10	2.14	1.87
	8.42	8.22	1.38	2.52	1.67
	7.98	7.14	1.14	1.78	2.24
	7.12	6.48	1.00	1.58	2.25
	5.70	4.96	1.08	1.18	2.42

Cunanax crassidentata (Cotton, 1930)

(Figs 26*a–g*, 27)

Condylocardia crassidentata Cotton, 1930: 236, fig. 9 (type locality: Beachport, South Australia, 73 m. Holotype (Fig. 26*a*, *b*) SAMA D.10110). – Cotton, 1961: 204, fig. 204; Lamprell & Healy, 1998: 168, fig. 474.

Other material examined. **Tasmania**. Bass Strait, E of Grassy, King Is., 40°11′S 144°39′E, 58 m, 23 June 1962, C379865 (3v). **South Australia**. Off Beachport, 37°29′S 140°E, 73 m, 1909, C25985 (5v) and C25986 (4v); 64 km S of Cape Wiles, 35°39′S 136°40′E, 174–183 m, 28 Aug. 1909, C32086 (24v).

Description

Shell. Maximum length 6.95 mm, height 7.57 mm, inequilateral, with umbo equidistant from centre and end of shell, opisthogyrate and white. Inflation ratio, 1.51–2.23.

Prodissoconch. Maximum length 1.13 mm long, consisting of prodissoconch I and II. Prodissoconch I pitted, prodissoconch II with slight radial pattern and sharp rim.

Dissoconch. Lunule and escutcheon short, narrow and smooth. Outline triangular, with anterior end extended and broadly rounded, posterior end shorter and narrowly rounded. External sculpture of commarginal growth lines and up to 21 faint radial ribs. Inner margin denticulate with 24 denticles. Hinge plate very wide. Right valve anterior cardinal tooth (CA3) weakly bifid, and directed obliquely anterior. Posterior cardinal tooth (CP3) divided into slender marginal CP3a and ventrally directed CP3b. Left valve anterior cardinal tooth (CA4) divided into marginal and narrow CA4a and more ventrally directed CA4b. Posterior cardinal teeth (CP2 and CP4) present, CP4 very small. Internal ligament about 30 µm, triangular, in resilium.

Dimensions. See Table 17.

Distribution

South Australia and north western Tasmania, 58–183 m depth. Habitat unknown. This species is only known from shells.

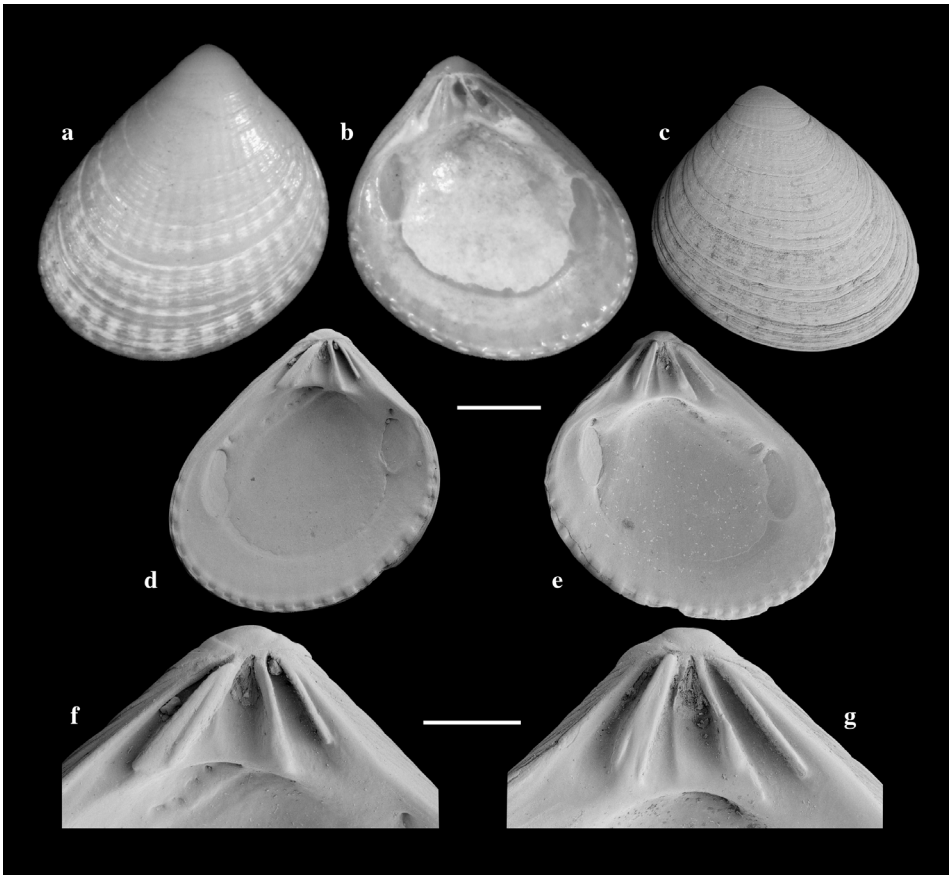

Fig. 26. *Cunanax crassidentata*. *a*, *b*, *Condylocardia crassidentata* holotype SAMA D.10110, Beachport, South Australia. *c–g*, C025985, off Beachport, South Australia. *d*, *f* and *c*, *g* same valves. Scale bars: *a–e*, 2 mm; *f*, *g*, 1 mm.

Table 17. Measurements of specimens of *Cunanax crassidentata* (Cotton, 1930)

	SL (mm)	SH (mm)	PL (mm)	SI (mm)	SL/SI×2
Condylocardia crassidentata, holotype, SAMA D.10110 (Fig. 26*a*, *b*)	6.95	7.57	1.08	2.30	1.51
Cunanax crassidentata, C025985	6.38	6.92	0.71	1.66	1.92
	5.87	6.14	0.76	1.50	1.96
	6.34	6.60	0.92	1.42	2.23
	6.19	6.40	1.13	1.55	2.00
	5.63	5.46	1.05	1.40	2.01

Remarks

Cunanax crassidentata has characters that appear intermediate between *C. compressa* and *C. subradiata*. Externally, some specimens resemble large *C. subradiata*, but the large hinge teeth and hinge plate clearly set it apart. See Remarks under *C. compressa* for separation from *C. crassidentata* and *C. compressa*.

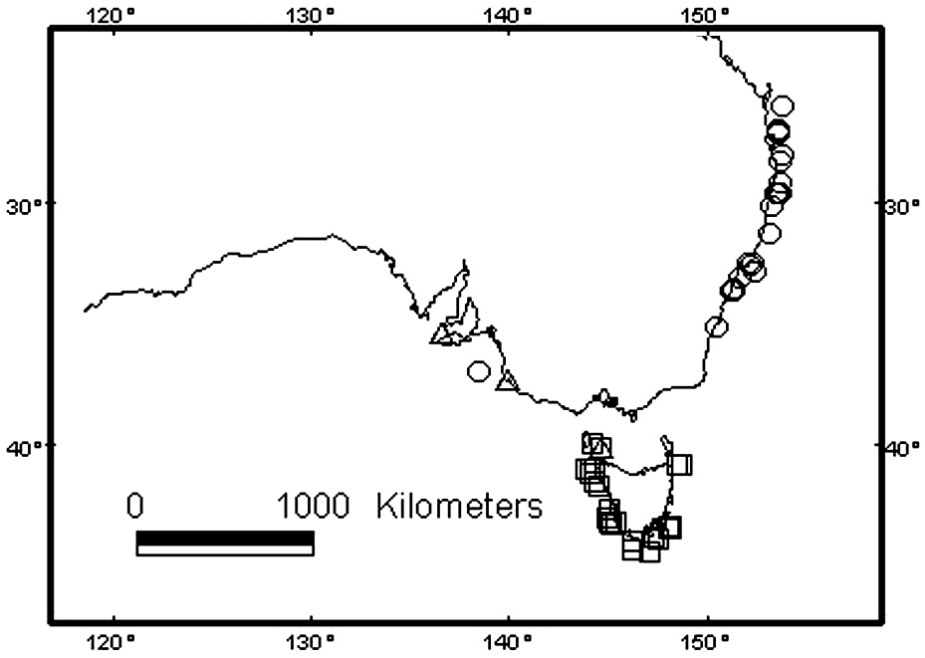

Fig. 27. Distribution of *Cunanax compressa* (□), *C. crassidentata* (Δ) and *C. pisum* (○).

Cunanax subradiata (Tate, 1889)

(Figs 28*a–n*, 29)

Carditella subradiata Tate, 1889: 62, pl. 11, fig. 7 (type locality: Royston Head, South Australia, in shell sand. Holotype (Fig. 28*c*) (1v) SAMA D.12919).

Condylocardia porrecta Hedley, 1906*b*: 475, pl. 38, fig. 24 (type locality: dredged off Masthead Island, Capricorn Group, Great Barrier Reef, Queensland, 23°32′S, 151°45′E. 31–37 m. 25–29 Oct. 1904,

coll. and pres. C. Hedley. Lectotype (here selected) (Fig. 28*d*) (1v) C019659, paralectotypes (including Fig. 28*e*, *f*) (12pr, 48v), C388167. There are more paralectotypes in the Tomlin Collection, National Museum of Wales, Cardiff (Oliver, 1982)). – Verco, 1908*a*: 360; Gatliff & Gabriel, 1910: 97; Hedley, 1918: M.17; May, 1921: 17; May, 1923: pl. 7, fig. 11; Macpherson & Chapple, 1951: 149; Lamprell & Healy, 1998: 172, fig. 493.

Condylocardia subradiata (Tate, 1889). Verco, 1908*a*: 358, pl. xvii, figs 25–28. – Gatliff & Gabriel, 1922: 160; Macpherson & Chapple: 1951: 149; Cotton, 1961: 204, fig. 206; Lamprell & Healy, 1998: 168, fig. 477.

Radiocondyla ampla Laseron, 1953: 42: fig. 22 (type locality: dredged off Long Reef, Collaroy, Sydney, New South Wales, 33°45′S, 151°19′E, pre 1948. Lectotype (here selected) (Fig. 28*a*) (1v) C090560, paralectotype, (1pr), C388170). – Iredale & McMichael, 1962: 17; Lamprell & Healy, 1998: 172, fig. 495.

Radiocondyla rotunda Laseron, 1953: 42, fig. 9 (type locality, off Crookhaven, New South Wales. 34°55′S, 150°54′E. 55–64 m, pre 1948, coll. C. F. Laseron. Holotype (Fig. 28*b*) (1v) C090561). – Iredale & McMichael, 1962: 17; Lamprell & Healy, 1998: 172, fig. 496.

Radiocondyla subradiata (Tate, 1889). Macpherson & Gabriel, 1962: 321.

Radiocondyla porrecta (Hedley, 1906*b*). Macpherson & Gabriel, 1962: 321. – Lamprell & Healy, 1998: 172, fig. 493.

Other material examined. **Queensland**. *Great Barrier Reef*: Euston Reef, SW side, 16°40′S 146°13′E, 21 m, at bottom of sand slope below steep coral walls, 30 Nov. 1972, C379238 (13v); Swain Reefs, 3 km NE of W side of Bylund (Gillett) Cay, 21°42′S 152°26′E, 64–73 m, 17 Oct. 1962, C378488 (20+v), and 21°43′S 152°25′E, 27–37 m, coral rubble, inside reef, 16 Oct. 1962, C379237 (12v); Heron Is., 23°26′S 151°57′E, 36.5 m, Dec. 1956, C378492 (4v), and 2 m, 1959, C378498 (1v); Masthead Is., 23°32′S 151°45′E, 31–37 m, 25 Oct. 1904, C19659 (many v and pr); E of Lady Musgrave Is., 23°50.1′S 152°32.1′E, 132 m, 4 July 1984, C378491 (1v) and 23°51.2′S 152°34.5′E, 175–200 m, 4 July 1984, C378490 (5v). Off Maryborough, 25°47′S 153°33′E, 64 m, 25 Oct. 1970, C378489 (5v). Off S end Fraser Is., 25°48′S 153°46′E, 73 m, soft corals, 10 Nov. 1976, C378493 (1v), and 25°57.9′S 153°34.4′E, 58–60 m, coarse sand and shell, 10 Nov. 1976, C379227 (6v). NE of Cape Moreton, 26°55.5′S 153°33.5′E, 115–119 m, 1968, C378495 (1v), 115–124 m, 1967, C378499 (4v), and 27°S 153°35′E, 128–183 m, 1967, C378494 (3v). **New South Wales**. Off Ballina, 29°10.2′S 153°43.7′E, 86 m, 22 Feb. 1972, C379240 (2v). N of Coffs Harbour, 29°39.8′S 153°37.4′E, 82 m, 22 Feb. 1972, C379239 (11v). 14 km NE of Coffs Harbour, 30°15′S 153°19′E, 73–82 m, 1967, C366846 (1v). Off Port Macquarie, 31°20′S 153°5′E, 77 m, 25 Feb. 1972, C366841 (1v). Off Forster, 32°13.13′S 152°51.1′E, 111 m, 6 Dec. 1957, C366829 (3v). *Sydney area*: 33°43′S 151°46′E, 174 m, 19 Dec. 1985, C379230 (1v); Collaroy Beach, 33°43.7′S 151°18′E, 1950, C366825 (1v); S end of Collaroy Beach, 33°44′S 151°18′E, Aug. 1971, C366834 (2v); Long Reef, 33°44.6′S 151°18.6′E, rocks, 1967, C378496 (2v); off Long Reef, 33°45′S 151°19′E, 26 m, 1948, C90560 (3v); 33°45.4′S 151°21.6′E, 40 m, 29 March 1972, C366848 (1v); 33°46′S 151°43′E, 176 m, 5 Dec. 1977, C379225 (1v); Manly Beach, 33°47.7′S 151°17.19′E, 13 May 1917, C366810 (1pr); off North Head, 33°50′S 151°18′E, 27 m, 1953, C90555 (2v); 33°50′S 151°19′E, 46–73 m, 1967, C378520 (2v); 33°51.3′S 151°14.8′E, 1967, C366849 (1v); 33°55′S 151°25.5′E, 75–150 m, 18 June 1962, C378518 (3v); 33°58′S 151°29′E, 150 m, 18 June 1962, C379244 (3v); *c*. 30 km E off Little Bay, Malabar, 33°58.8′S 151°34.5′E, 192–203 m, 9 Aug. 1973, C379232 (1v); SW end of Gunnamatta Bay, 34°4.3′S 151°8.7′E, in channel, 1950, C378519 (1pr); S of Port Hacking, 34°9.6′S 151°26.3′E, 205 m, 13 March 1972, C379247 (1v). 8–13 km off Port Kembla, 34°27.9′S 151°4.5′E, 115–137 m, mud and pebbles, 18 March 1898, C13265 (6v). Off Montague Is., Narooma, 36°15′S 150°13′E, 9–16 m, 3 Jan. 1916, C379229 (6v). SE of Montague Is., 36°19.9S 150°16.9′E, 124 m, 31 March 1972, C366845 (1v). Twofold Bay, 37°5′S 149°54′E, 1919, C366850 (1v). 32 km SE of Twofold Bay, 37°26′S 150°15′E, 149 m, 19 June 1962, C379243 (2v). **Victoria**. Off Western Port, 38°40.5′S 144°47.4′E, 75 m, 2 May 1973, C379241 (4v). S of Warrnambool, 38°43′S 142°29′E, 75 m, 24 June 1962, C379242 (1v). Spring Creek, Minhamite, 38°1′S 142°26′E, 26 April 1980, C378512 (2v). **Tasmania**. S of West Point, 41°9.2′S 144°24.2′E, 88 m, 14 April 1973, C378475 (6v). W of West Point, 41°1.2′S 144°21.5′E, 80 m, 14 April 1973, C378487 (1v). 41°S 144°7.5′E, 104 m, 14 April 1973, C378497 (6v). *King Island area*: 40°24.8′S 143°34.3′E, 110 m, 29 April 1973, C378468 (16v). 40°22.5′S 143°39′E, 128 m, 25 April 1973, C378484 (7v). 40°20′S 144°10′E, 58 m, 12 April 1973, C379864 (7v). 40°20′S 144°36.4′E, 55 m, 12 April 1973, C378500 (22v). 40°11′S 144°39′E, 58–77 m, 23 June 1962, C378482 (19v). 40°10.5′S 144°18.6′E, 51 m, 24 April 1973, C378476 (17v). 40°0.1′S 144°13.7′E, 33 m, 30 April 1973, C378486 (1v). 40°S 144°38.5′E, 46 m, 30 April 1973, C378479 (13v). **South Australia**. Off Beachport, 37°29′S 140°E, 73 m, 1909, C25984 (10v), and C30669 (6v). 80 km SE of Kangaroo Is., 37°S 138°33′E, 77 m, 26 June 1962, C379235 (36+v). SE of Kangaroo Is., 37°10′S

138°30′E, 155 m, 26 June 1962, C379236 (55v). 64 km S of Cape Wiles, 35°39′S 136°40′E, 174–183 m, 28 Aug. 1909, C378515 (5v). Nuyts Archipelago, N of St Francis Is., 32°29′S 133°18′E, 20–30 m, Sep. 1974, C379245 (20v). Petrel Bay, N of St Francis Is., 32°29′S 133°18E, 20–30 m, 28 Dec. 1973, C379248 (13v). Great Australian Bight, 80 km SW of Cape Adieu, 32°42′S 131°27′E, 79 m, 4 July 1962, C379226 (57v). **Western Australia**. *Great Australian Bight*: 33°5′S 128°40′E, 75 m, 5 July 1962, C378516 (6v); 33°5′S 128°40′E, 75–147 m, 5 July 1962, C379249 (21v); 121 km E of Rocky Point, 33°43′S 125°4′E, 77–80 m, 7 July 1962, C378517 (32v); 34°13′S 125°4′E, 75 m, 8 July 1962, C379863 (7). *Recherche Archipelago*: 34°27.5′S 122°0.3′E, 27 March 1981, C378509 (29v); 34°14′S 121°23′E, 78 m, March 1981, C382747 (1v); E of Hood Point, 34°25′S 121°20′E, 158 m, 9 July 1962, C378972 (45v); 34°2.9′S 121°17.4′E, 82 m, March 1981, C382744 (1v); E of Hood Point, 34°21′S 121°16′E, 79 m, 9 July 1962, C378968 (7v). *Off Esperance*: 34°6.75′S 121°11.55′, 85 m, coarse shell sand, Feb. 1981, C382732 (8v); 34°21.6′S 121°9.6′E, 70–90 m, fine sand and shell, Feb. 1981, C382735 (8v); 34°22.9′S 121°3.5′E, 85 m, coarse shell sand, Feb. 1981, C382730 (7v); 34°1.8′S 121°1.8′E, sand, 3 Feb. 1981, C378966 (14v). E of Cheyne Bay, 34°55′S 119°E, 71–76 m, 7 Aug. 1962, C378971 (29v). *Off Albany*: 35°2.4′S 118°50′E, 73 m, sand and broken shell, 21 March 1980, C378973 (2v); 35°6′S 118°39′E, 76 m, sand and broken shell, 20 March 1980, C378974 (7v); 35°14.8′S 118°30′E, 124 m, sand, 20 March 1980, C378970 (17v); 35°14.4′S 118°20.5′E, 75 m, sand and shell, 12 March 1980, C378501 (5v); 35°20′S 118°20′E, 112 m, sand and shell, 12 March 1980, C378969 (18v); 35°14.7′S 118°10.4′E, 71 m, 12 March 1980, C378502 (9v). *Off Rottnest Island*: 31°45′S 115°16.4′E, 93 m, 12 Nov. 1980, C378504 (12v); 31°43.1′S 115°15′E, 100 m, broken shell and coral, Jan. 1981, C378513 (20v); 31°41.1′S 115°14′E, 98 m, broken shell and coral, Jan. 1981, C378511 (5v); Stn 61, 31°43.4′S 115°13.8′E, 120 m, 12 Nov. 1980, C382736 (13v); Stn 62, 31°43.4′S 115°13.8′E, 120 m, 12 Nov. 1980, C382738 (1v); 31°42.2′S 115°13.6′E, 105 m, 12 Nov. 1980, C382729 (8v); 31°37.8′S 115°10.7′E, 110 m, fine sand and broken shell, Jan. 1981, C378510 (5v); 31°39′S 115°10′E, 124 m, fine sand and broken shell, Jan. 1981, C382737 (1v); 31°40.6′S 115°9.6′E, 100 m, 12 Nov. 1980, C378979 (14v); 31°45′S 115°9′E, 144–150 m, 18 March 1972, C382745 (1v). SW of Mandurah, 32°43′S 114°48′E, 192–179 m, C382741 (1v). S of Cape Leeuwin, 34°25′S 114°40′E, 73–144 m, 9 Aug. 1962, C378976 (2v). NW of Green Head, 30°37′S 114°38′E, 128–140 m, 22 March 1972, C378507 (2v). NW of Cervantes, 30°30′S 114°38′E, 256–192 m, 22 March 1972, C378977 (4v). W of Jurien Bay, 30°14′S 114°35′E, 146–151 m, 19 March 1972, C378506 (3v). NW of Green Head, 29°58′S 114°27′E, 197–219 m, 22 March 1972, C378508 (3v). NW of Green Head, 29°59′S 114°25′E, 150 m, 22 March 1972, C378967 (2v). NW of Beagle Is., 29°43.5′S 114°20′E, 183 m, 19 March 1972, C378503 (6v). Off Dongara, 29°33′S 114°19.5′E, 152–157 m, 19 March 1972, C378505 (2v). W of Cliff Head, 29°34.1′S 114°17.4′E, 126 m, 18 Feb. 1976, C378978 (4v). NW of Beagle Is., 29°43′S 114°17′E, 274–283 m, 20 March 1972, C378975 (3v). 32 km W of Dongara, 29°6.7′S 114°E, 91 m, 19 Feb. 1976, C382733 (2v). W of Dongara, 29°7.5′S 113°57.4′E, 110 m, sponges and stone rubble, 19 Feb. 1976, C382734 (13v).

Description

Shell. Maximum length 4.43 mm, maximum height 4.4 mm, inequilateral, with umbo slightly displaced from middle, orthogyrate and white to cream in colour. Inflation ratio, 1.18–1.92.

Prodissoconch. Maximum length 820 μm, consisting of prodissoconch I and II. Prodissoconch I with knobs and two commarginal rib structures, largest forming discontinuity between prodissoconch I and II. Prodissoconch with faint radial pattern and sharp rim.

Dissoconch. Lunule and escutcheon short, narrow, smooth. Outline oval, to triangular with anterior end slightly extended, anterior and posterior end broadly rounded. External sculpture of commarginal growth lines and 12–16 strong radial ribs. Inner margin denticulate with 12–16 denticles. Hinge plate short and narrow. Two smooth lateral teeth in each valve. Right and left valve anterior lateral teeth (LAI, LAIII) and posterior lateral teeth (LPIII, LPII) longer than half the length of the dorsal slopes. Right valve anterior cardinal tooth (CA3) narrow and oblique. Posterior cardinal tooth (CP3) arched, divided into cardinal elements CP3a,b. Left valve anterior cardinal tooth (CA4) arched, divided into CA4a,b. Posterior cardinal teeth (CP2 and CP4) present, CP4 vestigial. Internal ligament 175 μm long, rounded, in resilium.

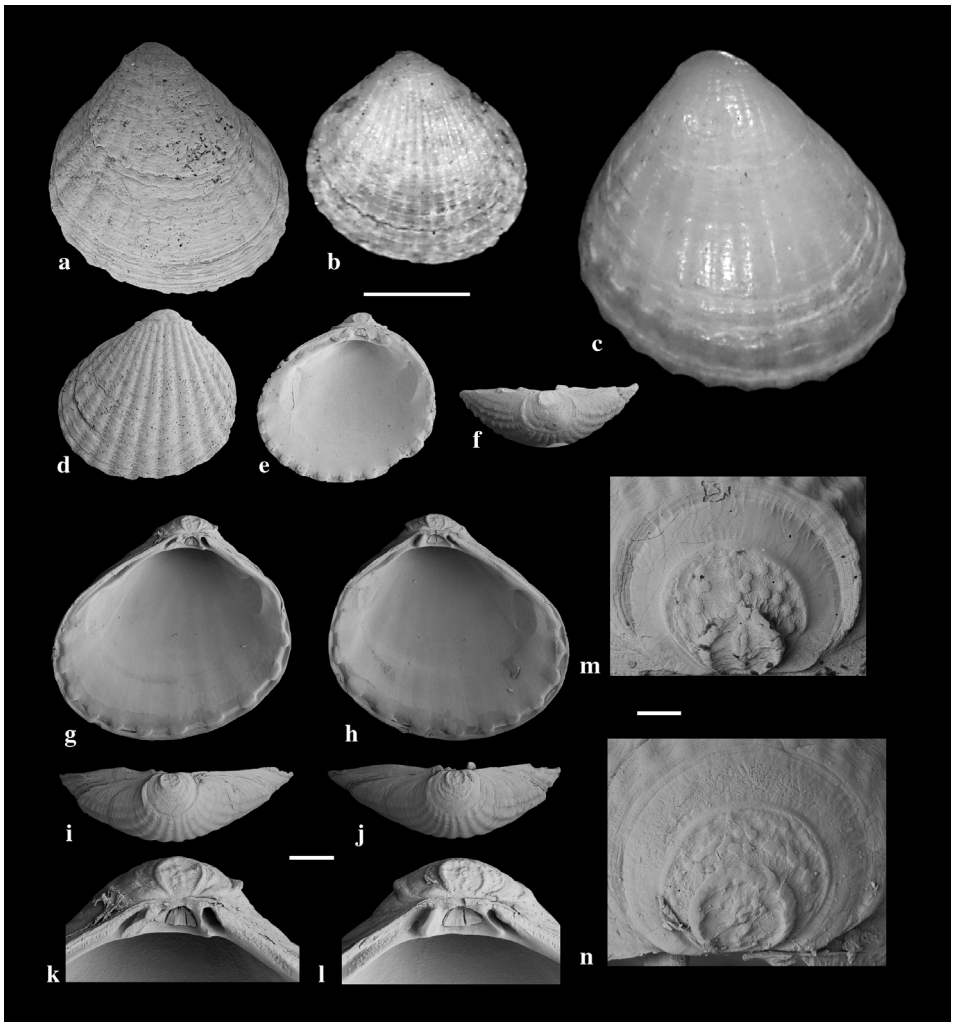

Fig. 28. *Cunanax subradiata*. *a*, *Radiocondyla ampla* lectotype C090560, off Long Reef, Collaroy, Sydney, New South Wales. *b*, *Radiocondyla rotunda* holotype C090561, off Crookhaven, New South Wales. *c*, *Carditella subradiata* holotype SAMA 12919, Royston Head, South Australia. *d*, *Condylocardia porrecta* lectotype C019659, off Masthead Is., Queensland. *e*, *f*, *C. porrecta* paralectotype C388167, off Masthead Is., Queensland. *g–l*, *n*, C379863, Great Australian Bight, Western Australia. *m*, C378488, Great Barrier Reef, Queensland. Scale bars: *a–j*, 1 mm; *k*, *l*, 200 µm; *m*, *n*, 100 µm.

Dimensions. See Table 18.

Distribution

From Euston Reef, Great Barrier Reef, Queensland, to west of Dongara, Western Australia, including southeastern and northwestern Tasmania;. 2–219 m depth. Shells are recorded from fine and coarse sand, coral and stone rubble and shell grit. This species is only known from shells.

Table 18. Measurements of specimens of *Cunanax subradiata* (Tate, 1889)

	SL (mm)	SH (mm)	PL (mm)	SI (mm)	SL/SI×2
Carditella subradiata, holotype, SAMA D.12919 (Fig. 28*c*)	3.39	3.74	0.70	1.13	1.50
Condylocardia porrecta, lectotype, C019659 (Fig. 28*d*)	1.68	1.58	0.55	0.71	1.18
Radiocondyla ampla, lectotype (here selected), C090560 (Fig. 28*a*)	2.70	2.67	0.74	0.87	1.55
Radiocondyla rotunda, holotype, C090561 (Fig. 28*b*)	2.30	2.19	0.59	0.72	1.60
Cunanax subradiata, C378488 (northern phenotype)	2.43	2.42	0.55	0.86	1.41
	2.50	2.45	0.57	0.85	1.47
	2.45	2.42	0.59	0.84	1.46
	2.27	2.33	0.58	0.95	1.19
	2.02	2.07	0.54	0.78	1.29
Cunanax subradiata, C025984 (southern phenotype)	4.43	4.40	0.76	1.46	1.52
	4.21	4.09	0.80	1.32	1.59
	4.02	3.74	0.82	1.15	1.75
	3.62	3.36	0.80	0.97	1.87
	3.30	3.26	0.72	0.86	1.92

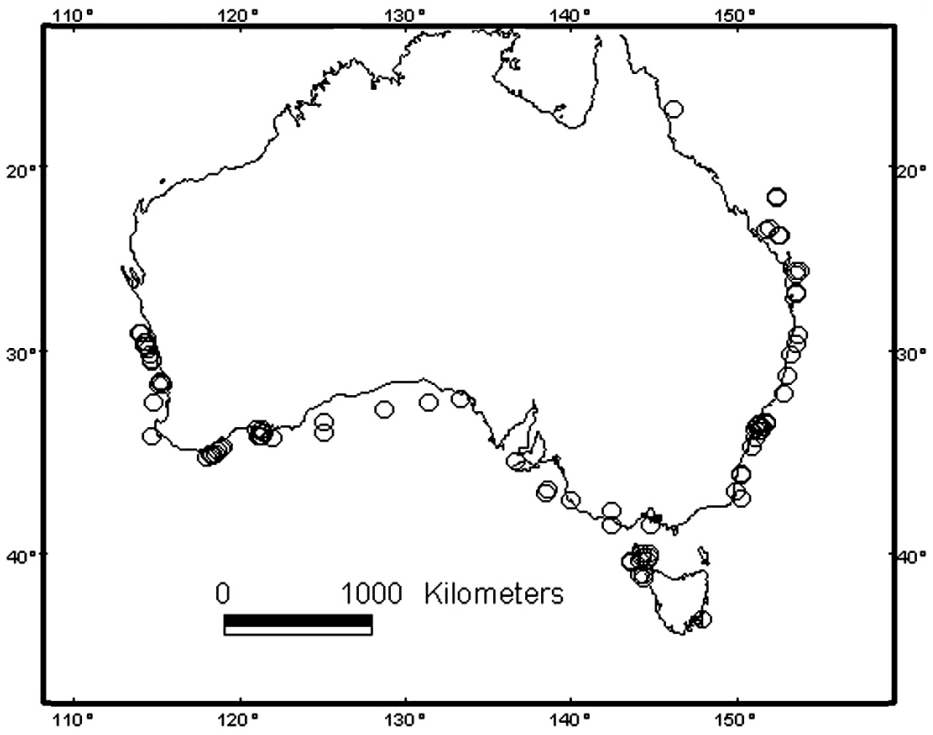

Fig. 29. Distribution of *Cunanax subradiata*.

Remarks

Many references cite *C. subradiata* as having been described in 1888, but Tate's paper was actually published in 1889. Verco (1908*a*) argued that the reason Tate (1889) included this species in *Carditella* was that he did not observe the hinge teeth and assumed that the posterior part of the shell was elongate. As Verco stated, the hinge teeth clearly place this species with the condylocardiines and the shell is in fact anteriorly elongate.

The inclusion of *Condylocardia porrecta* in the synonymy of this taxon is based on the apparent lack of distinguishing characters. Shells from the northern part of the range are smaller and more strongly sculptured, the hinge teeth more spread out and the prodissoconch smaller and (possibly consistently) with nodules not coalescent into commarginal ribs (see Fig. 28*m*, *n*). *Condylocardia porrecta* is not recognised as a separate species or subspecies herein despite the southern-most specimens being easily separated from those from the Great Barrier Reef. Specimens from intermediate localities completely intergrade in terms of shell size, hinge size and general morphology.

As noted under *C. crassidentata*, large specimens of southern *C. subradiata* show some similarities in outline to this taxon. However, as mentioned earlier, the hinge teeth and hinge plate of *C. crassidentata* are larger that those of *C. subradiata*.

Genus ***Isodontocardia*** n. gen.

Type species: *Isodontocardia microcardia* n. sp.

Diagnosis

External sculpture consisting of scabrous radials and fenestrate interradial spaces. Hingeplate wide and solid. Right valve hinge elements consist of one anterior cardinal tooth (CA3) and posterior subdivided cardinal (CP3 divided into CP3a,b). Left valve hinge teeth consist of anterior arched and subdivided cardinal (CA4 divided into CA4a,b) and two posterior cardinals (CP2, CP4). Anterior and posterior dorsal slopes dorsally angled and extended beyond lateral teeth. Extended areas sculptured with surface ripples. Prodissoconch consisting of prodissoconch I sculptured with five radial indentations.

Remarks

The type species, *Isodontocardia microcardia*, is distinctly different from any species or genus described. The species has a unique combination of anterior and posterior slope convexity, small prodissoconch and elaborate external radial and commarginal sculpture. The hinge teeth layout resembles that of *Cunanax* and *Austrocardiella* (see Fig. 31). The surface ripples dorsal to the lateral teeth, developed to a lesser extent in some species of *Condylocardia* (see e.g. *C. notoaustralis* Fig. 6*l*, *m*), might assist the cardinal and lateral teeth in locking the valves together. Prodissoconch morphology and the external sculpture suggest a relationship with the Cuninae and Carditidae, whereas the hinge teeth place it firmly in Condylocardiinae.

Etymology

Iso from Greek, meaning 'equal', *odonto* from Greek for 'tooth' and *cardia* from Greek for 'heart'.

Isodontocardia microcardia n. sp.

(Figs 19, 30*a–h*)

Material examined

Holotype. (Fig. 30*g*). C388188, Torres Strait, off Murray Is., 9°56′S 144°4′E, 9–15 m, 30 Aug. 1907, coll. C. Hedley.

Paratypes. C379251 (including Fig. 30*h*), (5pr, 8v), Torres Strait, off Murray Is., 9°56′S 144°4′E, 9–15 m, 30 Aug. 1907, coll. C. Hedley, C379259, (more than 60v, 3v and 1pr illustrated here, Fig. 30*a–f*), NTM P14471, (1pr, 4v), Amazon Bay, Milne Bay District, Papua New Guinea, 10°19′S 149°21′E, seaweed dredge, 13 m, 13 Sep. 1948, coll. CSIRO fisheries.

Other material examined. **Northern Territory**. Arafura Sea, *c*. 72 km N Croker Is., 10°17′S 132°38′E, 65 m, 9 Nov. 1969, C379255 (1v). **Queensland**. Cape York Peninsula, Albany Passage, 10°45′S 142°37′E, 7–26 m, mud and sand, 9 Oct. 1907, C36162 (4v). Gannet Passage, Torres Strait, 10°35′S 141°55′E, 0–11 m, coral mud, 9 Sep. 1874, C379253 (1v). **Papua New Guinea.** Lolorua Is., SW Port Moresby, 9°30′S 147°6.5′E, 13–18 m, 21 June 1970, C379256 (7v), and 9°30′S 147°7′E, 13–22 m, 21 June 1970, C379257 (21v).

Description

Shell. Maximum length 1.58 mm, maximum height 1.53 mm, inequilateral, with umbo slightly displaced from middle, prosogyrate and white or bone coloured. Inflation ratio, 1.07–1.74.

Prodissoconch. Maximum length 180 µm, consisting of prodissoconch I. Prodissoconch I with five indented areas in radial pattern and thickened rim.

Dissoconch. Lunule and escutcheon long and broad with commarginal sculpture. Outline triangular or rectangular with convexly angled anterior and posterior slopes, sharply angled anterior and posterior ends. External sculpture of about 59–61 fine commarginal ribs, creating a fenestrate pattern between radial ribs, with scabrous structures on the 9–10 strong radial ribs. Inner margin with 9–10 denticles. Hinge plate wide. Lateral

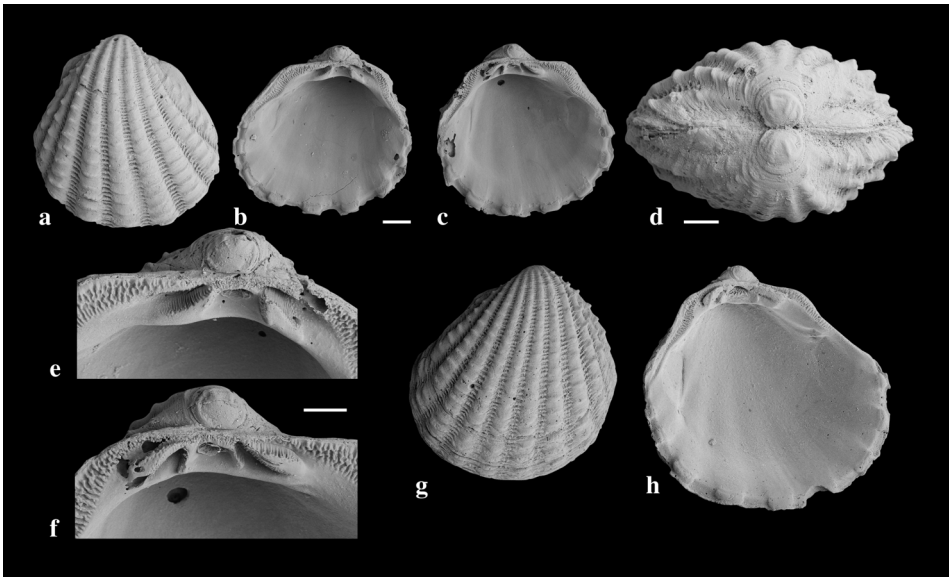

Fig. 30. *Isodontocardia microcardia*. *a–f*, Paratypes, C379259 Amazon Bay, Papua New Guinea. *g*, *h*, Murray Island, Torres Strait, Queensland. *g*, Holotype C388188. Scale bars: *a–c*, *g*, *h*, 200 µm; *d*, 100 µm; *e*, *f*, 100 µm.

teeth area dorsally extended into plate-like structure, with sculptured/wrinkled surface. Lateral teeth positioned just ventrally from these surface ripples. Two lateral teeth in each valve. Teeth all longer then half length of dorsal slopes and consist of anterior lateral (LAI) and posterior lateral (LPIII) in right valve and anterior lateral (LAII) and posterior lateral (LPII) in left valve. Right valve anterior cardinal tooth (CA3) oblique and strong. Posterior cardinal tooth (CP3) present, divided into cardinal elements CP3a,b. Left valve anterior cardinal tooth CA4 arched, divided into cardinal elements CA4a,b. Posterior cardinal teeth (CP2 and CP4) dorsally connected. Internal ligament 60 μm long, rounded, in resilium.

Dimensions. See Table 19.

Table 19. Measurements of specimens of *Isodontocardia microcardia* n. sp.

	SL (mm)	SH (mm)	PL (mm)	SI (mm)	SL/SI×2
Isodontocardia microcardia, holotype, C388188 (Fig. 30*g*)	1.52	1.57	0.17	0.71	1.07
Isodontocardia microcardia, paratypes, C379259	1.49	1.48	0.13	0.51	1.46
	1.48	1.40	0.16	0.54	1.37
	1.58	1.53	0.17	0.60	1.32
	1.51	1.50	0.14	0.57	1.32
	0.94	0.90	0.18	0.27	1.74

Distribution

Northern Territory, Queensland and Papua New Guinea (Coral Sea), subtidal to continental shelf, 0–65 m depth. Found in mud or sand. This species is only known from shells.

Etymology

Micro from Greek for 'small' and *cardia* from Greek for 'heart'.

Excluded taxa

Family ?**NEOLEPTONIDAE**

Puyseguria chapmani (Gatliff & Gabriel, 1912*a*)

Condylocardia chapmani Gatliff, & Gabriel, 1912*a*: 167 (type locality: off Portsea, Port Phillip, Victoria, dredged. Holotype NMV F.481). – Macpherson & Chapple, 1951: 149; Kershaw, 1955: 296; Lamprell & Healy, 1998: 168, fig. 478.

Benthocardiella chapmani (Gatliff & Gabriel, 1912*a*). Macpherson & Gabriel, 1962: 321.

Remarks

Puyseguria chapmani was initially described as a species of *Condylocardia*. The hinge teeth, flat prodissoconch and shape suggest placement in *Puyseguria* Powell, 1927, although compared to the type of *Puyseguria* (*P. cuneata* Powell, 1927) the hinge teeth are transposed.

This species emphasises, like the two *Benthocardiella* species described above, a possible close relationship between the Condylocardiinae and Neoleptonidae.

Family **GALEOMMATIDAE** *sensu* Ponder (1998)

Mysella ovata (Hedley, 1906*a*)

Condylocardia ovata Hedley, 1906*a*: 539, pl. 31, figs 5, 6 (type locality: Manly Beach, Sydney, New South Wales. 33°48′S, 151°17′E, pres. L. Parkes. Holotype C024500). – Hedley, 1906*b*: 465; Verco, 1907: 109; Verco, 1908*b*: 18; Gatliff & Gabriel, 1908: 389; Verco, 1908*a*: 359; Hedley, 1918: M17.

Calvitium glabra Laseron, 1953: 46, figs 32 and 32a,b (type locality: Gunnamatta Bay, Port Hacking, Sydney. Syntypes C090588 (48 v)). – Lamprell & Healy, 1998: 166, fig. 464.

Condylocuna ovata (Hedley, 1906*b*). Laseron, 1953: 40, figs 17, 17a. – Cotton, 1961: 206, fig. 210; Macpherson & Gabriel, 1962: 321; Jansen, 1995: 101, fig. 425; Lamprell & Healy, 1998: 170, fig. 482.

Remarks

This taxon resembles species of *Condylocuna* superficially although it differs markedly in hinge detail. The cardinal CA3 is larger, longer and more or less detached from the anterior margin. The posterior cardinal in the right valve is bigger than in *Condylocuna*. There are no real cardinals in the left valve. The shell and hinge agree with species of *Mysella* Angas, 1877.

Examination of the type specimens of *C. ovata* and *C. glabra* using SEM shows that these two taxa are synonymous. Since *C. glabra* is the type species of *Calvitium* Laseron, 1953 (Neoleptonidae), *Calvitium* becomes a synonym of *Mysella*.

Discussion

The aim of this review was to produce a revision of the Condylocardiinae based on available characters. Unfortunately only the shells of all but one species of Condylocardiinae (*s.s.*) are known to date. Since the review is based on shells alone, future analyses of anatomical and molecular characters are required to underpin the taxonomic decisions made.

As a consequence of the lack of available live material, virtually nothing is known about where the species live or what their role might be in marine ecosystems. With the descriptions provided herein it is hoped that more work on the group will be stimulated.

The biggest challenge in this revision was to correctly identify the hinge teeth. Although labelling of the lateral teeth follows Bernard's (1898) scheme, several deductions had to be made in respect to the cardinal teeth. The absence of ontogenetic sequences from prodissoconch through juvenile to adult in most species made direct observations of cardinal teeth ontogeny impossible. The deductions made are largely based on adult hinge teeth similarities (Fig. 31). The lines in Fig. 31 that link the cardinal teeth elements do not represent any evolutionary sequence but simply connect teeth that are considered homologous. The anterior cardinal teeth of the right valve consist of a dorsally recurved and subdivided cardinal CA3 in *Benthocardiella* and *Condylocardia* following Bernard's (1898) scheme. In all other genera treated herein, this tooth is not subdivided. However, in *Austrocardiella* a small fold proximal to the ligament is apparent and has here been labelled CA5. The posterior cardinal teeth in the right valve are mostly consistent throughout the subfamily with the exception of *Condylocuna tricosa*, in which these elements are undeveloped or reduced, and *Benthocardiella*, in which CP2 is absent.

The most striking difference in the cardinal teeth elements of the left valve is the presence of CA2 in *Benthocardiella* and *Condylocardia* and the absence of a CP2 in *Benthocardiella*.

The species *C. subradiata* and *C. notoaustralis* are variable and appear to show clinal integration in New South Wales. Both require further study to clarify their status. *Condylocardia limaeformis*, *C. notoaustralis*, *Condylocuna projecta* and *C. tricosa* have closely similar relatives outside Australia in New Zealand, on St Paul Island, and in South Africa. The development of these widespread species-complexes is certainly non-pelagic and likely means of dispersion would be by rafting, utilizing macro-algae haptors, thalli or other rafting objects. Comparative studies on Australian, New Zealand, South Africa and St Paul Island taxa would be useful in determining character differences between the taxa.

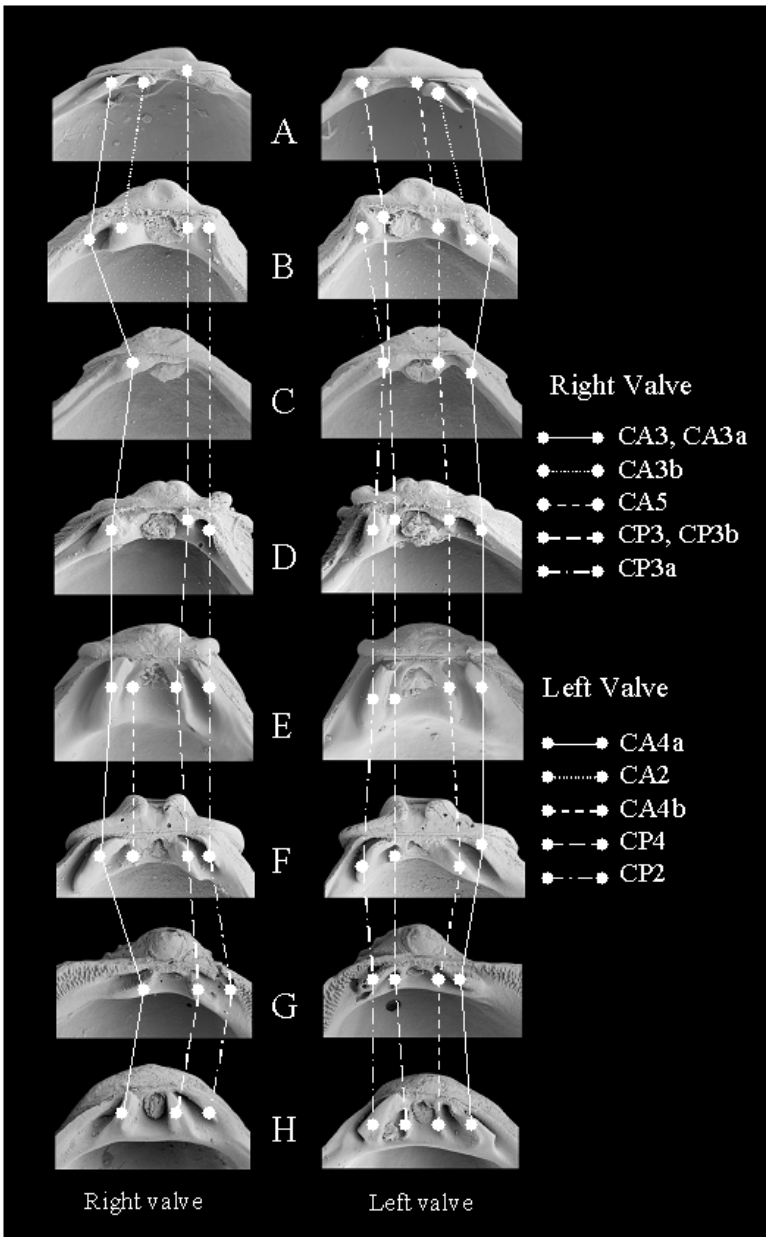

Fig. 31. Homologous hinge teeth elements linked between representatives of condylocardiine genera. *A*, *Benthocardiella burtonae*. *B*, *Condylocardia limaeformis*. *C*, *Condylocuna tricosa*. *D*, *C. projecta*. *E*, *Austrocardiella trifoliata*. *F*, *A. pouli*. *G*, *Isodontocardia microcardia*. *H*, *Cunanax pisum*. The link between CA3b in *A* and *B* indicates the secondary subdivision of CA3 only believed to be present in *Benthocardiella* and *Condylocardia*. See Fig. 1 for explanation of symbols.

Previously used terms for the mode of reproduction in the condylocardiines are confusing. The term 'larvae' was used for the prodissoconch stage in the female suprabranchial cavity by Salas and Rolán (1990), but as the presence of velum or other larval characters have not been proven, this term should not be applied (see Levin and Bridges 1995). The presence of two distinct morphological areas on the prodissoconch was interpreted as prodissoconch I and II (prodissoconch I being the centre of the prodissoconch) by Salas and von Cosel (1991) against the traditional usage of these terms in connection with pelagic developing larvae of either the lecithotrophic or planktotrophic type (Jørgensen 1946; Ockelmann 1965). However, the presence of these prodissoconch parts is independent of the ontogenetic pathway because some embryos develop two shell parts, even if they are brooded and lack any pelagic development.

The inner shell area, here referred to as prodissoconch I, is created by the shell gland of the embryo (see Ockelman 1965), *viz*., not the mantle edge, following the interpretation of Salas and von Cosel (1991) in other condylocardiines. *Condylocuna jimbecki* (Fig. 20*s*) provides evidence for this theory, as the first shell (prodissoconch I) possesses characters indicative of ontogenesis by a complex shell gland. Firstly, the microstructures consist of pits with no commarginal pattern, and secondly the complex calcified structures that create the appearance of three radiating indentations could not have been created by the mantle edge.

The second area has fine commarginal lines and a radial pattern created by the mantle edge of the embryo. It is this part that is prodissoconch II as defined by Ockelmann (1965). This resolution follows Salas and von Cosel's (1991) terminology.

The available information indicates that the reproductive mode in the condylocardiines is brooding and lecithotrophic, i.e. brooded embryos that live on yolk supplied in the egg. The likely embryonic morphogenetic pathway is direct development (i.e. a larval stage is lacking) but this needs to be confirmed.

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