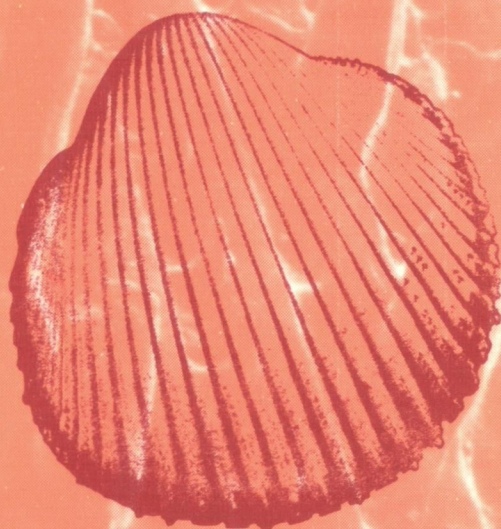


Cardiidae of Western Australia



**B. R. WILSON
&
S. E. STEVENSON**

**WESTERN AUSTRALIAN MUSEUM
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CARDIIDAE (MOLLUSCA, BIVALVIA)
OF WESTERN AUSTRALIA

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and
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ABSTRACT

Thirty-one species of the bivalve family Cardiidae are reported and described from the Western Australian coast. Four of the species are described and named as new. Nine genera are represented and one species is generically unplaced. A key to the genera is given.

Most of the species (22) are widely distributed throughout northern Australia and the Central Indo-West Pacific Region, extending their range southwards into the northern waters of Western Australia. Only three species occur in the temperate waters of the southern coastline. There are six species which appear to be endemic to Western Australia.

INTRODUCTION

This annotated account of the bivalve family Cardiidae in Western Australia is based on relatively recently collected material in the Western Australian Museum. It is intended primarily to place on record the species which occur in the State, to give descriptions, diagnoses and illustrations which will enable them to be identified, and to indicate their geographic distributions within and beyond the State. In order to accomplish this we have chosen to use mainly the characters of the shell, for these are generally sufficient to distinguish between the species, although probably inadequate as a basis for subfamily and generic classification.

It has not been our intention to meddle with the generic and subfamilial classification of the family, for, although the need for a comprehensive family review is very apparent, this is beyond the scope of our aims and the time available to us. Nevertheless in this and similar studies, having determined the species and resolved the major species-level nomenclatural matters involved, it is necessary then to assign the species to genera and this has proved to be most difficult.

The Cardiidae, like many other bivalve families, is strongly represented in both the western and eastern hemisphere but its classification is based mainly on its American and European representatives (see Clench & Smith, 1944; Keen, 1958; Olsson, 1961; Keen, 1969). The majority of Western Pacific and Indian Ocean species have never been 'fitted' into the current taxonomic scheme, while some have been placed in higher categories of their own without reference to possible American or European congeners. We have repeatedly met with difficulty when we have tried to assess the position of our generically unplaced or misplaced Western Australian species

in relation to the arrangement of the genera and subgenera given in the most recent classifications. These Indo-West Pacific species frequently transgress the taxonomic boundaries devised for the American and European forms.

For these reasons we feel a little sensitive about the limitations of this provincial, faunistic catalogue of species which falls far short of the need for a thorough family revision and anatomical survey which we believe it has exposed. It may have been possible to avoid the generic problem altogether by calling all our species "*Cardium*" *sensu lato* (see Petersen & Russell, 1971) but it seemed more constructive to make approximate generic placements and, in so doing, draw attention to deficiencies in the higher category nomenclature of the family wherever we came across them. Future amendments to the generic nomenclature used in this paper must be expected when the family is next revised. We have avoided description of new genera and subgenera and have taken a conservative attitude toward these higher categories. These are matters best left to the next monographer of the family.

Abbreviations

Localities:	W.A.	Western Australia
	S.A.	South Australia
	Vic.	Victoria
	N.S.W.	New South Wales
	Tas.	Tasmania
	Qld	Queensland
	N.T.	Northern Territory
Type species designation:	O.D.	Original designation
	S.D.	Subsequent designation
	M.	Monotypy
	T.	Tautonymy
Institutions:	WAM	Western Australian Museum
	AM	Australian Museum (Sydney)
	BM (N.H.)	British Museum (Natural History)
	SAM	South Australian Museum
	NMV	National Museum of Victoria (Melbourne)
	CSIRO	Commonwealth Scientific and Industrial Research Organization

Note: Where catalogue numbers are given they refer to specimens in the Western Australian Museum unless otherwise indicated by one of the listed abbreviations for institutions as a prefix. (The prefix N before some catalogue numbers refers to the W.A. Naturalists Club collection in the Western Australian Museum.)

GENERAL ACCOUNT OF THE FAMILY

The Cardiidae is world-wide in distribution with species in tropical, temperate and boreal waters. Cardiids are shallow burrowers in sand or mud and species may be found in these substrates almost anywhere on the continental shelf from the intertidal zone to the continental slope. They have a large sickle-shaped (geniculate) foot capable of rapid digging. Although they do not burrow far below the surface of the substrate they are capable of considerable horizontal movement. Their incurrent and excurrent siphons are short, tubular, fused together and are capable of little extensile and retractile movements for they have no elaborate siphonal retractor muscles. Consequently a pallial sinus is lacking. The siphons are surrounded by sensory papillae or tentacles which, in some species, bear minute 'eyes' (Kishinouye, 1894; Küpfer, 1915; Roche, 1925; Braun, 1954).

The anatomy of several cardiids has been described by Johnstone (1899), Zugmayer (1904), Pelseneer (1911) and Kawaguti (1950).

Shells of the Cardiidae are usually equivalve, ovate or quadrate and rather tumid with prosogyrate umbos, a short parivincular ligament and a cyclodont hinge. There are usually two non-bifid cardinal teeth in each valve which are cruciform in arrangement and may be joined at their dorsal ends or separate. Lateral teeth are usually strong with one anterior and one posterior lateral in the left valve, and one or two anterior and one or two posterior laterals in the right valve. Adductor scars are subequal and the pallial line is entire. Externally the shell is usually sculptured with smooth, nodulose, rugose, squamose or spinose radial ribs. There may be secondary sculpture in the intercostal space. A smooth or hirsute periostracum is present.

Recently Kenneth Boss (1971) again raised the question of the status of the genus *Hemidonax* Mörch, 1870 and has offered arguments for placing this genus in the family Cardiidae rather than in the tellenacean family Donacidae or in the Crassatellidae. Iredale and McMichael (1962) introduced a new family name Hemidonacidae for *Hemidonax*. It seems to

us that, although the arguments of Dr Boss are persuasive, a final decision on this matter is best left until better anatomical data are available for the species of *Hemidonax* and established members of the Cardiidae. Consequently we do not include the two Western Australian species of *Hemidonax* in our account of the Cardiidae of the State but mention them briefly here. They are *Hemidonax donaciformis* (Schröter, 1786) which we have recorded from the Dampier Archipelago, and *H. chapmani* Gatliff and Gabriel, 1923 (= *dactylus* Hedley, 1923) which occurs along the southern coast of Western Australia at least as far north as Safety Bay.

Without including the two species of *Hemidonax* the family Cardiidae is represented by 31 species in Western Australia, a list of which follows.

Distribution key: + Indo-West Pacific
 x Southern Australian
 o Endemic W.A.

- + *Ctenocardia perornata* (Iredale, 1929)
- + *Ctenocardia fornicata* (Sowerby, 1841)
- + *Lyrocardium lyratum* (Sowerby, 1841)
- + *Fragum* (*Fragum*) *fragum* (Linnaeus, 1758)
- + *Fragum* (*Fragum*) *unedo* (Linnaeus, 1758)
- + *Fragum* (*Lunulicardia*) *retusum* (Linnaeus, 1767)
- + *Fragum* (*Lunulicardia*) *hemicardium* (Linnaeus, 1758)
- o *Fragum* (*Afrocardium*) *erugatum* (Tate, 1889)
- + *Fulvia aperta* (Bruguière, 1789)
- x *Fulvia tenuicostata* (Lamarck, 1819)
- + *Laevicardium attenuatum* (Sowerby, 1841)
- + *Laevicardium biradiatum* (Bruguière, 1789)
- + *Acrosterigma elongatum* (Bruguière, 1789)
- + *Acrosterigma reeveanum* (Dunker, 1852)
- + *Acrosterigma alternatum* (Sowerby, 1841)
- o *Acrosterigma dupuchense* (Reeve, 1845)
- o *Acrosterigma fultoni* (Sowerby, G.B., 1916)
- x *Acrosterigma cygnorum* (Deshayes, 1855)
- + *Acrosterigma dampierense* sp. nov.
- + *Acrosterigma transcendens* (Melville & Standen, 1899)
- o *Acrosterigma marielae* sp. nov.
- o *Acrosterigma vlamingi* sp. nov.
- o *Acrosterigma rosemariensis* sp. nov.
- + *Nemocardium* (*Nemocardium*) *bechei* (Reeve, 1840)

- + *Nemocardium (Microcardium) torresi* (Smith, 1885)
- + *Nemocardium (Microcardium) exasperatum* (Sowerby, 1838)
- x *Nemocardium (Pratulium) thetidis* (Hedley, 1902)
- + *Plagiocardium (Maoricardium) setosum* (Redfield, 1848)
- + *Plagiocardium (Maoricardium) frazeri* (Garrard, 1963)
- + *Vepricardium multispinosum* (Sowerby, 1838)
- + "*Cardium*" *victor* Angas, 1872

DISTRIBUTION OF CARDIIDS IN WESTERN AUSTRALIA

Although further field studies may extend the known geographic range of some of the 31 cardiid species recorded here (Fig. 2) the present data provide a useful basis for discussion of the distribution patterns and the composition of the Western Australian marine fauna. This family is much more strongly represented in the tropical north than in the temperate south. Three components may be distinguished:

1. Indo-West Pacific 'tropical' species (22) which range southward into W.A. Most of these are widespread throughout the tropical parts of the Western Pacific and Indian Oceans; a few are apparently more restricted to the central part of this region, i.e. the Indo-Malay Archipelago, New Guinea and northern Australia. Of these 22 species 14 range as far south as North West Cape but no further. One is recorded in W.A. only from the extreme north (*P. (M.) frazeri* which is otherwise known only from Qld). Another (*A. reeveanum*) appears to be confined to the Australian coast but is widely distributed within Australia from northern N.S.W. across the north and down the W.A. coast as far south as Geographe Bay (lat. 33°40'S) which is well within the southern temperate water zone. Cotton (1961: 240, Fig. 255) records this species as a "subfossil" in S.A. (under the name *Vasticardium flavum* Linnaeus, 1758) indicating an even greater penetration of the species into temperate waters in the recent past. Of the remaining 7 Indo-West Pacific species, 3 range as far south as Shark Bay, 3 continue on to the Abrolhos region and 1 reaches as far south as Geographe Bay.

2. Southern Australian "temperate" species (3) which range across the southern coast of the continent and up the lower parts of the eastern and western coasts. All 3 cardiid species in this group extend well up the east coast of Australia as far as N.S.W. or southern Qld. On the W.A. coast 2 of them (*F. tenuicostata* and *A. cygnorum*) are found as far north as Fremantle.

The other (*N. (P.) thetidis*) penetrates the 'tropical' region as far north as North West Cape but it is significant that this is a deepwater species which may be occupying a cool water depth zone.

3. Endemic W.A. species (6). Of this group 3 species (*A. dupuchense*, *A. rosemariensis* and *A. fultoni*) are confined to the north-west coast from North West Cape to the Kimberley (although *A. dupuchense* reached south to Shark Bay in the late Quaternary). One (*A. vlamingi*) is known so far only from the central west coast. One (*A. marielae*) is a deepwater central west coast species living along the outer part of the continental shelf between North West Cape and Cape Naturaliste. The sixth species (*F. [A.] erugatum*) has an unusual range from the middle part of the North West coast at the Dampier Archipelago to the central part of the west coast. Its southern end of range appears to be unstable. Dense living populations are present in the Abrolhos area but we have no specimens taken alive further south although fossils of the species are a characteristic feature of Quaternary shell beds as far south as Geographe Bay. The species was in fact first described from a few fossil valves in S.A.

Thus, the Cardiidae of W.A. illustrate nearly all of the commonly recurring species distribution patterns of the region. The northern fauna is quite distinct from that of the south but must be seen as part of the greater Indo-West Pacific fauna because 22 of the 27 species to be found there range beyond the State, most of them being widespread Indo-West Pacific species. Only 4 of the 27 northern cardiids are peculiar to the North West Australian region so that there is little support here for recognition of this region as a distinct faunal province (i.e. the "Dampierian Province" of authors). North West Cape appears to be the cutting off point for a majority of the northern species.

Recognition of a southern Australian (temperate) fauna is also supported by the cardiid distribution data, although only 3 species are involved. But all of them range up the East Coast of Australia as well as up the West Coast so that they give no support to the concept of a 'Flindersian Province' with an eastern boundary in the Bass Strait region (see Whitley, 1932; Iredale, 1939).

Of interest is the fact that the 3 southern species belong to the 3 cardiid genera (*Acrosterigma*, *Nemocardium*, *Fulvia*) which are represented in the Tertiary fossil beds of southern Australia (see Darragh, 1970; Ludbrook, 1955, making allowances for variations in generic nomenclature). *A. cygnorum* and *N. (P.) thetidis* each has a close relative in the Pliocene of S.A., viz. *Vasticardium praecygnorum* Ludbrook, 1955 and *N. (P.)*

proterothetidis Ludbrook, 1955 respectively. They also have other congeners in the middle Tertiary of south-eastern Australia. The third living southern Australian species, *F. tenuicostata*, is itself present in South Australian Pliocene shell beds (Ludbrook, 1955: 62-63). No other cardiid genera appear to have established in the southern Australian region during the Tertiary.

There have, however, been brief incursions of northern forms (*A. reeveanum* and *F. [A.] erugatum*) from the west, probably during late Pleistocene or Recent times. Both these species are most abundant alive today in the warm waters of the North West and central West Coast with fossil or occasional living records as far south as Geographe Bay. Both apparently have such dispersal capacity and thermal tolerance that they have been able to take advantage of minor changes in ocean current and/or climatic conditions in the recent past and substantially increase their southward and eastward range.

The central West Coast between Cape Naturaliste and North West Cape has particular zoogeographical interest, not as a distinct faunal province but as an exceptionally long zone of overlap between the northern (tropical) and southern (temperate) faunas. It contains a few endemic species (e.g. *A. marielae*) but these alone are insufficient to warrant recognition of the central west coast as a faunal province.

KEY TO THE GENERA OF WESTERN AUSTRALIAN CARDIIDAE

- 1a. right valve with two posterior lateral teeth
below the dorsal margin *Ctenocardia*
- b. right valve with only one posterior lateral
tooth below the dorsal margin (dorsal margin
itself may be sharp and tooth-like) 2
- 2a. anterior area with strong sharp oblique
ridges overlying radial sculpture *Lyrocardium*
- b. anterior area sometimes with radial ribs but
without oblique ridges 3

- 3a. right cardinal teeth of almost equal size and height or fused together 4
- b. right anterior cardinal tooth obviously smaller and shorter than right posterior cardinal 6
- 4a. ribs on posterior area with spines *Vepricardium*
- b. ribs on posterior area without spines but may bear transverse or crescent-shaped rugae 5
- 5a. lunule prominent, broad and flat or deeply sunken; posterior margin crenulate *Fragum* (sub. gen. *Lunulicardia*)
- b. lunule not prominent, consists only of a narrow raised margin; posterior margin strongly denticulate *Fragum* s.s.
- 6a. radial ribs without spines or rugae 7
- b. radial ribs with spines or rugae 8
- 7a. radial ribs on posterior area as thick as or thicker than medial ribs *Fulvia*
- b. radial ribs on posterior area obsolete or less well developed than medial ribs *Laevicardium*
- 8a. right cardinal teeth joined by saddle 9
- b. right cardinal teeth separate or merely touching dorsally 10
- 9a. right anterior lateral tooth abruptly truncated anteriorly "*Cardium*" *victor*
- b. right anterior lateral tooth not truncated *Nemocardium*
- 10a. shell outline ovate, without umbonal keel 11
- b. shell outline quadrate or trapezoidal, angulate or rounded umbonal keel demarcates posterior area *Fragum* (sub. gen. *Afrocardium*)
- 11a. shell height greater than length *Acrosterigma*
- b. shell height equal to or less than length *Plagiocardium* (sub. gen. *Maoricardium*)

PLATE 1

- Figs 1-4 *Vepricardium multispinosum* (Sowerby, 1841)
WAM. 2838-67, Tweed Heads, N.S.W. (x ¾)
- 5 *Cardium multispinosum* Sowerby, 1841 [*Vepricardium*]
Lectotype (here selected) B.M.(N.H.) Cuming Collection, "Mindanao and Cebu". (x ½)
- 6 *Cardium mirabile* Deshayes, 1854
[= *Vepricardium asiaticum* (Bruguière, 1792)]. Holotype, B.M.(N.H.)
Cuming Collection, reg. no. 1971.28, Philippines. (x ½)
- 7 *Vepricardium asiaticum* (Bruguière, 1792)
WAM. 799-71, Magueda Bay, Philippines. (x 1)
- 8-9 *Plagiocardium (Maoricardium) frazeri* (Garrard, 1963)
Paratype, WAM. 2843-67, Wide Bay, Queensland. (x ¾)
- 10-12 *Plagiocardium (Maoricardium) setosum* (Redfield, 1848)
WAM. 70-67, Bay of Rest, Exmouth Gulf, W.A. (x ½)
- 13 *Plagiocardium (Maoricardium) setosum* (Redfield, 1848)
WAM. 70-67. Enlargement of medial sculpture.
- 14 *Plagiocardium (Maoricardium) setosum* (Redfield, 1848)
WAM. 4852-68, Cape York, Queensland. Showing periostracal hairs.
- 15-16 *Nemocardium (Nemocardium) bechei* (Reeve, 1840)
WAM. 243-67, NNE of Anchor I. off Onslow, W.A. (x 1)
- 17 *Nemocardium (Nemocardium) bechei* (Reeve, 1840)
WAM. 243-67. Enlargement of ventral margin. (x 1)
- 18-19 *Cardium bechei* Reeve, 1840 [*Nemocardium*]
Lectotype (here selected) B.M.(N.H.) Cuming Collection. Ticao, Philippines. (x ¾)

PLATE 2

- Figs 1-3 *Fragum (Lunulicardia) hemicardium* (Linnaeus, 1758)
WAM. 1014-66, Shark Bay, W.A. (x ¾)
- 4 *Fragum (Lunulicardia) hemicardium* (Linnaeus, 1758)
WAM. 732-66, Dampier Arch., W.A. (x ¾)
- 5 *Fragum (Lunulicardia) hemicardium* (Linnaeus, 1758)
WAM. N 4073, Denham, Shark Bay, W.A. (x ¾)
- 6-9 *Fragum (Lunulicardia) retusum* (Linnaeus, 1758)
WAM. 3368-68, North West Cape, W.A. ["subretusum" form] (x ¾)
- 10 *Fragum (Lunulicardia) retusum* (Linnaeus, 1758)
WAM. 1010-66, Shark Bay, W.A. ["subretusum" form] (x ¾)
- 11-14 *Fragum (Lunulicardia) retusum* (Linnaeus, 1758)
WAM. 4882-68, loc. unknown. [extreme "retusum" form] (x ¾)
- 15-18 *Fragum (Fragum) fragum* (Linnaeus, 1758)
WAM. 2374-67, Cardabia Station, W.A. (x ¾)
- 19-22 *Fragum (Fragum) unedo* (Linnaeus, 1758)
WAM. N 4032, Monkey Mia, Shark Bay, W.A. (x ¾)

PLATE 3

- Figs 1-3 *Fulvia tenuicostata* (Lamarck, 1819)
WAM. N 2386, Dunsborough, W.A. (x 1)
- 4-7 *Fulvia aperta* (Bruguière, 1789)
WAM. 168-67, Rosemary I., Dampier Arch., W.A. (x ¾)
- 8 *Cardium attenuatum* Sowerby, 1841 [*Laevicardium*]
Lectotype (here selected), Cuming Collection, B.M.(N.H.) reg. no. 1971.26, Ceylon(?). (x ¾)
- 9-11 *Laevicardium attenuatum* (Sowerby, 1841)
WAM. 10-67, off Bongao Light, Tawitawi Bay, Sulu, Philippines. (x ¾)
- 12 *Laevicardium attenuatum* (Sowerby, 1841)
WAM. 1067-66, 11 km N of Long I., off Onslow, W.A. (x ¾)
- 13-15 *Laevicardium multipunctatum* (Sowerby, 1834)
WAM. 920-66, Cabulan I., off Mactan I., Cebu, Philippines. (x ¾)
- 16-18 *Laevicardium biradiatum* (Bruguière, 1789)
WAM. 1073-66, between Malus and Gidley Is., Dampier Arch., W.A. (x 1)
- 19-21 *Fragum (Afrocardium) erugatum* (Tate, 1889)
WAM. N 2793, Easter Group, Abrolhos, W.A. (x 1¼)

PLATE 4

- Figs 1-3 "*Cardium*" *victor* (Angas, 1872)
WAM. 95-67, Panglao I., off Bohol, Philippines. (x 1)
- 4-5 *Cardium victor* Angas, 1872
Holotype, B.M.(N.H.) reg. no. 1872. 5. 18. 3, Mauritius. (x 1)
- 6-8 *Cardium imbricatum* Sowerby, 1841
[= *Ctenocardia perornata* (Iredale, 1929)]. Lectotype (here selected),
Cuming Collection, B.M.(N.H.) reg. no. 1971.22. (x 1)
- 9 *Ctenocardia perornata* (Iredale, 1829)
WAM. 1-73, Point Cloates, W.A. (x 1)
- 10-13 *Ctenocardia fornicata* (Sowerby, 1841)
WAM. 232-67, W side of Peak I., off Onslow, W.A. (x 1)
- 14-17 *Cardium exasperatum* Sowerby, 1841 [*Nemocardium (Microcardium)*]
Lectotype (here selected), Cuming Collection, B.M.(N.H.). (x 1)
- 18 *Nemocardium (Microcardium) exasperatum* (Sowerby, 1841)
WAM. 97-67, Sulu Arch., Philippines. (x 1)
- 19 *Nemocardium (Microcardium) exasperatum* (Sowerby, 1841)
WAM. 197-67, Cabulan I., off Mactan I., Cebu, Philippines. (x 1)
- 20-21 *Nemocardium (Microcardium) torresi* (Smith, 1885)
WAM. 228-67, 80 km NE Adele I., W.A. (x 1)
- 22 *Nemocardium (Microcardium) torresi* (Smith, 1885)
WAM. 99-67, Sulu Arch., Philippines. (x 1)
- 23-25 *Nemocardium (Pratulum) thetidis* (Hedley, 1902)
WAM. 2860-69, 11 km N Montagu I., N.S.W. (x 1)
- 26-28 *Cardium lyratum* Sowerby, 1841 [*Lyrocardium*]
Type, Cuming Collection, B.M.(N.H.) reg. no. 1971.27, Negros,
Philippines. (x ½)

PLATE 5

- Figs 1-4 *Acrosterigma elongatum* (Brugière, 1789)
WAM. 732-66, Rosemary I., Dampier Arch., W.A. (x ½)
- 5-7 *Acrosterigma reeveanum* (Dunker, 1852)
WAM. N 2357, Dunsborough, W.A. (x ½)
- 8-9 *Acrosterigma enode* (Sowerby, 1841)
WAM. 3761-67, Anse Vate, Noumea, New Caledonia. (x ½)
- 10-12 *Acrosterigma alternatum* (Sowerby, 1841)
WAM. 3351-68, North West Cape, W.A. (x ½)
- 13 *Cardium alternatum* Sowerby, 1841 [*Acrosterigma*]
Lectotype (here selected), Cuming Collection B.M.(N.H.) reg. no.
1971.24, Ticao, Philippines. (x ½)
- 14-15 *Acrosterigma dupuchense* (Reeve, 1845)
WAM. 668-66, Rosemary I., Dampier Arch., W.A. (x ½)
- 16-17 *Cardium dupuchense* Reeve, 1845 [*Acrosterigma*]
Lectotype (here selected), Cuming Collection, B.M.(N.H.) reg. no.
1971.25, Depuch I., W.A. (x ½)

PLATE 6

- Figs 1-5 *Acrosterigma dampierense* sp. nov. Holotype
WAM. 3334-68, Port Hedland, W.A. (x ¾)
- 6-9 *Acrosterigma fultoni* (Sowerby, 1916)
WAM. 266-67, Surf Point, Barrow I., W.A. (x ¾)
- 10 *Cardium fultoni* Sowerby, 1916 [*Acrosterigma*]
Holotype, B.M.(N.H.) reg. no. 1919. 12. 31. 69. (x ¾)
- 11-15 *Acrosterigma marielae* sp. nov. Holotype
WAM. 215-67, W of Cape Leschenault, W.A. (x 1½)
- 16-18 *Acrosterigma transcendens* (Melvill & Standen, 1899)
WAM. 905-66, N of Long I., off Onslow, W.A. (x 1)
- 19-20 *Cardium (Trachycardium) transcendens* Melvill & Standen, 1899
[*Acrosterigma*] Holotype, B.M.(N.H.) reg. no. 1899. 2. 23. 6, Torres
Straits. (x 1)
- 21-22 *Acrosterigma Vlamingi* sp. nov.
WAM. 1029-66, South Passage, Shark Bay, W.A. (x 1)
- 23-24 *Acrosterigma rosemariensis* sp. nov.
WAM. 650-66, Rosemary I., Dampier Arch., W.A. (x 1½)
- 25-27 *Cardium cygnorum* Deshayes, 1855 [*Acrosterigma*]
Paratype, Cuming Collection, B.M.(N.H.) reg. no. 1971.23, W.A. (x 1)

PLATE 1

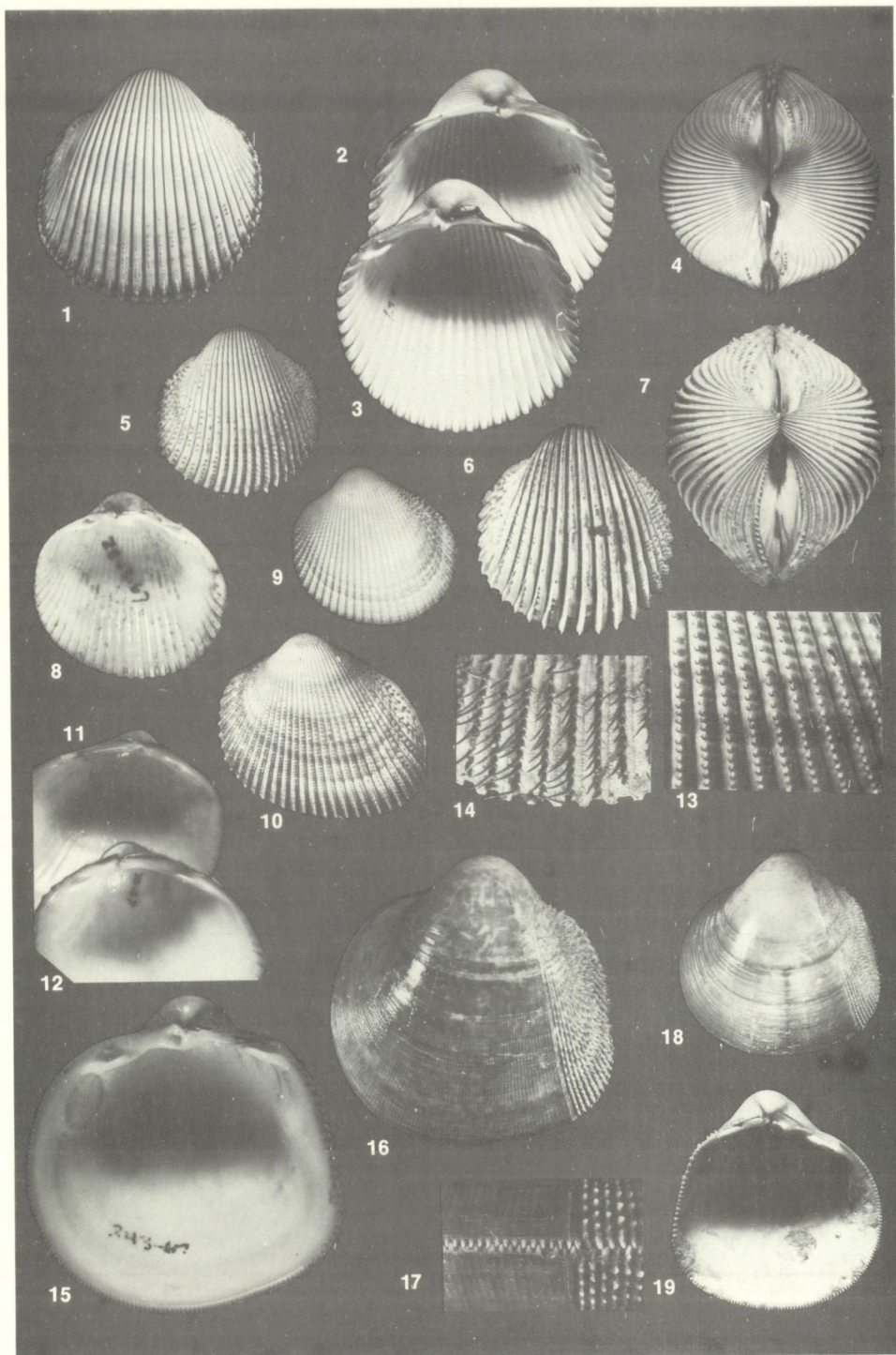


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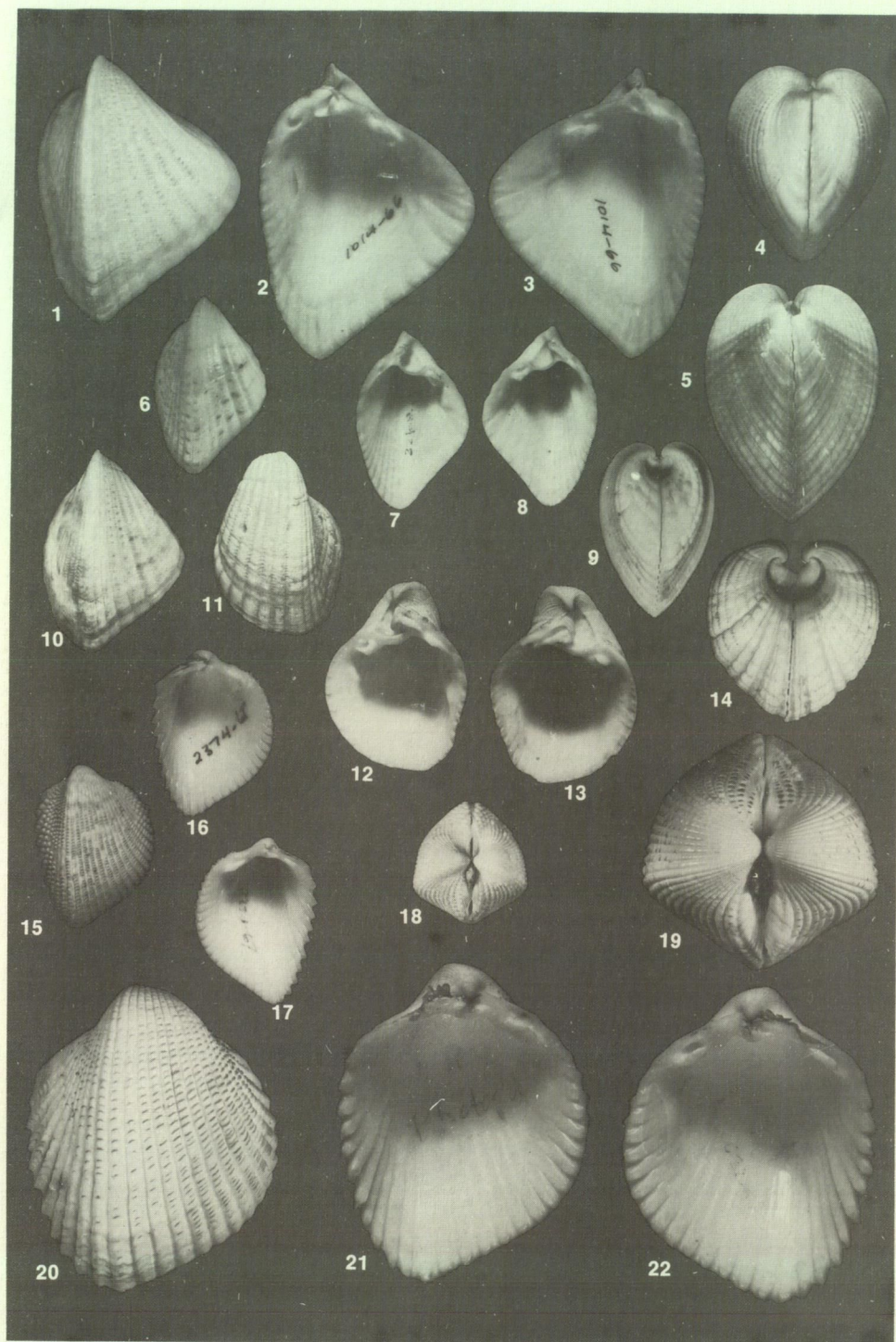


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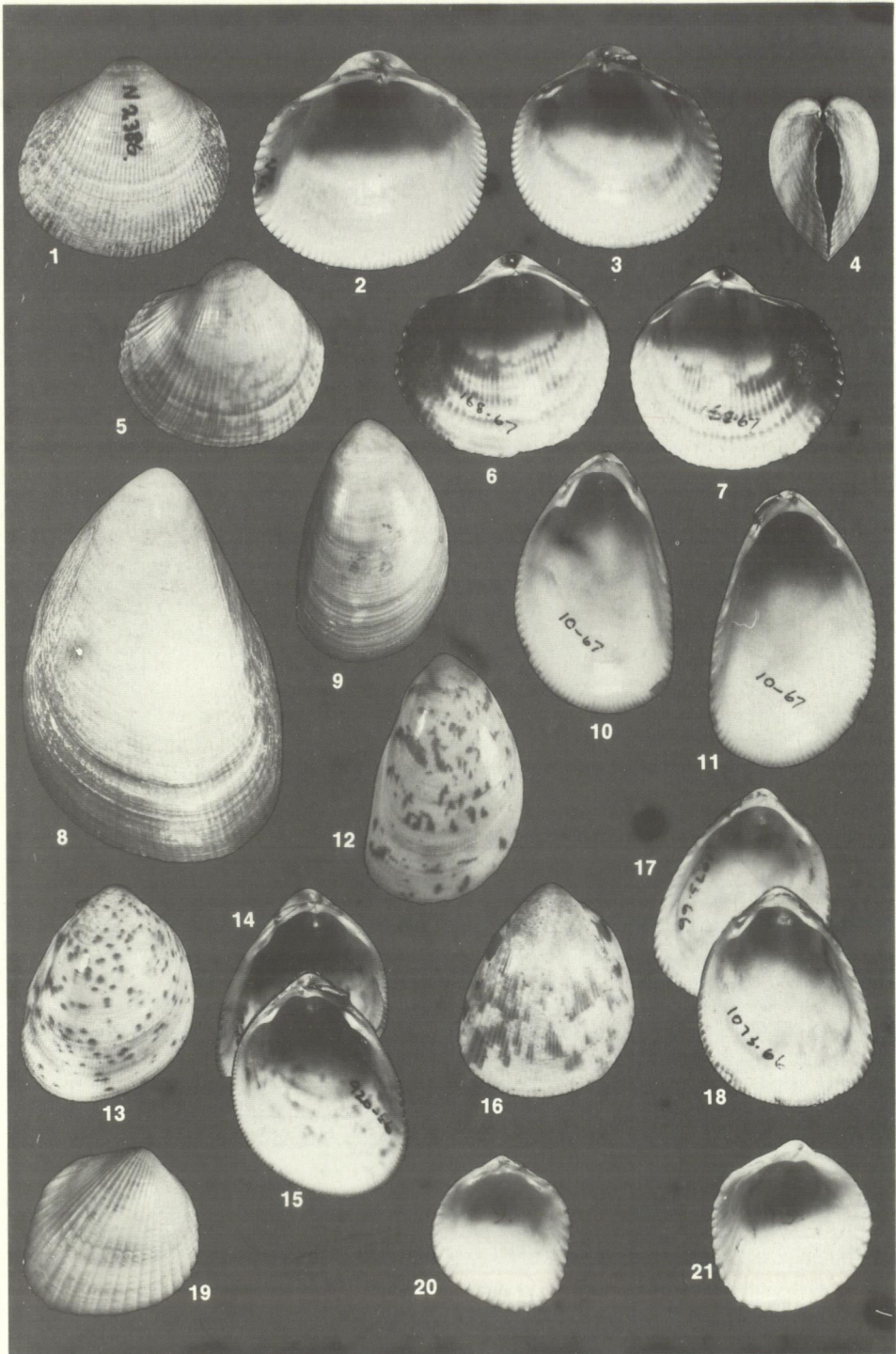


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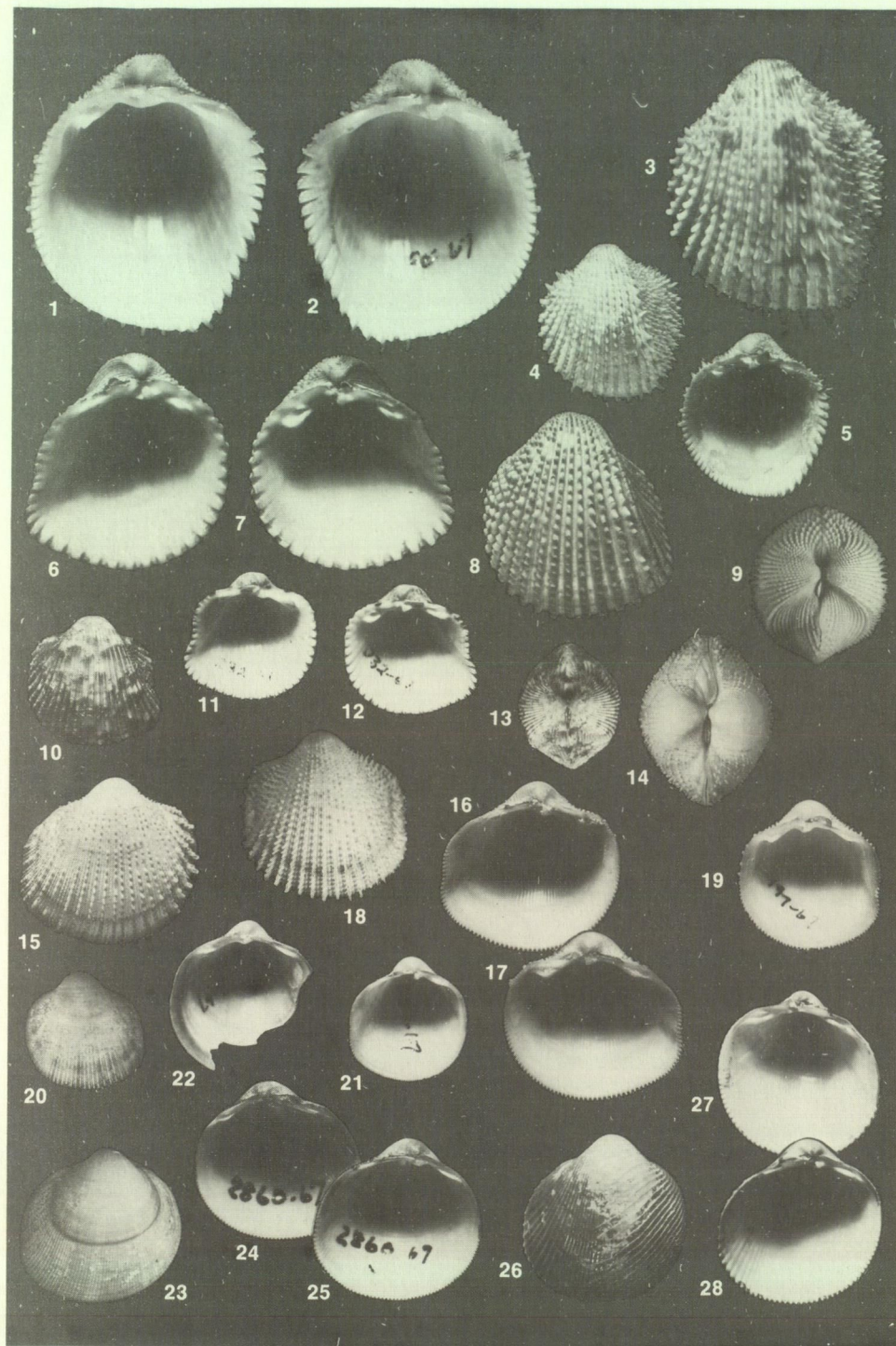


PLATE 5

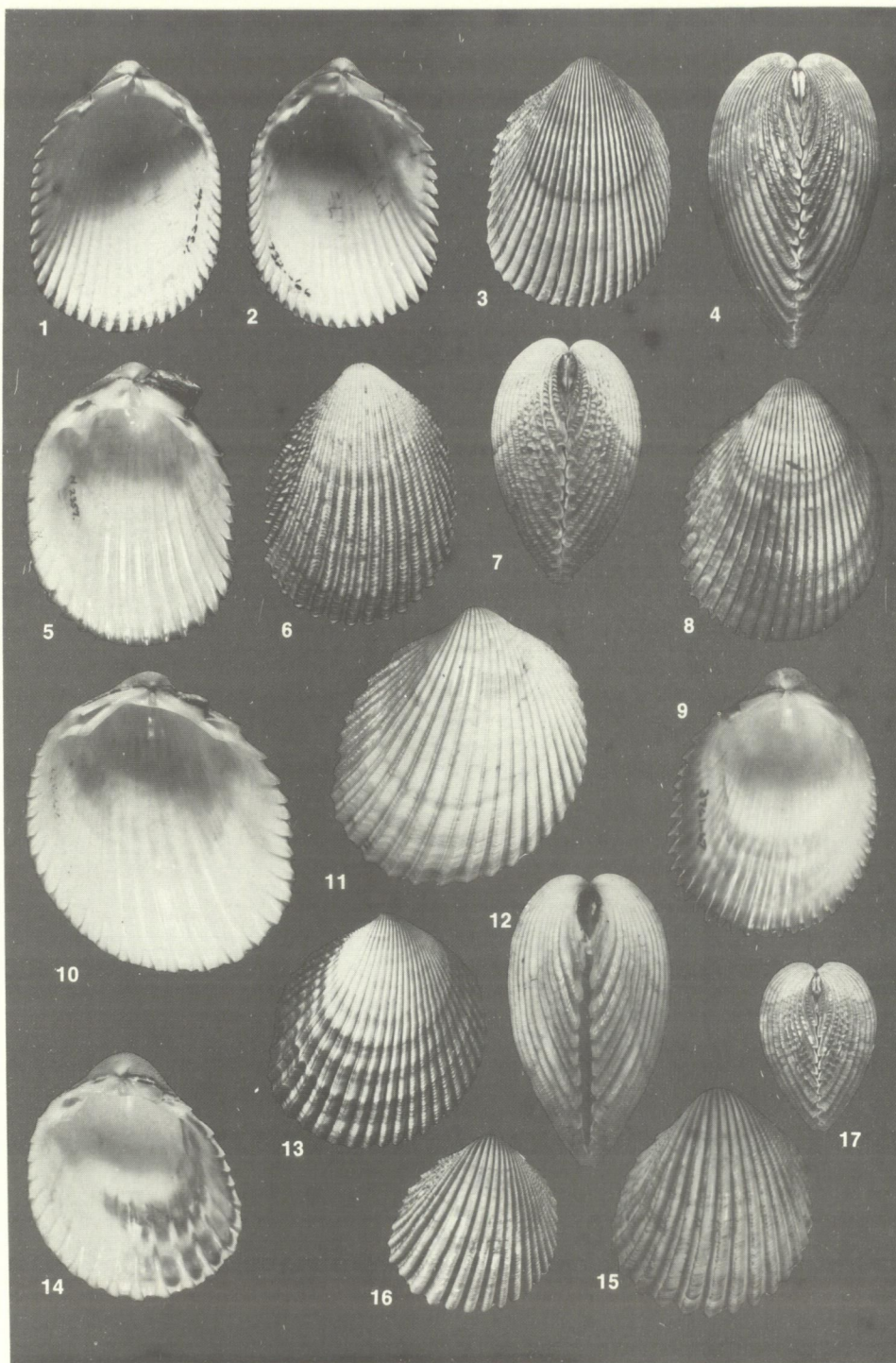
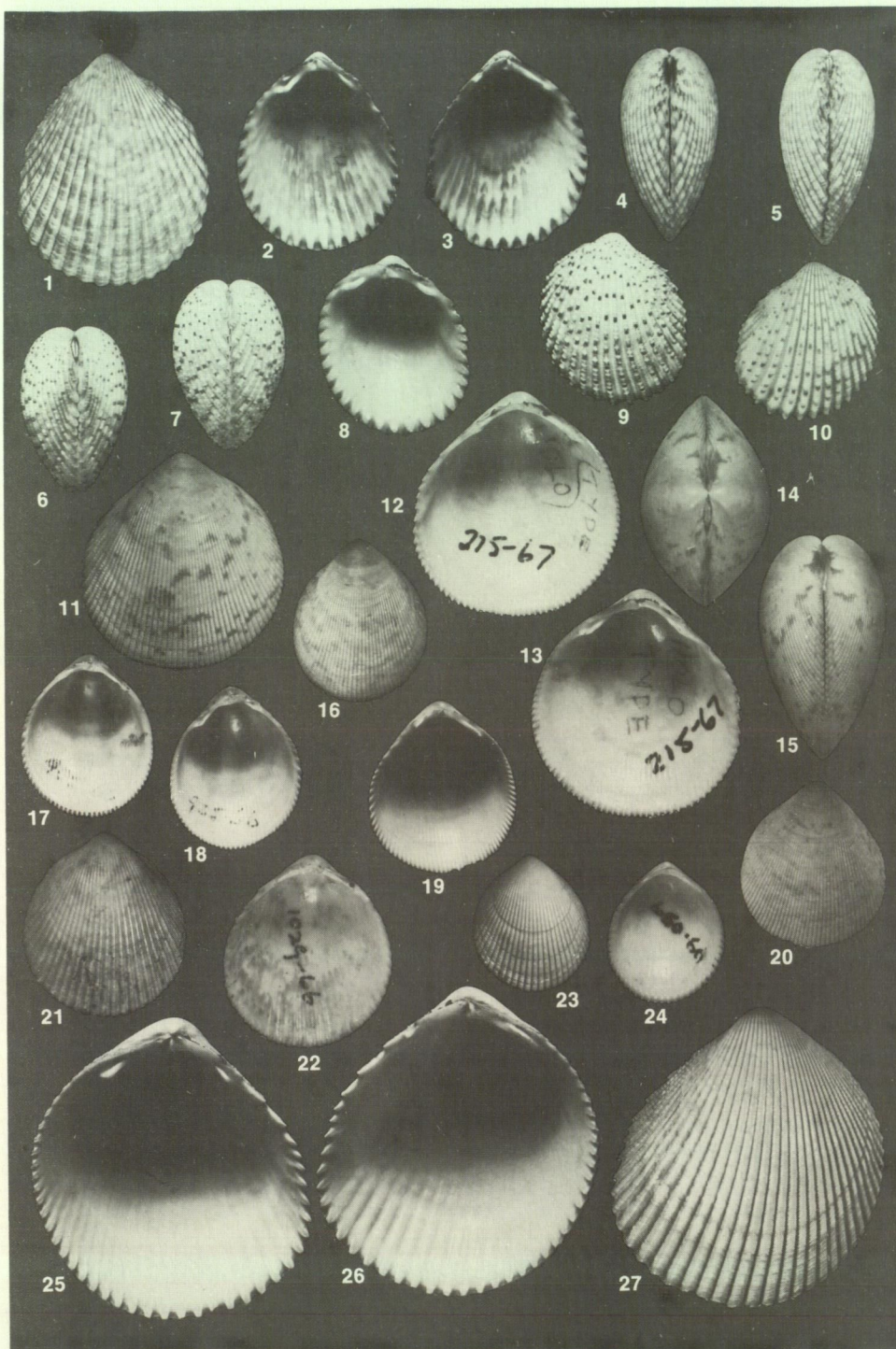


PLATE 6



MAP 1



Map 1: Map of Western Australia showing principle coastal localities referred to in the text.

TABLE 1

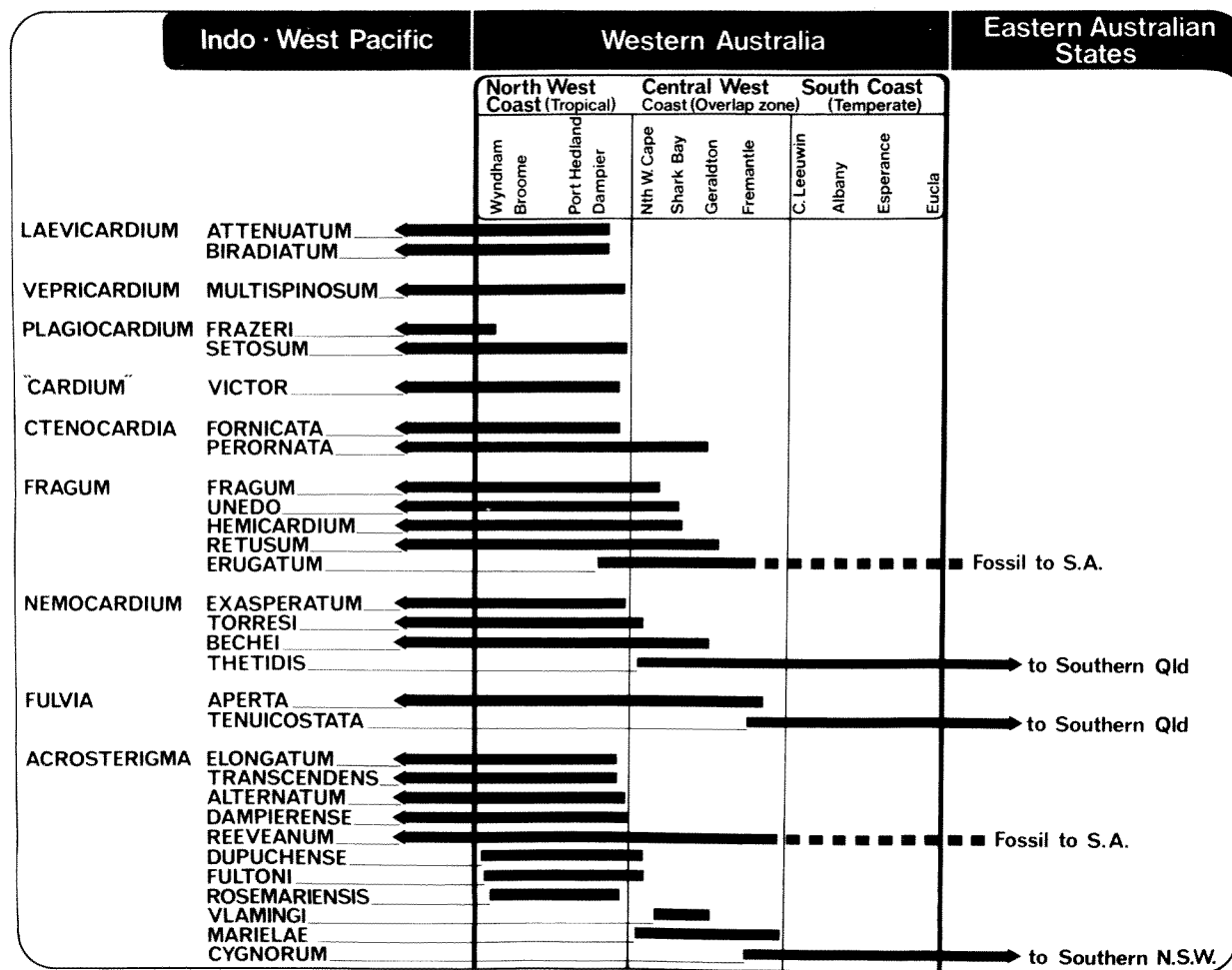


Table 1: Graphic representation of cardiid species distribution along the coast of Western Australia. Arrows indicate that a species extends beyond the borders of the State.

DESCRIPTIONS OF THE TAXA

Genus *Ctenocardia* H. & A. Adams, 1858

Ctenocardia H. & A. Adams, 1858, *The genera of recent mollusca*, 2: 459.

Type species: *Fragum (Ctenocardium) symbolicum* Iredale, 1929 (new name for *Cardium hystrix* Reeve, 1833, *non* Lightfoot, 1786) S.D. Iredale, 1929, *Mem. Qd. Mus.*, 9: 264.

Description

Shell quadrate, inflated; anterior and ventral margins rounded, posterior margin truncated, almost straight; umbonal keel strongly angled and demarcating a slightly concave posterior area; umbos approximately central; margins crenulate. Sculpture of radial ribs which bear numerous spines or transversely elongated nodes; intertices with fine concentric striations and sometimes delicate spinelets or scales on their sides. Lunule present, smooth. Escutcheon poorly defined. Hinge line sinuous. Left cardinals unequal, widely separated; anterior left cardinal pointed and larger than posterior tooth; single left anterior and left posterior laterals. Right cardinals unequal, joined by dorsal saddles; two right anterior and two right posterior laterals.

Remarks

Possession of two posterior lateral teeth in the right valve is a characteristic of this genus found in no other cardiids. In shape and sculpture the shells of *Ctenocardia* resemble those of *Fragum* but the right posterior hinge teeth clearly distinguish between the two genera. We have not followed Keen (1969) in placing *Afrocardium* and *Microcardium* as subgenera of *Ctenocardia* but have placed them in *Fragum* for they possess *Fragum* hinge dentition.

H. & A. Adams (1858) proposed the name *Ctenocardia* as a subgenus of *Hemicardia* Klein, 1753. No type species was named but six species were listed as members of the subgenus (*adamsii* Reeve, *exasperata* Sowerby, *fornicata* Sowerby, *hystrix* Broderip (sic), *imbricata* Sowerby, and *virgo* Reeve). Iredale (1929) designated *C. hystrix* Reeve, 1844 as type of the genus, but replaced that name with *C. symbolica* because *hystrix* was preoccupied by *Cardium hystrix* Lightfoot, 1786. Iredale (1929) also replaced the name *imbricatum* Sowerby, 1841 (*non* Born, 1780) with the new name *perornatum*. We consider *Cardium virgo* to be a synonym of *Cardium imbricatum*, and *Cardium adamsii* a synonym of *Cardium fornicatum*, while Sowerby's species *exasperatum* is a *Nemocardium*. This leaves three of the six species listed by H. & A. Adams in *Ctenocardia*.

We have examined the 3 syntypes of *C. symbolica* in the British Museum (Natural History) (i.e. *hystrix* Reeve, reg. no. 1971.21) and have found that they agree in hinge detail with the type of *C. perornata*. We are satisfied that these are congeneric species. We also consider *C. fornicata* to be congeneric with these species because of the similarity of form and sculpture (although the intercostal spinelets are more profuse) and the presence of two posterior lateral teeth in the right valve.

Cardium (Ctenocardia) translatum Prashad, 1932 shares the generic characters and may be included as a fourth member of *Ctenocardia*. All four species live in the central Indo-West Pacific.

The position of *C. fornicata* in *Ctenocardia* casts in doubt the status of the American genus *Trigonicardia* Dall, 1900 (type species *Cardium graniferum* Broderip & Sowerby, 1829), and its subgenus *Americardia* Stewart, 1930 (type species *Cardium medium* Linnaeus, 1758). *C. fornicata* is a very close match for *T. (Americardia) media* and there can be little doubt that they are congeneric. *Americardia* should then be synonymized with *Ctenocardia* and, if *Americardia* is correctly allied with *Trigonicardia* s.s., then the whole genus may suffer the same fate.

Ctenocardia perornata Iredale, 1929

(Pl. 4, Figs 6-9; Text fig. 1)

Cardium imbricatum Sowerby, 1841 (*non* Born, 1780), *Proc. zool. Soc. Lond.*, 1840: 110; figured by Sowerby, 1841. *Conchological Illustrations*, p. 7, fig. 48. Type locality: "ad Australiae (Swan River)" [Swan River Colony, Western Australia]. Types: Holotype (Pl. 4, Figs 6-8), plus 1 paratype, Cuming Collection, BM (N.H.) reg. no. 1971.22.

Cardium virgo Reeve, 1845, *Conchological Iconica*, 2: Pl. 21, Fig. 120. Type locality unknown. Type not located.

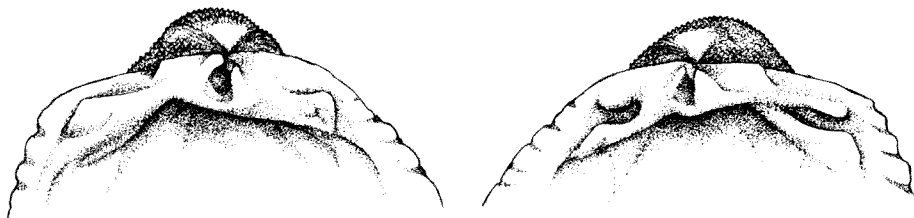
Fragum (Ctenocardium) perornatum Iredale, 1929, *Mem. Qd. Mus.*, 9: 264; new name for *Cardium imbricatum* Sowerby.

Diagnosis

Shell solid and inflated; umbos central prosogyrate; shell height usually slightly greater than shell length.

Lunule well defined, short and broad, approximately equal in left and right valves; escutcheon poorly defined, elongate. Radial ribs strong, intercostal spaces wide and deep; each rib bears on its crest a single row of prominent spines which are crescent-shaped in section with the concavity facing ventrally; spines on posterior ribs smaller and closer together than those of central and anterior ribs; intercostal spaces anterior to umbonal keel smooth or crossed by minute crowded transverse lamellae; intercostal spaces behind keel crossed by stronger transverse lamellae which thicken and extend up over posterior ribs as closely packed V-shaped scales or ridges; delicate, compressed, pointed scales or spinelets sometimes present projecting into intercostal spaces from sides of ribs. Shell exterior white or cream, interior white, rose-red, yellow or with broad radial band of rose-red or yellow arising from below umbo.

Sample number 17; measurements of largest shell: length 2.11 cm, height 2.28 cm, width 1.84 cm; mean ratio length to height 0.95:1 (range 0.88:1 to 1.03:1) mean ratio length to width 0.97:1 (range 0.93:1 to 0.99:1).



Text Fig. 1 *Ctenocardia perornata* Iredale x 4

Remarks

Iredale (1929) introduced the name *perornatum* to replace *Cardium imbricatum* Sowerby, as the latter name had already been used by Born (1780).

W.A. specimens show a few differences from WAM series from Qld and the Sulu Archipelago, Philippines. In the W.A. shells examined (including the lectotype of *imbricatum*) the ridges and scales in the intercostal spaces are absent or poorly developed. Some Qld specimens have poorly developed intercostal sculpture but in WAM specimens from the Sulu

Archipelago, strong intercostal ridges and spinelets are present. Also, the internal coloration in W.A. shells is usually a uniform rose-red although the type specimen (*imbricatum*) is entirely white internally. Some Qld specimens are uniformly rose-red or yellow internally but in the majority, and in all of the Philippine specimens which we have seen, the interior is entirely white or else the internal colour is restricted to the posterior region and the umbonal cavity. Additional material is needed to determine the consistency of these variations.

Distribution

Central Indo-West Pacific including the Philippines, northern W.A. (as far south as the Houtman Abrolhos) and Qld (as far south as Keppel Bay).

W.A. records

50 fm mud, app. 250 km ENE Troughton I., 104-67; 1-3 fm, sand, sponge and dead shells, N of Point Cloates, 1-73; 40 fm sand N of Dirk Hartog I., Shark Bay, WAM 236-67; 21 fm Zeewyk Channel, Abrolhos, 27-67.

Ctenocardia fornicata (Sowerby, 1841)

(Pl. 4, Figs 10-13; Text fig. 2)

Cardium fornicatum Sowerby, 1841, *Proc. zool. Soc. Lond.*, 1840: 110, illustrated by Sowerby, 1841, *Conchological Illustrations*, p.7, Figs 50a and b. Type locality unknown. Types not located.

Cardium adamsii Adams and Reeve, 1850, *Mollusca, the zoology of the voyage of H.M.S. Samarang*, p. 77, Pl. 22, Fig. 2. Type locality: Borneo. Holotype: BM (N.H.) reg. no. 1874. 12. 11. 391.

Diagnosis

Shell rather compressed, markedly quadrate; height about equal to length; umbos slightly anterior of centre, prosogyrate. Postero-ventral corner often slightly rostrate.

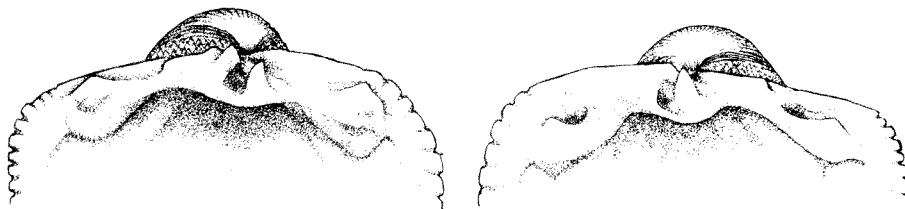
Lunule short and wide in right valve and sculptured with about 7 squamose radial ribs, narrow and elongate in left valve with indistinct squamose ribs.

Escutcheon only discernable in right valve where it is elongate and very narrow.

Mean number of radiating ribs 37, range 32 to 42. Ribs square, bearing numerous spines which are stout, crescent-shaped in section, with deep concavity facing ventrally; towards ventral margin, especially at anterior end, spines flattened, flared out at their ends and tend to lose concavity, at extreme anterior end spines crowded, almost touching, so short and expanded at their ends that laterally projecting points are formed. Fine transverse ridges in intercostal spaces becoming stronger on sides of ribs where they form numerous, delicate, multi-pronged, antler-like spinelets projecting into intercostal spaces.

Exterior white with red irregular orange-brown or purple blotches, lunule purple; interior white with purple blotches, usually solid purple in posterior end; hinge line white except below ligament and immediately below lunule where it is orange-purple.

Sample number 9; measurements of largest shell, length 2.21 cm, height 2.56 cm, width 1.72 cm; mean ratio length to height 1:1 (range 0.94:1 to 1.11:1); mean ratio length to width 1.32:1 (range 1.24:1 to 1.36:1).



Text Fig. 2 *Ctenocardia fornicata* x 4

Remarks

Smith (1885), Lynge (1909) and Prashad (1932) synonymized *adamsii* Adams & Reeve and *virgo* Reeve with *fornicata*. The holotype of the former species agrees with *fornicata* and we are satisfied that they are conspecific but the type illustration of *virgo* seems to us to more closely resemble *perornata* Iredale (= *imbricatum* Sowerby). *C. fornicata* is an easily identifiable species that should not be confused with any other in the Indo-West Pacific region although it resembles *Trigonicardia* (*Americardia*) *media* (Linnaeus, 1758) of the tropical West Atlantic. The shape, colour, and especially the extraordinary delicate intercostal sculpture make *C. fornicata* a distinctive and remarkable species.

Distribution

Widely distributed in Indo-Pacific, including Persian Gulf, Red Sea, Seychelles, Thailand, Philippines, northern W.A. (south to Pasco I.) and Qld (specimens in AM from Swain Reef, St Crispin Reef and Albany Passage).

W.A. records

23 fm, sponge and rubble, 3 km W. Legendre I., Dampier Arch., 235-67; 1 to 2 fm, sand, E side of Pasco I., 258-67; 10 fm, W side of Peak I., near Onslow, 232-67.

"Cardium" victor Angas, 1872

(Pl. 4, Figs 1-5; Text fig. 3)

Cardium (*Ctenocardium*) *victor* Angas, 1872, *Proc. zool. Soc. Lond.*, 1872: 612, pl. 42, fig. 9. Type locality: Mauritius. Holotype: paired valves, B.M. (N.H.) regn no. 1872.5.18.3, bearing the data "stomach of a fish, Mauritius, G.F. Angas Esq."; the specimen does not agree exactly with the original figure but fits the description well and the data agree.

Description

Shell quadrate, inflated; umbos approximately central, touching, prosogyrate. An angled umbonal keel demarcates posterior area. Anterior and ventral margins rounded, posterior margin nearly straight; margins serrate, anterior and ventral serrations truncated, posterior serrations larger and pointed. Lunule ovate and bears two spinose ribs in each valve; escutcheon long, narrow, slightly wider in right valve, bears single spinose rib in each valve.

Sculpture of strong radial ribs. Mean number of ribs, 48, range 41 to 52. In area immediately anterior to umbonal keel every second or third rib bears long, pointed spines which curve dorsally. At anterior end spines thicker, shorter and dorsoventrally flattened at their ends. Longest spines occur on ribs which run along crest of umbonal keel.

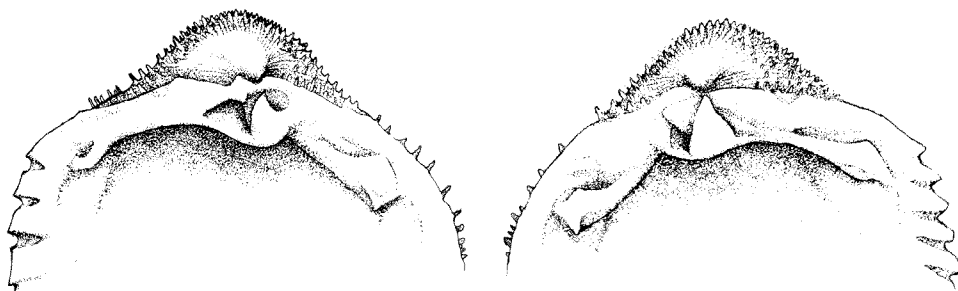
In area posterior to keel every rib bears short, fine, pointed spines. Interstices and spineless intermediate ribs bear numerous thin and fragile concentric lamellae, some of which run up and coalesce on sides of spines.

Hinge-line sinuous. Left cardinals unequal, separated by deep pit; anterior cardinal very strong, long, pointed and curved dorsally; posterior

cardinal weak, low, pointed. One anterior and one posterior lateral tooth; anterior lateral larger and closer to cardinals than posterior; each lateral bears notch on ventral edge. Right cardinals unequal and joined by dorsal saddle; posterior cardinal long, pointed, curved dorsally; anterior cardinal forms ridge on dorsal wall of deep pit in front of posterior cardinal. Two right anterior laterals present, ventral one large and curved from umbonal cavity, its truncated anterior end abruptly terminates hinge line. Single large right posterior lateral, anterior and posterior laterals approximately equidistant from umbos.

Shell exterior cream with splashes of orange or red; lunule and escutcheon orange-red; interior white, tinged with splashes of yellow and with a poorly defined ray of pink from beneath umbos.

Sample number 9; measurements of largest shell: length 3.58 cm, height 4.14 cm, width 3.60 cm. Mean ratio length to height 0.88:1 (range 0.84:1 to 0.93:1); mean ratio length to width 1.10:1 (range 0.98:1 to 1.20:1).



Text Fig. 3 "*Cardium*" *victor* x 2½

Remarks

Angas (1872) placed this species in the 'subgenus' *Ctenocardium*. This is doubtful as the shell has only a single right posterior lateral tooth compared with the two posterior laterals in *Ctenocardia*. The truncated nature of the right ventral anterior lateral is also distinctive and different from *Ctenocardia*. However the beautiful and delicate micro-sculpture on the external surface of *victor* recalls the sculpture present in the species of that genus (e.g. *fornicata*) although the details are very different and distinctive in each case. The generic status of '*Cardium*' *victor* must remain in doubt for the time being.

Distribution

Indian Ocean and central Indo-West Pacific, with records from Mauritius, north W.A., Buton Straits (Indonesia), and Bohol I. (Philippines). A specimen from Long I., Onslow, is the most southern W.A. record.

W.A. records

25 fm, 115 km NW of Bedout I., 231-67; 28 fm, fine sand and rubble, 11 km N of Long I., near Onslow, 234-67.

Genus *Vepricardium* Iredale, 1929

Vepricardium Iredale, 1929, *Aust. Zool.* 5: 338, pl. 37, fig. 5. Type species *V. pulchricostatum* Iredale, 1929 [= *Cardium multispinosum* Sowerby, 1838], O.D.

Description

Shell rotund, inflated, equilateral; margins rounded, deeply crenulate, crenulations continuous with radial grooves on shell interior. Sculpture of strong radial ribs each carrying row of spines, nodules or scales. Hinge line rather straight, deviating less than 25° from straight line. Lunule broad and smooth, thickened and elevated in front of umbos; escutcheon prominent in both valves. Left valve: cardinals erect, unequal; anterior lateral large and high, shallow cleft above anterior lateral reaches to cardinal area; posterior lateral small, thin and lamellate and located almost on dorsal margin. Right valve: cardinals erect, pointed, equal or subequal, anterior cardinal located dorsally on or below lunular elevation, posterior cardinal arising from ventral margin of hinge, cardinals joined by high saddle dorsally and separated antero-ventrally by deep socket. Ventral anterior lateral large, wedge-shaped; dorsal anterior lateral represented by thin rib or nodule below dorsal margin, with deep slotted socket sweeping around from below hinge line and separating ventral tooth from dorsal margin. Posterior lateral single, wedge-shaped, low, thin and tends to be recurved over deep slot separating it from dorsal margin. Laterals approximately equidistant from cardinals.

Remarks

Iredale (1929) introduced the generic name *Vepricardium* for *V. pulchricostatum* Iredale, 1929 [= *Cardium multispinosum* Sowerby, 1838] commenting that "the present species has been classed with the Palaearctic

aculeata [type species of *Acanthocardia* Gray, 1851] but it does not appear to have any relationship with it". This opinion was not shared entirely by Keen (1969) who recognised *Vepricardium* as a distinct genus but placed it in the subfamily Cardiinae along with the Palaearctic genera *Cardium*, *Acanthocardia*, *Plagiocardium* and several fossil groups, and drew attention to the similarity of *Vepricardium* to the *Cardium* subgenus *Bucardium*.

There are at least two Indo-West Pacific species of *Vepricardium* viz: *multispinosum* Sowerby, 1838 and *asiaticum* Brugière, 1792. A third species, *sinense* Sowerby, 1838, may also be congeneric but we have seen no specimen of this.

Vepricardium multispinosum and *V. asiaticum* have much in common with the Palaearctic species of *Cardium* and related genera. Prashad (1932) placed them in the subgenus *Ringicardium* Fischer, 1887 (= *Bucardium*, Gray, 1853). The general form and sculpture and the structure and dentition of the hinge are similar, but these two Indo-West Pacific species differ significantly in the way that the right cardinals are joined by a high dorsal saddle which is lacking in the Palaearctic species. Generic distinction of *Vepricardium* seems warranted.

Vepricardium multispinosum (Sowerby, 1838)

(Pl. 1, Figs. 1-5, Text fig. 4)

Cardium multispinosum Sowerby, 1838, *The Conchological Illustrations*, p.3, fig. 38a, b. Described Sowerby, 1841, *Proc. zool. Soc. Lond.* 1840: 106. **Type locality:** Mindanao, Philippines (label with types gives Mindanao and Cebu). **Types:** Lectotype (here selected, see pl. 1, fig. 5) plus two paralectotypes, all paired-valve specimens, Cuming Coll., BM (N.H.).

Vepricardium pulchricostatum Iredale, 1929. *Aust. Zool.* 5: 338, pl. 37, fig. 5. **Type locality:** Sydney Harbour, dredged Captain Comtesse. **Holotype:** AM reg. no. C 57839.

Diagnosis

Shell round, inflated; umbos almost central, prosogyrate; slightly concave anteriorly and posteriorly; margins evenly rectangularly serrate.

Mean number of ribs 36, range 33 to 40; ribs straight-sided, rounded on top. Each rib with numerous, scattered pustules (visible under magnification) as well as single row of spines; spines short, stout with concavity facing

postero-dorsally; spines more numerous ventrally and smaller at anterior and posterior ends, usually worn in adult specimens; intertices broad, flat with concentric growth striae.

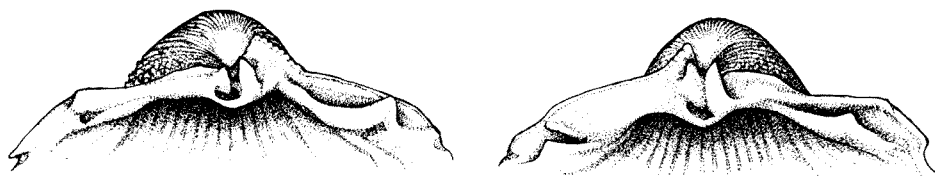
Lunule smooth, raised just anterior to umbos; escutcheon elongate, smooth. Valves overlap just posterior to ligament.

Hinge-line slightly curved, deepest below cardinal area. Left cardinals unequal; left posterior cardinal small, pyramidal.

Right cardinals subequal; right laterals equidistant from cardinals.

Cream externally with one or more concentric bands of pink-orange towards ventral edge; white interiorly with pink margin, on posterior edge pink may extend up below umbos. Dorsal margin of hinge also pink, darkest on lunule and below ligament; teeth white.

Sample number 32; measurements of largest shell: length 4.89 cm, height 5.27 cm, width 4.68 cm; mean ratio length to height 0.96:1 (range 0.93:1 to 1:1); mean ratio length to width 1.16:1 (range 1.04:1 to 1.28:1).



Text Fig. 4 *Vepricardium multispinosum* x 2

Remarks

Iredale (1929) gave the name *V. pulchricostatum* to shells from Caloundra, Qld, differentiating them from *C. multispinosum* Sowerby because the latter species "came from the Philippines, and was described as having 33 ribs, sharply angled on both sides, with a larger variety having 24-28 ribs. Our shell is very much larger and has 38-40 ribs, which are rounded, not angulate". In fact the type of *multispinosum* has 36 ribs while in the WAM series of Australian shells the number of ribs ranges from 33 to 40 (mean 36). Thus the difference in the number of ribs cited by Iredale is not substantiated. We have examined the types of *multispinosum* and *pulchricostatum* and compared them with our Australian series. Rib counts obtained from these specimens are shown in Table 1. In all specimens the ribs are rounded on top but have angulate edges which apparently was Sowerby's meaning. The only variation is that the spines on the ribs are

slightly more numerous in Australian specimens but this is unworthy of specific distinction.

A similar congener of this species is *Vepricardium asiaticum* (Bruguère, 1792) from the central western Pacific and the western and northern Indian Ocean. (Pl. 1, Figs 6-7) This species has stronger and fewer ribs (Table 1) than *multispinosum* and the anterior and central ribs have vertical sides and an inverted V-shaped top with an angular central crest. The posterior ribs are more rounded than the others and bear along their posterior edges rows of high, pointed, lamellate scales which are connected and which in some specimens (e.g. the type of *mirabile*) form a thin continuous palisade near the margin. We have not seen the type of *asiaticum* but from the original description and illustration and those of Reeve (1843, *Conch. Icon.*, 2: *Cardium* sp. 90) it seems very likely that this name is a senior synonym of *Cardium mirabile* Deshayes, 1854. *Cardium coronatum* Spengler, 1786 and *Cardium fimbriatum* Wood, 1835 may also be synonyms of *asiaticum* according to Melvill and Standen (1906) although Lynge (1909) disagrees with that opinion. The holotype of *mirabile* is figured here (Pl. 1, Fig. 6) for comparison with that of *multispinosum* (figured also by Smith, 1885, pl. 8, figs 1a - 1c).

Distribution

Widely distributed in Indo-West Pacific; recorded from Mozambique, West Malaysia, the Philippines, northern Qld and north-western Australia. The most southern record in W.A. is from North West Cape.

Table 1: Rib counts of *V. multispinosum* and *V. asiaticum*.

	Number of specimens	Locality	Number of ribs	
			Mean	Range
<i>V. multispinosum</i>				
Lectotype <i>multispinosum</i>	1	Mindanao, Philippines	36	-
Holotype <i>pulchricostatum</i>	1	Caloundra, Queensland	38	-
WAM series (a)	10	Western Australia	36	33-40
WAM series (b)	20	Queensland	36	33-40
<i>V. asiaticum</i>				
Holotype ' <i>mirabile</i> '	1	Philippines	26	-
WAM series 799-71	12	Maqueda Bay, Philippines	26.5	26-29

W.A. records

40 fms, mud and sand, 104 km NE Adele I., 121-67; 40 fms, 33 km N Adele I., 120-67; on sand flats opposite jetty Broome, 113-67; Broome, 114-67; Eighty Mile Beach, 134-67; Condon, 115-67; 'Black Tank', Port Samson, 211-67; Port Samson, 135-67; North West Cape, 198-68, 3339-68.

Genus *Fragum* Röding, 1798

Fragum Röding, 1798, *Museum Boltenianum*, pt 2: 189. Type species: *Fragum flavum* Röding, 1798 (= *Cardium fragum* Linnaeus) T.

Hemicardium Swainson, 1840 (*non* Spengler, 1799), *A treatise on malacology*: 373. Type species: *Hemicardium unedo* Linnaeus, 1758, S.D. Gray, 1847, *Proc. zool. Soc. Lond.*, 1847: 185.

Description

Shell trapezoidal to quadrate, inequilateral; umbos prosogyrate or orthogyrate; umbonal keel usually strong and angulate demarcating a flat or slightly concave posterior area. Antero-ventral margin usually rounded, posterior margin usually almost vertical, straight, forming sharp angle with postero-dorsal margin. Margins deeply serrate or crenulate, serrations or crenulations deeply excavated for some distance on internal surface. Ligament and ligamental plate short. Hinge-line usually strongly bent, widens beneath cardinal area. Escutcheon poorly defined; lunule poorly defined, or broad and flat, or broad and deeply impressed. Sculpture consisting of strong radial ribs often bearing imbrications nodules or transverse nodulose lamellae; intertices smooth, punctate, or with fine transverse striae.

Left cardinals strong, peg-like, separate, almost equal in height. Left anterior lateral strong, either high and peg-like or long, compressed and wedge-shaped; left posterior lateral small or obsolete; anterior lateral closer (sometimes very much closer) to cardinals than posterior lateral. Right cardinals separate or connected dorsally, may be of equal height or antero-dorsal cardinal may be small or missing. Posterior lateral prominent, thin and elongate or conical; two anterior laterals, ventral one large and wedge-shaped, dorsal one small, rib-like ridge on dorsal wall of intervening notch; anterior laterals closer (sometimes much closer) to cardinals than posterior laterals.

Remarks

The genus has several Indo-West Pacific species but does not appear to be represented in European and American waters. Keen (1969) recognised two subgenera, *Fragum* s.s. and *Lunulicardia* Gray, 1853. The relationship of these two groups seems well established on the basis of shell characters, although the exaggerated trapezoidal shape, very angular umbonal keel, and especially the broad (sometimes deeply impressed) lunule of *Lunulicardia* indicate that this group should be accorded subgeneric distinction.

Keen (1969) placed *Afrocardium* Tomlin, 1931, and *Microfragum* Habe, 1951, as subgenera of the genus *Ctenocardia* H. & A. Adams, 1857. But *Ctenocardia*, in our view, has distinctive hinge dentition and sculptural characteristics not present in *Afrocardium* and *Microfragum* and these two groups are much better allied with *Fragum*. We therefore propose four subgenera of *Fragum*, i.e. *Fragum* s.s., *Lunulicardia*, *Afrocardium* and *Microfragum*, all but the last of which are represented in the Western Australian fauna.

Subgenus *Fragum* Röding s.s.

Diagnosis

Shell trapezoidal, umbos prosogyrate, umbonal keel strong, sometimes angulate. Margins serrate, posterior serrations long and pointed. Intertices between radial ribs narrow, without sculpture. Lunule and escutcheon poorly defined, dorsal margin in lunule area elevated immediately anterior to umbones. Cardinal teeth more or less equal in both valves, joined in right valve by dorsal saddle, right anterior cardinal located dorsal to posterior cardinal and only slightly in front of it.

Fragum (Fragum) fragum (Linnaeus, 1758)

(Pl. 2, Figs. 15-18)

Cardium fragum Linnaeus, 1758, *Systema Naturae*, 10th ed.: 679, no. 67.

Type locality: "O. Asiatico, Americano", here restricted to Ambon, Moluccas, Indonesia (see discussion). **Holotype:** Linnean Society, London, paired valves.

Cardium imbricatum Born, 1778, *Testacea Musei Cesarei Vindobonensis*: 42, pl. 3, figs 3-4. **Type locality** unknown.

Cardium nexum Humphrey, 1797, *Museum Calonnianum*: 49 [non-binomial].

Fragum flavum Röding, 1798, *Museum Boltenianum*: 191. Type locality not given.

Diagnosis

Shell solid, strongly inequilateral, considerably higher than long, sharply pointed ventrally; posterior and ventral margins meet at an angle less than 90°. Umbonal keel angulate; posterior side narrow, steep; postero-dorsal margin shorter than antero-dorsal margin. Umbos displaced posteriorly.

Sculpture of strong radial ribs; mean number of ribs 32, range 27 to 37. Ribs broad and flat; extreme anterior ribs bear stout and conical nodules; medial ribs bear rather crowded rugae or scales with concavities facing ventrally; rugae on posterior ribs thickened, often oblique and more or less straight. Lateral teeth grossly inequidistant from cardinals, posterior laterals much closer than anterior laterals.

Shell cream externally, often with pale pink or fawn blotches, particularly near umbos; posterior ribs usually bear series of rectangular greenish fawn blotches; rugae or nodules on ribs usually yellow. Interior white, usually with 1 or 2 pale orange radial flares emerging from umbonal cavity.

Sample number 26; measurements of largest shell: length 3.78 cm, height 3.14 cm, width 2.50 cm; mean ratio length to height 0.79:1 (range 0.70:1 to 0.94:1); mean ratio length to width: 1.17:1 (range 1:1 to 1.31:1).

Remarks

Linnaeus cited two figures for this species. That of Gualtieri is not identifiable, but that given by Rumphius (1705, D'Amboinische Rariteikamer, pl. 44, fig. 6), which he called *Fragum album*, is a fair representation of the species now generally known as *Fragum fragum*. The American locality given by Linnaeus is clearly erroneous and we here restrict the type locality to Ambon, Moluccas, Indonesia, on the basis of his citation of the Rumphius figure.

F. (F.) fragum may be distinguished from *F. (F.) unedo* by its colour, higher shell with a more steeply sloping posterior side and shorter postero-dorsal margin. Also the concave rugae on the radial ribs are finer and more crowded in *F. (F.) fragum*. The rugae are 'dehiscent', i.e. they wear off easily leaving the ribs smooth and flat.

F. (F.) fragum is occasionally found alive on intertidal sand flats but is more often taken by dredging on sandy substrates in shallow water.

Iredale (1929) described another small species like this from North Queensland which he named *F. whitleyi*. Although not recorded from W.A. this species might be expected to occur on the northern coast and it could easily be overlooked among samples of young *F. (F.) fragum*. It is white or pale yellow, but more quadrate than *F. (F.) fragum*, the postero-dorsal margin is not so short, the ribs are fewer (a WAM sample of 6 specimens has a mean number about 26, range 24 to 28), the rugae on the ribs are stout, and the intertices between the ribs are wider and finely latticed.

Distribution

Widely distributed in the Indo-West Pacific. The most southern W.A. record is Bill Bay, near Point Maud.

W.A. records

Clerke Reef, Rowley Shoal, 1907-67; Mt Blaze, 1908-67; Bay of Rest, Exmouth Gulf, 1610-70; 19 km S of Yardie Creek Station, North West Cape, 952-66; 43 km S of Yardie Creek Station, North West Cape, 949-66; dredged, sand, 1-2 fm, 19 km N of Point Cloates, 1608-70; Point Cloates, 1609-70; 19 km N of Cardabia Homestead, 2374-67; 3 km S of Point Maud, 294-67.

Fragum (Fragum) unedo (Linnaeus, 1758)

(Pl. 2, Figs 19-22)

Cardium unedo Linnaeus, 1758. *Systema Naturae*, 10th ed.: 680, no. 68.

Type locality not given. Holotype: Linnaean Society, London, paired valves.

Fragum rubrum Chemnitz, 1782, *Neues systematisches, Conchylien-Cabinet*, 6: 174, pl. 16, figs 168-9, *non-binomial*.

Cardium cruentum Perry, 1811, *Conchology*, pl. 57, fig. 1.

Diagnosis

Shell solid, inequilateral; umbonal keel rounded not sharply angulate; postero-dorsal wing fairly broad, length of postero-dorsal and antero-dorsal margins approximately equal; posterior and ventral margins meet almost at right angles.

Sculpture of strong radial ribs. Mean number of ribs 27, range 23 to 31. Ribs broad, flat with irregular, transverse red scales; scales thicker, more

nodular and more numerous anteriorly, usually curved on posterior area, with concavity facing ventrally. Lunule narrow, smooth; dorsal margin in lunule raised. Escutcheon broad, smooth. Posterior lateral teeth only slightly closer to cardinals than anterior laterals. Exterior white with dark red scales, sometimes with pale brown blotches; interior white.

Sample number 35; measurements of largest shell: length 5.34 cm, height 6.24 cm, width 4.70 cm; mean ratio length to height 0.86:1 (range 0.76:1 to 1.10:1); mean ratio length to width 1.11:1 (range 0.93:1 to 1.37:1).

Remarks

This species is characterised by prominent red scales on the ribs. Other characters distinguishing it from *F. (F.) fragum* have already been noted.

The red scales of W.A. specimens are notably and consistently more numerous, narrower and not as high as they are in specimens we have examined from the Pacific and Philippines. This character may ultimately warrant taxonomic separation of W.A. populations.

Living specimens of this cardiid may be found in abundance on intertidal sand flats in many sheltered bays on the northern coast of W.A. It is a potential commercial species.

Distribution

Common and widely distributed in the Indo-West Pacific. In W.A. it ranges as far south as Shark Bay.

W.A. records

Yampi Sound, 978-66, 979-66; Sunday I. (near Derby), 980-66, 976-66; Lacepede Is, 973-66; Broome, 984-66, 1019-66; Antonni Mia, Port Samson, 985-66; Port Samson, 971-66; between E and W Lewis I., Dampier Arch., 1072-66; Rosemary I., Dampier Arch., 759-66; Barrow I., 262-67, 261-67; 260-67, 285-67; Yardie Creek Station, North West Cape, 981-66; 32 km N of Point Maud, 967-66; 19 km N of Point Maud, 2375-67; Bill Bay, 3 km S of Point Maud, 1024-66; Shark Bay, 986-66, 975-66, 965-66, 963-66, 974-66. 988-66. 964-66; South Passage, Shark Bay, 966-66, 1020-66; Useless Loop, Shark Bay, 961-66, 969-66, 1021-66; Denham, Shark Bay, N4053; Point Gregory, Shark Bay, N4711, N4053; Dirk Hartogs I., Shark Bay, N4093, 1031-66, 1670-66, 1071-60; Monkey Mia, Shark Bay, N4032.

Subgenus *Lunulicardia* Gray, 1853

Lunulicardia Gray, 1853, *Ann. Mag. nat. Hist.* (2), 11: 41. Type species:
Cardium retusum Linnaeus, 1758, O.D.

Opisocardium Bayle, 1879, *J. Conch.*, Paris, 27: 35. Type species:
Cardium retusum Linnaeus, 1758, O.D.

Hemicardia Spengler, 1799, *Skriv. Natur. Selsk.* 5: 00. Type species:
Cardium hemicardium Linnaeus, 1758, S.D., Stewart, 1930.

Isocardia Oken (non Lamarck), 1815, *Lehrbuch der Naturgeschichte*: 8:
234. Type species: *Cardium hemicardium* Linnaeus, 1758, M.

Diagnosis

Strongly trapezoidal, umbos orthogyrate; umbonal keel angulate. Lunule broad, may be deeply impressed (as in type species). Margins with wide crenulations. Intertices between radial ribs punctate or transversely striate. Hinge-line strongly bent, sometimes (as in type species) distorted in cardinal area by deeply impressed lunule. Position and size of cardinal teeth depend on depth of lunule and degree of hinge distortion; right anterior cardinal small or absent; when both right cardinals present they are joined by dorsal saddle. Posterior lateral teeth close to cardinals, anterior lateral teeth much lower and more distant.

Remarks

Following Keen (1969) this taxon is ranked here as a subgenus of *Fragum*. We differ from Keen in placing the generic name *Hemicardia* in the synonymy of *Lunulicardia* rather than of *Fragum* s.s. As type of the genus *Hemicardia* Spengler, 1799, Stewart designated *Cardium hemicardium* Linnaeus. Keen (1969) rejected this generic name as invalid because, as Stewart (1930) showed, Spengler's usage was a plural group name for several species (pers. comm. from Dr Myra Keen, Nov. 1970). For the reasons given below we believe that the closest affinities of the species *hemicardium* lie with the *F. (L.) retusum* complex, so that the invalid genus-group name *Hemicardia* is best placed in the synonymy of the subgenus *Lunulicardia*.

Some authors recognise two species in the *F. (L.) retusum* complex, the typical form and another with weaker sculpture and less deeply impressed lunule named *subretusum* by Sowerby (1834). The distinction between these two forms remains in doubt for there seems to be a full series of inter-

mediates between the two extremes (see discussion of the species). But in any case, whether they be regarded as distinct species or not, the two forms together with *F. (L.) hemicardium* constitute a remarkable morphological series in the degree of impression of the lunule and the consequent distortion of the hinge and cardinal teeth.

In *F. (L.) hemicardium* the lunule is broad but flat and not impressed (Pl. 2, Fig. 4). In the 'subretusum' form of *F. (L.) retusum* the lunule is deeply impressed forming a cavity below the umbones. This distorts the hinge, displaces the cardinal teeth posteriorly, and renders the right anterior cardinal obsolete (Pl. 2, Figs. 7-9). The types of *F. (L.) retusum* represent the extreme of the same trend. In this form the lunule is very deeply impressed and undercuts the cardinal area of the hinge so that the hinge appears almost S-shaped. The cardinal teeth are again displaced posteriorly and in this case they are so distorted that the true homologies of the teeth are difficult to determine, although it seems that the right anterior cardinal is missing altogether (Pl. 2, Figs 12-14).

It is presumed that the condition seen in *F. (L.) hemicardium* is the primitive one in this series, and that the sunken lunule and distorted hinge of *F. (L.) retusum* is an advanced or specialised condition. What the adaptive significance of this hinge distortion can be is difficult to conceive. A comparison of the functional morphology of the two species would make an interesting study.

The collections of the W.A. Museum contain one specimen from the Philippines of another cardiid with a deeply impressed lunule which may be an undescribed species. It differs from all the forms of *F. (L.) retusum* in having large conical tubercles on the central radial ribs but otherwise shares the characteristics of the subgenus *Lunulicardia*.

Fragum (Lunulicardium) retusum (Linnaeus, 1767)

(Pl. 2, Figs 6-14)

Cardium retusum Linnaeus, 1767, *Systema Naturae*, 12th ed.: 1121.

Type locality: "In India". Holotype: pair of valves in marked box, Linnaean Society, London.

Cardium auricula Forskal, 1775, *Descriptiones Animalium*: 122. Type locality: not stated, probably Red Sea. Type: not located.

Cardium subretusum Sowerby, 1834, *The Conchological Illustrations*, fig. 24. Described Sowerby, 1841, *Proc. zool. Soc. Lond.* 1840: 110.

Type locality: "Unknown". **Types:** Three paired syntypes, BM (N.H.) reg. no. 1971.29.

Diagnosis

Outline usually triangular, sometimes tending to be ovate. Umbonal keel very pronounced, sometimes rounded but usually sharply angular, often forming a sharp raised ridge; umbonal keel demarcates a broad, rather flat or concave posterior area; anterior keel less prominent, rounded, usually demarcates another rather flat area anteriorly; depressed sulcus sometimes present medially between the two keels. Antero-dorsal margin steeply descending, convex; antero-ventral margin oblique, usually rather straight but sometimes convex; antero-dorsal and antero-ventral margins usually meet at an angle of about 90° forming angular corner, but sometimes entire anterior margin forms a simple curve. Posterior margin nearly vertical, slightly convex. Posterior and antero-ventral margins usually meet at an acutely angled ventral corner, but sometimes this is rounded.

Valves sculptured with broad, low, rounded or flattened radial ribs, usually 4 on anterior area, 7 or 8 on medial area, and 11 to 13 on posterior area. 4 or 5 medial ribs usually bear nodules or transverse scales. Anterior ribs thick, rounded; posterior ribs usually flat and crowded except for last 3 or 4 which are thicker, more widely spaced and rounded. Intertices pitted or crossed by raised transverse bars.

Lunule wide, smooth, deeply impressed to form cavity below umbones; cavity sometimes undercuts cardinal area (Pl. 2, Figs 7-9, 12-14). Escutcheon short, narrow. Ligamental plate short, notch weak.

Left cardinal teeth approximately equal, separated by deep oblique pit; pit separated from lunular cavity by thin convex ridge. Anterior cardinal situated near ventral edge of hinge; posterior cardinal situated on ligamental plate dorsal and only slightly behind anterior tooth. Left anterior lateral prominent, wedge-shaped. Ventral posterior lateral reduced or lacking; dorsal posterior lateral rather small and conical or ridge-like. Right valve bears only a single, large, cardinal tooth usually more or less conical but becoming compressed in specimens in which lunular cavity undercuts cardinal area.

Tiny protuberance sometimes present on dorsal margin may represent other cardinal tooth in vestigial condition. Right ventral anterior lateral large, dorsal one reduced; right posterior lateral large and compressed.

Interior white. Exterior white, often with light red (rarely yellow) spots or blotches, especially anteriorly; posterior ribs may bear series of rectangular greenish fawn blotches (cf. *F. (F.) fragum*); thin yellow periostracum usually present.

Measurements: Largest shell examined (Stradbroke I., Moreton Bay, Qld sample, WAM 204-59); length 37.9 mm, height 49.9 mm, width 32.3 mm. Ratios of length to height and width to height in W.A. and Qld samples are given in Table 2.

Remarks

Shell shape, sculpture and hinge structure and dentition are very variable in this species complex. At one extreme the umbonal keel is sharply angulate and often elevated, the shell outline is distinctly triangular (like *F. (L.) hemicardium*), the radial ribs are low, and the lunule, although deeply impressed, does not undercut the cardinal area. At the other extreme the umbonal keel is rounded, the shell outline is almost ovate, the radial ribs are heavy, and the lunule is so deeply impressed that it undercuts the cardinal area and grossly distorts the hinge in that region. The type specimen of *Cardium retusum* is of the latter form. All the Australian specimens examined by us are either the angulate form or intermediate between the two. The three syntypes of *Cardium subretusum* are also intermediates.

Some authors have considered *Cardium retusum* and *Cardium subretusum* to be distinct species. Large series from more localities may yet show this to be the case but the material at our disposal suggests that these names represent variations of a single species. Referring to the type series of *C. retusum* Dodge (1952: 56) remarked that further confusion may arise "from the fact that several specimens of *Cardium subretusum* Sowerby, 1841, are found in the same marked box in Linnaeus' collection". When this box was examined by one of us it contained only the type specimen.

We cannot locate the type of *Cardium auricula* Forskal, 1775, and presume it was lost, but the figure given by Reeve (1843, *Conchologica Iconica* 2, sp. 39) seems to represent the '*subretusum*' form.

Our material indicates that there may be considerable differences in shell characters between local populations. For example, the Exmouth population seems to be characterised by unusually high shells with pronounced ribbing, a pronounced sulcus between the umbonal and anterior keels, and heavy red spotting. The Abrolhos population is characterised by shells with flexous umbonal keels and consequent convex posterior margins. But there is no suggestion of regional variation between W.A. and Qld populations which might warrant subspecific separation.

In W.A. *F. (L.) retusum* is sympatric with *F. (L.) hemicardium* over most of its range, although available data suggest that they do not often share the same habitats. While *F. (L.) hemicardium* is common on intertidal

Table 2: Shell dimensions of samples of *Fragum (Lunulicardia) retusum*

	N	L : H		L : W	
		Mean	Range	Mean	Range
Houtman Abrolhos, W.A. (N2864, 33-67, 32-67)	12	0.69:1	0.66:1 to 0.73:1	0.93:1	0.88:1 to 0.99:1
Dirk Hartogs I., W.A. (373-71)	3	0.68:1	0.67:1 to 0.70:1	0.95:1	0.92:1 to 0.97:1
Point Cloates, W.A. (346-71)	16	0.67:1	0.63:1 to 0.70:1	—	—
North West Cape, W.A. (200-68)	3	0.63:1	0.62:1 to 0.65:1	0.99:1	0.94:1 to 1.05:1
Hervey Bay, Qld (4880-68)	14	0.70:1	0.66:1 to 0.73:1	0.91:1	0.82:1 to 1.01:1
Stradbroke I., Moreton Bay, Qld (204-59, 4879-59)	9	0.69:1	0.64:1 to 0.74:1	0.93:1	0.84:1 to 0.99:1

sand flats in sheltered bays, *F. (L.) retusum* is more often taken by dredging below low tide level in more open ocean situations.

Distribution

Indo West Pacific including the east coast of Africa, possibly as far south as Delagoa Bay, southern Mozambique (Barnard, 1964: 495), Red Sea, India, Sri Lanka, Philippines and as far north as southern Japan (Kira, 1962: 55-56). In Australia the species lives at least as far south as Moreton Bay, Qld on the East Coast, and the Houtman Abrolhos on the West Coast. Fossils indicate that the species' range extended further south to Fremantle and the Swan Estuary during Holocene times.

W.A. records

(a) living

Yampi Sound, 85-59, 1001-66; Port Hedland, 2874-67; Hampton Harbour, Dampier Arch., 39-68; 6 fm, mud, between Rosemary and Malus Is, Dampier Arch., 1003-66; North West Cape, 200-68, 3368-68; 10 fm off Maud Landing, 2379-67; 6-20 ft, dredged, north of Point Cloates, 1614-70; Shark Bay, 1010-66, 36-67; 2-4 fm, weed and sand, SE corner Dirk Hartogs I., 13-67, 1016-66, 373-71; 21 fm, Middle Channel, Abrolhos, N2864; 21 fm, coral and sand, Zeewyk Channel, Abrolhos, N2757.

(b) fossil (Holocene)

Leighton Beach, N91; Attadale Beach, Swan Estuary, 1027-66, 70-2353 a-b; Point Walter, Swan Estuary, 70-1051 a-c; Peppermint Grove, 0.3 km S of Keane's Pt, Swan Estuary, 70-2419 a-d; South Street, Fremantle, dredge spoil from fishing harbour, 70-2005 a-g; Kwinana, Cockburn Sound, spoil pumped into blast furnace site, 68-84 a-w.

Fragum (Lunulicardia) hemicardium (Linnaeus, 1758)

(Pl. 2, Figs 1-5)

Cardium hemicardium Linnaeus, 1758, *Systema Naturae* 10th ed.: 678. **Type locality:** "O. Asiatico" [probably = Ambon, Moluccas]. **Holotype:** Linnean Society, London, paired valves.

Cardium tumoriferum Lamarck, 1819, *Histoire Naturelle des Animaux sans Vertèbres*, 6: 15. **Type locality:** "l'Océan de la nouvelle Hollande, a la baie des Chiens-Marins" [Shark Bay, Western Australia]. **Holotype:** Museum Nat. d'Histoire Naturelle, Paris.

Diagnosis

Umbonal keel pronounced, angular, demarcates a broad, rather flat posterior area. Anterior keel also angular, demarcates another rather flat area posteriorly. Antero-dorsal margin steeply descending, slightly convex to almost straight, antero-ventral margin oblique, almost straight; posterior margin nearly vertical; convex or almost straight; antero-dorsal and antero-ventral margins meet at approximately 90° forming slightly rounded corner; antero-ventral and posterior margins meet at acute angle forming sharply angled ventral corner; three margins give shell triangular lateral outline.

Shell sculptured medially with broad, low, flattened radial ribs which usually bear central row of nodules or scales. Anterior area smooth or bearing 2 to 5 radial ribs; posterior area with broad, smooth, flat radial ribs. Interstices narrow, usually punctate or with numerous transverse ridges. Mean total number of ribs 23, range 18 to 27 (Shark Bay population).

Hinge strongly bent but not distorted in cardinal area. Lunule wide, smooth, flat, but not impressed (Pl. 2, Fig. 4). Escutcheon short, narrow (Pl. 2, Fig. 5); ligamental plate short, notch weak.

Left cardinals well developed, equal, separated by deep socket. Left anterior lateral large, compressed, wedge-shaped; ventral left posterior lateral obsolete or lacking, dorsal one small and knob-like. Right cardinals large, equal, fused together. Ventral right anterior lateral large, dorsal one small; posterior lateral large, compressed.

Sample number 55; measurements of largest shell: Length 4.76 cm, height 6.84 cm, width 5.00 cm; mean ratio length to height 0.72:1 (range 0.63:1 to 0.82:1), mean ratio length to width 0.98:1 (range 0.83:1 to 1.07:1).

Remarks

The broad flat lunule of this species indicates that it has closer affinity with *Lunulicardia* than with *Fragum* s.s., even though the lunule is not deeply impressed as it is in the type species of the former subgenus.

F. (L.) hemicardium shows some geographic variation in shape and sculpture. Qld shells are generally more flared posteriorly (i.e. posterior margin convex), the nodules or scales on the medial ribs are weaker, and the interstices more deeply punctate than in W.A. shells. Also, the medial ribs in Qld shells are strong and rounded and there are usually several radial ribs on the anterior area; in W.A. shells the medial ribs are low and rather flat, and the anterior area is smooth or bears only weak radial ribs.

New Caledonian specimens are broad (almost quadrate), the radial ribs are flat with weak nodules, there are 2 or 3 strong ribs on the anterior area, and the umbonal keel is quite sharp and angular. WAM series from the Philippines and the Moluccas Province of Indonesia are rather thin-shelled, quadrate, and have low radial ribs and a sharp angular umbonal keel, thus resembling New Caledonian specimens.

When better series are available from central Indo-West Pacific localities it may become evident that the species is divisible into subspecies. In that event the name *tumoriferum* Lamarck, 1819 may need to be resurrected at subspecific rank for W.A. populations.

Like *F. (F.) unedo*, this species is often abundant alive on intertidal sand flats in sheltered bays on the northern coast of W.A. It is possibly commercially exploitable.

Distribution

Central Indo-West Pacific. In W.A. the species occurs as far south as Shark Bay, and on the eastern Australian coast as far south as the islands of the Capricorn Group.

W.A. records

(a) living

Town Reef, Port Hedland, 2881-67; Antonni Mia, Port Samson, 998-66, 999-66, 1002-66; Bay of Rest, Exmouth Gulf, 1569-70; dredged on sand 6-20 ft, Point Cloates, 1570-70; Shark Bay, 1023-66, 997-66, 1014-66, 1009-66, 1010-66; Dirk Hartogs I., Shark Bay, 14-67; sand flats, Useless Loop, Shark Bay, 1008-66, 28-67; sand flats, Denham, Shark Bay, N4073; Hamelin Pool, Shark Bay, 15-67; mud flats, Gladstone Jetty, Shark Bay, 1017-66; South Passage, Shark Bay, 1006-66, 24-67; Pelican Point, Shark Bay, 1011-66.

(b) fossil (Quaternary)

Wooramel Cliff, 8 km N of Gladstone, 66-1285; Lyndon River near Lake McLeod, W side of Marsh Hill, 70-2660 a-b; sand pit off White Rd, Orange Grove, 68-411, 63-52 a-b, 68-404 a-d, 62-91 (age and nature of the deposit doubtful).

Subgenus *Afrocardium* Tomlin, 1931

Afrocardium Tomlin, 1931, *Ann. Natal Gov. Mus.*, 6: 449. Type species: *Fragum (Afrocardium) shepstonense* Tomlin, 1931, O.D.

Diagnosis

Shell small, quadrate, umbos prosogyrate, umbonal keel low, rounded; posterior larea broad, slightly concave. Antero-ventral margin rounded, posterior margin straight, almost vertical to hinge line, postero-ventral corner rounded not angulate. Left valve posterior lateral weak or vestigial; left anterior lateral long, thin, slightly closer to cardinals than posterior lateral. Right cardinal teeth separate, antero-dorsal cardinal weak or obsolete, posterior cardinal strong; right posterior lateral slightly closer to cardinals than anterior laterals.

Remarks

The type species and the several other small cardiids usually referred to this group possess only one posterior lateral tooth in the right valve and therefore may not be closely affiliated with *Ctenocardia* as proposed by Keen (1969: N588). Nor do the radial ribs bear imbricating or tubular spines as is the case with *Ctenocardia*. Where it exists the rib sculpture consists of transversely elongate nodules or lamellae quite like those of *Fragum* (*F.*) *fragum*. For these reasons we revert to the use of *Afrocardium* as a subgenus of *Fragum* as was originally proposed by Tomlin (1931), noting however that the right valve cardinal teeth are not joined by a dorsal saddle as is the case in *Fragum* s.s. and *Fragum* (*Lunulicardia*).

Fragum (*Afrocardium*) *erugatum* (Tate, 1889)

(Pl. 3, Figs 19-21)

Cardium erugatum Tate, 1889, *Trans. R. Soc. S. Aust.*, 11: 62, pl. 11, fig. 6. Type locality: Royston Head, Southern York Peninsula [South Australia]. Types: two worn right valves, SAM reg. no. D 12927; Holotype: 12.28 mm length, marked "Type", paratype: 11.12 mm length.

Fragum hamelini Iredale, 1949, *Proc. R. zool. Soc. N.S.W.*, 1947-48: 18-19. Type locality: Hamelin Pool, Shark Bay, W.A. Types: not located in AM collection by Dr D.F. McMichael (pers. comm. 16 Feb. 1966).

Diagnosis

Shell form variable, sub-trapezoidal to obliquely quadrate with low rounded umbonal keel. Anterior margin rounded, posterior margin oblique, straight; margins serrate. Umbos prosogyrate, not central. Sculpture of

broad, low, flat ribs; mean number of ribs 25, range 24 to 28. Ribs imbricated, with semicircular rugae anteriorly; interstices narrow, shallow, may be crossed by numerous fine raised lines. Lunule short, smooth, escutcheon elongate, broad, smooth. Lateral teeth approximately equidistant from umbos, anterior teeth slightly closer.

Shell white, often yellow or pink in umbonal cavity and sometimes externally; some Shark Bay specimens are orange-pink on anterior half externally and around margin.

Measurements of largest shell: Largest 1.74 cm, height 1.88 cm, width 0.90 cm.

Remarks

This is an extremely variable species. The shell varies from quadrate and compressed to trapezoidal. A trapezoidal form abundant at Hamelin Pool, Shark Bay was named *Fragum hamelini* by Iredale (1949) but field evidence indicates that this is merely an ecophenotype of hyper-saline conditions (B.R. Wilson and G.W. Kendrick, unpublished data). The Hamelin Pool population is so great in some years that windrows feet wide and inches thick accumulate on the beaches. This accumulation has gone on for many centuries for there are extensive, thick, semi-consolidated beds of wind-sorted *Fragum* behind the beaches in the area. Sawn blocks of the material are used as building stone.

Although the type locality of *F. (A.) erugatum* is in S.A. the species is apparently only fossil there. The late Bernard Cotton of the South Australian Museum (pers. comm. 10 Jan. 1961) wrote: "The species has not been taken alive in S.A. I agree that W.A. is the true home of this species and S.A. is marginal as happens so frequently."

The species lives in dense populations on sandy bottom to depths of at least 5 fathoms, usually in protected bays.

Distribution

Living from the Dampier Archipelago to Houtman Abrolhos, W.A. Fossil to Yorke Peninsula, S.A.

W.A. records

(a) living

Rosemary I., Dampier Arch., 990-66, 1-66; between E and W Lewis I., Dampier Arch., 387-67; 1-2 fms, sand and sponge, 1.6 km E of N Pasco I., 317-67, 386-67; Bill Bay, 3 km S of Point Maud, 1432-67; 4 fms, near

Petit Point, Hamelin Pool, Shark Bay, N 3593; Hamelin Pool, Shark Bay, 348-67; small lagoon, 0.8 km N of Eagle Bluff, Shark Bay, N 4763; small salt lagoon, 1.6 km N of Denham, Shark Bay, N 1603; 20-30 ft, Bragedee, bottom of Useless Inlet, Shark Bay, N 4732; Gladstone, Shark Bay, 993-66; Freycinet Reach, Shark Bay, 208-66; West Wallabi I., Abrolhos, N 3910, N 3914; Turtle Bay, East Wallabi I., Abrolhos, N 3948; Easter Group, Abrolhos, N 2793; 5 fms, Good Friday Bay, Abrolhos, 992-66, 302-67; Bluff Point, Geraldton, N 1242.

(b) fossil

Attadale Beach, Swan River, 349-67; Salmon Bay, Rottnest I., N 1486; SW corner of Garden I., N 4873; Windy Harbour via Northcliffe, N 5060.

Genus *Fulvia* Gray, 1853

Fulvia Gray, 1853, *Ann. Mag. nat. Hist.* (2) 11: 40. Type species: *Cardium aperta* Bruguière, 1789, M.

Diagnosis

Shell thin to moderately thick, obliquely ovate, sometimes flared and slightly gaping posteriorly; anterior and ventral margins rounded, posterior margin rounded or tending to be truncated and straight; inequilateral, umbos prosogyrate. Marginal serrations weak or obsolete except on posterior margin where they may be moderately deep. Sculpture of low or obsolete radial ribs or cords. Periostracum forms thin brown radial palisades growing from apices of ribs.

Hinge-plate narrow, thin, especially posteriorly, slightly curved; ligamental notch shallow. Lunule broad, well defined, smooth; escutcheon smooth, narrow, elongate. Anterior and posterior lateral teeth equidistant from cardinals. Dorsal margin of lunule raised and thickened in front of umbones.

Left valve: cardinals unequal, separate anterior cardinal strong, conical; posterior cardinal a weak, almost vertical ridge below umbo. Anterior lateral high, elongate, separated from dorsal margin by deep cleft which almost reaches cardinal area. Posterior lateral low, elongate, located almost on dorsal margin.

Right valve: Cardinals approximately equal, touching at their bases dorsally; posterior cardinal conical, located at ventral edge of hinge

directly below umbo; anterior cardinal conical and located high on lunular thickening almost level with umbo. Ventral anterior lateral thin, compressed and triangular; separated from dorsal margin by deep cleft which curves postero-ventrally into umbonal cavity; dorsal anterior lateral represented by weak ridge on dorsal wall of cleft. Single posterior lateral also thin, compressed, triangular, separated from dorsal margin by deep cleft.

Remarks

Keen (1969) placed this taxon as a subgenus of *Laevicardium* but the species of *Fulvia* do not agree with the diagnosis of *Laevicardium* for the ribs on their posterior slopes are stronger not weaker than the medial and anterior ribs. Other features worthy of special interest are the narrow, rather delicate hinge with high but thin and compressed triangular teeth which fit into deep and narrow clefts in the opposing valves. The curious periostracum consisting of rows of short, fine tufts arising from the radial cords also seems to be a distinctive character of *Fulvia*. For these reasons we prefer to rank the taxon as a full genus with doubtful affinity with *Laevicardium*.

Fulvia is represented by species in the Indo-West Pacific, southern Australia, and North Pacific regions, but has no representatives in the Atlantic or Mediterranean. Keen (1969) gives the time range as from Miocene to Recent.

Fulvia aperta (Bruguière, 1789)

(Pl. 3, Figs 4-7)

Cardium rugatum Gronovius, 1871, *Zoophylcaium Gronovianum*, 3: V, 266, pl. 18, fig. 5 [non-binomial].

Cardium apertum Chemnitz, 1782, *Conchylien Cabinet*, 6: 189, pl. 18, figs 181-183 [non-binomial].

Cardium apertum Bruguière, 1789, *Encyclopédie Méthodique*, 1: 226. Figured by Bruguière, 1797, *Encyclopédie Méthodique*, 21: pl. 296, figs 5a, b. **Type locality:** Asiatic oceans. **Holotype:** paired valves (right valve broken), Lamarck collection, Museum d'Histoire Naturelle, Geneva, regn no. 1085/39.

Cardium virgineum var. *B.* Gmelin, 1791, *Systema Naturae*, edit. 13: 3253.

Cardium natalense Krauss, 1848, *Die sudafrikanischen Mollusken*, :12, pl. 1, fig. 9. **Type locality:** Natal, South Africa. **Type** not located.

Cardium natalense var *adjacens* Turton, 1932, *The Marine Shells of Port Alfred, S. Africa*, :243, pl. 65, no. 1710. Type locality: Port Alfred, South Africa. Types: Oxford University?

Diagnosis

Shell thin, strongly inequilateral; strongly flared and slightly gaping posteriorly; posterior margin weakly serrate.

Sculpture of fine, radial cords which become thicker ribs posteriorly; mean number of ribs 43, range 37 to 51. Interstices wide, flat, usually bearing minute granulae anteriorly. Hinge-plate thin posteriorly where in left valve it is little more than thickened rim on dorsal margin. Posterior dorsal hinge margin often slightly concave. Left anterior lateral thin, compressed, but long, high, triangular, separated from sharp-edged dorsal margin by deep and narrow slot which reaches cardinal area. In right valve slot between lateral teeth deep, sweeps well into umbonal cavity below hinge-plate.

Exterior cream with yellow and purple flecks and radial streaks; umbos purple or wine-red; hinge purple or wine-red below ligament and in lunular region; interior yellow or white with purple or wine-red blotches and flecks in umbonal cavity, becoming more uniformly purple or wine-red toward margins, especially posteriorly.

Sample number 66; measurements of largest shell: length 5.22 cm, height 4.55 cm, width 3.16 cm; mean ratio length to height 1.05:1 (range 0.97:1 to 1.17:1) mean ratio length to width 1.17:1 (range 1.45:1 to 2.03:1).

Remarks

F. aperta is a variable and widely distributed Indo-West Pacific species. In the same place that he described this species but on a later page, Bruguière described another which he named *Cardium papyraceum* (1789, *Encycl. Meth.* 1: 231) and which is also generally accepted in the literature as an Indo-West Pacific species. The latter is said to differ from the former by its nearly equilateral outline and less pronounced radial sculpture. The types of both species are preserved in the Lamarck collection at the Museum d'Histoire Naturelle, Geneva and Dr E. Binder comments: "These specimens have been owned by Lamarck and they still have a label by Lamarck's hand. They were used by Bruguière for his descriptions in 'Encyclopedie'." (pers. comm. 21 May, 1971).

It seems to us, however, that there is probably only one variable species in nature to which both types belong. If that is the case then *aperta* has

page priority over *papyraceum*, but more material is needed before the two can be safely synonymised.

The minute intercostal granulae are characteristic of *F. aperta* and distinguish it from its Japanese congener *F. mutica* (Reeve, 1884). The other common tropical Indo-Pacific species referable to *Fulvia* is *australe* Sowerby, 1841. In this species the shell is more quadrate and solid than in *aperta*, it gapes little if at all, and the surface beneath the periostracum is very shiny. Many authors have placed it in *Laevicardium* but it has the typical hinge dentition, sculpture and periostracum of *Fulvia*.

Distribution

Widely distributed in Indo-Pacific from Natal, Mauritius, Persian Gulf, Suez to Japan, Philippines, east and west Australia. The most southern W.A. record is from Dunsborough, Geographe Bay.

W.A. records

Yampi Sound, 150-67, 155-67, 62-59; reef flats, 3 km SW of jetty, Broome, 132-67; Nickol Bay, Dampier Arch., 188-67; 23 fms, 32 km N of Delambre I., Dampier Arch., 190-67; between E and W Lewis Is, Dampier Arch., 186-67; Rosemary I., Dampier Arch., 168-67, 169-67, 157-67; Barrow I., 1138-67, 287-67; E side of S. Pasco I., 288-67; 333-67; Barrow I., North West Cape, 147-67; Exmouth Gulf, 149-67, 133-67, 137-67, 136-67, 138-67, 1045-66, 165-67; 10 fms, Maud Landing, 187-67; South Passage, Shark Bay, 332-67; NE Peron Peninsula, Shark Bay, N 3996; Monkey Mia, Shark Bay, N 4641; 2-4 fms, sand and weed, mainland side South Passage, Shark Bay, 143-67, 153-67, 1047-66, 1028-66, 131-67, 164-67; 2-4 fms, SE end of Dirk Hartogs I., Shark Bay, 185-67; Easter Group, Abrolhos, N 2758; 20 fms 144-67; Abrolhos, 299-67; W of Causeway, Perth, (fossil) 152-67, 151-67; Swan River, Causeway, Perth, 1851-67; Blackwall Reach, Swan River, N 2545; Melville Water, Swan River, N 1878; N 2545, N 2546; Owen Anchorage, Fremantle, N 1495; South Beach, Fremantle, 156-67, 145-67; Cockburn Sound, 130-67, 141-67, 146-67; 9 fms N 1545, 4 fms, weed, N 4493, N 848, N 850, N 851, 300-67, N 5372, 307-67, 308-67, N 5202, N 157, N 66; 6 fms, Dunsborough, Geographe Bay, 166-67.

Fulvia tenuicostata (Lamarck, 1819)

(Pl. 3, Figs 1-3; Text fig. 5)

Cardium tenuicostatum Lamarck, 1819, *Histoire Naturelle des Animaux sans Vertèbres*, 6: 5. Type locality: "Timor et a la Nouvelle Hollande"

[i.e. Western Australia; reference to Timor is erroneous]. **Holotype:** Lamarck collection, Laboratoire de Malacologie, Museum National d'Histoire Naturelle, Paris.

Cardium racketti Donovan, 1825, *The Naturalist's Repository*, 4: pl. 124. **Type locality:** New South Wales, Australia. **Type** not located.

Diagnosis

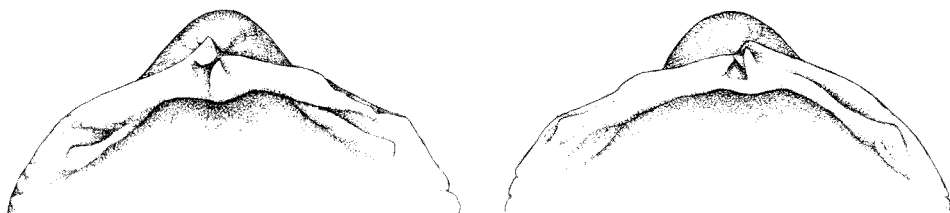
Shell thin to moderately thick, without posterior gape. Posterior margin oblique and almost straight; marginal serrations relatively weak, more or less uniform.

Sculptured with radial ribs; mean number of ribs 52, range 48 to 59; ribs fine, triangular, interstices narrow, smooth.

Hinge behind umbos curved; cardinals of right valve connected; right anterior lateral teeth fairly solid.

Exterior cream, may be mottled with orange; umbos pink; interior white with pink beneath umbos and at ventral edge.

Sample number 48; measurements of largest shell: length 5.52 cm, height 5.20 cm, width 3.83 cm; mean ratio length to height 1.03:1 (range 0.93:1 1.10:1); mean ratio length to width 1.55:1 (range 1.32:1 to 1.66:1).



Text Fig. 5 *Fulvia tenuicostata* x 2

Remarks

This species may be distinguished from *F. aperta* by its heavier shell, stronger ribs, shorter and stronger hinge, and the slightly flared posterior area.

Ludbrook (1955: 63) has given reasons for abandoning the use of the name *racketti* for the S.A. shell as advocated by Hedley (1917: 685), in favour of *tenuicostata*.

Distribution

Southern Australia from the vicinity of Sydney on the East Coast to Fremantle in W.A.

W.A. records

River (fossil), 1880-67; North Leighton, 123-67; South Beach, Fremantle, 184-67; Woodman Point, Cockburn Sound N 846, N 847; Careening Bay, Cockburn Sound N 4037, N 114; Myalup via Harvey, 319-67; 18 fms, 5 km W of Bunbury, N 4136; Geographe Bay, N 2969; Busselton, 127-67, 5 fms N 3637; Vasse, 8 km W of Busselton, 385-67; Dunsborough, 126-67, N 2386, N 239, 6 fms 303-67; Rocky Point, Bunker Bay, Cape Naturaliste, 309-67; 20 fms, N of Bald Head, King George Sound, N 1590; 17 fms, SE of Mistaken I., King George Sound, N 3084; Emu Point, Albany, N 5335; sand pit among *Katelsia*, Emu Point, Albany, N 1157, N 1158; 20 ft, Oyster Harbour, Albany, N 3220, N 3294; Oyster Harbour, Albany, N 3982, N 1475; Middleton Beach, Albany, N 133; Middleton Beach, Albany, N 1, N 2, N 3, N 6, N 7.

Genus *Laevicardium* Swainson, 1840

Laevicardium Swainson, 1840, *Treatise on malacology*, p.373. **Type species:** *Cardium oblongum* Gmelin, 1791, S.D. Stoliczka, 1871, *Mem. geol. Surv. India Palaeont. Indica* 3: 209.

Liocardium Mörch, 1853, *Catalogus Conchyliorum quae reliquit D.A. d'Aguirra & Gadea, Commes de Yoldi*, pt 2, p.35.

Diagnosis

Shell obliquely or elongately ovate, rounded without prominent umbonal keel, umbos central, orthogyrate or weakly prosogyrate. Anterior and ventral margins rounded, posterior margins often tending to be straight; margins with serrations which tend to be reduced on the posterior side.

Sculpture of numerous radial cords or weak ribs medially; anterior and posterior areas smooth or sculptured by ill-defined low undulations; cords visible interiorly; ribs or cords without sculpture.

Hinge-line strongly arched; lunule and escutcheon poorly defined; lunule sometimes forms an elevated protuberance in dorsal margin anterior to umbo.

Left valve: anterior cardinal tooth strong, posterior cardinal weak and close to dorsal margin, these teeth separated by deep pit; posterior lateral

weak and sometimes notched ventrally, situated on dorsal margin; laterals approximately equidistant from cardinals. Right valve: anterior cardinal tooth situated on dorsal margin, weak or may be obsolete; dorsal anterior lateral forms elongate blunt-ended rod on dorsal wall of trough close to dorsal margin; single strong posterior lateral; laterals approximately equidistant from cardinals.

Remarks

The genus *Laevicardium* has often been conceived as a wide group encompassing a number of subgenera including *Trachycardium* (Thiele, 1935; Adam and Leloup, 1939). Keen (1958; 1969) and Olsson (1961) recognised two distinct subfamilies, the Laevicardiinae containing a single genus *Laevicardium* with a number of subgenera, and Trachycardiinae with *Trachycardium*, *Acrosterigma* and other genera and subgenera.

Shell characters of species assigned to *Laevicardium s.l.* are variable and in some, including the type species *L. oblongum*, they approach the shell characters of the Trachycardiinae quite closely. The hinge teeth of *Laevicardium* are particularly variable; the cardinals of the right valve may be joined by a saddle or separated. This character is normally consistent within genera. The radial ribs may be indistinct internal structures as stated by Olsson (1961) but in the type species at least they are distinct raised ribs like those of the Trachycardiinae.

This variability of shell characters within *Laevicardium* suggests that subdivision of *Laevicardium* as conceived by Keen (1958; 1969) and Olsson (1961) may be necessary. For instance the Indo-Pacific species *attenuatum* shows many distinctive characters by which it differs from *oblongum* the type species of *Laevicardium s.s.*

We have previously given reasons for ranking *Fulvia* as a full genus and not as a subgenus of *Laevicardium*.

Laevicardium attenuatum (Sowerby, 1841)

(Pl. 3, Figs 8-12; Text fig. 6)

Cardium attenuatum Sowerby, 1841, *Proc. zool. Soc. Lond.* 1840: 109.

Type locality: Sri Lanka. **Types:** Lectotype (here selected, see Pl. 3, Fig. 8) paired valves, BM (N.H.) regn no. 1971.26, bearing data "Ceylon, Zanzibar, Philippines, M.C." although only Ceylon is mentioned in the original description.

Diagnosis

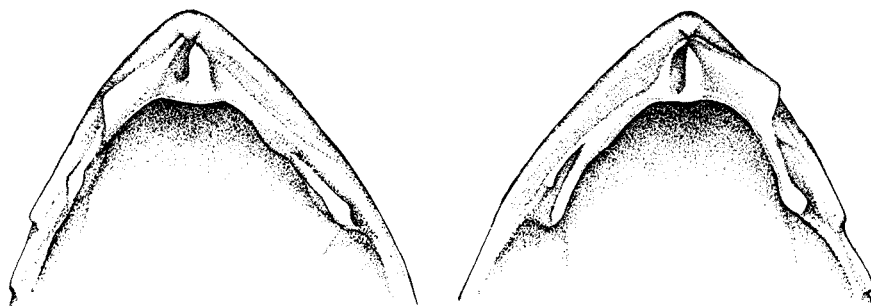
Shell elongately ovate, inequilateral; sharply tapered towards the umbos; umbos nearly orthogyrate. Posterior margin oblique, almost straight; lunule slightly thickened but not elevated.

Shell surface smooth and glossy with fine radial cords visible within subsurface structure; mean number of cords 53, range 51 to 55; anterior area without cords, posterior area with low undulations. Lunule and escutcheon elongate, poorly defined.

In both valves hinge-line strongly arched (angle of arch approx. 80°). Lateral teeth strongly developed in both valves, cardinals small. In left valve anterior cardinal compressed, wedge shaped, slightly oblique, located slightly anterior to umbo; posterior cardinal weak. In right valve posterior cardinal located directly below umbo, wedge-shaped; anterior cardinal oblique and almost obsolete. Cardinal teeth in both valves separated by deep groove.

Exterior smooth, glossy, cream with irregular red brown jagged lines, sometimes external pattern visible internally through shell. Interior white, sometimes with two rays of pale orange or rose from beneath the umbos. Exterior covered by smooth glossy green periostracum.

Sample number 8; measurements of largest shell (the type): length 5.14 cm, height 7.69 cm, width 3.44 cm; mean ratio length to height 0.63:1 (range 0.56:1 to 0.71:1), mean ratio length to width 1.54:1 (range 1.45:1 to 1.62:1).



Text Fig. 6 *Laevicardium attenuatum* x $3\frac{1}{2}$

Remarks

This species is characterised by its glossy surface, elongate and attenuate form with the sides tapering to a point at the umbones. The hinge-line is

strongly arched with the angle of the anterior laterals more nearly vertical than in other species. Also the small cardinals are compressed, wedge shaped and radiate from a point directly below the umbones.

Young specimens of *L. attenuatum* may be confused with *L. biradiatum*, particularly in Western Australia where the latter species tends to be more elongate than elsewhere, although the shell characters given are usually adequate to distinguish them. When living or preserved specimens are available the guard papillae surrounding the incurrent and excurrent apertures provide an additional diagnostic character. In *biradiatum* the papillae are approximately of equal size, those around the margins of the apertures are only slightly smaller than the outer papillae. The outer papillae in *attenuatum* are large but there is a distinct zone of small papillae surrounding both apertures.

Distribution

Indo-West Pacific. We have examined specimens from the Philippines, New Caledonia and northern W.A., where the species occurs as far south as Onslow.

W.A. records

12-25 fm, 16-32 km W of La Grange Bay, 928-66; 22 fm, sponge, 64 km W of Cape Jaubert, 927-66; 25 fm, 96 km NW of Bedout I., 922-66; 25 fm, 116 km NW of Bedout I., 932-66; 28 fm, fine sand and rubble, 11 km N of Long I., Onslow, 1067-66. 1135-67.

Laevicardium biradiatum (Bruguière, 1789)

(Pl. 3, Figs 16-18)

Cardium biradiatum Bruguière, 1789, *Histoire Naturelle des Vers: Encyclopedie Methodique*, 1: 231. Type locality: Sri Lanka. Holotype: paired valves, Lamarck Collection, Muséum d'Histoire Naturelle, Geneve, regn no. 1085/60.

Cardium serratum Gmelin, 1791, *Systema Naturae*, 13th ed. p. 3251.

Diagnosis

Shell elongately to roundly ovate; almost equilateral; umbones weakly prosogyrate. Anterior margin gently curved; ventral margin rounded; posterior margin curved in Philippines specimens, relatively straight in W.A.

specimens. In right valve lunule prominent, a raised protuberance bearing anterior cardinal tooth.

Mean number of external radial cords 41, range 35 to 53; anterior and posterior areas generally without cords (in some specimens undulations evident on posterior area giving large variation in rib count).

Lunule and escutcheon elongate. Right anterior cardinal tooth weak, low, almost horizontal; cardinal teeth separated by deep groove. In both valves angle between horizontal tangent to hinge-line and ventral anterior lateral tooth about 55° in W.A. specimens, slightly less in Philippine specimens.

Exterior of shell mottled brown and cream, anterior and posterior areas with large splashes of purple brown; interior white with two broad ill-defined rays of mottled pink.

Sample number 17; measurements of largest shell: length 3.85 cm, height 4.78 cm, width 2.49 cm; mean ratio length to height 0.84:1 (range 0.76:1 to 0.92:1); mean ratio length to width 1.60:1 (range 1.49:1 to 1.93:1).

Remarks

W.A. shells compared with a series of specimens from the Sulu Sea (Pele-Sulu Exp. 1964) were found to be more elongate, with straighter posterior sides and with the hinge-line slightly more arched. These differences are consistent and consideration may be given later to separation of the W.A. forms as a distinct subspecies. Before this can be done however comparison must be made with specimens from Indonesia and other parts of the Indo-Pacific area.

This species resembles *L. multipunctatum* Sowerby, 1838 (not represented from W.A. in our collection). The latter species may be recognised by its strongly oblique form, more prominent marginal serrations and red spotted exterior. Also there is a deep notch in the hinge on the postero-ventral side of the posterior lateral tooth in *multipunctatum* which is only weakly developed in *biradiatum*.

Distribution

Widely distributed in the Indian Ocean (including the Red Sea) and the central Indo-Pacific area with records from Amani I., Japan, Sri Lanka, Indo-Malay Archipelago, Philippines and the East and West Coasts of Australia; the most southern W.A. record is Onslow.

W.A. records

25 fm, 16 km W of La Grange Bay, 929-66; 15 fm, coral and sponge, 16 km W of Gordon Bay, 923-66; 10 to 15 fm, sand and sponge, between Malus and Gidley Is, Dampier Arch., 1073-66; 10 fm, W side of Peak I., near Onslow, 1074-66, 1075-66; 28 fm, W of Flat I. (N of Long I.) off Onslow, 925-66, 1054-66.

Genus *Nemocardium* Meek, 1876

Nemocardium Meek, 1876, *Rep. U.S. Geol. Geogr.* 9: 167. Type species: *Cardium semiasperum* Deshayes, 1858 [an Eocene fossil of the Paris Basin]; O.D.

Diagnosis

Shell quadrate or ovately quadrate, inflated, approximately equilateral; umbones prosogyrate. Posterior margin straight or almost straight; anterior and ventral margins rounded. Umbonal keel rounded; posterior area behind keel slightly concave. Margins serrate, sometimes more strongly so posteriorly. Sculpture consists of numerous fine radial ribs; ribs in posterior region are spinose, anterior ribs spinose or spineless; spines may arise from interstices or from ribs. Interstices sometimes very narrow but when wide they are pitted or contain secondary concentric sculptured crossbars. Hinge margin raised to form a triangular dorsal projection anterior to umbo. Liagment relatively strong; lunule and escutcheon present.

Left valve: Anterior cardinal strong, curved and peglike; posterior cardinal almost obsolete, situated close to dorsal margin; cardinal teeth separated by pit which is deep and wide behind anterior tooth but becoming a V-shaped notch between anterior tooth and dorsal margin. Posterior lateral almost obsolete and located almost on postero-dorsal margin; anterior lateral large, flat, triangular; laterals approximately equidistant from cardinals. Right valve: Right cardinals unequal, joined by saddle, separated antero-ventrally by deep pit; anterior cardinal weak, situated high and close to dorsal margin; posterior cardinal strong and peglike; shallow V-shaped notch present above posterior cardinal. Two anterior laterals present; dorsal anterior lateral represented by a thin, blunt-ending, rod-like rib; single posterior lateral low, flat, triangular; laterals approximately equidistant from cardinals.

Remarks

The subgeneric determinations used here for the four living Australian species follow the subgeneric classification proposed by Keen (1969: N 589) although the boundaries between the subgenera, which are based solely on shell shape and sculpture, seem very tenuous in some cases.

The genus is represented in tropical seas of the Indo-West Pacific region, the western Atlantic and the eastern Pacific, and in the temperate waters of southern Australia and New Zealand.

It has a long fossil record. According to Meek (1876: 168) and Finlay and Marwick (1937: 30) *Nemocardium* occurred in the Cretaceous and flourished in the early Tertiary. It is represented by nine fossil species in Eocene sediments of the Paris Basin. The genus is also recorded in the Miocene-Recent of California (Grant and Gale, 1931: 311), the Oligocene of Victoria (Chapman and Crespin, 1928: 103), the Pliocene of South Australia (Ludbrook, 1955: 64), the Palaeocene to the Recent of New Zealand and the Miocene of Chatham Island (Finlay and Marwick, 1937: 30).

Subgenus *Nemocardium* Meek, s.str.

Diagnosis

Shell sculpture of central and anterior slopes consisting of numerous, crowded, fine, spineless radial ribs so that in these areas shell almost smooth; radial ribs of posterior slope relatively coarse and strongly spinose. Anterior and ventral margins finely crenulate; posterior margin strongly serrate.

Remarks

Although there are several fossil species of this subgenus, there is but one Recent species, *N. bechei* Reeve, which lives in the central Indo-West Pacific region.

Nemocardium bechei (Reeve, 1840)

(Pl. 1, Figs 15-19; Text fig. 7)

Cardium bechei Reeve, 1840, *Proc. zool. Soc. Lond.* 1840: 25. Type locality: "Sooloo Seas" [Sulu Sea, Philippines] and "Korean Arch". [?]. Holotype: single left valve; BM (N.H.) reg. no. 1971.31.

Pratulium probatum Iredale, 1927, *Aust. Zool.* 4: 333, pl. 46 fig. 8.

Type locality: Trial Bay, New South Wales. Types: 2 syntypes, both right valves; AM reg. no. C 28434.

Diagnosis

Shell ovately quadrate. Posterior margins strongly serrate, anterior and ventral margins finely serrate. Mean number of radial ribs 121, range 110 to 132. External surface prominently demarcated into two regions; posterior region (behind umbonal keel) with about 30 relatively strong spinose ribs, spines generally arise from the sides of the ribs; central and anterior region almost smooth but beneath thin, translucent superficial layer of shell material a series of numerous, crowded, fine radial ribs can be seen. Examined microscopically, anterior and ventral marginal serrations seen to be projections of ribs with laterally compressed but rounded edges. Interstices represented in ventral margin by deep pits covered by superficial external layer (Pl. 1, Fig. 17). Hinge-line sinuous; lunule short, broad, with fine striae at approximately right angles to margin; escutcheon long, narrow, smooth.

Exterior pink, darker pink to red toward margins; interior white; lunule pink, hinge dark pink to red behind ligamental notch; spines yellow. Central and anterior region bearing a thin silky yellow-brown periostracum which forms fine concentric lamellae. At line of demarcation between posterior region and central and anterior region, periostracal lamellae raised to form projecting feather-like tufts; a more regular periostracum present on posterior region.

Sample number 16; measurements of largest shell, length 4.40 cm, height 4.36 cm, width 3.28 cm; mean ratio length to height 1.02:1 (range 0.99:1 to 1.05:1); mean ratio length to width 1.37:1 (range 1.31:1 to 1.49:1).



Text Fig. 7 *Nemocardium bechei* Reeve x 2

Remarks

Iredale (1927) differentiated *P. probatum* from *Cardium bechei* Reeve because the former "differ in shape and sculpture from the true *C. bechei*".

However we have examined Iredale's type specimens in the Australian Museum, Sydney and the type of *bechei* in the BM (N.H.) and are satisfied that this distinction is not justified.

This species and its fossil relatives are quite distinct from all other living species of *Nemocardium* known to us and subgeneric distinction seems well warranted. The shell is much larger, the striking demarcation between the posterior region and the rest of the shell and the unique character of the ventral marginal serrations are quite distinctive.

N. (N.) bechei inhabits sandy substrates over a wide bathymetric range from the intertidal zone to at least 54 fathoms. Reference in the original description to the "Korean Arch" seems likely to have been an error.

Distribution

Central Indo-West Pacific from southern Japan to northern Australia; recorded from as far south as Trial Bay, New South Wales on the eastern coast of Australia, and as far south as Geraldton in W.A.

W.A. records

54 fm, NW of Bluff Point, 1046-66; 40 fm, sand and shell, N of Dirk Hartog I., 244-67. 242-67, 246-67; 40 fm, sand, 16 km W of Bernier I., 247-67; 22 fm, mud, approx. 5 km NNE of Anchor I., off Onslow, 243-67; 10 fm, W side of Peak I., off Onslow, 251-67; 32 fm, sand, 48 km N of Legendre I., Dampier Arch., 245-67; 25 fm, 96 km NW of Bedout I., 89-67; 25 fm, 125 km NW of Bedout I., 94-67; 50 fm, 80 km NE of Adele I., 107-67; 40 fm, 104 km NE of Adele I., 106-67; 32 fm, 346 km ENE of Troughton I., 108-67.

Subgenus *Microcardium* Thiele, 1935

Microcardium Thiele, 1935, *Handbuch der Systematischen Weichtierkunde*, Pt 3: 878. Type species: *Cardium peramabile* Dall, 1881; S.D. Keen, 1937.

Diagnosis

Shell small with secondary concentric sculpture on central and anterior slopes of transverse striae or ridges in interstices and beads or spines along ribs.

Remarks

The subgenus is represented in tropical seas of the Indo-West Pacific, eastern Pacific and western Atlantic Oceans. Thiele (1935) listed two species as members of his new subgenus *Microcardium* viz. the Indo-West Pacific species *torresi* Smith and the Caribbean species *peramabile* Dall, the latter being subsequently designated as type species by Keen (1937). Several other Indo-West Pacific and American species have since been added. It seems probable that the Japanese subgenera *Trifaricardium* Habe, 1951, *Frigidocardium* Habe, 1951 and *Keenaea* Habe, 1951 will prove to be synonyms of *Microcardium*. We have not seen specimens of the type species of these subgenera but the diagnostic characters given seem trivial.

Nemocardium (Microcardium) torresi (Smith, 1885)

(Pl. 4, Figs 20-22; Text fig. 8)

Cardium (Fragum) torresi Smith, 1885, *Report on the Lamellibranchiata collected by H.M.S. Challenger during . . . 1873-76. Zoology*, pt 35, 13: 164, pl. 8 figs 4-4b. **Type locality:** (Stn 188), south of New Guinea at a depth of 28 fms. **Types:** Holotype and 3 paratypes, all single valves (one broken) BM (N.H.) reg. no. 1887.2.9.2736.

Diagnosis

Shell quadrate, posterior margin almost straight. Mean number of radial ribs 111, range 100 to 121. Ribs rounded, narrow, crowded; radial rows of short blunt-ending or spoon-shaped spines arise from tops or sides of ribs or from interstices. On central and anterior slopes relatively large spines usually present on or beside every third or fourth rib, smaller spines on or beside intermediate ribs on posterior slope all ribs bear relatively large spines. Interstices narrow, fine concentric striae cross ribs and interstices. Hinge-line sinuous; ligamental notch small; lunule broad, smooth; escutcheon elongate, narrow, smooth. Shell exterior white, with wide radial rays of pale orange, sometimes orange concentric bands; interior yellow or white below umbones, irregularly marked with pink toward margins and in posterior region; lunule and escutcheon pink or orange.

Sample number 27; measurements of largest shell: length 2.48 cm, height 2.50 cm, width 1.92 cm; mean ratio length to height 0.97:1 (range

0.91:1 to 1.06:1), mean ratio length to width 1.25:1 (range 1.15:1 to 1.36:1).



Text Fig. 8 *Nemocardium torresi* x 5½

Remarks

In his original description of this species Smith suggested that the types were possibly juveniles, the largest specimen (the holotype) having the following dimensions: length 4.5 mm, height 4.25 mm, width 3.5 mm. Our series includes specimens much larger than this but the length:height and length:width ratios of the holotype (1.05 and 1.29) fall within the ranges calculated for our series. We have compared our specimens with the types and conclude that they match well in shape and in details of sculpture and can safely be regarded as adults of the same species.

N. (M.) torresi is quite similar to *N. (M.) exasperatum* Sowerby and can easily be confused with it. The latter species has a thicker shell, with fewer ribs (range 80 to 90 compared to 100 to 121 in *torresi*), heavier and more uniform rib sculpture, and more quadrate shape. The Pacific species *N. (M.) thaanumi* Pilsbry, 1921 bears sculpture similar to that of *torresi* but has a smaller, thinner, more quadrate shell which more closely resembles *N. (P.) thetidis* in shape.

N. (M.) torresi is a deepwater species inhabiting sandy substrates and is recorded at depths between 28 and 75 fathoms.

Distribution

Northern Indian and western Pacific Oceans from the Persian Gulf to the Sulu Sea, Philippines. In W.A. it occurs as far south as Point Cloates. Not yet recorded from the eastern coast of Qld.

W.A. records

50 fms, 80 km NE of Adele I., 228-67; 42 fms, 40 km NNE of Adele I., 326-67; 28 fms, fine sand and rubble, 11 km N of Long I., Onslow, 189-67; 75 fms, W of North West Cape, 327-67; 73 fms, W of Point Cloates, 209-67.

Nemocardium (Microcardium) exasperatum (Sowerby, 1838)

(Pl. 4, Figs 14-19; Text fig. 9)

Cardium exasperatum Sowerby, 1838, *The Conchological Illustrations*, fig. 37. Described Sowerby, 1841, *Proc. zool. Soc. Lond.* 1840: 106.

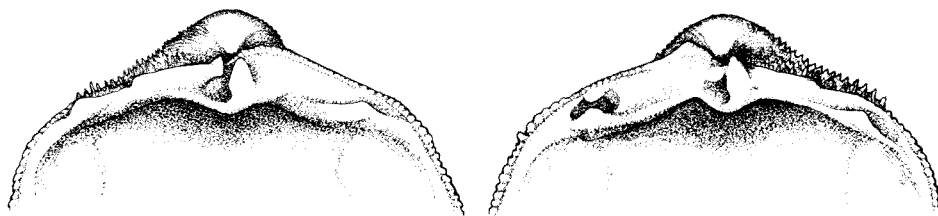
Type locality: Swan River [Swan River Colony = Western Australia].

Types: **Lectotype** (here selected, see pl. 4, figs 14-17) plus 2 **paralectotypes**, BM (N.H.) reg. no. 1971.32.

Diagnosis

Shell quadrate, posterior margin almost straight but sometimes with a slight indentation. Mean number of radial ribs 84, range 80 to 90. Ribs narrow, rounded; usually every third rib bears strong, regularly spaced spines, sometimes intermediate ribs bear a few relatively small spines, spines arise from sides of ribs; spines more numerous on a few weak anterior ribs. Prominent crossbars in interstices. Hinge-line sinuous, ligament rather short; lunule long, broad, smooth except for fine ridges parallel to hinge-line; lunule raised just anterior to umbones; escutcheon elongate, narrow, smooth. Shell white both externally and internally except for posterior slope, lunule and escutcheon which are pink.

Sample number 8; measurements of largest shell, length 2.44 cm, height 2.40 cm, width 2.04 cm; mean ratio length to height 0.97:1 (range 0.94:1 to 1.03:1); mean ratio length to width 1.21:1 (range 1.15:1 to 1.29:1).



Text Fig. 9 *Nemocardium exasperatum* x 4

Remarks

W.A.M. specimens have been compared with the types and their identity confirmed. Shells of *N. (M.) exasperatum* are quite like those of *N. (M.) torresi*. Differentiating characters are noted in the remarks on the latter species.

Kira (1962) referred *exasperatum* to the subgenus *Frigidocardium* (Habe, 1951, type species *Cardium eos* Kuroda, 1929), but this species is so similar to *N. (M.) torresi* in shell characters that doubt is cast on the status of *eos* and the subgenus *Frigidocardium*.

N. (M.) exasperatum is a relatively deepwater, muddy bottom species recorded from depths between 60 and 70 fathoms in W.A.

Distribution

Central Indo-West Pacific; recorded from Honshu in southern Japan to North-West Cape in W.A.

W.A. records

65 fms, mud, 32 km NW of Anchor I., near Onslow, 292-67; 65 fms, mud and sand, approximately 16 km NNW of Anchor I., near Onslow, 248-67; 60-70 fms, W of North West Cape, 210-67.

Subgenus *Pratulum* Iredale, 1924

Pratulum Iredale, 1924, *Proc. Linn. Soc. N.S.W.* 49: 182, 207. Type species: *Cardium thetidis* Hedley, 1902; O.D.

Diagnosis

Small with fine radial ribs which are coarser on the anterior slope and secondary concentric sculpture of thin, somewhat irregular ridges crossing the interstices.

Remarks

Represented living in temperate waters of southern Australia and New Zealand but fossil species are reported from Europe (Keen, 1969: N 589).

Iredale (1924) considered the Australian *thetidis* Hedley to be specifically distinct from *pulchellum* Gray, 1843 of New Zealand (= *striatulum* Sowerby, 1841, *non* Brocchi) and cited the former species as type of his new genus *Pratulum* without further description or comment. Finlay and Marwick (1937) observed that little separates *Pratulum* from *Nemocardium*. They separated them subgenerically because the radial ribs in *Pratulum* are crossed by thin, widely separated somewhat irregular concentric ridges (Pl. 7, Fig. 1) whereas in *Nemocardium* the interstices between the ribs are very fine and concentric ridges are not developed.

In our view *Pratulium* is sufficiently distinct from *Nemocardium* s.s. to warrant subgeneric separation. Its relationship to *Microcardium* and other tropical groups is more problematical. For example, the tropical Pacific species *N. thaanumi* Pilsbry, 1921 closely resembles *N. (P.) thetidis* in size, shape and sculpture except for the presence of spines on the central and anterior ribs, which is a characteristic more typical of the subgenus *Microcardium*.

Nemocardium (Pratulium) thetidis (Hedley, 1902)

(Pl. 4, Figs 23-25; Text fig. 10)

Cardium striatulum thetidis Hedley, 1902, *Mem. Aust. Museum* 4: 322.

Type locality: off Port Kembla, off Cape Three Points. **Holotype:** AM reg. no. C13261.

Diagnosis

Shell ovately quadrate, posterior margin oblique, almost straight. Hinge narrow, ligament and ligamental notch weak; lunule and escutcheon elongate, smooth. Mean number of radial ribs 81, range 65 to 98; posterior area spinose, spines short, arranged in radial rows along sides of ribs or in interstices; medial and anterior ribs and interstices smooth but for short, fine, concentric and oblique cords; spinose posterior area abruptly demarcated from rest of shell at umbonal ridge. Shell white externally, with pink radial rays which are often darker posteriorly; umbos pale orange; interior white or pale yellow.

Sample number 53; measurements of largest shell, length 1.39 cm, height 1.30 cm, width 0.98 cm; mean ratio length to height 1.03:1 (range 0.95:1 to 1.09:1); mean ratio length to width 1.40:1 (range 1.18:1 to 1.79:1).



Text Fig. 10 *Nemocardium thetidis* x 6½

Remarks

This species shows considerable variation in rib count and shape. The rib counts of specimens we have examined from southern N.S.W., Vic. and Tas. approximately equal those of specimens from the southern part of W.A. Specimens from the northern limit of the species range in W.A. tend to have a higher rib count. There is no indication from our data that this variability is clinal; rather it seems to be an end-of-range characteristic because the change takes place fairly abruptly north of latitude 28°S.

This species is similar to the Pacific species *N. thaanumi* Pilsbry, 1921 but in that species all the ribs are spinose, whereas in *N. thetidis* spines are confined to the posterior ribs. (*N. thaanumi* was believed to be endemic to Hawaii but the species was dredged recently in the Marquesas by the National Geographic Society — Smithsonian-Bishop Museum Expedition, 1967.)

Hedley (1902) originally proposed the name *thetidis* as a subspecies of the New Zealand species *N. striatulum* Sowerby. Iredale (1924) correctly separated them as distinct species. The New Zealand species is more elongate, less quadrate, the demarcation of posterior area is less evident, the ribs are stronger, especially anteriorly, and the spines of the posterior area are relatively weak.

This is a deepwater species which inhabits sandy substrates at depths from 25 to at least 103 fathoms.

Distribution

Southern part of Australia including Tas., from N.S.W. in the east to North West Cape, W.A.

W.A. records

25 fms W of North West Cape, 199-67; 102 fms, SW Point Cloates, 205-67; 71 fms, SW of Point Cloates, 200-67; 182 fms, SW of Point Cloates, 201-67, 329-67; 75 fms, SW of Point Cloates, 326-67; 61 fms, NW of Carnarvon, 206-67; 71 fms, W of Carnarvon, 203-67; 78 fms, W of Dirk Hartogs I., 207-67; 54 fms, NW of Bluff Point, Geraldton, 1043-66, 198-67, 323-67, 85-67, 227-67; 62 to 67 fms, W of Lancelin I., 1034-66; 100 to 103 fms, NW of Rottnest I., N 4334; 85 fms, sponges and sand, NW of Rottnest, N 4364; 65 fms, sponge and sand, NNW of Rottnest I., N4447; 97 to 100 fms, W of West End of Rottnest I., 196-67; 95 to 96 fms, sponge and sand, WNW of Rottnest I., N 4313; 70 fms, sand, W of West End of Rottnest I., 192-67; 74 to 80 fms, sand, W of West End of Rottnest I., N 4197. N 4823; 80 to 83 fms, SW of Rottnest I., 92-67; 50 fms, W of Rottnest I., 202-67; 75 fms, W of Rottnest I., 194-67; 75 to 78 fms, W of

Rottneest I., 237-67; 63 to 67 fms, NW of Bunbury, 91-67; 75 fms, NW of Cape Naturaliste, 193-67, 218-67, 223-67.

Genus *Lyrocardium* Meek, 1876

Lyrocardium Meek, 1876, *Rep. U.S. Geol. Geogr.* 9: 173. Type species: *Cardium lyratum* Sowerby, 1841; S.D. Dall, 1900.

Amphicardium von Martens, 1880, (in) Mobius, K.A., *Beitrage zur Meeresfauna der Insel Mauritius und der Seychellen etc.*, p. 324. Type species: *Cardium lyratum* Sowerby, 1841, S.D. Keen, AM 1937.

Diagnosis

Shell rotund to ovate; inequilateral; umbos prosogyrate; umbonal keel lacking; posterior end slightly flared. Anterior and ventral margins rounded, postero-dorsal margin oblique or almost straight. Ventral margins serrate, serrations tightly interlocking; anterior and posterior margins smooth or weakly serrate. Hinge-line moderately strong, sinuous. Cardinals in both valves erect, curved upward, pointed, unequal; left cardinals separated by deep pit, right cardinals joined by saddle. Right posterior lateral single, strong; two right anterior laterals present, ventral one strong, dorsal one a mere ridge below antero-dorsal margin. Left posterior lateral small, located almost on postero-dorsal margin; left anterior lateral large, flat, triangular.

External sculpture of radial cords usually fine in medial area, obsolete on anterior area, either obsolete or strong, widely spaced and sharp-edged on posterior area. Prominent, sharp-edged, oblique ridges present on anterior part of shell. Lunule well defined, broad, wider in right valve, lunular margin with a high dorsal projection just anterior to umbones, especially in right valve. Escutcheon elongate, smooth, not well defined. External surface shiny, may be covered by thin, smooth, closely adhering periostracum.

Remarks

Dall (1900) and Thiele (1939) considered the genera *Discors* Deshayes, 1860 (type species *Cardium discors* Lamarck, 1805, a European Tertiary fossil) and *Lyrocardium* to be subjective synonyms with the former taking priority. Keen (1969) listed them as separate taxa and although the criteria for distinguishing between them seem to be only relative we follow suit because we have not seen the fossil species of *Discors*.

Discors and *Lyrocardium* were ranked by Keen (1969) as subgenera of *Nemocardium* but this seems unwarranted as the oblique secondary sculpture on the central and anterior slopes in the type species of both is very distinctive and quite unlike the condition in *Nemocardium*, and the posterior margin in *Lyrocardium* is smooth, or nearly so, lacking the prominent crenulations characteristic of *Nemocardium*.

Nevertheless *Lyrocardium* and *Nemocardium* are certainly closely related for the condition of the hinge and hinge teeth are quite similar in these two groups. *Lyrocardium* is represented by two living species in the Indo-West Pacific region, i.e. *L. lyratum* (Sowerby, 1841) and *D. aurantiacum* (Adams and Reeve, 1848). A third living species, *L. pectinatum* (Linnaeus, 1758) (= *aeolicum* Born, 1778) is said to occur in the tropical eastern Atlantic but we have not seen specimens of it.

Lyrocardium lyratum (Sowerby, 1841)

(Pl. 4, Figs 26-28; Text fig. 11)

Cardium lyratum Sowerby, 1841, *Proc. zool. Soc. Lond.* 1840: 109; figured Sowerby, 1841, *The Conchological Illustrations*, fig. 40. **Type locality:** Dumaguete, Island of Negros, Philippines. **Holotype:** paired valves, BM (N.H.) reg. no. 1971.27.

Diagnosis

Posterior margin smooth or with weak crenulations. Medial and posterior radial ribs (i.e. those on area behind oblique ridges) strong, sharp-edged, becoming more prominent and widely spaced posteriorly; mean number of medial and posterior ribs 25, range 23 to 29; anterior radial ribs fine or lacking.

Exterior cream, covered by smooth and glossy wine-red periostracum; interior, including hinge-plate, white except for one or two broad rays of yellow (or pink) which are usually present beneath umbones; dorsal margin orange-pink or red below lunule and immediately behind ligamental notch.

Sample number 12; measurements of largest shell: length 5.48 cm, height 6.13 cm, width 4.70 cm; mean ratio length to height 0.97:1 (range 0.89:1 to 1.02:1); mean ratio length to width 1.35:1 (range 1.16:1 to 1.51:1).



Text Fig. 11 *Lyrocardium lyratum* Saw x 1½

Remarks

The sculpture and colour of the shell makes this species readily identifiable. The only species with which it could be confused is its congener *L. aurantiacum* (Adams and Reeve, 1848) which also inhabits the waters of the central Indo-West Pacific. Specimens of *L. aurantiacum* are uncommon in collections. The species is represented in the WAM collections by several specimens from the Moluccas province of Indonesia. The shell is smaller than that of *L. lyratum*, slightly more inflated, and lacks the dark wine-red periostracum so characteristic of that species. Also the posterior part of the shell in *L. aurantiacum* is quite smooth and shiny recalling the condition in *Laevicardium*, and the posterior margin is smooth.

Distribution

Widely distributed in the Indo-West Pacific from East Africa, Red Sea, Seychelles, eastern and western Australia, the Philippines, New Caledonia, and as far north as Honshu, Japan. Abrolhos is the most southerly W.A. record.

W.A. records

Sand flats low tide, Rosemary I., Dampier Arch., 42-67; 21 fm, Middle Channel, Abrolhos, N2865; 21 fm, coral and sand, Zeewyk Channel, Abrolhos, N2866, 295-67.

Genus *Acrosterigma* Dall, 1900

Acrosterigma Dall, 1900, *Trans. Wagner Free Inst. Sci.*, 3 (5): 1073.

Type species: *Cardium dalli* Heilprin, 1887; O.D.

Vasticardium Iredale, 1927, *Rec. Aust. Mus.* 16: 75. **Type species:** *Cochlea nebulosa* Martyn, 1792 (= *Cardium elongatum* Bruguière, 1789); O.D.

Regozara Iredale, 1936, *Rec. Aust. Mus.* 19: 275. Type species: *Regozara olivifer* Iredale, 1936 (= *Cardium reeveanum* Dunker); O.D.

Diagnosis

Shell higher than long; ovate or elliptical and attenuate towards umbones; umbones prosogyrate or sometimes nearly orthogyrate; rounded without posterior angulation. Margins serrate or digitate. Sculpture of strong radial ribs which may be relatively smooth but usually bear transverse rugae becoming nodules or scales on anterior and posterior areas.

Hinge-plate curved, wide in cardinal area. Left valve: cardinal teeth unequal or almost equal; anterior cardinal strong, peg-like or wedge-shaped, posterior cardinal weaker and close to dorsal margin; anterior lateral teeth high and compressed, with indentation on ventral side; posterior lateral weak, close to dorsal margin with indentation on its ventral side. Right valve: cardinal teeth unequal, separated by socket or touching at their bases; posterior cardinal strong, peg-like, anterior cardinal weak; posterior lateral tooth high, compressed, separated from dorsal margin by deep v-shaped notch; 2 anterior laterals present, ventral one large and usually knob-like, dorsal one merely small blunt-ended rib on dorsal side of deep notch separating ventral tooth from dorsal margin.

Remarks

Our selection of the generic name *Acrosterigma* for all the species dealt with here was made with much hesitation. The shell characters on which the current classification of the subfamily Trachycardiinae is based are unsatisfactory and an anatomical review seems to be necessary.

Keen (1969) recognised three genera and a number of subgenera in the subfamily Trachycardiinae viz:

Genus

Trachycardium Mörch, 1853 (type species *C. isocardia* Linnaeus, 1758).

Subgenus

Trachycardium s.s.

Dallocardia Stewart, 1930 (type species *C. quadragenarium* Conrad, 1837).

Mexicardia Stewart, 1930 (type species *C. procerum* Sowerby, 1833).

Phlogocardia Stewart, 1930 (type species *C. belcheri* Broderip & Sowerby, 1829).

Genus

Acrosterigma Dall, 1900 (type species *C. dalli* Heilprin, 1887).

Subgenus

Acrosterigma s.s.

Ovicardium Marwick, 1944 (type species *Trachycardium* (O.) *rossi* Marwick, 1944)

Regozara Iredale, 1936 (type species *R. olivifer* Iredale, 1936)

Vasticardium Iredale, 1927 (type species *V. nebulosum* Martyn, 1799)

Genus

Papyridea Swainson, 1840 (type species *Cardium soleniforme* Bruguière, 1789).

This arrangement appears to be based primarily on earlier classifications (Stewart, 1930; Keen, 1958; Olsson, 1961) devised to accommodate species groupings discernible in the American region. The diagnostic criteria used to differentiate between these taxa are mainly concerned with the general shape of the hinge, the shell outline, and sculpture. Consideration of the many and varied Indo-Pacific species together with the American ones shows that the boundaries between some of these taxa cannot be maintained on the basis of these characters alone.

For example the main character given by Keen (1969) to differentiate between *Trachycardium* and *Acrosterigma* is the "heavy, short, nearly straight" hinge in the former, and the "strongly bent" hinge in the latter. The series of Indo-Pacific species before us shows a wide range of hinge conditions and it is not possible for us to place many of these species in one genus or the other on this character.

Sculpture is used by Keen and others mainly to differentiate between the subgenera. In *Trachycardium* s.s. the ribs bear prominent imbricating scales, reduced to beads anteriorly. In *Trachycardium* (*Mexicardia*) the ribs are smooth, triangular in juveniles, and separated by grooved interstices. In *Acrosterigma* s.s. the ribs are almost smooth, the scale ornamentation being reduced to vestiges along the sides of the ribs.

The Indo-Pacific species form a highly variable series in respect to sculpture. Where ornamentation of the ribs occurs it is usually in the form of transverse rugae or some modification of this. Often the rugae become nodules on the anterior ribs and more or less scale-like structures on the posterior sides of the posterior ribs. In many species the rugae in the mid-area are reduced to vestiges along the sides of the ribs (e.g. *elongatum*,

enode). In a few the rugae on the medial ribs are reduced to mere irregular lines, strongest in the interstices (e.g. *dampierense*). The Pacific species *hawaiiensis* has the rugae tending to become elevated forming u-shaped scales, especially at the posterior end, but nowhere are these as prominent as in *Trachycardium* s.s. In some species (e.g. *reeveanum*, *dupuchense*, *alternatum*) the ribs are more or less triangular with rugae or lamellae of different strengths on one or both sides. In other species (e.g. *fultoni*) the transverse rugae become so dominant that each forms a flat-topped plateau with undercut edges at the tops of the ribs.

Thus, many of the Indo-Pacific species may be accommodated satisfactorily in the American taxa *Acrosterigma*, *Mexicardia* and perhaps *Dalloccardia*, according to the diagnostic sculptural characteristics of those taxa. For example *elongatum*, *enode* and *dampierense* may be affiliated with *Acrosterigma*. (In fact Clench and Smith (1944) have shown that *elongatum* and *T. (A.) magnum* of the eastern Atlantic are "exceedingly close".) The Indo-Pacific species *dupuchense* and *alternatum* show some characteristics of *Mexicardia*. On the other hand many Indo-Pacific species do not precisely fit within the boundaries of the American subgenera, but are transitional in respect to their sculptural characteristics.

Although hinge shape and external sculpture do not seem to be diagnostic for *Trachycardium*, *Acrosterigma* and their subgenera we believe that the condition of the cardinal teeth in the right valve may be a useful character. In *T. (T.) isocardium*, *T. (M.) procerum* and *T. (P.) belcheri* the right cardinals are connected by a high and narrow dorsal saddle (but not present in *T. (D.) quadragenarium*). We have not seen specimens of *A. (A.) dalli* the type species of *Acrosterigma*, but in other American species usually assigned to this genus, and in the whole series of Indo-Pacific trachycardiinids, these teeth are separated or merely touching at their bases, and a dorsal saddle is lacking. It is for this reason that we have used, provisionally, the generic name *Acrosterigma* for all the Western Australian species considered here.

Iredale (1927) introduced the name *Vasticardium* for the Indo-Pacific species *C. elongatum* Bruguière, 1789 (= *Cochlea nebulosa* Martyn, 1799). Subsequently Iredale (1936) introduced another new generic name, *Regozara*, for his species *olivifer* (= *reeveanum* Dunker) differentiating "this group of Cardiums" from the American *Trachycardium*, but without comment on the relationship of *Regozara* to *Vasticardium*. We have compared shells of the type species of Iredale's two genera with each other and with other Indo-Pacific species. We could find no basis for generic or subgeneric distinction of these species; the full series of species shows an intergradation between the rugose condition of the ribs in *reeveanum* and

the smooth-topped ribs of *elongatum*. Therefore, while we are not familiar with the type species of *Acrosterigma* s.s., or with the fossil group *Ovicardium*, we have preferred not to attempt subgeneric division of the genus *Acrosterigma*.

Although 'sculpture' appears to be of very limited value in separating the genus-level taxa so far proposed for this group of cardiids we have observed one sculptural character of possible generic significance among the Indo-West Pacific and southern Australian species. In the smaller Australian species *cygnorum*, *vlamingi*, *rosemariensis*, *transcendens*, *marielae*, *dampierense*, the South-East Asian species *arenicolum* and the Japanese species *burchardi*, the posterior ribs are divided down their centres so that each has a smooth cord-like anterior part and a scale or nodule-bearing posterior part. In other species the posterior ribs are simple and the scales or nodules are arranged in a single row along the apex. It would be worth investigating whether this grouping correlates with any anatomical characters which might support genus-level separation.

KEY TO THE WESTERN AUSTRALIAN SPECIES OF THE GENUS *ACROSTERIGMA*

This key is applicable only to fully adult shells. A low power microscope, or at least a hand lens will be necessary for determination of some characters.

1. Medial ribs with straight sides, sharp corners,
flat and smooth tops *elongatum*
Medial ribs rounded or triangular, rugose
(though may be worn smooth)... .. 2
2. Posterior ribs are simple, undivided, strong
radial rays, heavily scaled or rugose 3
Posterior ribs are low, reduced, usually
divided into two parts separated by a furrow,
with small nodules or scales on posterior parts... .. 6
3. Medial ribs in cross section triangular,
asymmetrical (anterior slope longer than
posterior slope, rugae on anterior slope
reduced) *alternatum*
Medial ribs in cross section round or
triangular, symmetrical 4

4. Medial ribs and next 3 more posterior ribs
strongly rugose... .. 5
Medial ribs and next 3 more posterior ribs
finely and weakly rugose *dupuchense*
5. Rugae on medial ribs v-shaped, sometimes
confined to sides of ribs with rib apex
smooth *reeveanum*
Rugae on medial ribs straight, transverse,
confined to tops of ribs, sides of medial
ribs sculptured by weak striae only *fultoni*
6. More than 50 ribs 7
Less than 50 ribs 8
7. Hinge pink below ligament, shell usually
equilateral *transcendens*
Hinge pink below lunule, shell usually
inequilateral *marielae*
8. Shell inequilateral *cygnorum*
Shell equilateral 9
9. Lateral hinge teeth very inequidistant from
cardinals, ribs less than 40, ratio height over
length less than 0.84... .. *dampierense*
Lateral hinge teeth almost equidistant from
cardinals, ribs more than 40, ratio height
over length more than 0.84 10
10. Weak transverse bars in the rib interstices,
shell broad, compressed *vlamingi*
Strong transverse bars in the rib interstices,
shell relatively narrow, attenuate toward
umbones, tumid *rosemariensis*

Acrosterigma elongatum (Bruguère, 1789)

(Pl. 5, Figs 1-4; Text fig. 12)

Cardium elongatum Bruguère, 1789, *Histoire Naturelle des Vers. Encyclopedie Methodique*, 1: 228. Holotype: Paired valves in Lamarck Collection, Mus. d'Histoire Naturelle, Geneva, reg. no. 1085/54.

Diagnosis

Shell large, rectangular-ovate; posterior area slightly concave; umbones almost central, weakly prosogyrate. Antero-ventral margins curved, posterior margins straight. Marginal serrations long and tapered but the ends are truncated.

Lunule well defined, elongate, smooth, slightly elevated in both valves; escutcheon elongate, smooth. Hinge broad and strong; ligament strong.

Cardinals of left valve almost equal; cardinals of right valve not joined by dorsal saddle but joined at bases on dorsal edge just below umbo; left anterior and right posterior cardinals pointed and peg-like. In both valves anterior laterals a little closer to cardinals than posterior laterals.

Mean number of ribs 40, range 35-43; ribs flat-topped and square-sided, with deep narrow interstices; anterior ribs with transverse rugae; rugae numerous on median ribs but confined to sides; posterior 7 or 8 ribs with flat fan-like projections from posterior sides; interstices smooth except for fine concentric growth striae.

Exterior cream to yellow, may be splashes of pink antero-dorsally; interior white with a wide band of yellow under umbones; lunule sometimes pale purple.

Sample number 14; measurements of largest shell: length 5.91 cm, height 7.97 cm, width 4.58 cm; mean ratio length to height 0.79:1 (range 0.70:1 to 0.90:1); mean ratio length to width 1.39:1 (range 1.09:1 to 1.98:1).



Text Fig. 12 *Acrosterigma elongatum* x 1½

Remarks

This species is similar to *enode* Sowerby, 1840, which may be distinguished by the less rectangular outline (more rounded posterior margin), shallow posterior concavity (no postero-dorsal wing), wider, rounded ribs and weaker

ridges on the anterior ribs. Characteristically the postero-ventral margin serrations in *enode* form pointed overlapping teeth when the two valves are articulated. Marginal serrations of *elongatum* are less pointed and interlock but do not overlap. *A. elongatum* resembles *A. reeveanum* (Dunker) but the latter species differs by the lower rib count, the triangular and more distant ribs which are more heavily rugose, and in having a less rectangular, more ovate shape.

Clench and Smith (1944, p.7) remark that *elongatum* and the tropical western Atlantic species "*Trachycardium*" *magnum* L. "are exceedingly close", but that the latter species tends to have fewer ribs (32 to 35) although some specimens may have as many as 40 ribs. We have not seen the Atlantic species but the illustrations given by Clench and Smith indicate a more rounded outline than is the case with *elongatum*.

Distribution

Widely distributed in Indian Ocean from Mauritius to northern W.A. as far south as Dampier Archipelago. In the Holocene the range extended as far south as Lake MacLeod.

W.A. records

50 fm, 80 km NE Adele I., 723-66; 12-25 fm, 16-32 km W of La Grange Bay, 731-66; 22 fm, sponge, 64 km W of Cape Jaubert, 711-66; Port Hedland, 22-67; Antonni Mia, Port Samson, 733-66; 23 fm, sponge and rubble, 3 km W of Legendre I., Dampier Arch., 896-66; intertidal sand flats, Malus I., Dampier Arch., 771-66; Rosemary I., Dampier Arch., 732-66. West side, Lake MacLeod, (fossil) 69-958, a-b.

Acrosterigma reeveanum (Dunker, 1852)

(Pl. 5, Figs 5-7; Text fig. 13)

Cardium reeveanum Dunker, 1852, *Z. Malakozool.* 9: 54; 1859, *Novitates Conch.*, *Meeres-Conchylien*: 22, pl. 6, figs 6-8. **Type locality:** New Holland [Western Australia]. **Type specimen:** not located.

Regozara olivifer Iredale, 1936, *Rec. Aust. Mus.* 19: 275-276, pl. 20, fig. 8. **Type locality:** Sydney Harbour, New South Wales. **Holotype:** AM reg. no. C 60606.

Diagnosis

Shell ovate; umbones almost central, orthogyrate (W.A. specimens tend to be more equilateral than others). Anterior and ventral margins rounded;

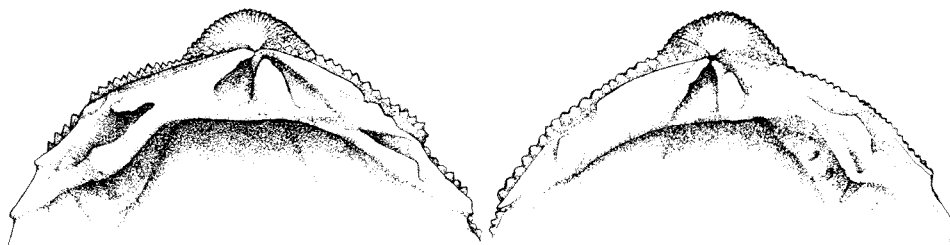
posterior margin usually almost straight, sometimes slightly rounded. Marginal serrations truncated on ventral margin.

Lunule without ribs; escutcheon smooth, elongate and narrow. Hinge broad and strong; ligament strong. Cardinal teeth unequal in both valves; left anterior and right posterior cardinals peg-like, pointed; left posterior cardinal weak, right anterior cardinal almost obsolete. Lateral teeth approximately equidistant from cardinals.

Mean number of ribs 29, range 23 to 34; ribs thick, high, usually rounded but sometimes almost triangular, with numerous transverse ridges or rugae; anterior ribs bearing few, thick rugae; rugae more numerous but confined to sides of medial ribs; few rugae on posterior ribs, these, broad, flat, fan-like processes. Interstices flat, wider at anterior and posterior ends, with fine concentric lamellae, lamellae thicker towards ventral edge particularly at the postero-ventral edge.

Exterior mottled orange, becoming darker on antero-dorsal side and around ventral margin; lunule and marginal teeth rose or orange; interior white.

Sample number 53; measurements of largest shell: length 5.28 cm, height 6.28 cm, width 4.14 cm; mean ratio length to height 0.82:1 (range 0.61:1 to 0.95:1); mean ratio length to width 1.31:1 (range 1.09:1 to 1.46:1).



Text Fig. 13 *Acrosterigma reeveanum* x 1½

Remarks

Dr R. Kiliass of the Natural History Museum in East Berlin informs us that there is no type of this species in that Museum but the original figure and type locality clearly identify this species.

Although *A. reeveanum* is one of the most common and distinctive of the larger cardiids along the whole west, north and north-eastern coasts of Australia, its identity has rarely been correctly noted. Hedley (1910: 348) listed the name *reeveanum* Dunker in his Qld catalogue but not in his *Preliminary Index of Molluscs of Western Australia* (1916). Brazier (1884: 801) listed

a "*Cardium subrugosum* Sowerby" among a collection from Cossack, North Western Australia, and this may well have been the species described above. In popular literature (Allan, 1950: 316, pl. 34, fig. 4; Ripplingale and McMichael, 1961: 186, pl. 26, fig. 9) the name *flavum* Linnaeus, 1758 has been used for this species, but that Linnaean name is indeterminable (see Iredale, 1936: 275) although it probably relates to another common Indo-West Pacific species now generally known as *rugosum* Lamarck, 1819. The latter species is also common in Qld but does not occur in W.A. (*Acrosterigma rugosum* was recorded from Qld by Garrard (1966: 4) as *Vasticardium nigropunctatum* Habe and Kosuge, 1966, which is a junior synonym.)

Iredale (1936) introduced the name *Regozara olivifer* for N.S.W. specimens but the reasons given are obscure and there is little doubt that the type is conspecific with the W.A. shells figured here.

In parts of the Indonesian, Malaysian and Philippine archipelagos adjacent to Australia the related species *rugosum* Lamarck and *subrugosum* Sowerby, 1841 are common but we have not seen specimens of *reeveanum* from any non-Australian locality. *Cardium rubicundum* Reeve, 1844, which is found on the tropical east coast of Africa, is very similar to *reeveanum* although the shells are distinguishable. The two could perhaps be regarded as allopatric subspecies. *Cardium lacunosum* Reeve, 1845 from the Persian Gulf, is probably also closely related. The shell of *rubicundum* is more tumid and thinner, the ribs more numerous (31 to 36, average 34 in the WAM series of 9 specimens) and not as strong. The colour is generally purple or reddish rather than orange.

The Pacific islands species *orbita* Broderip and Sowerby, 1833 and *hawaiiensis* Dall, Bartsch and Rehder, 1938 also resemble *reeveanum* but differ in their much stronger rib sculpture, more numerous ribs and the dark purple margins internally.

In W.A. the species most likely to be confused with *reeveanum* are *elongatum*, *dupuchense* and *alternatum*. The high rib count (35-43), flat-topped medial ribs and rectangular outline suffice to distinguish *elongatum*; *dupuchense* has a heavier, less elongate and more obliquely quadrate shell and the purple interior staining is generally characteristic. More difficulty may be experienced separating *reeveanum* and *alternatum* because some specimens of the former species, especially Qld ones, are rather obliquely quadrate and approach the characteristic shape of *alternatum*. In these instances the equal-sided triangular ribs will usually allow differentiation of *reeveanum*, for in *alternatum* the triangular medial

ribs are asymmetrical. Another useful, though not universal character, is the strong coloration of the inner margins in *reeveanum* and the lack of colour on the inner margin in *alternatum*.

Distribution

Western, northern and eastern Australia; south to Geographe Bay in W.A. and Sydney, N.S.W. The species is a Quaternary fossil in S.A.

W.A. records

North end of E Montaliver I., 721-66; Yampi Sound, 702-69; 1140-67; Broome, 713-66; 3-5 fm, 3 km NE of Cape Bassut, 1037-66; 23 fm, sponge, 64 km W of Cape Jaubert, 712-66; Port Hedland, 1026-66; beach at S of Watering Valley, Depuch I., 343-67; Black Tank, Port Samson, 720-66; Sam's Creek, Port Samson, 716-66; sand flats Malus I., Dampier Arch., 706-66; Rosemary I., Dampier Arch., 717-66; sand flat, NE side Rosemary I., Dampier Arch., 708-66, 667-66; coral reef and sand, NE corner Delambre I., Dampier Arch., 897-66; Delambre I., Dampier Arch., 724-66; 10 fm, sand flats W side of Peak I., Onslow, 899-66; Sholl I., near Onslow, 887-66; sand flats with rocks and sponges, E of Cape Poivre, Barrow I., 284-67, 267-67, 272-67; rocky shore platform pools and brown algae covered stones, between Cape Dupuy and Cape Malouet, Barrow I., 274-67; 1 fm, rocky shore platform with sand caves, Surf Point, Barrow I., 265-67; 1-2 fm, sand and sponge, 1.6 km E of North Pasco I., 318-67; North Sandy I., 1904-67; Exmouth Gulf, near Charles Kinife Rd., 701-66; Bay of Rest, Exmouth Gulf, 1025-66, 1059-66; Exmouth Gulf, 16 km S of town, 693-66; Wapet Jetty, Exmouth Gulf, 342-67, 705-66; Learmonth, 341-67, 744-66; Maud Landing, Cardabia Station, 694-66; 10 fm, Maud Landing, Cardabia Station, 900-66; Freycinet Reach, Shark Bay, 697-66; Turtle Bay, E. Wallabi I., Abrolhos, 695-66; Port Gregory, N2618; Dunsborough, N2357.N2511, 542-39.

Fossil records

Wooramel Cliff, 3 m. N of Gladstone, Shark Bay, Pleistocene, 66-1281; Geraldton, reclaimed beach near groyne, dredged, Holocene, 66-1382; Geraldton Harbour, dredgings, Holocene, 66-1395; Geraldton, dredged ashore at W end of Harbour extension, Holocene, 66-1396; fresh rock fall, W end Minim Cove, Mosman Park, Pleistocene, 66-1387; North Fremantle, dredged from Swan River deepening, Holocene, 66-1384; North Fremantle, dredged foreshore between road and rail bridge, Holocene, 66-1383; East Fremantle, dredged foreshore near HMAS Leeuwin, Holocene, 66-1393; Fremantle, dredged during deepening of fishing anchorage, Holocene,

66-1388; Kwinana, B.H.P., Holocene, 66-1385; Lake Richmond via Rockingham, W side, lake edge, Quaternary, 66-1322; bed of Harvey River diversion drain, near 'Stonehouse', Pleistocene, 7724; Harvey Cut, Coast Rd, south of L. Preston, Pleistocene, 66-1389; near 'Stonehouse', Harvey River diversion drain, hole 50 yds N of drain, Pleistocene, 66-1390; Harvey R. diversion drain, near 'Stonehouse', between Coast Rd and Myalup Beach, Pleistocene, 66-1391.

Acrosterigma alternatum (Sowerby, 1841)

(Pl. 5, Figs 10-13)

Cardium alternatum Sowerby, 1841, *Proc. zool. Soc. Lond.* 1840: 108; figured Sowerby, 1841, *The Conchological Illustrations*, fig. 64.

Type locality: Ticao, Philippines. Types: Lectotype (here selected, see pl. 5, fig. 13) plus 2 paralectotypes, BM (N.H.) reg. no. 1971.24.

Diagnosis

Shell heavy, obliquely ovate; antero-ventral edge rounded, posterior margins flared out forming a 'wing'; umbones not central, weakly prosogyrate, displaced to anterior. Marginal serrations broad and more or less truncated.

Lunule narrow but well defined, smooth, wider in right valve than in left; smooth escutcheon present for only short distance behind ligament. Hinge moderately deep, strong; ligament strong. Left anterior and right posterior cardinal teeth strong, rather triangular; left posterior cardinal small and oblique; right anterior cardinal almost obsolete, located close to dorsal margin. Left anterior lateral elongate, flattened; left posterior lateral a small knob close to dorsal margin; laterals in both valves almost equidistant from cardinals.

Mean number of ribs 32, range 28 to 34. Ribs between midline and postero-dorsal wing broad, triangular, tending to curve away posteriorly, posterior slopes steeper and shorter than anterior slopes. Ribs of postero-dorsal wing low, triangular bearing fine, flattened scales. Ribs anterior to midline more rounded, bearing transverse rugae which are strongest on anterior slopes; in mid region rugae developed only on posterior slope, anterior slope almost smooth. Interstices between ribs broad, each may contain a fine rounded radial riblet.

Exterior cream with splashes of orange or yellow, often becoming darker towards margins. Hinge-line and interior of shell (including inner surface of marginal serrations) white.

Sample number 15; measurements of largest shell: length 7.58 cm, height 8.57 cm, width 4.76 cm; mean ratio length to height 0.88:1 (range 0.84:1 to 0.97:1), mean ratio length to width 1.54:1 (range 1.44:1 to 1.74:1).

Remarks

This species is characterised by its asymmetrical shape, the asymmetrical triangular ribs and the lack of colour on the margins. These characters suffice to distinguish the species from *reeveanum*, *elongatum* and *dupuchense*, the species which most resemble it in W.A.

Distribution

Widely distributed in the central Indo-Pacific from Ryukyu, Japan southward to Exmouth Gulf, W.A.

W.A. records

40 fm, sand and mud, 104 km NE of Adele I., 776-66; Yampi Sound, 93-59, 773-66; 25 fm, 96 km NW of Bedout I., 877-66; Bedout I., 1906-67, 894-66; Eaglehawk I., Dampier Arch., 891-66; Port Samson, 735-66; Sholl I., near Onslow, 890-66; beach, 40 km N of Wapet, Exmouth Gulf, 674-66.

Acrosterigma dupuchense (Reeve, 1845) (Pl. 5, Figs 14-17)

Cardium dupuchense Reeve, 1845, *Conchologica Iconica* 2, pl. 14, species 67. **Type locality:** Depuch Island, Western Australia [here amended from the original "Island of Dupuch, Torres Straits"]. **Types:** Holotype plus 2 paratypes. Cuming Collection, BM (N.H.) reg. no. 1971.25.

Diagnosis

Shell solid, obliquely ovate; umbones approximately central, almost orthogyrate, shell inequilateral. Antero-ventral margin rounded; posterior margin slightly flared out; postero-dorsal wing poorly developed. Marginal serrations strong, truncated on antero-ventral margin, more pointed on posterior margin. Lunules not raised.

Lunule and escutcheon not well defined, smooth; lunule elongate, narrow, escutcheon short. Hinge-line and ligament strong. Left cardinals unequal;

left anterior and right posterior cardinal teeth peg-like, pointed; left posterior and right anterior cardinals weak. Laterals approximately equidistant from cardinals in both valves.

Mean number of ribs 24, range 22 to 26. Ribs high, rounded, widely spaced; anterior ribs with transverse rugae on sides and tops, ribs behind mid-line smooth or with numerous fine rugae; posterior ribs bear a few small slightly spiny processes; rugae become fine concentric striae in wide, flat interstices.

Exterior white (covered with mud brown periostracum); interior purple ventrally, white beneath umbones; hinge-plate white.

Sample number 17; measurements of largest shell: length 4.74 cm, height 5.45 cm, width 3.93 cm; mean ratio length to width 1.25:1 (range 1.14:1 to 1.37:1); mean ratio length to height 0.89:1 (range 0.81:1 to 0.96:1).

Remarks

A. dupuchense has a distinctive shell and appears to be confined to the northern coasts of W.A. Reeve's type locality reference to the Torres Straits is considered by us to be an error for the only "Island of Dupuch" we know of is on the northern coast of W.A. Reeve gave "Dring, HMS Beagle" as the collector. Stokes (1846: 176) refers to a Mr Dring who collected a new "*Helix*" on Depuch Island, W.A., when the *Beagle* visited there in June-July, 1840. It is very probable that the types of Reeve's cardiid were collected there by Dring at the same time. Accordingly we have amended the type locality.

Several authors (e.g. Prashad, 1932: 268) have suggested that *Cardium dupuchense* Reeve is a synonym of *C. rugosum* Lamarck, 1819 (= *flavum* Linnaeus, 1758, of authors). We are satisfied that *dupuchense* is a distinct taxon. *A. rugosum* differs in having a greater number of ribs (average 30, range 27 to 32 in a WAM sample of 20 specimens), and usually a thinner and less oblique shell. The dark purple interior colouring, especially near the posterior margin, is an almost unequivocal character (except in juveniles) in *dupuchense*. The interior of *rugosum* is generally white, or stained with yellow, although some South-East Asian specimens have a purple patch below the umbones. Otherwise shells of these two taxa are much alike and a close relationship seems certain.

It is of interest to note that while typical *rugosum* are common on the Qld coast and among the islands of Indonesia to the north of W.A., they are

not present on the W.A. coast itself and appear to be replaced there by *dupuchense*. A case might be made for considering *dupuchense* to be an allopatric subspecies of *rugosum*.

Distribution

Northern W.A. from Broome south to Point Cloates. Fossil records at Shark Bay indicate that the range of *dupuchense* has contracted to the north by several hundred km since the Late Quaternary.

W.A. records

Broome, 18-68; Port Hedland, 2880-67; beach at mouth of Watering Valley, Depuch I., 749-66; Antonni Mia, Port Samson, 740-66; Port Samson, 752-66; Rosemary I., Dampier Arch., 748-66; sand flats, NE side of Rosemary I., Dampier Arch., 668-66; coral and sand, NE corner Delambre I., Dampier Arch., 889-66; low tide, Sholl I., near Onslow, 888-66; sand flats with rocks and sponges, E of Cape Poivre, Barrow I., 283-67; brown algae-covered reefs, mangroves on shore, Shark Point, Barrow I., 269-67; sheltered intertidal sand and mud flats, Bandicoot Bay, Barrow I., 264-67, 268-67, 270-67, 281-67, 279-67; sand flats with rocks and sponges, E of Cape Poivre, Barrow I., 276-67; Barrow I., 1-67; brown algae-covered intertidal reef, rocks high intertidal zone, airport beach, Barrow I., 2377-67, 40-67; Exmouth Gulf, 739-66, 675-66, 1058-66, 1061-66, 747-66, 745-66, 741-66, 751-66; 22 km N of Point Cloates. 4747-68.

Fossil records

66-1280, Wooramel Cliff, 5 km N of Gladstone, Quaternary; 66-1386, Tamala (Shark Bay); 3 km W of homestead, Quaternary; 66-1397, Useless Loop, Shark Bay, Quaternary.

Acrosterigma fultoni (Sowerby, G.B., 1916)

(Pl. 6, Figs 6-10; Text fig. 14)

Cardium fultoni Sowerby, G.B., 1916, *Proc. malac. Soc. Lond.* 12: 76, pl. 3, fig. 7. Type locality: "Philippines" [probably erroneous, see Remarks]. Holotype: BM (N.H.) reg. no. 1919.12.31.69.

Diagnosis

Shell rotund to obliquely ovate; umbones not central, prosogyrate. anterior edge rounded, posterior edge slightly flared, postero-dorsal wing weak.

Antero-ventral marginal serrations truncated, posterior marginal serrations pointed.

Lunule and escutcheon not well defined, smooth, wider in right valve than in left. Hinge-line and ligament fairly strong, ventral margin of hinge-line sinuous. Left cardinals almost equal; right anterior cardinal small, located just below lunule on dorsal margin; left anterior and right posterior cardinals peg-like. Anterior laterals slightly closer to cardinals than posterior laterals.

Mean number of ribs 29, range 25 to 33. Medial ribs high, triangular, with apex almost flat-topped and laterally expanded by strong transverse rugae, giving ribs a flat-topped mesa-like appearance in cross section; sides of ribs bear fine oblique lamellae; anterior and posterior ribs lower and more rounded; posterior ribs with prominent transverse rugae; anterior ribs with scale-like processes.

Exterior white or cream with spots of dark red on ribs; hinge-line, lunule, interior (including margins) white.

Sample number 22; measurements of largest shell: length 3.04 cm, height 3.42 cm, width 2.25 cm; mean ratio length to height 0.91:1 (range 0.86:1 to 0.99:1); mean ratio length to width 1.32:1 (range 1.18:1 to 1.46:1).



Text Fig. 14 *Acrosterigma fultoni* x 2½

Remarks

Although Sowerby gave the Philippines as the locality for his single specimen there now seems little doubt that the species is confined to the northern coast of W.A. (perhaps extending into the N.T.). Except for the holotype we can locate no specimens from localities beyond the shores of W.A. in the collections of the WAM, the AM, the NMV, the BM (N.H.), the Smithsonian Institution, the Harvard Museum of Comparative Zoology, or the Academy of Natural Sciences, Philadelphia. Therefore we conclude that Sowerby's locality was probably incorrect and that the holotype came

from W.A. The holotype agrees in every detail with our W.A. series. We can find no information on how Sowerby obtained his specimen.

Young specimens of *Acrosterigma rugosum* (Lamareck, 1819) which is very common in the central Indo-West Pacific region, including the Philippines and in Qld (but not recorded from W.A.) may be confused with *A. fultoni*. They may be distinguished from *A. fultoni* by several characteristics. *A. rugosum* has a less oblique, posteriorly flared outline; the ribs are rounded or triangular in cross section and not flat-topped; the exterior is cream with grey-brown blotches and lacks the red spots characteristic of *A. fultoni*. In *A. rugosum* there are rather short spines, not rugae, on the posterior ribs; the medial ribs bear thick but low lamellae on their sides.

Shape, colour, rib sculpture and the higher rib count easily distinguish *A. fultoni* from *A. dupuchense*, *A. reeveanum* and *A. alternatum*, the only similar species of the genus with which it is sympatric in W.A.

Distribution

Northern W.A. from the Buccaneer Archipelago to Point Cloates.

W.A. records

Augustus I., Buccaneer Arch., MC Z 145967; Yampi Sound, 65-59, 670-66, 770-66; Fraser Inlet, Adele I., 768-66; Roebuck Bay, Broome, AM C57179; Port Hedland, 1243-67; Town Reef, Port Hedland, 2877-67; Port Samson, 769-66; Landing, Barrow I., 275-67; sand flats with rocks and sponges, E of Cape Poivre, Barrow I., 271-67; rocky shore platform (limestone) with sand cays, Surf Point, Barrow I., 266-67; sheltered intertidal sand and mud flats, Bandicoot Bay, Barrow I., 282-67, 277-67, 278-67, 2656-67; intertidal coral reef, S end of Flaycourt Bay, Barrow I., 280-67; 22 km N of Point Cloates, 4748-68.

Acrosterigma cygnorum (Deshayes, 1855)

(Pl. 6, Figs 25-27; Text fig. 15)

Cardium cygnorum Deshayes, 1855, *Proc. zool. Soc. Lond.*, 1854: 331.

Type locality: Swan River [Swan River Colony = Western Australia].

Type series: 3 paired specimens, a holotype and two paratypes, BM (N.H.) reg. no. 1971.23.

Diagnosis

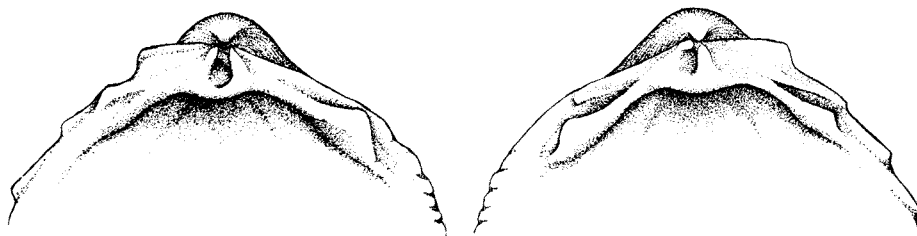
Shell relatively thin, variable in shape, ovate to obliquely ovate; umbones weakly prosogyrate, may be approximately central but usually displaced anteriorly; shell usually inequilateral. Margins rounded; posterior margin sometimes flared. Antero-ventral marginal serrations truncated, posterior marginal serrations fairly weak and pointed.

Lunule well defined, elongate, smooth; escutcheon not well defined, elongate, bears radial row of rugae in left valve, smooth in right valve. Hinge-line and ligament relatively weak, hinge-line sinuous, widest in cardinal area. In left valve cardinals unequal; posterior one small and located just below dorsal margin; anterior one wedge-shaped but high and pointed. posterior left lateral reduced; anterior lateral high, wide and flattened. In right valve posterior cardinal wedge-shaped; anterior cardinal smaller, located just below dorsal margin. Right laterals well developed, approximately equidistant from cardinals.

Mean number of ribs 40, range 35 to 44. Ribs broad, low, rounded; interstices narrow; anterior ribs bear numerous transverse rugae; medially rugae become obsolete on tops of ribs but persist on sides; behind midline rugae restricted to posterior slopes of ribs; posterior ribs finer than remainder, divided down their centres, anterior parts being smooth and cord-like, posterior parts bearing numerous scale-like nodules.

Exterior white with pale brown blotches and a wide band of yellow around margin; interior, including margins and hinge-line, white.

Sample number 27; measurements of largest shell: length 3.74 cm, height 4.19 cm, width 2.58 cm; mean ratio length to height 0.91:1 (range 0.87:1 to 0.95:1); mean ratio length to width 1.52:1 (range 1.41:1 to 1.80:1).



Text Fig. 15 *Acrosterigma cygnorum* Deshayes x 4

Remarks

Deshayes (1855) described this species from material in Hugh Cuming's collection. The type series in the BM (N.H.), which we have examined, consists of 3 paired specimens with the following dimensions:

	Height	Width (x2)	Length	Ribs
1.	5.26 cm	3.00 cm	4.68 cm	44
2.	4.44	2.55	4.15	42
3.	3.28	2.13	3.01	42

The largest of these specimens (1 above) has a black spot on the inner side of the right valve and a label bearing the printed word "Type". Ludbrook (1955: 62) cited this specimen as the holotype.

Prior to this publication by Deshayes, Sowerby (1841, *Proc. zool. Soc. Lond.* 1840: 111) had introduced the name *foveolatum* for a small cardiid from the Swan River Colony, also in the Cuming collection. On the south west coast of W.A. there is no other small cardiid of this kind and, assuming the type localities of the two names to be accurate, *Cardium foveolatum* Sowerby and *Cardium cygnorum* Deshayes are certain to be synonyms. This matter could be resolved by comparison of the types but we have been unable to locate specimens which we can confidently determine as Sowerby's types of *foveolatum*. There is a suspicion that both names were based on the same material or that types of *cygnorum* and *foveolatum* have been mixed together in the BM (N.H.) collection. The dimensions and rib count given by Sowerby approximate roughly to those of one (no. 2 above) of the paratypes of *cygnorum*.

The BM (N.H.) specimen figured by Reeve (1845, *Conch. Icon.* pl. 18, fig. 87) as *foveolatum* Sowerby is a different species altogether and there is no species like it in W.A. Its dimensions (length 26.7 mm, height 32.0 mm, width 19.6 mm) do not agree with the figures given by Sowerby in the original description and it has the prominent purple-brown flecking characteristic of *arenicolum* Reeve, 1845 which must surely have been mentioned by Sowerby if this was the type of his species. We have also examined Reeve's type of *arenicolum* and we are satisfied that it is the same species as the shell he figured as *foveolatum*.

While *cygnorum* is in general use for this common southern Australian cardiid, *foveolatum* has been used only occasionally and apparently incorrectly for other species on the north coast and in Queensland (Mjöberg, 1917; Hedley, 1910). In view of this and the uncertainty about the identity of *foveolatum*, we believe that it would be unwise to use this older name to replace *cygnorum*. An application should be made to the

I.C.Z.N. for exercise of its Plenary Powers to suppress *foveolatum* Sowerby, 1841 in favour of *cygnorum* Deshayes, 1855.

Distribution

Southern Australia, the most northern records being Fremantle on the West Coast and Montagu I., N.S.W. on the East Coast.

W.A. records

Off Rottnest I., 892-66; 19 fm, sponge and weed, 8 km N of E end of Rottnest I., 898-66; off Cottesloe, 908-66; Leighton, N205, N206, N4105, 727-66; N. Fremantle, N310; Fremantle, 728-66; 16 fm, sponge, 5 km W of Carnac I., N3969; 20 ft, N side Jervoise Groyne, Cockburn Sound, N2362; Jervoise Groyne, Cockburn Sound, 725-66; 9 fm, off Dunsborough, N1706; 5 fm, Esperance, N1488; NE corner of Mondrain I., Recherche Arch., 886-66.

Fossil records

Fremantle, dredged during deepening of fishing anchorage, Holocene, 60-1401; between Robbs Jetty and South Beach, South Fremantle, pumped ashore from P.W.D. dredge 200 m off shore, Holocene, 66-1394; Kwinana dredged from Cockburn Sound into blast furnace, Holocene, 66-1400; Harvey R. diversion drain, near 'Stonehouse', 2.4 km E of Myalup, Pleistocene, 66-1399.

Acrosterigma vlamingi sp. nov.

(Pl. 6, Figs 21-22; Text fig. 16)

Holotype: WAM 1029-66, a single left valve. **Type locality:** mainland side of South Passage, Shark Bay, Western Australia (26°11'S, 113°13'E); dredged on sand and weed, 2-4 fm, B.R. Wilson & G.W. Kendrick, 6.III.1966.

Description of the Holotype

Shell rather solid, compressed and ovate, attenuate toward umbo; umbo nearly orthogyrate, shell approximately equilateral. Margins rounded, crenate antero-ventrally, serrate posteriorly. Hinge weakly arched with its ventral margin weakly sinuous. Cardinal teeth unequal, posterior cardinal a low oblique ridge, anterior cardinal high and pointed, concavely dished on its vertical side facing cardinal pit. Posterior lateral tooth a thick, truncated

rectangular ridge at posterior end of hinge; anterior lateral high, thin, compressed and wedge-shaped; posterior lateral slightly closer to cardinals than anterior lateral.



Text Fig. 16 *Acrosterigma vlamingi* x 5½

Sculptured externally with 41 low, rounded ribs; 8 most anterior ribs consist of radial rows of oblique nodules which become irregular rugae on ribs closer to mid-line; medial ribs smooth, medial interstices with concentric growth lamellae which ascend onto sides of ribs; 8 most posterior ribs longitudinally furrowed and consist of an angular radial cord with a parallel row of rounded or pointed nodules or spinelets on posterior part.

Exterior cream with pale yellow maculations; interior white, flecked with purple spots and two pale orange rays emerging from beneath umbones; hinge white, lunule faintly purple.

Measurements and rib count:

	WAM no.	height	length	width	Ribs
Holotype	1029-66	2.74 cm	2.42 cm	0.83 cm	41
Paratype 1	492-74	1.87	1.74	0.51	43
" 2	19-67	2.28	2.04	0.69	38
" 3	1035-66	1.82	1.59	0.54	40
" 4	1032-66	2.28	2.04	0.68	40
" 5	20-67	1.91	1.79	0.56	47
" 6	493-74	1.65	1.57	0.51	41
" 7	210-67	2.74	2.47	0.84	45
" 8	683-66	1.08	1.02	0.31	46

Variations

The paratypic series comprises 4 left valves, 3 right valves, and one whole juvenile specimen with body intact and preserved in spirit. Majority of

specimens are approximately equilateral but paratypes 1 and 3 slightly inequilateral with posterior slope almost straight and umbo slightly anterior of mid-line. Right valves have dorsal margin elevated immediately in front of umbo; lunule well defined, elongate, smooth; a narrow escutcheon present which must overlap narrower escutcheon of left valve. Cardinal teeth very unequal, touching dorsally; anterior cardinal an almost obsolete ridge located on lunule's marginal elevation; posterior cardinal high and pointed.

Sculpture in paratypic series varies slightly. Ribs number 38 to 45 (mean 42), with 8 to 10 furrowed posterior ones and 8 to 9 nodulose anterior ones. Interstices between medial ribs may be smooth or with weak growth lamellae ascending the sides of ribs.

Colour is fairly consistent although degree of purple spotting on inner surface varies.

Remarks

A. vlamingi most closely resembles *A. cygnorum* (Deshayes) but is distinguished by its equilateral shell, orthogyrate umbos, the lack of strong oblique rugae on the sides of the medial ribs, and the characteristic purple spotting on the inner surface. *A. arenicola* (Reeve) is probably another close relative but *A. vlamingi* differs from it in the much flatter, broader shell and the lack of external red-brown spots and bars so characteristic of that South-East Asian species.

A. vlamingi is also like *A. rosemariensis* described here from the N.W. coast of W.A., but it has a larger, broader shell than that species, with larger, less pointed umbones, less steeply sloping dorsal margins and the transverse sculpture in the interstices and on the sides of the medial ribs, when present, is much weaker. Ribs in *A. vlamingi* tend to be less numerous.

A. vlamingi is so far known only from a few single valves from Shark Bay and one whole juvenile specimen (preserved in alcohol) from the Abrolhos. We name it after the early Dutch explorer William Vlaming who visited Shark Bay in 1697 and left an inscribed metal plate as testimony of his visit at Cape Inscription on Dirk Hartogs I.

Distribution

The central west coast of W.A. from Abrolhos to Shark Bay.

Paratypes

1-3: 492-74 (left valve); 1035-66 (right valve); 20-67 (left valve): mainland side of South Passage, Shark Bay, dredged on sand and weed, 2-4 fm, B.R. Wilson and G.W. Kendrick, 6.III.1966.

4-7: 1032-66 (left valve); 19-67 (right valve); 493-74 (right valve); 210-67 (left valve: S.E. end Dirk Hartogs I., South Passage, Shark Bay, dredged on sand and weed, 2-3 fm, B.R. Wilson and G.W. Kendrick, 5.III.1966.

8: 683-66 (whole juv. preserved in alcohol): Zeewyk Channel, Abrolhos, dredged on coral and sand, 2 fm, J. Seabrook on *Lancelin*, 16.III.1963. 1963.

Acrosterigma rosemariensis sp. nov.

(Pl. 6, Figs 23-24)

Holotype: WAM 650-66, paired valves. Type locality: Rosemary I., Dampier Archipelago, W.A. (20°28'S, 116°37'E) 27.VIII.1961.

Description of the Holotype

Shell small, rather tumid, ovate, attenuate toward umbones, approximately equilateral with small almost orthogyrate umbones. Margins rounded, crenate antero-ventrally, serrate posteriorly.

Hinge strongly arched, weakly sinuous, especially in right valve; lunule long and narrow, slightly wider and longer in left than in right valve; lunular margin raised in front of umbo in right valve; escutcheon not distinguishable. Left cardinal teeth unequal, do not meet dorsally, posterior one a small short ridge, anterior one high, upwardly curved, pointed peg. Left posterior lateral merely a short posteriorly truncated ridge on hinge-plate; left anterior lateral, high, compressed, wedge-shaped. Right cardinal teeth unequal, touch dorsally at their bases directly below umbo, anterior one a small but distinct, nearly horizontal, slightly curved ridge near margin of lunular elevation, posterior one a high, upwardly curved, pointed peg (broken). Two right anterior laterals, dorsal one a rounded, truncated, ridge below dorsal margin bordering a deep socket; ventral one a slightly raised and thickened end of ventral hinge-plate rim. Right posterior lateral short, moderately high, compressed and comprises raised end of ventral hinge-plate rim; separated from dorsal margin by deep but short socket which reaches below end of ligamental plate. In both valves posterior laterals slightly closer to cardinals than anterior laterals.

Sculptured externally by 44 strong, radial ribs. Medial ribs smooth-topped, rounded, widely spaced with prominent transverse bars in interstices which ascend onto sides of ribs; ribs near ventral margin bearing crescent-shaped rugae and 4 conspicuous concentric growth breaks. Six most anterior ribs comprise rows of low, thick, crescent-shaped rugae. Nine most

posterior ribs each bears a row of prominent nodules; 1st and 2nd ribs (i.e. closest to hinge margin) really just rows of round-ended nodules, with ribs themselves vestigial; 3rd to 9th ribs consist of thin cords with rows of smaller nodules along their posterior sides.

Exterior pale yellow, slightly darker toward ventral margin, umbones white; interior white with a few diffuse rose spots and two faint broad rays of pale yellow emerging from beneath umbones. Hinge white.

Measurements and rib count

	WAM no.	height	length	width	ribs
Holotype	650-66	2.02 cm	1.70 cm	1.18	44
Paratype 1	651-66	1.85	1.56	1.16	44
2	649-66	1.42	1.27	0.88	43
3	893-66	1.66	1.39	0.96	45
4	494-74	1.38	1.21	0.78	48
5	880-66	1.59	1.36	2x(0.51)	49
6	906-66	1.27	1.16	2x(0.41)	44
7	660-66	0.97	0.85	2x(0.25)	47
8	273-67	1.38	1.18	2x(0.43)	40
9	1245-67	1.55	1.31	0.86	47
10	648-66	1.70	1.47	0.96	42

Variations

Paratypic series comprises 6 specimens with paired valves, 3 left valves and 1 right valve. Mean ratio length to height 0.86:1 (range 0.84:1 to 0.89:1); mean ratio length to width 1.42:1 (range 1.34:1 to 1.56:1); mean number of ribs 45 (range 40 to 49).

Strong cross-bars in medial interstices quite consistent but condition of medial rib tops varies; some specimens with smooth-topped medial ribs, others with crescent-shaped rugae on ribs close to ventral margin, especially on ribs anterior to mid-line. Eight to 10 furrowed or nodulose posterior ribs and 6 to 9 nodulose anterior ribs.

Holotype and some paratypes uniformly pale yellow externally with little or no internal colour, others have pale rose maculations on outer surface, rose or purple maculations or spots on a white internal surface, and two broad radial rose rays emerging from beneath umbones. Hinge usually white, sometimes pale rose; ligamental plate usually pale or dark rose.

Remarks

This small species is quite distinctive and unlikely to be confused with any other on the North West Coast. It is equilateral like *A. transcendens* and *A. dampierense* with which it is sympatric but has fewer, finer ribs than the former and more, stronger ribs than the latter. It also resembles *A. ulamingi* from the central west coast but has a smaller, less ovate shell with smaller umbones, more steeply sloping dorsal margins and stronger transverse bars in the interstices between the ribs. Though there may be rose maculations and a few purple spots on the inner surface in *A. rosemariensis* the conspicuous purple spotting characteristic of *A. ulamingi* is absent. The nearest ally beyond W.A. is probably *A. arenicola* (Reeve) but that is a much larger species with a tumid shell characterised by red-brown spots and bars on the outer surface.

Distribution

Northern coast of W.A. from Point Cloates to Troughton Island.

Paratypes

1: 651-66 (paired valves). 16 km S of Exmouth town, Exmouth Gulf, G.W. Kendrick, 16.V.1965.

2: 649-66 (paired valves). Antoni Mia, Nickol Bay, on sand flats at low tide, B.R. Wilson & G.W. Kendrick, 28.VIII.1961.

3-4: 494-74 (paired valves) 893-66. 3 km W of Legendre I., Dampier Arch., dredged with sponge and rubble, 23 fm, Hawaiian-W.A. Exp., 9.VI.1960.

5: 880-66 (left valve). Approx. 346 km ENE of Troughton I., dredged on mud, 32 fm, R.W. George on *Dorothea*, 23.X.1962.

6: 906-66 (left valve). 32 miles N of Delambre I., Dampier Archipelago, dredged on sand, 23 fm, Hawaiian-W.A. Exp., 7.VI.1960.

7: 660-66 (left valve with broken right valve). N side of Rosemary I., Dampier Archipelago, dredged on sand, 15 fm, B.R. Wilson & G.W. Kendrick, 28.VIII.1961.

8: 273-67 (right valve). E side Pasco I., southern end Barrow I., 20°58'S: 115°20'E, dredged sand with coral-heads, 1-2 fm, WAM-Smithsonian Barrow I. Exp., 5.IX.1966.

9: 1245-67 (paired valves). Maud Landing, Point Cloates, dredged, 10 fm, Hawaiian-W.A. Exp., 20.V.1960.

10: 648-66 (paired valves). SE of Rosemary I., Dampier Archipelago, dredged 5 fm, B.R. Wilson & G.W. Kendrick, 26.VIII.1961.

Acrosterigma dampierense sp. nov.

(Pl. 6, Figs 1-5, Text fig. 17)

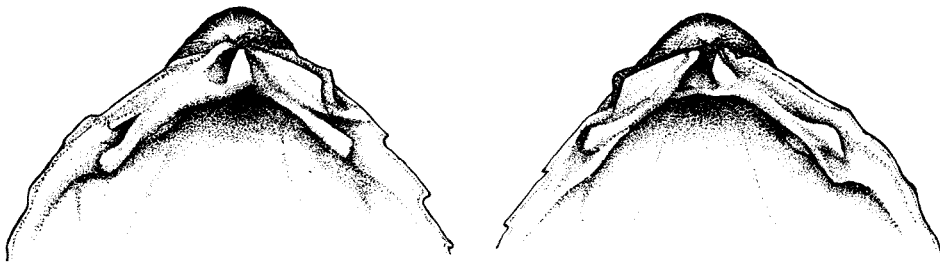
Holotype: WAM 3334-68, a dry shell specimen with paired valves.

Type locality: Port Hedland, W.A. (20°15'S, 118°35'E). Collected by Mr A. Kalnins, September 1966.

Description of the Holotype

Shell solid, ovate, attenuate toward umbones, laterally compressed, almost equilateral; umbones nearly orthogyrate. Anterior and ventral margins rounded, postero-dorsal margin almost straight; margins crenate except at extreme postero-dorsal edge where last 3 ribs terminate in small pointed serrations; external ribs mirrored internally by shallow radial grooves.

Hinge strongly arched; lunule well defined and elongate in both valves, its margins are not elevated; escutcheon elongate, indistinct especially in right valve. Left cardinals unequal, do not meet dorsally; posterior one a mere ridge (broken) below dorsal margin; anterior one a thick, triangular, upwardly curved, pointed peg. Left posterior lateral represented by a thick, more-or-less truncated hinge-plate ridge; left anterior lateral strong, high, compressed and wedge-shaped, separated from dorsal margin by a rounded groove which extends upwards to region below umbo and above anterior cardinal. Right cardinals unequal, touch dorsally at their bases directly below umbo; anterior one a small near-horizontal ridge (broken) below dorsal margin; posterior one a thick, triangular, upwardly curved, pointed peg. Two right anterior laterals; ventral one being the slightly thickened truncated end of ventral hinge-plate rim; dorsal one a smaller ridge on dorsal wall of anterior lateral socket. Right posterior lateral represented by truncated and elevated end of ventral hinge-plate rim. In both valves posterior laterals closer to cardinals than anterior laterals.



Text Fig. 17 *Acrosterigma dampierense* x 2¼

Sculptured externally with 29 radial ribs. Medial ribs strong but low and rounded, slightly curved, shiny and smooth except for indistinct transverse folds which become stronger in interstices; folds stronger and more oblique on anterior ribs giving them appearance of coarsely twisted ropes. Seven most posterior ribs each bears a row of prominent nodules; 1st and 2nd (i.e. closest to hinge margin) really rows of nodules with rib itself vestigial; 3rd and 4th narrow angular ribs divided down centre with rows of squamose nodules along posterior parts; 5th, 6th and 7th rounded ribs, also divided, with nodules along posterior parts.

Exterior white, suffused with purple in interstices, ribs crossed by diffuse pale tan-orange marks. Lunule dark purple; hinge white except for dark purple lunular margin and pale purple patch on hinge plate between posterior cardinals and posterior laterals. Interior shiny white suffused with pale purple with darker purple patches between marginal crenulations.

Measurements of the holotype: height 39.3 mm, length 32.4 mm, width (double valves) 19.5 mm; length: height ratio 0.82, width: height ratio 0.50.

Variations

Of 15 specimens in type series 3, including holotype, are fresh paired valves collected in shallow water or on beach. Remainder smaller single valves most of which taken by dredging in deeper water; worn. Smaller specimens more tumid with slightly higher rib count than others (probably eco-phenotypic variations for no consistent differences in micro-sculpture or colour apparent).

In some specimens (e.g. paratype no. 1 from Broome) margin of lunule slightly raised, especially in right valve. In this specimen also, and in majority of series, transverse folds more prominent in interstices of medial area than they are in holotype. In paratype no. 2 (from Hervey Bay, Qld) folds quite strong in the interstices and on sides of medial ribs.

Most specimens faded but where colour present it is essentially same as in holotype. Purple patch on hinge-plate between cardinals and posterior laterals consistent, purple patch below lunule not always present.

Type series (15 specimens): length to height ratio: mean 0.81:1 (range 0.79:1 to 0.84:1); length to width ratio: mean 0.56:1, (range 0.50:1 to 0.60:1) with mean rib count 36, range 29 to 40.

Remarks

This new species is known to us by only a few specimens from widely scattered localities in northern Australia and south eastern Indonesia. Its

habitat is not known but it occupies a bathymetric range from 0 to at least 100 metres. It belongs to that series of species, here provisionally included in *Acrosterigma*, in which the posterior ribs are divided down the centre into a thin cord-like anterior part and a posterior part which bears scales or small nodules. This group includes the Australian species *cygnorum*, *transcendens*, *vlamingi* and *rosemariensis* plus the South-East Asian species *arenicolum* (Reeve) and the Japanese species *burchardi* (Dunker). In none of these species is the shell so high, nor has any such a low rib count as *dampierense* (Table 3). Were it not for the low rib count and the high shell, small faded specimens of *dampierense* might be confused with *vlamingi* and *rosemariensis*; the purple colour of fresh specimens distinguishes *dampierense* from all other species.

Cardium (*Trachycardium*) *beauforti* Prashad, 1932 from Indonesia is narrow and high like *A. dampierense* but is more pyriform and has a high rib count like *arenicola* according to Dr H.E. Coomans who kindly compared some of our specimens with Prashad's type in the Zoologisch Museum, Amsterdam. *Cardium oxygonum* Sowerby, 1841 (type locality "ad mare Sinense") is the only comparable species described from the region with a low rib count. It was described as having 35 distinctly angulated ribs but the other characters given, and the illustrations, could easily be those of almost any small member of the genus. In *A. dampierense* the ribs could not be described as angulated and we are confident that it is a different species. Dr John Taylor (pers. comm.) has informed us that types of *Cardium oxygonum* Sowerby cannot be found in the collections of the British Museum (Natural History).

Distribution

Northern Australia from Exmouth Gulf in W.A. to Hervey Bay in central Qld, with a single record from Aru Islands in south-eastern Indonesia.

Paratypes

1: Broome, W.A., E.M. Cherico, CII 67, 2441-67, fresh paired valves.

2: sandbank, Urangan, Hervey Bay, Qld, Kerslake Coll., 4787-68, fresh paired valves.

3: mud and shell, 14-16 fm, S.W. of Tg. Ngabordamlu, S. Trangan, Aru, Moluccas, Indonesia, 6°58'S, 134°5'E, Mariel King Memorial Exp. Stn. AN1/2, 20.VI.70, 325-73, single valve.

4-6: mud, 15-22 fm, Clarence Straits, N.W. of Charles Pt., N.T. 12°6'S, 130°17'E, Mariel King Memorial Exp., Stn. B11/1-4, 30.VI.70, 24-73, 3 single valves.

7: 42 fm, 40 km N.N.E. of Adele I., W.A., R.W. George on *Dorothea*, 20.X.62, 657-66, single valve.

8-11: mud, 32 fm, approx. 346 km N.N.E. of Troughton I., W.A., R.W. George on *Dorothea*, 23.X.62, 654-66, 4 single valves.

12: mud and sand, 40 fm, 104 km N.E. Adele I., R.W. George on *Dorothea*, 20.X.62, 658-66, single valve.

13: sand and shell, 35 fm, approx. 322 km E.N.E. of Troughton I., W.A., R.W. George on *Dorothea*, 23.X.62, 652-66, single valve.

14: 50 fm, 80 km N.E. of Adele I., W.A., R.W. George on *Dorothea*, 20.X.62, 653-66, single valve.

15: Learmouth, Exmouth Gulf, W.A., R.J. Slack-Smith, May 1965, 746-66, single valve.

Acrosterigma transcendens (Melvill and Standen, 1899)

(Pl. 6, Figs 16-20; Text fig. 18)

Cardium (*Trachycardium*) *transcendens* Melvill and Standen, 1899, *J. Linn. Soc.*, 27: 191, pl. 2, fig. 21. Type locality: Torres Straits.

Holotype: single left valve, BM (N.H.) reg. no. 1899.2.23.6.

Diagnosis

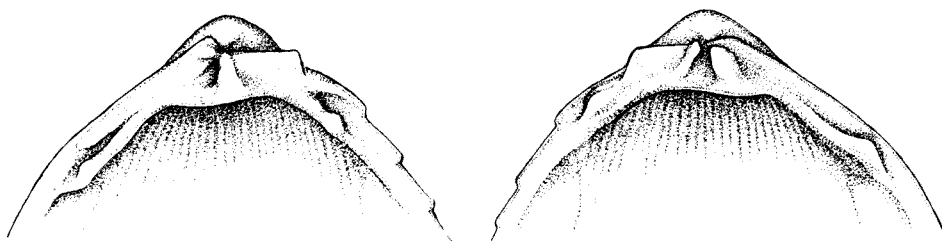
Shell small, thin, tumid, ovate, almost equilateral, attenuate toward umbones; umbones prosogyrate, approximately central. Dorsal margin sloping, margins otherwise rounded; marginal serrations fine, truncate.

Lunule and escutcheon poorly defined, elongate, smooth. Hinge-line strongly arched; lunule elevated, in right valve elevation bearing anterior cardinal tooth, dorsal rim of valve in this area bearing numerous fine serrations. Left cardinals unequal, left ventral anterior lateral tooth broad, flat much higher than posterior lateral. Right cardinal teeth joined at their bases below umbones. Posterior lateral in both valves closer to cardinals than anterior lateral.

Sculpture of numerous rounded radial ribs. Mean number of ribs 57, range 50 to 64; anterior ribs represented by radial rows of low rounded nodules; near midline ribs more elevated, transverse rugae or nodules obsolete and represented only by rugae on sides of ribs; 8 to 9 most posterior ribs broad, low, weakly divided down centres, anterior part smooth posterior part bearing small nodules or low rounded scales.

Exterior white, becoming yellow towards margins, heavily mottled with pink or orange, usually larger splashes of darker orange on anterior and posterior sides (sometimes whole shell yellowish); hinge-line below ligament purplish-pink, elsewhere white; margins white internally, interior otherwise purple-pink or yellow with two broad darker radiating bands from umbo (sometimes faintly visible externally); umbones shining, usually darker colour than other parts of shell.

Sample number 20; measurements of largest shell: length 2.12 cm, height 2.37 cm, width 1.48 cm; mean ratio length to height 0.88:1 (range 0.82:1 to 0.94:1); mean ratio length to width 1.41:1 (range 1.20:1 to 1.54:1).



Text Fig. 18 *Acrosterigma transcendens* x 5

Remarks

A delicate shell characterised by its tumid, almost equilateral shape, numerous fine ribs, strongly arched hinge and bright colour. Its numerous ribs, the divided nature of the posterior ribs and semi-equilateral shape show that this species is probably related to *A. arenicolum* (Reeve, 1843).

Distribution

Indo-West Pacific. The most southern W.A. record is Long I. (near Onslow).

W.A. records

32 fm, mud, approx. 346 km ENE of Troughton I., 880-67; 25 fm, sponge and sand, 37 km SW of Troughton I., 18-67; 50 fm, 80 km NE of Adele I., 881-66; 28 fm, fine sand and rubble, 11 km N of Long I., Onslow, 905-66, 1069-66.

Acrosterigma marielae sp. nov.

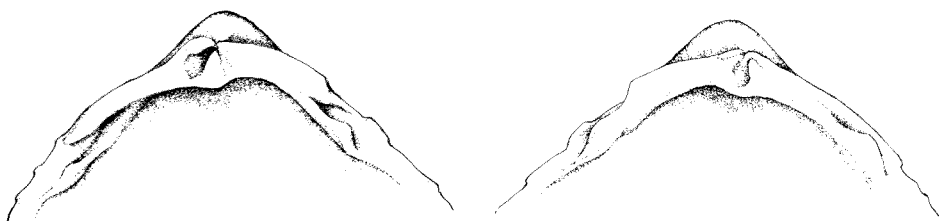
(Pl. 6, Figs 11-15; Text fig. 19)

Holotype: WAM 215-67, a dry shell specimen with paired valves. **Type locality:** 50 fm, W of Cape Leschenault, mid-west coast of W.A. (31°18'S, 115°03'E). Collected CSIRO Stn 216, DM 6/63, 11.x.63.

Description of Holotype

Length 2.00 cm, height 2.16 cm, width 1.28 cm. Shell thin, obliquely ovate, rather compressed, inequilateral; umbones small, smooth, shining, prosogyrate, displaced a little to anterior; antero-ventral margin broadly rounded; postero-dorsal margin rather straight; marginal serrations fine, slightly pointed.

Lunule well defined, elongate, narrow (wider in right valve than in left); escutcheon less clearly defined. Hinge-line narrow, sinuous; lunule elevated in front of umbones, especially in right valve. Left cardinals unequal; anterior one large, wedge-shaped; posterior one a low ridge below dorsal margin. Right cardinals touch dorsally; anterior one an angular almost horizontal ridge on lunular elevation; posterior one wedge-shaped, situated directly beneath umbo. In both valves posterior laterals only slightly closer to cardinals than anterior laterals.



Text Fig. 19 *Acrosterigma marielae* x 5

Sculpture of 63 radial ribs. Anterior ribs bearing prominent, crowded, rounded, transverse rugae becoming lateral nodules on ribs closer to midline. Medial and more posterior ribs bearing lateral nodules on posterior slopes only. Fourth to sixth posterior ribs flattened, separated by incised interstices; weakly divided down their centres, anterior parts smooth, posterior parts bearing rounded spinelets three most posterior ribs consisting of radial rows of rounded spinelets.

Exterior cream with splashes of orange; interior white with two rays of pink from beneath umbones; rays faintly visible externally; lunule and hinge

below it orange-pink, more noticeable in right valve; remainder of hinge white.

Variation

28 paratypes measured. Mean ratio length to height 0.91:1 (range 0.84:1 to 0.96:1); mean ratio length to width 1.60:1 (range 1.42:1 to 1.74:1). Mean number of ribs 57, range 51 to 63. Holotype largest specimen in whole type series.

Shell cream with discreet splashes of orange (e.g. type) or having cream-orange mottled appearance.

Remarks

This species apparently belongs to that group of small species here tentatively assigned to *Acrosterigma*, in which the posterior ribs are divided, with nodules or scales confined to their posterior sides, although this characteristic is not very marked in the new species. It resembles *transcendens* in size, sculpturing and colour but may be distinguished from the latter species by the inequilateral outline, more equidistant laterals, more prominent sculpture in the interstices between ribs and by coloration of the hinge (coloured beneath the lunule rather than beneath the ligament).

A. marielae seems also to be related to its partially sympatric congener *A. cygnorum* which it resembles in shape and sculpturing, but the latter species differs in colour, has stronger less numerous ribs with weaker sculpturing in the interstices. The much lower rib count and equilateral shell of *A. vlamingi* and *A. rosemariensis* easily distinguishes them from *A. marielae*.

We have named this species after the late Mrs Mariel King of Honolulu, who dredged the first specimens off W.A. and who first introduced the senior author to the thrills of deep-water dredging.

Distribution

Between 33 and 152 fathoms off the mid-west coast of W.A. from Cape Naturaliste to Point Cloates.

Paratypes

152 fm, SW of Point Cloates, CSIRO, Stn 186, DM 6/63, 7.x.63, 328-67 (3 valves); 33 fm, SW of Point Cloates, CSIRO, Stn 183, DM 6/63, 7.x.63, 320-67 (3 valves); 75.5 fm, W of Carnarvon, CSIRO, Stn 192, DM 6/63, 8.x.63, 221-67 (2 valves); 40 fm, sand, 16 km W of Bernier I., Hawaiian-W.A. Exp., 15.v.60, 904-66 (2 specimens); 40 fm, sand and shell, N of Dirk

Table 3: Dimensions and other characters of small Western Australian Acrosterigma.

Name	Measurements of largest shell (cm)			Length : height		Length : width		Ribs		Other distinguishing characters
	L.	H.	W.	mean	range	mean	range	mean	range	
<i>A. ulamingi</i>	2.45	2.74	1.64	0.90:1	0.87:1 to 0.94:1	1.49:1	1.44:1 to 1.55:1	42	40-49	Equilateral.
<i>A. rosemariensis</i>	1.70	2.02	1.18	0.86:1	0.84:1 to 0.89:1	1.42:1	1.34:1 to 1.56:1	45	43-49	Equilateral.
<i>A. cygnorum</i>	3.74	4.19	2.58	0.91:1	0.87:1 to 0.95:1	1.52:1	1.41:1 to 1.80:1	40	35-45	Inequilateral.
<i>A. dampierense</i>	2.24	2.72	1.60	0.81:1	0.79:1 to 0.84:1	1.43:1	1.21:1 to 1.66:1	36	30-40	Equilateral.
<i>A. transcendens</i>	2.12	2.04	1.24	0.88:1	0.82:1 to 0.94:1	1.41:1	1.20:1 to 1.54:1	57	50-64	Equilateral. Hinge coloured beneath ligament.
<i>A. marielae</i>	2.00	2.16	1.28	0.91:1	0.84:1 to 0.96:1	1.60:1	1.42:1 to 1.74:1	57	51-63	Inequilateral. Hinge coloured beneath lunule

Hartog I., Hawaiian-W.A. Exp., 15.v.60, 895-66 (2 valves), 902-66 (2 specimens plus 1 valve); 60 fm, W of Shoal Pt, CSIRO Stn 78, DM 1/70, 6.xii.70, 326-73 (1 specimen plus 2 valves); 70 fm, NW of Bluff Point, CSIRO, Stn 131, DM 6/63, 21.viii.63, 222-67 (43 valves); 54 fm, NW of Bluff Point, CSIRO, Stn 204, DM 6/63, 9.x.63, 882-66 (5 valves), 1033-66 (32 valves), 1031-66 (16 valves), 17-67 (21 valves), 26-67 (30 valves); 71-81 fm, SW of Geraldton, CSIRO, Stn 54, 16.ii.64, 1040-66 (1 valve), 1039-66 (1 valve); 60-80 fm, E of Zeewyk Channel, Houtman Abrolhos, Hawaiian-W.A. Exp., May 1960, 901-66 (5 valves); 21 fm, coral and sand, Zeewyk Channel, Houtman Abrolhos, J. Seabrook on *Lancelin*, 16.iii.63, N 2755 (1 specimen); 70-72 fm, SW of Dongara, CSIRO, Stn 214, DM 6/63, 11.x.63, 217-67 (2 valves); 60 fm, WSW of Dongara, CSIRO Stn 104, DM 1/70, 8.xii.70, 328-73 (1 specimen plus 10 valves); 60 fm, SW of Jurien Bay, CSIRO, Stn 108, DM 1/70, 9.xii.70, 327-73 (1 specimen); 70 fm, sand, NW of Rottnest, *Bluefin*, 15.ix.65, 213-67 (1 specimen); 60 fm, W of Rottnest I., CSIRO, DM 1/70, 2.xii.70, 329-73 (1 valve); 75 fm, NW of Cape Naturaliste, CSIRO, Stn 134, 28.viii.63, 220-67 (2 valves).

Genus *Plagiocardium* Cossman, 1886

Plagiocardium Cossman, 1886, *Annls. Soc. malac. Belg.* 21: 168. Type species: *Cardium granulosum* Lamarck, 1805; S.D., Crosse, 1887.

Diagnosis

Shell elliptical — oblique, hinge arched; sculptured externally with strong radial ribs bearing bead-like nodes on their crests; posterior margin digitate or crenulate; posterior left cardinal elevated.

Remarks

Because we have not seen the type species of *Plagiocardium* s.s., the above brief diagnosis is taken from Keen (1969) who recognised three subgenera, *Plagiocardium* s.s., *Papillocardium* Sacco, 1899, and *Maoricardium* Marwick, 1944. The distribution of the genus is uncertain because of confused nomenclature. Living species of the subgenus *Maoricardium* occur in the tropical Indo-West Pacific; the type species of the subgenus *Papillocardium* (*papillosum* Poli, 1795) occurs on the coast of western Europe, the Mediterranean and West Africa.

Subgenus *Maoricardium* Marwick, 1944

Maoricardium Marwick, 1944, *Trans. roy. Soc. N.Z.* 74: 263-264. **Type species:** *Cardium spatiosum* Hutton, 1873, O.D. (a New Zealand Tertiary fossil).

Diagnosis

Shell elliptical-oblique; inequilateral, anterior section of hinge shorter than posterior section; umbones prosogyrate. Margins rounded, crenulate, strongly so posteriorly. Sculptured with strong, broad, rather flat, radial ribs bearing prominent dehiscent nodes on their crests. Lunule small but well in evidence, lunule margin elevated in front of umbones; esutcheon long, narrow but well defined, smooth except for an obsolete rib in left valve. Hinge-line arched, strong, broad; ligamental plate broad, long, flat. Left cardinals equal or subequal, separated; anterior one high and knob-like; posterior one elongate, compressed, oblique. Left anterior lateral high, compressed, separated from dorsal margin by a shallow furrow; left posterior lateral forms a low, elongate ridge or small knob on dorsal margin. Right cardinals separated, unequal; posterior one erect, anterior one small and erect or consisting of a small knob. Right ventral anterior lateral strong, compressed and wedge-shaped; right dorsal anterior lateral a small knob below dorsal margin, with a deep socket between; posterior lateral elongate, compressed, separated from dorsal margin by a furrow.

Remarks

Living species of *Maoricardium* occur throughout the tropical waters of the Indo-West Pacific faunal region. Five fossil species occur in the middle Tertiary of New Zealand (Fleming, 1966). Keen (1969: N 585) gives the time range as Oligocene to Recent. Although the shells of the type species of *Maoricardium* (i.e. *spatiosum* Hutton, 1873) and other New Zealand fossils belonging to this subgenus are very much thicker and heavier than the two W.A. living species, the shape, hinge dentition and external sculpture all agree well. Habe (1951: 150) placed one of the living W.A. species (*setosum* Redfield) and a close relative of the other (*mansitii* Otuka) in *Maoricardium* which he ranked as a full genus. The eastern African species *pseudolima* Lamarck, 1819 is also referable to this subgenus. Some authors have placed these living species in *Vepricardium* but the cardinals of the right valve are not joined by a high saddle as they are in that genus and the shell outline is elliptical-oblique and characteristic of *Plagiocardium*.

The long spiky periostracal hairs arising in rows from the crests of the ribs are a noteworthy feature of the living species of *Maoricardium*.

Plagiocardium (Maoricardium) setosum (Redfield, 1848)

(Pl. 1, Figs 10-14; Text fig. 20)

Cardium setosum Redfield, 1848, *Am. Lyceum Nat. Hist. New York* 4: 55. Type locality: "Seas of China." Type: not located.

Diagnosis

Shell moderately thin, light, inequilateral, slightly gaping anteriorly. Mean number of ribs 36, range 33 to 38. Ribs nodulose, nodules forming single rows in shallow furrows down centre of each rib; nodules crowded on anterior ribs, more widely spaced but longer, spine-like on posterior ribs; sides of ribs with minute oblique lamellae. Left cardinals equal. Hinge arched but not strongly sinuous.

Exterior cream to rusty brown; interior white; hinge-line and teeth white, margin of lunular elevation purple. Periostracum with long spine-like hairs arising from spines on centre of radial ribs.

Sample number 12; measurements of largest shell, length 6.10 cm, height 5.17 cm, width 3.64 cm; mean ratio length to width 1.22:1 (range 1.13:1 to 1.28:1); mean ratio length to width 1.62:1 (range 1.38:1 to 1.82:1).



Text Fig. 20 *Plagiocardium setosum* x 1½

Remarks

Smith (1885, p.158) considered the shell figured by Reeve (*Conch. icon.* fig. 21) as *Cardium latum* Born to be this species and different from the species described by Born (1780: 48, pl. 3, fig. 9). Our specimens agree with Redfield's description except that they are not equilateral.

Distribution

Widely distributed in the Indo-West Pacific including Persian Gulf, Gulf of Aden, India, Philippines, the South East Asian mainland and down the eastern and western coasts of Australia. The most southern W.A. record is Exmouth Gulf.

W.A. records

25 fm, sponge and sand, 37 km SW of Troughton I., 214-67; Port Hedland, 124-67, 310-67; beach at mouth of Watering Valley, Depuch I., 125-67; Depuch I., 249-67; Port Samson, 122-67; Bay of Rest, Exmouth Gulf, 70-67.

Plagiocardium (Maoricardium) frazeri (Garrard, 1963)

(Pl. 1, Figs 8-9; Text fig. 21)

Regozara frazeri Garrard, 1963, *J. Malac. Soc. Aust.* 1(7): 42, pl. 7, fig. 1. **Type locality:** trawled in 35 fms E of Tin Can Bay, south east of Fraser Island, Qld. **Types:** **Holotype**, AM reg. no. C 64068; **paratype**, WAM reg. no. 2843-67.

Description

Shell thin, rotund, inflated, inequilateral, posterior slightly flared.

Sculpture of 37 to 42 flat, rectangular, radial ribs; ribs with low transverse lamellae, short stout nodules evenly spaced down crests; interstices narrow, flat with fine transverse lamellae continuous with those of ribs; interior sculptured by ribs corresponding to external interstices.

Hinge-line markedly sinuous. Right cardinals unequal. Thick brown periostracum present over entire shell forming projecting, pointed hairs from around spines. Shell white tinged with rust.

Shell Dimensions

	Length	Height	Width	ribs
Holotype AM reg. no. C 64068	3.7 cm	3.6 cm	2.9 cm	37
Paratypes WAM reg. no. 2843-67 a)	3.28	3.14	2.31	38
Paratypes WAM reg. no. 2843-67 b)	3.10	2.80	2.30	42
WAM reg. no. 119-67 (single valve)	2.15	2.09	0.82x2	42
WAM reg. no. 2437-67 (single valve)	1.75	1.74	0.66x2	38



Text Fig. 21 *Plagiocardium frazeri* x 2½

Remarks

P. (M.) frazeri resembles *P. (M.) setosum* with which it is at least partly sympatric, and it may in fact be a deep water eco-phenotype of that species. Broad flat ribs, each with a single row of simple stout spines and a thick brown periostracum are common to both species, but the number of ribs of *frazeri* are usually greater than in *setosum* and the shell is consistently higher relative to the length. Until more is known of the depth ranges of the two species, they should be considered distinct.

We have studied the description and figures of *Cardium (Ringicardium?) mansitii* Otuka, 1937 (*Venus* 7(3): 137, figs 52a, b) and suspect that this Japanese species may be conspecific with the Australian *V. frazeri*.

Distribution

V. frazeri was previously only known from the southern Qld type locality so that these W.A. records considerably extend the range. There are also specimens from Low Isles and Port Curtis, Qld in the AM collection.

W.A. records

35 fm, 200 m ENE Troughton I., 119-67; 40 fm, mud and sand, 65 m NE Adele I., 2437-67.

DOUBTFUL SPECIES

Cardium minutum Lamarck, 1819. *Histoire Naturelle des Animaux sans Vertèbres*, 6: 14. Type locality: "Nouvelle Hollande, au port due Roi Georges" [i.e. King George Sound, W.A.].

Hedley (1916: 14) and Lamy (1942: 128) list this name but we cannot account for it among the cardiid species known to us in W.A.

Lamarck's description is very brief and unhelpful and his reference to transverse rugae suggests that the species he wished to determine may not have been a cardiid at all. Professeur E. Fischer-Piette informs us that, although Lamy (1942: 128) indicated that the type should be in the collections of the National Museum of Natural History in Paris, it cannot be found there. We conclude that the name *Cardium minutum* Lamarck should be regarded as a *nomen dubium* until either the type is located or the species to which it belonged is rediscovered.

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