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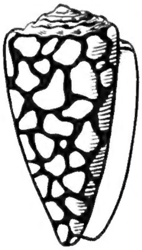

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A NEW ARCHIBENTHAL SPECIES OF FASCIOLARIIDAE FROM NEW ZEALAND

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Plate 1

SUMMARY

A new species, provisionally placed in the New Zealand Palaeocene genus *Microfulgur* Finlay and Marwick, is described from 730 metres off the Otago coast, South Island, New Zealand. The radula, operculum, shell features and the gross morphology of the animal are described. *Microfulgur* has been previously placed in the Galeodidae but, on the radula characters of the Recent species, is transferred to the Fasciolariidae.

INTRODUCTION

Under the supervision of Dr. E. J. Batham, the R. V. *Munida* has obtained many interesting molluscs while working off the Eastern Otago coast of New Zealand. Dr. Batham has kindly allowed the writer to describe the following new species which does not appear to have any other Recent Australasian relatives.

Of the four specimens obtained from the type locality, three were collected alive and preserved in alcohol. The fourth, a dead shell, is the only specimen with a mature aperture. Two specimens were dissected and brief anatomical notes are given below. The material examined is housed in the Dominion Museum, Wellington, except for one paratype which is located in the Australian Museum, reg. no. C 71221.

DESCRIPTION

Genus *Microfulgur* Finlay and Marwick, 1937: 73.

Type Species (o.d.): *Latirus (Mazzalina) longirostris* Marshall.

Microfulgur (?) carinatus sp. nov.

Plate 1, Figs. 1-4.

Shell: Medium size, rather thin, fusiform with spiral cords. Whorls 5½, including a slightly swollen protoconch of 1½ whorls, smooth except for 3-4 weak axial ribs on last whorl, terminated by a distinct varix. Teleoconch with convex whorls, subangled in middle of each whorl by uppermost of two strong, rounded spiral cords on lower half of all whorls. Shoulder almost flat, with weak spirals (4-5 on body whorl), these stronger as they approach the periphery. In a small (male) paratype the lowest shoulder spiral is nearly equal in strength to the upper main spiral. A rather weak cord emerges from the suture on the penultimate whorl. Base with numerous, rather weak, spiral cords (about 36 in holotype); the uppermost 1-2 basal spirals nearly equal in strength to the two main spirals. Axial sculpture of fine, dense growth lines, slightly and evenly curved corresponding to the weak apertural sinus. Whole surface covered with very fine, dense, irregular spiral striæ. Outer lip with a slight posterior concavity a little below suture, thin (in the one paratype which appears to be mature), with a little external thickening but no varix. Inner lip a thin glaze with a distinct boundary. There is no apertural ornament. Anterior canal long, initially nearly straight, then twisted to the right and behind. Anterior end of canal notched.

Operculum: Thin, semi-transparent, yellowish-brown, with distinct growth lines and sub-apical nucleus (Fig. 4).

Radula: Ribbon 3 mm long, with wide lateral teeth and small central teeth. Lateral teeth curved, each with 9 cusps, the inner and outermost cusps small, the remainder large, heavy, and curved slightly inwards. There is a short, blunt projection on outer end of each lateral tooth. Central teeth rather weakly developed, less thickened than lateral teeth. Each central tooth with 3 short, sharp cusps, frequently broken off, the median cusp slightly larger. Base barely distinguishable from radular membrane (Fig. 3; slide housed in the Australian Museum.)

Head-foot: Rather small, unpigmented. A pair of broad, short (contracted) cephalic tentacles lie close together with the eyes at their outer bases.

Anatomy: (Preservation rather poor.) Mantle cavity normal buccinacean. Osphradium large, broad, brown, bipectinate. Ctenidium normal, a little narrower than the osphradium. Hypobranchial gland appears to be well-developed. Male with large, broad penis 3.2mm long, lying transversally across right side of body at opening to mantle cavity; attached near base of right cephalic tentacle. Ejaculatory duct muscular, slightly convoluted and opens into the straight, narrow pallial sperm duct on the right side of the mantle cavity. There is apparently no distinct prostate gland. Pallial oviduct massive, occupying all of the right pallial wall in the female; appears to be typically " buccinid " in structure (Fretter, 1941), but no ingesting gland could be distinguished. This was apparently not due to the poor preservation of the specimen as all of the other structures in the pallial genital duct could be located. The specimen may not have been sexually mature, although the size of the capsule gland suggested that it was. There is no anal gland.

Salivary glands large, compact, white, paired; situated immediately behind head. They surround the proboscis sheath laterally and ventrally. Gland of Leiblein on left, behind and outside left salivary gland. This gland is relatively much larger than in *Buccinum* (Dakin, 1912) but is of similar structure. The proboscis sheath extends to end of cephalic cavity, its distal half swollen and thin-walled except for the extreme posterior end. A powerful retractor muscle, accompanied by a weaker one, is attached to proximal end of proboscis sheath and extends posteriorly on right to become embedded in columellar muscle near end of cephalic cavity. Proximal part of proboscis sheath narrow and rather muscular. Retracted proboscis muscular, wide at base, tapers evenly and ends about half way along proboscis sheath. Buccal mass lies within whole of non-inverted portion; odontophore rather weak, elongate, the radular sac extending along its entire length. Buccal cavity muscular, opening into a muscular anterior oesophagus which lies, for most of its length, on the ventral side of proboscis sheath. Valve of Leiblein about twice width of œsophagus. Mid-œsophagus short, not noticeably glandular. Posterior

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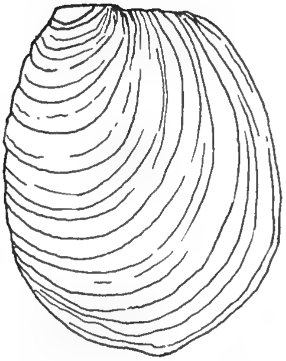

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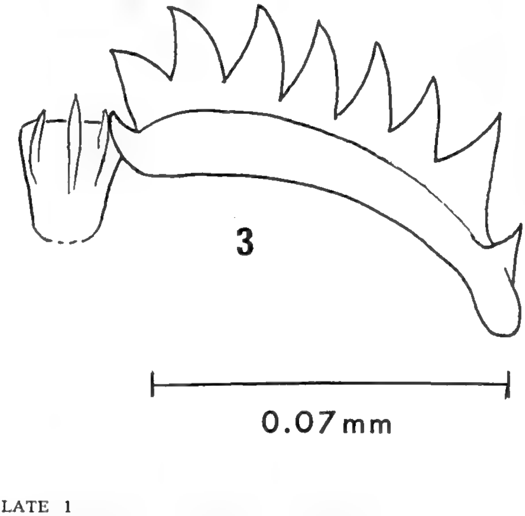

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PLATE 1

Figures 1 - 4. *Microfulgur (?) carinatus* sp. nov. 1, holotype. 2, paratype. 3, radula of paratype. 4, operculum of paratype (3.4mm x 4.6mm).

œsophagus straight, not forming a crop. Stomach elongate, tubular, without a cæcum. Nervous system not examined.

Type material:

	Height	Diameter	
Holotype M23204	25.0mm	9.6mm	Female (Fig. 1)
Paratypes M23205	19.5mm	9.0mm	A dead shell with outer lip mature. (Fig. 2)
	20.0mm	8.0mm	Male.

Locality: Portobello R. V. *Munida* station Mu 67-142; 171°02'E, 45°51'S, 730 metres in Papanui Canyon, Otago coast, New Zealand (4 specimens).

An additional specimen was obtained from Mu 68-27; 171°08'-07'E, 45°38'S, 720-540 metres in Karitane Canyon off the Otago coast (Portobello Marine Station reference collection).

DISCUSSION

The generic placement of this species has proved difficult. *Microfulgur* Finlay and Marwick is a monotypic genus in the Palæocene of New Zealand which agrees fairly closely in protoconch and teleconch features but differs from *carinatus* in some respects. For example, although the anterior canal is similar, it is less curved than in the Recent species. The protoconch of all specimens of the type species, *Microfulgur longirostris* (Marshall) is worn or missing, although as far as can be judged it appears to be similar to that of *carinatus* except that it is relatively smaller. The spire in *longirostris* is much more depressed and evenly conical in outline than in the Recent species and the spiral chords are narrower and sharply raised. Finlay and Marwick state that the columella bears a weak fold and groove where " it is bent to the canal ". This feature is not visible in *carinatus*. Examination of topotypes of *longirostris* shows that Finlay and Marwick exaggerated the extent of the fold, this being hardly visible, and there is no idication of a groove.

Another similar species is *Lirofusus thoracicus* (Conrad) from the Eocene of Alabama. This species, however, has stronger axial sculpture and a protoconch of three whorls. There do not appear to be any other closely allied forms.

Possibly the erection of a new genus or sub-genus for *carinatus* will be required eventually, but as a full scale revision of the " buccinacean " genera is long overdue, a tentative placement in *Microfulgur* is preferred to encumbering the literature with yet another monotypic genus—group name. The new species can be regarded as a *Microfulgur* which has lost the weak columellar ornament and has developed a more elongate spire than its Palæocene ancestor. There do not appear to be any connecting forms known in the New Zealand Tertiary.

The shell of *carinatus* somewhat resembles the Antarctic genera *Proneptunea* Thiele and *Prosipho* Thiele but differs from both of these in its longer canal and in radular characters.

Finlay and Marwick place *Microfulgur* in the " Busyconidæ " (= Galeodidæ) but the original placement of *longirostris* in the Fasciolariidae by Marshall appears to be correct judging by the radular features of the

Recent form and the ornament on the lower columellar of the fossil species. Most fasciolariids have an orange or red head-foot but the preserved specimens of this species were unpigmented. It is unlikely that alcohol bleaching removed all traces of pigmentation as this does not occur completely in other species. The internal anatomy shows that the new species belongs to the Buccinidæ — Nassariidæ — Galeodidæ — Fasciolariidæ complex (= Thiele's (1929) Buccinacea). Unfortunately there are no reliable anatomical differences that readily distinguish these families.

This case proves to be an informative illustration of the resemblance of shell (as well as anatomical) features between the families of the Buccinacea. With this one example, the Buccinidæ, the Galeodidæ and the Fasciolariidæ come very close together on shell features and the final determination of familial position could only be made by a study of the radula.

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CHELIDONURA INORNATA BABA AND *C. ELECTRA* SP. NOV. FROM THE SOLOMON ISLANDS (OPISTHOBRANCHIA, AGLAJIDAE)

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SUMMARY

The anatomy of *Chelidonura inornata* Baba (1949) and *C. electra* sp. nov. is described. Both specimens follow the normal aglajid pattern of alimentary canal, with muscular buccal bulb and distended crop. The posterior notum is extended into two unequal processes, typical of the genus. The specimens were collected at Guadacanal, British Solomon Is, and have been recorded from Queensland and New South Wales, Australia.

INTRODUCTION

During the Royal Society Expedition to the Solomon Islands in 1965, three specimens of *Chelidonura* were collected by Mr. Ian Gower, a resident planter, and given to the leader of the marine party, Professor J. E. Morton. One of these, a dark, white-spotted animal, is *C. inornata* Baba, 1949. The other two specimens, white with gold margins, belong to a new species which is described below.

DESCRIPTIONS

Chelidonura inornata Baba, 1949

Fig. 1-2

Chelidonura inornata Baba, 1949: 22, 124, pl. 2, fig. 5.

Body elongate. Head-shield tapering posteriorly ending half-way down body. Visceral hump quite distinct from head region, beginning behind head-shield. The dorsum extends posteriorly to form a pair of unequal fleshy processes, the left slightly longer than the right. Parapodia broad and fleshy, folding over each other on the dorsal surface. Gill and mantle enclosed by posterior processes. Anterior end of head-shield tri-lobed. No sensory bristles or papillæ were observed in preserved animal although observed by Baba (1949). 6-7 large compound folds of Hancock's organ on each side of the head. Size of preserved animal approx. 6.5cm x 2.0cm.

Colour. Dorsal surface sepia black; outer surface of parapodia and foot black, flecked with white; very fine silvery margin continuous around parapodial edge. Inner surface of parapodia gray. Caudal lobes black. Anterior lateral lobes of the head-shield are opaque white, bordered by orange-red region; central lobe white.

Alimentary Canal. Follows typical pattern found in the Aglajidæ (Rudman, 1968). A muscular buccal bulb, devoid of jaws or radula, leads into an extensible crop. The œsophagus leaves the crop and passes through the diaphragm to enter an ill-defined stomach region with many branches to the digestive gland. The intestine loops up and over the digestive gland, opening by the anus, into the reduced mantle cavity, just left of centre. Compared with *Aglaja cylindrica* (Cheeseman, 1881), and *Aglaja depicta* Renier, 1807 (Guiart, 1901) where the buccal bulb is half the length of the body, the buccal bulb of *C. inornata* is small, being approximately one-fifth the body length. A massive oral gland lies under the buccal bulb and is equal in size to it.

Nervous System. Similar to that of other aglajids studied (Guiart, 1901; Rudman, 1968). Ganglia of nerve ring concentrated dorsally, the pedal commissure very long. Buccal ganglia placed posteriorly just below œsophageal opening. Hancock's organs are large, consisting of 6-7 compound vertical folds.

Reproductive System. This is probably also typical of the family. However the preservation of the one specimen available made it difficult to follow the ducts of the genital mass. The penis is very simple, being a conical, muscular sac with a deep seminal groove and no prostate gland. (Fig. 2)

When discussing this paper with Mr R. Burn he suggested that my description of the penis was incorrect. He kindly gave me some Australian specimens to study. In these specimens, which were one-third the size of the Solomon Is. specimen, the penis is very similar to that of the new species described below. After re-examining the specimen it is possible that the penis had suffered from bad preservation. It is very possible that my description and drawing of the penis of the Solomon Is. specimen is incorrect.

Shell. The specimens were preserved in formalin and the shell therefore disintegrated. By following the organic membrane that remained, the shell appears to be similar in shape to *C. evelinae* Marcus, 1955 or *C. phocae* Marcus, 1961, the long process reaching into the right posterior lobe of the dorsum.

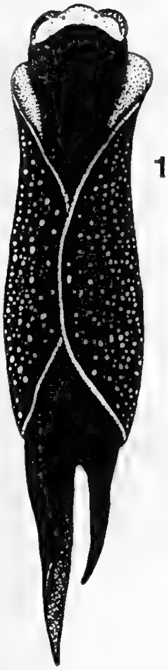
DISCUSSION

This specimen is *Chelidonura inornata*, originally described from Japan. The colour of the type material was " glossy purplish-black, white dots on outer side of parapodia and posterior edge of head-shield, central anterior lobe white, two lateral lobes white with yellow borders." Burn (1966) notes *C. inornata* from Australia as having " blue spotting on parapodia and sole, black cephalic shield and visceral hump, and a white and yellow anterior margin to the head. Its penis .... being conical with a deep channel-like seminal groove."

Risbec (1928) describes a *Chelidonura* from New Caledonia as having a pair of " tentacules ", the base of which were white, the extremities being chestnut yellow. The head was black with white border, parapodia gray inside, externally black with white spots. He identifies this as *C. obscura* (Bergh, 1901). Bergh's original description was unavailable, but Mr. R. Burn has kindly informed me that *C. obscura*, as described by Bergh, is " dark brown, with gill and sides of body greyish-white; margins of head-shield and foot dark ". Also the penis has " two long horns of the prostate gland ". Risbec has apparently misidentified his specimens.

Chelidonura electra sp. nov. Fig. 3-7

Body elongate. Head-shield tapering posteriorly, the bluntly triangular posterior end extending beyond the limits of the anterior cavity and forming an unattached flap. Behind the flap, the visceral hump rises from the foot. A pair of lobes extend from posterior end of visceral hump, left being long and fleshy, about as long as the body, right lobe half this length.



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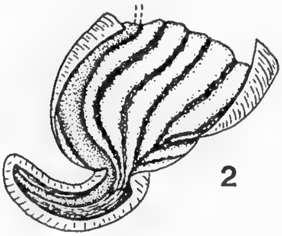

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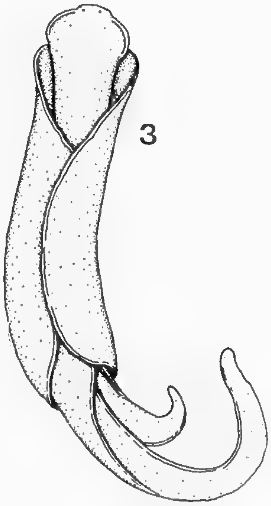

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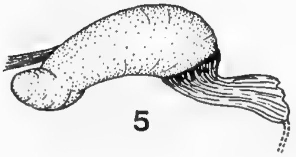

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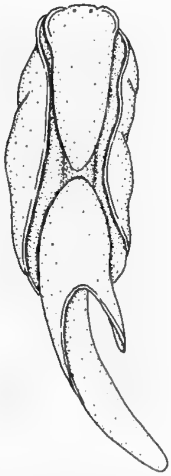

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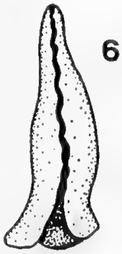

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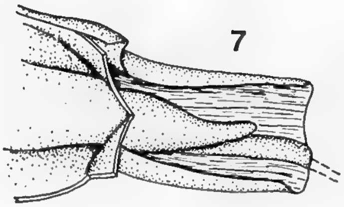

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Figures 1 - 2. *Chelidonura inornata Baba* 1, animal (from field sketch of living animal by J. E. Morton). 2, penis, opened.

Figures 3 - 7. *Chelidonura electra* n.sp. 3, animal (from field sketch of living animal by J. E. Morton). 4, preserved animal showing typical chelidonuran separation of visceral hump and anterior body cavity. 5, penis. 6, vental view of penial papilla. 7, penis, opened to show penial papilla,seminal groove, and part of prostate gland. (Broken lines denote external seminal groove).

Parapodia large and fleshy, folding over the dorsum. Gill large almost completely enclosed by posterior processes. Hancock's organ a region of 10 distinct compound folds behind which is an area of indistinct folding. Organ large, on right side running vertically from seminal groove to dorsal flap of head-shield. Eyes, small and black, situated on each side of centre line close to anterior edge of head-shield. No sensory processes observed on anterior edge of head.

Colour. Animal translucent white; margins of parapodia, posterior lobes and anterior corner margins of head, being bright lemon-yellow.

Alimentary Canal. Similar to that of *Chelidonura inornata,* buccal bulb relatively small. Oral gland-mass massive, situated below buccal bulb. Crop small.

Nervous System. Similar to that of *C. inornata.* A description of this system will form part of a comparative study of the Bullomorpha to be published later. Nerve-ring ganglia dorsally placed, buccal ganglia placed posteriorly below the œsophageal opening. Eyes small, on either side of midline, very near anterior border of head. Hancock's organs comparatively large. No development of anterior sensory processes observed.

Reproductive System. Genital mass similar to the normal pattern of the Aglajidæ (Rudman, 1968). Penis unlike any as yet described in this genus. It opens just to the right of the mouth, leading into a thin-walled vestibule on the floor of which runs a deep seminal groove. This groove passes into a muscular sac enclosing the prostate gland. At the posterior end of the vestibule a penial papilla is attached, the lateral edges of which fold under to form a ventral groove running to the end of the papilla. Posteriorly the groove is continuous with the opening of the seminal groove into the prostate region, enabling passage of sperm in both directions (Fig. 5-7). The penis complex lies alongside the buccal bulb, and is of similar length. *Chelidonura evelinae* has a similar type of penis but lacks a penial papilla (Marcus, 1955).

Shell. The preservation of the material destroyed the shell. The organic matrix remaining suggests that the long process on the shell, typical of this genus, is not as pronounced as in *C. evelinae* or *C. velutina* Bergh, 1905.

Material. The holotype is deposited in the British Museum (Natural History), London, No. 196951. Size of holotype: 5.0cm x 1.5cm.

A microscope slide of the organic matrix of the shell of a second specimen and the dissected animal of this specimen are also deposited at the British Museum. Size of second specimen: 7.0cm x 1.7cm.

Both specimens were collected along with *C. inornata* on a small brown coral (*Porites* sp.) in a lagoon at Paruru, Marau Sound, Guadacanal, Solomon Islands, in 25 feet of water by Mr. Ian Gower.

DISCUSSION

This species is named after the Greek goddess Electra, "the bright or brilliant one", daughter of Oceanus and Tethys. This species has been found in eastern Australia. Allan states, "I have .... seen a very lovely little pure white tailed-slug with yellow bordering collected in the vicinity of Clarence River Heads (northern New South Wales), but this appears to be unnamed at present" (Allan, 1959). It has also been collected at Orpheus and Hook Islands in Queensland (R. Burn, pers. comm.). A species of *Chelidonura, C. pallida,* described from one specimen from New Caledonia, (Risbec, 1951) is similar in colour. The animal is white and the borders of the parapodia and posterior lobes are coloured "orange et liseres d'une fine ligne noire". In the same description, while comparing his specimen with *C. amoena* Bergh, 1905 Risbec states that "bordures jaune vif et noir". The important colour difference therefore, between *C. pallida* and *C. electra* is the possession of a black line in the former case. Neither animal from the Solomon Is. had any black markings and Allan mentions no black in her Australian observation. Unfortunately, anatomical differences are difficult to determine, the reproductive system and penis of *C. pallida* not being described. In *C. pallida,* Risbec describes a pair of oral glands, one on each side of the buccal bulb, which appears to be greater in size, relative to body-length, than in *C. electra.* A large ventral oral gland is present in *C. electra.*

The parapodia in Risbec's drawing of the live animal of *C. pallida* suggest that they may not be as large as those of *C. electra.* One other colour difference is the lack of yellow markings on the dorsal edge of each side of the anterior of the head shield in *C. pallida.* The differences are admittedly slight, and knowing the colour variation that can occur, the author had some hesitation in describing these animals as a new species. However, although there are intraspecific colour differences in the genus, these are usually differences in marking patterns rather than in presence or absence of a colour. I know of four pure white aglajids; *A. dubia* O'Donoghue, 1929, *A. lorrainae* Rudman, 1968, *A. seurati* (Vayssiére, 1926) and A. *virgo* Rudman, 1968, and a number of black species differing only in colour markings, *C. hirundinina* (Quoy and Gaimard, 1832), *C. obscura* (Bergh, 1901), *A. splendida* Risbec, 1951, and *A. ocelligera* (Bergh, 1894).

C. electra and *C. pallida* may prove to be colour variations, but until further observations of the two forms are recorded, I feel justified in distinguishing the Solomon Is. specimens as a distinct species.

ACKNOWLEDGEMENTS

I would like to thank Professor J. E. Morton, Head of the Zoology Department, University of Auckland, for making available the specimens of *Chelidonura* described and field notes of these animals, Mr. Ian Gower for collecting them, and the Royal Society, London who made the Solomon Is. Expedition possible. I wish also to thank Dr. M. C. Miller of the Zoology Department, University of Auckland, and Mr. R. Burn, Hon. Associate, National Museum of Victoria, for their interest.

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NOTES ON THE ANATOMY OF *VICTAPHANTA ATRAMENTARIA* (Shuttleworth) AND *V. COMPACTA* (Cox and Hedley), AND THE DESIGNATION OF A NEOTYPE FOR *V. ATRAMENTARIA*.

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Plate 2

SUMMARY

A neotype for *Victaphanta atramentaria* (Shuttleworth) is designated, and its anatomy is described and compared with that of *V. compacta* (Cox and Hedley).

INTRODUCTION

During work on the redescription of the genus *Victaphanta* Iredale (Smith, 1969) an extensive search for the type specimen of *Victaphanta atramentaria* (Shuttleworth, 1852) failed to reveal its whereabouts. This created a problem as the two species of the genus are very closely similar and the type locality in the original description was not sufficiently specific to enable separation of the species on geographical criteria. The confusion was further aggravated because *V. atramentaria* is the type species of the genus. It was therefore decided that as sufficient steps had been taken to trace the type, and having failed to do so, that, in the interests of stability of nomenclature, a neotype should be designated. It was also thought necessary to redescribe the two species and fully describe their anatomy since work by Kondo (1943) and Solem (1959) has shown how vital the knowledge of the anatomy of this group is to the full understanding of the correct relationships of related species.

DESCRIPTIONS

Victaphanta atramentaria (Shuttleworth, 1852)

Pl. 2, fig. 1a-d.

Nanina atramentaria Shuttleworth, 1852, *Mitt. Naturf. Ges. Bern.*, p. 194.

Helix (Nanina) atramentaria. Pfeiffer, 1853. *Monographia Heliceorum Viventium Lipsiae*, 3: 630.

Paryphanta atramentaria. Menke and Pfeiffer, 1854, *Malakozoologische Blatter, Cassel*, 2: 122.

Nanina (Paryphanta) atramentaria. Shuttleworth, 1856, *Notitiae Malacologicae*, Leipzig, 1: 16.

Paryphanta atramentaria. Adams and Adams, 1858, *Genera of Recent Mollusca*, Van Voorst, London, 2: 226.

Helix atramentaria. Pfeiffer, 1859, *Monographia Heliceorum Viventium, Lipsiae*, 4: 8.

Paryphanta atramentaria. Albers, 1861, *Die Heliceen*, Leipzig, p. 48.

Helix (Paryphanta) atramentaria. Cox, 1868, *Monograph of Australian Land Shells*, Sydney, p. 5, pl. 3, fig 2 a - b.

Nanina (Paryphanta) atramentaria. Shuttleworth, 1877. *Notitiae Malacologicae*, Leipzig, 2: 5, pl. 1. fig 2.

Paryphanta atramentaria. Tryon, 1885, *Man. Conch.*, (2), 1: 127, pl. 26, figs. 5 - 6.

Paryphanta atramentaria. Cox and Hedley, 1912, *Mem. Natn. Mus. Vict.*, 4: 8.

Victaphanta atramentaria. Iredale, 1933, *Rec. Aust. Mus.*, 19: 60.
Victaphanta atramentaria. Iredale, 1938, *Aust. Zool.*, 9: 116.
Victaphanta atramentaria. Smith, 1939, *Proceedings of Symposium on Mollusca, India,* part 1, p. 164-169.

Diagnosis: Paryphantid snail of the genus *Victaphanta,* shell depressedly globose, thin, glossy, four whorls white to yellow to dark brown or black on the outer whorls, umbilicus narrowly open with the internal spire visible, fine concentric lines on upper surface, lower surface smooth, reaches 34 mm maximum diameter. Animal black with orange frill around foot, foot white, mucus orange and viscous. Pharynx long cylindrical, radula without rachidian, teeth unicuspid with oblong base-plate bearing a notch at posterior extremity. Reproductive system simple, vas deferens free from common duct, attached to the outer wall of the vagina, running in a loop past the genital atrium and entering the penis just before its posterior end; penis equal in length to the vagina.

Distribution: This species is confined to the temperate rain-forest areas of the Dandenong Ranges and the east-central part of the Great Dividing Range in Victoria. It is only found in the wet litter in fern gullies in climax rain-forest. The original type locality was given as Port Phillip which is the old name for the colony area surrounding Melbourne which was later changed to Victoria. The original specimen must have been collected in the 1840's and no more exact record of locality is given. All distribution records except one fall within a 1,500 sq. mile area bounded in the north by Marysville, the south by Neerim, the east by Wood's Point and the west by Mount Dandenong. The one anomalous record is by Cox (1868) who records it from Bendigo. However this is so long ago and he associates it with Mount Arnold which is within the area described above and many of Cox's localities have been proved erroneous (Mrs. J. Richardson — personal communication) that this record can be discounted.

Neotype: National Museum of Victoria No. F27376 from Gentle Annie Camp at junction of Labertouche, Neerim, and Powelltown roads near 1448 feet marker (State Aerial Survey of Victoria — Sheet Gembrook D, Ref. 823206); collected by B.J. Smith on 8 November, 1966. Neotype narcotized using a nicotine solution, preserved by injecting with Formol/Calcium and stored in a formalin-glycerine-Perminal fluid. Major diameter 31.62 mm, minor diameter 26.50 mm, maximum height of shell 17.76 mm.

Fate of Original Type: Shuttleworth's collection and types all went to Berne and Basle Museums in Switzerland (Dance, 1966). Requests were therefore made to these two museums and also to the museums in Zurich, Geneva and Neuchatel in Switzerland and to the Natural History Museums in Paris and London. Dr. J. Oberling in Berne informed me that the type was missing from the Shuttleworth Collection held in that institution, together with many other type specimens. All the other museums, except Zurich, failed to find any material which could be relevant to this search. Dr. H. Jungen of Zurich University Museum informed me of a specimen of this species in the Mousson Collection which Mousson was believed to have obtained from Shuttleworth. Through the good offices of the Zurich Museum this specimen was sent on loan. The label with this specimen states '*Par. atramentaria* Shttl. 2, Victoria (Shuttlew. 67) ' and there is a small label inside the shell with the species name: *atramentaria.*

Dr. Jungen, and through him Frl. V. Gerber of the Berne Museum, informed me that the large label is in Mousson's handwriting while the small label inside the shell could possibly be in Shuttleworth's handwriting but they could not be certain of this. No label could be found from Shuttleworth with any dates or other data which would indicate that this specimen was the type. Therefore because no direct documentary evidence exists and because Mousson records the genus as *Paryphanta* and not *Nanina* and the locality as Victoria and not Port Phillip, as in the original description, a grave doubt is thrown on this specimen being the original type specimen.

The dimensions of this specimen are: Max. dia. 31 mm, min. dia. 25.7 mm, height 16 mm compared with 30 mm, 24 mm, 14 mm from the type description. The species was not figured when it was described and the earliest figure of an authentic nature is found in *Not. Malac.*, 2: pl. 1, fig. 2. This was from Shuttleworth but was published by Fischer in 1877, after the death of Shuttleworth. It could be reasonably assumed that the figures were drawn from the type. If so then the specimen in the Mousson Collection at the Zurich Museum is not the type as the drawing shows an obvious abnormal growth fold not present in the Mousson specimen. Taking all these factors into consideration it is therefore reasonable to assume that the specimen from the Mousson Collection in Zurich is not the type specimen, and as the type can be located nowhere else, it must be presumed lost.

Comparison with the Original Type: Because of the brevity of the original description and the close similarity of the two species of the genus there is little in the original description to distinguish to which species the original specimen belonged. However it has recently been shown (Smith, 1969) that the two species can be distinguished on a statistical basis by shell shape, *V. compacta* being significantly more globular in shape than *V. atramentaria.* If the shape of the original type specimen is considered in this way, it more nearly approaches the *V. atramentaria* group than the *V. compacta* group. Also its maximum diameter exceeds the maximum diameter found for any specimen of *V. compacta.* It can therefore be assumed that the neotype is consistent with the original type material.

Victaphanta compacta (Cox & Hedley, 1912)

Pl. 2, fig. 2a-b.

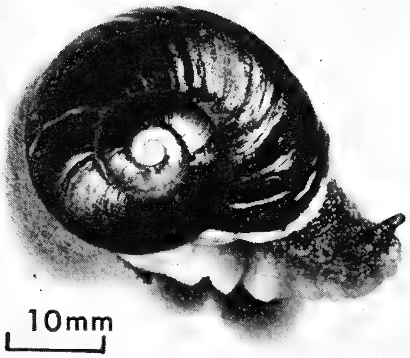
Paryphanta compacta Cox and Hedley, 1912, *Mem. Natn. Mus. Vict.*, 4: 8. pl. 1, figs. 3 - 5.
Victaphanta compacta. Iredale, 1938, *Aust. Zool.*, 9: 116.
Victaphanta compacta. Smith 1969, *Proceedings of Symposium on Mollusca, India,* part 1, p. 164 - 169.

Diagnosis: Paryphantid snail of the genus *Victaphanta,* shell more globular than *V. atramentaria,* four to five whorls, yellow to dark brown, rarely black, umbilicus nearly closed by reflection of the inner insertion of the aperture margin, reaches 28 mm maximum diameter. Animal black with no orange pigment in skin or mucus, mucus colourless and less viscous than *V. atramentaria.* Radula teeth unicuspid, tooth base-plate without posterior notch. Penis shorter in length than vagina and vas deferens enters at the posterior extremity of the penis.

Type Material: Type in the Australian Museum — C31179 collected by Mr. A. D. Hardy from Smithers Creek, Otway Ranges, Victoria; dimensions (from original description) Maj. diam. 24 mm; min. diam. 19 mm;

PLATE 2

1a

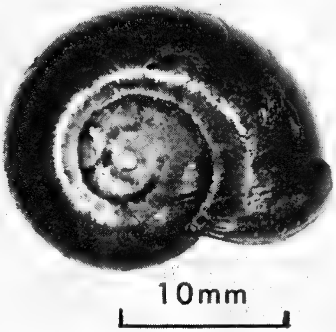


1b

1c

1d

2 a



2 b

height 17 mm. The specimen is badly split and no measurement is now possible. Three paratypes in the National Museum of Victoria — F 690, collected by Mr. Kershaw at Erskine Falls, Loutit Bay, near Lorne, Victoria; dimensions. Paratype 1 (Figured), maj. diam. 20 mm; min. diam. 15.5 mm; height 14.5 mm, paratype 2, maj. diam. 19 mm; min. diam. 15.5 mm; height 14 mm, paratype 3, Maj. diam. 19.5 mm; min. diam. 16 mm; height 13.5 mm.

Distribution: This species is confined to the temperate rain forest in the Otway Ranges in the south-western part of Victoria. It is confined to a triangle of approximately 250 sq. miles in area from Lorne to Cape Otway to Gellibrand. However because of extensive land clearance it is only found in pockets of untouched forest within that area.

ANATOMY

Four specimens of each species were narcotized using a nicotine solution, injected with 5% formalin solution and stored in a formalin — glycerine — Perminal fluid. These were used for the dissection to describe the anatomy. The anatomy of *V. atramentaria* was described by Murdoch (1906) and of both species by Davies (1913). However a number of features now considered of systematic significance were omitted from these descriptions. As the anatomical differences between the two species are so slight and few in number, the following descriptions refer to both species except where otherwise stated.

Pallial Region. (Fig. 3). The pallial cavity is large, approximately five times the length of the kidney, with a large heavy mantle collar. The pulmonary orifice is deeply depressed with two large triangular lappets. The hindgut follows the parietal-palatal margin for the length of the pallial cavity, terminating a short distance before the pulmonary orifice into a deep grove in the ventral part of the orifice. On the posterior margin of the collar is a large white area in *V. atramentaria,* similar to the mantle gland described in *Ouagapia sp.* by Kondo (1943). The kidney is a small light brown triangular curved organ next to the heart with the ureter, a wide thin walled tube, emerging at its apex and reflexing posteriad on the left side. It appears to terminate here in an indistinct orifice which exhausts into a " secondary pseudoureter " which consists of a channel next to the rectum enclosed by a thin membrane. This appears to open into the pulmonary orifice groove next to the anus. The heart gives rise to an extensive vessel system covering the entire dorsal wall of the pallial cavity.

Alimentary System. (Fig. 4). The alimentary system is completely specialised for the carnivorous habit. The mouth is simple leading into a strongly muscular cylindrical pharynx as long as the body cavity. This is attached on the ventral surface to columellar muscle by the large pharyngeal retractor muscle. The œsophagus arises as a narrow tube from the dorsal surface of the pharynx and about one third of the way along its length. The salivary gland is a single ovoid gland dorsally placed on the œsophagus and opening by two long fine salivary ducts into the œsophagus at its junction with the pharynx. The œsophagus is short and simple and leads into an expanded crop with thin walls with numerous

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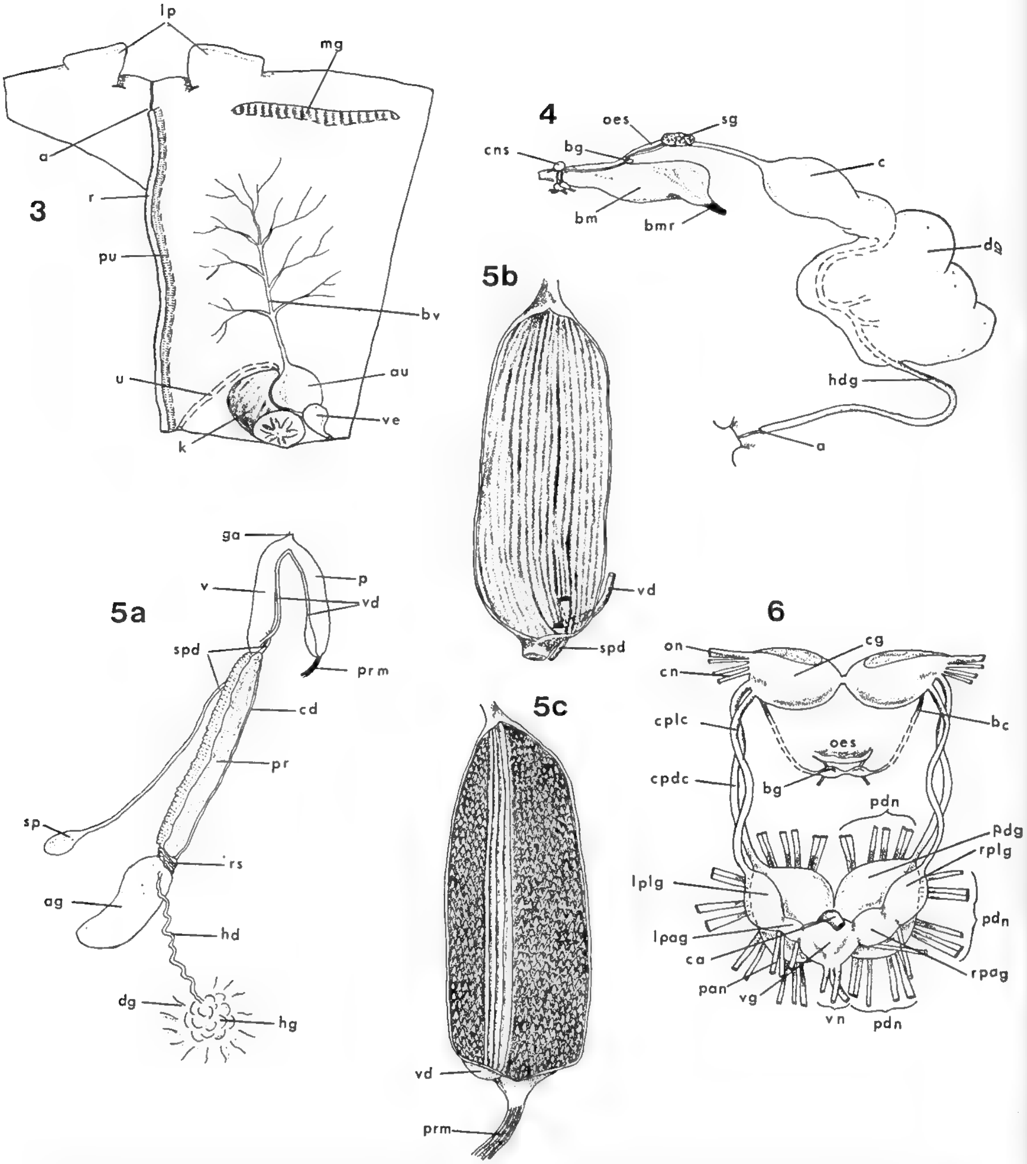
PLATE 2

Figure 1. *Victaphanta atramentaria* Shuttleworth. Neotype (NMV No. 27376) showing (a) dorsal view, (b) ventral view, (c) view from the right side and (d) view from the left side.

Figure 2. *Victaphanta compacta* Cox and Hedley. Paratype (NMV No. F690) showing (a) dorsal and (b) ventral views.



Figures 3 - 6. *Victaphanta atramentaria.* 3, Diagram of the pallial region. 4, Diagram of the alimentary system. 5, Diagram of the reproductive system showing (a) a general view, (b) the internal structure of the vagina and (c) the internal structure of the penis. 6, Diagram of the central nervous system viewed from the posterior.

fine longitudinal folds. From here the intestine coils and is embedded in the digestive gland which occupies all the left and dorsal part of the second body whorl and the remaining whorls. The intestine sends several diverticulæ into the digestive gland. The hindgut then runs along the ventro-lateral margin of the pallial cavity and exhausts at the anus into the ventral groove of the pulmonary orifice. The radulæ of the two species were compared recently by Smith (1969).

Reproductive System. (Fig. 5a, b, c.) The species are oviparous, laying large, white, hard-shelled eggs approximately 2 - 3 mm in diameter. The reproductive system is simple. The hermaphrodite gland is a small lobate structure, consisting of an indeterminate number of small lobules rather than one or two easily recognisable lobes, embedded in the latero-ventral part of the digestive gland with about 1½ whorls of digestive gland above it. The hermaphrodite duct is a long, thin, convoluted duct which enters the swollen end of the receptaculum seminalis which is embedded in the anterior end of the albumen gland. To do this it appears that the hermaphrodite duct passes through the anterior end of the albumen gland and enters the receptaculum seminalis from the ventral side.

The receptaculum seminalis is a bipartite structure with the large second lobe appearing to be divided into two on the ventral side. It appears as a compressed white structure between the large yellow albumen gland and the salmon coloured common duct.

The common duct in the mature animal is about one and a half times the length of the vagina and consists in life of a salmon coloured convoluted longitudinal half on the right side and a blue-grey smooth left half. The convoluted salmon part comprises the thin glandular wall of the single duct forming the common duct while the blue-grey area comprises a large prostate gland consisting of small alveolar-like acini inside a thin outer membrane. From sections these appeared to open into the single common duct at intervals along its length by small connecting ducts.

The common duct ends with the termination of the prostate gland and enters the long muscular vagina. At this point the vas deferens emerges and runs as a fine, free duct up the right side of the vagina to the genital atrium where it forms a sharp loop, becomes embedded in the outer connective tissue of the penis and runs down the left side of the penis to enter by a dilated end into the posterior part of the penis near the insertion of the penal retractor muscle. Also at the junction of the vagina and common duct a fine duct emerges from the vagina and runs down the ventral side of the common duct. This is the spermathecal duct which terminates in the small sac-like spermatheca which is found ventral to the region where the hindgut deflects close to the auricle. It therefore deflects away from the common duct before reaching the posterior end of the later and lies ventral to and outside the first digestive gland lobe.

The vagina is a long, narrow tubular structure approximately two-thirds of the length of the common duct. At its distal end emerges the vas deferens and the spermathecal duct and it terminates in the small genital atrium at its proximal end. Its internal surface is made up of many fine longitudinal folds which show no recognisable tracts or structural differentiation in the region of the outlets of the two ducts at the distal end. Some of the folds seem to be continuous for the full length of the organ while others extend for a short distance only.

The penis is also a long, narrow, tubular organ which leads into the genital atrium at its proximal end. In *V. compacta* the vas deferens enters at the posterior extremity of the penis and the penis is slightly shorter in length than the vagina. In *V. atramentaria* the vas deferens enters the penis a short distance from the end and the penis is equal in length to the vagina. The penis retractor muscle is a long broad band of muscle inserting into the apex of the penis and having its origin on the floor of the mantle cavity near the mantle collar on the right side. The internal surface of the penis in both species is identical, being made up of two or three fairly deep grooves running from the point of entry of the vas deferens to the genital atrium. The remainder of the internal surface is covered with conical papillæ and shows no special structures or arrangement.

Nervous System. (Fig. 6). The central nervous system consists of a nerve ring permanently situated in a small constriction in the pharynx immediately posterior to the mouth and anterior to the origin of the œsophagus. Because of the size of the pharynx the cerebro-pleural and cerebro-pedal commissures are very long and flexible. The cerebro-buccal commissures are also very long and flexible originating from the latero-ventral margins of the cerebral ganglia and running posteriad to the buccal ganglia immediately posterior to the origin of the œsophagus from the pharynx. The pair of buccal ganglia give off three pairs of nerves to the œsophagus, and the pharynx.

The cerebral ganglia are a pair of oval bodies on the dorsal side of the pharynx joined by a very short inter-cerebral commissure. The entire nerve ring is enveloped in a thin connective tissue sheath which, while being thin enough to make the ganglia easily visible, obscures the origins and exact number of many of the nerves. At the anterior end of each cerebral ganglia is a small opaque area at the base of the optic nerve. This probably corresponds to an area of small cells in a similar position described for many pulmonates (Lever et al, 1961; Smith, 1966). Apart from these nerves and the commissures described above, the cerebral ganglia also give rise to nerves running to the optic and inferior tentacles and their retractor muscles and to the pharynx and anterior sensory areas.

The sub-pharyngeal part of the central nervous system consists of two large ovoid pedal ganglia with commissures joining them to the pleural and cerebral ganglia and to each other and with approximately ten to sixteen nerves or nerve trunks arising from their anterior, lateral and posterior sides and running to all parts of the foot and integument. Dorsal to the pedal ganglia is the pleuro-parieto-visceral ganglion complex with the cephalic artery passing between. The two lateral ganglia of this ganglion complex, the left and right pleural ganglia, receive commissures from the cerebral and pedal ganglia but appear to have no nerves originating from them. The left pleural ganglion is slightly larger than the right. The two ganglia fused to, and central to the pleurals, are the left and right parietal ganglia, the right one being much larger than the left, which is almost lost. However, the left parietal forms the origin for three nerves to the tentacular and pharyngeal retractor muscles and to parts of the foot and pedal gland. The right parietal ganglia gives rise to two nerves to the tentacular and penis retractor muscles and to parts of the integument and mantle cavity floor. The single visceral ganglion, which lies posterior to and joins with the parietal ganglia, consists of a small triangular ganglion giving rise to three large nerve trunks from its posterior apex. These innervate the mid and hind gut, the vagina and common duct and the heart and renal structures. A more detailed survey of the nervous system of these two species is proposed as future study.

ACKNOWLEDGEMENTS

I would like to thank Dr. J. Oberling at the Berne Museum, Switzerland and Dr. H. Jungen at the Zurich Museum, Switzerland for their special assistance in endeavouring to locate the original type specimen, and the mollusc departments at the Museums in Basle, Geneva, Neuchatel, Paris and London for their assistance in searching for the type. I would also like to thank Dr. W. F. Ponder of the Australian Museum, Sydney. for supplying details of the type of *V. compacta,* Mr. F. Guy of Royal Melbourne Institute of Technology for the photography and Mrs. N. Wortley for typing the manuscript.

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ABBREVIATIONS

a — anus
ag — albumen gland
au — auricle
bc — buccal commissure
bc — buccal ganglion
bm — buccal mass
bmr — buccal mass retractor
bv — blood vessel
c — crop
ca — cephalic artery
cd — common duct
cg — cerebral ganglion
cn — cephalic nerve
cns — central nervous system
cpdc — cerebro-pedal commissure
cplc — cerebro-pleural commissure
dg — digestive gland
ga — genital atrium
hd — hermaphrodite duct
hdg — hind gut
hg — hermaphrodite gland
k — kidney
lp — lappet
lpag — left parietal ganglion
lplg — left pleural ganglion
mg — mantle gland
oes — oesophagus
on — optic nerve
p — penis
pan — parietal nerve
pdn — pedal nerve
pr — prostate gland
prm — penal retractor muscle
pu — pseudo-ureter
r — rectum
rpag — right parietal ganglion
rplg — right pleural ganglion
rs — receptaculum seminalis
sg — salivary gland
sp — spermatheca
spd — spermathecal duct
u — ureter
v — vagina
vd — vas deferens
ve — ventricle
vg — visceral ganglion
vn — visceral nerve

A REVISION OF THE GENUS *PHILINE* IN NEW ZEALAND WITH DESCRIPTIONS OF TWO NEW SPECIES (GASTROPODA OPISTHOBRANCHIA)

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Plate 3

SUMMARY

The Tertiary and Recent species of the genus *Philine* in New Zealand are reviewed. Two new species are described, one from both the Recent fauna and Pleistocene (Castlecliffian) deposits, the other only from the Castlecliffian. The other species recorded from New Zealand are re-described and photographs of the type specimens are included. Suter's type material of *Philine auriformis* contains three different species, two of the genus *Philine* and one of *Aglaja*.

INTRODUCTION

The bullomorph opisthobranchs are very poorly known biologically. Many species have been described on the basis of the shell alone, and although in some cases this is valid, it has led to much confusion amongst later workers as to what name should be given to what species. While engaged in biological studies on the group, I have collected specimens and descriptions in anticipation of a taxonomic revision of these opisthobranchs. The name *Philine auriformis* has been used for at least three different species, and although there is a common animal with a shell similar to Suter's shell description, it has a radula that differs from that of Suter's species. It was therefore decided to review the New Zealand species of *Philine*. This review has ignored the anatomy of the species involved, not because this is unimportant but because the significance of anatomical differences from species to species is still not clear. It was found that the shell, gizzard plates and radula provide sufficient differences on which to base specific descriptions.

The following abbreviations have been used in the collecting records: S.R.C. — Suter Reference Collection, Geological Survey; N.Z.G.S. — Reference number for N.Z. Geological Survey Collection; B.S. — Dominion Museum Bottom Station reference number; and M. — Dominion Museum reference collection number.

DESCRIPTIONS

Genus PHILINE Ascanius, 1772

Type species: *Bulla aperta* Linné, 1767.

Opisthobranch mollusc, usually white, large head-shield often two-thirds body length, parapodial lobes extending along both sides of body. Shell internal, ovate or subquadrate thin and fragile, smooth, spirally striate or punctate, consisting of a few loosely convoluted whorls, entirely open from below. Spire immersed, aperture very large. Gizzard plates three, calcareous, sometimes similar in shape, sometimes not. The radula formula varies from 1.0.1. to 6+1.0.1+6,; the inner laterals being of typical shape as described below for *Philine angasi*, the outer laterals are small and degenerate either as in *Philine auriformis* or as in *Philine alba* Mattox, 1958.

Philine auriformis Suter, 1909

Fig. 1 B-E, 2 P, Pl. 3, D-F, H, O.

Synonymy: *Philine angasi Hutton*, 1880: 123, *Non* Crosse and Fischer, 1865.
Philine constricta auriformis Suter, 1909.

Shell auriform, almost quadrangular, more calcified than *P. angasi*. Sculptured by spiral markings, bead-like in pattern, each separated by a wider smooth area. Growth lines visible. Colour white, spire immersed, body-whorl very large, flatly convex, open from below. Outer lip narrowly convex and projecting slightly beyond the spire above, and slightly rounded below on joining the basal lip. Basal lip oblique and straight, seldom convex, arching toward the high oblique and very thin columella. Inner lip hardly visible. Size: Lectotype, height 8.8 mm, width 7 mm. Paralectotype, height 9.2 mm, width 7.5 mm. Large specimen from Manukau Harbour, height 16 mm, width 12 mm.

Animal elongate, flattened, white to cream in colour. Orange of buccal bulb and gizzard visible dorsally. Head shield long, usually two-thirds body-length, having anterior median indentation and distinct median longitudinal groove. Posterior third of dorsum quadrangular, enclosing shell and extending ventrally on each side to enclose mantle cavity. Parapodial lobes not muscular, extending posteriorly down each side of the body from just behind the head to just beyond head-shield. The brown leaflets of Hancock's organs are visible on each side of the anterior body. Four sensory pits are situated around the mouth.

Gizzard very large, between two-and three-fifths the body length. Gizzard plates identical in shape, one lying dorsally the other two ventrolaterally. Plates spindle-shaped in outline, inner surface convex; outer face hollowed out on each side of central longitudinal flat bar, without perforations as in *Philine angasi*.

The radula contains 18 rows of four teeth, of which seven rows are functional and the other eleven replacements. Inner teeth are of typically philinid shape, having triangular basal plate extending into an incurved hook, bearing recurved denticles on inner edge. Outer row of teeth much reduced, having thin rectangular basal region, the longest side being in vertical plane, extending up into an even thinner elongate process. These teeth are neither curved nor denticulate.

Types. Lectotype and paralectotype in the New Zealand Geological Survey Coll., Lower Hutt, labelled T.M. 1192 and T.M. 1193 respectively, collected at Akaroa Harbour in 4-6 fathoms.

Collecting Records. Herne Bay, Auckland; Ngataringa Bay, Auckland; Cheltenham Beach, Auckland; Ihuamatao, Manukau Harbour, Whakatiwaiwai, Firth of Thames(coll. W.B.R.); Port Pegasus, Stewart Is. (Coll. E. Batham); Wet Jacket Arm, Resolution Is. in 12 faths. (S.R.C. 3453); Tahuna Beach, Nelson (N.Z.G.S.2186); Oneroa Beach, Waiheke Is. (N.Z. G.S.2189). It has been recorded from N.Z. Tertiary deposits (Fleming, 1966).

This species is apparently common throughout New Zealand both intertidally and in deeper water, burrowing in fine sand and sandy-mud. The author found it to feed on the bivalve *Nucula hartvigiana.* The shell and gizzard plates of a specimen of *Philine,* collected by W. S. Ayrers from 40 fathoms off Lakes Entrance, Victoria, Australia were sent to me by Mr. R. Burn, for examination. I have tentatively identified them as belonging to *P. auriformis.* Until a whole animal is available, I am not willing to positively identify this specimen and so increase this species' range to Australia.

Discussion. Following the description of the next species is an explanation of the type material of *Philine auriformis.* In this account it is suggested that Suter's description of the radula of this species was incorrect, the correct formula being 1+1.0.1+1 rather than 1.0.1. The mistake was probably the result of the poor instruments available to Suter, the outer rows of degenerate teeth being rather difficult to see.

Philine powelli sp. nov.

Fig. 2 N-O, Pl. 3, I-N.

Synonym; *Philine auriformis* Powell, 1937, et seq.; pl. 10, figure 22, *non* Suter, 1909.

Shell auriform, more calcified than in *P. angasi.* Sculptured on outer surface by strong spiral pitted grooves producing a punctate pattern. Inner surface of shell heavily glazed. Colour white, spire sunken, body whorl very large, convex and open from below. Outer lip extending beyond spire, forming a spinous process. Spine often denticulate through extension of strong spiral ridges that sculpture the upper end of the shell. Basal lip straight, sometimes oblique. Inner lip, a thin calcareous layer over the parietal wall. Size; holotype, height 8.2 mm, width 6.0 mm; paratype, height 4.8 mm, width 3.5 mm (B.S. 153).

Animal. Although only preserved animals were available for study, certain important features were visible. The animal is flatter and more muscular than *P. auriformis,* being nearer *P. angasi* in shape. Head-shield probably extends only halfway down body and parapodial lobes are thick and muscular, as in *P. angasi,* forming body into hard wedge-shaped animal. Paratype from B.S. 153, measured 6.5 mm x 5 mm. Hancock's organs and sensory pits around mouth are present.

Gizzard large, containing three identical calcareous plates. Because of partial decalcification, shape was difficult to determine. Similar to *P. auriformis* in having median bar on outer surface of plate. Radula, 14 rows, formula 1.0.1. Teeth typically philinid in shape with recurved denticles on the inner edge.

Types. Holotype; Shell deposited in Dominion Museum, Wellington, number M.7970.

Paratypes; 1; Radula, gizzard plates and shell deposited in Dominion Museum.

2; Radula and shell deposited in Dominion Museum.

The holotype was collected from B.S.143, " Kotuku " Expedition. 39° 30.5'S., 177° 06'E. Hawke Bay in 16 fathoms, collected by J. A. F. Garrick, 20 May 1952. Paratype 1 B.S.155, 39° 27.5'S., 176° 54'E., Hawke Bay in 8 fathoms, and paratype 2 B.S.153, 39° 25.5'S., 176° 58'E., Hawke Bay in 10 fathoms, also collected by J. A. F. Garrick.

Collecting Records. Paraparaumu, Wellington, R. K. Dell, 1948, Dom. Mus.Coll.; Tokomaru Bay, 45 fathoms, N.Z.G.S. 2185; Waikanae Beach, Wellington, W. F. Ponder, August 1956, Dom.Mus.Coll. M.9900; Sealers Bay, Codfish Is. coll. R. K. Dell, 5 November 1948 (Dom.Mus.Coll.) M.7879, B.S.170, off coast of Manawatu, 40° 42'S., 174° 10.6'E. " Alert " Station K, in 58 fathoms. 2 September 1951 (Dom.Mus.Coll.).

Fossil material has been found; one broken specimen (Pl.1m) N.Z.G.S. 4103. Castlecliff Section, " Tainui Zone ", Wanganui N137/353. Age; Castlecliffian Stage, Putikian Substage, coll. C. A. Fleming, 23 January 1945.

Discussion. Philine powelli has been mistakenly identified as *P. auriformis* by a number of workers. Specimens in the Dominion Museum have been so named, as has a specimen illustrated by Powell (1937 et seq.: pl. 10, fig. 22). This species was found alive in some numbers in dredgings taken in Hawke Bay by the " Kotuku " Expedition in 1952, and shells have been washed up around the Wellington area. Futher studies could show that this species is widely distributed in New Zealand. The broken shell from the collection of the N.Z. Geological Survey labelled *Philine* cf *auriformis* N.Z.G.S. 4103 is most probably a broken shell of a large specimen.

Philine teres Hedley, 1902, recorded from Tasmania (Macpherson, 1958) and New South Wales (Iredale and McMichael, 1962) is similar to this species, having the upper lip attenuated. However, from illustrations, the sculpturing and shape of the shell are quite different. The genus, *Yokoyamaia* Habe, 1950, has been erected for two Japanese species of *Philine, P. pygmaea* Yokoyama and *P. argentata* (Gould, 1860) with the latter as type species. *P. argentata* is distinguished by a dentate spine on the outer lip, as in *P. powelli.* and a plate-like fold on the parietal wall. The other species has the fold, but not the spine (Habe, 1955, 1964). The original definition of the genus *Yokoyamaia* is; " Shell like *Philine,* but with the posterior lip strongly produced and dentate. It bears a distinct fold on the inner wall and sculptures with punctate grooves. Radula formula 2.0.2, the inner marginal tooth larger than the outer; stomachal plates fusiform and brownish in colour."

I do not consider that each new combination of radula formula and shell shape should result in the erection of a new genus, and feel justified in relegating *Yokoyamaia* to the synonymy of *Philine.*

The species has been named in honour of Dr. A. W. B. Powell, who has recently retired from the positions of Conchologist and Assistant Director of the Auckland War Memorial Museum.

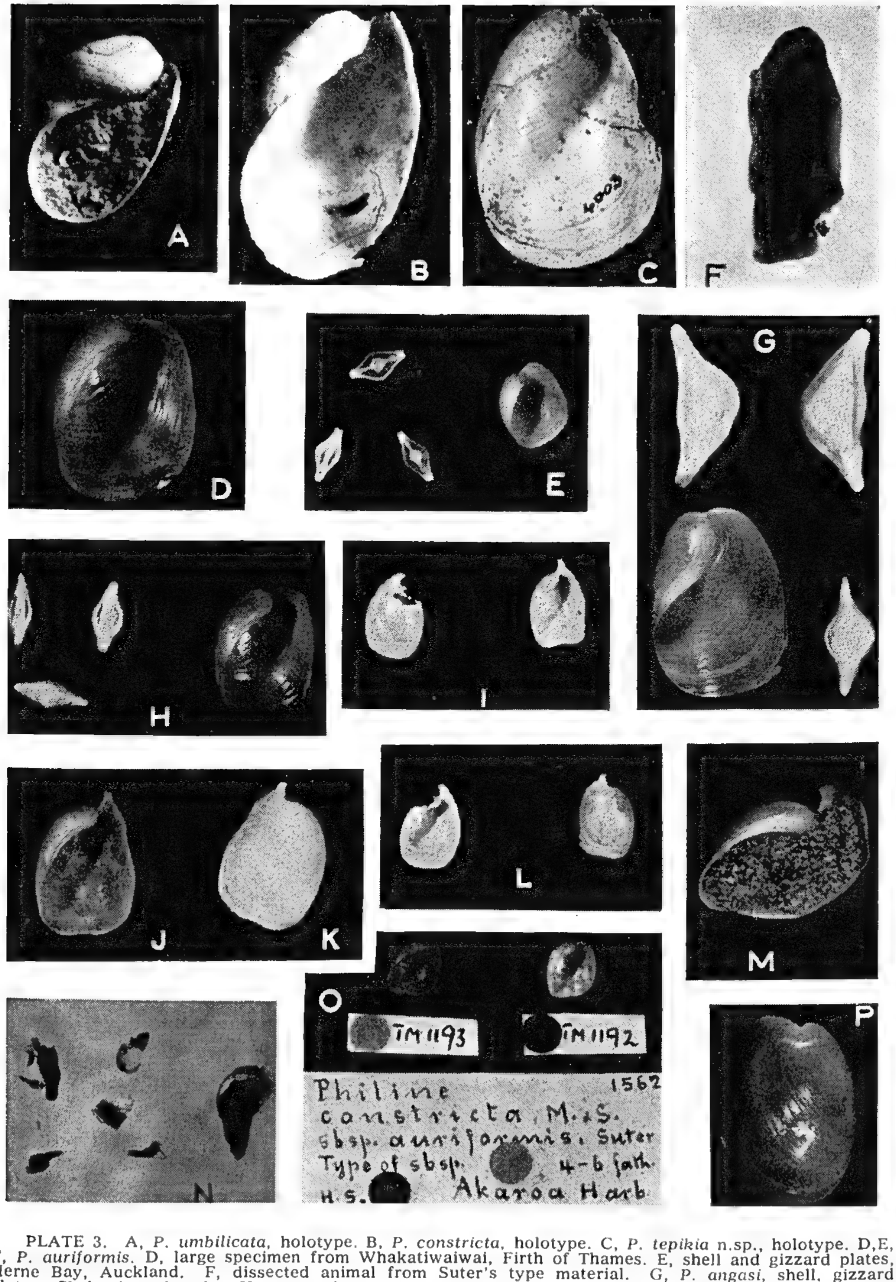

PLATE 3. A, *P. umbilicata*, holotype. B, *P. constricta*, holotype. C, *P. tepikia* n.sp., holotype. D,E, F, *P. auriformis*. D, large specimen from Whakatiwaiwai, Firth of Thames. E, shell and gizzard plates, Herne Bay, Auckland. F, dissected animal from Suter's type material. G, *P. angasi*, shell, gizzard plates, Cheltenham Beach. H, *P. auriformis*, shell, gizzard plates, Ihuamatao, Manukau Harb. I - N, *P. powelli* n.sp. I, L, paratype 1 on right, paratype 2 on left. J, K, holotype. M, fossil. N, dried animals of *P. powelli* from Suter type series of *P. auriformis*. O, *P. auriformis*, lectotype (right), paralectotype (left). P, *P. angasi*, shell, Cheltenham Beach.

THE SUTER TYPE SERIES OF *PHILINE AURIFORMIS*

Suter's type series of *P. auriformis* presents an example of the confusion that can be caused when a holotype is not chosen by the original author. This material was kindly lent to the author by Dr. C. A. Fleming from the collection of the N.Z. Geological Survey. It was in two parts; the first was in a plastic box which contained two tubes, both labelled 1562, and the smaller contained three gizzard plates, labelled (no doubt by Suter) " stomach plates ". The larger tube contained two shells one apparently from a live animal and labelled with a card bearing T M 1192 and a red spot. The other is discoloured and was probably collected dead. It has a card bearing T M 1193 and a green spot. These two shells have previously been selected as lectotype and paralectotype respectively (Boreham, 1959). The shape of these shells and the dimension of the lectotype are similar to the shell originally described by Suter. No radula mount was available.

The second part of the type series was in a bottle bearing a label similar to that on the plastic box (Pl. 3, O). In this were a number of dried up animals which were partially reconstituted by detergent. There were three different specis of opisthobranch in this material:

(i) One animal (approx. 16 x 5 mm) in which the buccal bulb, radula and shell were missing. This carcase is probably the specimen from which Suter obtained the radula, gizzard plates and shell of the lectotype, (Pl. 3, O).

(ii) Two complete animals and parts of three others of *P. powelli* n.sp., (Pl. 3, N).

(iii) Three complete animals of *Aglaja lorrainae* Rudman, 1968.

Philine powelli and *auriformis* are distinguished by the shape of the shell and the radula formula. Suter's description of *P. auriformis* was of a species with a radular formula 1.0.1, and a shell without a spine on the upper lip. However the only species found in New Zealand with this type of shell has a radular formula 1+1.0.1+1. *P. powelli* has a radular formula of 1.0.1. It is possible that Suter described *auriformis* from the shell of one species and the radula of another. As the shell chosen as the lectotype is easily recognised from Suter's description, it must stand. *P. auriformis,* as redescribed above, differs from the original description as far as the radula is concerned. Suter probably dissected only one animal and was mistaken with the radula.

Suter's mistake is readily explained; all the animals are white, with internal shells, and were possibly taken in a single dredge haul in Akaroa Harbour. If the first animal he dissected had a shell similar to the dead shell he also collected (the paralectotype), he probably saw no need to dissect any more animals. This material also extends the range of the recently described *Aglaja lorrainae* from Nelson to Akaroa Harbour. The specimens from the Suter type series have been separately labelled and are deposited in the collection of the New Zealand Geological Survey, Lower Hutt.

Philine constricta Murdoch and Suter, 1906

Pl. 3, B

Shell small, thin, convolute, imperforate, spirally grooved, auriform, slightly contracted above. Sculpture of shallow, fine spiral grooves, with

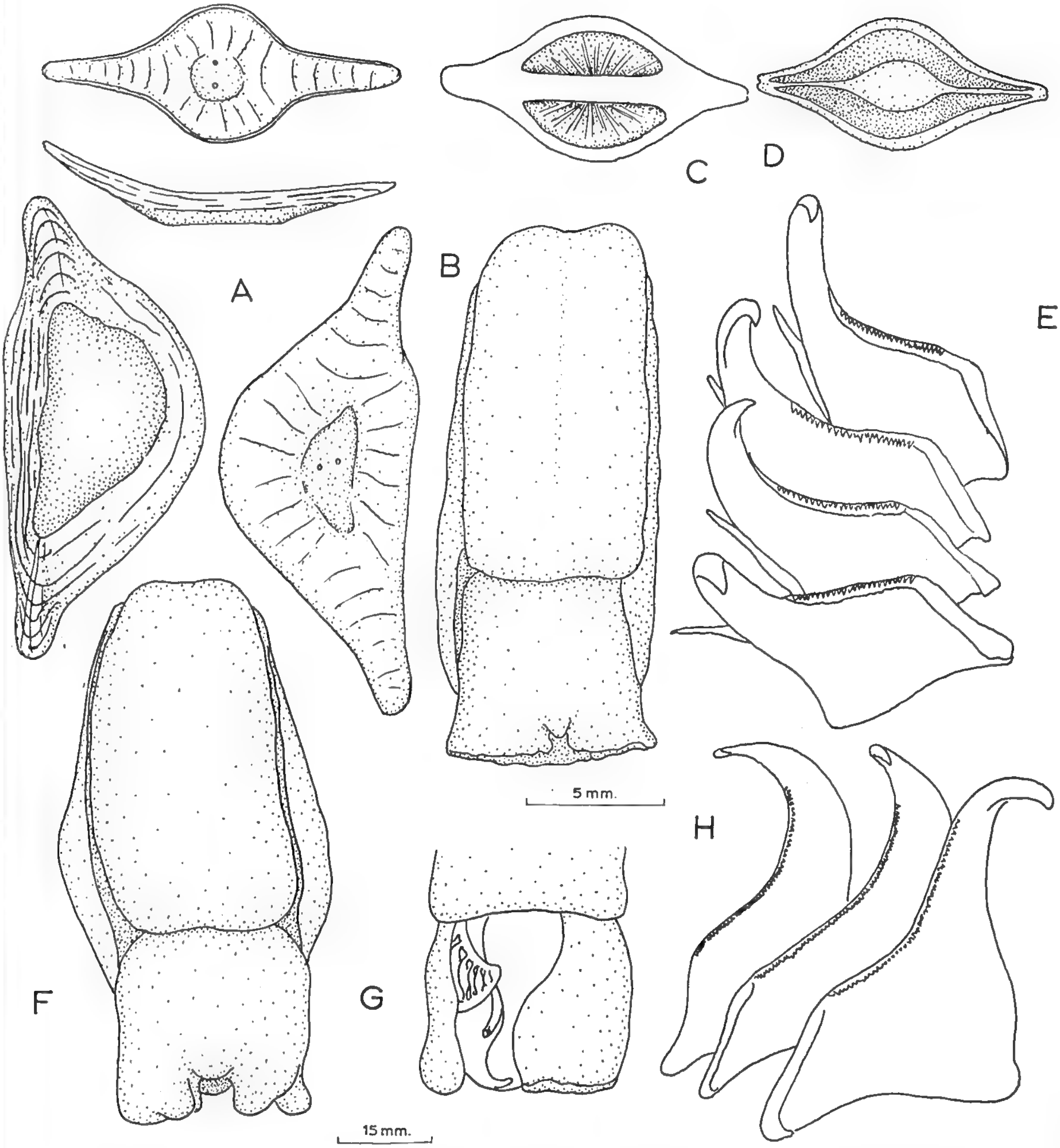

Figure 1. A, F - H. *P. angasi.* A, gizzard plates. F, animal. G, ventral view of mantle region. H, radula. B-E, *P. auriformis.* B, animal. C, outer side of gizzard plate. D, crushing side of gizzard plate. E, radula.

broader bands between, crossed by irregularly arranged growth lines. Colour white. Whorls one and a half, very rapidly increasing, the last very large, contracted below the vertex. Aperture elongately oval, acuminate above. Outer lip slightly convex, lower or basal lip regularly rounded. Inner lip forming a broadly spread callosity upon the parietal wall. Size of the holotype; height 5 mm, width 3 mm.

Type. The holotype is in the Dominion Museum, Wellington, M.1720, taken from off Great Barrier Island in 110 fathoms.

Collecting Records. The following specimens are deposited in the Dominion Museum M.10630, Chatham Rise; M.2793, off North Cape; M.2794, East end of Hen and Chicken Is., Hauraki Gulf; M.12379, Petre Bay in 94 fathoms, Chatham Is. It is recorded from N.Z. Tertiary (Fleming, 1966).

Discussion. This species has yet to be found alive. The above description is essentially that of the original authors. The species is quite distinct from any other yet described and approaches *Scaphander* is general shape.

Philine umbilicata Murdoch and Suter, 1906

Fig. 2L, Pl. 3, A.

Shell small, oval and truncate above, umbilicated. Sculpture inconspicuous, distant fine microscopic lines crossed by irregular and often raised growth lines. Colour white. Spire slightly immersed. Whorls two, very rapidly increasing, the last truncated above, rounded at the base, narrowed and flatly convex above. Aperture elongately oval, slightly excavated above the body whorl, broad and open towards the base. Outer lip thin, sometimes straight, usually concave for the upper half then forming a regular arch with the convex basal lip. Inner lip forming a rather broad but thin callosity upon the parietal wall. Umbilicus very distinct, formed by gap between parietal wall and columella. Size of holotype; height 3.5 mm, width 2.25 mm.

Type. The holotype, deposited in the Dominion Museum, Wellington, M.1721, was dredged from 110 fathoms off Great Barrier Island.

Collecting Records. Two specimens are deposited in the collection of the Geological Survey: N.Z.G.S.55, 110 fathoms off Gt. Barrier Is., coll. H. Suter; N.Z.G.S.2190, Daggs Sound in 58 fathoms (New Golden Hind Expedition, No.80). It is recorded from N.Z. Tertiary (Fleming,1966).

Discussion. This species has seldom been collected and as far as is known, no live animals have been collected. As the original authors stated, this species is distinguished by the almost total lack of spiral sculpture and the presence of a distinct umbilicus, which is an exception in the genus.

Philine angasi (Crosse and Fischer, 1865)

Fig. 1A, F-H. Pl. 3, G, P.

Shell fragile and thin, ovately subquadrate. Whorls 1½, the last very large and open, sides of penultimate whorl almost parallel. Spiral sculpture not visible, but growth lines clear. Inner lip a calcification over the parietal wall. Size of shell; to 40 mm in length (Macpherson and Gabriel, 1962). Specimen from Cheltenham Beach measured 25 mm x 18 mm.

Animal white, roughly diamond-shaped, the parapodial lobes thick and muscular; anterior body cavity occupying only relatively small volume of body. Animal flat, having two brown sensory regions above the mouth and two below it. Hancocks organs present, but not easily visible.

Gizzard large, with three plates each of a different shape, the shapes and position of each being constant within the species. Two plates are large and mirror images of each other, triangular, the long side being either straight or slightly concave, the other sides being equal and slightly convex. One of these plates is mid-dorsal, the other occupying a right ventro-lateral position. The third plate is smaller and is placed left ventro-laterally. This plate is symmetrical and spindle-shaped. The plates have a convex inner and a concave outer surface. At the centre of the outer surface of each are two small holes.

Radula formula 1.0.1., teeth of typically philinid shape, having a broad slightly curved base and rising to a recurved point. The inner edge of each tooth is incurved and bears minute denticles. Normally eleven functional rows of teeth and fourteen rows in the radular sac. The very small size of the radula of this species, relative to the size of the buccal bulb, indicates that in this species the radula is of little use in feeding.

Type. The type and its whereabouts are not known. Iredale and McMichael (1962) suggest that the type locality is St. Vincent Gulf, South Australia.

Collecting Records. New Zealand: Paua Bay, Parengarenga Harbour; Whakatiwaiwai, Firth of Thames; Cheltenham Beach, Auckland. Australia: Southern Queensland, New South Wales, Victoria, Tasmania, South Australia, and southern Western Australia (Macpherson & Gabriel, 1962; Burn, 1966A; 1966B).

Discussion. This species is common in southern Australia and not uncommonly found at times in northern New Zealand. Found burrowing on sand-flats and sandy-mud flats, feeding on small bivalves (*Chione* in New Zealand).

Philine tepikia sp.nov.

Fig. 2M, Pl. 3, C.

Shell white, more calcified than *P. angasi,* but similar in outline, having rounded basal lip. Inner lip and inner whorls occupying upper left quarter of shell whereas in *P. angasi* inner lip extends into lower left quarter. Spire slightly sunken, pit so-formed sculptured with deep spiral ridges (Fig. 2M). Growth lines irregular but often very distinct, forming transverse ridges accross outer surface of the shell. Irregularly and widely spaced, deep spiral grooves present on upper half of body whorl. Size of type; height 29.5 mm, width 22 mm.

Types. The holotype is deposited in the collection of the N.Z. Geological Survey. N.Z.G.S. 4003. It was collected from Landguard Sand, Landguard Bluff (below road junction, 16 chains at 90° from Landguard Trig.),

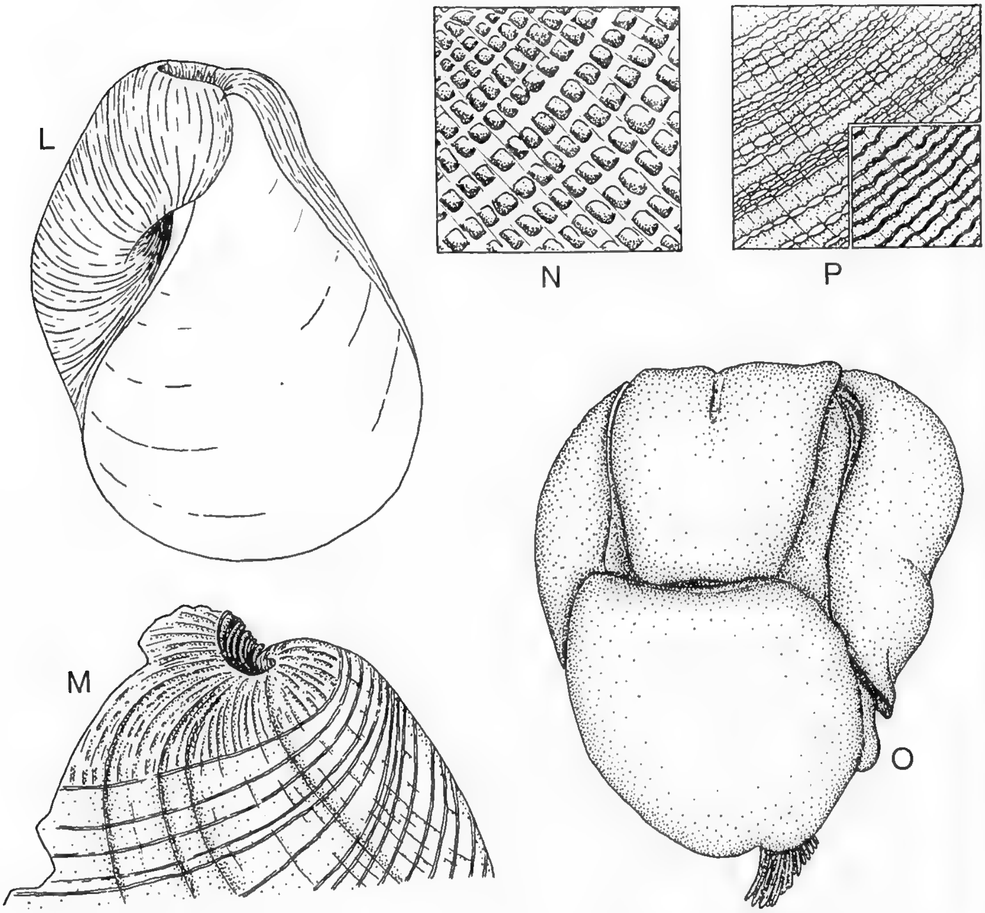

Figure 2. L, *P. umbilicata*, 58 fathoms, Daggs Sound. M, *P. tepikia* n.sp., holotype, showing sculpturing of shell. N - O, *P. powelli* n.sp. N, sculpturing of shell. O, animal of paratype (preserved). P, *P. auriformis*, sculpturing of shell, (inset, sculpturing of large shell).

Wanganui, N138/394; age: Castlecliffian Stage (Putikian Substage); Collected by C. A. Fleming, A. C. Beck, 16 January 1945.

The paratype is deposited in the reference collection of the Geology Department, University of Auckland, Palaeontology Catalogue No. G 5868. It is a broken shell collected from the Te Piki Shellbed, N62/505, 5-7½ feet above the main road, M. Chapman-Smith, 1968; age: Castlecliffian.

Discussion. This fossil species is known from only three broken specimens. *Philine columnaria* Hedley & May, 1908, a recent species from Australia is also spirally sculptured. However the general shape of the shell and the extent of the sculpturing is quite different (Burn, 1969).

CONCLUSION

The genus *Philine* is widespread, species being found from tropical to polar regions. They commonly burrow in soft sediments from the inter-tidal zone to the benthic regions. All species so far studied are active carnivores ingesting and crushing hard-shelled bivalves, gastropods, worms and foraminiferans. *Philine aperta,* a European species ingests its prey, the tube worm *Pectinaria,* by everting the buccal bulb and grabbing with the now external radula (Hurst, 1965). Variations of this process have been found in two New Zealand species, *P. auriformis* sucking in *Nucula* without everting the buccal bulb, and *P. angasi* ingesting the bivalve *Chione,* with its everted buccal bulb. In the latter species the radula is small and degenerate and of no functional significance (Rudman, 1967). The family Philinidæ contains a number of doubtful genera, each with slight anatomical or shell differences. A comparative study of the anatomy of this group was not possible at this stage and, until this is done, one cannot discuss the relationships of the New Zealand species either to one another, or to other species described.

ACKNOWLEDGEMENTS

I wish to thank the many people who have made available material for study; these include Dr. W. F. Ponder, formerly of the Dominion Museum; Dr. E. J. Batham, Portobello Marine Station; Dr. C. A. Fleming, N.Z. Geological Survey; Dr. M. C. Miller, Zoology Department, University of Auckland; Mr. M. Chapman-Smith, Geology Department, University of Auckland, and Mr. R. Adams. I also wish to record my gratitude to Dr. M. C. Miller for his continued interest and encouragement in what has become a lengthy research project.

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THE VALIDITY OF THE GENERA *LISSARCA, AUSTROSAREPTA, CRATIS* AND *DENTICOSA*, WITH NOTES ON SOME AUSTRALIAN SPECIES (BIVALVIA, PHILOBRYIDAE)

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SUMMARY

The genera *Austrosarepta* Hedley, 1899, and *Denticosa* Iredale, 1930, are considered to be synonyms of *Lissarca* E. A. Smith, 1877, and *Cratis* Hedley, 1915, respectively. A colour variety of *Lissarca elliptica* (Laseron, 1953) and a new species, *Cratis delicata*, are described and figured.

DESCRIPTIONS

Lissarca and *Austrosarepta*

Hedley (1899) proposed the genus *Austrosarepta*, type species *A. picta* Hedley (1899), and placed his new genus in the subfamily Sareptinæ Dall (Nuculaceæ). Later, in 1908, he stated that *Austrosarepta* was a synonym of *Lissarca* E. A. Smith, 1877, (type species *L. rubrofusca* E. A. Smitn, 1877.), and transferred this genus to the family Limopsidæ. Cotton and Godfrey (1938), apparently having overlooked Hedley's withdrawal of *Austrosarepta*, independantly concluded its synonymity with *Lissarca* Smith and also placed the genus in the family Limopsidæ.

Iredale (1930), in his fashion, revived *Austrosarepta* with the comment " as more material and study of Antarctic material shows this genus to differ materially from, though superficially resembling, the Antarctic and Subantarctic *Lissarca*." Following this revival, Laseron (1953) and Crozier (1966) maintained *Austrosarepta* as a good genus, but neither discussed its taxonomy. Iredale and McMichael (1962) listed it as a member of the family Limopsidæ, without comment.

Iredale did not mention by what characters *Austrosarepta* could be separated from *Lissarca*. Powell (1933) suggested that the main differences were to be found in the form of the resilium (narrow and oblique in *Lissarca*, broadly triangular in *Austrosarepta*) and the structure of the ligamental area (smooth in *Lissarca*, vertically striated in *Austrosarepta*). From the comparison of *A. picta* Hedley (1899) and *A. elliptica* Laseron (1953) from New South Wales with *L. rubricata* Tate (1886) and *L. rhomboidalis* Verco (1907) from South Australia and Victoria, it appears that these four species are indisputably congeneric. The form of the ligamental pit is, however, different in each species, due to the direction of the anterior pit margin. In *A. elliptica* it points forwards, in *L. rubricata* downwards, and it is always more vertical than the posterior pit margin which runs rearwards. That the pit is more or less oblique is most evident in *A. picta;* moreover, it can be narrow *(L. rubricata)* or rather broad *(A. elliptica)*. At any rate its form is not constant and therefore should not be considered a useful generic character.

With regard to the rows of vertical striae at each side of the resilium, I found these to be present in specimens of *L. rubrofusca* E. A. Smith (1877) from Heard Island, narrow but distinct in juvenile and difficult to

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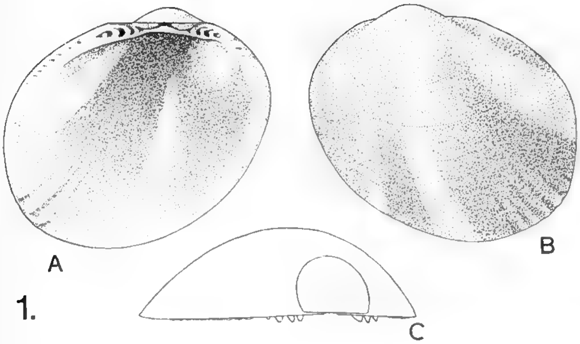

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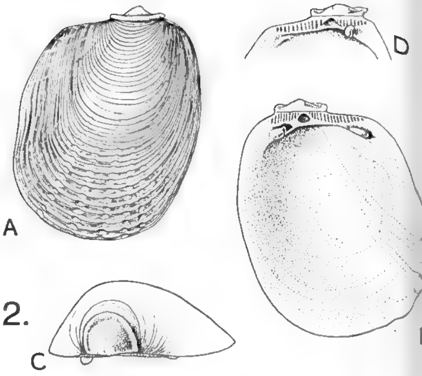

Figure 1 a - c, *Lissarca elliptica* (Laseron), colour variety;

Figure 2 a - d, *Cratis delicata* sp. nov.; a - c, holotype; d, paratype. (Drawings by the author).

trace in adult shells. As each of the four Australian species has the hinge features, sculpture and adductor scars corresponding with the original description and figures of *L. rubrofusca,* and with the specimens from Heard Island, it follows that they are correctly placed in *Lissarca* and that *Austrosarepta* is a synonym.

Dell (1964) located *Lissarca* in the family Philobryidæ, and with some reservations (Nicol, 1966), I agree with this placement.

Lissarca elliptica

Lissarca elliptica (Laseron, 1953) has been described from uniformly brownish coloured shells. Two big samples, dredged in 64 m and 80 m off Cronulla (collections Rijksmuseum van Natuurlijke Historie, Leiden, and Zoölogisch Museum, Amsterdam, both in The Netherlands) and some small samples from other localities in New South Wales contain almost only valves with broad, more or less reddish brown, radiating bands. The alternating colour is whitish. One of these valves has been figured (Fig. 1a-c). One valve from Point Halliday (collection Van der Slik, Rotterdam, The Netherlands) measures 3.3 mm in length and 3.0 mm in height and has four anterior and five posterior teeth. The species is very closely related to *Lissarca rubricata,* but seems to be more elongate and to have relatively less heavy hinge components. The ventral margin in almost all the valves that I have seen lacks the coarse crenelation that is often, but not always, present in *rubricata.*

Cratis and *Denticosa*

When describing *Philobrya cuboides* from Backstairs Passage and Spencer Gulf, South Australia, Verco (1907) doubted this generic location as his species differed from other *Philobrya* species in possessing true teeth. Hedley (1915) erected the genus *Cratis* for species closely related to *Philobrya* which have massive divaricate cardinal teeth in the adult shell. Next to the types species, *C. progressa* Hedley (1915) from 100 fathoms, north-east of Port Macquarie, New South Wales, Hedley included

P. cuboides Verco (1907). Iredale (1930) proposed the new generic name *Denticosa* for *Philobrya cuboides,* " the strong teeth developed being sufficient to define the genus ". A study of Hedley's descriptions of the genus *Cratis* and its type species, and comparison of *Philobrya cuboides* with *Cratis progressa* (two paralectotypes, Australian Museum, Sydney, Australia, no. C. 37760) and *C. delicata* described below indicate that *P. cuboides* answers well the conception of *Cratis.* This species should therefore be placed in *Cratis,* and *Denticosa* reduced to synonymy of the latter.

Cratis delicata sp.nov.

Fig. 2a-d

Description: Shell of medium thickness, transparent white, convex, high, in outline a parallelogram with weakly curved sides and strongly rounded angles, equivalve. Prodissoconch distinct, raised in the centre, with a projecting rim. Valves with a concentric sculpture of irregular rounded ribs with concentrically striated interstices. These ribs are hardly developed in the top half and well developed and more regular in the lower half. From the ventral margin about seven radial rows of pits run halfway the valve into the direction of the umbo. The ventral margin is very slightly waved according to these rows. The nontransparent white pits are situated in the interstices of the concentric ribs, that are narrowed by them. The rows towards the posterior end are best developed. The posterior valve end shows a weak radial depression, that may cause a weak incurvation of the margin. Between this depression and the posterodorsal margin some indistinct radial striæ can be observed.

The hinge consists of provincular crenulations and real teeth. The vertical crenulations are divided in two rows, one at either side of the small, triangular ligamental pit. In both valves there is one strong anterior and one weaker, almost horizontal posterior tooth. The anterior tooth in the right valve falls in front of that in the left valve.

There is only a rather distinct posterior muscle scar. The radial area between the umbo and this scar is nontransparent white. From two to four interior, radial ribs start from the lower posterior margin to become weaker and vanish on their way to the umbo, the most ventral one first. The remaining parts of the inner margin are smooth.

Type material: Holotype, a single right valve, Rijksmuseum van Natuurlijke Historie, Leiden, The Netherlands, collection no. 8450; paratypes, three right and two left valves, same collection, no. 8451. Holotype and paratypes were taken from shell sand, collected by Mr. J. Voorwinde at the beach of Narrabeen, New South Wales, Australia, in 1961.

Measurements: Holotype, length 1.0 mm, height 1.3 mm and section 0.4 mm. Paratypes not much different.

Discussion: Hedley did not give details of the outer sculpture of *Cratis progressa.* The following notes are based on two paralectotypes of the species. *C. progressa* has threadlike concentric ridges with depressed interstices. The ridges seem to represent growth stages. The depressions gradually decrease in depth towards the next ridge at their ventral side. This system of concentrics is crossed by radial ribs that are broader and more pronounced, but interrupted by the concentrical depressions. The interior margin shows about ten anteroventral and five posteroventral denticulations that are the distinct endings of less distinct, interior radial ribs. *C. delicata* differs from *progressa* in the much smaller prodissoconch (the dorsal margin of the prodissoconch measures less than 0.3 mm in *delicata* and more than 0.7 mm in *progressa*), in exterior sculpture features and in the absence of interior anteroventral marginal crenelations. In *progressa*, moreover, the posteroventral marginal crenelations are situated next to the muscle scar instead of under it as in *delicata*.

ACKNOWLEDGEMENTS

I am greatly indebted to Dr. B. J. Smith, Curator of Marine Invertebrates, National Museum of Victoria, Melbourne, for presenting a sample of *Lissarca rubrofusca* from Heard Island, and to Dr. W. F. Ponder, Curator of Molluscs of the Australian Museum in Sydney, for selecting and sending me the paralectotypes of *Cratis progressa*, to serve for the present study.

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TAXONOMIC POSITION OF *LIPPISTES PEHUENSIS* MARWICK, WITH A REVIEW OF THE SPECIES OF *CONCHOLEPAS* (GASTROPODA, MURICIDAE)

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Plate 4

SUMMARY

Lippistes pehuensis Marwick, 1926, placed in *Hartungia* Bronn (Janthinidae) by recent workers, is transferred to *Concholepas* Lamarck (Muricidae) on the basis of its resemblance to the Australian Miocene *C. antiquata* Tate, 1894. *C. antiquata* Tate is redescribed, and other species of *Concholepas* are briefly reviewed.

INTRODUCTION

The gastropod species described as *Lippistes pehuensis* by Marwick (1926: 319, pl. 73, figs. 6, 8) has had a chequered nomenclatural history since its erection. Finlay (1927: 396) placed it in his new genus *Zelippistes*, but the lack of relationship to *Zelippistes benhami* (Suter) (see Dell and Ponder, 1964) is obvious. Later Finlay placed the species in *Heligmope* Tate, considered by Tate to be a naticid but by Finlay to be a janthinid. Finlay had placed *Turbo postulatus* Bartrum in *Heligmope* earlier in the same paper, and noted its close resemblance to the Australian Pliocene *Heligmope dennanti* Tate. Late in the paper he commented: " .... *Heligmope postulatus* (Bartrum) seems to have an ancestor in New Zealand in *Lippistes pehuensis* Marwick .... This has the same sculpture and basal sinus, but the spire is so much lower as to be sunk below the body whorl, so that the shape of *Lippistes* is simulated" (Finlay, 1931: 5). Later Fleming (1953: 135) synonymised *Heligmope* with *Hartungia* Bronn [1861], based on a species from the Azores, retaining *pehuensis* in *Hartungia* and *Hartungia* in the Janthinidæ. Thus in the current list of New Zealand Cenozoic Mollusca (Fleming, 1966: 49) *pehuensis* is maintained as a species of *Hartungia*, in the Janthinidæ.

Chance examination of a specimen of *Concholepas antiquata* Tate in the Dennant Collection, National Museum of Victoria, with Mr. T. A. Darragh, during September 1969, immediately suggested a much closer relationship between *Lippistes pehuensis* Marwick and *Concholepas antiquata* than between *Lippistes pehuensis* and *Hartungia*. This led to more detailed comparison of specimens, confirming the relationship with *Concholepas* to my satisfaction. This note formally transfers *Lippistes pehuensis* Marwick to *Concholepas* Lamarck (Muricidæ, Suborder Neogastropoda) and removes it from *Hartungia* Bronn (Janthinidæ, Suborder Heterogastropoda), and lists the species of *Concholepas* of the world that I have been able to trace.

TAXONOMY

Family Muricidæ

Subfamily Thaidinæ

Genus *Concholepas* Lamarck, 1801

1801. *Concholepas* Lamarck, *Systéme des Animaux sans Vertèbres:* 69. Type species (by monotypy): *Concholepas peruviana* Lamarck, 1801 (= *Buccinum concholepas* Bruguière, 1789), Recent, western South America.

1847. *Conchopatella* "Chemnitz" Herrmannsen, *Indicis Generum Malacozoorum primordia* 1: 291 (*genus caelebs*, stated to be a synonym of *Concholepas Lamarck;* type species, here designated and here placed in the genus, *Conchopatella concholepas* = *Buccinum concholepas* Bruguière, 1789).

Concholepas pehuensis (Marwick, 1926)

Pl. 4, fig. 1-3

1926 *Lippistes pehuensis* Marwick, *Trans. N.Z. Inst.*, 56: 319, pl. 73, fig. 6, 8.
1927 *Zelippistes pehuensis.* Finlay, *Trans. N.Z. Inst.*, 57: 396.
1931 *Heligmope pehuensis.* Finlay, *Trans. N.Z. Inst.*, 62: 5.
1953 *Hartungia pehuensis.* Fleming, *Aust. Jl Sci.*, 15: 135.
1966 *Hartungia pehuensis.* Fleming, *Bull. N.Z. Dept. Scient. Ind. Res.*, 173: 49, pl. 80, fig. 948, 950.

" Shell large, subdiscoidal, inflated, test thin. Spire scarcely projecting, surpassed but not involved by body. Whorls convex; body-whorl increasing rapidly in size, with narrow umbilicus. Suture impressed. Sculpture of about 13 broad very low spirals, absent on umbilical area, and becoming obsolete round aperture, crossed by numerous waved fairly strong growth-ridges. Aperture subcircular, dilated, adhering to parietal wall, with a well-marked sinus well out on lower margin; on early part of body this sinus forms low ridge bounding umbilicus " (Marwick). Apart from the sculptural details, Marwick's description would apply almost equally well to any of the fossil species of *Concholepas*.

Concholepas pehuensis is known only by the holotype, a slightly incomplete shell from GS1144, 60 chains west of Pehu Trig. Station, Okoko Road, Upper Waitara Survey District, North Taranaki (Tongaporutuan, Upper Miocene), lodged in the New Zealand Geological Survey (TM4494).

The upper part of the aperture of the holotype is partly broken away; the remaining posterior part of the last whorl bears a low, indistinct ridge, stronger than that in *C. concholepas* (Bruguière) but considerably weaker than that in *C. antiquata* Tate. The sinus ridge described by Marwick is in fact a fasciolar ridge, formed by the normal neogastropod siphonal notch in the anterior edge of the aperture; it is present in all species of *Concholepas*, but considerably more weakly developed in *C. pehuensis* than in the other species. The large, flaring aperture, the small spire, the narrow umbilicus (absent in *Hartungia*), the presence of a fasciolar ridge and smooth fasciolar-umbilical area, and the presence of a low posterior ridge clearly show that *pehuensis* belongs in *Concholepas*. The position of the spire about a third of the way down the inner lip and the very broadly flaring aperture cause a greater resemblance to *C. deshayesi* Rambur, from the Miocene of France, than to *C. antiquata;* the spire is close to the top of the aperture in *C. antiquata* and all other species. The sculpture of low, broad, indistinct, slightly rounded spiral ribs with linear interstices and no interstitial threads is highly distinctive. *Concholepas antiquata* and *C. deshayesi* have almost identical, relatively narrow, low, spiral cords with one to three low, broad threads filling each interspace, whereas the South American fossil and living species have relatively narrow, well-raised, widely spaced, nodulose spiral cords.

It is interesting to note that Marwick himself first suggested the relationship of *Lippistes pehuensis* to *Heligmope postulatus* (Finlay, 1931: 5). Dr. Marwick has informed me (pers. comm.) that the holotype of *Concholepas pehuensis* was the basis of his record (Marwick, 1931: 40) of "*Turbo*" *postulatus* from "the Taranakian beds of North Taranaki". Both Marwick and Finlay were influenced in this opinion by the close resemblance of the sculpture of *C. pehuensis* to that of species of *Hartungia.*

Concholepas antiquata Tate, 1894

Pl. 4, fig. 4-9

1894 *Concholepas antiquata* Tate, *Proc. R. Soc. N.S.W.*, 27: pl. 20, fig 2.

The species has not been fully described previously. The shell is of small to medium size and very thin compared to that of *C. concholepas,* with a low spire reaching the same level as the top of the aperture or sunken slightly below it, so that it is very small in proportion to the last whorl. The last whorl is moderately to very greatly expanded, particularly over the last half-whorl, so that the aperture is very large, occupying almost the whole ventral surface of the shell. The sutures of the spire are deeply incised. The inner lip is smooth and thin, and reflected slightly over the parietal region and spire. The interior of the outer lip of some specimens bears low spiral ridges and grooves, corresponding respectively to the grooves and ridges of the external sculpture. A weak posterior sinus in the top of the aperture forms a relatively very prominent rib around a slight shoulder near the spire, and the only sculpture between the rib and the upper suture consists of low, irregular growth folds crossed by fine, ill-defined spiral threads. A well-marked anterior siphonal notch at the base of the aperture forms a very prominent fasciolar rib curving regularly from the base of the spire to the basal tip of the shell, marking off a narrow, deep umbilical chink beneath the spire and an unsculptured area between the fasciole and the inner lip. Between the posterior and anterior ridges the sculpture consists of low, irregular growth folds crossed by 12 to 24 low, broad, slightly round-topped spiral cords. Usually there is one broad, flat-topped thread filling each spiral interspace, but in some interspaces there are no threads (so that the primary cords are separated by a linear groove) and in others there may be up to three. The proportion of width to height varies greatly, so that in some specimens (in apertural view) the spire protrudes well to the left, the fasciolar rib and umbilicus are prominent, and the aperture is greatly expanded to the right (as in the specimen figured in Pl. 4, fig. 4-6). At the opposite extreme the spire, fasciole and umbilicus are scarcely visible in apertural view and the outer lip is relatively very little expanded (as in the specimen figured in Pl. 4, fig. 7-9).

Tate (1894: 171) compared the species with *C. concholepas* only, being unfamiliar with *C. deshayesi* Rambur (although he knew of the species name). However, *C. antiquata* is much more similar to *C. deshayesi* than to *C. concholepas.* To judge from the available figures of the French species, the only significant difference between C. *antiquata* and C. *deshayesi* is that the spire is situated markedly lower down the inner lip in C. *deshayesi* than it is in C. *antiquata* and resembles that of C. *pehuensis*.

Tate recorded his two specimens of C. *antiquata* from G. B. Pritchard's collection, from " the clays at Mornington, Port Phillip Bay, and in the calcareous sands at Muddy Creek, Hamilton ", and noted that they extended the range of the genus to the Eocene. The rocks at both localities mentioned by Tate are now known to be of Balcombian age. The Balcombian is correlated with the Helvetian (Middle Miocene) of Europe (Ludbrook, 1967: fig. 2), and *Concholepas* is not known before the Middle Miocene.

Dr. Mary Wade, Department of Geology and Mineralogy, University of Adelaide, has informed me (*in litt.*, 30.9.1969) that both the paratype from Muddy Creek, and the holotype (i.e. figured syntype), labelled " Schnapper Point " in Tate's hand-writing, are present in the Tate collection, lodged in the University of Adelaide. Mr. T. A. Darragh has informed me (*in litt.*, 9.10.1969) that Tate's usage of the term " Schnapper Point " is almost always synonymous with the locality now known as Fossil Beach, Balcombe Bay, Mornington, to judge from material in recent collections; in a few cases specimens labelled " Schnapper Point " came from Grice's Creek. As Tate (1894: 171) published the locality as Mornington, and as *Concholepas antiquata* has been recollected several times at Fossil Beach but never at Grice's Creek (see localities below), there can be little doubt that the holotype came from Fossil Beach, Mornington, and not from Grice's Creek.

In J. Dennant's personal copy of Tate's paper, held at the National Museum of Victoria, a note in the margin states that the specimen from Muddy Creek was collected by Dennant, and not by G. B. Pritchard. Thus either the " paratype " in the University of Adelaide could have been collected by Dennant rather than by Pritchard, or the National Museum of Victoria specimen in Dennant's collection could be Tate's paratype, and the Adelaide University specimen from Muddy Creek added after 1894. Apparently Tate frequently added material to his tablets (T. A. Darragh, pers. comm.); and the two Adelaide specimens, while both labelled in Tate's handwriting, were probably labelled at different times as their labels are in different inks (Dr. Mary Wade, pers. comm.). It is unlikely that this minor point will ever be resolved.

Nine specimens of *Concholepas antiquata* are held in the National Museum of Victoria: one in the Dennant Collection from Muddy Creek, Hamilton, Victoria (Balcombian; P26911); one in the F. S. Colliver Colln., from Mornington, Balcombe Bay, Port Phillip (Balcombian); three incom-

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PLATE 4.

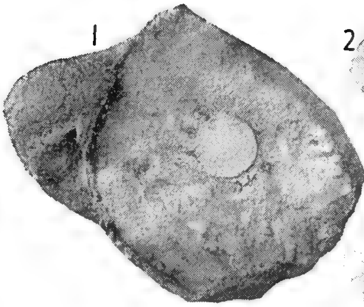
Fig. 1-3. *Concholepas pehuensis* (Marwick), holotype, ventral, apical and dorsal views. GS1144, Okoko Road, North Taranaki, New Zealand, Tongaporutuan (Upper Miocene); N.Z. Geological Survey, TM4494; 35.0 X 28.0 mm.

Fig. 4-6. *Concholepas antiquata* Tate, ventral, apical and dorsal views. Clifton Bank, Muddy Creek, Hamilton, Victoria, Balcombian (Middle Miocene); Dennant Colln., National Museum of Victoria, P26911; 39.6 X 39.4 mm.

Fig. 7-9. *Concholepas antiquata* Tate, ventral, apical and dorsal views. Fossil Beach, Mornington, Victoria, Balcombian (Middle Miocene); National Museum of Victoria, P5298; 28.6 X 23.6 mm.

Fig. 10-12. *Concholepas concholepas* (Bruguiere), young specimen; ventral, apical and dorsal views; beach shell, Chepu, west coast of Chiloe Island, Chile; N.Z. Geological Survey, WM7702; 38.9 X 30.4 mm.

(All figures approx. X 1.5).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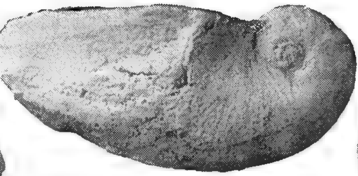
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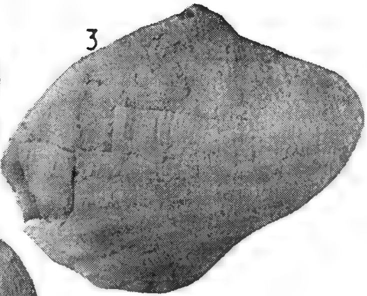
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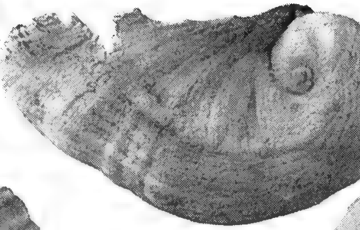
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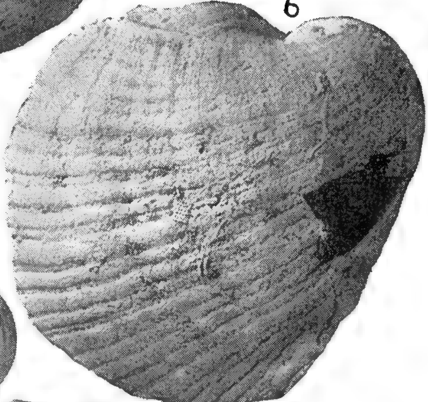
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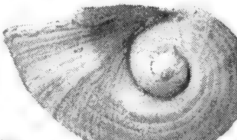
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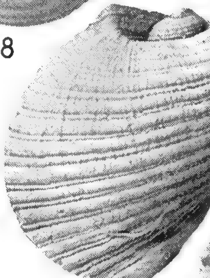
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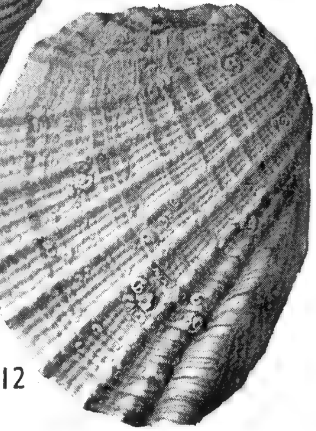
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plete in the G. B. Pritchard Colln., from Muddy Creek; one in the W. Kershaw Colln., from Balcombe Bay (P4983); one with no data other than " Balcombe Bay " in F. Chapman's collection of comparative material (P5298); one excellent specimen from Balcombe Bay presented by Mr. R. Ferguson, 22.10.1969 (P26907); and one in the F. A. Cudmore Colln., from Balcombe Bay (P24868). The specimen in J. Dennant's collection from Muddy Creek is the most broadly expanded, and is figured here because it most closely resembles the holotype of *C. pehuensis;* the other figured specimen (P5298) was the most complete one at 5.9.1969, and resembles Tate's figure of the holotype.

Concholepas deshayesi Rambur, 1862

1862 *Concholepas deshayesi* Rambur, *J. Conch., Paris,* 10: 86.
1862 *Concholepas deshayesi* Rambur, *J. Conch., Paris,* 10: 180, pl. 8, fig. 1, 2.
1903 *Concholepas deshayesi.* Cossman, *Essais de Paléoconchologie Comparée,* 5: 81, pl. 2, fig. 28.
1952 *Concholepas deshayesi.* Glibert, *Mem. Inst. R. Sci. nat. Belgiques,* (2), 46: 300, pl. 6, fig. 3.
1963 *Concholepas deshayesi.* Glibert, *Mem. Inst. R. Sci. nat. Belgiques,* (2), 74: 26.

No attempt has been made to compile a complete synonymy. Rambur (1862a) originally described the species in a few lines of Latin, with few data other than dimensions, and the locality in the title of the paper, " .... des Faluns de Touraine ". Later (Rambur, 1862b) he gave a much fuller description in French, compared the species with *C. concholepas* (Bruguière), and gave two excellent figures (pl. 18, fig. 1, 2). More recently the species has been figured clearly by Cossman (1903: pl. 2, fig. 28) and by Glibert (1952: pl. 6, fig. 3). The species is known only from the " Faluns de Touraine " and adjacent formations (Helvetian, Middle Miocene; Denizot, 1957: 195) of the Loire Basin, and is apparently rare.

Concholepas concholepas (Bruguière, 1789)

Pl. 4, fig. 10-12

1789 *Buccinum concholepas* Bruguiere, *Encyclopédie, Méthodique, Vers,* 1 (1): 252.
1801 *Concholepas peruviana* Lamarck, *Systeme des Animaux sans Vertebres:* 69.

No attempt has been made to compile a synonymy. Several other names have been given to South American Recent specimens of *Concholepas concholepas,* such as *C. patagonicus* Rochebrune and Mabille (1891: H63, Pl. Moll. 2, fig. 6, 6) based on specimens from Cape Horn, and *C. oblongus* Reeve (1863: Pl. 2, fig. 2 a-c) based on specimens from " Cape Horn and the East side of Tierra del Fuego ", but my knowledge of these is incomplete.

The species is common today on intertidal rocks in Chile, and has a latitudinal range from at least as far north as 17°S, and possibly as far as Mexico, to Cape Horn (Dr. R. K. Dell, pers. comm.). It has a relatively larger aperture and smaller spire than have the Miocene species discussed above, and has much coarser, nodulose sculpture. A specimen that probably belongs in this species was recorded from the Quaternary of Chile by Philippi (1887: 59, p. 58, fig. 12).

Concholepas kieneri Hupé, 1854

1854 *Concholepas kieneri* Hupé, *Hist. fis. pol. Chile, Zoologia,* 8: 203, pl. 3, fig. 4 (not seen).
1887 *Concholepas kieneri.* Philippi, *Tert. Quart. Verstein. Chiles;* 59: pl. 6, fig. 1.
1896 *Concholepas kieneri.* Möricke, *N. Jahrb. f. Min. Geol. Pal.,* 10: 567.

The original work by Hupé (1854) is not available to me, but Philippi (1887: 59) stated that his figures were copies from those of Hupé. They show a small shell of similar form to *C. concholepas*, but with narrower, more widely spaced, and smoother spiral cords than in that species. The type locality is Coquimbo, Chile; the species was known to Möricke (1896: 567) from Coquimbo and Caldera, in the Coquimbo Formation (upper Pliocene) of Chile.

Concholepas nodosa Möricke, 1896

1896 *Concholepas nodosa* Möricke, *N. Jahrb. f. Min. Geol. Pal.*, 10: 567, pl. 11, fig. 14, 15.

Möricke figured a shell of similar form to narrow specimens of *C. concholepas*, sculptured as in *C. kieneri* Hupé but with very large, widely spaced nodules on the spiral cords. The " species " is possibly part of the variation of *C. kieneri*. It was known to Möricke only from Coquimbo, type locality of the Coquimbo Formation (upper Pliocene) of Chile.

Two further species have been referred to *Concholepas*: *Concholepas imbricata* " A. Valenciennes in Humboldt, *Voy. Intér. Amér.* (*Obs. Zool.* II, 1832), 322 " (Sherborn, 1927a: 3122); and *Concholepas laevigata* " A. Valenciennes in Humboldt, *Voy. Intér. Amér.* (*Obs. Zool.* II. 1832), 323 " (Sherborn, 1927b: 3360). Neither Humboldt's work nor Valciennes' section of it is available in Australia or New Zealand, so that I have no knowledge of the status of the named forms. They are presumably South American fossils.

DISCUSSION

As far as I am aware the genus *Concholepas* is known fossil in the Middle Miocene of France and Australia and the Upper Miocene of New Zealand, and also occurs in the Pliocene to Recent of eastern South America. Many Thaidinæ have wide distributions and, apparently, long-lived planktotrophic veligers; that of Miocene *Concholepas* must have been longer-lived than most, allowing a rapid and wide dispersal of very similar forms. The French species and *C. antiquata* are both Helvetian (Middle Miocene) in age, so that correlation by means of species of *Concholepas* may eventually be possible.

In view of the wide distribution of *Concholepas* during Miocene times it is difficult to understand why it should now be restricted to the western coast of South America. A possible explanation is that the relatively narrow-shelled, coarsely sculptured *Concholepas concholepas* (and its relatives in the Pliocene) has a very much shorter larval life than Miocene species did. The finely sculptured, broadly-flaring, relatively very thin-shelled Miocene species may deserve separation in a new subgenus of *Concholepas*.

To judge from the present distribution of Mollusca, the Balcombe Clay at Fossil Beach, Balcombe Bay, was deposited in a depth of the order of 50 fms. (T. A. Darragh, pers. comm.), and a depth of at least this order is suggested by the fine siltstone matrix filling the aperture of the holotype of *Concholepas pehuensis*. The soft shelly sands making up the " Faluns de Touraine " (Gignoux, 1960, p. 624) were probably deposited in shallower water than the formations containing the Australasian *Concholepas*, but there seems little doubt that the Miocene species of *Concholepas* lived in considerably deeper water than the Recent ruggedshelled *C. concholepas,* which has not been reported from below the littoral zone (Dr. R. K. Dell, pers. comm.). Thus the thin shells and fine sculpture of the Miocene species may be merely ecophenotypic characters.

ACKNOWLEDGEMENTS

I am grateful to Mr. T. A. Darragh, Curator of Fossils, National Museum of Victoria, for the loan of the two figured specimens of *C. antiquata,* for copies of Rambur's papers, for valuable discussion and assistance during my visit to Australia, and for critical comments on the manuscript. Dr. Mary Wade, University of Adelaide, kindly provided information on Tate's type specimens; Dr. R. K. Dell, Director, Dominion Museum, provided information on the range of *Concholepas concholepas;* Dr. R. M. Carter, University of Otago, provided a copy of Reeve's monograph of *Concholepas;* and Dr. C. A. Fleming, Chief Paleontologist, New Zealand Geological Survey, drew my attention to the references on *C. kieneri* and *C. nodosa,* and provided critical comments on the manuscript. Messrs. D. L. Homer and T. R. Ulyatt, New Zealand Geological Survey, took the photographs reproduced in the plate. This research was supported by a travel grant from the New Zealand Department of Scientific and Industrial Research.

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A NEW APLACOPHORAN FROM NEW ZEALAND

W. F. PONDER

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Plate 5

SUMMARY

A new species of the Aplacophora, *Proneomenia quincarinata*, is described from New Zealand. The anatomy, radula and spicules place this species in *Proneomenia*, but it differs from all other members of the genus in having five longitudinal folds. This is the first aplacophoran to be recorded from New Zealand.

INTRODUCTION

Records of the class Aplacophora in the South and West Pacific are few, probably because these animals are scant in this area, but also because there has been little interest shown in the group by local workers. Nierstrasz (1902), Thiele (1902), Heath (1911) and Thiele (1897) cover species from the Indonesian Archipelago, Zanzibar, Hawaiian Islands and northern Australia respectively. Antarctic expeditions have not recorded any species from the Subantarctic, although Pelseneer (1903) and Nierstrasz (1908) each describe one species from the Antarctic and Thiele (1913a) describes 13 species. No species have been previously described from New Zealand.

The material on which the new species is based consists of 3 specimens collected from two localities. All of the specimens were preserved in 70% alcohol when collected so that their state of preservation was not good enough for histological work, or even very detailed anatomy. The determination of diffuse glandular masses and fine structures was difficult and often impossible. Thus only the gross anatomy is presented here, and this proves to be sufficient to determine the systematic position of the species.

Two specimens were dissected dorsally and laterally, and longitudinal and transverse slices were made to supplement the results of dissection. The third specimen was left intact and has been designated the holotype. All of the material, including the radular slide, has been housed in the Dominion Museum, Wellington, New Zealand.

DESCRIPTION

Family Proneomeniidæ

Genus *Proneomenia* Hubrecht, 1880, *Zool. Anz.*, 3: 589.

Type species: *Proneomenia sluiteri* Hubrecht (1880).

Proneomenia quincarinata sp. nov.

Figures 1-14

Diagnosis. Animal vermiform, up to 52 mm in length, with small, slit-like openings ventrally at anterior and posterior ends. Five longitudinal ridges run the length of the body. Spicules on body straight, simple; some cloacal spicules hooked. Radula with two rows of large, unicuspid central teeth, and about 19 weakly-chitinized lateral teeth. Shell glands paired, with separate openings into cloacal chamber. Seminal receptacle apparently represented by a strip of simple follicles along dorsal edge of shell glands. Copulation spiculæ present.

External Features and Pedal Groove. The animal is elongate, bluntly pointed posteriorly and rounded anteriorly. It is slightly wider on the anterior half of the body and has five longitudinal rounded ridges (Fig. 14). These ridges consist of a median dorsal ridge and two symmetrically placed lateral ridges on either side. The lowest pair of ridges terminate just in front of the cloacal opening but the others extend to the extreme ends of the body (Fig. 5, 6). The pedal groove is represented externally by a rather inconspicuous furrow extending from the mouth to the cloacal opening (Fig. 1). The living animal was yellowish-pink, but the preserved specimens have bleached to a yellowish-white.

Immediately behind the mouth lies the pedal pit (Fig. 11; pp), a round, thick-walled chamber with laterally compressed walls. This pit receives the pedal groove at its posterior side. The pedal groove is a tightly closed slit containing a single, short fold (Fig. 14; fp). A thick band of longitudinal muscle (Fig. 14; lm) lies on either side of the inner part of this slit and above this is a thinner layer of circular muscle (Fig. 14; cm). These muscles form a very thin sheath on the inside of the remainder of the body wall.

The cloacal opening (Fig. 12; ca) is more widely open than the mouth in the preserved material and receives the pedal groove at its anterior end.

The body spicules (Fig. 9) are straight, hollow tubes, pointed at both ends and variable in size. The largest reach a length of about 0.04 mm. There does not seem to be any regional differentiation apart from a hooked type that occurs in the cloacal aperture (Fig. 10). The spicules form an interwined mass which forms the thick outer integument of the body.

Alimentary Canel. The mouth opens into a cavity which is divided into two sections. The narrow posterior portion receives the pharynx and is separated from the large, sac-like anterior section or vestibule (Fig. 11; v), by a pair of thick, pleated (glandular?) ridges which run backwards ventro-laterally and then dorsally thus forming the posterior limit of the vestibule. They then run forwards across the vestibular roof. The lateral faces of the vestibule are made up of very numerous, minute, close-packed villi.

The muscular pharynx (Fig. 11, 13; ph) is initially longitudinally ridged but over most of its length is transversely folded (due to contraction). Its walls are muscular and at its posterior end a sudden constriction is formed by a pair of cuticle-lined lips (Fig. 11; cl), behind which lies the radula. The short radular sac (Fig. 11, 13; rs) lies above a muscular odontophore containing a hollow, cartilaginous bulb (Fig. 11; cb) to which are attached a complex series of muscles. A pair of slender retractor muscles (Fig. 11; rm) extend behind the odontophore and become embedded in the latero-ventral body wall. There is no subradular organ such as described in two species of *Proneomenia* by Heath (1904, 1918).

The radula (Fig. 7) is of the polystich type (Nierstrasz, 1905), consisting of about 18 rows of teeth, about 40 teeth in each row. There is a double row of large, alternating central teeth which have a long base

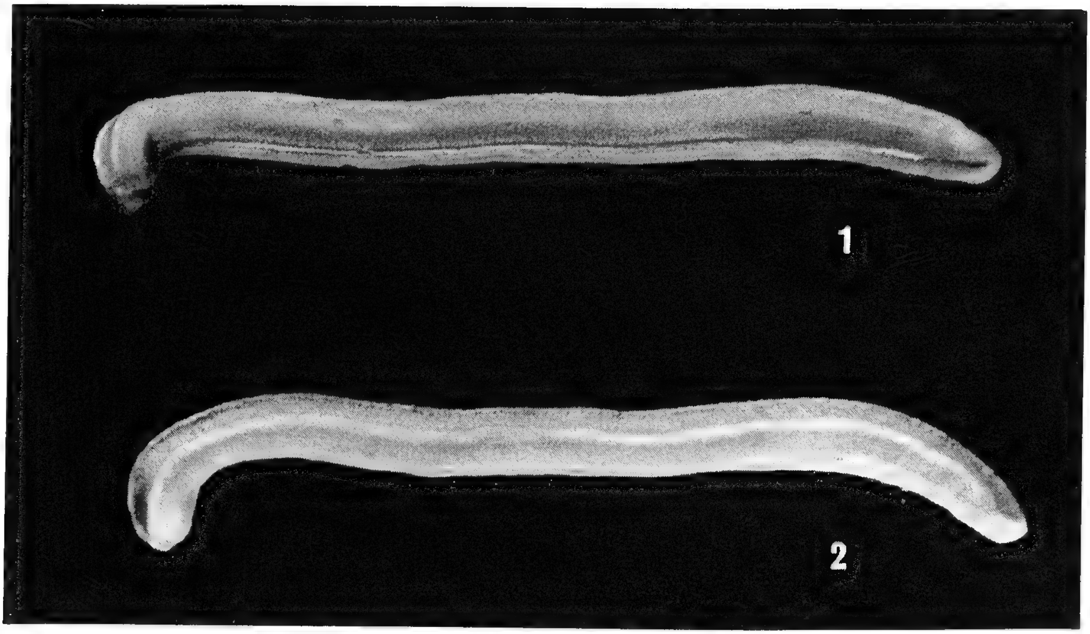

PLATE 5.

Fig. 1-2. The holotype of *Proneomenia quincarinata*, showing latero-ventral (Fig. 1) and lateral (Fig. 2) views of the whole animal. Photo: A. Healy.

and a single, hooked cusp. The lateral teeth are very weakly chitinized, undifferentiated, small and slender, and with slightly flanged bases in side view. There are about 19 laterals on each side and they are probably functionless.

After looping forward, the long, paired salivary glands (Fig. 11, 13, 14; sg) open into the buccal cavity at the side of the radula. These glands run ventrally and terminate a little in front of the cloacal cavity. There is no definite indication of a dorsal salivary gland although some diffuse glandular material is present around the pharynx.

Immediately above the odontophore opens the short oesophagus (Fig. 11, 13; os). This bends forward over the radular mass and opens into the mid-gut (Fig. 11; mg). Its walls are made up of thick, mainly longitudinal, muscles and its position presumably facilitates the evagination of the odontophore from the mouth. At the distal end of the oesophagus the walls are continuous with a series of lateral muscles which radiate out towards the body walls in an anterior and posterior series (Fig. 13; ram).

A mid-gut cæcum (Fig. 11; mgc) extends, in the usual fashion for this group, over the pharynx. The thin walls of the mid-gut contains massive lateral glandular pouches (Fig. 12, 14; mgg) throughout its length. A very short rectum (Fig. 12; rt) opens dorsally into the cloacal chamber.

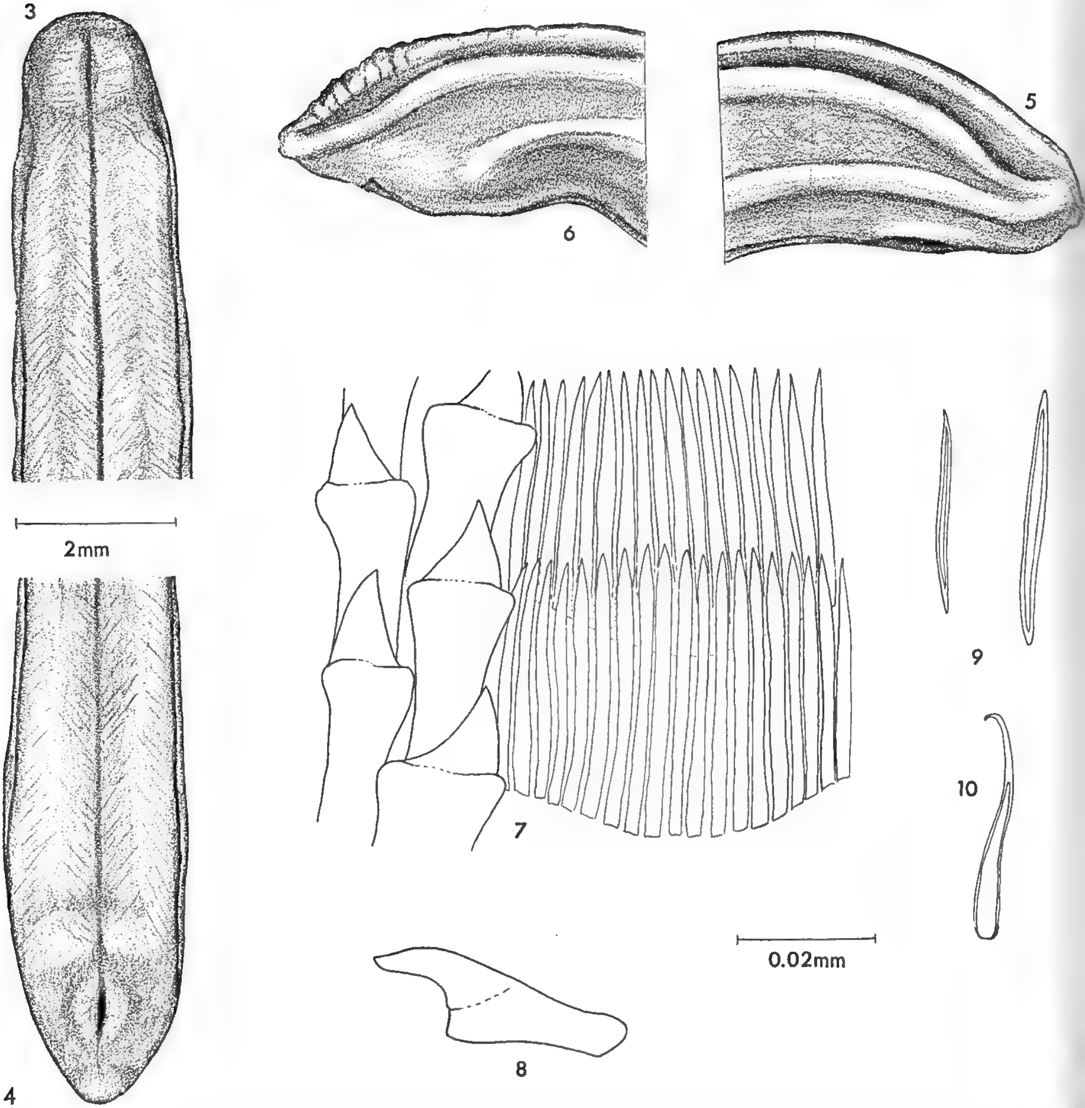

Fig. 3-10. *Proneomenia quincarinata.* 3, ventral view of anterior end of the paratype from the Chatham Islands. 4, ventral view of the posterior end of the same specimen. 5, lateral view of the anterior end of the paratype from Lyall Bay. 6, lateral view of the posterior end of the same specimen. 7, portion of the radula of the Lyall Bay specimen showing two rows of marginal teeth on the right. 8, lateral view of a central tooth. 9, body spicules of the Lyall Bay specimen. 10, a cloacal spicule from the same specimen.

The cloaca (Fig. 12) consists of a thin-walled sac into which the rectum and a pair of shell glands open, and a slit-like opening provides access to the exterior. The cloacal chamber extends behind the opening for about the same distance as the length of the external opening. Impingeing laterally on the walls of the chamber are the shell glands, and a pair of thick (glandular?) plates (Fig. 12; dp) are attached dorsally and hang vertically into the chamber immediately behind the cloacal opening. The anus opens between the postero-dorsal ends of these plates.

Reproductive System. The large, paired gonads (Fig. 11, 12, 14; g) lie dorsally immediately above the lumen of the mid-gut and between the dorsal exterior of the mid-gut glands. A very short, wide gonopericardial canal (Fig. 12; gp) enters the pericardium (Fig. 12; p) which lies dorsally over the posterior end of the gut. The gonoducts are extremely delicate, transparent structures and consequently difficult to trace. They appear to run almost directly to the posterior end of the shell glands (Fig. 12; sgl), a pair of massive bodies lying on either side of the cloacal chamber. Immediately behind each shell gland is a small, thick-walled bulb, the copulation spicule bulb (Fig. 12; csb). Each bulb is fixed by a ring of very short muscles to a narrow tube lying along the inside latero-ventral wall of the shell gland — i.e. between the shell gland and the cloacal chamber. This tube opens immediately inside the slit-like opening of the shell gland to the dorsal chamber (Fig. 12; sga). The outer latero-ventral and posterior walls of the shell glands are clothed with a complex series of radiating muscles that serve to operate the copulation spicule apparatus. They consist of an anterior set of retractor muscles (Fig. 12; rm) which are largely attached to the shell glands and latero-ventral body wall, a stronger posterior group of protractor muscles (Fig. 12; pm) attached to the bulbs and fixed to the body wall and shell glands, and a pair of strap-like retractor muscles attached to both bulbs and attached ventrally to the body wall. Another strap-like muscle runs forward ventrally from each bulb forming the ventral protractor muscles.

There is no separate seminal receptacle but the shell glands have a slit along the entire glandular dorsal wall and these each communicate with a rather diffuse, external strip of (follicular?) tissue (Fig. 12; f). There is no evidence that this tissue does, in fact, have a sperm storing function.

The nervous and vascular systems could not be investigated with the material available.

Type Material.

Holotype and paratype 1: 44°04' S, 175°23.5' E, east of the Forty Fours, Chatham Islands, east of New Zealand, in 130 fathoms. 1 Feb. 1954. (Station 34 of the 1954 Chatham Islands Expedition).

Holotype, M23193. Length: 31mm; diameters: 2.0mm (middle of body)
2.3mm (immediately behind mouth)
2.1mm (immediately in front of cloaca)

Paratype 1, M23194. Length: 30mm; diameters: 2.1mm (5mm in front of centre of body)
1.9mm (5mm behind centre of body).

Paratype 2, M23195. Off Lyall Bay, Wellington, Cook Strait, in 8 fathoms. In a pocket of sand amongst rocks. Coll. S. G. Hulme, 1962.

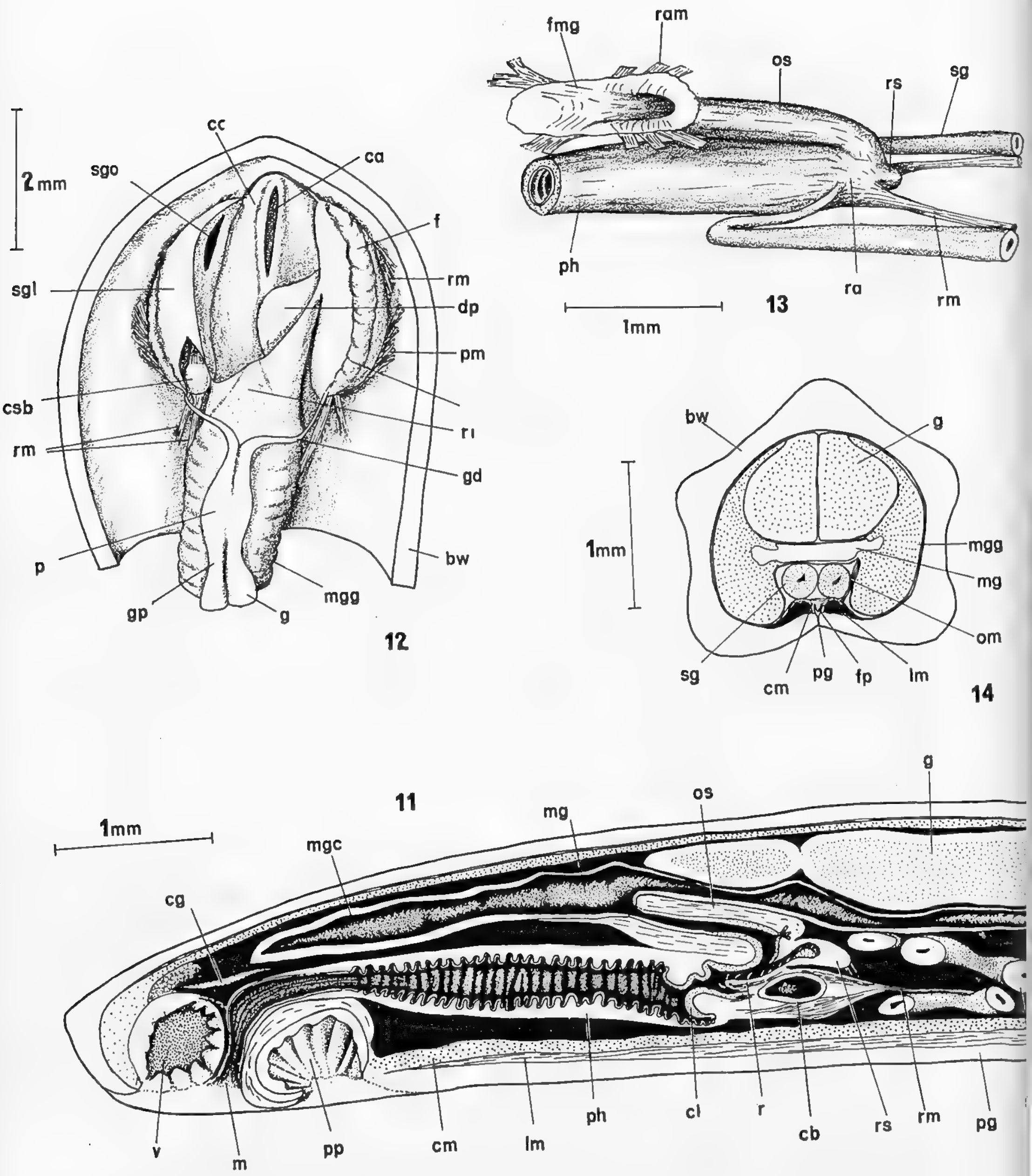

Fig. 11-14. *Proneomenia quincarinata.* 11, semidiagrammatic median, vertical longitudinal section through the anterior end of the Chatham Island paratype. 12, posterior end of the Lyall Bay paratype dissected dorsally. The roof of the cloacal cavity and the left dorsal leaf has been removed. The left shell gland has been split to show the copulation spicule bulb beneath it. 13, posterior part of the pharynx, the oesophagus, the radular apparatus and the anterior portion of the salivary glands dissected from the Lyall Bay paratype; the mit-gut has been removed except for a portion of its floor. 14, semidiagrammatic transverse section of the Chatham Island paratype taken about 5mm behind the centre of the body.

Length: 52mm; diameters: 2.5mm (8mm behind anterior end of body)
2.1mm (6mm in front of posterior end of body)
2.5mm (middle of body)

DISCUSSION

Most species of *Proneomenia* are evenly rounded in section but the Antarctic *P. tricarinata* Thiele (1913a) has three longitudinal ridges. Thiele's species is also similar to *quincarinata* in the general appearance of the radula, although the marginal teeth in the Antarctic species are stronger and different in shape. The genital organs also separate the two species because the shell glands of *tricarinata* join before reaching the cloaca and the Antarctic species has prominent, rounded seminal receptacles attached by a narrow duct.

The radula and the longitudinal folds on the body of *tricarinata* and *quincarinata* are somewhat atypical of *Proneomenia* but in most other features they agree with the genus as defined by Heath (1911) and Thiele (1913b). Another unusual feature of the new species is the presence of the two dorsal plate-like structures. If these were interpreted as gills it may result in *quincarinata* being removed from *Proneomenia*. The lack of separate seminal receptacles in *quincarinata* is certainly unusual, but further discussion on this point should await histological investigation.

Hyman (1967, p.68) gives the shallowest depth recorded for an aplacophoran as 18 metres. The specimen of *P. quincarinata* from Lyall Bay in 8 fathoms was found (allowing for some error) at about the minimum depth recorded for the class. The depth range of the new species is at least 8 - 130 fathoms and it is reasonable to assume that it extends beyond both these limits. Such a range of depth and locality (Chatham Islands to Cook Strait) suggests that *P. quincarinata* may be widely distributed around New Zealand.

Nothing is known of the habits of the new species except that it is likely that it burrows into sand or mud.

This species is the first recorded from Southern Australasia in recent literature, but it is probable that with careful searching additional species of this fascinating group will be found.

ACKNOWLEDGEMENTS

I am grateful to Dr. R. K. Dell for generously allowing me to work on the material on which this species is based. A tribute must be paid to the late Mr. S. G. Hulme who first discovered this species and would have described it if it were not for his untimely death. Mr. Anthony Healy kindly took the photographs for Figures 1-2.

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ABBREVIATIONS

bw — body wall
ca — cloacal aperture
cb — cartilaginous bulb
cc — cloacal cavity
cg — cerebral ganglion
cl — cuticle-lined lip
cm — circular muscle
csb — copulation spicule bulb
dp — dorsal plate-like structure
f — dorsal follicular structures
fmg — floor of mid-gut
fp — fold in pedal groove
g — gonad
gd — gonoduct
gp — gonopericardial canal
lm — longitudinal muscle
m — mouth
mg — mid-gut
mgc — mid-gut caecum
mgg — mid-gut gland
om — oblique muscle
os — oesophagus
p — pericardium
pg — pedal groove
ph — pharynx
pm — protractor muscle
pp — pedal pit
r — radula
ra — radular apparatus
ram — radiating muscle
rm — retractor muscle
rs — radular sac
rt — rectum
sg — salivary gland
sgl — shell gland
sga — shell gland aperture
v — vestibule

SOME ASPECTS OF THE MORPHOLOGY OF FOUR SPECIES OF THE NEOGASTROPOD FAMILY MARGINELLIDAE WITH A DISCUSSION ON THE EVOLUTION OF THE TOXOGLOSSAN POISON GLAND

W. F. PONDER
Dominion Museum, Wellington *

SUMMARY

The living animal, alimentary canal and reproductive system of *Mesoginella (Sinuginella) pygmaea* (Sowerby), *Volvarina (Haloginella) mustelina* (Angas), *Volvarinella cairoma* (Brookes) from New Zealand and *Diluculum* sp. from the New Hebrides are described. *V. cairoma* has the duct of the gland of Leiblein opening into the buccal cavity and has no buccal mass or radula, whereas the other species have a well developed buccal mass and the gland of Leiblein discharges into the oesophagus behind the nerve ring. An unusual feature of the oesophagus of *M. pygmaea*, *V. mustelina* and *Diluculum* sp. is a tube, derived largely from the ventral channel of the anterior oesophagus, which by-passes the valve of Leiblein and then opens into the mid-oesophagus just behind the valve. The male genital system has a large prostate gland which is closed except for a small posterior opening, and the female system has no gonopericardial canal and has vesicular seminal receptacles that do not ingest sperm. The albumen and capsule glands are similar to those of other Rachiglossa.

An hypothesis is presented on the possible evolution of the toxoglossan poison gland from the combination of the gland of Leiblein, glandular dorsal folds of the mid-oesophagus and ventral channel of the anterior oesophagus.

INTRODUCTION

The marginellids are, with a few exceptions, small animals and probably for this reason are not a ‘popular’ group like the large, colourful cowries, cones, olives and volutes. They are, never-the-less, allied to the volutes and olives and their beautifully polished shells and handsome animals are extremely attractive.

Although there have been a number of works dealing with the classification of the marginellids these have been based mainly on shell features. Coan (1965) has discussed the taxonomic history of this group and has listed the Recent and fossil genera attributed to the family. He groups the Marginellidæ into three subfamilies, each with distinctive radular characteristics, and includes, for the two major groups, information on the external features of the animal of a few species.

Unfortunately the radula and form of the living animal have been described for only a handful of species and only four species are known anatomically. Bouvier (1887) noted the general features of the nervous system of the “Marginellidæ” and later (1888) described the oesophagus of “*Marginella*” *cingulata* Dillwin. Eales (1923) has provided some notes on the animal of the Antarctic species “*Marginella*” *hyalina* Thiele and Graham (1966) described the foregut of “*Marginella*” *marginata* (Linné) and “*M*” *desjardini* Marche-Machad. He also included a brief note on

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* Present position: Curator of Molluscs, Australian Museum, Sydney.

the female reproductive system of the latter species. Marcus and Marcus (1968) have recently described the anatomy of "*Marginella*" *fraterculus* E. A. Smith.

The following study outlines the morphology of the living animal, alimentary canal and reproductive organs of four species of the Marginellidæ in an attempt to determine some of the morphological characteristics of this family.

TAXONOMY

Of the four species dealt with in this account, three are from New Zealand and one from the New Hebrides. There is no difficulty in identifying the New Zealand material at the specific level but their generic allocations must be reshuffled in the light of Coan's (1965) review.

The most recent attempts to revise the supraspecific status of the New Zealand species of the Marginellidæ were those of Powell (1932, 1952) in which he realigned the New Zealand species of the genus *Marginella* (which included nearly all of the species in the family) into three existing subgenera. No attempt will be made here to reallocate the New Zealand species apart from those actually dealt with. These may be reclassified in narrower groups than at present because they all show considerable differences in their morphology. This need not imply that further genera are necessary for the New Zealand species, as Laseron (1957) has already supplied these in abundance for the closely related Australian fauna.

Mesoginella (Sinuginella) pygmaea (Sowerby)

1846. *Marginella pygmaea* Sowerby, *Thes. Conch.*, 1: 386, pl. 75, fig. 78, 79.
1932. *Marginella (Gabella) pygmaea.* Powell, *Trans. R. Soc. N.Z.*, 62: 205, pl. 34, fig. 18; pl. 35, fig. 20 (radula).

Marginella pygmaea agrees very closely with the type species of *Sinuginella* and can be included in that group where Coan (1965) has also placed it.

Laseron (1957) introduced *Mesoginella* and *Sinuginella* on the same page (p.282) with the former appearing first. These two groups differ only in the possession of weak axial ribs by the former, *Sinuginella* being smooth. Coan (1965) has used *Mesoginella* as a genus which includes three subgenera, while *Sinuginella* is treated as a subgenus of *Volvarina*. Thus all factors are not equal in the determination of priority and it is proposed that *Mesoginella* should continue to be used as a full genus with *Sinuginella* as one of its subgenera.

Volvarina (Haloginella) mustelina (Angas)

1871. *Halinc (Volvarina) mustelina* Angas, *Proc. Zool. Soc.*, p. 14, pl. 1, fig. 5.
1913. *Marginella (Volvarina) mustelina.* Suter, *Man. N.Z. Moll.*, p. 460, pl. 20, fig. 13.
1932. *Marginella (Volvarina) mustelina.* Powell, *Trans. R. Soc. N.Z.*, 62: 209.

V. mustelina is the type species of Laseron's (1957) genus *Haloginella* which has been reduced to a subgenus of *Volvarina* by Coan (1965).

Volvarinella cairoma (Brookes)

1924. *Marginella cairoma* Brookes, *Trans. N.Z. Inst.*, 55: 154, pl. 7, fig. 4 - 5.
1932. *Marginella (Serrata) cairoma.* Powell, *Trans. R. Soc. N.Z.*, 62: 211, pl. 33, fig. 6.

Powell (1952) has already indicated that this species should be included in *Volvarinella* Habe. Coan (1954) shows that *Longinella* Laseron is a synonym.

Diluculum sp.

The accurate specific determination of this minute form from the New Hebrides is impossible because of the present state of the nomenclature for Pacific marginellids. A figure of the shell of this species is given and this, together with the other data, should make its future identification possible.

The form of the head of this species closely resembles that of *Euliginella angasi* (Crosse) (Laseron, 1957) except that in the latter species the mantle can be extended over the shell, whereas it cannot in the New Hebrides species. There are also some shell differences; *E. angasi* has additional columellar folds and lacks the narrow parietal callus seen in the New Hebrides species.

Diluculum inopinatum Barnard (1962) has a similar shell and radula to the New Hebrides species. *Diluculum* was reduced to a synonym of *Volvarina* by Coan (1965), and *Euliginella* (which Coan made a synonym of *Cysticus* Stimpson) is probably closely allied to it. The relationships of these two genera and *Cysticus* are discussed below. For the purposes of this account the New Hebrides species can be tentatively included in *Diluculum*, but a definite allocation will not be possible until the head of *D. inopinatum*, the type species of the genus has been examined.

MATERIALS AND METHODS

Both *V. mustelina* and *M. pygmaea* were collected at Leigh, north of Auckland, *V. cairoma* was obtained from Island Bay, Wellington and *Diluculum* sp. from Port Vila, Efate Island, New Hebrides.

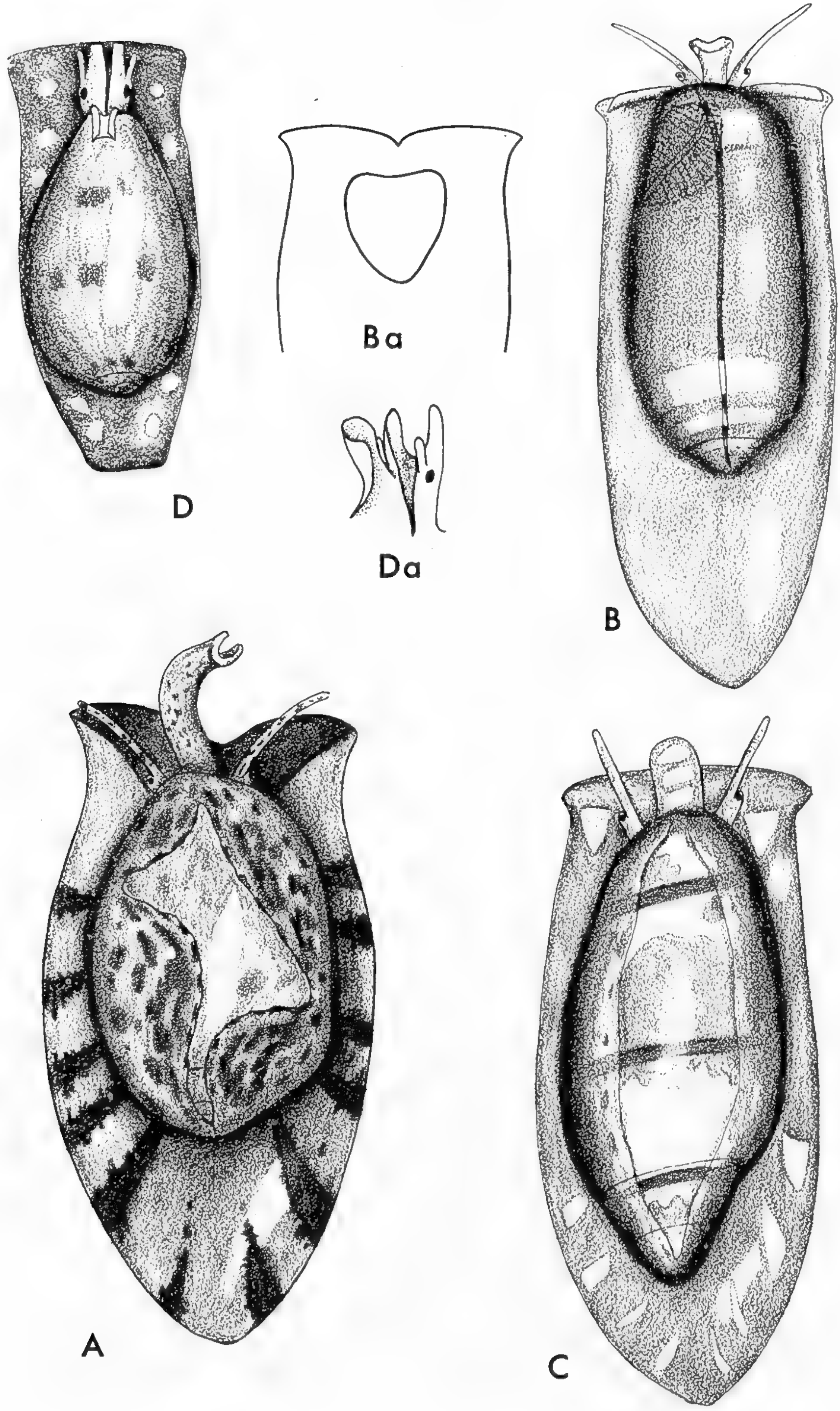
All of the material for sectioning was fixed in Bouin's solution and double embedded by Peter's celloidin-paraffin method. It was cut at 6-8 μ and stained in Mallory's triple stain. Specimens were dissected after fixation in formalin and Bouin's solution, and *M. pygmaea* and *V. mustelina* were also dissected alive.

DISTRIBUTION AND HABITAT

M. pygmaea is found in the North Island where it occurs as far south as Wellington, although it is most abundant on the north eastern coast. This species is generally found from just below low tide level down to several fathoms on coarse, sandy substrate on moderately exposed coasts.

V. mustelina appears to be restricted to the north east of the North Island in New Zealand as it has not been recorded south of East Cape, but it also occurs commonly in the south and south east of Australia, including Tasmania. It is found mainly on semi-exposed coasts beneath stones and in crevices at low tide.

V. cairoma is common throughout the North Island, and it occurs at the Chatham Islands, but there do not appear to be any records of it from the South Island. It is generally found at low tide level living beneath stones, on brown algæ or amongst coralline algal turf.


D
Ba
Da
B
A
C

Four living specimens and a few dead shells of *Diluculum* sp. were obtained from Port Vila living amongst short, encrusting brown algæ and corallines in a low tidal pool in sheltered conditions within the harbour.

THE SHELL AND HEAD-FOOT

Mesoginella (Sinuginella) pygmaea

The glossy, solid shell is generally white or pale yellow and usually varies from 5.5 mm to 6 mm in length and 4.0 mm to 4.8 mm in width. The short spire, thick outer lip, which is smooth within the aperture, and well pronounced anterior and posterior canals, are good recognition features of this species. There are four columellar plaits within the rather large aperture. Powell (1932) has provided a good figure of this species.

The living animal (Fig. 1, A) has a very broad foot which is deeply indented in front and has a large ventral pedal gland in females. There is no operculum. Powerful cilia remove sediment backwards and outwards from the foot, but the delicate mantle edge covering the shell lacks ciliary currents. The foot is opaque yellow and normally has narrow, lateral radiating zones of mixed brown, yellow and orange spots and an anterior triangular area of similar pigmentation. This colour pattern is very variable and sometimes the foot is nearly uniform yellow. The reflected mantle edges covering the shell have black, brown and yellow blotches which are slightly raised as broad pustules. The ground colour is mottled brown, or nearly black, with dense yellow, there being a predominance of the darker colour towards the upper edges. The long tentacles, with the large eyes a little above their outer bases, are translucent with opaque yellow blotches and a few deep orange spots. Small, pale orange spots lie on the opaque yellow, rather long siphon. The superficial pigmentation of the pallial roof can be seen through the dorsal side of the body whorl of the shell and is mottled, greenish-yellow and pale to dark brown or black, the relative density being variable in different individuals.

An allied species *M. (S.) tryphenensis* (Powell), found at Taurikura Bay, Whangarei Heads along with *M. (S.) pygmaea,* has a very similar animal but it has more dark pigmentation and the yellow pustules on the mantle are more distinctly raised.

Volvarina (Haloginella) mustelina

The handsome, cylindrical shell of this species has a short spire and very long body whorl. The aperture has a distinct anterior and posterior sinus and occasionally the outer lip is covered with denticles, although it is usually smooth. The white shell is ornamented with a broad, median band on the body whorl, with one or two narrow bands above and one on the base. There are four strong plaits on the columella. The shell is usually between 6.2 and 7.0 mm in length and 3.0 and 3.3 mm in width, and has been figured by Suter (1913) and Laseron (1957).

The living animal (Fig. 1, B) has previously been described and figured by Hedley (1916) and Laseron (1957). It is white with a very large foot which is indented in front. There is no operculum, and delicate,

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Figure 1. Dorsal view of the living animals of: A — *Mesoginella (Sinuginella) pygmaea* (Sowerby), B — *Volvarina (Haloginella) mustelina* (Angas), Ba — Ventral view of anterior end of foot, C — *Volvarinella cairoma* (Brookes), D — *Diluculum* sp., Da — Dorsal view of head and siphon.

smooth mantle edges are reflected over the shell when in the dark. These quickly retract as soon as light falls on the animal. The animal is very active and moves about rapidly, chiefly by ciliary action. Ciliary currents pass around the lower edges of the mantle but the dorsal surface of the foot is unciliated. There is a large ventral pedal gland in females (Fig. 1, Ba). The tentacles are long and slender and the large eyes are a little above their outer bases. The siphon is short.

Volvarinella cairoma

The shell is small, rather thin and semitransparent and elongate oval in shape. It is pale yellowish with a thickened, white outer lip and two narrow brown bands on the body whorl. The rather broad aperture has four columellar folds and there is sometimes a single denticle in the upper third of the outer lip. No anterior notch is developed and the posterior canal is weak. The spire is moderately tall with slightly convex whorls. The shell has been figured by Powell (1932).

In the Island Bay population studied, females were regularly larger than males as shown in the examples below.

Female: 4.4 x 2.0 mm; 4.0 x 1.9 mm; 4.1 x 2.0 mm; 4.1 x 1.8 mm; 4.6 x 2.3 mm.

Male: 3.3 x 1.5 mm; 3.4 x 1.6 mm; 3.6 x 1.5 mm; 3.45 x 1.6 mm; 3.4 x 1.6 mm.

In addition to this difference the colour of the pallial roof, as seen through the shell, is mottled grey in females and black in male specimens.

The living animal (Fig. 1, C) is translucent white with small opaque white patches on the foot, siphon and tentacles. It resembles *V. (H.) mustelina* in the shape of its tentacles and general appearance. The foot has a slightly rounded anterior edge and is tapered behind. Ciliary currents sweep material off the dorsal surface of the foot and others remove particles posteriorly around the mantle edge, which, as in the other species, is capable of being reflected over the shell. A large pedal gland is found beneath the anterior edge of the foot in females.

Diluculum sp.

To facilitate future recognition of this species a figure (Fig. 3, G) and a formal description of it is given.

Shell small, ovate, thin, semitransparent, shining but not glossy, spire very short, 2¼ flat whorls. Aperture with a pronounced anterior and posterior canal and 4 columellar plaits, the upper weakest, the lower plait strongest. Outer lip smooth within, inner lip forming a moderately wide, sharply defined callus. A fairly well marked fasciole present. Sculpture of weak growth lines only.

Length 2.3 mm., Diameter 1.5 mm (figured specimen)

Length 2.5 mm., Diameter 1.6 mm (largest specimen)

The shells of this species are housed in the Dominion Museum, Wellington.

The living animal (Fig. 1, D) differs from the three previous species in two respects. The head has the tentacle bases fused ventrally and these are extended forward laterally below and beyond the short tentacles (Fig. 1, Da), and in addition, the mantle edges do not appear to extend over the shell. The animal is translucent white with small orange blotches behind the eyes and dense white spots on the head and foot. A few black and orange spots lie on the otherwise white mantle which is visible through the shell. The foot is slightly rounded in front and truncated behind and the short siphon is fused to the head just to the left of the mid-line (Fig. 1, Da).

THE PALLIAL CAVITY

The pallial cavity of the four marginellid species is similar to that of the Olividæ (Marcus and Marcus, 1959) and the Volutidæ (Ponder, a) and was probably adapted initially in response to a burrowing mode of life. The siphon opens directly above the head, its left margin being fused to the left side of the head. The right corner of the pallial aperture lies far down on the right side, nearly at the base of the cavity. Thus the right pallial wall is considerably shortened and the gonoduct and rectum are consequently displaced and lie nearly transversely across the back of the cavity. A broad, brown, bipectinate osphradium lies alongside a somewhat narrower ctenidium on the left, the latter having broadly triangular filaments. Between the ctenidium and the right edge of the cavity lies a rather narrow hypobranchial gland. This covers the gonoduct and rectum and is pale yellow-brown with scattered dark brown cells in *M. (S.) pygmaea* and *V. (H.) mustelina.* The hypobranchial secretion does not turn purple as in some other neogastropods.

THE RENAL ORGAN AND NERVOUS SYSTEM

The renal organ of all four species has the secondary glandular lamellæ separated into an antero-dorsal area whereas the primary lamellæ make up the remainder of the renal tissue, with the exception of the nephridial gland. This arrangement is similar to that of the Olividæ (Marcus and Marcus, 1959) and the Volutidæ (Perrier, 1889) but differs from most other rachiglossan groups.

The nervous system was not studied although it was noted that the circum-œsophageal ganglia are extremely concentrated in the four species examined.

THE ALIMENTARY CANAL

The terminology used for the œsophageal portion of the alimentary canal is that of Graham (1941) and that of the buccal musculature follows Carriker (1943).

Mesoginella (Sinuginella) pygmaea

Only the posterior half of the retracted proboscis (Fig. 2, A; pro) is covered by the rather delicate proboscis sac, the anterior end protruding into an anterior proboscis cavity probably formed by the fusion of the sheath to the body wall. The pleurembolic proboscis is rather broad when retracted, with a blunt distal end and a small, terminal mouth. In section (Fig. 2, B) the proboscis wall is seen to consist of an outer cuboidal, ciliated epithelium, below which is a very delicate layer of circular muscle, but the bulk of the wall, which is only two or three times thicker than the epithelium, is made up of longitudinal fibres. Red and blue staining gland cells and mucous cells lie in the proboscis hæmocoel around the buccal cavity and the anterior end of the odontophore and oesophagus.

The buccal cavity (Fig. 2, A; b. ca) has muscular walls and a wide, ciliated lumen into which the salivary ducts open laterally just in front of the oesophageal opening, and on the lower side of the dorsal folds. There are no jaws or cuticle lined surfaces and the mouth is only a simple aperture. The œsophagus (Fig. 2, B; oes) has a rather thick wall of circular muscle, is ciliated dorsally and laterally and the epithelium is devoid of gland cells. A few longitudinal muscle fibres can be seen beneath the epithelium and the salivary ducts lie within the well defined dorsal folds. Thin strands of muscle attach the œsophagus to the proboscis wall laterally and dorsally, but the anterior part of the rather massive odontophore (Fip. 2, A; od) is encased below the œsophagus in a common, thin sheath of circular muscle. This structure extends from the buccal cavity to the inner end of the retracted proboscis and has a pair of powerful ventral odontophoral retractor muscles (v.od.r) attached to its posterior end. A few short dorsal odontophoral retractor muscles (d.od.r) are found in the posterior third of the odontophore and are attached directly to the proboscis wall. A conspicuous radular sac (Fig. 2, B; r.s) extends the length of the odontophore, and a series of subradular membrane retractor muscles are attached to it dorsally along its whole length. Thick muscle sheets lying latero-ventrally are the odontophoral protractors and these are continuous with the wall of the buccal cavity in front and are fixed to the posterior end of the odontophore behind. The odontophoral cartilages (od.c) are fused into a single structure in the front half of the odontophore but posteriorly are connected by a transverse muscle in the usual way. The radular sac spreads out in front to encompass the entire anterior end of the odontophore by fusing antero-laterally with its reflected end lying below. Thus the anterior end of the odontophore appears to lie in a separate cæcum as was noted by Graham (1966) in '*Marginella*' *marginata*. The radula (Fig. 2, C) has been described by Powell (1932). It consists of only a single row of

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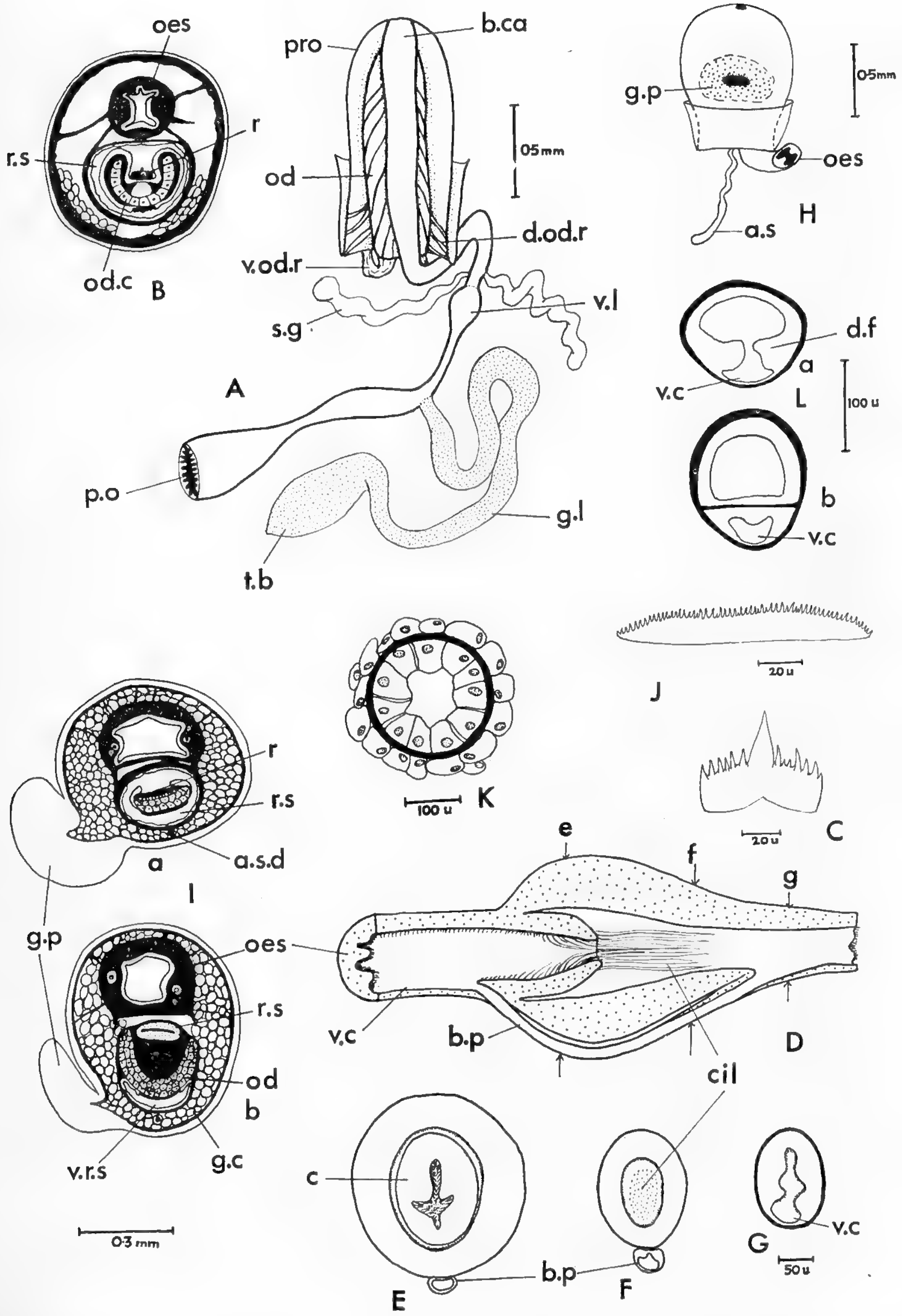
Figure 2. *Mesoginella (Sinuginella) pygmaea* (Sowerby). A — The anterior alimentary canal showing the proboscis opened dorsally. B — A diagrammatic transverse section through the proboscis near the anterior end of the odontophore. C — Radular tooth. D — A diagrammatic, vertical, longitudinal section through the valve of Leiblein. The arrows indicate the positions of transverse sections E to G. E — A section of the anterior part of the valve of Leiblein. F — A section of the posterior part of the mid-oesophagus just behind the valve of Leiblein.

Volvarina (Haloginella) mustelina (Angas). H — Ventral view of the proboscis showing the glandular pad. I a-b — Transverse sections through the anterior (a) and middle (b) parts of the proboscis. The glandular pad is displaced to the left in these sections. J — Radular tooth. K — Transverse section of accessory salivary gland. L, a-b — Transverse sections through the narrow part of the mid-oesophagus behind the valve of Leiblein (a is posterior to b).

a.s — accessory salivary gland
a.s.d — accessory salivary gland duct
b.ca — Buccal cavity
b.p — narrow tube below valve of Leiblein
c — cone-like extension of anterior oesophagus forming the valve in the valve of Leiblein
cil — cilia
d.f — dorsal fold
d.od.r — dorsal odontophoral retractor muscle
g.c — gland cells
g.l — gland of Leiblein
g.p — glandular pad
od — odontophore
od.c — odontophoral cartilage
oes — oesophagus
p.o — posterior oesophagus
pro — proboscis
r — radular tooth
r.s — radular sac
s.g — salivary gland
t.b — terminal bulb of gland of Leiblein
v.c — ventral channel
v.l — valve of Leiblein
v.od.r — ventral odontophoral retractor muscle
v.r.s — reflected portion of radular sac.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teeth, each tooth being fairly solid and moderately wide. A long, sharp median cusp is bordered by six or seven short, lateral cusps on each side.

The salivary glands (Fig. 2, A; s.g) are simple tubules and the cells have purplish-red staining granules. They have ciliated ducts which enter the œsophageal wall just in front of the valve of Leiblein. There is no accessory salivary gland.

The anterior œsophagus does not change in structure until just behind the valve of Leiblein (v.1) where the ventral, non-ciliated groove detaches itself and becomes a separate, thin-walled tube (Fig. 2, D-F; b.p) which lies below the valve of Leiblein.

The valve of Leiblein is about twice the diameter of the anterior œsophagus. It has a very thin outer coat of muscle and is lined with relatively tall, blue staining gland cells which have small, wedge-shaped cells between their distal ends. A cone-shaped extension of the anterior œsophagus protrudes into the anterior half of this glandular structure, its long cilia wafting into the posterior half of the valve. The narrow opening of this cone must form a very efficient valve.

The tube derived from the ventral channel of the anterior œsophagus is lined with a pavement epithelium, except below the valve of Leiblein where the latter is reduced in diameter upon entering the circum-œsophageal nerve ring. Here the cells on the dorsal side of the tube become thicker before it becomes confluent with the ventral channel (v.c) of the mid-œsophagus just behind the valve. The low, non-glandular dorsal folds of the narrow part of the mid-œsophagus which passes through the nerve ring, meet and so cut off the ventral channel to form the thin walled, ventral tube. Just behind the nerve ring the œsophagus expands and receives the duct of the gland of Leiblein (Fig. 2, A; g.l) on its right side. The ventral channel, just before this point, swings from its ventral position to the right where it meets the opening to the gland of Leiblein. Torsion is presumably completed just behind this opening. The wall of the mid-œsophagus has a rather thick layer of inner longitudinal and outer circular muscles.

The long, convolute gland of Leiblein (Fig. 2, A; g.l) is the most conspicuous part of the alimentary canal. It is reddish-brown in life and opens into the right œsophageal wall. Most of the gland consists of a long, narrow tube with a small central lumen lined with tall gland cells. A very thin coat of muscle surrounds this part of the gland which lies coiled up in the anterior body cavity. There are three types of gland cell; red, orange and blue staining, and all have basal nuclei and granular cytoplasm. The blue and red staining cells occur throughout in more or less eqlal abundane, but the orange staining cells are found mainly in the distal part of the tube. Very small ciliated cells lie between the distal ends of the glandular cells in the tube. The terminal bulb (t.b) is wider than the tubular part of the gland and has a thick, external muscle layer composed of outer circular and inner longitudinal fibres. Numerous partitions divide up the interior of this bulb and it is lined with small, irregular cells that bud off their distal ends. The cells contain greenish-brown granules similar to those found in the anal gland.

The posterior œsophagus (p.o) widens behind the opening of the gland of Leiblein into an almost crop-like expansion, but this does not differ histologically from the mid-œsophagus except that the cells are a little larger and rather more irregular in height, forming about nine low ridges. There is, over the anterior part, an outer wall of circular muscle which becomes very thin a little further behind. The œsophagus narrows as it passes behind the pallial cavity and over the columellar muscle, but it rapidly expands again as it approaches the stomach. At the narrow portion the epithelium abruptly changes to taller, narrower cells which have short cilia and very dense cytoplasm distally. There are no gland cells, and the epithelium is thrown into tall, irregular ridges which have connective tissue and a few muscle fibres in their axes.

The stomach of this species is very similar to that of *V. mustelina* (Fig. 3, A). It consists of a rather small sac into which open the wide, posterior œsophagus (p.o), the rather narrow intestine and a very wide digestive gland duct. The latter has become so expanded that it resembles a cæcum, and a wide slit (d.o) at its inner end opens directly into the gland, in which minute fragments of food material can be seen. The gastric epithelium is of columnar cells which bear very short cilia and are thrown into high folds. A wide groove lined with cuboidal cells lies along the antero-ventral wall and leads from the œsophagus to the intestine.

The digestive gland is situated entirely behind the stomach, and a small right lobe lies on the lower edge of the large left lobe. These both open into the same aperture, and are difficult to distinguish. The digestive cells are very uniform and they surround a rather large, single lumen within each lobe. Dense, orange to yellow staining granules are concentrated in the proximal two thirds or half of each cell, the distal part having minute purple or blue staining granules.

The intestine has no gland cells in its posterior section where it leaves the stomach and becomes surrounded by the renal organ. The short pallial section, however, is well supplied with orange to yellow staining gland cells and opens a little behind the exhalant aperture.

A rather conspicuous black anal gland lies near the posterior end of the pallial cavity. It consists of a single branched tubule which opens into the rectum just behind the anus by way of a short, ciliated duct. The epithelium of this gland is non-ciliated and the cells liberate accumulations of very dark green staining granules from small vacuoles. These granules lie loose in the lumen of the gland together with minute purplish staining granules. The latter type are concentrated in the proximal third of the cells where they form a dense mass along with the larger, green staining granules.

Volvarina (Haloginella) mustelina

The alimentary canal of this species resembles that of *M. (S.) pygmaea* fairly closely and only the differences will be noted. The proboscis (Fig. 2, H) has a rounded, slightly bulbous end and is shorter than that of *M. (S.) pygmaea.* A thick pad (g.p) lies on the ventral surface and this is made up of a rim of very elongate, purple staining gland cells that have finely granular contents, which surround a small, central depression. The remainder of the epithelium is of ciliated, short columnar cells which contain a few blue staining gland cells. The muscular part of the proboscis wall is thinner than the epithelium (Fig. 2, I; a, b) and consists of a delicate outer circular layer and a few longitudinal fibres. A mass of gland cells (g.c) fills the proboscis cavity. These are similar to the cells seen in *M. (S.) pygmaea* but are much more numerous. The odontophore (od) is not as powerful as that of *M. (S.) pygmaea* and, as in that species, extends to the end of the retracted proboscis. A thicker wall of circular muscle surrounds the anterior œsophagus (oes) and the buccal cavity, the latter being lined with short, ciliated, columnar cells. Numerous, fine strands of muscle attach the œsophagus to the proboscis wall. It is ciliated throughout, including the ventral channel, and its lateral and dorsal walls have a few, small glandular cells.

The odontophoral cartilages are fused together apart from a very short posterior portion where the rather weak odontophoral retractor muscles are attached. The subradular membrane muscles are relatively weak compared with those of *M. (S.) pygmaea*, but the radular sac opens out anteriorly in a similar manner. Each radular tooth (Fig. 2, I, J) is about 120 μ across, is low and relatively very wide. It is armed with a series of short, sharp cusps that are rather irregular and variable in shape and size. Powell (1932) failed to find the rather delicate radula of this species.

A short accessory salivary gland (Fig. 2, H; a.s) extends a little behind the proboscis. Its posterior end is only 60 μ in diameter and is lined with relatively large, irregular cuboidal gland cells (Fig. 2, K) which contain bluish staining, finely granular contents and large orange to red staining nuclei. Similar staining oval cells form a single layer on the outer surface of the thin layer of circular muscle that surrounds the lumen. The duct of the gland (Fig. 2, I; a.s.d) opens ventrally into the buccal cavity.

The paired salivary glands each consist of about three tubules, each about 80 to 100 μ in diameter, which lie just in front of the circumœsophageal ganglia on either side of the valve of Leiblein. A very thin outer wall of connective tissue and a few muscle fibres surround each of the tubules which, themselves, are composed of the normal type of cell with occasional minute ciliated cells. The salivary ducts are constructed like those of *M. (S.) pygmaea* and behave in the same way.

The mid-œsophagus is very like that of *M. (S.) pygmaea* except that the dorsal folds (Fig. 2, L; d.f) are more conspicuous and consist of red staining gland cells. They fuse together (Fig. 2, L) and the ventral channel becomes a separate tube as in *M. (S.) pygmaea*.

The gland of Leiblein is also like that of *M. (S.) pygmaea* except that the glandular section is considerably longer. The gland cells of this section, which are about 30 μ high, show a distinct pattern, although it varies slightly in detail between individuals. A short proximal portion has red staining cells continuous with those of the dorsal folds in the mid-œsophagus, but blue staining cells soon appear in the ventral epithelium and at about one quarter along the length of the tube they are about equal in number with the red cells. The blue cells take over the epithelium almost completely although a few red cells remain scattered throughout the tube. Occasional orange staining cells appear in a narrow dorsal zone when the blue cells become numerous, a little over halfway through the gland they comprise about half of the epithelium, and about two thirds along the length of the tube they form the bulk of the epithelium, sometimes with the complete exclusion of the blue cells. A thin coat of muscle comprised of outer longitudinal and inner circular fibres surrounds this part of the gland. The terminal bulb is about 180 μ in diameter (compared with the tube which is 120-150 μ wide), is short and is subdivided by transverse lamellæ. The change in the epithelium between the two regions is abrupt and the outer muscle coat of the bulb is much thicker than that of the tube. An irregular epithelium like that seen in *M. (S.) pygmaea* covers the walls of the bulb.

The posterior œsophagus, stomach (Fig. 3, A) and intestine are like those of *M. (S.) pygmaea.* The cells of the anal gland have fewer green staining granules, and budding cells are infrequent, the majority of the granules being liberated directly from vacuoles as in *M. (S.) pygmaea.* The bulk of the secretion consists of minute, purple staining granules. A single, branched tubule makes up the gland, but this has a very wide lumen in some individuals.

Volvarinella cairoma

The most striking feature of the buccal mass of this species is the complete absence of an odontophore and radula. The proboscis (Fig.3, B) differs from those of the preceding species in having a sharply pointed distal end and by being lined with a cuticle-covered epithelium anteriorly, although the cuboidal cells have very short cilia posteriorly. There is a moderately thick layer of circular muscle below the epithelium (Fig. 3, Ca, Cb) and about two layers of longitudinal fibres. Most of the proboscis cavity is filled with loose gland cells similar to those in the preceding species, and there are also irregular, thin muscle strands attached to the centrally placed œsophagus. A rather thick layer of circular muscles surrounds the œsophagus (oes) which is lined internally with very small, weakly ciliated cuboidal cells. There is a ventral ridge but no dorsal folds. Below this ridge lies the duct of the gland of Leiblein (d.g.l) (see discussion). On either side of this duct are the inconspicuous salivary ducts (s.d) and below it lies the very narrow accessory salivary gland duct (a.s.d). Near the anterior end of the proboscis the gland cells are largely occluded by a rather dense mass of transverse and radial muscles. The very short buccal cavity, which is lined with squamous epithelium, has a thinner wall than the œsophagus. It is only one fifth to one quarter of the outside diameter of the proboscis. The minute mouth opens directly into the buccal cavity at the tip of the proboscis and, just behind it, opens the accessory salivary gland duct. The duct of the gland of Leiblein opens ventrally into the posterior end of the buccal cavity (Fig. 3, D) whereas the salivary ducts discharge alongside this opening after emerging from a pair of low, lateral swellings that lie in the posterior part of the buccal cavity. These ducts do not extend into the œsophageal wall.

The posterior part of the proboscis contains the salivary glands (s.g) and the accessory salivary gland (a.s), although both also extend into the cephalic cavity when the proboscis is retracted. A thick muscular wall, the longitudinal and circular elements being equal in thickness, surrounds the œsophagus (Fig. 3, Cb; oes) which is narrower in this region. It is lined with strongly ciliated, short columnar cells and it continues unchanged through the nerve ring. Thus the mid-œsophageal region may be represented by this narrow part of the œsophagus but there is no definite indication of the usual mid-œsophageal features.

The salivary glands (s.g) are like those of the foregoing species and extend beyond the accessory salivary gland (a.s) which, just in front of the salivary gland, suddenly narrows to give off its exceedingly narrow, winding duct. The accessory salivary gland displaces the duct of the gland of Leiblein (d.g.l) so that it lies in a lateral position. This duct is lined with a non-ciliated, cuboidal epithelium and lies below the very narrow part of the œsophagus that passes through the nerve ring but, on emerging behind it, twists to the right and lies above the œsophagus. Although there are four longitudinal ridges in this section of the œsophagus, none of these correspond to the dorsal folds. Behind the nerve ring the œsophagus broadens but the epithelium remains non-glandular and the cells are cuboidal in shape.

The gland of Leiblein (g.l) widens progressively behind and the outer muscle layer increases in thickness. This is mostly composed of longitudinal fibres but there is also a very thin, inner circular layer. Orange, blue and red staining cells make up the glandular epithelium, the orange type being the most abundant posteriorly whereas only blue and red occur near the nerve ring. The terminal bulb is not as discrete as in the other species and the glandular epithelium has invaded its walls, apart from a small pocket in the most posterior part. Here it is lined with a simple squamous epithelium which does not contain any distinctive cytoplasmic inclusions.

The posterior œsophagus can be distinguished a little behind the nerve ring by its taller epithelium which, like the foregoing species, has dense purplish staining contents in the distal ends of the cells. The posterior part is not greatly expanded, however, and has fairly evenly rounded walls which are lined with rather dense staining cells with central nuclei and very short cilia.

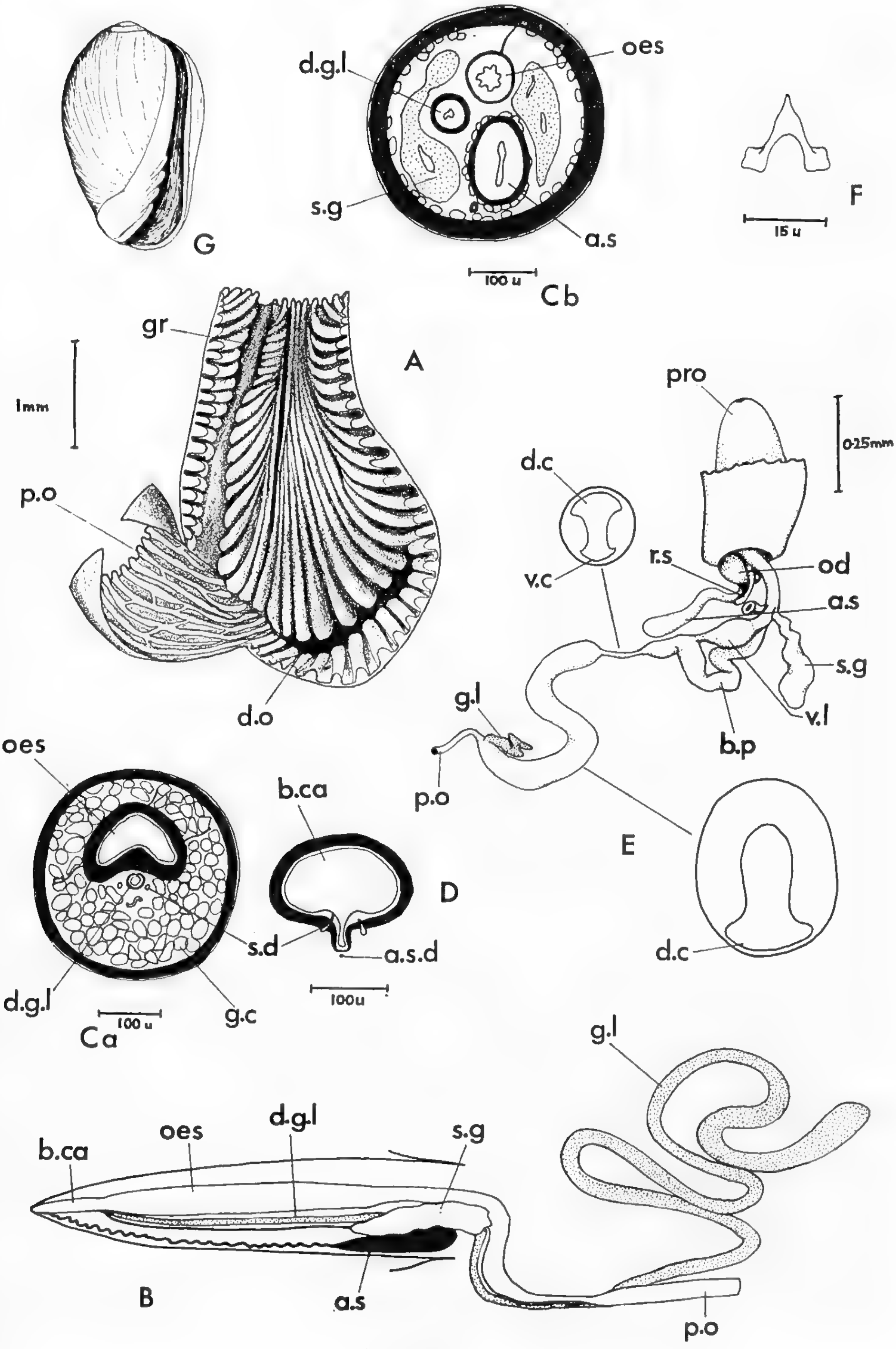
The stomach and digestive gland are like those of the previous species, although the stomach is relatively smaller. As in the previous species the intestine can be divided into an upper non-glandular section which is lined with short columnar cells and a wide pallial portion with a liberal number of orange staining gland cells. This opens into the posterior part of the pallial cavity some distance behind the exhalant opening. The anal gland is a simple, pale brown tube lying along the right pallial wall and it opens well in front of the anus. Posteriorly the cells secrete minute, purplish staining granules, but anteriorly budding is active. There were no large green staining granules in the cells of the anal glands of the specimens sectioned.

Figure 3. *Volvarina (Haloginella) mustelina* (Angas). A — The stomach opened dorsally.

Volvarinella cairoma (Brookes). B — Diagrammatic, lateral view of anterior alimentary canal. Ca, Cb — Diagrammatic transverse sections through the middle (a) and posterior (b) parts of the proboscis. D — A diagrammatic transverse section through the posterior end of the buccal cavity, showing the duct of the gland of Leiblein and the salivary glands opening into it.

Diluculum sp. E — A dorsal view of the anterior alimentary canal showing sections through the mid-oesophagus at the points indicated. The left salivary gland has been removed. F — Radular tooth. G — Shell.

a.s — accessory salivary gland
a.s.d — accessory salivary gland duct
b.ca — buccal cavity
b.p — glandular tube below the valve of Leiblein
d.c — dorsal channel
d.g.l — duct of gland of Leiblein
d.o — opening to digestive gland
g.c — gland cell
g.l — gland of Leiblein
gr — groove
od — odontophore
oes — oesophagus
p.o — posterior oesophagus
pro — proboscis
r.s — radular sac
s.d — salivary duct
s.g — salivary gland
v.c — ventral channel
v.l — valve of Leiblein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It is highly probable that *V. cairoma* is a suctorial feeder and that the transverse muscles surrounding the buccal cavity work in conjunction with the buccal circular muscles and those of the œsophagus, to draw in the food material. Fine particulate remains in the rectum were of variable composition and included algal fragments, diatoms, miscellaneous inorganic particles, and spicules. Possibly this species feeds on the external mucoid secretion of some sedentary animal and could thus pick up a certain amount of debris.

Diluculum sp.

The rather large proboscis (Fig. 3, E; pro) has a blunt end and lies partially within a thin-walled proboscis sac. The small mouth opens into a very muscular buccal cavity which is lined with cuticle ventrally. A very weak layer of muscle surrounding a cuboidal, ciliated epithelium makes up the thin proboscis wall. There are abundant subepithelial gland cells in the anterior part of the proboscis hæmocoel but only a few posteriorly. The œsophagus is narrower and has a thinner wall than that of *M. (S.) pygmaea* and *V. (H.) mustelina.* The relatively massive odontophore (od) has the cartilages separated throughout its length. Thick muscles are attached to the cartilages in the posterior half of the odontophore, but there is only a small amount in the anterior half. A cæcum formed by the expansion of the radular sac (r.s) surrounds the anterior end of the odontophore in the same manner as in *M. (S.) pygmaea* and *V. (H.) mustelina* but the remainder of the radular sac is relatively narrow and extends behind the odontophore. The radula consists of only one row of teeth (Fig. 3, F), these being wish-bone shaped, minute (15 μ wide) and very numerous. Each tooth has a short, triangular median cusp and is supported by two, thin, latero-basal projections which have large, club-like ends.

The salivary ducts open in the same way as in *M. (S.) pygmaea* and the glands (s.g), which lie on either side of the œsophagus in the region of the valve of Leiblein, consist of wide, single tubules, their structure being like those of the other species. A rather long accessory salivary gland (a.s) lies behind the proboscis and its exceedingly fine duct opens ventrally into the buccal cavity. The gland is composed of a muscular tube lined with cuboidal cells containing granulate, weakly staining cytoplasm.

The valve of Leiblein (v.l) lies a little in front of the nerve ring and is a simple swelling lined with short, blue staining gland cells. A ciliated cone protrudes into the valve as in the other species. Behind the valve there is a short portion of the mid-œsophagus which has thick, glandular walls and a thin-walled dorsal food groove (d.c). These glandular walls are nipped off just before the valve and continue as a somewhat coiled, glandular tube (b.p) below the valve. This tube opens into the anterior œsophagus in front of the valve after losing its glandular tissue. The gland cells in this tube are identical with those in the mid-œsophagus behind the valve and consist of blue and red staining cells. There are no cilia apart from those borne by a narrow strip of columnar cells which borders the dorsal food groove on either side. The œsophagus narrows as it passes through the nerve ring and is ciliated by the same tracts as in front and behind. A ventral channel (v.c) becomes apparent in this narrow, slightly glandular part, but just behind the nerve ring the œsophagus again expands and at this point the ventral channel swings to the right and quickly becomes occluded by the glandular tissue. The dorsal food groove (d.c) lies ventrally behind this point, so that in section the mid-œsophagus in front and behind the nerve ring is identical, apart from being reversed.

The posterior part of the mid-œsophagus is long and folded back on itself, and a small narrow, slightly folded gland of Leiblein (g.l) lies at its posterior end. This has muscular walls consisting of inner circular and outer longitudinal fibres and is lined with relatively large cells containing green staining granules. It opens into the œsophagus laterally due to a slight, secondary rotation.

The posterior œsophagus is very like that of *M. (S.) pygmaea* and *V. (H.) mustelina* but does not expand behind the pallial floor. Some of the irregular ridges of the crop are very tall and subdivide the lumen. The stomach is of the same plan as that of *M. (S.) pygmaea* but the gastric lumen appears to be even smaller, the œsophagus and intestine opening very close together. The digestive gland has the normal digestive cells seen in the other species, but in addition has large storage cells with bulging bases and narrow distal ends.

There is a short upper intestine lined with strongly ciliated cuboidal cells with central nuclei, and orange staining gland cells appear at the edge of the pallial cavity. The rectum is very short, the anus lying about halfway along the glandular, pallial gonoduct. There is no anal gland.

THE GENITAL SYSTEMS

The Male Genital System

The male genital system of all the species examined is similar, that of *V. (H.) mustelina* being shown in Figure 4, A. The large testis does not ramify into the digestive gland and it opens into a much coiled vas deferens. This is swollen with stored sperm and thus acts as a seminal vesicle (s.v), but narrows a little way behind the pallial cavity. Here the duct becomes ciliated, the squamous epithelium of the seminal vesicle having changed to cuboidal cells. A short branch from the renal organ (r.o) makes contact with the renal vas deferens but does not open into it. There is no gonopericardial duct, but the vas deferens passes close to the pericardium. Immediately behind the pallial cavity the vas deferens opens into the prostate gland (pr) and at this point a short, ciliated tube in *M. (S.) pygmaea, V. cairoma* and *Diluculum* opens into the pallial cavity, but in V. *(H.) mustelina* there is a short slit. The gland itself is rather short and wide in *M. (S.) pygmaea* and *V. (H.) mustelina*, narrower and a little more elongate in *V. cairoma* and folded and doubled back on itself in *Diluculum*. Simple, tall epithelial cells which have red staining secretory granules concentrated especially near their distal ends, surround the narrow lumen, and minute ciliated cells lie between them. There is no trace of a line of fusion showing the position of an originally open groove as in some muricids (Fretter, 1941).

The ejaculatory duct (ej) is rather narrow and is lined with a ciliated cuboidal epithelium, although the proximal region has short, blue staining gland cells. A layer of muscle surrounds this duct, being very thick in *V. cairoma*, moderately so in *V. (H.) mustelina* and thin in the other two species. The duct is unusually long owing to the considerable distance from the exhalant aperture to the base of the penis on the right side of the head.

The structure of the penis shows marked differences in each species so they are described individually below.

The penis of *M. (S.) pygmaea* (Fig. 4, B) is broad, short, flattened and broadly oval in section. Its lateral edges are brown and the remainder white. The circular muscle surrounding the duct is considerably increased in thickness at the base of the penis. The duct lies in the centre of the penis and the remainder of the tissue is made up of loose transverse muscles and fairly dense, blue staining gland cells. A cuboidal epithelium covers the penis, this being ciliated proximally but covered with cuticle distally. The penial duct opens ventrally, just behind the distal edge.

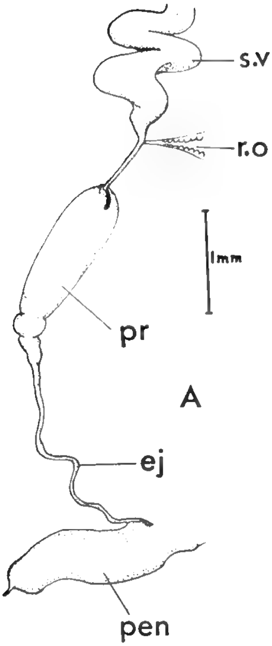
The penis of *V. (H.) mustelina* is about twice as long as that of *M. (S.) pygmaea* and is oval in section (Fig. 4, Aa). Its lateral edges have a rather tall, glandular epithelium which becomes especially prominent near the distal end. The remainder of the epithelium is cuboidal and covered with thin cuticle on the distal part, but is ciliated nearer the base. At the base of the penis the penial duct is narrow, with a ciliated, cuboidal epithelium and a rather thick layer of circular muscle which persists throughout the penis. The duct soon expands and mucous cells appear between the ciliated cells. These are replaced by tall prostatic cells (pr.t) with a few goblet cells lying amongst them. This epithelium persists through most of the penis and this part of the duct takes up much of the bulk of the penis. Numerous subepithelial gland cells, staining orange and purple, lie in the penial tissue around the duct along with scattered muscle fibres. Just behind the distal end the duct narrows and enters a short filament. The outer wall of the penis has only a thin layer of muscle.

V. cairoma has a moderately long penis (Fig. 4, C) which, unlike the preceding species, is divided into two terminal parts; a thick anterior portion which contains the duct, and a posterior, thin-walled sheath (sh) which partially encloses the proximal end of the anterior portion. The thin outer wall has a cuboidal epithelium which is ciliated behind and lined with cuticle in front. Scattered transverse muscles lie in the penial tissue amongst blue staining gland cells. The penial duct resembles the ejaculatory duct in having a very thick wall of circular muscle and a narrow lumen, but it is only about half the diameter. Near the distal end of the penis the duct widens considerably and is lined with blue staining gland cells (Fig. 4, Ca). The ciliated cells are lost and the muscle surrounding the duct is reduced in thickness, whereas the subepithelial gland cells increase in density.

The penis of *Diluculum* sp. (Fig. 4, D) is rather long, slender, and oval in section (Fig. 4, Da) with a very muscular, relatively large, central

Figure 4. A — The male genital system of *Volvarina (Haloginella) mustelina* (Angas). Aa — Transverse section of the penis. B — Penis of *Mesoginelia (Sinuginella) pygmaea* (Sowerby). C — Penis of *Volvarinella cairoma* (Brookes). Ca — Transverse section through distal papilla and its sheath. D — Penis of *Diluculum* sp., a — Transverse section. E — Lateral view of the pallial oviduct of *M. (S) pygmaea*. F, Fa — Dorsal and lateral views of the egg capsule of *V. cairoma*. G, Ga — Dorsal and lateral views of the egg capsule of *V. (H.) mustelina*.

b.c — bursa copulatrix
cap — capsule
ej — ejaculatory duct
i.g — ingesting gland
o.d — renal oviduct
pen — penis
p.o — albumen gland
pr — prostate
pr. t — prostatic tissue
r.o — branch of renal organ
sh — sheath
s.v — seminal vesicle
v.c — ventral channel of capsule gland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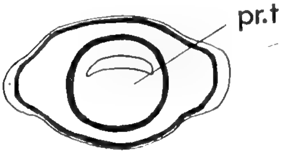
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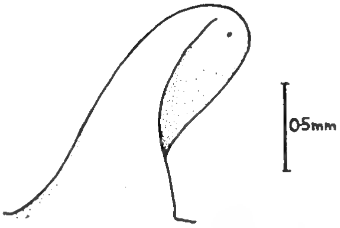
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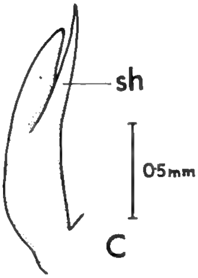
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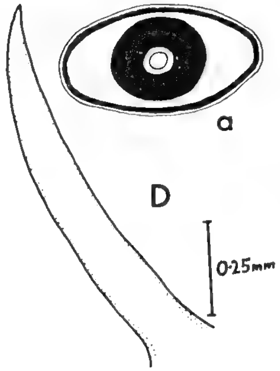
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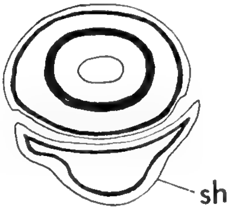
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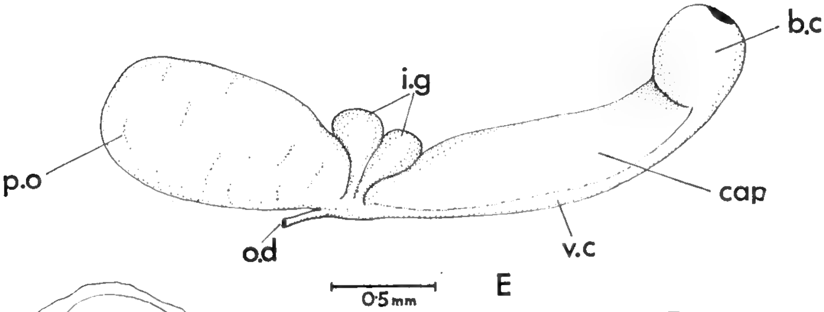
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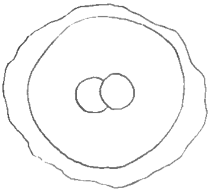
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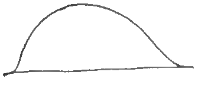
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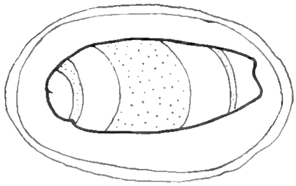
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duct. This has a narrow ciliated lumen and the cuboidal lining continues unchanged to the distal end of the penis. The outer epithelium is of cuboidal cells covered with thin cuticle.

The Female Genital System

The female genital tracts of the three New Zealand species are very similar to one another. The pallial oviduct of *M. (S.) pygmaea* is shown in Fig. 4, E. The rather small ovary does not penetrate the digestive gland and contains large yolky eggs. The upper oviduct is a non-ciliated tube, but the wider renal section (o.d) has short, ciliated, columnar cells. There is no gonopericardial canal, but an arm of the renal organ touches, but does not enter, the renal oviduct.

The large albumen gland (p.o) has complexly folded walls and its posterior half lies beside the renal organ behind the pallial cavity. Its glandular walls stain pale reddish and are made up of long, narrow, columnar cells which alternate with wedge-shaped ciliated cells. A short portion of the pallial oviduct between the albumen gland and the capsule gland is a relatively narrow tube with folded, ciliated, non-glandular walls. It receives the renal oviduct below and two or three narrow, ciliated ducts (two in *M. (S.) pygmaea* and *V. (H.) mustelina* and three in *V. cairoma)* which open into an equal number of wide vesicles (i.g) above. These ducts have a cuboidal epithelium and a thin outer layer of muscle. The vesicles, or seminal receptacles, have an irregular lining of cells that are mostly cuboidal in form and variable in size and which have conspicuous, red staining nuclei. The ducts are bound together near their bases by a few common fibres, and at the point where they open into the vesicles there is often a mass of orientated spermatozoa attached to their walls. Groups of sperm can also be seen lying loose in the lumen of the vesicles. No indication of sperm ingestion was observed.

The capsule gland (cap) is a relatively massive structure which, owing to the posteriorly placed exhalant aperture of the pallial cavity, lies transversely across the back of the cavity. The middle glandular region stains orange and there are no clearly marked lateral zones like those seen in certain other rachiglossans. This region has the epithelium arranged in complex units like those in the species described by Fretter (1941) but the glandular regions at either end of the capsule gland have a simple epithelium. In *V. cairoma* there is a zone of mucous cells at both ends of the gland but in *M. (S.) pygmaea* and *V. (H.) mustelina* the anterior region has red staining cells. Some variation in detail was apparent in different individuals of each species. The broad ventral channel of the capsule gland has no prominent ciliated folds overhanging it as in some larger rachiglossans (Fretter, 1941), although there is a rudimentary fold in *M. (S.) pygmaea.* This channel is continuous with the median ciliated region. The short vestibule lies immediately in front of the capsule gland. It has several sharp ridges formed from ciliated columnar cells on its lateral walls. The vestibule opens into the short, thick walled bursa copulatrix (b.c) which lies just in front of the capsule gland and a little behind the exhalant opening. Its walls consist of muscle fibres embedded in connective tissue, and it is lined with ciliated columnar *(M. (S.) pygmaea)* or cuboidal (the other species) cells. The vestibule narrows to form the vagina, a very short ciliated tube which discharges into the bursa just before the latter opens into the pallial cavity terminally.

A large ventral pedal gland consisting of a mass of subepithelial cells can be found behind the anterior edge of the foot in all four species.

The female genital system of *Diluculum* sp. is like that of the other species except that there is only one vesicle making up the seminal receptacle. The capsule gland has no anterior mucous zone and its walls are lined with only a simple glandular epithelium. The vestibule is relatively more spacious and is lined with cuboidal, ciliated cells. Only a few muscle fibres surround the relatively larger bursa copulatrix which is lined with a ciliated epithelium continuous with that of the vestibule in front where these two sections of the duct open together into the pallial cavity. The bursal lining is taller and stains more densely within the bursal lumen.

The egg capsules of only *V. (H.) mustelina* (Fig. 4, G,a) and *V. cairoma* (Fig. 4, F,a) have been found. *V. (H.) mustelinia* lays lens-shaped, thin, semitransparent capsules throughout the summer. They are laid in small groups in crevices near low tide mark. *V. cairoma* likewise lays its capsules in groups under clean stones, where they were found nestling in small cracks and crevices in the surface of the stone. The capsules of this species were found at Island Bay, Wellington, in November. In both species only one embryo usually reaches maturity, although in *V. cairoma* at least, two ova are sometimes placed in a capsule. The embryo fills the capsule before emerging as a crawling juvenile.

The capsule of *V. (H.) mustelina* is elongately oval, about 2.75 mm in length and has a narrow, flat margin. The embryo shell is usually about 2 mm when hatched. *V. cairoma* has a circular capsule 1.2 mm in diameter, and the shell of the newly hatched juvenile is of the same length. An irregular flat margin surrounds the capsule in both species.

DISCUSSION

The family Marginellidae

It is clear that further species will have to be examined before a complete diagnosis of this family can be formulated. The range of form in the alimentary canal is considerable and it is highly probable that further modifications will be found. The species investigated by Graham (1966) and Marcus & Marcus (1968) show a different morphology from the species considered in this study and also from one another. This family thus appears to be unlike most rachiglossan groups each of which generally show a remarkable uniformity in the structure of the alimentary canal, but which have considerable variation in shell morphology. In the Marginellidæ the difficulty of grouping species into generic units because of the overall similarity of their shells has often been expressed, with the result that the majority of species in most molluscan checklists continue to be retained within one genus, *Marginella*.

Some of the distinctive features of the family shown in the species so far examined, can be summarised as follows: The shell is small to medium in size, usually smooth and glossy, with a thickened outer lip, large body whorl and long, narrow aperture. There are always columellar folds within the aperture and frequently additional accessory denticles. The protoconch is paucispiral and development is thus probably always direct.

The foot is wide but not thick, and there is no operculum. The tentacles usually have the eyes near their outer bases. The siphon is above the head and its left margin is fused to the left side or midline of the head, whereas the exhalant opening is situated almost at the posterior end of the pallial cavity on the right side. The mantle edge is often capable of being reflected over the shell.

Although the proboscis is variable in form it is generally rather short. The buccal apparatus is variable, but when a radula is present the radular sac is expanded and encompasses at least the anterior end of the odontophore. The radula has only the central teeth remaining and these are very variable in form. A single accessory salivary gland is often present and the gland of Leiblein opens either into the œsophagus behind or in front of the nerve ring, or into the buccal cavity. In the case where it opens behind the nerve ring, there is a narrow tube derived from the ventral side of the œsophagus which by-passes the valve of Leiblein. The position of torsion lies immediately behind the nerve ring. The stomach is small, without any cuticle-lined surfaces and usually has a single, wide opening to the digestive gland. An anal gland is usually present. The renal organ has the primary and secondary glandular lamellæ in separate areas and the circum-œsophageal ganglia are highly concentrated. There is no gonopericardial duct in the male or female genital systems and the male has the pallial prostate gland and penial duct closed. The female pallial oviduct has an albumen and capsule gland and usually a small bursa copulatrix. There are one or a few small sperm sacs lined with irregular cuboidal cells. A ventral pedal gland is found in females and the egg capsules are usually lens-shaped and horny.

The accessory salivary gland reaches its greatest development in *V. cairoma* and is also well developed in *V. (H.) mustelina* and *Diluculum* sp. but is absent from *M. (S.) pygmaea* and "*M.*" *marginata.* "*M.*" *desjardini* appears to have an accessory salivary gland which is referred to as a "vestigial buccal pouch" by Graham (1966). No members of the Marginellidæ appear to have paired accessory salivary glands.

Graham has shown that the odontophore of "*M*" *marginata* lies within a "buccal pouch" derived from the radular sac instead of lying in its normal position on the floor of the buccal cavity. Examination of *M. (S.) pygmaea, V. (H.) mustelina* and *Diluculum* sp. show how this pouch is formed. The dorsal and ventral parts of the radular sac become continuous laterally and thus the anterior radular teeth appear to lie naked on the odontophore. The posterior continuation of the expanded anterior portion seen in these three specis would provide the situation seen in "*M.*" *marginata* along with the resultant modification of the odontophoral muscles noted by Graham (1966).

The loss of the buccal mass in several species (*V. cairoma,* "*M.*" *hyalina* (Eales, 1923) and "*M.*" *desjardini* (Graham, 1966)), is of special interest as it must necessitate a suctorial method of feeding. There are only a few other stenoglossans that have been reported as having lost the buccal mass entirely, these including certain toxoglossans and the Magilidæ.

The absence of an anal gland in *Diluculum* sp. is probably unusual for the family. The function of this organ is still rather obscure. In *V. (H.) mustelina* the gland often has a very wide lumen in which appears a finely granular secretion. The anal gland cells in this species, and in *M. (S.) pygmaea*, do not bud off their apices as they do in many stenoglossans. These cells in *M. (S.) pygmaea* contain numerous, dark greenish staining granules which are much more sparse in the cells of *V. (H.) mustelina* and are absent in the anal gland of *V. cairoma*. None of these species have amoebocytes which accumulate dark green granules in their digestive glands, although these are seen in many stenoglossans (Smith, 1967b).

Graham (1966) has described the oviduct of *"M." desjardini* and though he gives no histological details it seems likely that the structure he referred to as a receptaculum seminalis is homologous with the albumen gland of the species dealt with here. The " ingesting gland " of " *M.*" *desjardini* is broken up into several vesicles and is probably equivalent to the seminal receptacles in the species studied here. There is apparently no bursa copulatrix in " *M.*" *desjardini*.

The egg capsules of the two species described here are similar in being domed, oval or circular, thin and transparent, and in having only one embryo develop. The capsules of six species have been described by Knudsen (1950) and except those of " *Marginella* " *cornea* (Lamarck) and " *M.*" *goodalli* which are lens-shaped and have stalked bases, they are similar to those of the New Zealand species. They all contain only one embryo and do not appear to contain nurse eggs, the embryo probably relying only on its own yolk supply.

The real relationships of the relatively primitive *Diluculum* to the remainder of the Marginellidæ cannot be satisfactorily established here. The animal of the type species of *Cystiscus, C. cystiscus* (Redfield) has been figured by Stimpson (1865) and it has the same anterior expansion of the head seen in *Diluculum* and *Euliginella* (Laseron, 1957), although this appears to have become fused dorsally, whereas in *Diluculum* it remains open. In addition the radula of *C. cystiscus*, also figured by Stimpson, is quite different from that of *Diluculum* sp., although it is strongly arched and this may indicate a relationship. Until the morphology of the alimentary canal of *Cystiscus* is known, *Diluculum* can be tentatively placed within the Cystiscinæ.

The Evolution of the poison gland of the Toxoglossa

The derivation of the poison gland of the Toxoglossa has never been satisfactorily accounted for and several homologues have been proposed, these including the œsophageal gland (Amaudrut, 1898; Shaw, 1915; Risbec, 1955; Marcus and Marcus, 1960; Kohn, 1963; Graham, 1966), the left salivary duct (Alpers, 1931), and the accessory salivary gland (Graham, 1941; Robinson, 1960 and doubtfully by Marcus & Marcus, 1968). Smith (1967a) suggests that it is an entirely new structure.

Graham (1966) has termed the gland, referred to here as the gland of Leiblein, a poison gland because in one of the species he deals with, " *M.*" *marginata*, the duct of the gland opens into the buccal cavity in much the same manner as does the poison gland of the Toxoglossa. This duct opens in a similar position in " *M.*" *fraterculus* (Marcus & Marcus, 1968). In " *M.*" *desjardini*, however, the gland opens ventrally into the œsophagus a little in front of the nerve ring and Graham showed that this gland is orientated in the same way as the œsophageal gland of the Mesogastropoda. Graham followed Amaudrut's (1898) suggestion that the poison gland was probably stripped off the œsophagus from behind forwards and was therefore derived independently from the gland of Leiblein (see Graham, 1941).

The nature of the "gland of Leiblein" in the Marginellidæ, and in the other rachiglossan and toxoglossan species studied by the writer, suggests the following derivation of this gland in the Marginellidæ, and there is every reason to suppose that the poison gland was derived in a parallel fashion in the Toxoglossa.

The comparatively primitive stenoglossan arrangement of a mid-œsophagus with glandular dorsal folds and a posterior gland of Leiblein is found in several families, including the Muricidæ (Graham, 1941), Olividæ (Marcus & Marcus, 1959), Vexillidæ, Volutomitridæ (Ponder, b), Volutidæ (Woodward, 1900; Pace, 1902) and the Marginellidæ. Amaudrut (1893) and Graham (1941) showed that the gland of Leiblein was formed in most of the Rachiglossa by the mid-œsophageal gland of the mesogastropods being stripped off backwards so that it was connected by a narrow duct opening dorsally into the posterior end of the mid-œsophagus. In doing so a thin-walled groove remained which indicated the line of fusion remaining after the removal of the gland. Although this groove is continuous with the ventral groove in the anterior œsophagus it is thus not homologous with it.

The next stage is apparently the fusion of the apices of the glandular dorsal folds to form a glandular tube with the true gland of Leiblein attached behind by its original duct. This is well illustrated in *Austromitra rubiginosa* (Hutton) and *Vexillum* spp. (Ponder, b), where the tubular part of the gland of Leiblein is in no way differentiated from the glandular dorsal folds lying in what remains of the mid-œsophagus, and a thin walled "scar" is visible along the ventral side of the tube. The original duct of the gland of Leiblein is also visible in species of the genus *Vexillum*. This change appears to be followed by a simplification of that part of the mid-œsophageal region deprived of its glandular tissue, to a simple conducting tube not separable from the posterior œsophagus. Alternatively the atrophication of the mid-œsophagus posterior to the opening of the new duct of the gland of Leiblein and the subsequent forward extension of the posterior œsophagus, would produce the same result.

The stripping off of the dorsal glandular area of the mid-œsophagus must have occurred from behind forwards. The evidence for this in the Marginellidæ is as follows. Firstly, in *Diluculum* sp. similar gland cells to those found in the tube of the "poison gland" of the other species are found in the dorsal glandular area of the mid-œsophagus, and the small gland of Leiblein (sensu stricto) is attached to the posterior end of the mid-œsophagus. Secondly the extension of the stripping off of the dorsal glandular area is halted behind the nerve ring in *M. (S.) pygmaea* and *V. (H.) mustelina,* but in the latter species the glandular tissue of the œsophagus and tube are continuous. In addition a tubular loop representing the lower half of the dorsal folds (this area being pre-torsional) and the ventral channel, by-passes the valve of Leiblein to become confluent with the ventral channel of the anterior œsophagus. The same by-pass is found in *Diluculum* sp. but in that species it is glandular. "*M.*" *desjardini* (Graham, 1966) indicates the next stage in having the duct of the gland continous with the tubular by-pass through the nerve ring, and so past the valve of Leiblein to open into the anterior œsophagus. This step could be achieved by continuing the pinching off of the ventral channel through the nerve ring. *Volvarinella cairoma* shows how further anterior extension of the poison gland probably took place. In this species the narrow duct of the poison gland opens ventrally into the buccal cavity as it does in " *M.*" *marginata* (Graham, 1966) and " *M.*" *fraterculus* (Marcus & Marcus, 1968). The duct lies beneath a median, ventral ridge in the anterior œsophagus which almost certainly represents the fused dorsal edges of the dorsal folds. This is indicated by the occurrence of two separate folds in the most posterior section of the anterior œsophagus which quickly fuse to form the median fold. There are, in addition, two low swellings in the buccal cavity which probably represent the dorsal folds. No other structures occur within the œsophagus that could represent these folds, although they are prominent in the other species. It would appear then, that the apices of the dorsal folds have become fused so that their ventral portions, and the channel between them, have been nipped off and lie as a separate duct. This is merely an anterior extension of the by-pass beneath the valve of Leiblein which opens ventrally into the posterior end of the buccal cavity.

The salivary ducts are typically embedded in the œsophageal wall beneath the dorsal folds, but in *V. cairoma,* " *M.*" *fraterculus,* and in " *M.*" *marginata* they lie free owing to the dissociation of these folds. " *M.*" *desjardini* also has free salivary ducts which apparently run outside the œsophageal wall in front of the point where the " poison gland " becomes confluent with the anterior œsophagus. This, however, may be due to an independent stripping of the salivary ducts from the proboscis wall as has occurred in several groups (e.g. some Buccinidæ (Dakin, 1912) and some Mitridæ (Risbec, 1928)).

The terminal sac of the " poison gland " is, as shown above, equivalent to the gland of Leiblein (sensu stricto) of the Muricidæ and Buccinidæ, as it generally has a similar histology, and has the same morphological relations. The glandular activity is, however, usually much reduced. The cells can be characterised by their very irregular shape, the budding of their distal ends and the production of greenish-brown staining granules. It is these granules that give the gland its characteristic brown colour in life. Similar cells have been observed by the writer in the terminal sac of the poison gland of certain Turridæ, notably *Leucerapex angustatus* (Powell) and *Maoritomella albula* (Hutton). This sac becomes a muscular bulb in the toxoglossa that pumps the secretion formed in the duct from the gland.

The anterior migration of glandular tissue through the duct of the poison gland could readily occur once the duct had been freed from its morphological straight jacket, and thus the whole nature of the anterior and mid-œsophagus could be altered. A duct derived in the above way would follow the same path around the œsophagus as would a derivative from the œsophageal gland.

Most toxoglossans are at a stage comparable with those marginellids with a radula. Some have lost this structure and thus resemble *V. cairoma.* All of the toxoglossans that have been investigated either have a fully developed poison gland or have lost this structure. There are no dorsal folds in the œsophagus and the salivary ducts are always free from the œsophageal wall. The main difference from the Rachiglossa lies in the very much shorter anterior œsophagus, if indeed this can be distinguished at all.

One notable absence in the alimentary canal of the Toxoglossa is the valve of Leiblein (Smith, 1967a). This is also absent in *V. cairoma* and is not mentioned in either of the species studied by Graham (1966) but in "*M.*" *fraterculus* a slight swelling in interpreted as an "individually inconstant valve of Leiblein" by Marcus & Marcus although there was no histological verification. Its efficiency as a valve in the three marginellid species which posses it is undoubted, because of the extreme development of the valvular cone and the lack of a ventral groove through this structure. The necessity for the by-pass tube could possibly be associated with allowing the forward flow of the secretion from the "poison gland", or alternatively, a safety valve useful during the sudden contraction of the proboscis. The former function would allow retention of the valve after the incorporation of the by-pass tube in the poison gland duct, but the latter would not. It is of interest to note that most rachiglossan species not having a gland of Leiblein have also lost the valve of Leiblein.

In summary the "gland of Leiblein" of the Marginellidæ and the poison gland of the Toxoglossa were probably formed in the same way. This involved the formation of a long duct to the gland of Leiblein (sensu stricto) by the fusion of the apices of the dorsal folds of the œsophagus which passed through the nerve ring and entered the buccal cavity. The glandular tissue of the mid-œsophageal section of the dorsal folds migrated anteriorly. This was accompanied by a reduction in the glandular activity of the gland of Leiblein, this becoming the terminal sac of the marginellid "gland of Leiblein" or the muscular bulb of the toxoglossan poison gland. The by-passing of the valve of Leiblein was accompanied by its reduction and eventual loss.

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TAXONOMIC NOTES ON *EOLIS MILITARIS* ALDER AND HANCOCK, 1864 (OPISTHOBRANCHIA, EOLIDACEA)

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SUMMARY

Eolis militaris Alder and Hancock (1864) is identical with and a prior synonym of *Learchis indica* Bergh (1896). *Caloria* Trinchese (1888) and *Learchis* Bergh (1896) are anatomically identical, the respective type species being distinguished by dorsally emarginate and dorsally rounded jaws.

INTRODUCTION

Eolis militaris is a fairly common eolid mollusc at localities in the Gulf of Kutch on the north-western coast of India. As it has not previously been anatomically studied nor its systematic position and relationship to other genera and species determined, one of us (K.R.N.) collected and observed living specimens and the other (R.B.) examined the preserved material and investigated the taxonomy.

We are indebted to the Fisheries Commissioner, Gujarat State, Ahmedabad, India, for permission to report on the Gulf of Kutch specimens. Mr. Gordon A. Robilliard, Friday Harbour Laboratories, Oregon, generously presented Hawaiian specimens already identified as *Learchis indica* (Baba, 1969). A grant from the Science and Industry Endowment Fund, C.S.I. R.O., Melbourne, enabled one of the writers (R.B.) to carry out this and other research.

DESCRIPTION AND TAXONOMY

Since the original description of the unique type specimen, *Eolis militaris* has been reported twice: by O'Donoghue (1932) from Ceylon and by Narayanan (1969) from the Gulf of Kutch. The only taxonomic advancement was the transference (Farran, 1905) to *Hervia* where it has remained.

Preserved specimens from the Gulf of Kutch have been examined and compared with specimens from other localities. The Gulf of Kutch specimens have typical facelinid appearance with 6 - 7 rows of cerata in the right liver, the anus behind two rows of the 4 - 5 row second liver group, and tentaculiform foot corners, but with special characteristics of smooth rhinophores and conical unarmed penis. The 25mm long living animals had a translucent body with a line of reddish-orange along each side below the cerata and forward to the tentacles; a V-shaped patch of the same colour lies on the head with the point between the rhinophores and the anteriorly directed arms uniting with the lateral lines on the tentacles; the tentacles and rhinophores had yellowish tips, and the cerata were brick-red with light black digestive glands and yellowish tips. The jaws and radula agree completely with earlier descriptions (Alder and Hancock, 1864; Eliot, 1906; O'Donoghue, 1932).

The special characteristics of this species mentioned above, i.e. smooth rhinophores and conical unarmed penis, combined with facelinid liver branching, necessitate the transference of *Eolis militaris* from *Hervia* (which is a synonym of *Facelina*) to *Learchis*. The type species of the latter, *L. indica Bergh* (1896: 386) has been lately excellently redescribed from Japanese and Hawaiian specimens (Baba, 1969), from which it is obvious that *Learchis indica* is identical with and a junior synonym of *Eolis militaris*.

The genus *Caloria* Trinchese (1888; Haefelfinger, 1960: 234) also has all the characteristics of *Learchis*, and their respective types, *C. maculata* Trinchese (1888) and *L. indica* Bergh (1896; = *Eolis militaris* Alder and Hancock, 1864), are separated only by the shape of the jaws, dorsally indented in the former and dorsally rounded in the latter. Similar variation occurs between species of other genera; for example the deeply indented jaws of *Facelina (Acanthopsole) quatrefagesi* (Vayssière, 1888: 42, pl. 7, fig. 140) and the rounded jaws of *F. (A.) rubrovittata* (A. Costa, 1866; Vayssière, 1888: 36). It is therefore unwise to maintain two taxa for this undoubted single genus. Accordingly, *Caloria militaris* (Alder and Hancock) will be the correct name for this species.

A full synonymy of the species is listed, together with the material examined.

Caloria militaris (Alder and Hancock)

Eolis militaris Alder and Hancock, 1864: 144, pl. 33, fig. 15; Eliot, 1906: 1007.

Hervia militaris. Farran, 1905: 331; O'Donoghue, 1932: 143; Satyamurthi, 1952: 350, pl. 33, fig. 4a - c; Narayanan, 1969: 211.

Learchis indica Bergh, 1896: 386, pl. 16, fig. 1 - 4; Baba, 1969: 399, pl. 27.

Aeolidia dangeri Risbec, 1928: 252, pl. 9, fig. 1.

Hervia dangeri. Risbec, 1953: 136, fig. 75a - f.

Learchis howensis Burn, 1966: 25, fig. 7 - 10.

Material

1. South reef lagoon, Lord Howe Island, 2 January 1938, 1 specimen (holotype of *L. howensis* Burn) collected by Joyce Allan and R. Baxter, Australian Museum no C65663.
2. Funafuti, Ellice Islands, central Pacific, 1897, 1 specimen collected by Charles Hedley during the Royal Society Expedition to study coral atoll origins, A.M. no 6263. New record for this area.
3. Kaneohe Bay, Oahu, Hawaii, July 1968, 3 specimens on *Pennaria* hydranths, collected by Gordon A. Robilliard, National Museum of Victoria no. F27353.
4. Dona Reef, Gulf of Kutch, western India, December 1966 - November 1968, 7 specimens collected by K. R. Narayanan, deposited in the Museum of the Fisheries Research Station, Jamnagar, Gujarat, India.

Eolis Militaris A. & H., 1864

Distribution. INDO-WEST PACIFIC: southern and western India (Alder and Hancock, O'Donoghue, Narayanan), Amboina (Bergh), New Caledonia (Risbec), Japan and Hawaii (Baba), Lord Howe Island and Funafuti (Burn).

REMARKS ON OTHER SPECIES ASSIGNED TO *CALORIA*

Marcus (1958: 58) noted three Indo-West Pacific species that were possibly acceptable to the genus *Caloria*.

1. *Hervia rosea* Bergh (1889: 677; 1890: 877) from Amboina is a large (55 mm live length) species with the cerata set in broad arches along each side and the anus projecting at mid-length of the rear leg of the second arch on the right side. These are favorine characteristics, hence the species cannot belong to a faceline genus such as *Caloria*. Smooth rhinophores and unarmed penis plus cerata set in more than one series in the liver arches suggest that this species is a *Godiva* as intimated by Macnae (1954: 9) and Lemche (1964: 56). Baba and Hamatani distinguish those *Godiva* species without a penial hook as *Setoeolis* (1965: 108), but there is little justification for this move as the presence or absence of such a hook must be regarded as a specific characteristic.

2. *Caloria guenanti* (Risbec, 1928: 244; 1953: 155) from New Caledonia is a small 7 mm long species with a single series of four cerata in the right liver and the anal position not stated. The rhinophores are weakly annulate. The elongate cuspidate radular teeth suggest that this is a cleioproct species, hence the inference that the anus opens behind the first row of two cerata in the posterior liver. *C. guenanti* is obviously a favorine of some kind; if the right liver is a simple row it could be assigned to *Herviella*, if an arch to *Favorinus, Cratena, Amanda* or *Noumeaella*.

3. *Caloria australis* Risbec (1937: 162; 1953: 155) from New Caledonia is an even smaller species (5 mm) with annulate rhinophores and five rows of cerata in the right liver. The anal position is not clearly defined, though the description places it to the right of the pericardium and a little behind the genital aperture, and from which it could be interpreted as opening in the interhepatic space or acleioproctic. The radular teeth are very similar in shape to those of the acleioproct genus *Njurja* Marcus and Marcus (1960b: 921, fig. 75), which furthermore has an unarmed penis, tentaculiform foot corners, five rows of cerata in the right liver, and perfoliate rhinophores. *C. australis* would be better placed in *Njurja* where it would be separated from the type species, *N. netsica* Marcus and Marcus, by annulate rhinophores and asymmetrical hammer-like penis.

The remaining species is the trans-Atlantic *Learchis poica* Marcus and Marcus (1960a: 183) for which supplementary descriptions have been given by Edmunds (1964: 18; 1968: 208). This differs from *C. maculata* and *C. militaris* in a number of points, namely annulate rhinophores, broad radular teeth, and a reduced penial gland at the base of the conical penis. Cerata mounted on arches in the posterior liver are common to both *C. maculata* and *L. poica*. It is better to retain *L. poica* in *Caloria*, than to build upon these subjective differences and create a new monotypic genus for it.

The *Caloria maculata* of Pruvot-Fol (1951: 60; 1954: 397) was renamed *Hervia costai* Haefelfinger (1961), but according to Schmekel (1967: 269) this is synonymous with the favorine, *Cratena peregrina* (Gmelin, 1791).

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A LIVING SPECIES OF *AUSTROTRITON* (GASTROPODA, CYMATIIDAE) FROM NEW SOUTH WALES

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Plate 6

SUMMARY

The first living species of the endemic Australian genus *Austrotriton* is described from the continental shelf off central New South Wales. It is related to an undescribed species from the uppermost Miocene of Gippsland, Victoria.

INTRODUCTION

Austrotriton, an endemic Australian genus of Cymatiidæ, is represented by numerous species in the Eocene, Oligocene and Lower to Upper Miocene of Victoria, South Australia and Tasmania (*see* species described by Tate, 1888; and generic assignments by Darragh, 1970), and a small, nodulose species from the uppermost Miocene of Gippsland, Victoria, is as yet undescribed (T. A. Darragh, pers. comm.; also specimens examined at the National Museum of Victoria during September, 1969, and collected in Gippsland by T. A. Darragh and the writer). The genus was erected for the Miocene *Triton radialis* Tate, 1888 and related species by Cossmann (1903, p.98); Iredale (1914, p.459) placed the Recent Australian and New Zealand species *Septa parkinsonia* Perry, 1811 in the genus, considering it to be the living representative of the long line of Tertiary species typified by *Triton radialis* Tate. However, Finlay (1931, p.7) showed that there were two genus-group taxa in Iredale's concept of *Austrotriton,* and designated *Septa parkinsonia* as the type species of a new genus, *Austrosassia.* Several of the species described by Tate (1888), having regularly coiled, turbinate protoconchs, belong in Tertiary lineages of *Austrosassia.* All species of *Austrotriton* have irregularly coiled, variably shaped protoconchs, apparently the remnants of a primarily chitonous larval shell which was lost soon after metamorphosis to a crawling benthic juvenile. Since Finlay referred *Septa parkinsonia* to his genus *Austrosassia,* no living representatives of *Austrotriton* have been recognised, and the genus has been regarded as an extinct, endemic Australian group.

During examination of the collections of Cymatiidæ in the Australian Museum, Sydney, during August, 1969, the writer recognised an undescribed living species of *Austrotriton* in the collections made by the Commonwealth Government prawn trawling investigations with M.V. " Challenge ", from the outer half of the continental shelf off central New South Wales. The molluscan collections were assembled through various contacts late in the investigations by Mr. T. A. Garrard, of Sydney, and presented to the National Museum of Victoria and the Australian Museum. Most novelties were described by Garrard (1961), who gave the dates and localities of the prawning investigations in more detail.

The specimens of *Austrotriton* are small and finely sculptured, apart from their three rows of moderately large, sharp nodules, and closely resemble both *Austrosassia parkinsonia* (Perry) and *Sassia* (= *Phanozesta)* *remensa* (Iredale), both of which were taken in moderate to large numbers at many stations by M.V. "Challenge". It is not surprising, then, that the specimens of *Austrotriton* remained undetected in specimen-lots of *Austrosassia* and *Sassia.*

The undescribed species of *Austrotriton* from the uppermost Miocene of Gippsland differs from the new species only in its coarser nodular sculpture, in the broader form of young shells, and in reaching a slightly larger adult size, and may be no more than a subspecies of it. The two have very similar apices of a unique form, apparently lacking protoconchs altogether. *Austrotriton woodsi* (Tenison-Woods, 1879) is a Miocene species from Victoria with a markedly different apex (bearing a prominent spike similar to that of the *Caricella* apex of the Volutidæ) but with similar rows of peripheral and basal nodules to those of the Gippsland and New South Wales species. It appears to have been the ancestor of the lineage that culminated in the living species.

The new species is named after Mr. Tom Garrard of Sydney in recognition of his personal generosity to the writer, of his useful and continuing contributions to the study of eastern Australian Mollusca, and of his collection of all the known specimens of the new species.

TAXONOMY

Family Cymatiidæ

Genus *Austrotriton* Cossmann, 1903

1903. *Austrotriton* Cossmann, *Essais de Paléoconchologie Comparée*, 5: 98.

Type species (by original designation): *Triton radialis* Tate, 1888, Miocene, South Australia and Victoria.

Austrotriton garrardi n.sp.

Pl. 6, figs. 1-6; Text-fig. 1.

Shell small, with moderately tall spire, moderately long siphonal canal curved slightly towards the dorsum, moderately sloping slightly concave shoulder just covering central row of nodules on preceding whorl so that only peripheral row of nodules is visible on spire whorls, and with two rows and weakly defined third row of small but sharp-tipped nodules forming two angulations on last whorl. Varices narrow, relatively low, placed regularly every 270° around shell, with very low nodules. Upper row of nodules maintaining strength over each intervariceal space, almost always five in each space but four in last space of some specimens; well-marked gap between last nodule and succeeding varix in each intervariceal space. Lower row of nodules decreasing rapidly in strength over intervariceal space, stopping after about two thirds of space; nodules small and closely spaced, not corresponding in position with much larger nodules of upper row; seven on holotype, four to seven on paratypes. Nodules of basal row very small or absent, often represented by colour band only, up to five nodules present in last intervariceal space when developed. Other sculpture consisting of low, flat-topped, moderately widely spaced, sometimes lightly beaded spiral threads with complex, increasingly fine secondary and tertiary interstitial threads; narrow flat interspaces between finest threads crossed by extremely fine axial growth lamellæ. Primary spiral threads grouped into twos or threes to form ill-defined cords that cross rows of nodules; about eight primary threads on base, below basal row of nodules, are raised into low cords more prominent than other spiral sculpture. Obvious first and second order threads (often indistinguishable) on holotype are: 12 on shoulder of penultimate whorl, 15 on shoulder of last whorl; four to nine below shoulder on penultimate whorl; about 13 in space between upper two rows of nodules on last whorl, about six between lower two rows of nodules, and about 20 on base. Aperture relatively small, oval; interior of outer lip may be almost smooth, with only a few fine denticles at top and bottom, or may have up to nine fine denticles over its whole length, with three fine plicæ crowded together on weak callus pad at top of canal; inner lip thin, smooth and glossy, reflected slightly over last whorl, forming a narrow false umbilical chink between canal and slight fasciole; bearing a low white callus pad on parietal wall, forming a very shallow posterior canal, and three to five fine, sharp plicæ on callus pad at top of siphonal canal. Protoconch apparently deciduous, entirely absent in all specimens, leaving apex of shell a spiral hollow of one whorl, with smooth inner sides, and with a sloping, irregular surface blocking beginning of teleconch; teleoconch spiral sculpture beginning immediately at outer edge of oblique protoconch scar; apex in all specimens thus appears broken off. Periostracum very thin, pale straw coloured, closely adherent to all sculptural details, but apparently readily lost. Colour light fawn to pale reddish brown, usually with alternating light fawn and medium reddish brown splashes on nodular cords.

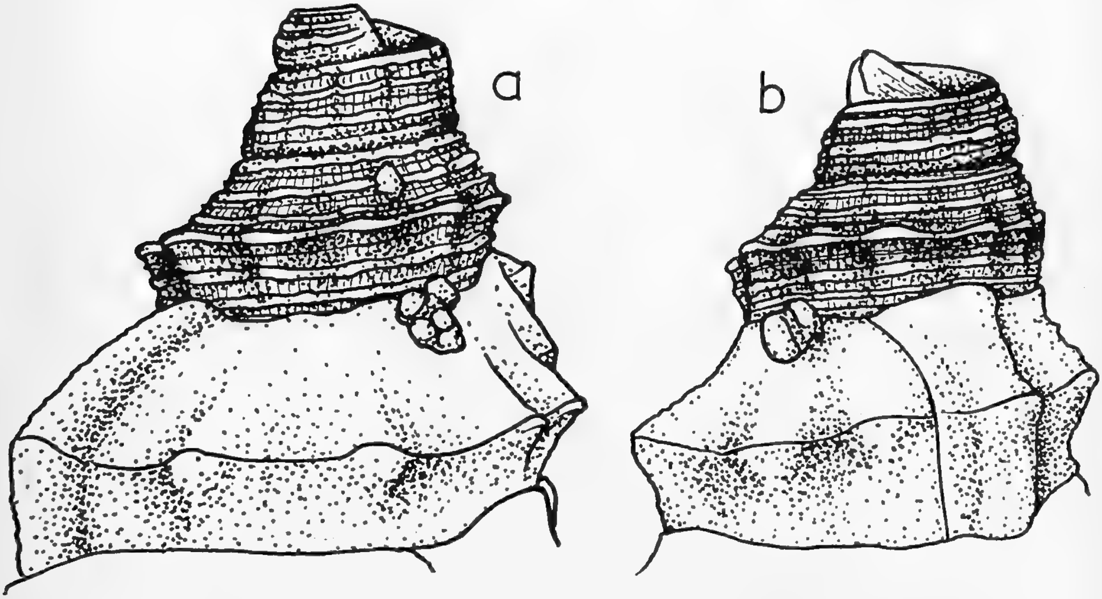

Figure 1. *Austrotriton garrardi* n. sp., apex of holotype; a — view of edge of protoconch scar; b — view of face of protoconch scar. Sculpture not shown on lowest whorl.

Dimensions of all specimens are shown in Table 1.

Table 1. — Dimensions of *Austrotriton garrardi* n.sp.

	Height (h), mm	Diameter (d), mm	h/d
Holotype	23.5	13.7	1.71
Paratype C63399, figured	30.8	16.3	1.89
Paratype C63399	24.8	12.8	1.94
Paratype C70101, figured	24.7	13.9	1.78
Paratype C70101	24.9	13.8	1.80
Paratype C63413	25.6	13.8	1.86
Paratype F27375	28.7	15.7	1.83

Localities: C66599, 50 fms., off Ulladulla, New South Wales, M.V. " Challenge ", pres. T. A. Garrard, holotype; C70101, 45 fms., off Broken Bay, New South Wales, M.V. " Challenge ", pres. T. A. Garrard, two paratypes; C63413, 75 fms., off Broken Bay, New South Wales, M.V. " Challenge ", pres. T. A. Garrard, one paratype; C63399, 75 fms., off Botany Bay, New South Wales, M.V. " Challenge ", pres. T. A. Garrard, two paratypes; F27375, 70 fms., off Botany Bay, New South Wales, M.V. " Challenge " pres. T. A. Garrard, one paratype.

Holotype and five paratypes (C63399, C63413, C70101) in the Australian Museum, Sydney; one paratype (F27375) in the National Museum of Victoria, Melbourne.

There is some variation in colour pattern, height of spire, and strength of nodulation. The holotype has weakly developed pale bands on varices at the positions of the upper two rows of nodules, and on the tips of the nodules themselves, with medium reddish brown patches between the nodules; this pattern is very much more marked and contrasting on the larger of the two paratypes in lot C63399, but is almost identical to that of the holotype on the two paratypes in lot C70101, and is absent or nearly so in all other paratypes, which are uniform fawn to pale reddish brown in colour. The smaller of the two paratypes in lot C63399 is markedly taller and narrower than any other specimen (see Table 1); it and paratype F27375 have the central row of nodules more weakly developed than in the other specimens, and the lowest row of nodules is hardly distinguishable from the normal fine surface nodulation covering the shells.

Austrosassia parkinsonia is very much more abundant than *A. garrardi* in the area where the type series was taken. *Austrotriton garrardi* can readily be distinguished from *Austrosassia parkinsonia* by the absence of bristles on the periostracum; by the more prominent, sharper, and more widely spaced nodules in the peripheral row, by the more numerous, sharper, more closely spaced, and more prominent nodules of the central row, and by the presence of a basal row of small nodules below the two present in *A. parkinsonia;* by bearing up to nine fine denticles inside the outer lip, compared with the five large ones always present in *A. parkinsonia;* by bearing plicæ on the base of the inner lip; by the details of the fine spiral sculpture, which consists of alternating beaded primary and smooth secondary threads in *A. parkinsonia;* and, most obviously, by lacking the small, polyspiral, smooth, shining, turbinate protoconch of *A. parkinsonia.*

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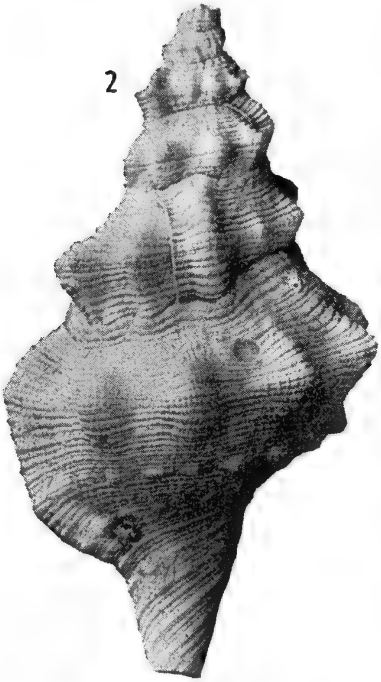

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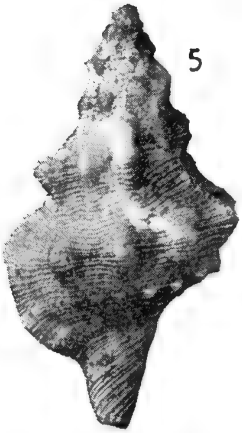

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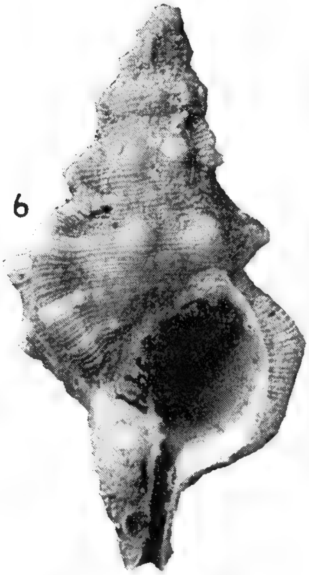

Plate 6 — *Austrotriton garrardi* n. sp.

Fig. 1-2. Holotype, X 4, whitened with ammonium chloride to show sculptural detail; 50 fms, off Ulladulla, N.S.W., M.V. " Challenge ", pres. T. A. Garrard; Australian Museum, C66599.

Fig. 3. Paratype, X 2.5; 45 fms, off Broken Bay, N.S.W., M.V. " Challenge ", pres. T. A. Carrard; Australian Museum, C70101.

Fig. 4-5. Holotype, unwhitened, X 2.5.

Fig. 6. Largest paratype, X 2.5; 75 fms, off Botany Bay, N.S.W., M.V. " Challenge ", pres. T. A. Garrard; Australian Museum, C63399.

Unfortunately all specimens of *Austrotriton garrardi* are empty shells, and appear to have been dead when collected (although some of them must have been very frshly so), so that it was not possible to examine the operculum, radula or other anatomical features of the new species. When live specimens of *A. garrardi* are collected, it will be of great importance for the understanding of phylogeny and the generic status of Australian and New Zealand Cymatiidæ to compare these features with those of *Austrosassia parkinsonia*.

DISCUSSION

Seven specimens of *Austrotriton garrardi* were taken by M.V. " Challenge " whereas no other specimens are known to have been taken before or since. This is presumably due to the fine mesh and unusual techniques used in the prawn trawling investigations. The fact that, so far, the species appears to be restricted to the outer part of the continental shelf, in depths of 45 to 75 fms., off central and southern New South Wales, calls for some comment. The restricted depth and, for Cymatiidæ, highly restricted area of distribution of the new species indicate an extremely limited dispersal. The absence of a well-developed shelly polyspiral protoconch, usually characteristic of Cymatiidæ, and the reduced, irregular, mammillate to *Caricella*-like apex of all fossil species indicate that the major part of the larval shell of *Austrotriton* is chitinous and deciduous. Together with the great variation observed in large populations of fossil species and the large number of species that developed in a relatively short time in separate depositional basins during the Miocene, the extremely limited dispersal of *A. garrardi* and the presence of a chitinous protoconch strongly suggest that *Austrotiton* has either a very short larval life, or, more probably, direct development. This contrasts strongly with almost all other Cymatiidæ, which are well known for their wide distributions and, presumably, long planktotrophic larval lives. No species of *Austrotriton* are known from the extensive deposits and almost complete sequence of the Tertiary of New Zealand, so that it is one of very few genera of Cymatiidæ that were unable to cross the Tasman Sea.

Austrotriton has not yet been taken off South Australia or Victoria, despite many years of extensive trawling and dredging by May, Verco, Gatliff, Gabriel, and many other workers. As the genus was abundant in South Australia and Victoria during the Lower and Middle Miocene, and was still present during the uppermost Miocene, its present apparent restriction to New South Wales may be due either to the lowering of sea temperature during the Pleistocene, and the continuing cooler temperatures today in southern Australia than in New South Wales, or to inadequate sampling. In the uppermost Miocene of Gippsland, *Austrotriton* occurs in rich shellbeds containing some shallow-water Mollusca and lacking many of the deep-water Mollusca now occurring with *A. garrardi* such as *Sassia, Tolema, Torvamurex, Xenophora, Ficus*, and the many new forms recorded by Garrard (1961), and there can be little doubt that it was able to live in depths of the order of 10 to 20 fathoms. Thus the lineage has apparently retreated to deeper water since the Miocene.

ACKNOWLEDGEMENTS

I wish to thank Dr. W. F. Ponder, Curator of Molluscs, the Australian Museum, and Dr. B. J. Smith, Curator of Invertebrates, National Museum of Victoria, for the loan of specimens and for permission to describe the new species; Mr. T. A. Darragh, Curator of Fossils, National Museum of Victoria, for guidance in the field in Victoria, for valuable discussion on the relationships of the new species, and for critical comments on the manuscript; Dr. C. A. Fleming, Chief Paleontologist, New Zealand Geological Survey, for critical comments on the manuscript; and Messrs. D. L. Homer and T. R. Ulyatt, New Zealand Geological Survey, for the photographs reproduced in the plate. This research was supported by a travel grant from the New Zealand Department of Scientific and Industrial Research.

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A NEW SUBSPECIES OF *FISSIDENTALIUM FORMOSUM* (Adams and Reeve) FROM THE SOUTH CHINA SEA

TADASHIGE HABE

National Science Museum, Tokyo, Japan

On his way to Japan from Australia, Mr. Matthew Harrison, formerly president of the Marine Study Group of Victoria (National Museum of Victoria, Melbourne), visited Formosa to collect molluscs for his private collection and unexpectedly obtained a beautiful red-banded scaphopod which is new to science. Through his generosity, I have been able to examine it, and I am very pleased to describe it as a subspecies of *Fissidentalium (Pictodentalium) formosum* (Adams and Reeve) in honour of Mr. Harrison. I also express my thanks to Mr. Seiji Suzuki who gave me another specimen of this subspecies.

Fissidentalium (Pictodentalium) formosum harrisoni subsp. nov.

Figures 1 - 2

Shell large and long, slowly enlarging in diameter to the aperture, solid and gently curved dorsally. Surface with strong rounded longitudinal ribs, 15 - 17 in number, and broad concave intervals in the bottom of which occur weak interstitial riblets and weak growth lines at the apertural end. Colour richly variegated with deep red, fleshy red and white bands alternately placed. Inner surface covered by white enamel except at the edge of the aperture. Apicial orifice circular internally and crenulated externally with a V-shaped notch on the ventral side. Aperture slightly oblique, circular internally, and rimmed by the ends of the ribs and riblets externally.

Holotype: length 90 mm, diameter of aperture 10.8 mm; from the collection of Mr. M. Harrison, deposited in the National Science Museum, NSMT Mo 37303.

Paratype: length 80.8 mm, diameter of aperture 12 mm; from the collection of Mr. S. Suzuki, deposited in the National Science Museum, NSMT Mo 37304.

Type locality: South China Sea.

Remarks: This beautiful red-banded scaphopod has been obtained from Kaohsung, Formosa, but is said to have been collected by trawling boats from the South China Sea. The new subspecies differs from typical specimens of *F. (P.) formosum* (Adams and Reeve) from the Philippines and the variental form *hirasei* Kira from Japan in having (i) the narrower and longer shell less bent dorsally, (ii) red and white colour bands only without any trace of green, and (iii) the longitudinal ribs narrower than their intervals.

Mr. Harrison has since obtained two further specimens of this new subspecies from the same source in Formosa. These specimens remain in his private collection.

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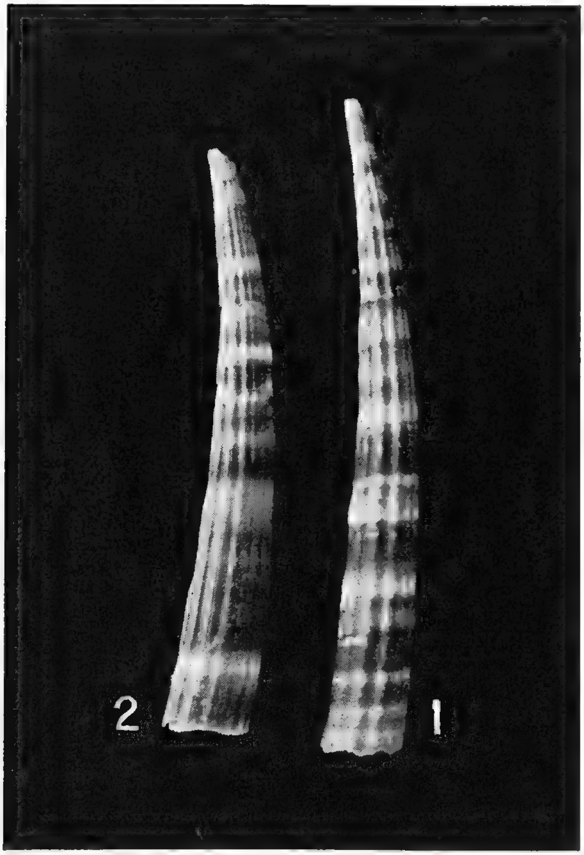

Fissidentalium (Pictodentalium) formosum harrisoni subsp. nov. Fig. 1. Holotype Mo 37303, from Harrison collection. Fig. 2. Paratype Mo 37304, from Suzuki collection.

OBITUARY

FLORENCE V. MURRAY, 1908 - 1970

Florence (Fay) Vivienne Murray died in Melbourne on Saturday 12th September 1970, ending a life with remarkable courage and fortitude in the face of a long, painful and crippling illness.

FAY MURRAY
1962

Born at Gormanston, Tasmania, on 22nd January 1908, she was the second child and first daughter of a family of three boys and two girls born to Russell Mervyn Murray and his wife Vivienne (née Douglas). R. M. Murray was general manager of the Mt Lyell Mining and Railway Co. Ltd. for 25 years, and a son Hugh later occupied the same position for 20 years. With her brothers and sister, she attended boarding schools in Melbourne, the girls going to Fintona Girls School at Camberwell. Three times a year, the children made the return trip home for holidays. This involved a night passage across the notoriously rough Bass Strait on either the steamer 'Oonah' or 'Loongana', followed by a day's travel on the Emu Bay Railway from Burnie to Zeehan, and thence to Queenstown where the parents then resided.

The successful completion of school life brought her to the University of Melbourne, where in four years she attained her degree of Master of Science in zoology. In her last year at University (1930), she was president of her hall of residence students club, Janet Clarke Hall, and also won the McBain Research Scholarship for her degree thesis 'Gill trematodes from some Australian fishes'. The thesis became her first publication.

She stayed on at the University for some years as a demonstrator, and worked with Dr (later Professor) O. W. Tiegs on the metamorphosis and embryonic development of the grain weevil, *Calandra oryzae.* Two papers resulted from this work.

In 1936, she joined the library staff of the Council for Scientific and Industrial Research (now Commonwealth Scientific and Industrial Research Organization), and worked at head office library in Melbourne. In 1938, she moved to the Fisheries Division at Cronulla, New South Wales, where she was both librarian and biological assistant. Her considerable research on salps in the planktonic fauna while at Cronulla resulted in far less acknowledgement than was deserved. She returned to head office library in 1941 and transfered to the Animal Health Division, Parkville, as librarian in 1955. Finally, in 1964, increasing physical disabilities brought about by rheumatoid arthritis necessitated her retirement from work.

Her interest in molluscs began with a holiday to Hayman Island, Queensland, in 1953, and rapidly she and her sister Margery built up a well-identified representative collection of Victorian, Australian and over-seas species. Past years of scientific training prodded her conscience and she was not content just to collect shells. Saltwater aquaria were set-up in her home and a stereo-miscroscope purchased, and the long physically hard years of observation on the breeding and embryology of many species of molluscs of the south-eastern Australian temperate fauna began. Copious notes filled note-book after note-book. Always it seemed that there was something hatching and the new ' babies ' needed attention and time. Despite bouts of ill-health and time consumed by other matters, she published nine molluscan papers between 1959 and 1970, and began in the last year of her life the collation of her notes for her *opus magnum* on the breeding and embryology of the Victorian molluscs.

The association of Miss Murray with the Malacological Society of Australia began just one year after its foundation in 1953. Over the years she was a committee member, the acting secretary, and the editor of the *Journal* and the *Australian Newsletter*. She and her sister never missed a field-day of the Society, and assiduously collected privately whenever possible. With the transfer of the Society from Melbourne to Sydney in late 1964, she took upon herself to look after the members resident in Victoria, and in early 1965 organized the very successful Victorian Branch. Until her death, she was secretary-treasurer of the Branch, as well as fulfilling the positions of organizer, leader, identifier of species and recorder of locality lists for each of the field-days. Junior and younger members had a special place in her life and she greatly encouraged their interests by identifications, donations of specimens, and explanations of the literature.

Her contributions to malacology led to her appointment as an Honorary Associate of the National Museum of Victoria in early 1969, and her embryological collection is housed in that institution. One of her donations to the Museum was a pair of magnificent specimens of the extremely rare chiton, *Bassethullia glypta* (Sykes, 1896), collected, intertidally at Flinders, Victoria.

She was an honorary member of the Underwater Research Group of Victoria, to which she lectured and donated many library books, and identified much of the molluscan material brought in by the divers. Other societies of which she held membership included the Royal Society of Victoria, the National Trust of Australia, the Field Naturalists Club of Victoria, and the Australian Marine Sciences Association.

Miss Murray's interests prior to molluscs centred largely on ballet. She was instrumental in founding, and for 10 years from 1946 was president of the Australian Ballet Company (not to be confused with the present ballet company of the same name). This small company gave many recitals and performances throughout the length and breadth of Victoria. Beyond this she loved her garden and its many varieties of camellias, and for many years created and devotedly attended to a large number of bonzai trees.

She is survived by her sister Miss Margery M. Murray, of Melbourne from whom much of the above was elicited, and two brothers Mr D. S. Murray of Beaufort, Victoria, and Mr H. M. Murray of Hobart, Tasmania.

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The following trematodes were described as new species in her first paper (1931): *Ancyrocephalus vesiculosus, A. robusta, Lamellodiscus pagrosomi, L. major, Lepidotrema bidyana, Microcotyle bassensis, M. pagrosomi, M. australis, M. sciaenae.* The last specific name being preoccupied, a new name *sciaenicola* was provided in a note of correction (1932). The genus *Murraytrema,* type species *Ancyrocephalus robusta* Murray, 1931, was proposed in her honour by E. W. Price, 1937 (*J. Washington Acad. Sci.,* 27: 147, and *Proc. Helminth. Soc. Washington,* 4: 27-29).

Syntypes of all species except *Lamellodiscus pagrosomi* and *L. major* are housed in the invertebrate collection of the National Museum of Victoria.

R.B.

SOME SYNONYMIES IN THE MOLLUSCAN FAMILY CYMATIIDAE

A. G. BEU

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PLATES 7-8

ABSTRACT

Figures are published for the first time of *Simpulum papillosum* A. Adams, 1870 (= *Bufonariella ranelloides* (Reeve)) and *Triton obscurus* A. Adams, 1854 (= *Septa (Cabestanimorpha) tabulata durbanensis* (E. A. Smith), non *Triton obscurus* Reeve, 1844). *Triton loebbeckei* Lischke, 1870, usually regarded as the earliest name for the Japanese subspecies of *Septa (Cabestanimorpha) tabulata*, is a synonym of *Tritoniscus labiosus* (Wood, 1828). The earliest name for the Japanese form of *S. tabulata* is *Lotorium kiiensis* G. B. Sowerby III, 1915; type specimens of *L. kiiensis* are figured.

Triton imbricata W. H. D. Adams, 1868, published in "The Mysteries of the Ocean", is a synonym of *Charonia tritonis tritonis*.

The date of publication of *Cryotritonium* von Martens is discussed: *Fusitriton* Cossmann is the valid name for the genus. The name *Gyrineum (Biplex) jacundum* (A. Adams, 1853) is used instead of the preoccupied *Biplex pulchella* (Forbes), and a neotype is designated for *Ranella jacunda* A. Adams.

INTRODUCTION

Preparation of a proposed preliminary catalogue of the Cymatiidae led to several discoveries of items of synonymy and nomenclature in need of clarification.

Inquiry at the Department of Zoology, British Museum (Natural History), provided the information that type material of three of A. Adams's unfigured species supposedly belonging in the Cymatiidae is present in the collection of that department, and photography of the three types was arranged by Dr J. D. Taylor of the Mollusca Section. Type material of four species (*Simpulum dorsuosa, S. lirostoma, S. nodiliratus, S. tringa,* all of A. Adams, 1870) is not present in the British Museum (Natural History) (Miss S. Stevenson, *in litt.*, 16 July 1969), and there is no evidence of its location, so that the names must remain *nomina dubia* unless type material should be located elsewhere. Of available types, the holotype of *Triton pyriformis* A. Adams (=*Ranularia encaustica* Reeve, 1844) was figured by Yen (1942, pl. 18); the type material of the other two species is figured here and the status of the names considered.

Acquisition of Lischke's work *Japanische Meeres-Conchylien* (Lischke, 1869-74) and the opportunity to examine the collection of the Australian Museum, Sydney, during August 1969, led to a re-evaluation of some current interpretations of Japanese Cymatiidae. Accidental discovery of an unrecorded synonym of *Charonia tritonis tritonis* (Linnaeus) is discussed, as are evidence for the status and date of publication of the generic name *Cryotritonium* von Martens and a replacement name for the preoccupied *Biplex pulchella* (Forbes).

TAXONOMY

Family Cymatiidae

Genus *Charonia* Gistel, 1847

Charonia tritonis tritonis (Linnaeus, 1758)

Pl. 7, Fig. 1.

1758 *Murex tritonis* Linnaeus, *Systema Naturae*, ed. 10, 1: 754.

1807 *Triton marmoratum* Link, *Beschreibung der Naturalien - Sammlung der Universitat zu Rostock*, (2): 122.

1822 *Triton variegatus* Lamarck, *Animaux sans Vertebres*, 7: 178 (in part — *Triton variegatus* Lamarck, 1816, the Atlantic subspecies).

1868 *Triton imbricata* W. H. D. Adams, *The Mysteries of the Ocean*, ed. 1: 268, fig. 1.

As only two junior synonyms of *Charonia tritonis tritonis* Linnaeus have been recorded previously, it was of some surprise to discover accidentally a further synonym, a figure (repeated here) of the species in W. H. D. Adams' English translation of Mangin's early book on oceanography, *Les Mystères de l'Océan*, labelled *Triton imbricata*. Determining the date and authorship of the name was difficult. The name occurs only as a caption to the first of four shells (the others are *Nautilus pompileus*, "*Helix ovata*" *[*a species of *Achatina]*, and *Argonauta* "*papyracea*" *[A. argo]*) noticed by me in the third (1874) English edition of the work. The figure is the second one of molluscs and the fifty-second part-page figure in the book; there are also 15 full-page plates. The figures are unnumbered, except that the components of figures are numbered to key them to the captions.

Through the kind help of Mr H. Lewis, of Philadelphia, Mr D. Heppell of the Royal Scottish Museum, Edinburgh, and Dr K. Boss of Harvard University, I have learned that the French editions of *Les Mystères de l'Océan* have the same figures as the English ones, but the identifications are in French vernacular. The figure of *Charonia tritonis* is identified as "Triton émaillé" in all French editions. Thus the name *Triton imbricata* appears to date from the first English edition in 1868, and in the absence of contrary evidence should be attributed to the translator, W. H. D. Adams. Editions of the work known to me are: French, 1864, 1865, 1868, 1889; English, 1868, 1870, 1874, 1875. The cited figure is on pp. 267, 273, 299 and 242 of French editions, respectively, and on p. 268 of all English editions (K. Boss, *in litt.*, 16 Sept. 1970). Probably many other new names will be found to date from this work.

The figure of *Triton imbricata* is repeated here (Pl. 7, fig. 1) from the third (1874) English edition of *The Mysteries of the Ocean* (Mangin, 1874).

PLATE 7.

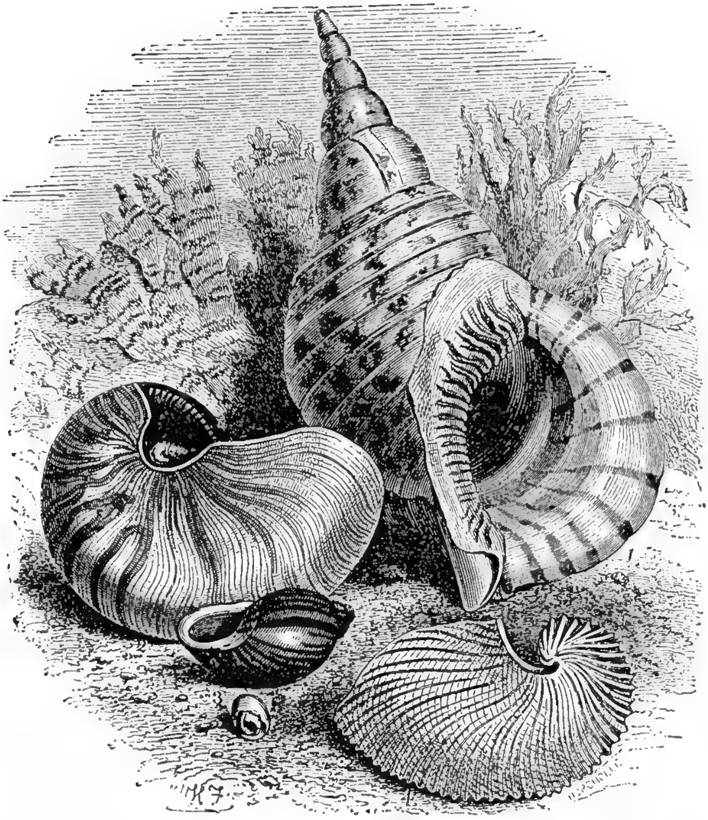
Fig. 1. Copy of figure of *Charonia tritonis tritonis* (Linnaeus) on p. 268 of Mangin, "The Mysteries of the Ocean," third English edition, 1874; labelled *Triton imbricata;* original size.

Figs. 2, 3. Copies of front and rear of label accompanying Australian Museum paralectotypes of *Septa tabulata kiiensis* (Sowerby); natural size.

Fig. 4. Copy of E. A. Smith, 1899, *J. Conch. Lond.* 9, pl. 5, fig. 4; holotype of *Lotorium durbanense* E. A. Smith (=*Septa (Cabestanimorpha) tabulata durbanensis*); height shown by line at left.

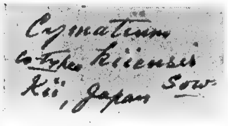
Figs. 5, 6. Copies of Lischke, 1871, *Japanische Meeres-Conchylien* (2), pl. 4, figs. 13, 14; front and rear of the presumed holotype of *Triton loebbeckei* Lischke, 1870 (=*Turritriton labiosa* (Wood, 1828)).

Fig. 7. Copy of G. B. Sowerby III, 1915, *Ann. Mag. Nat. Hist.*, ser. 8, 14, pl. 10, fig. 7; lectotype of *Lotorium (Cymatium) kiiense* G. B. Sowerby III (=*Septa (Cabestanimorpha) tabulata kiiensis*).



1. Triton imbricata.
2. Nautilus pompilius.
3. Helix ovata.
4. Argonauta papyracea.

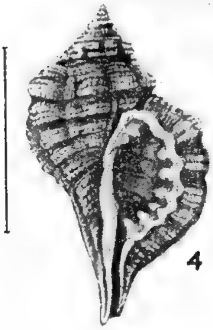
1



Cymatium
co-type kiiensis
Kii, Japan Sow.

2

3



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Genus *Gyrineum* Link, 1807

Subgenus *Biplex* Perry, 1811

Gyrineum (Biplex) jacundum (A. Adams, 1853)

Pl. 8, figs. 16, 17

1852 *Ranella pulchella* E. Forbes, *Narrative of the voyage of H.M.S. Rattlesnake*, 2: appendix (Mollusca), p. 382, pl. 3, figs. 6, 6a (non *Ranella pulchella* G. B. Sowerby I, 1825).

1853 *Ranella jacunda* A. Adams, *Proc. zool. Soc. Lond.* 1853: 70, No. 3.

1877 *Bursa (Eupleura) pulchella*: Brazier, *Proc. Linn. Soc. N.S.W.*, (1), 1: 176.

1886 *Ranella (Eupleura) perca* Watson, *Rep. scient. Results explor. Voyage Challenger, zool.*, 15: 402 (non *Biplex perca* Perry, 1811).

1909 *Gyrineum pulchellum*: Hedley, *Rep. Aust'n Assoc. Adv. Sci.*, 12: 361.

1933 *Argobuccinum (Gyrineum) perca* var. *pulchella*: Bayer, *Zool. Meded. Leiden*, 16: 40.

1937 *Apollon pusillum* Allan, *Aust. Mus. Mag.*, 6 (7): 233, bottom left fig. (non *Ranella pusilla* Broderip, 1833).

1957 *Biplex pulchella*: Cotton, *Malac. Soc. Aust. Publ.*, 4: 3rd page.

1961 *Biplex pulchella*: Rippingale and McMichael, *Queensland and Great Barrier Reef Shells*: 68, pl. 7, fig. 17.

1964 *Biplex pulchella*: Cotton, *Rec. American-Aust. scient. Exped. Arnhem Land*, 4: 25, pl. 2, fig. 14.

The name *Ranella pulchella* was first used by Sowerby (1825, app., p. 18) in his catalogue of the shells in the collection of the Earl of Tankerville. He referred to figures given by Chemnitz, *Systematische Conchylien Cabinet*, 9: Pl. 193, figs. 1860 and 1861. These are clear figures of the large north-western Pacific *Gyrineum (Biplex) perca* (Perry), so that Sowerby's name is a synonym of Perry's. A copy of Forbes' description and figures of *Ranella pulchella* (Forbes, 1852) kindly sent to me by Mr Hal Lewis of Philadelphia showed that Forbes described the small northern Australian species of *Biplex* as a new species in this work, and was not merely using Sowerby's name for the Australian shell. *Ranella pulchella* Forbes, 1852 is thus preoccupied by *Ranella pulchella* Sowerby, 1825, and the name *Gyrineum jacundum* (A. Adams, 1853) is here instituted instead of *Biplex pulchella.*

The nominal species *Ranella jacunda* was described by A. Adams (1853) in six lines of Latin, followed by the brief data: " *Hab.* North Australia. Mus. Cuming ". Some phrases in the description leave no doubt that the species described belongs in the subgenus *Biplex*, notably: " ......; *varicibus duabus, lateralibus, dilatatis, radiatim costellatis, marginibus dentatus; apertura orbiculari, postice integra, antice canaliculata;* ... ". These clearly describe the expanded, laterally continuous, spinose varices and circular, muriciform, posteriorly entire and canel-less aperture of the little north Australian " Kookaburra " shell, known until now as *Biplex pulchella.* The description clearly refers to a single species, an unusual occurence with the brief, usually obscure Latin descriptions, unaccompanied by figures, by which A. Adams introduced many still mysterious names into molluscan literature.

Unfortunately, type material of A. Adams' species *Ranella jacunda* cannot be found. Dr J. D. Taylor of the Mollusca Section, British Museum (Natural History) has informed me (per Mrs K. M. Way, *in litt.*, 2 July 1970) that he has " been unable to locate any specimen bearing this name, and can find no evidence to suggest that we *[*the British Museum (Natural History)*]* ever received the type ".

The National Museum of Victoria, Melbourne, Australia, holds portions of the following collections: 1) Metcalfe Collection, purchased from L.

Reeve; 2) Cuming Collection, purchased from H. Cuming; 3) A. Adams Collection, purchased from R. Geale. Types have been located in the first, and are probably present in the other two. All three collections were searched for material of *Ranella jacunda* or *R. pulchella,* but none was found *(in litt.,* Dr B. J. Smith, 2 Sept. 1970; R. Burn, 5 Dec. 1970).

Mr S. P. Dance *(in litt.,* 3 Nov. 1970) informed me there is no type material of *Ranella jacunda* in the National Museum of Wales, but the material labelled "*Ranella pulchella* Forbes" and "*Ranella jacunda* A. Ad." is conspecific, strongly supporting identification of A. Adams' name with this species.

I know of no other institutions that might have type material of *Ranella jacunda,* and it is presumed that the type material is lost. Because of the present change in name and because A. Adams did not figure *Ranella jacunda* and gave a description consisting of only six lines of imprecise Latin, it is considered best to stabilise the name of the Australian " Kookaburra " shell as *Gyrineum jacundum* (A. Adams) by designating as a neotype a specimen of the species formerly known as *Biplex pulchella.*

Consequently the specimen figured here (Pl. 8, figs. 16, 17), which has been lodged in the Australian Museum, Sydney (reg. no. C76466), is here designated the neotype of *Ranella jacunda* A. Adams, 1853. The specimen was dredged from Bowen, Queensland, and is from a lot of 13 specimens in the New Zealand Geological Survey.

Gyrineum (Biplex) jacundum (A. Adams) differs from the northern Pacific species *G. (Biplex) perca* (Perry) and *G. (Biplex) aculeata* Schepman (= *G. (Biplex) microstoma* Fulton) in its very much smaller size *(G. perca* and *G. aculeata* commonly reach more than 55 mm in height, whereas *G. jacundum* is rarely more than 26 mm in height); in the less digitate outer margins of the thin, broad varices that are united up the sides of the spire; in having rounded nodules rather than spines where the spiral cords meet the margins of the varices; in having a much more deeply incised, in places canaliculate, suture; and in having a much more nearly closed siphonal canal. Other species assigned to *Biplex* lack the broadly expanded variceal flanges of these three species.

Dimensions of neotype: height, 21.9 mm; maximum diameter, 16.7 mm.

Genus *Fusitriton* Cossmann, 1903

1903 *Fusitriton* Cossmann, *Essais de Paléoconchologie Comparée,* 5: 109. Type species (by original designation): *Triton cancellatus* Lamarck, 1816. Recent, South America.

1903 *Cryotritonium* von Martens, *Wiss. Ergebn. Deut. Tiefsee - Exped. "Valdivia,"* 7(1): 38. Type species (by subsequent designation, Powell, 1951): *Lampresia* (sic; = *Lampusia*) *murrayi* E. A. Smith, 1891, Recent, South Africa.

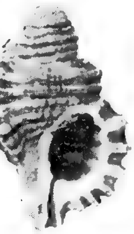
The status of *Cryotritonium* has never been resolved satisfactorily. *Fusitriton* was published in Vol. 5 of *Essais de Paléoconchologie Comparée,* dated December 1903 (Cossmann, 1903). Only the year of publication appears in von Martens' work (von Martens, 1903). The date of publication of von Martens' work is determinable from the following sources:

1. the title-page of the part bears the date " 1903 ";

2. it is listed in the *Zoological Record* for 1902 and for 1903, mentioned only briefly in 1902 but described in full in 1903, with the date " 1903 ".

PLATE 8


8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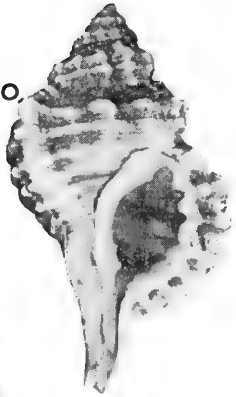
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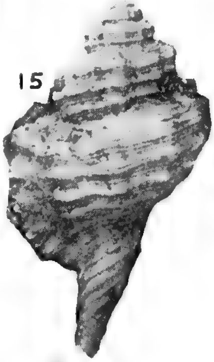
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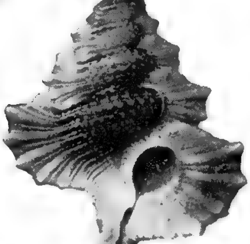
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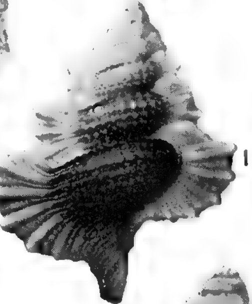
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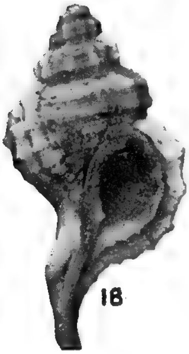
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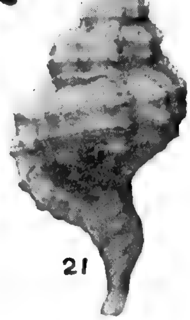
21

As von Martens was the compiler of *Zool. Rec.* at this time, the brief 1902 mention is probably based on a proof copy. The 1903 volume of *Zool. Rec.* appeared in 1904;

3. it is listed in the contemporary German *Bibliographia Zoologica* (second part of Vol. 10; each page dated 13 July 1904), under "von MARTENS 1903";

4. It is listed in the July 1904 number (No. 3) of *Nachrichsblatt der deutschen Malacozoologischen Gesellschaft* (p. 126), but not in earlier numbers (numbers appeared quarterly) (*in litt.*, Dr L. B. Holthuis, 5 July 1970);

5. von Martens published preliminary descriptions of new species, later published more fully in his *Valdivia* report, in the July-August 1903 number of *Nachr. d. deut. Malacoz. Ges.*, indicating publication of the *Valdivia* report after this date (*in litt.*, Dr L. B. Holthuis, 5 July 1970);

6. the catalogue of the Library of the British Museum (Natural History), under " GERMANY ", lists the contents of the *Valdivia* expedition reports, including:

" Bd. VII . . . 1903-4
Lief. 1. 1903
Lief. 2. 1904 . . . Lief. 6. 1904 ";

7. although no exact dates of publication are given in Vol. 7 of *Wiss. Ergebn. deut. Tiefsee-Exped. " Valdivia "* the dates of " Eingegangen " (receipt of manuscripts by the editor; *in litt.*, Dr L. B. Holthuis, 5 July 1970) for all parts after 7 (1) are printed on the back of the title page of respective parts, signed by C. Chun (editor), as:

Vol. 7 (2) — 26 April 1903
(3) — 15 June 1903
(4) — 1 August 1903
(5) — 25 January 1904
(6) — 18 February 1904;

8. the copy of Part 1 in the General Library of the British Museum (Natural History) bears the accession stamp date 16 February 1904 (Mr N. B. Tebble, in litt., 22 May 1968).

Thus it appears likely that the part containing the description of *Cryotritonium* was published late in 1903, but the day or month of publication cannot be determined.

The date of publication of von Martens' work, following Article 21 (b) ii, must be interpreted as 31st December 1903. Also, following Article 21 (b) i,

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PLATE 8.

Fig. 8. *Bufonariella ranelloides* (Reeve, 1844); holotype of *Simpulum papillosum* A. Adams, 1870. British Museum (Natural History), reg. no. 1967680; enlarged x 1.4. B.M. (N.H.) photo no. 51573.

Figs. 9, 10. *Septa (Cabestanimorpha) tabulata durbanensis* (E. A. Smith, 1899). Fig. 9, specimen from East London, South Africa, pres. D. H. Kennelly; N.Z. Geological Survey, WM 9317; natural size. Fig. 10, holotype of *Triton obscurus* A. Adams, 1855; British Museum (Natural History), reg. no. 1967685; enlarged x 1.1 B.M. (N.H.) photo no. 51572.

Figs. 11-15, 18-21. *Septa (Cabestanimorpha) tabulata kiiensis* (G. B. Sowerby III, 1915). Figs. 11, 12, 14, lectotype (compare pl. 7, fig. 7); British Museum (Natural History), reg. no. 1919.12.31.30; natural size, 36.8 x 18.4 mm (figs. 11, 12) and enlarged x 2 (fig. 14): B.M. (N.H.) photographs. Figs. 13, 15, specimen from Tamioka, Amakusa, Japan, pres. Dr. T. Habe; N.Z. Geological Survey, reg. no. WM 8459; natural size. Figs. 18-21, two paralectotypes, Australian Museum, reg. no. C72368; natural size.

Figs. 16, 17. *Gyrineum (Biplex) jacundum* (A. Adams), neotype of *Ranella jacunda* A. Adams, 1853; Bowen, Queensland; Australian Museum reg. no. C76466; enlarged x 2.

the date of publication of Cossmann's work also must be interpreted as 31st December 1903. The works were published simultaneously within the meaning of the Code, and the provisions of Article 24 (a) must apply. An opinion to this effect was expressed by Commissioner Dr L. B. Holthuis (*in litt.*, 5 July 1970). In this instance the first reviser is Thiele (1929: 281), who listed *Cryotritonium* as a synonym of *Fusitriton*. This satisfies the strict requirement of Article 24 (a) i, and having been clearly selected by Thiele as the name to be used for the genus named *Fusitriton* by Cossmann (1903) and *Cryotritonium* by von Martens (1903), *Fusitriton* must remain the valid name, as currently used.

Genus *Septa* Perry, 1810

Subgenus *Cabestanimorpha* Iredale, 1936

(= *Turritriton* of recent authors, not of Dall, 1904)

Septa (Cabestanimorpha) tabulata (Menke, 1843)

There are several well-defined subspecies of this species, distinguished by the strength and number of the cords on the dorsum of the siphonal canal, as well as other less constant features. Subspecies occur in Western Australia (*S. tabulata tabulata*), eastern Australia and New Zealand (*S. tabulata exarata* Reeve, 1844), South Africa (*S. tabulata durbanensis* E. A. Smith, 1899), and Japan (*S. tabulata kiiensis* G. B. Sowerby III, 1915). The correct name for the Japanese subspecies has been a problem for for many years, but I hope now to resolve it.

Septa (Cabestanimorpha) tabulata kiiensis (Sowerby, 1915)

Pl. 7, fig. 7; pl. 8, figs. 11-15, 18-21

1869 *Triton exaratus*: Lischke, *Japanische Meeres-Conchylien*, 1: 35; 1871, 2: 30, pl. 2, figs. 15-17 (not of Reeve, 1844).

1915 *Lotorium (Cymatium) kiiensis* G. B. Sowerby III, *Ann. Mag. Nat. Hist.*, ser. 8, vol. 16: 165, pl. 10, fig. 7.

Turritriton loebbeckei of recent Japanese authors, not *T. loebbeckei* Lischke, 1870 (= *Tritoniscus labiosus* Wood, 1828; see below).

When only one primary type specimen of early species is present in the British Museum (Natural History), I here regard it as a holotype. When more than one specimen is present in this and other museums they are regarded as syntypes and the figured specimen is here designated the lectotype, the others being regarded as paralectotypes. Thus the specimen of *Lotorium kiiensis* figured by Sowerby (1915: pl. 10, fig. 7), and lodged in the British Museum (Natural History) (reg. no. 1919. 12.31.30), is here designated the lectotype of *Lotorium (Cymatium) kiiensis* G. B. Sowerby III, 1915.

Two shells in the Australian Museum, Sydney (reg. no. C45736) bear a small (35.8 x 15.2 mm) label (pl. 7, figs. 2, 3) bearing the words: " *Cymatium kiiensis* Sow. Co-Types. Kii, Japan ", in faded brown ink. The label is written on a piece of envelope or thin post-card, bearing on the back a post-mark with the date " 1919 ", demonstrating that the label is approximately contemporaneous with the description of *L. kiiensis*, and with the date when the British Museum specimen was catalogued. It seems likely that the specimens were sent to Charles Hedley by G. B. Sowerby III, and they are here regarded as paralectotypes.

Clear photographs of the lectotype of *L. kiiensis* sent by Dr J. D. Taylor show that the specimen was poorly figured by Sowerby (1915: pl. 10, fig. 7; repeated here, Pl. 7, fig. 7) and the name is not a synonym of *Turritriton loebbeckei*, as Japanese authors have interpreted it in recent years (e.g. Habe, 1961: 45; 1964: 72). The lectotype has considerably stronger axial and spiral sculpture than on any specimens I have seen of the other valid Japanses species, *Septa (Cabestanimorpha) tenuilirata* (Lischke), and has a much more prominent, more densely bristled periostracum. The lectotype and paralectotypes clearly represent a form of *Septa tabulata* (Menke), although the larger paralectotype is a distorted individual. To judge by Lischke's figures (Lischke, 1871: pl. 4, figs. 13, 14), the name *Triton loebbeckei* is a synonym of *Turritriton labiosus* (Wood, 1828) (see below), and should not be used for a member of the *Septa tabulata* group. Thus the earliest name for the Japanese subspecies of *tabulata* is apparently *Lotorium (Cymatium) kiiensis*, Sowerby, 1915, and this name is here used for the subspecies. Lischke (1869: 35; 1871: 30, pl. 2, figs. 15-17) recorded the Japanese form as the eastern Australian subspecies, *T. exarata* Reeve, 1844, which in itself points to problems with current Japanese identifications.

Septa (Cabestanimorpha) tabulata durbanensis (E. A. Smith, 1899)

Pl. 7, fig. 4; Pl. 8, figs. 9, 10

1855 *Triton obscurus* A. Adams, *Proc. Zool. Soc. Lond.* 1854: 312 (non *Triton obscurus* Reeve, 1844).
1899 *Lotorium durbanense* E. A. Smith, *J. Conch., Lond.*, 9: 248, pl. 5, fig. 4.
1932 *Cymatium labiosum*: Turton, *Marine Shells of Port Alfred*: 110, pl. 24, No. 796 (non *Murex labiosus* Wood, 1828).

A clear photograph of the best syntype (here designated the lectotype; B.M. (N.H.) reg. no. 1967685) of *Triton obscurus* A. Adams, 1855, kindly sent by Dr J. D. Taylor, British Museum (Natural History) shows it to be a member of the *Septa (Cabestanimorpha) tabulata* group. A. Adams (1855) gave the locality " South coast of South Africa " for his species, and did not figure it, giving only a few lines of Latin description. There seems no reason to doubt the locality data, so that *Triton obscurus* A. Adams 1855 is an earlier name for *Lotorium durbanense* E. A. Smith, 1899, the South African sub-species of the *Septa tabulata* complex. However, the name is preoccupied by *Triton obscurus* Reeve (1844: pl. 16, fig. 63), a species of *Colubraria*, so that E. A. Smith's name will continue to be used.

Genus *Turritriton* Dall, 1904

(= *Tritoniscus* Dall, 1904)

Turritriton labiosus (Wood, 1828)

1828 *Murex labiosus* Wood, *Index Testaceologicus, Suppl.*, 15: pl. 5, fig. 18.
1843 *Tritonium rutilum* Menke, *Molluscorum Novae Hollandiae specimen . . .* : 25.
1852 *Triton loroisii* Petit de la Saussaye, *J. Conch. Paris*, 3: 53.
1864 *Triton strangei* A. Adams and Angas, *Proc. Zool. Soc. Lond.* 1864: 35.
1870 *Triton loebbeckei* Lischke, *Mal. Blätter*, 17: 23; 1871, *Japanische Meeres-Conchylien*, 2: 36, pl. 4, figs. 13, 14.
1874 *Trifon (Gutturnium) orientalis* G. and M. Nevill, *J. Asiatic Soc. Bengal*, 43: 29.

The writer, as first reviser, here selects *Turritriton* Dall, 1904, as the valid name for the genus named *Turritriton* by Dall (1904: 133) and *Tritoniscus* by Dall (1904: 134).

Lischke's clear figures (1871: pl. 4, figs. 13, 14; repeated here) of *Triton loebbeckei* show that this name is yet another synonym of *Turritriton labiosus* (Wood, 1828), the well-known, small exquisitely sculptured cymatiid that occurs throughout the Indo-West Pacific and in the northern Caribbean Sea. Recent Japanese authors have used the name *loebbeckei* for the Japanese representative of the *Septa tabulata* group, but as noted above this form should be called *S. tabulata kiiensis* (Sowerby, 1915).

Lischke's 1871 figures (presumably of the holotype) of *Triton loebbeckei* show that it is a specimen of the relatively large (up to 30 mm) central Indo-West Pacific form of *labiosus* that has all varices well-developed and placed regularly every 270° around the shell. Most specimens I have seen, and all from southern Australia, the Kermadec Islands and New Zealand, are smaller (rarely more than 25 mm high) and have their varices placed irregularly. The characteristic three-corded spiral ribs of *labiosus* show clearly in the figures. The locality given by Lischke is Nagasaki.

Family Bursidae

Genus *Bufonariella* Thiele, 1929

Bufonariella ranelloides (Reeve, 1844)

Pl. 8, fig. 8

1844 *Triton ranelloides* Reeve, Conch. Icon., 2, *Triton*: pl. 3, fig. 10.
1870 *Simpulum papillosum* A. Adams, Ann. Mag. Nat. Hist., ser. 4, 5: 419.

The locality given by A. Adams (1870) for his species *Simpulum papillosum* is Takano-Sima, Japan. The species is not identifiable from his brief Latin description, and has never been figured. A photograph of the holotype (reg. no. 1967680; repeated here) sent by Dr J. D. Taylor, British Museum (Natural History), shows that it is a faded specimen of the bursid *Bufonariella ranelloides* (Reeve, 1844), and does not refer to a species of Cymatiidae.

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GENERA OF THE BIVALVE FAMILY MESODESMATIDAE, WITH COMMENTS ON SOME AUSTRALASIAN SPECIES

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ABSTRACT

The status of major genus-group names in the Mesodesmatidae is reviewed. Genera recognised in the Subfamily Mesodesmatinae are *Donacilla* de Blainville, 1819, Mediterranean; *Mactropsis* Conrad, 1854, Tertiary of North America; *Atactodea* Dall, 1895, Indo-West Pacific; doubtfully *Ceroniola* Wilckens, 1904, Upper Cretaceous of South America; and *Paphies* Lesson [1831], with subgenera *Paphies* s.str., New Zealand; *Mesodesma* Deshayes [1832], (=*Taria* Gray, 1853), eastern and western South America, and New Zealand: *Amesodesma* Iredale, 1930, south-eastern Australia: and *Ceronia* Gray, 1853, eastern North America. Other generic names in the family are briefly reviewed, and the preoccupied *Nesis* "Monterosato" Locard, 1899, is renamed *Monterosatus*.

Paphies (Amesodesma) perfuga (Iredale, 1930), type species of *Amesodesma*, is synonymised with *Paphies (Amesodesma) angusta* (Reeve, 1854). It is suggested that *Mesodesma quoyi* Deshayes, [1832] is an earlier name for *Paphies (Mesodesma) forsteriana* (Finlay, 1927), which in turn is inseparable from *P. (Mesodesma) pliocenica* (Oliver, 1923).

Myadesma Clark, 1922, seems to belong in the Mactracea, but is placed in the family Myadesmatidae Clark, 1922, rather than in the Mesodesmatidae.

INTRODUCTION

In the latest catalogues of the Bivalvia, Vokes (1967: 268) and Keen (1969: *N*608) did not list the genus-group name *Amphidesma* in the family Mesodesmatidae Gray, 1840 (= Amphidesmatidae Iredale, 1914, of Australasian workers), but included *Amphidesma* Lamarck, 1818 in the family Semelidae Stoliczka, 1870 (Vokes, 1967: 292; Keen, 1969: *N*636). Australian and New Zealand workers have been aware for some years that the continued currency of *Amphidesma* was incorrect in the sense of the large, abundant, matracean bivalves so characteristic of sand beaches in New Zealand, but the nomenclature has never been formally stabilised. Dawson (1959) was the first Australasian worker to comment publicly on the situation, while Macpherson and Gabriel (1962) and Garrard (1969) followed Dawson and used *Donacilla* de Blainville, 1819 for the group of small southern Australian shells for which Iredale (1930) provided the genus-group name *Amesodesma*.

Dall (1895a) was the first modern taxonomist to attempt to review generic names in what was then consistently called the Mesodesmatidae. His brief analysis was included in his summary of the classification of the Mactracea, later included in his " new classification of the Pelecypoda " (Dall, 1895b: 556-7) and published in full in Part 4 of his monumental " Tertiary fauna of Florida " (Dall, 1898). Dall's final classification (Dall, 1898: 908-14) is summarised here, with his original statements of type species in most cases. Where comment was thought necessary on dates of publication and on the identity of type species, the original form is given in quotes and the revised one in brackets (not parentheses, which are Dall's). Dall's synonymising of some names, e.g. of *Erycina* and *Eryx* with *Atactodea*, and of *Amphidesma* with *Mesodesma*, is a synonymising of generic concepts, and has not been followed in the present paper. Dall (1900: 985) later formally synonymised *Amphidesma* with *Semele*, using an invalid " selection " by Bowdich of *Amphidesma variegata* as type.

Family Mesodesmatidae

Subfamily Mesodesmatinae

Genus *Mactropsis* Conrad, 1854 (nom. nov. for *Triquetra* Conrad, 1846, non de Blainville, 1818); type *M. aequorea* Conrad, Eocene, North America.

Genus *Atactodea* Dall, 1895 (= *Paphia* Lamarck, 1799, non Röding, 1798; = *Erycina* Sowerby, 1822, non Lamarck, 1805; = *Eryx* Swainson, 1840, non Daudin, 1832, nec Stevens, 1833, Insecta); type, " *Paphia glabrata* (Lam.), Indo-Pacific region " *[= Mactra glabrata* Gmelin *[*1791*]*, despite Dall's statement to the contrary*]*.

Genus *Mesodesma* Deshayes, " 1830 " [1832]. Subgenus *Mesodesma* s.str. (= *Ceronia* Gray, 1853); type, *M. donacium* (Lamarck) (+ *M. chilense* Orb.); Chile. Subgenus *Donacilla* Philippi, 1836 (= *Amphidesma* Lamarck, 1818); type *M. corneum* (Poli); Mediterranean. Subgenus *Taria* Gray, 1853; type, *M. stokesii* Gray (MS.?) = *M. latum* Desh., New Zealand.
Subgenus *Paphies* Lesson, " 1830 " *[*1831*]* (= *Machaena* (Leach MS.) Gray, 1823); type *Mya australis* Gmel. (= *Mya novaezelandiae* Chemnitz, *Paphies Roissyana* Lesson, *et Mesodesma Chemnitzii* Deshayes); New Zealand.

Subfamily Davilinae Dall, 1895

Genus *Davila* Gray, 1853; type *D. polita* Gray (MS.?) = *D. plana* Hanley, *[*Indo-Pacific*]*.

Genus *Anapella* Dall, 1895 (= *Anapa* Gray, 1853, non Gray, 1847); type, *Anapa Smithii* Gray, = *A. triquetra* Hanley, Tasmania.

Subfamily Erviliinae Dall, 1895

Genus *Coecella* Gray, 1853; type, *C. Horsfieldii* Gray (MS.?); China.

Genus *Ervilia* Turton, 1822; type, *Mya nitens* Montagu; Britain, South Europe.

The only generic names listed by Vokes (1967) that are not included in Dall's classification are many incorrect subsequent spellings (not considered in this paper), *Nesis* " Monterosato, 1875 " (*nomen nudum*) Locard, 1899, four times preoccupied and apparently never renamed; and the four later-erected names *Argyrodonax* Dall, 1911; *Rochefortina* Dall, 1924; *Amesodesma* Iredale, 1930; and *Spondervilia* Iredale, 1930. Keen (1969: *N*608, *N*610) has recently included *Ceroniola* Wilckens, 1904 and *Myadesma* Clark, 1922 in the family. These, the genera of the Davilinae and Erviliinae, and *Mactropsis* Conrad, *Atactodea* Dall, and *Ceroniola* Wilckens will be considered briefly later; the main purpose of the paper is to evaluate the generic names of the *Mesodesma-Donacilla* complex.

Iredale and McMichael (1962: 26) placed *Benthoquetia* Iredale, 1930 (June 27th) in the " Amphidesmatidae ", but there is no justification for such a position. Iredale (1930: 403) placed the genus in the Family Myacidae (sic), whereas Cotton (July 18th, 1930: 239) placed the absolute synonym *Austroturquetia* (=*Autroquetia* Ponder, 1968, incorrect subsequent spelling), by inference, in the same family as *Turquetia* Velain (currently in the Galeommadiate). Vokes (1967: 250) placed the genus in the Montacutidae; Chavan (1969: *N*541) placed it in the Sportellidae, as a subgenus of *Isoconcha* Dautzenberg and Fischer; and Ponder (1968: 129) showed that on anatomical features " thc Montacutidae is a likely position".

Attempts after that of Dall to classify the family in Australia and New Zealand led to highly incorrect conclusions. Suter (1913) followed Dall. Iredale (1914) tried to rectify Suter's nomenclature, but considered the type species of *Amphidesma* to be " *Donacilla* " *donacilla* Lamarck by tautonymy, as *Amphidesma* was Lamarck's Latin name for his vernacular " Donacille ".

An application has been made to the International Commission on Zoological Nomenclature (Beu, 1971), to have *Amphidesma variegata* Lamarck, 1818 (= *Tellina purpurascens* Gmelin, *[*1791*]*), selected by subsequent designation of Children (1823: 301), confirmed as type-species of *Amphidesma* Lamarck, 1818; and to have *Donacilla lamarckii* Philippi, 1836, selected by subsequent monotypy of Philippi (1836: 37), confirmed as type-species of *Donacilla* de Blainville, 1819. If the requests are granted, this will have the effect of making *Amphidesma* a junior subjective synonym of *Semele* Schumacher, 1817, and of using *Donacilla* (attributed to de Blainville, 1819: 429) in its place in the Mesodesmatidae. This paper is written as though the requests has been grantcd, since the results are the current majority opinion; the name *Amphidesma* need not be considered further.

Finlay (1927: 467-9) followed Iredale's generic nomenclature, and as Finlay's large paper has been regarded until recent years as the " starting point " in New Zealand molluscan taxonomy, the generic nomenclature has not been questioned. Thus all Powell's lists of New Zealand Mollusca (e.g. Powell, 1962) and Fleming's (1966) list of New Zealand Cenozoic Mollusca continued to use the names *Amphidesma* and Amphidesmatidae.

Dawson (1959) arrived at very different conclusions from either Dall (1895a; 1895b; 1898) or Iredale (1914), pointing out the type-designation for *Amphidesma* by Children. He concluded that *Donacilla* de Blainville, 1819 should be used instead of either *Amphidesma* or *Mesodesma*, for a mesodesmatid genus. Dawson's work has unaccountably received little attention in New Zealand. An attempt has been made here to evaluate the genera from both a nomenclatural viewpoint and the conchological characters of their included species.

Combined Descriptions of Genera and Species

Gray (1853) gave succinct diagnoses of five new genera of Mesodesmatidae (one of them, *Coecella*, in the preceding Mactridae), and included a single species in each genus. One of the species, in *Ceronia*, he had named previously, so that this is the type species by monotypy, and all is clear. In the cases of *Coecella, Anapa, Davila* and *Taria* the species names had not been published in earlier works, and no description or definition was given for any of them. My first instinct was to regard the included species as *nomina nuda,* and the four generic names thus as *genera caelibes,* and to seek the first subsequent placing of species in them (and subsequent designation of a type, if the two were different). However, I now regard these cases as joint descriptions of genera and species (Code, Article 16 (a) vi). There is a subtle (but important) difference between a new generic name followed by the description of a new genus and species, and the description of a new genus followed by a new specific name; but the Code does not distinguish between the two, and the names erected by Gray (1853) appear to fall under Article 16 (a) vi. The alternative results that would obtain if this conclusion is not accepted are given under each of the relevant generic headings.

TAXONOMY

Family Mesodesmatidae Gray, 1840

As was pointed out to me by Professor Keen (*in litt.*, January 22, 1970), in the *Treatise on Invertebrate Paleontology* review of Mesodesmatidae (Keen, 1969: *N*608) the name Mesodesmatidae was attributed to Gray, 1839, but the subfamily Mesodesmatinae was attributed to Gray, 1840. The reference intended for both by Keen is that of Gray (1840: 149). Vokes (1967: 278) attributed the name to Deshayes, 1839, but a reference to this name cannot be found (Prof. H. E. Vokes, *in litt.;* Prof. A. Myra Keen, *in litt.*). Determining the first publication and author of family-group names is very difficult, and its value appears slight.

Subfamily Mesodesmatinae

Genus *Donacilla* de Blainville, 1819

1819. *Donacilla* de Blainville, *Dictionnaire des Sciences Naturelles,* 13: 429. Type species (by subsequent monotypy, Philippi, 1836): *Donacilla lamarckii* Philippi, 1836 (=*Amphidesma donacilla* Lamarck, 1818, = *Mactra cornea* Poli, 1795), Recent, Mediterranean (I.C.Z.N. opinion pending).

Dawson (1959: 44) treated *Donacilla* de Blainville, 1819 (de Blainville, 1819: 429) as an available name, but most recent authors have attributed it to Philippi (1836: 37). Vokes (1967: 278) considered *Donacilla* de Blainville to be a *nomen nudum,* but it is not, as de Blainville (cited in full by Dawson, 1959: 44; and earlier by Iredale, 1914: 490) gave a bibliographic reference to Lamarck's description of *Amphidesma* (Lamarck, 1818: 489), which constitutes an indication under Article 16 (a) i. Possible consideration of *Donacilla* to have been published in synonymy because of the cited description of *Amphidesma* (e.g. by Keen, 1969: *N*609) is incorrect, since it was used as an available name for a taxon by Dawson, and earlier by Philippi (1836: 37) (Article 11d). An application to the International Commission on Zoological Nomenclature (Beu, 1971; discussed above) will have the effect of ratifying the present usage of *Donacilla* in place of *Amphidesma* in the Mesodesmatidae, attributing *Donacilla* to de Blainville, and reducing *Amphidesma* to a synonym of *Semele* Schumacher, 1817, if granted. Since this is the current majority usage, this paper is written as if the requests to the Commission had been granted.

" *Donacina* Blainville, 1818 " was listed as a generic name (but as an error for *Donacilla* Lamarck, 1819 *[*sic*]*) by Neave (1939: 143). The only place where a word resembling the Latinised *Donacina* appears in de Blainville (1818) is in a fold-out table of classification of Mollusca, following p. 216; all generic names on the table are French vernacular *nomina nuda.* The word " Donacine " appears on the eighth line of examples from the bottom of the table. Thus the name *Donacina* does not date from de Blainville (1818).

The hinge of *Donacilla cornea* (Poli), apparently the sole living species to be included in the genus, is unique in the Mesodesmatidae in having a very narrow, insignificant resilifer, and in having large, well-developed cardinal teeth (see Fig. 10); in all other Mesodesmatidae the cardinal teeth are greatly reduced or absent. Thus *Donocilla* seems best treated as a full genus, and another name must be used for most large species of Mesodesmatidae.

Genus *Paphies* Lesson, *[1831]*

[1831]. *Paphies* Lesson, in Lesson and Garnot, *Voyage Autour du Monde . . . sur . . . La Coquille . . . , Zoologie,* 2 (1) : 424. Type species (by monotypy) : *Paphies (Crassatella) roissyana* Lesson, 1831 (=*Mya australis Gmelin, [1791]*), Pliocene to Recent, New Zealand.

The figures of *Paphies roissyana* given by Lesson (in Lesson and Garnot, 1826-*[31]*, Atlas, pl. 15, figs. 4, 4a) are beautifully accurate, natural-size, coloured illustrations of the common New Zealand " pipi ", long known as *Amphidesma australe* (Gmelin). The species is rendered highly distinctive in the Mesodesmatidae by its elongate form with central umbones, and by its prominent but short, only slightly oblique lateral teeth. Apart from the differences in shell shape (which presumably reflect a significantly different anatomy), and relatively minor differences in the hinge, the species is very similar to species of *Mesodesma* (as interpreted here), and the two groups seem best ranked as subgenera. As *Paphies* Lesson was proposed in December 1831 (Sherborn and Woodward, 1906a) whereas *Mesodesma* Deshayes was not proposed until 1832 (Sherborn and Woodward, 1906b), *Paphies* must become the nominate subgenus.

The generic name *Machaena* " Leach " J. E. Gray (Gray, 1843: 252) and the included species *M. ovata* Leach and *M. subtriangulata* (presumably *Mactra subtriangulata* Wood) were all published in the synonymy of *Mesodesma chemnitzi* Deshayes, *[1832]* (= *Mya australis* Gmelin, *[1791]* and have never been used as available generic names. Thus they are unavailable under Article 16 (b).

The subgenus *Paphies* (s.str.) is represented by only three named forms, *P. anteaustralis* (Dell, 1950) from the Lower Miocene of New Zealand, *P. australis australis* (Gmelin, *[1791]*) from the Pliocene to Recent of mainland New Zealand, and the doubtful subspecies *P. australis aucklandica* (von Martens, 1879) from the Auckland Islands.

The interior of a right valve of *Paphies* (s.str.) *australis* is figured as Fig. 8.

Subgenus *Mesodesma* Deshayes, *[1832]*

[1832]. *Mesodesma* Deshayes, *Encyclopédie Méthodique, Vers,* 2 (2) : 441. Type species (by subsequent designation, Anton, 1839) : *Mesodesma donacium* Deshayes, *[1832]* (=*Mactra donacia* Lamarck, 1818), Recent, Chile and Peru.

1853. *Taria* J. E. Gray, *Ann. Mag. Nat. Hist.,* (2), 11: 44. Type species (by monotypy) : *Taria stokesii* Gray, 1853 (=*Mactra subtriangulata* Wood, 1828), Recent, New Zealand.

Herrmannsen (1847: 40), Gray (1847: 186) and Gray (1853: 44) all designated *Mya Novae Zelandiae* Chemnitz (sometimes subsequently written *M. novaezelandiae)* as type species of *Mesodesma,* but this is not only an unavailable non-binominal name, but also was not among the species originally included in *Mesodesma* by Deshayes (1832: 442-4). Thus the designation by Dall (1895a: 213) of *Mesodesma donacium* Lamarck as type species of *Mesodesma* has generally been accepted as the first valid one. However, as shown by Keen (1969: *N*608), Anton (1839: 3) had much earlier validly designated the same species as type.

H. and A. Adams (1856: 413) were the first after Gray to use *Taria;* they included *Mesodesma latum* Deshayes and *M. spissum* Reeve, without designating a type species. Both of these species are available for designation as type species of *Taria* (Article 69 (a) ii), if *stokesii* is not accepted. Dall (1898: 912) stated: " Subgenus *Taria* Gray . . . Type *M. stokesii* Gray (MS.?) = *M. latum* Desh., N. Zealand ". This would constitute designation of the available synonym, *Mesodesma latum* Deshayes, 1843, as type species of *Taria* Gray (Article 69 (a) iv), if my conclusions on combined genus and species descriptions are not accepted.

South American species, particularly *Paphies (Mesodesma) donacia* (Lamarck) (Fig. 1), differ from New Zealand species such as *P. ventricosa* (Gray, 1843) (Fig. 2) and *P. subtriangulata* (Wood, 1828) (type species of *Taria* Gray, 1853) and, in particular, from *P. subtriangulata porrecta* (Marwick, 1928), (Fig. 6), in only minor specific features, and I can see no reason for maintaining *Taria* as a separate genus-group from *Mesodesma.* Figures of interiors and hinges of several species are given (Figs. 1-3, 6-9) to support this contention. All South American and New Zealand species have smooth lateral teeth.

The status of some New Zealand forms of *Paphies (Mesodesma)* calls for comment (Deshayes' types must be examined before a detailed revision can be carried out). Firstly, most recent authors have quoted the Latin name of the common " tuatua " as " *Amphidesma* " *subtriangulatum* (Wood, 1828), whereas Suter (1913: 957), Lamy (1914: 22) and Dawson (1959: 45) quote *Mesodesma* (or *Donacilla) subtriangulatum* (Gray, 1825). Iredale (1914: 491) long ago cleared this point up by giving a full quotation from Gray (1825, *Ann. Philos., 35,* p. 135; not seen by me): " *Ery(cina) subangulata. Crassatella cuneata* Lam., 483?". Iredale (1914: 491) commented: " Note the spelling of the specific name, and, as the above is the complete entry, it is quite obvious that it is a *nomen nudum* ". If Iredale's quotation from Gray is correct, the name *Erycina subangulata* Gray, 1925 is a synonym of the synonymised available name *Crassatella cuneata* Lamarck, 1818, which applies to a small southern Australian species of *Paphies (Amesodesma).* In the same work Iredale (1914: footnote to p. 491) stated that Lamy's work showed that the next available name is *Mactra subtriangulata* Wood, 1828.

Secondly, Iredale again seems to have been more correct on a point of nomenclature than later workers gave him credit for. On p. 492 he used " *Amphidesma quoyi* (Deshayes) " as a good New Zealand species, noting that Deshayes' type specimen had a " flattened " posterior slope, whereas *A. gaimardi [sic]* (Deshayes) and *A. ventricosum* (Gray) have bicarinate posterior slopes. From this description and from Lamy's (1914: 24, fig. 1) sketch of the type of *Mesodesma quoyi* Deshayes, it seems very likely that this is the form later named *Amphidesma plioceni-*

cum by Oliver (1923: 187) and *Amphidesma forsterianum* by Finlay (1927: 468). Finlay stated that all named forms were based on "northern" shells, and could not be the form he named *forsterianum,* but I know of no evidence to support his statement. The status of the form here called *quoyi,* compared with that of *P. subtriangulata* (Wood), is greatly in doubt. Dawson (1959) regarded it as a recognisable southern subspecies of *subtriangulata,* suggesting the name *pliocenica* be used for it. Certainly *pliocenica* Oliver and *forsteriana* Finlay are not sufficiently different to be maintained as separate subspecies, whatever their status compared with those of *quoyi* and *subtriangulata.* In my opinion *P.* "*pliocenica*" is a valid southern subspecies of *P. subtriangulata,* having a broad zone of overlap in the Wanganui-Christchurch region, but it seems likely that *Mesodesma quoyi* Deshayes will prove to be the earliest name for it. I tentatively list the named New Zealand forms of *Paphies (Mesodesma)* as follows:

P. crassiformis (Marshall and Murdoch, 1920), Pleistocene; Fig. 9;

P. subtriangulata subtriangulata (Wood, 1828) *[= gaymardi* Deshayes, *[1832] = spissa* Reeve, 1854*]*, Pleistocene to Recent; Recent in northern New Zealand; Fig. 3;

P. subtriangulata quoyi (Deshayes, *[1832] [= lata* Deshayes, 1843 = *pliocenica* Oliver, 1923 = *forsteriana* Finlay, 1927*]*, Pliocene to Recent; Recent in southern New Zealand; Fig. 7;

P. subtriangulata porrecta (Marwick, 1928), Pleistocene to Recent, Chatham Island; Fig. 6;

P. ventricosa (Gray, 1843), Pleistocene to Recent; Recent throughout mainland New Zealand; Fig. 2.

Subgenus *Amesodesma* Iredale, 1930

1930. *Amesodesma* Iredale, *Rec. Aust. Mus.*, 17: 402. Type species (by original designation): *Amesodesma perfuga* Iredale, 1930 (=*Mesodesma angustum* Reeve, 1854), Recent, south-eastern Australia.

Garrard (1969: 7) regarded *Amesodesma* as not validly introduced, and placed New South Wales species in *Donacilla* de Blainville, following Macpherson and Gabriel (1962: 360), who in turn were following Dawson (1959). Garrard stated that the name was associated only with the new subspecies *Amesodesma cuneatum vanadicum* Iredale, but in a much fuller description Iredale established "*Amesodesma perfuga* n.sp." on the same page as *A. cuneatum vanadicum.* The genus-group name *Amesodesma* is quite validly introduced under Article 12, and in the paper in which it was introduced, Iredale (1930: 407) designated *Amesodesma perfugum* Iredale as type species of the genus-group.

The type species of *Amesodesma* has a highly unusual resilifer, which is relatively long and inclined at a high angle to the normal vertical position, directed strongly towards the anterior end of the shell, and projecting prominently below the hinge line at its posterior end. The muscle scars are as in *Mesodesma,* and the pallial sinus is of medium depth. However, the siphons of preserved specimens of *Paphies (Amesodesma) angusta* (Reeve) examined in the Australian Museum during August 1969, with the help of Dr W. F. Ponder, were extremely short for the genus-group, being about 2 mm long in a shell about 20 mm long. The hinges of the other south-eastern Australian species of "*Mesodesma*" examined in the Australian Museum (notably *cuneata* Lamarck, 1818, common in Victoria and New South Wales) have vertical resilifers that project only moderately below the hinge line; their hinges are otherwise similar but their relative siphon length has not been seen. Thus hinge differences are too minor to be used to separate *Amesodesma* from *Mesodesma,* but it seems likely that species placed in *Amesodesma* have shorter siphons than those of *Mesodesma.* The group is separable also by its consistently very small size; individuals of *Paphies angusta* and *P. cuneata* rarely reach more than 25 mm in length, whereas *P. (Mesodesma) donacia* (Lamarck) is frequently more than 100 mm long, and *P. (Mesodesma) ventricosa* (Gray) is commonly over 200 mm in length and reaches over 300 mm. Judged by the small percentage of bivalves having trans-Tasman relationships, trans-Tasman dispersal of bivalves is rare, and the group of small Australian shells seems likely to have had a long geological history separate from that of *Mesodesma* (as here interpreted). In my opinion the Australian group is worthy of recognition as the subgenus *Amesodesma.* Interiors of right valves of *Paphies (Amesodesma) angusta* (Fig. 5) and *P. cuneata* (Fig. 4) are figured here.

Specimens examined in the Australian Museum during August 1969 show that *Paphies (Amesodesma) perfuga* (Iredale) cannot consistently be separated from *P. angusta* (Reeve). The type series of *perfuga,* from Gunnamatta Bay, Port Hacking, N.S.W., consisting of 35 single valves plus the holotype, is consistent in having a slightly longer posterior end than in typical *P. angusta,* but is the only such population known to me. Populations with end members resembling both Reeve's figure of *P. angusta* and the holotype of *P. perfuga* were seen from: C13017, Stradbroke Id., Queensland, coll. C. Hedley; C50912, Flat Rock, north of Richmond River, N.S.W., coll. A. O'Sullivan; C69072, Jervis Bay, N.S.W., coll. W. F. Ponder; Shoal Bay, Port Stephens, N.S.W., coll. G. P. Whitley; Gunnamatta Bay, Port Hacking, N.S.W., coll. T. A. Garrard (topotypes of *P. perguga,* but only one specimen in the collection of 14 resembles the holotype of *perfuga).* There can be no doubt that *P. perfuga* (Iredale) is based on specimens of *P. angusta* with slightly longer posterior ends than usual, and the two names are here synonymised.

Subgenus *Ceronia* Gray, 1853

1853. *Ceronia* J. E. Gray, *Ann. Mag. Nat. Hist.,* (2), 11: 44. Type species (by monotypy): *Ceronia denticulata* (=*Erycina denticulata* Gray, 1825 =*Mesodesma deauratum* Turton, 1822), Recent, Gulf of St Lawrence.

The commonly-accepted synonymy of *Ceronia* Gray with *Mesodesma* Deshayes seems to me to be incorrect. Davis (1965: pl. 9) figured the holotype of *Mesodesma deauratum* Turton, type species of *Ceronia,* and noted that it is a common, in some places abundant, species in the St Lawrence estuary and the Gulf of St Lawrence. Superficially the figured shell closely resembles *Paphies* (s.str.) *australis* (Gmelin), but closer comparison shows that the pallial sinus is much shorter and more angular, the outer anterior lateral tooth is very much shorter and more steeply inclined, all lateral teeth protrude further and are smooth (transversely ridged in *P. deaurata*), the resilifer is narrower, and the posterior end of the shell is slightly longer in *P. australis* than in *P. deaurata.* The lectotype of *P. arctata* (Conrad), figured earlier by Davis (1964: pl. 4), has rigid lateral teeth similar to those of *P. deaurata,* but is not quite as elongate posteriorly. Figures of the hinge of *P. arctata* given by Davis (1967: pl. 1, figs. 1, 2) show the ridged lateral teeth clearly. The group of eastern North American species of *Paphies* is considered to warrant separation from *Mesodesma* because of its rigid lateral teeth and elongate posterior end of the shell. The name *Ceronia* Gray, 1853 is available for the group.

The subgenus has a fossil history from the Oligocene in eastern North America (Dall, 1898: 912). *Paphies (Mesodesma) donacia* is known fossil in the Tertiary (late Pliocene and above; Herm, 1969: 94) of Chile, whereas no species of *Paphies* (sensu lato) are known in the Tertiary of Patagonia (von Ihering, 1907: 522). This suggests that *Mesodesma* is a recent immigrant to the east coast of South America, apparently from the west coast. There can be little doubt that *Ceronia* and *Mesodesma* are phylogenetically separate groups.

OTHER GENERA OF THE MESODESMATIDAE

To fill out the bald statements of Dall's (1898) catalogue, from which the status of many names cannot be determined in detail, and to clarify some minor errors in the Bivalvia volume of the *Treatise* (Keen, 1969), a list is given here of the recognised genera of the Mesodesmatidae that have not been discussed above. Nomenclatural comments are appended where necessary. Nomenclatural data are based on Lamy's (1914) excellent review of the family to which readers are referred for figures and descriptions of almost all known species.

Subfamily Mesodesmatinae

Genus *Atactodea* Dall, 1895

1799. *Paphia* Lamarck, *Mem. Soc. Hist. Nat. Paris*, (1), 1: 85 (*genus caelebs*) (non Röding, 1798, Mollusca). Type species (by subsequent designation, Gray 1847): *Mactra glabrata* Gmelin [1791] (? = *Mactra striata* Gmelin, [1791]), Recent, Indo-West Pacific.

1895. *Atactodea* Dall, *Proc. Malac. Soc. Lond.*, 1: 213. New name for *Paphia* Lamarck, 1799, non Röding, 1798.

Keen (1969: *N*608) indicated that the type species of *Paphia* Lamarck was selected by original designation. However, Lamarck (1799: 85) did not include a species name beneath the description of the new genus *Paphia*, as he did with almost all other generic names in his " Prodrome d'une nouvelle classification des coquilles ". The description given by Lamarck includes a clear description of the mesodesmatid hinge: " . . . fossette du ligament située sous les crochets entre les dents de la charnière, . . . ", so that *Paphia* is available under the Code, Article 12, and is a *genus caelebs* where proposed. The first designation of a type seems to be the quoted one by Gray (1847). Dall (1895; 1889) included *Erycina* " Sowerby, 1822 " and *Eryx* Swainson, 1840 in the synonymy of *Atactodea*. In the first of these references, J. Sowerby and G. B. Sowerby 1st (1822) included three species of Mesodesmatidae [*Paphies (Amesodesma) cuneata* (Lamarck), *Atactodea striata* (Gmelin), and an unidentifiable species, possibly *Donacilla cornea* (Poli)] in *Erycina*, which in concept is thus not *Erycina* in the sense of Lamarck. However, Dall was

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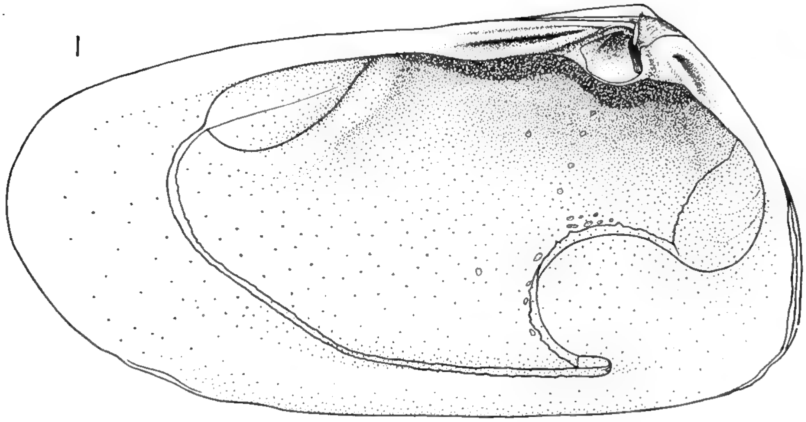
Figures 1 - 5. Right valves of *Paphies*. 1, *Paphies (Mesodesma) donacia* (Lamarck), type species of *Mesodesma* Deshayes; Chepu, west coast of Chiloe Id., Chile; N.Z. Geological Survey, WM7694. 2, *Paphies (Mesodesma) ventricosum* (Gray); Muriwai Beach, Auckland, New Zealand; N.Z. Geological Survey, RM2759. 3, *Paphies (Mesodesma) subtriangulata subtriangulata* (Wood), type species of *Taria* Gray; Ohope Beach, Whakatane, New Zealand; N.Z. Geological Survey, RM2907. 4, *Paphies (Amesodesma) cuneata* (Lamarck), Tasmania; N.Z. Geological Survey, WM9716. 5, *Paphies (Amesodesma) angusta* (Reeve); paratype of *Amesodesma perfugum* Iredale, type species of *Amesodesma*; Gunnamatta Bay, Port Hacking, New South Wales; Dominion Museum, MF21733.

Figs. 1 - 3 approx. natural size; figs. 4, 5 enlarged approx. X 2.



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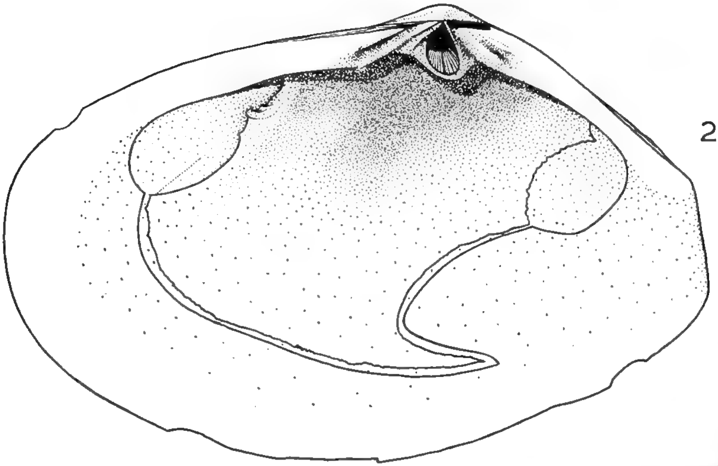

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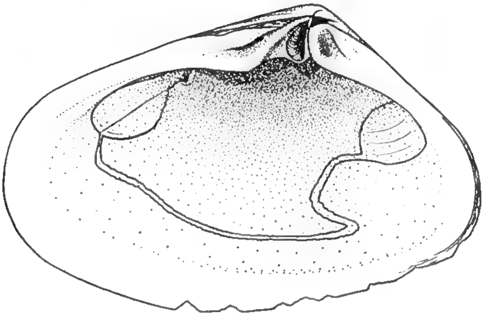

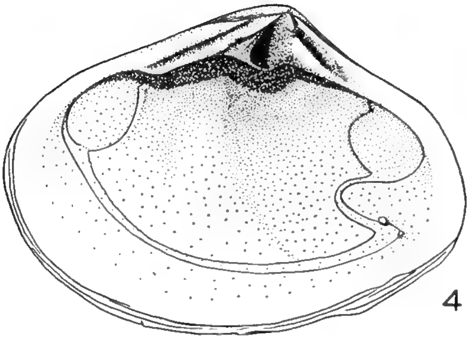

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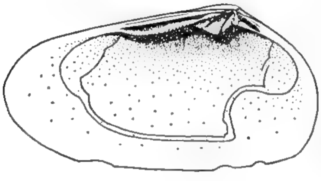

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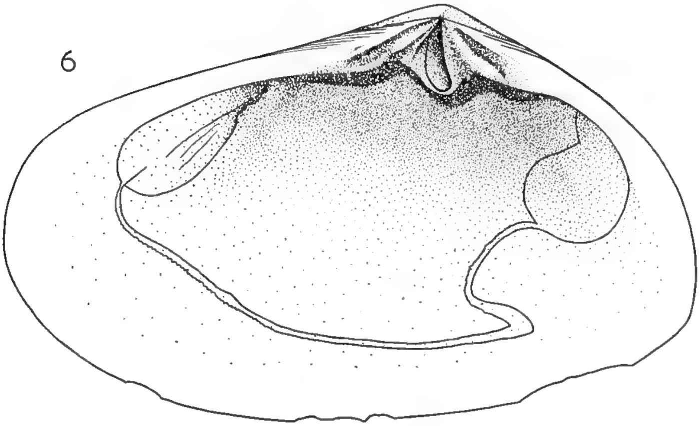

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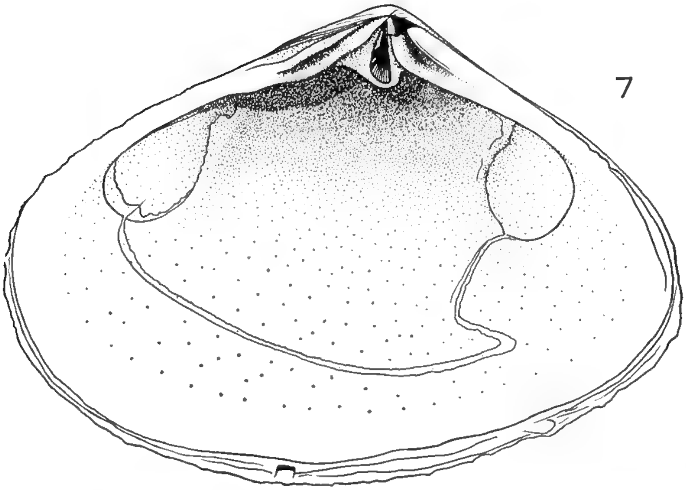

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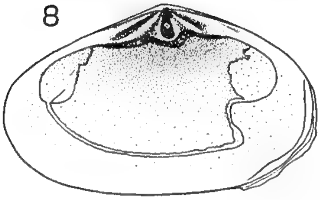

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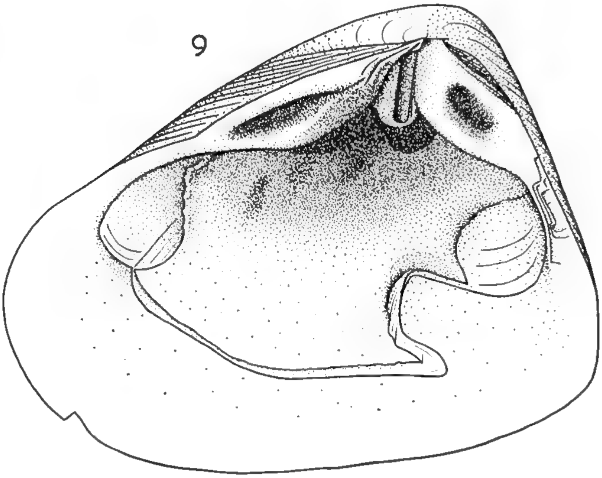

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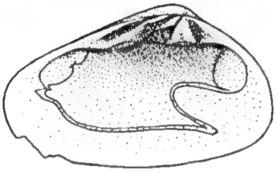


only synonymising the generic concepts, and this name and *Eryx* are not synonyms of *Paphia.* Swainson (1840: 370, footnote) stated clearly that he was proposing the new name *Eryx* to replace *Erycina* Lamarck, which he believed to be preoccupied by a name proposed in Insecta by Fabricius. Thus *Eryx* Swainson is a junior objective synonym of *Erycina* Lamarck (it was so treated by Vokes, 1967; 248; Chavan, 1969: *N*519), regardless of what species Swainson included in *Eryx* (he actually included what appears to be *Atactodea striata;* Swainson, 1840: 368, figs. 118, d, e).

Atactodea is the abundant, small, relatively strongly concentrically ribbed mesodesmatid of atoll lagoons throughout the Indo-West Pacific. *Davila,* occurring in the same area and habitat, is readily distinguished by its smooth, rounded form, slight inflation, and almost complete absence of a pallial sinus.

Genus *Mactropsis* Conrad, 1854

1846. *Triquetra* Conrad, *Am. J. Sci.* (2), 1: 217 (non de Blainville, 1828, Mollusca). Type species (by subsequent designation, Dall, 1895a): *Erycina aequorea* Conrad, 1833, Middle Eocene, Alabama.

1854. *Mactropsis* Conrad, *Proc. Acad. Nat. Sci. Philad.*, 7: 30. New name for *Triquetra* Conrad, 1846, non de Blainville, 1828.

Dall (1898: 910-11) presented evidence for considering *Mactropsis* as a primitive mesodesmatid, rather than as a mactrid. For this reason the genus is retained here. Palmer and Brann (1965: 190) placed *Mactropsis* in the Mactridae, whereas Keen (1969: *N*610) retained it in the Mesodesmatidae.

? Genus *Ceroniola* Wilckens, 1904

1904. *Ceroniola* Wilckens, *Neues Jb. Min. Geol. Paläont., Beil.*, 18: 249. Type species (by monotypy): *Cultellus australis* Gabb, 1860, Upper Cretaceous, Chile.

This genus, included in the Cultellidae by Vokes (1967: 280), was tentatively included in the Mesodesmatinae by Keen (1969: *N*608). Wilckens (1904: 250-1) was most emphatic that the genus belongs in the Mesodesmatidae in spite of its unusual hinge, interpreted by him as having the resilium triangular, small, and attached behind a small, oblique, forward-directed tooth protruding below the beaks. The lateral teeth are well developed and show clearly in Wilckens' (1904: pl. 20, fig. 11a, b) figures, copied clearly by Keen (1969: fig. E101, *8a-c.* Wilckens thought the hinge was perhaps slightly damaged during preparation, and did not have a perfect example among approximately 50 specimens. If the resilium is correctly interpreted the genus must be placed in the Mactracea, but the details may rule out its inclusion in the Mesodesmatidae. It is here tentatively retained in the Mesodesmatidae for want of a better position.

Wilckens (1904) recorded *Ceroniola australis* (Gabb), the sole species, only from the Quiriquina beds (Campanian-Maastrichtian) of Chile, suggesting it was an ancestor of "*Ceronia*" [in his sense, *Ceronia* = *Meso-*

Figures 6 - 10. Right valves of Mesodesmatidae. 6, *Paphies (Mesodesma) subtriangulata porrecta* (Marwick), holotype; GS1178, Titirangi, Chatham Is. (Nukumaruan, early Pleistocene); N.Z. Geological Survey, TM4738. 7, *Paphies (Mesodesma) subtriangulata quoyi* (Deshayes); Kartigi Beach, Dunedin, New Zealand; N.Z. Geological Survey, TM4874. 8, *Paphies* (s. str.) *australis australis* (Gmelin), type species of *Paphies* Lesson; Petone Beach, Wellington Harbour, New Zealand; N.Z. Geological Survey, RM1313. 9, *Paphies (Mesodesma) crassiformis* (Marshall and Murdoch), holotype; Nukumaru Beach, Wanganui, New Zealand (Nukumaruan, early Pleistocene); N.Z. Geological Survey, TM4736. 10, *Donacilla cornea* (Poli), type species of *Donacilla* de Blainville; Toulon, France, C. Cooper Colln.; Auckland Institute and Museum, AM24945.

Figs. 6 - 9 approx. natural size; fig. 10 enlarged approx. X 2.

desma of this paper]. A much more likely ancestor of the Mesodesmatidae, with a considerably more generalised shape and a more typical mactracean hinge, is *Mactropsis* Conrad from the Eocene of North America. This evolutionary relationship supports the view that *Ceroniola* is not a mesodesmatid. Keen's (1969: *N*608) statement that *Cerioniola australis* is of upper Tertiary age is presumably an error for Upper Cretaceous.

Subfamily Davilinae Dall, 1895

The usefulness of the subfamilies erected by Dall (1895a) is open to considerable doubt. He separated *Anapella* and *Davila* from the Mesodesmatinae by their absence of a pallial sinus, but a very small posterior inflection of the pallial line is present in both genera, immediately in front of the posterior adductor muscle scar. Anatomical examination will show the validity or otherwise of Dall's groups, which are tentatively maintained in this primarily nomenclatural review.

Genus *Anapella* Dall, 1895

1853. *Anapa* J. E. Gray, *Ann. Mag. Nat. Hist.*, (2), 11: 44 (not *Anapa* Gray, 1847, = *Lasaea*). Type species (by monotypy): *Anapa smithii* Gray, 1853 (=*Mesodesma triquetrum* Hanley, 1843, =*Amphidesma cycladeum* Lamarck, 1818), Recent, south-eastern Australia.

1895. *Anapella* Dall, *Proc. Malac. Soc. Lond.*, 1: 213. New name for *Anapa* Gray, 1853, non Gray, 1847.

Macpherson and Gabriel (1962: 359) pointed out that the earliest name for the type species of *Anapella* is *Amphidesma cycladeum* Lamarck, 1818. *Anapella cycladea* is a readily recognisable, strongly inflated, weakly concentrically sculptured, prominently toothed species occurring in Tasmania and south-eastern Australia. It appears to me to be related to *Paphies* (s.lat.) rather than to *Davila*, and thus the Davilinae is probably heterogeneous.

If my conclusions on combined genus and species descriptions are not accepted, Dall's (1895a: 213) statement that the type species of *Anapella* is " *Anapa triquetra*, Hanley " would constitute subsequent designation of that species as type.

Genus *Davila* Gray, 1853

1853. *Davila* J. E. Gray, *Ann. Mag. Nat. Hist.*, (2), 11: 44. Type species (by monotypy): *Davila polita* Gray, 1853 (=*Mesodesma planum* Hanley, 1843), Recent, Indo-West Pacific.

The statement by Dall (1898) that the type species of *Davila* was " *D. polita* Gray (MS.?) = *D. plana* Hanley " would constitute designation of the synonymised available species as type species of *Davila* if my conclusions on combined genus and species description are not accepted.

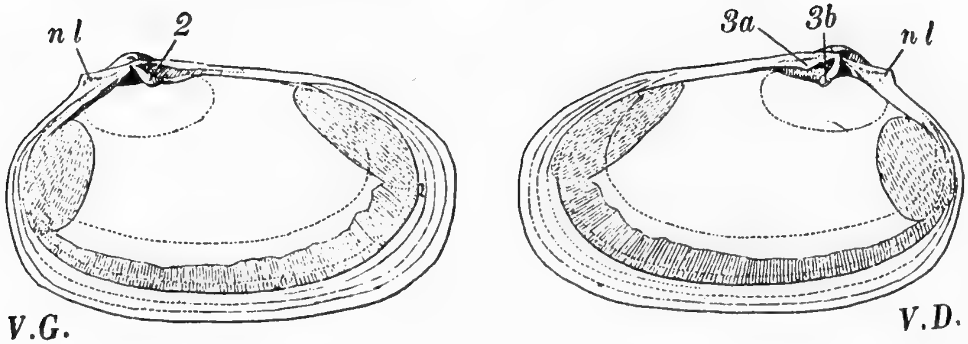
Davila plana, with its smooth, polished exterior, its slight inflation, its heavy hinge plate, and its very small posterior inflection in the pallial line, is one of the most easily recognised members of the family. It occurs commonly in atoll lagoons throughout the Indo-West Pacific.

Genus *Monterosatus* nom. nov.

1875. *Nesis* Monterosato, *Atti Accad. Palermo*, (2), 5: 4 (*nomen nudum*).

1899. *Nesis* Locard, *Les coquilles marines au large des côtes de France*: 135. Type species (by monotypy): *Nesis prima* "Monterosato" Locard, 1899, Recent, Mediterranean. [Non *Nesis* Mulsant, 1850. Coleoptera; nec Stal, 1860, Hemiptera; nec Conrad, 1871, Mollusca; nec Cambridge, 1883, Arachnida].

The four-times preoccupied nominal genus *Nesis* " Monterosato " Locard, 1899 seems never to have been renamed, and is not included in



Charnière de *Nesis prima* Monts.

Figure 11. Copy of Lamy's figure of the interior of both valves of *Monterosatus primus* (Locard), X 2; original magnification not stated by Lamy.

the Bivalvia volume of the " Treatise on Invertebrate Paleontology " (Keen, 1969). The replacement name *Monterosatus* (gender: masculine) is here proposed for it (type species: *Nesis prima* " Monterosato " Locard, 1899).

Although Lamy (1914: 13) and several earlier authors regarded *Nesis* Monterosato as an available name, where first published *Nesis* satisfies none of the requirements of the International Code of Zoological Nomenclature, and can only be construed as a *nomen nudum* (Monterosato, 1875: 4). *Nesis prima,* the single species included in the genus later in the original work (Monterosato, 1875: 17), is a *nomen nudum* also. The same species was listed in two later works by Monterosato (1878: 73; 1884: 27) but was not made available. As noted by Pallary (1900: 408), at the next subsequent reference Locard (1899: 135-6) published the first description of the genus and species, and thus rendered them available. Thus Locard must be considered the author of the genus and species. Monterosato (in Sacco, 1901: 21) later published a description of *Nesis secunda* from the Italian Pliocene, and (Sacco, 1901: pl. 29, figs. 47-50) gave clear photographs of both *Nesis prima* Locard and *Nesis secunda* Monterosato. Pallary (1900: 408) noted that *Nesis prima* is a reasonably common Mediterranean shell.

The best figure of the interior of " *Nesis* " *prima,* based on " type " material of " *Nesis prima* Monterosto " and showing the hinge features clearly, is the drawing published by Lamy (1914: 13), and repeated here (Fig. 11). It shows a minute shell with large muscle scars, and a broad pallial line that lacks any trace of a posterior sinus. Thus the genus *Monterosatus* is here tentatively referred to the Davilinae. It bears a most unusual dorsally-projecting posterior hinge structure, interpreted by Lamy (1914) to be a ligamental nymph. If the apparent mactracean resilifer is correctly interpreted, the genus can be placed in no other family but the Mesodesmatidae, but shells and, preferably, animals should be re-examined before such a position can be accepted with confidence.

In summary, the valid names of the species of *Monterosatus* are:
Monterosatus primus (Locard, 1899);
Monterosatus secundus (Monterosato in Sacco, 1901).

Subfamily Erviliinae Dall, 1895

Genus *Ervilia* Turton, 1822

1822 *Ervilia* Turton, *Conchylia Insularum Britannicarum* (2): 55. Type species (by monotypy): *Mya nitens* Montagu, 1808, Recent, West Indies (Europe?).

A widespread genus containing many species of small, generalised form. It bears fine but well-marked radial sculpture which, if present, is usually limited to the posterior part of the shell.

Subgenus *Spondervilia* Iredale, 1930

1930 *Spondervilia* Iredale, *Rec. Aust. Mus.*, 17: 402. Type species (by original designation): *Ervilia australis* Angas, 1877, Recent, eastern Australia.

As pointed out by Dall, Bartsch and Rehder (1938: 170), *Spondervilia* differs from *Ervilia* mainly by bearing radial sculpture all over, rather than merely on the posterior end. They reduced *Spondervilia* to a subgenus of *Ervilia.*

Genus *Argyrodonax* Dall, 1911

1911. *Argyrodonax* Dall, *Nautilus*, 25: 85. Type species (by original designation): *Argyrodonax haycocki* Dall, 1911, Recent, Bermuda.

This genus still seems to be known only by the type species, a minute (5.5 x 4.5 mm) shell from Bermuda. Dall (1911) compared it with *Anapella* (Davilinae) but stated that the pallial sinus is " large and deep ". Thus Keen (1969: *N*610) referred *Argyrodonax* to the Erviliinae. If the genus is correctly referred to the Mesodesmatidae (Dall also compared it with *Cumingia*), the Erviliinae would appear to be the better location for it.

Keen (1969: *N*610) stated that the type was selected by monotypy, but Dall (1911: 85) clearly named *Argyrodonax haycocki* as type.

Genus *Coecella* Gray, 1853

1853. *Coecella* J. E. Gray, *Ann. Mag. Nat. Hist.*, (2), 11: 43. Type species (by monotypy): *Coecella horsfieldii* Gray, 1853, Recent, Indo-West Pacific.

In the original paper, Gray (1853: 43) spelled *Coecella* with a digraph. The " o " and " e " are joined together, disguising the shape of the " o "; all subsequent workers have interpreted the spelling as *Caecella.* As pointed out by Mr D. Heppell, examination of the " ae " digraphs at the ends of family names throughout Gray's paper, including two on p. 43, shows that *Coecella* is spelled with an " oe " digraph rather than an " ae ". Thus the correct original spelling, *Coecella,* is used in this paper.

Coecella was placed in the Mactridae by Gray (1853: 43), but Dall (1898: 914) pointed out that it was closely related to *Ervilia.* Lamy (1914: 10) considered that *Coecella* was based on little more than large species of *Ervilia.*

If my conclusions on combined genus and species descriptions are not accepted, no type species will have been validly designated for *Coecella.*

No-one has ever designated any species but " *C. horsfieldii* Gray " as type of *Coecella,* but strictly speaking, as this would be unavailable if my conclusions are not accepted, another species must be designated. Accordingly, I here designate *Coecella horsfieldii* Deshayes, 1854 as type species of *Coecella* Gray, 1843.

Genus *Rochefortina* Dall, 1924

1924. *Rochefortina* Dall, *Proc. Biol. Soc. Wash.*, 37: 88. Type species (by original designation): *Rochefortia (Rochefortina) semele* Dall, 1924 (=*Ervilia sandwichensis* E. A. Smith, 1885), Recent, Hawaii.

Dall (1924) erected *Rochefortina* as a subgenus of *Rochefortia* (Montacutidae). Later Dall, Bartsch and Rehder (1938: 169) pointed out that the type species was a junior synonym of *Ervilia sandwichensis* E. A. Smith, 1885, and that *Rochefortina* was a genus of the Mesodesmatidae. The type species is very similar to *Ervilia* in most respects, and *Rochefortina* evidently belongs in the subfamily Erviliinae.

Family Myadesmatidae Clark, 1922

(*nom. correct.* herein *pro* Myadesmidae Clarke, 1922)

Genus *Myadesma* Clark, 1922

1922. *Myadesma* Clark, *Univ. Calif. Publs., Bull. Dep. Geol. Sci.*, 14 (4): 116. Type species (by original designation): *Myadesma dalli* Clark, 1922, Oligocene, Vancouver Id.

Clark (1922) erected *Myadesma* and the family " Myadesmidae " for three species previously thought to belong in *Mesodesma.* The species are similar to *Mesodesma* in their trigonal shape with beaks near the posterior end, in having a well-marked shallow pallial sinus, in having anteriorly directed resilifers, and in having prominent, smooth lateral teeth like those of *Paphies* (s.str.) and *Mesodesma;* also, " tooth-like structures " alongside the resilifers described by Clark appear to be better interpreted as cardinal teeth. Clark referred the family to the " Anomalodesmacea " on the basis of the resemblance of the resilifers to those of the Myidae; the resilifer of the right valve protrudes strongly beyond the plane of the commissure, whereas that of the left valve is sunken, and fused to the valve itself. What was identified as a lithodesma by Clark is sometimes fused to the resilifer of the right valve.

In general features *Myadesma* closely resembles *Mesodesma,* and seems better referred to the Mactracea than to the Myacea. Keen (1969: *N*610) included *Myadesma* tentatively in the Mesodesmatidae. However, the *Mya*-like projection of one resilifer and sinking of the other precludes inclusion in that family, and the genus is here retained in its own family, in the Mactracea. Until the shell structure and hinge details are adequately known, this must remain a tentative assignment.

SYNOPSIS OF CLASSIFICATION OF THE MESODESMATIDAE

The tendency to form geographic genera and subgenera is unusually well marked in this family, particularly in the subgenera of *Paphies*.

Family Mesodesmatidae Gray, 1840

Subfamily Mesodesmatinae Gray, 1840

Genus *Atactodea* Dall, 1895; Indo-Pacific;

? Genus *Ceroniola* Wilckens, 1904; Upper Cretaceous, South America;

Genus *Donacilla* de Blainville, 1819; Mediterranean;

Genus *Mactropsis* Conrad, 1854; Eocene, south-eastern U.S.A.;

Genus *Paphies* Lesson, *[*1831*]*;
    Subgenus *Amesodesma* Iredale, 1930; southern Australia;
    Subgenus *Ceronia* Gray, 1853; eastern North America;
    Subgenus *Mesodesma* Deshayes, *[*1832*]*; New Zealand and South America;
    Subgenus *Paphies* s.str.; New Zealand.

Subfamily Davilinae Dall, 1895

Genus *Anapella* Dall, 1895; southern Australia;

Genus *Davila* Gray, 1853; Indo-Pacific;

Genus *Monterosatus* nom. nov.; Mediterranean.

Subfamily Erviliinae Dall, 1895

Genus *Argyrodonax* Dall, 1911; Bermuda;

Genus *Coecella* Gray, 1853; Indo-Pacific;

Genus *Ervilia* Turton, 1822; Cosmopolitan;

    Subgenus *Spondervilia* Iredale, 1930, Indo-Pacific;

Genus *Rochefortina* Dall, 1924; Hawaii.

? Family Myadesmatidae Clark, 1922

Genus *Myadesma* Clark, 1922; Oligocene of Western Canada.

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GUILDFORDIA TRIUMPHANS (PHILIPPI) FROM AUSTRALIA (MOLLUSCA: TURBINIDAE)

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Plate 9

ABSTRACT

Guildfordia triumphans (Philippi) is recorded from the Arafura Sea and from southern Queensland. Its previous range was Japan, China and Indonesia.

INTRODUCTION

Recent dredging and trawling on the Australian continental shelf has revealed the presence of several species originally described from Japanese seas. The most intensive trawling on the Queensland coast has been done from the vicinity of Cape Moreton north to Fraser Island, chiefly by prawn trawlers.

Mr. Lance Moore of Sydney recently acquired a collection of shells which were trawled in the vicinity of Cape Moreton. Among these were three specimens of *Guildfordia triumphans* (Philippi), perhaps one of the most characteristically Japanese species known. Mr. Moore has kindly presented these shells to the Australian Museum so that their occurrence in Australia can be officially placed on record.

Additional specimens of *Guildfordia triumphans* have recently been taken in the Arafura Sea so that it is probably spread around much of tropical Australia.

TAXONOMY

Turbinidae, Astraeinae.

Guildfordia J. E. Gray (in M. E. Gray), 1850.

Type species: *Trochus triumphans* Philippi, 1841.

Guildfordia triumphans (Philippi)

1841 *Turbo triumphans* Philippi, *Jahresber. des Vereinsf. für Naturk.*, 5: 8.
1842 *Trochus guildfordiae* (Gray MSS) Reeve, *Conch. Syst.*, 2: 166, pl. 218, fig. 17.
1882 *Guildfordia triumphans*. Dunker, *Index Mollus. Maris Japonici*: 129.
1957 *Guildfordia triumphans*. Habe, *Proc. Malac. Soc. Lond.*, 32 (5): 208, fig. 1 (p. 207) (radula).
1962 *Guildfordia triumphans*. Kira, *Shells of the Western Pacific in colour*: 19, pl. 11, fig. 9.

Distribution: Habe (1953) states that *G. triumphans* is widely distributed in the "East Indies, China and Japan". Its occurrence in Australia is thus not surprising. The Australian shells show no constant differences from Japanese specimens.

PLATE 9

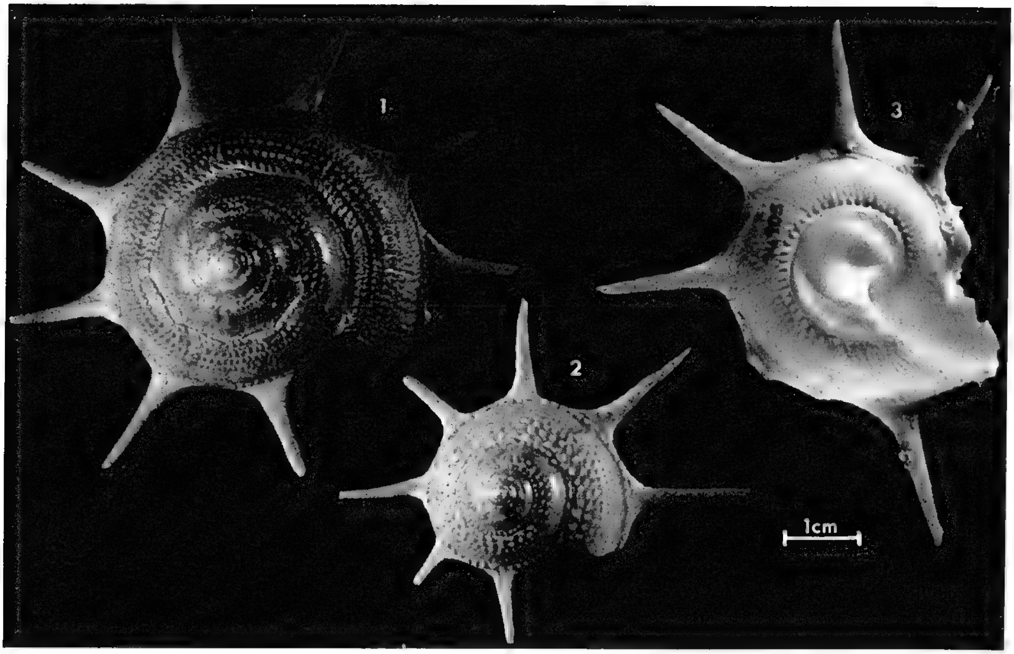

PLATE 9. *Guildfordia triumphans* (Philippi).

Figure 1. Large specimen from Japan, Australian Museum C72767.

Figures 2 - 3. Specimens trawled in vicinity of Cape Moreton, Queensland, Australian Museum C74905.

Australian Localities: Arafura Sea, off Arnhem Land, 9°30′ S, 132°34′ E, 124 metres, 9 Nov., 1969, P. H. Colman, M. V. *San Pedro Sound* (3 juveniles, 2 fragments) (Aust. Mus. reg. no. C. 72774); as last, 9°30′ S, 131°51′ E, 146 metres, 13 Nov., 1969 (1 fragment) (C. 72711); as last, 9°17′5″ S, 132°20′ E, 168 metres, 10 Nov., 1969 (1 juvenile) (C. 75826); trawled in vicinity of Cape Moreton, southern Queensland, between 1966 and 1967, W. Goode, 3 dead but fresh specimens, largest 40 mm at greatest diameter of periphery; diameter to tips of spines 71 mm (C. 74905).

Remarks: Another species of *Guildfordia, G. yoka* Jousseaume (see Habe, 1953) is known from Japan and Indonesia (Schepman, 1908). This species is distinguished from *G. triumphans* by its larger peripheral spines, absence of spiral cords on the base and deeper cavity in the basal callus.

Astralium (Guildfordia) moniliferum Hedley and Willey (1896) from Talili Bay, New Britain, has heavy beaded spiral cords on the base and very short peripheral spines. The operculum, basal callus and general facies are similar to those of *G. triumphans* so that the placement of this species in *Guildfordia* is justified.

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A REVISION OF THE FAMILY CLAVAGELLIDAE (PELECYPODA, MOLLUSCA) FROM AUSTRALIA, WITH DESCRIPTIONS OF TWO NEW SPECIES

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Plates 10-13

ABSTRACT

There are nine species of the family Clavagellidae recognised from Australian waters, including two new species, *Clavagella (Clavagella) majorina* sp. nov. an Upper Oligocene fossil from Victoria and Tasmania and *Brechites (Foegia) veitchi* sp. nov. a living and fossil species from South Australia and Western Australia. A key to the genera and species is given and the three genera and five subgenera are redefined. New information is given on the fossil record and distribution of the species, and the zoogeography of the group is discussed.

INTRODUCTION

This study grew out of a search to identify a member of the family dredged at Port Lincoln, South Australia, which is described herein as a new species. This work revealed the taxonomic confusion in this very unusual bivalve family and the need for a revision of the Australian members. However this revision must be considered as only tentative due to the lack of comprehensive series of specimens and to the total lack of knowledge of the anatomy of many of the species.

The watering-pot shells (Clavagellidae) are highly modified for a sessile mode of life, are usually cryptic in habit, often buried in the substrate, mainly sub-littoral, and therefore only rarely collected. For this reason the geographic distribution of most species is unknown. In addition, the shell structure may show large individual variations due to distorted tube growth in response to objects such as rocks in the environment. The anatomical features of many of the species are unknown, the only good accounts being given for *Clavagella lata* by Owen (1835), *Brechites* species by Lacaze-Duthiers (1870, 1883) and for *Brechites penis* (Linnaeus) by Purchon (1956, 1959). The papers by the latter author also gave the only detailed account of various activities of living specimens of a species of this family.

The family was recently revised by L. A. Smith (1962), though no reasons were given for his placement of the species or for his synonymies. Prior to this the only works of major importance were by Chenu (1843), in which he described many new species, and Gray (1847, 1858a) who proposed a number of generic and sub-generic groupings.

The generic and sub-generic groups suggested by Smith (1962) are retained, as it is felt that anatomical details should be fully considered before statements can be made as to the status of the groups at this level. Likewise, though several named forms have been relegated to synonymy because it was felt that their shell characters fell within the individual variation of the species, the final elucidation of the species will also have to await more extensive collections and the acquisition of material upon which anatomical studies can be based. Detailed anatomical studies of four species for which material is available will be the subject of a separate paper to be published shortly.

The following abbreviations are used: AM — Australian Museum, Sydney; NMV — National Museum of Victoria; SAM — South Australian Museum; TM — Tasmanian Museum and Art Gallery; WAM — Western Australian Museum.

Family CLAVAGELLIDAE Orbigny, 1844
(= ASPERGILLIDAE Gray, 1858)

Shell nacreous, with one or both valves partially embedded in an elongated calcareous tube; hinge-plate absent; ligament external; tube anteriorly rounded or discoid; smooth, or fringed with simple or branching tubules; or partially closed by a calcareous disc having several pedal foramina.

The family is represented in Australia by nine species contained in three genera and five subgenera. This includes two new species, one recent and one fossil, described herein.

KEY TO THE AUSTRALIAN GENERA, SUBGENERA AND SPECIES.

1\. One valve fused with tube. *Clavagella* — 2

1\. Both valves fused with tube. — 5

2\. (1) Tube with simple siphonal end, with one or more longitudinal ridges, anterior portion free, or attached by anterior end only, with long irregularly shaped, spire-like tubules. *Clavagella* s. str. — 3

2\. (1) Tube with simple siphonal end, circular in section, wide with obvious growth rings, anterior end embedded in rock or other hard substrate, with many short tubules around valve. *Clavagella (Dacosta) australis* (only species in subgenus).

3\. (2) Tube multi-angular in section, with 6 or more longitudinal ridges, small, total length less than 3 cm. *Clavagella (Clavagella) multangularis.*

3\. (2) Tube with only one or two longitudinal ridges, large, total length exceeding 3 cm. — 4

4\. (3) Anterior portion swollen, hinge anteriorly placed, tubules mainly from side opposite hinge and anterior end. *Clavagella (Clavagella) torresi.*

4\. (3) Anterior portion only slightly wider than tube, hinge slightly anterior of centre of valve, tubules long, from anterior and only in plane of tube. *Clavagella (Clavagella) majorina* sp. nov.

5\. (1) Valves large, forming most of the anterior bag-like cavity, tube angular in section. *Humphreyia strangei* (only species in genus).

5. (1) Valves small, fused to side of tube, tube circular in section. *Brechites* — 6

6. (5) Siphonal end with a series of plaited ruffles, disc fringe often indistinct, of a series of thick tubules, valves depressed and exposed. *Brechites (Brechites) australis* (only Australian species in subgenus).

6. (5) Siphonal end of tube simple, disc fringed with single row of fine tubules, umbos exposed but valves not depressed and exposed. *Brechites (Penicillus) strangulatus* (only Australian species in subgenus).

6. (5) Siphonal end simple, disc often indistinct and without fringe, umbos almost covered by swollen prominences. *Brechites (Foegia)* — 7

7. (6) Disc small, of a tight cluster of tubules, anterior portion of the tube only slightly bulbous. *Brechites (Foegia) novaezelandiae.*

7. (6) No discrete disc, anterior portion of tube extremely swollen, tubules widely distributed on this portion. *Brechites (Foegia) veitchi* sp. nov.

TAXONOMY

Genus *Clavagella* Lamarck, 1818

Clavagella Lamarck, 1818, *H. N. Anim. sans Vert.*, 5: 430. Type species: *Clavagella echinata* Lamarck 1818 (S.D.: Children, 1823). Synonymy: *Fistulana* Lamarck 1818, *H. N. Anim. sans Vert.*, 5: 432 (no type species found).

One valve fused with the tube, the other remaining free inside the anterior cavity, both adductors persistent in the adult.

Species from two of the four subgenera described for this genus (Smith, 1962) are known from Australia. A species from a third subgenus, *Clavagella (Bryopa) lata* Broderip, 1834, was mentioned as coming from Australia (Smith, 1962) but no direct evidence of this has been found. The original specimen was described from the Cuming Collection and the locality quoted as the Pacific Ocean. This species has been omitted from this revision though future collecting may necessitate its re-instatement in the Australian list.

Subgenus *Clavagella*

Tube free or attached by anterior end only, siphonal end simple, anterior portion with spine-like tubules.

Known only from fossils in Europe and India, and from fossil and recent species in Australia.

Clavagella (Clavagella) multangularis (Tate, 1887)

(Pl. 10, figs. 1, 2, 3)

Aspergillum multangulare Tate, 1887, *Trans. R. Soc. S. Aust.*, 9: 64, pl. 4, 4a - b.
Aspergillum (Humphreyia) liratum Tate, 1887, *Trans. R. Soc. S. Aust.*, 9: 184, pl. 19, fig. 11.
Clavagella multangularis. Tate, 1892, *Trans. R. Soc. S. Aust.*, 15: 134.
Clavagella multangularis. Gabriel, 1908, *Victorian Nat.*, 25: 55.

Clavagella multangularis. Cotton and Godfrey, 1938, *Molluscs of South Australia, Pelecypoda*: 147, fig. 147.

Clavagella (Clavagella) multangularis. Smith, 1962, *Veliger* 4: 170.

Dacosta multangularis. Macpherson and Gabriel, 1962, *Marine Molluscs of Victoria*: 401, fig. 472.

DIAGNOSIS: Tube small, multi-angular in section, with 6 or more longitudinal ridges and slightly constricted at junction with anterior swollen portion; hinge forming apex of anterior portion; tubules mainly from anterior end, total length less than 3 cm.

TYPE MATERIAL: Holotype of *A. multangularis* in the SAM — D 13172; from Holdfast Bay, St. Vincents Gulf, South Australia. Holotype of *A. liratum* in Tate Museum, Geology Department University of Adelaide, S.A. — T.323; from Adelaide Bore, Kent Town, Adelaide, S.A., Blanche Point Marl, Aldingan (Upper Eocene).

DISTRIBUTION: Upper Eocene to Recent. FOSSIL: South Australia: Adelaide Bore, Kent Town, Adelaide; Blanche Point Marl, Aldinga, (Upper Eocene). Victoria: Jan Juc Formation, Janjukian (U. Oligocene), Bird Rock Cliffs, Torquay, Muddy Creek Formation, Balcombian (Miocene), Muddy Creek. RECENT: South Australia: St. Francis Island, Great Australian Bight, beach to 200 m. (Cotton 1961); St. Vincent's Gulf and other localities on the southern coast of South Australia and Victoria, from Western Port Bay, Victoria and Bass Strait and Sydney Harbour, N.S.W.

MATERIAL EXAMINED: FOSSIL: SOUTH AUSTRALIA: Adelaide Bore, Holotype of *A. liratum* Tate, Tate (Tate Mus., Geol. Dept., Univ. Adel.). VICTORIA: Torquay, J. Dennant Coll., 1 spec. (NMV) Muddy Creek, J. Dennant Coll., 1 spec. (NMV). RECENT: SOUTH AUSTRALIA: Holdfast Bay, Tate, Holotype, (SAM); Wallaroo, 27 m, J. Verco, 4 spec. (SAM); St. Francis Is., 64 m, 1 spec., 25 m, 1 spec. J. Verco, (SAM). (Plus many others with no locality). VICTORIA: Western Port Bay, C. J. Gabriel, 3 spec. (NMV); 13.v.1908, C. J. Gabriel, 1 spec. (NMV); Dec. 1905, J. H. Gatliff, 2 spec., (NMV); Bass Strait Cable, 5 spec. (NMV); 72 km S. of Lakes Entrance, 91 m W. S. Ayer, 2 spec., (NMV). NEW SOUTH WALES: Sydney, 2 spec. (AM); 1867, J. Brazier, 2 spec. (AM); 11 m June 1879, J. Brazier, 1 spec., (AM).

ANATOMY: Unknown.

REMARKS: The fossil *A. liratum* Tate is included in the synonymy of this species as it falls within the normal variation of *multangularis.* Tate (1887) states that the two forms differ only in the number of longitudinal ridges on the tube, *liratum* showing many more. However the number of longitudinal ridges in *multangularis* can vary from 6 to 25.

This species lives attached to rocks or dead shells by the disc. Nothing is known of its ecology or behaviour.

Clavagella (Clavagella) torresi Smith, 1885

(Pl. 10, figs. 4, 5.)

Clavagella torresi Smith, 1885. *"Challenger" Reports. Lamellibranchiata,* 13: 28, pl. 8, figs. 1a - b.

DIAGNOSIS: Tube with one or two longitudinal ridges, not constricted at junction with anterior swollen portion, hinge near anterior end of fixed valve; tubules mainly from side of anterior portion of tube opposite hinge and at anterior end.

TYPE MATERIAL: The holotype of this species could not be found in a recent extensive search of the collection of the British Museum. The type locality is Torres Strait.

DISTRIBUTION: Recent only. From Torres Strait and the Gulf of Carpentaria in North Queensland to Lindeman Island in Central Queensland.

MATERIAL EXAMINED: QUEENSLAND: Albany Passage, 7 - 26 m. C. Hedley, 5 spec. (AM); Hope Island, 9 - 18 m. C. Hedley, 1 spec., (AM); Lindeman Island, 9 spec. (AM); Port Curtis, 13 m. C. Hedley, 1 spec. (AM), Sweers Island, Gulf of Carpentaria, 14 - 22 m. D. F. McMichael, 9. xii 1962 1 spec. (AM).

ANATOMY: Unknown.

REMARKS: This species was described from a unique specimen which cannot now be found. Consequently the allocation of specimens to this species must remain tentative until the type is located or sufficient material is available to redescribe the species. The specimens from Albany Passage and Lindeman Island all closely resemble the original description.

Clavagella (Clavagella) majorina sp. nov.

(Pl. 10, figs. 6, 7, 8)

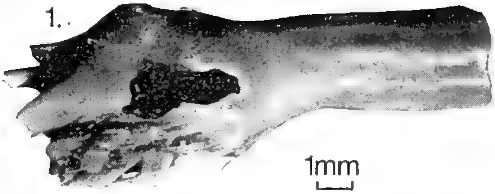
DIAGNOSIS: Left valve large, fused with tube, umbo central, valve with concentric striae. Anterior end only slightly swollen, tubules long, arising from the anterior end only; tube wide, oval in section with one slight dorsal ridge, siphonal end simple.

DESCRIPTION: Shell large consisting of a wide, oval tube with a very faint longitudinal ridge and a slightly swollen anterior section, the swelling being more pronounced dorso-ventrally than laterally. Anterior section elongated with the valve close to the junction of the swollen section with the tube. Tubules long, branching and confined to the anterior end. Left valve large, fused with tube, with concentric striae; umbo central; posterior end of valve rectangular; hinge covered by a prominence from the tube.

TYPE MATERIAL: Type series in National Museum of Victoria. Holotype P25943, collected by R. Daintree, 11.vii.1861, and presented by the Geological Survey of Victoria. Dimensions: total length 75.0 mm; max. width 14.0 mm; max. depth 19.5 mm; fused valve length 13.2 mm; valve depth 7.8 mm; length of anterior portion 36.5 mm. Four paratypes; Paratype No. 1, P25944, collected in 1901; dimensions; total length 80.5 mm (broken); max. width 16.5 mm; max. depth 20.3 mm; fused valve length 12.5 mm; valve depth 6.9 mm; length of anterior portion 28.0 mm. Paratype No. 2, P25945, from the F. A. Cudmore Collection; dimensions; total length 54.0 mm (broken); max. width 13.0 mm; max. depth 16.0 mm; fused valve length 13.0 mm; valve depth 9.0 mm; length of anterior portion 29.5 mm. Paratype No. 3, P25946, from the F. A. Cudmore Collection still partially embedded in matrix block set in plaster bed; dimensions; total length 40.5 mm; max. width 7.0 mm; max. depth indeterminable; fused valve length 10.5 mm; valve depth indeterminable; length of anterior portion 21.0 mm. Paratype No. 4, P17175, collected by F. S. Colliver, still partially embedded in matrix; dimensions; total length 81.0 mm; max. width 11.0 mm; max. depth indeterminable; fused valve length 9.5 mm; valve depth 6.0 mm; length of anterior portion 23.0 mm.

PLATE 10

1.



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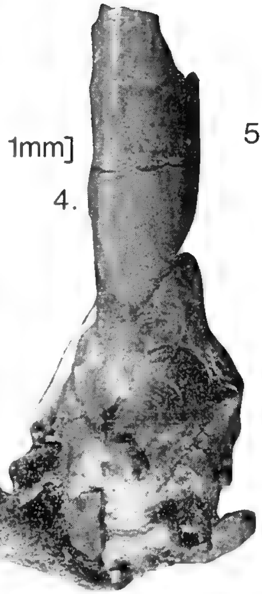

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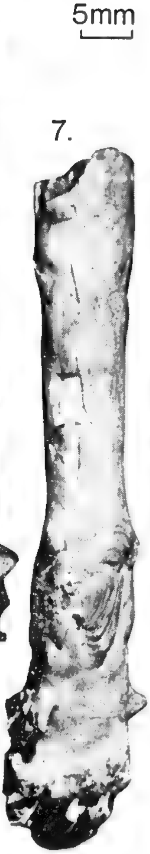

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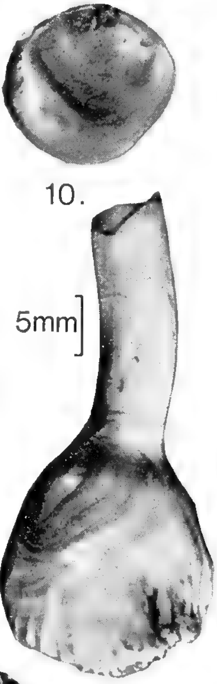


TYPE LOCALITY: Bird Rock Cliffs, near Torquay, Victoria, Grid Ref. Anglesea 378,704 Jan Juc For., Janjukian, Upper Oligocene.

DISTRIBUTION: Upper Oligocene only. Type locality and Table Cape, Tasmania.

MATERIAL EXAMINED: VICTORIA: Type locality, type series, topotypes (10 spec.) Cudmore Colln. (NMV), topotypes (6 spec.) R. Daintree 1861 (NMV). TASMANIA: Fossil Bluffs Sandstone, upper beds Table Cape, F. A. Cudmore Colln., 1 spec. partially embedded in matrix. (NMV).

REMARKS: This species is closely similar to *Clavagella (Clavagella) torresi* Smith from the warmer waters of northern and eastern Australia. It differs from *torresi* mainly in its larger maximum size, both in length and width; in the relative sizes of the tubes and anterior portions; in the position of the valve and hinge and in the distribution of the tubules. In *C. (C) torresi* the anterior portion is much more swollen relative to the diameter of the tube, the hinge is situated well towards the anterior end of the valve while in *majorina* it is more centrally placed. In addition, the tubules of *torresi* arise from the ventral side of the anterior portion as well as the anterior end instead of being confined to the anterior end as in *majorina.* It is easily separated from *C. (C.) multangularis,* the only other Australian species in this subgenus, by its much larger size and by having only one or two indistinct longitudinal ridges instead of six or more. Comparison was also made between this species and the other members of the subgenus listed by Smith (1962) all of which are European fossils, with one exception from India. All the European species are distinguished by their small size, their relatively large valves in comparison to total size and the presence of tubules in regions other than the anterior end. The Indian species, *Clavagella semiculcata* Forbes 1846, is close to *C. (C) majorina* in size but differs in having the umbo placed anteriorly on the valves instead of near the centre. In addition the posterior ends of the valves of *semiculcata* are rounded, whereas those of *majorina* are rectangular.

The presence of members of this subgenus in the Oligocene fauna of southern Australia necessitate minor alterations in Smith's (1962) historical zoogeographical theories for the family. This will be discussed below.

Clavagella (Clavagella) sp?

There are several fossil specimens referable to this subgenus in the collections of the National Museum of Victoria from Bird Rock Cliffs, Victoria and Table Cape, Tasmania. These will have to remain undetermined for the present due to their imperfect preservation or broken condition.

PLATE 10

Fig. 1-2. *Clavagella (Clavagella) multangularis* (Tate), D13172, holotype, Holdsfast Bay, St. Vincents Gulf, South Australia. (SAM).

Fig. 3. *Clavagella (Clavagella) multangularis,* T323, holotype of *Aspergillum (Humphreyia) liratum* Tate, Adelaide Bore, Kent Town, Adelaide, South Australia. (Geol. Dep. U. of Adel.).

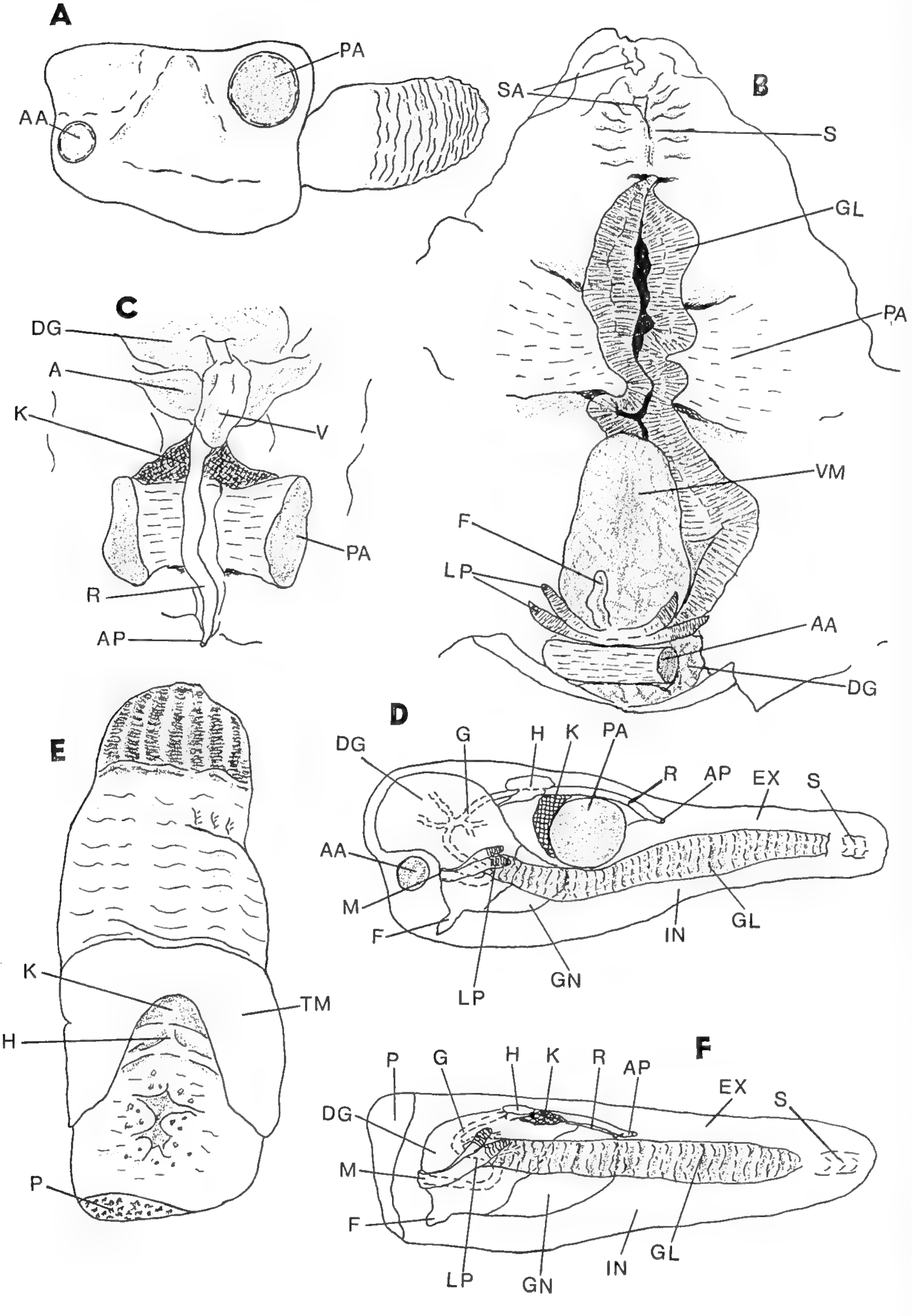
Fig. 4. *Clavagella (Clavagella) torresi* Smith. C36152, Albany Passage, Torres Strait. (AM).

Fig. 5. *Clavagella (Clavagella) torresi,* C58817, Lindeman Is., Queensland, (AM).

Fig. 6-7. *Clavagella (Clavagella) majorina* sp. nov., P25943, holotype, Bird Rock Cliffs, Torquay, Victoria, (NMV).

Fig. 8. *Clavagella (Clavagella) majorina* sp. nov., P25944, paratype. (NMV).

Fig. 9-10. *Clavagella (Dacosta) australis* (Sowerby), Sydney Harbour, N.S.W. showing interior of free valve. (AM).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Subgenus *Dacosta* Gray, 1858

Dacosta Gray, 1858, *Proc. Zool. Soc. Lond.* 26: 315. Type species: *Clavagella australis* Sowerby, 1829, (Monotypy).

Siphonal end simple, tube circular in section, wide, with obvious growth rings and many short tubules around valve. Anterior end usually embedded in rock or other hard substrate.

This sub-genus contains only one species.

Clavagella (Dacosta) australis (Sowerby, 1829)

(Pl. 10, figs. 9, 10)

Clavagella australis Sowerby, c. 1827 - 1829. *Stutchbury Catal.* app. :3.
Clavagella elongata Broderip, 1834, *Proc. Zool. Soc. Lond.* for 1834 :116.
Clavagella elongata. Broderip, 1835, *Trans. Zool. Soc. Lond.* 1: 265, pl. 35, figs. 1 - 4.
Dacosta australis. Gray, 1858, *Proc. Zool. Soc. Lond.* for 1858 : 315.
Clavagella australis. Reeve, 1872, *Conch. Icon.* 18, *Clavagella* pl. 2, figs. 4a - d.
Clavagella (Dacosta) australis. Tryon, 1884, *Struc. and Syst. Conch.* 3 : 119.
Clavagella australis. Pritchard and Gatliff, 1903, *Proc. R. Soc. Vict.* 16: 96.
Dacosta australis. Hedley, 1917, *Proc. R. Soc. N.S.W.*, 51 : M 14.
Clavagella (Dacosta) australis. Smith, 1962, *Veliger*, 4: 171.
Dacosta australis. Macpherson and Gabriel, 1962, *Marine Molluscs of Victoria*: 401, fig. 471.

DIAGNOSIS: As for sub-genus above.

TYPE MATERIAL: No type material of *C. australis* or *C. elongata* could be located in the British Museum and their location is unknown. The type locality is Sydney Harbour, N.S.W.

DISTRIBUTION: Recent only. From Sydney Harbour and Merimbula, N.S.W. and Lord Howe Island with two very doubtful records from Victoria.

MATERIAL EXAMINED: NEW SOUTH WALES: Sydney Harbour. 2 spec. (used for dissection) (AM); H. Cuming, 2 spec. (NMV); Petterd, 1873, 1 spec. (NMV); C. J. Gabriel, 5 spec. (NMV); H. Edwards, 1860, 5 spec., (NMV), J. C. Cox; 9 spec. (SAM). Merimbula, W. F. Ponder and P. H. Colman, 1970, 2 spec. (used for dissection) (AM). Lord Howe Island. 1 spec., (Old Coll. — AM). VICTORIA: Corio Bay, Tate, 1 spec., (SAM).

ANATOMICAL NOTES: (Text figs. A - D). Four specimens with the soft parts preserved, were made available by the Australian Museum for this study; two from Sydney Harbour and two from Merimbula, N.S.W. A full description of the anatomy will be published as a future paper.

The animal is weakly attached to the shell at the hinge and there seems to be little or no attachment of the adductor muscles to the shells. The body is completely enclosed in a thin, almost transparent, brown mantle, the opening to the pallial cavity being reduced to a small slit in the mid-

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TEXT Fig. A - F.

A. Diagram of the lateral view of the exterior of the animal of *Clavagella (Dacosta) australis*, showing the positions of the two adductor muscles.

B. Diagram of the interior of the pallial chamber of *Clavagella (Dacosta) australis* from the ventral side.

C. Diagram of the heart, kidney and hind-gut region of *Clavagella (Dacosta) australis* from the dorsal side.

D. Diagrammatic representation of the gross anatomy of *Clavagella (Dacosta) australis* from the lateral view.

E. Diagram of the dorsal view of the exterior of the animal of *Humphreyia strangei*.

F. Diagrammatic representation of the gross anatomy of *Humphreyia strangei* from the lateral view.

ventral region. The body is projected posteriorly (Text fig. A) into a contractile prolongation which, in life, projects up the tube and into the the water. As this prolongation contains the gills for much of its length, it cannot be termed the siphons, but must be considered part of the body. It terminates posteriorly in two short separate fused siphons, each surrounded by a number of fleshy lobes or papillae. Both adductor muscles persist as easily recognisable structures in the adult, the posterior adductor being approximately twice the size of the anterior.

The pallial cavity is almost filled by the viscero-pedal mass which is an egg-shaped structure flattened anteriorly and slightly compressed laterally (Text fig. B). The foot is a small, laterally flattened, finger-like projection at the anterior end of the visceral mass and is approximately a quarter its length. The mouth, which is situated between the foot and the anterior adductor muscle, is margined by two labial flaps which project laterally and dorsally into well developed pairs of labial palps. These are divided into many filaments soon after they leave the mouth and extend laterally to the dorsal wall of the pallial cavity where they enclose the anterior end of the gills. The gills start level with the foot at the dorso-lateral junction of the visceral mass. Each gill is composed of many V-shaped filaments attached to the pallial wall along the centre of the V. They fuse at the posterior end of the visceral mass to form a W-shaped double filament structure which extends practically to the posterior end of the body projection forming a complete horizontal, median barrier in this section of the body separating the in-current (ventral) from the ex-current (dorsal) chambers. Posterior to the gills, the two short siphons run to the exterior. The gills are ventral to the posterior adductor muscle and the rectum passes dorsal to it, opening by a short anal papilla on the posterio-dorsal end of the visceral mass. The large red heart consists of a large ventricle on the dorsal surface of the rectum and lateral auricular lobes on either side of the rectum anterior to the posterior adductor (Text fig. C). The brown kidney is ventral to the rectum closely associated with the anterior side of the posterior adductor. The visceral mass is composed of at least two easily separable glandular portions as well as the gut. The intestine appears to be short with little coiling; stomach inconspicuous with several branching ducts going to the brown, soft, alveolar-like digestive gland which occupies the anterior portion of the visceral mass. This gland also extends dorsally around the anterior adductor muscle and forms a pad of tissue occupying the anterior portion of the body. This pad of tissue occupies the region of the tube which bears perforations in the form of tubules, the function of which is not yet understood. The posterior part of the visceral mass contains the gonads. The details of the alimentary, circulatory, renal, nervous and reproductive systems will be described elsewhere.

REMARKS: C. elongata Broderip is relegated to synonymy because, from the description, no difference between it and *C. australis* could be found. Its locality of Pacific Ocean is also very unsatisfactory. Until more specimens of this unusual species are discovered in localities other than Sydney Harbour, the species variation and its distribution must remain unknown. Macpherson and Gabriel, 1962, list it as a Victoria species but state that it has only been recorded once and that the exact locality is unknown. This specimen could not be found in the National Museum collections. A specimen in the South Australian Museum, from the Tate Collection, is recorded as being from Corio Bay, Victoria. However, there is no other evidence to support this, even though two extensive faunal surveys have been carried out in the area in the last 80 years with a great deal of collecting. Therefore, until more specimens are found, the occurrence of this species in Victoria must be suspect.

Two specimens of this species recently collected from Merimbula, N.S.W. were found on the edge of an overhang on a large rock just above low tide. The tubular part was projecting vertically from the surface of the rock (at an angle of 45° approx.) on its sheltered side among short algae. A specimen in a similar habitat was collected from Long Reef, near Sydney, by Mr. P. H. Colman. This specimen was loosely attached to a rock on the southern side of the reef at extreme low water level in a pool (W. F. Ponder — pers. comm.).

Genus *Humphreyia* Gray, 1858

Humphreyia Gray, 1858, *Proc. Zool. Soc. Lond.*, 26: 317. Type species: *Aspergillum strangei* A. Adams, 1852 (Monotypy).

Tube angular in section, valves large, fused to the tube in a single plate forming most of anterior bag-like cavity.

This genus is known only from south-eastern Australia.

Humphreyia strangei (A. Adams, 1852)

(Pl. 11, figs. 11, 12)

Aspergillum strangei Adams, 1852. *Proc. Zool. Soc. Lond.* 20: 91, pl. 15, fig. 5.
Brechites (Foegia) strangei. H. Adams and A. Adams, 1858, *Genera of Recent Molluscs*, 2: 339.
Humphreyia strangei. Gray, 1858, *Proc. Zool. Soc. Lond.* 26: 317, figs. 1 - 2.
Humphreyia strangei. Gray, 1858, *Ann. Mag. N. Hist.* 3rd series, 2 (7): 16, figs. 1 - 2.
Aspergillum strangei. Reeve, 1860, *Conch. Icon.*, 12 *(Aspergillum)* pl. 2, fig. 4.
Humphreyia coxi Brazier 1872. *Proc. Zool. Soc. Lond.* for 1872 : 22, pl. 4, fig. 10a - b.
Humphreyia strangei. Tenison-Woods, 1878 *Pap. Proc. R. Soc. Tas.* for 1877 : 47.
Aspergillum (Humphreyia) strangei. Tryon, 1884, *Struct and Syst. Conch.*, 3: 118.
Humphreyia strangei. Pritchard and Gatliff, 1903, *Proc. R. Soc. Vict.* 16: 97.
Humphreyia strangei. Smith, 1910, *Proc. Malac. Soc. Lond.*, 9: 23.
Humphreyia strangei. Cotton and Godfrey, 1938, *Molluscs of South Australia (Pelecypoda)*: 148, figs. 145 - 6.
Humphreyia strangei. Ludbrook, 1955, *Trans. R. Soc. S. Aust.* 78: 37.
Humphreyia strangei. Smith, 1962, *Veliger*, 4: 171.
Humphreyia coxi. Smith, 1962, *Veliger*, 4: 171.
Humphreyia strangei. Macpherson and Gabriel 1962, *Marine Molluscs of Victoria*: 403, fig. 473.

DIAGNOSIS: As for genus above.

TYPE MATERIAL: Lectotype, here designated, in British Museum BM (NH) 1968667. Length 123 mm. Type locality, Sydney Harbour, N.S.W. One paralectotype, BM (NH) Reg. No. 1969261.

DISTRIBUTION: Pliocene to Recent. FOSSIL: From Abattoirs Bore, Dry Creek Sands, South Australia. (Ludbrook, 1955).

RECENT: From central New South Wales and Sydney Harbour to Victoria and the north coast of Tasmania to South Australia in Spencer and St. Vincents Gulfs and the Great Australian Bight. Cotton (1961) also records it from south-west Western Australia.

MATERIAL EXAMINED: NEW SOUTH WALES: Sydney Harbour, Capt. Comtesse, 1 spec., J. C. Cox, 4 spec., (SAM); J. H. Gatliff, 2 spec., (NMV). Port Stephens, Nov. 1874, Hargreaves, 1 spec. (NMV); 3 spec. (AM). Port Jackson, Capt. Comtesse, 4 spec. (AM). VICTORIA: Warrnambool, 15.ii.1913, Clarke, 1 spec., (NMV). Western Port Bay, 3.vi.1968, B. J. Smith, 1 spec. (animal preserved for dissection) (NMV); J. H. Gatliff, 6 spec., (NMV); 18.viii.1933, J. Segrave, 3 spec., (NMV); 13.v.1908, C. J. Gabriel, 1 spec. (NMV). TASMANIA: Burnie, March, 1946, H. Somerset, 3 spec., (TM). Blyth, Dec. 1945, H. Somerset, 2 spec., (TM). Clarke Is., 1 spec., (NMV). Killicrankie Bay, Flinders Is., J. A. Kershaw, 1 spec., (NMV). SOUTH AUSTRALIA: Backstairs Passage, J. C. Verco, 2 spec., (SAM). Beachport, 200m. J. C. Verco, 1 spec., (SAM). Corny Point, Yorke Peninsular, R. Anderson, 1 spec. (Anderson Coll. — Adelaide). Edithburg, J. C. Verco, 16 spec., (SAM). St. Vincent's Gulf, 1 spec. (AM).

ANATOMICAL NOTES: (Text figs. E - F). A single specimen dredged by the author in 7 m. off Stony Point, Western Port Bay, Victoria on 3.vi.1968 and preserved in 70% alcohol.

The animals appear to have little or no attachment to the shell. The body is enclosed in a thick muscular outer envestment except for the mid-dorsal region which is covered by a thin transparent membrane through which the heart can be seen. There are two semi-circular smooth patches of body wall on the sides of the anterior part of the body corresponding to the true mantle. The body is elongated posteriorly into a thick muscular contractile prolongation with the two siphons opening by separate apertures from its posterior end (Text fig. E).

The internal anatomy of this species is similar in most respects to that of *Clavagella (Dacosta) australis* described above. The main difference is the absence of the anterior adductor muscle in at least the adult and the probable reduction of the posterior adductor muscle to a non-functional vestige. A small piece of brown tissue on the dorsal surface of the kidney was tentatively identified as this structure because it was situated in the correct position, but confirmation of this identification will have to await histological examination. This species also differs in having the digestive gland confined to the visceral mass. The body wall anterior to the visceral mass is thick and muscular. The significance of this thickening and its relationships to the perforations in the shell are not understood.

As in the previously described species the gills commence as two V-shaped filamentous demibranchs attached to the latero-dorsal walls of the visceral mass. Posterior to the visceral mass they fuse and extend up the posterior prolongation of the body dividing it into in-current and ex-current chambers. A pair of labial palps extend from folds on either side of the mouth and overlap the gills. The foot is reduced to a small knob of tissue on the antero-ventral apex of the visceral mass.

REMARKS: Humphreyia coxi Brazier 1872 is included in the synonymy of this species because it falls within the specific variation of *H. strangei* and it occurs within the range of the latter species. It was originally separated because several specimens were found from Port Stephens with greatly swollen anterior ends. However, this is most likely only a local variation in which the anterior end is enlarged.

The type specimen of *H. coxi* could not be located in the Australian, British or Maclay Museums.

Clavagellidae

Genus *Brechites* Guettard, 1770

Brechites Guettard, 1770, *Mem. diff. Sci.*, 3: 154. Type species: *Aspergillum vaginiferum* Lamarck, 1818. (S.D.: Stoliczka, 1871).

Synonymy: *Verpa* Roding, 1798, *Mus. Bolten.* 2: 69. Type: *Serpula penis* Linne (Monotypy).
Aquaria Perry, 1811, *Conchology*, pl. 52. Type: (none found).
Arytena Oken, 1815, *Lehrb. Nat.* 3 (1), XIV: 379 (rejected ICZN 1956).
Clepsydra Schumacher, 1817, *Ess. Vers. test.*, 79: 261.
Aspergillum Lamarck, 1818, *H. N. Anim. sans. Vert.*, 5: 429.
Warnea Gray, 1858, *Proc. Zool. Soc. Lond.*, 26: 310.

Both valves fused with tube, valves small, tube circular in section.

In his revision of the family, Smith (1962) discarded this generic name, declaring Guettard 1770 to be non-binomial and therefore invalid, and put forward *Penicillus* Bruguiere as the valid name. However I have been able to find no evidence to support the contention that Guettard is to be regarded as non-binomial. On the contrary, in a personal communication from the Science Museum Library, South Kensington, London, the following opinion was given by a staff member of the British Museum (Natural History) and a member of the International Commission of Zoological Nomenclature.

> "Guettard, in this work *(Mem. diff. Sci.)*, gives acceptable generic names. His species are given only vernacular names. He may therefore be considered binominal. Any Latin specific names, polynominal or binominal, are only quoted from other authors, and are not 'adopted' by Guettard."

Other generic names erected by Guettard (1770) in the same publication have been considered valid by other authors; for example Turner (1966) considered *Kuphus* Guettard 1770 and *Uperotus* Guettard 1770 to be valid. The genus *Brechites* was also considered valid by Purchon (1956). Prior to this the genus was used by Adams (1858), Stoliczka (1871), Fischer (1887), Nomura (1933), Korobkov (1954) and Shikama (1954). There are, therefore, precedents both for the use of generic names from the Guettard 1770 publication, and for the continued use of *Brechites*. *Penicillus* therefore must be relegated to the synonymy of *Brechites*.

Species from three of the four subgenera described for the genus are found in Australian waters. The recent species of this genus are all confined to the Indo-Pacific region where they are known from the Red Sea and from Japan to Australia.

Until more material becomes available it seems better to retain the sub-generic groups of Smith (1962) than to elevate them to full genera. However because of the validation of *Brechites* and the discovery of a type species for this taxon, the sub-generic names differ from those listed by Smith (1962). Stoliczka (1871) designated *Aspergillum vaginiferum* Lamarck, 1818 as the type species for *Brechites* s.str. and as this appears to be the earliest type designation for the taxon, this relegates *Warnea* Gray, 1858 into its synonymy. However, the species *A. strangulatum* Chenu, 1843 does not fit into this group and *Penicillus* Bruguiere, 1789 can be used to accommodate it, thus causing *Clepsydra* Schumacher, 1817 to fall into its absolute synonymy.

Subgenus *Brechites*

Synonym: *Warnea* Gray, 1858.

Siphonal end with a series of plaited ruffles, disc fringe, often indistinct, of a series of thick tubules, valves depressed and exposed.

Brechites (Brechites) australis (Chenu, 1843)
(Pl. 11, figs. 14, 15, 16, 17)

Aspergillum australe Chenu, 1843. *Illus. Conch.*, 1, *Aspergillum*: 3, pl. 3, fig. 1, 1a.
Aspergillum cumingianum Chenu, 1843. *Illus. Conch.*, 1, *Aspergillum*: 3, pl. 3, figs. 4, 4a.
Aspergillum incertus Chenu, 1843. *Illus. Conch.*, 1 *Aspergillum*: 4, pl. 4, figs. 5, 5a, 6, 6a.
Brechites australis. H. Adams and A. Adams, 1858. *Genera of Recent Mollusca*, 2: 339.
Brechites (Foegia) cumingianus. H. Adams and A. Adams, 1858. *Genera of Recent Mollusca*, 2: 339.
Brechites (Foegia) incertus. H. Adams and A. Adams, 1858. *Genera of Recent Mollusca*, 2: 339.
Warnea australis. Gray, 1858. *Proc. Zool. Soc. Lond.* 26: 310.
Aspergillum cumingianum. Reeve, 1860. *Cinch. Icon.*, 12, *Aspergillum*, pl. 2, fig. 7a - b.
Aspergillum incertum. Reeve, 1860. *Conch. Icon.*, 12 *Aspergillum*, pl. 4, fig. 19.
Penicillus (Foegia) cumingianus. Smith, 1962, *Veliger*, 4: 173.
Penicillus (Warnea) australis. Smith, 1962, *Veliger*, 4: 174.

DIAGNOSIS: Valves, small and exposed, depression surrounding valves ovoid, symmetrical; disc tubules many, small, anterior portion of tube slightly swollen, plaited ruffles small.

TYPE MATERIAL: Type specimens of *A. australis* and *A. cumingianum* could not be found in the British Museum and their locations are not known. Two syntypes of *A. incertum* are in the British Museum BM (NH) 1968669/70. The type localities for *A. australis* and *A. cumingianum* are given as Australian seas while that for *A. incertum* is given as Swan River, New Zealand. This is certainly a mistake for Western Australia.

DISTRIBUTION: Lower Pleistocene to Recent. FOSSIL: Roe Plains, 53 km E. of Madura, Western Australia. RECENT: North-west Western Australia from Yampi Sound to Exmouth Gulf and one specimen from the eastern end of the Great Australian Bight in South Australia.

MATERIAL EXAMINED: FOSSIL: WESTERN AUSTRALIA: Roe Plain, Hampton Microwave Tower, 53 km E. of Madura, 6 km S. of Eyre Highway, 127° 34′45″ E., 31° 57′57″ S., Grid Ref. Eucla 563045, T. A. Darragh, 21.iv.1969, 2 spec. (NMV). RECENT: WESTERN AUSTRALIA: Barrow Is., 20.ix.1966, WAM-USNM Barrow I. W.A. Exp. 1966, 20° 52′S 115° 19′E, sheltered intertidal sand and mud flats, 3 spec. (in spirit) (WAM); June 1964, W. H. Butler, 1 spec. (in spirit) (WAM); 18.ix.1958, R. W. George, 1 spec. (WAM). Roebourne, Sept. 1959, L. Marsh, 1 spec. (in spirit) (WAM). Bay of Rest, Exmouth Gulf, July 1966, B. R. Wilson, 1 spec. (in spirit) (WAM). Cockatoo Is. 1 spec. (in spirit) (NMV). Yampi Sound, 1958, G. A. Robinson, 2 spec. (WAM). Sandy Is., Mary Ann Passage, 17.ix.1958, R. W. George, 1 spec. (WAM). Port Simpson, 1956, J. Balluci

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PLATE 11

Fig. 11. *Humphreyia strangei* (A. Adams), BM(NH) 1968667, lectotype, Sydney Harbour, N.S.W. (a) back of shell showing the remains of the shell to which the specimen was attached.

Fig. 12. *Humphreyia strangei*, F22283, Phillip Is., Victoria showing irregular tube growth (NMV).

Fig. 13. *Humphreyia strangei*, F27421, Port Stephens, N.S.W. (NMV).

Fig. 14. *Brechites (Brechites) australis* (Chenu), BM(NH) 1968669, syntype of *Aspergillum incertum* Chenu, Swan River, Western Australia; (a) top view of disc.

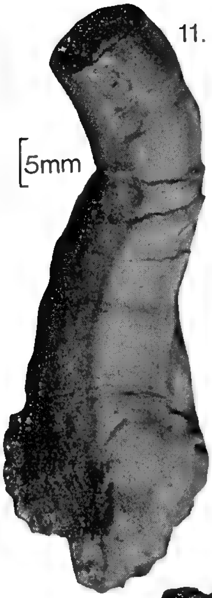
Fig. 15. *Brechites (Brechites) australis* BM(NH) 1968670, syntype of *Aspergillum incertum;* (a) top view of disc.

Fig. 16. *Brechites (Brechites) australis*, 5053-68, Broome, Western Australia, showing ruffles at the end of the tube (WAM).

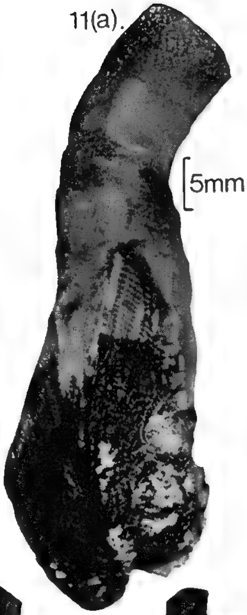
Fig. 17. *Brechites (Brechites) australis*, F27462, Point Sinclair, South Australia, (NMV).

PLATE 11

11.



11(a).



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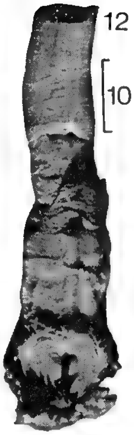

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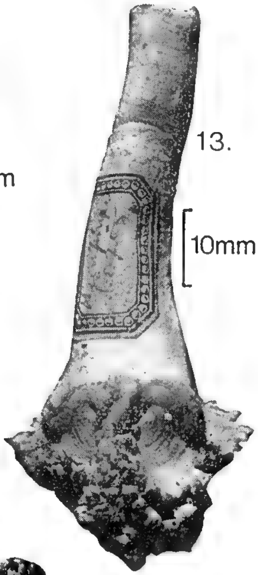
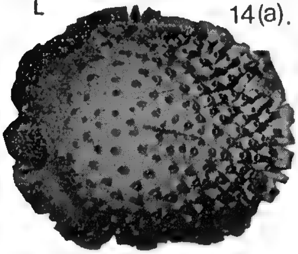


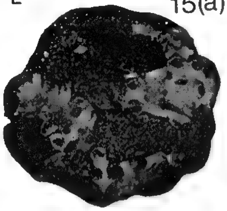
14.

14(a).



15.

15(a).



16.

17.

and B. R. Wilson, 1 spec. (WAM). Broome, B. Bardwell, 4 spec. (NMV). SOUTH AUSTRALIA: Point Sinclair, Neeves, 1 spec. (NMV).

ANATOMICAL NOTES: (Text figs. G - H). Preserved specimens from Broome were available in the NMV and WAM. The animal is large with a thin mantle surrounding the anterior part of the body. A thick, muscular, contractile posterior portion terminates with fused siphons. There is a small pore on the mid ventral line approximately level with the heart. This is the vestige of the opening to the pallial cavity. The anterior end consists of a flat pad of spongy tissue with small contracted processes projecting from its surface. This remains in close contact with the inside of the disc and the processes in life probably form filiments which protrude through the perforations in the disc. The function of these filaments is not known. There is a small nearly transparent area mid-dorsally in the hinge region through which the heart can be seen.

Internally the anatomy is essentially similar to *Clavagella (Dacosta) australis* except for the total absence of both adductor muscles. The visceral mass is large and the foot appears as a long, flattened, finger-like projection from its anterior end. The labial palps are long and consist of many filaments. The gills too are long and extend almost the full length of the body. The filaments are large and almost fill the branchial cavity dividing it into in-current and ex-current chambers.

REMARKS: This species is subject to a high degree of individual variation, a reflection of the substrate into which the animal was burrowing, either causing curvature of the tube or adhering to the disc causing gross distortion in this area. This is most probably the cause of the different forms which led Chenu (1843) into erecting the three species that are here synonymized. The name *australe* is used as it has page preference.

It is interesting to note that these occur intertidally in some localities where they were observed with the siphonal ends of the tubes protruding vertically out of the mud and sand and the anterior end permanently buried.

The one specimen found from the eastern end of the Great Australian Bight has a more delicate structure with finer anterior tubules but is undoubtedly referable to this species. This specimen was found alive embedded in a kelp root exposed by a very low tide. It was discovered because the collector saw it squirting water out of the siphon.

The two fossil specimens collected from the Lower Pleistocene deposits of the Roe Plain, Western Australia record this species as a fossil for the first time. The associated fauna appears to have Indo-Pacific affinities with some warm water representatives while others (like this species) still live in the Bight. (T. A. Darragh — pers. comm.).

Subgenus *Penicillus* Bruguiere, 1789

Penicillus Bruguiere, 1789, *Ency. Method. (Vers)*, 1: 126. Type species: *Serpula aquaria* Burrow, 1815 = *Serpula penis*, Linnaeus, 1758: (S.D. — Stoliczka, 1871).
Synonym: *Clepsydra* Schumacher, 1817.

Siphonal end of tube simple, disc fringed with single row of tubules, umbos exposed but valves not depressed and exposed.

Clavagellidae

Brechites (Penicillus) strangulatus (Chenu, 1843)

(Pl. 12, figs. 18, 19)

Aspergillum strangulatum Chenu, 1843. *Illus. Conch.*, 1, *Aspergillum*: 3, pl. 2, figs. 4 - 4a.
Brechites strangulatus. H. Adams and A. Adams, 1858, *Genera of Recent Mollusca*, 2: 339.
Clepsydra strangulata. Gray, 1858, *Proc. Zool. Soc. Lond.* 26: 313.
Aspergillum (Clepsydra) strangulatum. Tryon, 1884, *Struc. and Syst. Conch.*, 3: 118.
Penicillus (Penicillus) strangulatus. Smith 1962, *Veliger*, 4: 172.

DIAGNOSIS: Tube constructed into a " neck " region immediately behind disc, aperture in figure 8 form.

TYPE MATERIAL: Holotype in the British Museum, BM (NH) 1841 10.12. 38; from Port Essington, N.S.W. This is certain to be Port Essington, Coburg Peninsular, Northern Territory.

DISTRIBUTION: Recent only. Extends from Central Queensland round the north coast of Australia to Rottnest Island in southern Western Australia.

MATERIAL EXAMINED: QUEENSLAND: Albany Island, 7 - 25 m, C. Hedley, 1 spec., (AM). Bowen, T. Hartley, 17 spec., (NMV). Cape York Peninsular, T. A. Garrard, 4 spec., (AM). Crab Island, E. Jensen, 7 spec., (AM). C. D. George, 2 spec., (AM). Port Denison, Nov. 1874, W. H. Hargraves, 1 spec., (NMV). Torres Strait, Elliott, 12 spec., (SAM). NORTHERN TERRITORY: Cape Bedwell, 11.vi.1938, 14 - 16 m., 2 spec., (AM). WESTERN AUSTRALIA: West of Rottnest Island, 16.ix.1965, " Bluefin ", 146 m, 1 spec. (disc. only), 128 m (sand), 2 spec. (discs only), (WAM). 241 km ENE Troughton Island, 23.x.1962, 91 m (mud), 2 spec. (discs only), (WAM). 27°18′ S. 113°16′ E.N.W. of Bluff Pt., CSIRO St. 204, 9. x.1963, 98 m, 1 spec. (disc only), (WAM).

ANATOMY: Unknown.

REMARKS: This species appears to occur in relatively shallow waters off tropical north eastern Australia and in deep water off south and central Western Australia. This seems to agree with other findings of a tropical fauna occurring in deep water of southern Western Australia (B. R. Wilson — pers. comm.).

Three species described by Chenu (1843) could be considered synonyms of this species.

Aspergillum ornatum Chenu, 1843. *Illus. Conch.*, 1, *Aspergillum*: 4, pl. 4, figs. 3 - 3a.

Aspergillum clavatum Chenu, 1843. *Illus. Conch.*, 1, *Aspergillum*: 4, pl. 4, figs. 4 - 4a.

Aspergillum incrassatum Chenu, 1843. *Illus. Conch.* 1, *Aspergillum* p. 4. pl. 4, figs. 2 - 2a - b.

These have no localities given and the types cannot be located in the British Museum. They only seem to differ from *B. (P). strangulatum* in having variously shaped protuberences over the valves. This form of growth is most probably an abnormal growth character and a large series showing this character would be necessary before these species could be confirmed. However, because of their lack of locality, these names were not included in the synonymy of the species.

Subgenus *Foegia* Gray, 1847

Foegia Gray, 1847, *Proc. Zool. Soc. Lond.*, 15: 188. Type species: *Aspergillum novaezelandiae* Lamarck, 1818 = *Penicilius novaezelandiae* Bruguiere, 1789: (Monotypy).

Siphonal end simple, disc often indistinct, without fringe, umbos usually almost covered with swollen prominences.

Brechites (Foegia) novaezelandiae (Bruguiere, 1789)

(Pl. 12, figs. 20, 21, 22, 23)

L'Arrosoire de la Nouvelle Zelande Favanne, 1780. *Conchyliogie* 1: 642, pl. 79, fig. E. (non. binom.) Type figure.

Penicillus novaezelandiae Bruguiere, 1789. *Ency. Meth.*, 1: 129.

Aspergillum novaezelandiae Lamarck, 1818. *H. N. Anim. sans Vert.*, 5: 430.

Aspergillum agglutinans Lamarck, 1818. *H. N. Anim. sans Vert.*, 5: 430.

Aspergillum novaezelandiae Lamarck, Chenu, 1843. *Illus. Conch.*, 1, *Aspergillum*: 3, pl. 3, figs. 6a, b, 7, 9.

Aspergillum agglutinans Chenu, 1843. *Illus. Conch.*, 1, *Aspergillum*: 3, pl. 3, fig. 2a.

Aspergillum novaehollandiae Chenu, 1843. *Illus. Conch.*, 1, *Aspergillum*: 3, pl. 4, fig. 8.

Foegia novaezelandiae Gray, 1847. *Proc. Zool. Soc. Lond.*, 15: 188.

Foegia agglutinans Gray, 1858. *Proc. Zool. Soc. Lond.*, 26: 313.

Brechites agglutinans Adams, 1858. *Genera of Recent Molluscs*, 2: 339.

Brechites (Foegia) novaehollandiae Adams, 1858. *Genera of Recent Molluscs*, 2: 339.

Brechites (Foegia) novaezelandiae Adams, 1858. *Genera of Recent Molluscs*, 2: 339.

Aspergillum novaezelandiae Lamarck, Reeve, 1860. *Conch. Icon. (Aspergillum)* sp. 17.

Aspergillum agglutinans Reeve, 1860. *Conch. Icon. (Aspergillum)* sp. 18.

Penicillus (Foegia) agglutinans Smith, 1962. *Veliger*, 4(4): 173.

Penicillus (Foegia) novaezelandiae Smith, 1962. *Veliger*, 4(4): 173.

DIAGNOSIS: Disc small, of a tight cluster of tubules, fringe absent, anterior portion only slightly bulbous tapering to a narrow tube.

TYPE MATERIAL: The type was a figure in *Favanne* and no specimen of this can be found. No type specimen of *A. agglutinans* can be found in Paris or Geneva. Two syntypes of *A. novaehollandiae* are in the British Museum, BM(NH) Reg. No. 1968668. The type locality was described as New Zealand. However this is thought to be a mistake for the Swan River area of Western Australia (a not unusual error).

DISTRIBUTION: Recent only. The central and south-west coast of Western Australia and two specimens from the north coast of Queensland.

MATERIAL EXAMINED: WESTERN AUSTRALIA: South Passage, Shark Bay, 6.iii.1966, B. R. Wilson, 3 - 7 m in sand and weed, 1 spec. (WAM). Woods Point, Cockburn Sound, 26.xi.1967, G. W. Kendrick, 1 spec. (WAM); June 1958, B. R. Wilson, 1 spec. (WAM); 9.xi.1965, S. Slack-Smith, 4 spec. (WAM); 8.viii.1963, C.S.I.R.O. dredged 2 - 4 m 1 spec. (WAM); 24.vii.1965, G. W. Kendrick, 1 spec. (WAM). QUEENSLAND: Mapoon, C. Hedley 18 m, 1 spec. (AM). Sweers Is., 7.xii.1963, D. F. McMichael, 14 - 22 m, 1 spec. (AM).

ANATOMY: Unknown.

PLATE 12

Fig. 18. *Brechites (Penicillus) strangulatus* (Chenu), BM(NH) 1841. 10.12.28, holotype, Port Essington, Northern Territory; (a) top view of disc.

Fig. 19. *Brechites (Penicillus) strangulatus*, 208-71, 144 m off Rottnest Is., Western Australia, top view of disc. (WAM).

Fig. 20-21. *Brechites (Foegia) novaezelandiae* (Bruguiere), BM(NH) 1968668, two syntypes of *Aspergillum novaehollandiae* Chenu, Australia; (a) top views of discs.

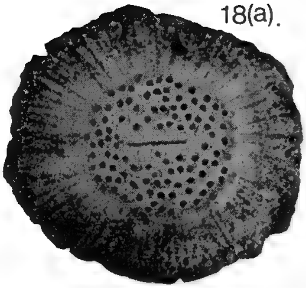
Fig. 22. *Brechites (Foegia) novaezelandiae*, 202-71, Cockburn Sound, Western Australia, (a) top view of disc. (WAM).

Fig. 23. *Brechites (Foegia) novaezelandiae*, C74002, Sweers Is., Gulf of Carpentaria, Queensland (AM).

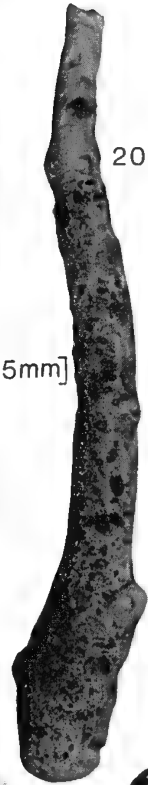
PLATE 12

18.

18(a).

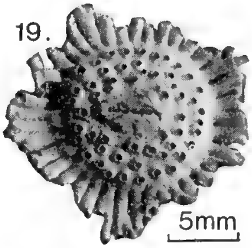


20.



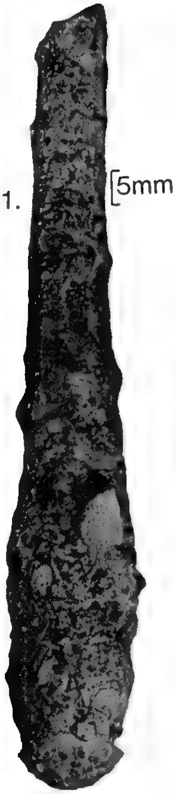
20(a).

19.



22(a).

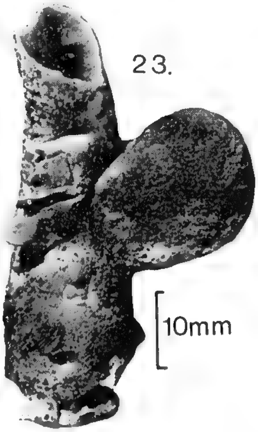
21.



21(a).

22.

23.



REMARKS: Both *A. agglutinans* and *A. novaehollandiae* are included here as synonyms because no specific differences could be found between them from the descriptions or published figures. It is however possible that if more specimens are discovered from Northern Australian waters, these may be found to differ from the southern forms, in which case either of these names could be available.

Brechites (Foegia) veitchi sp. nov.

(Pl. 13, figs. 24, 25, 26, 27)

Humphreyia incerta. Cotton, 1961. *South Australian Molluscs, Pelecypoda* p. 160, fig. 153. (not Chenu).

DIAGNOSIS: Shell large, anterior end greatly swollen, lacking a discrete disc; tubules covering bulbous portion except around valves; valves small, tending to become covered by swollen prominences, small anterior slit, small tube wide, circular in section, siphonal end simple.

DESCRIPTION: Shell large, consisting of a wide tube, circular in section, with a large, bulbous anterior end approximately twice the diameter of the tube and a third of its length. There is no discrete disc but the entire anterior end and the sides of the bulbous end away from the valves bear many short wide tubules each about 4 mm. long and 1 - 3 mm. in diameter. Both valves are small and fused with the tube just posterior to the centre of the bulbous anterior position. They are usually practically covered by overlapping anterior and posterior prominences. Shell fragments and stones are often attached to the anterior end and the shape of both the anterior bulbous portion and the tube is frequently distorted due to restriction of normal growth by large rocks and other obstructions in the environment.

The animals consist of a large, bulbous, thick walled anterior part and a long, thick walled contractile tube, terminating in the two siphonal apertures.

TEXT Fig. G - K.

G. Diagram of the dorsal view of the exterior of the animal of *Brechites (Brechites) australis.*

H. Diagrammatic representation of the gross anatomy of *Brechites (Brechites) australis* from the lateral view.

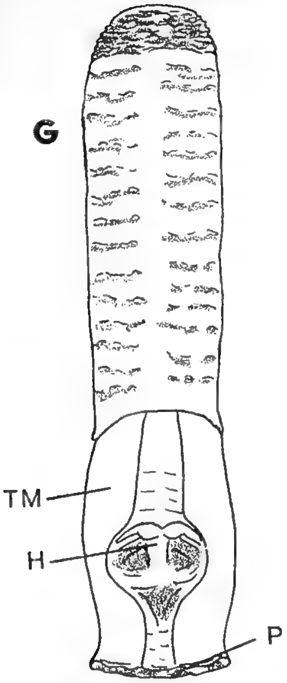
I. Diagram of the lateral view of the exterior of the animal of *Brechites (Foegia) veitchi* sp. nov.

J. Diagram of the interior of the pallial chamber of *Brechites (Foegia) veitchi* sp. nov. from the ventral side.

K. Diagrammatic representation of the gross anatomy of *Brechites (Foegia) veitchi* sp. nov. from the lateral view.

ABBREVIATIONS

a — auricle?
aa — anterior adductor muscle
ap — anal papilla
dg — digestive gland
ex — ex-current chamber
f — foot
g — gut
gl — gills
gn — gonad
h — heart
in — in-current chamber
k — kidney
lp — labial palps
m — mouth (position of)
p — pad of soft tissue
pa — posterior adductor muscle
r — rectum
s — siphons
sa — siphonal aperture
tm — true mantle area
v — ventricle?
vm — visceral mass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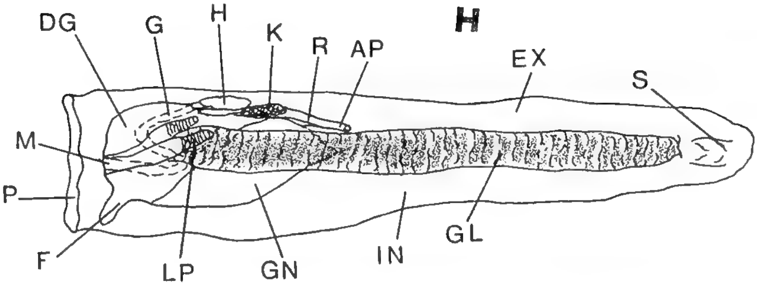
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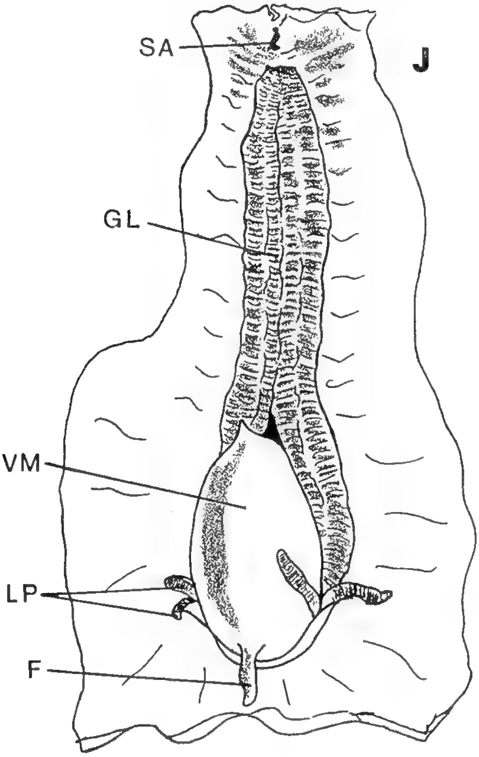
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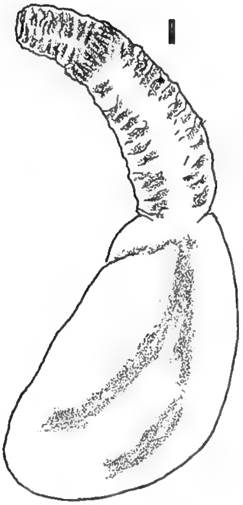
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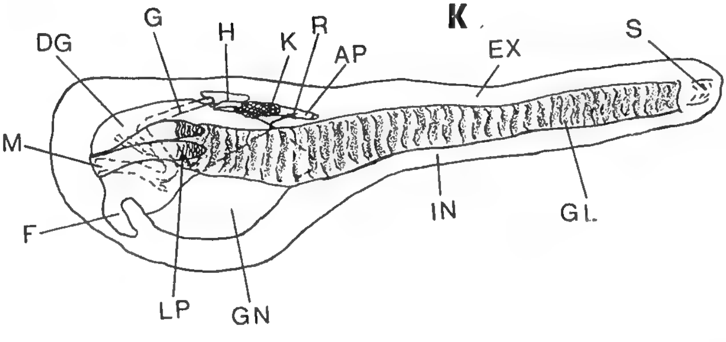
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TYPE MATERIAL: Holotype in National Museum of Victoria, F27419, complete specimen with the animal preserved in 70% alcohol. Dimensions: Length (broken) 108 mm; diameters of the anterior end 50.0 mm x 50.0 mm.

Four paratypes: Paratype No. 1 in South Australian Museum, D14890, shell broken by dredge but animal preserved in 70% alcohol(used for dissection). Measurement impossible — shell broken. Paratype No. 2 and No. 3 in National Museum of Victoria, F27419, taken as dead shells with tubes broken; dimensions: No. 2 — tube broken; anterior end diameters 49.3 mm x 49.0 mm; No. 3 broken.

Paratype No. 4 in South Australian Museum, D14992, taken as a dead shell and originally figured as *H. incerta* by Cotton (1961), dimensions: Length — 167.5 mm; diam. of anterior end 47.5 mm x 38.5 mm.

Paratype No. 5 in South Australian Museum, D14993, dead shell, complete; dimensions: Length 226 mm; anterior end diameters 47.5 mm and 50.0 mm.

TYPE LOCALITY: All the type series were dredged by Mr. J. Veitch in 10 - 13 m, 0.4 km east of Snapper Rock, off Cape Donnington, near Port Lincoln, South Australia. Paratype No. 4 was taken in October, 1960. Paratypes No. 1, 2, 3 and 5 taken between 1962 and 1966. Holotype collected in January, 1967.

DISTRIBUTION: Lower Pleistocene and recent. *Fossil*: Roe Plains, Eucla Basin on Road to Hampton 53 km E. of Madura, W.A. *Recent:* From Spencer Gulf and the eastern part of the Great Australian Bight — off Port Lincoln and St. Francis Island.

OTHER MATERIAL EXAMINED: FOSSIL: WESTERN AUSTRALIA: Roe Plain, 53 km E. of Madura, Hampton, G. Gardner and A. Jones, June, 1970, 1 spec. (WAM — 70.1509). RECENT: SOUTH AUSTRALIA: Port Lincoln, J. Veitch, 3 spec. (Veitch Colln. — Port Lincoln). Spencer Gulf, J. C. Verco, 2 spec. (tubes only), (SAM). St. Francis Island, D. Howlett, 1 spec. (NMV).

ANATOMICAL NOTES: (Text figs. I - K). A preserved specimen (Paratype SAM — D 14890) and one from J. Veitch of Port Lincoln, S.A. were used for dissection. The holotype is preserved complete.

The animal has a very thick, muscular body wall over its entire body. The anterior part of the body is a swollen bag-shaped structure which fills the swollen anterior portion of the shell. Posterior to this is the long, tubular contractile portion terminates in short fused siphons. Near the anterior end in the mid-ventral region is a small pore, the vestige of the opening of the pallial cavity.

Internally the anatomy is similar to that of *Clavagella (Dacosta) australis* described above, except for the absence of adductor muscles. The visceral mass is large, egg-shaped, nearly filling the anterior portion of

PLATE 13

Fig. 24. *Brechites (Foegia) veitchi* sp. nov., F27419, holotype, 11-13 m. off Cape Donnington, Port Lincoln, South Australia; (a) side view: (b) close-up of anterior end showing swollen prominences (arrowed) covering valves. (NMV).

Fig. 25. *Brechites (Foegia) veitchi* sp. nov., D14993, paratype; (a) close-up of anterior end showing valves (arrowed). (SAM).

Fig. 26. *Brechites (Foegia) veitchi* sp. nov., F27419, holotype showing specimen embedded in sponge.

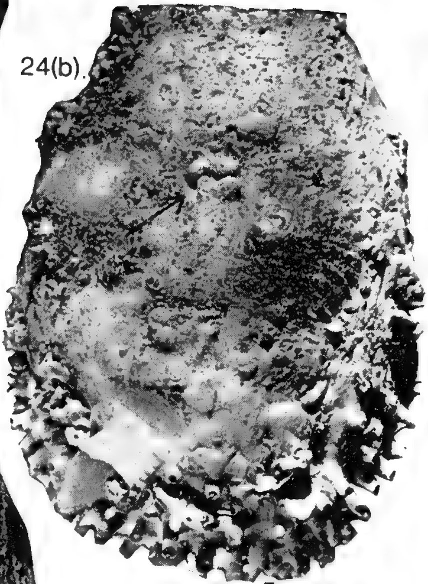
Fig. 27. *Brechites (Foegia) veitchi* sp. nov., 70.1509, fossil specimen from Lower Pleistocene deposits on Roe Plain, Western Australia. (WAM).

PLATE 13

24.

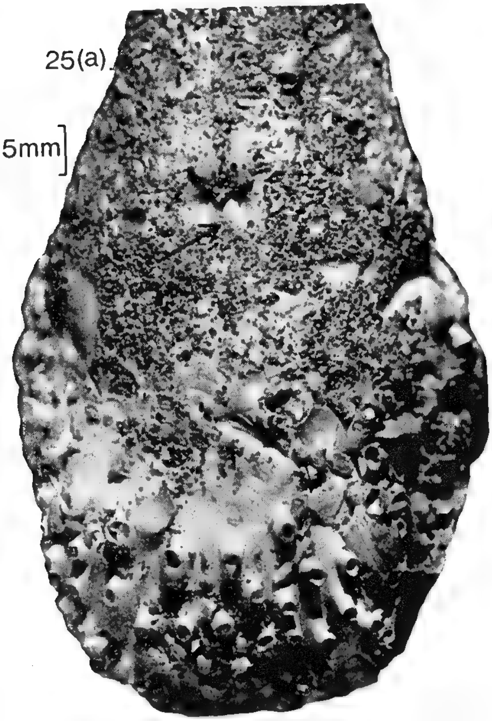
24(a).

24(b).

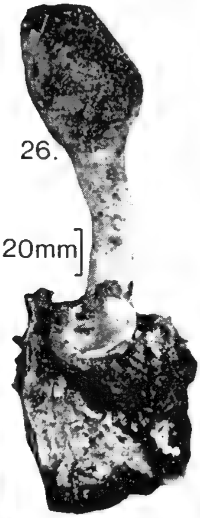


25.

25(a).



26.



27.

the pallial cavity, and the large, finger-like foot protrudes from its anterior end (Text fig. J). The most striking structures in the pallial cavity are the large gills which commence from each side of the visceral mass as V-shaped demibranchs and fuse posterior to the visceral mass into a large W-shaped structure which extends nearly the entire length of the posterior, contractile portion of the body. The labial palps running laterally and posterially from the mouth to the anterior ends of the gills are also large, well-formed structures composed of many V-shaped filaments. A detailed description of the anatomy will be published elsewhere.

REMARKS: Brechites (Foegia) veitchi is easily distinguished from all other species by its large size and large bulbous anterior portion. The degree to which the valves are covered by the overgrowing protuberances of the tube is variable; in the holotype they are completely covered (Fig. 24b) while in some paratypes they are almost entirely exposed (Fig. 25a). The species also seems to vary from many other species of the genus in its mode of life. Most of the large species appear to live buried in a soft substrate with only the open end of the tube protruding into the water. However the holotype was dredged attached to a large sponge *(Ircinia irregularis* (Polejaeff), identified P. Bergquist) by the tube end, which was in turn attached to a large limestone rock. However this may be atypical in habitat. All the specimens are clean and free of growths although there is a young oyster, *Ostrea angasi*, on the side of the holotype. It is hoped that more ecological data will be obtained from divers in the near future. There is said to be (J. Veitch — pers. comm.) a small colony of the molluscs at the type locality.

It is also of considerable interest to record a specimen of this species from the Lower Pleistocene deposits of the Roe Plain, Western Australia. The specimen is obviously referrable to this species although the anterior portion is not as swollen as any of the type series. The presence of this species in the Roe Plain fauna is another example of the similarity between this Lower Pleistocene fauna and the present fauna of the Great Australian Bight. (T. A. Darragh — pers. comm.).

The species is named for Mr. J. Veitch of Port Lincoln, who collected the type series, in honour of his very considerable contribution to the study of the mollusc fauna of Spencer Gulf and his assistance to the South Australian Museum and the National Museum of Victoria.

CONCLUSION

Although this study was confined to species found in Australian waters and fossil deposits, it was necessary to compare specimens with species found elsewhere. From this work it is evident that an intensive search through all the collections of the world followed by a critical world-wide revision of the family is necessary. There appear to be many names in the literature erected for abnormal growth forms and for first records for an area for no other reason than that the only similar species occurs many kilometres distant. The basic idea of recognising only three genera with many sub-generic groups put forward by Smith (1962a) was adhered to mainly because it was felt that too little material was available to undertake a redescription of the genera. However, there are many differences in specific and generic placement in this study and that of Smith, but because his revision gave no reasons for his actions a critical analysis is impossible.

Clavagellidae

The distributional data for all species in this family are insufficient and in many cases, there are gaps of hundreds of kilometres in the stated ranges. However, the distributions for living species, coupled with the many records of fossil specimens discovered in southern Australia, have caused considerable modification to the ideas of historical zoogeography for the family put forward by Smith (1962b). It is apparent that the family was present and widespread in Australia at a much earlier time than was previously thought, *Clavagella* s. str. being found fairly readily in Upper Oligocene deposits in Victoria and Tasmania and Pliocene deposits in South Australia, the latter deposits also containing *Humphreyia*. If Smith is correct in his assumption that the family originated in Europe in the Late Cretaceous, then the spread must have been very early and very rapid, probably in the Lower Oligocene. However, much more material is required to confirm this. The presence of this fauna in southern Australia also shows that this region should be included in any studies on the distribution of early Indo-Pacific faunas.

Little is known of the biology of these unusual bivalves, the only recorded observations on living animals being by Purchon (1956, 1960). From brief observations on the anatomy it is seen that both siphons open at the open end of the tube and that, therefore, in whatever position the shell lies, it must have the end of the tube protruding into the water. All the *Brechites* species most likely live buried vertically in a fairly soft substrate with only the end of the tube projecting into the water. However, some can live attached to rocks or other objects in the environment. For the animals that live buried, it would appear that Purchon's idea (1960) that the perforations in the disc are involved in the burying process by squirting water out through the holes, may be correct. However, this would not be the function of the perforations in the anterior end of *Clavagella* or *Humphreyia* species where many of specimens are found attached to dead shells or rocks by their anterior ends. The animals are believed to be filter-feeders using their very large, well-developed gills and labial palps to filter small suspended matter out of the water drawn into the in-current chamber, through the gills and out via the ex-current siphon. The ciliary current pathways on the gills, palps and the surfaces of the visceral mass and pallial cavity have been described by Purchon (1960) for *Brechites (Penicillus) penis* (L) and he also described the animals as ciliary feeders.

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ADDENDUM

The types of the following species were located in the collections of the British Museum (Natural History) by Dr. J. D. Taylor after this paper went to press.

Clavagella torresi Smith 1885. Holotype, Reg. No. 1887.2.9.2379.

Humphreyia coxi Brazier 1872. Holotype, Reg. No. 1904.5.10.74.

Aspergillum cumingianum Chenu 1842. Holotype, Reg. No. 19718.

Dr. Taylor notes that the Reeve (1860) figure of *A. cumingianum* resembles the type.

REVISION OF THE AUSTRALIAN TERTIARY VOLUTIDAE (MOLLUSCA: GASTEROPODA).

1. THE SUBFAMILY ATHLETINAE

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Plates 14-16

ABSTRACT

The genus *Athleta* Conrad 1853 is briefly discussed and the following are regarded as synonyms; *Volutocorbis* Dall 1890, *Volutopupa* Dall 1890, *Neoathleta* Bellardi 1890, *Volutospina* Newton 1906, *Notoplejona* Marwick 1926, *Eoathleta* Gardner 1945, *Volutovetus* Pilsbry and Olsson 1954 and *Bendeluta* Eames 1957. *Ternivoluta* Martens 1897 is regarded as a subgenus of *Athleta*, and *Austrovoluta* Cotton 1949 is shown to be a synonym of the former. *Ternivoluta* is restricted to Australia and ranges from Upper Eocene to Recent. A lineage in the subgenus from Upper Eocene to Upper Miocene is reported. *A. (Athleta) wangerrip* (Upper Paleocene), *A. (Ternivoluta) curvicostata* (Upper Eocene), *A. (T.) anticingulata craticula* (Lower Miocene), *A. (T.) subcrenulifera* (Lower Miocene) and *A. (T.) bungae* are newly described from Victoria, Australia and five other species and subspecies are redescribed.

INTRODUCTION

The sub-family Athletinae is represented in Australia by *Athleta* s.s. and the subgenus *Ternivoluta*. *Athleta* ss. is widespread throughout Europe, Asia and America particularly in the Paleogene, but in Australia it is represented by a single species in the Upper Paleocene of Victoria. It is probable that this species gave rise to the earliest known species of *Ternivoluta* present in the Upper Eocene.

The subgenus *Ternivoluta,* one of two living representatives of the ancient volutid sub-family Athletinae, occurs commonly in the Tertiary of South-eastern Australia and has not been recorded elsewhere. The initial appearance is in the Upper Eocene and from the Upper Eocene to Upper Miocene there is a single complete lineage with two minor offshoots. Finally there is a single living representative in the deeper waters of the continental shelf off Southern Queensland and Northern New South Wales.

Ternivoluta, established originally by Martens in 1897 as a subgenus of *Voluta,* has as its type species *Voluta (Ternivoluta) studeri* Martens 1897 based on a unique specimen collected by the " Gazelle " from Eastern Australia in 1875. The radula of this specimen had previously been described by Schacko in 1881 as that of *Voluta concinna* Broderip and due to its resemblance to that of *Volutocorbis abyssicola* (Adams and Reeve) Theile, in 1929, placed *Ternivoluta* as a sub-genus of *Volutocorbis* Dall 1890. There the matter rested until 1959 when McMichael reported the rediscovery of the type species in the neighbourhood of Tin Can Bay, Queensland, redescribed the shell and outlined the previous history of the genus and species. A year later McMichael (1960) briefly described the animal, refigured the radula and reported the occurrence of numerous specimens from off Cape Byron, N.S.W. Further specimens of *Ternivoluta studeri* have become available in recent years due to the activities of Queensland prawn trawlers.

An examination of actual specimens of this species has shown that a close relationship exists between it and fossils from the Tertiary of Southeastern Australia hitherto placed in the genus *Austrovoluta* Cotton 1949. This genus was erected for a group of species superficially resembling members of *Volutospina* (= *Athleta*) in overall shell morphology but having, inter alia, a paucispiral deviated protoconch unlike the multispiral turbinate protoconch of species of *Athleta*. The difference in protoconch was pointed out when McCoy first described the Australian fossil species in 1866 and for this reason he preferred to place his species in *Voluta* rather than *Volutilithes* (= *Athleta*). However Harris in 1897 placed the Australian fossils in *Volutilithes* and queried, on the evidence of the protoconchs, whether they should be placed in a new subgenus. Finally in 1949 Cotton erected *Austrovoluta* for these species but this present study shows that the living and fossil species, having similar protoconchs, are consubgeneric, therefore *Austrovoluta* falls into the synonymy of *Ternivoluta*.

RELATIONSHIPS WITHIN THE SUBFAMILY

The relationship of *Ternivoluta* to other members of the subfamily needs clarification but this cannot be done until the status of the other taxa has been re-assessed. At least nine names have been proposed for taxa in the *Athleta* complex but currently only *Athleta, Volutocorbis, Neoathleta* and *Volutospina* have received widespread acceptance following the classification proposed by Cossmann (1899, p. 99) which was slightly modified by Wenz (1943, p. 1317). It has not been possible to revise this group at this stage because of the large number of species involved and because of their wide and complex geographical and stratigraphical distribution. However some comments are worth presenting as a preliminary to such a revision.

Firstly it should be pointed out that most authors have overlooked or ignored Cossmann's re-assessment of his 1899 classification of these volutes (Cossmann 1906, p. 222, 1909, p. 209). He proposed that *Volutocorbis, Volutospina* (= *Volutilithes* auct.) and *Neoathleta* should be placed in the synonomy of *Athleta*. Essentially his reasons for this were that the grounds of separation were slight, mostly differences in sculpture, and that some species could equally well be placed in any one or other of the taxa. He further stated that some species in the Anglo-Paris Basin showed a gradation from one sculptural type to another and that Burnett Smith (1906) had shown that there was a gradual transition with time through various stages similar to the European forms in the Eocene species of the United States.

Recently Fischer, Rodda and Dietrich (1964) re-examined the American species and generally supported Smith's conclusions that the Eocene species of the south-eastern United States were derived from a Paleocene cancellate ancestor *(Volutocorbis limopsis)* and showed that a great variety of shape and sculptural diversity was possible within a single lineage or closely related lineages. They advocated the use of *Athleta* for the Eocene species and used *Volutocorbis* for the Paleocene cancellate species.

Examination of European Eocene volutes shows that they too probably have a cancellate ancestor but, unlike the American situation, both cancellate and non-cancellate species are present in the same beds in the Paleocene at Mons and in the stages of the Eocene of the Anglo-Paris Basin. There is every sculptural gradation between the two as already pointed out by Cossmann.

The author, therefore, takes the view of Cossmann that *Athleta* only should be used for the entire suite of volutes, at least until further phylogenetic studies are undertaken, particularly on the European and Pakistani volutes which have an important bearing on the problem. As Fischer, Rodda and Dietrich have stated (1964, p. 6) the multispiral protoconch of *Athleta* probably indicates a long pelagic larval stage, so that there is a possibility of wide and rapid dispersal which could explain the wide geographical distribution of this group of volutes in the Tertiary.

The various taxa which have been proposed in this complex of volutes are listed below and more detailed reasons given for the author's rejection of these names.

Athleta Conrad 1853. Type species (SD Dall, 1890) *Voluta rarispina* Lamarck 1811, Miocene, France.

This is the oldest valid name for this group of volutes. Unfortunately the type species is not typical of the group as a whole because of the prominent development of parietal callus, the thickening of the outer lip to produce a cassid-like aperture and the modification of the sculpture of the final whorl. These features have arisen independently in other species several times throughout the geological history of the group and in different lineages, so that there seems little justification for regarding such features as of generic or sub-generic importance. Some of the species which demonstrate the features alluded to are *A. labrella* (Lamarck), Upper Eocene, France; *A. cingulata* (Nyst), Lower Oligocene, Germany; *A. rathieri* (Hebért), Oligocene, Belgium and Germany; *A. affinis* (Brocchi) Miocene, Italy; *A. tuomeyi* Conrad, Lower Eocene, U.S.A. and *A. necopinata* Suter, Middle Eocene, New Zealand.

Volutocorbis Dall 1890. Type species (OD Dall, 1890) *Volutilithes limopsis* Conrad 1860, Paleocene, U.S.A.

The distinguishing features of this genus were the cancellate sculpture, the weaker anterior notch and the lack of spines on the shoulder. Currently the following European Eocene species are placed in the genus; *V. digitilina* (Lamarck), *V. lima* (Sowerby) and *V. crenulifera* (Bayan). However there is a gradation in morphology between the first two and *V. crenulifera*, and from the latter to the Eocene *Voluta bicorona* Lamarck and *V. elevata* Sowerby, both of which have been regarded as species of *Volutospina*. Both *bicorona* and *elevata* could equally well be regarded as species of *Volutocorbis* because of their cancellate sculpture and lack of a prominent shoulder. This gradation towards a *Volutospina*-like form suggests that *Volutocorbis* should be dropped in favour of *Athleta* as *Volutospina* is regarded as a synonym of this latter genus.

Rehder (1969) has illustrated the six known living species assigned to *Volutocorbis*, and they are somewhat variable in morphology; some species match *V. digitilina* (Lamarck) and *V. limopsis* (Conrad) but two living species, *V. boswellae* Rehder and *V. disparilis* Rehder are not unlike the ribbed form of the Miocene *Athleta suturalis* (Nyst) (= *cingulata* Nyst) with little or no cancellate sculpture and a small shoulder. He states (1969, p. 201) that there are no known species of *Volutocorbis* connecting the Eocene and Recent species. In view of the similarity of some of the living species to *Athleta suturalis*, and if as the author believes, the " *Volutocorbis* " appearance can arise independently, the living species could have developed from Oligocene or Miocene species and the gap in the fossil record is greatly reduced.

With regard to the Australian *Ternivoluta* lineage it should be stressed that there are all forms of sculpture from highly cancellate to smooth, and all types of shoulder form from small with no spines to large with prominent spines, yet all are in the one lineage.

In summary then it seems that whilst cancellate species with sutural grooves rather than prominent shoulders are typical of the early Tertiary and Upper Cretaceous there seems little point in differentiating these, at least until proper phylogenetic studies are made and the significance or otherwise of such features determined.

Neoathleta Bellardi 1890. Type species (OD) *Voluta affinis* Brocchi 1814, Lower Miocene Italy. Judging from illustrations this species appears to be closely related to *Athleta rathieri* (Hébert) which has been discussed under *Athleta*.

Volutopupa Dall 1890. Type species (Monotypy) *Voluta cithara* Lamarck 1803, Middle Eocene, France.

The distinguishing feature of this taxon was the high smooth multi whorled protoconch, which is not regarded as having any generic significance but merely indicates that the pelagic larval stage was probably longer than in other species of *Athleta*. Fischer, Rodda and Dietrich (1964, p. 5) have shown that the protoconch of this group of volutes can vary within a particular lineage.

Ternivoluta Martens 1897. Type species (SD Sykes, Smith and Crick 1898) *Voluta (Ternivoluta) studeri* Martens, Recent Australia.

The only significant differences which this taxon exhibits when compared with *Athleta* are the paucispiral deviated protoconch and the lack of internal ridges or denticles on the inner side of the outer lip. It is felt that as these differences are constant throughout its history, *Ternivoluta* can be regarded as a subgenus of *Athleta* which is confined to the Australian region during the Tertiary. The form of protoconch suggests that there was no planktonic larval stage but rather direct development, which would inhibit the distribution of the subgenus.

Volutospina Newton 1906. Type species (OD) *Conus spinosus* Linnaeus 1756, Middle Eocene, France.

The type species is typical of the group as a whole but as indicated above, *Athleta* founded on a rather bizarre member of the group has priority.

Notoplejona Marwick 1926. Type species (OD) *Athleta necopinata* Suter 1917, Middle Eocene, New Zealand.

This genus was distinguished by the crenulated and thickened outer lip, by the prominent anterior siphonal notch and fasciole, by the presence of one major and several minor plaits which were situated on a callus pad in mature specimens and by the nature of the parietal callus. Most of these features are present in *Athleta rarispina* or on other species of *Athleta* and there seems to be no grounds for maintaining the New Zealand species in a separate genus or even subgenus. Certainly it is no more bizarre than the type species of *Athleta*, or *A. tuomeyi* Conrad and *A. labrella* (Lamarck).

Eoathleta Gardner 1945. The species (OD) *Athleta tuomeyi* Conrad 1853, Lower Eocene, U.S.A.

The reasons for regarding this taxon as a synonym of *Athleta* have been discussed above.

Volutovetus Pilsbury and Olsson 1954. Type species (OD) *Voluta petrosa* Conrad 1833, Middle Eocene, U.S.A.

The features distinguishing this taxon from its European relatives were the stronger columella plaits but as the strength of the columella plaits varies from individual to individual within a species there are no grounds for using this feature as a generic distinction. In all features the type species bears a considerable resemblance to the European Eocene species of *Athleta*.

Bendeluta Eames 1957. Type species (OD) *Volutospina conicoturrita* Newton 1922, Upper Eocene, Nigeria.

This taxon was differentiated from *Volutospina* by sculptural and apertural differences which seem minor in view of the great variation found, for example, in the Paris Basin species of *Athleta (= Volutospina)*. Moreover the type species bears a considerable resemblance to the New Zealand *Athleta necopinata* Suter so that *Bendeluta* would be a synonym of *Notoplejona*, should the latter ultimately be accepted.

The other members of the subfamily are *Volutocristata* Gardner and Bowles 1934, *Retipirula* Dall 1907, and possibly one or two other Tertiarv genera, as well as certain Cretaceous genera such as *Volutomorpha* Gabb 1877 which has been placed in the subfamily Volutoderminae Pilsbry and Olsson 1954. In view of the similarity of the genera of this subfamily to those of the Athletinae there seems little need for a subfamily Volutoderminae.

STRATIGRAPHICAL DISTRIBUTION

The Upper Paleocene *Athleta (Athleta) wangerrip* sp. nov. is the only known species of the genus in Australia. Its origin is unknown at present but presumably it is derived from a late Cretaceous *Athleta*, such as *A. debeyi* (Binckhorst) from the type Maastrichtian. It seems reasonable to assume that this Paleocene species is the ancestor of the Uppermost Eocene *A. (Ternivoluta) curvicostata* sp. nov. though no intermediate records of the genus are known in the molluscan faunas of the earlier Upper Eocene sediments. *A. (T.) curvicostata* is the species which gives rise to a lineage which is well documented through to the late Miocene.

Members of the lineage are of considerable stratigraphic usefulness particularly in the Otway Basin because of rapid changes in morphology of members of the lineage with time. Broadly speaking the lineage can be divided into two parts; the first, typified by *A. (T.) anticingulata* (Mc-

Coy), having merely a presutural groove and a row of sutural nodules, and without spines or shoulders; and the second, typified by *A. (T.) antiscalaris* (McCoy), with prominent spinose shoulders. The change occurs rather abruptly in the upper part of the Longfordian, late Lower Miocene. Details of morphological changes within these two broad groups and stratigraphical ranges of taxa have been given in the systematic descriptions and need not be repeated here. Figure 1 shows the stratigraphical ranges of the several species and subspecies and illustrates the morphological changes through time.

NOTES ON SYSTEMATIC DESCRIPTIONS

All dimensions are in millimetres and a standard set of measurements have been taken as follows: L, total length of specimen; HA, height of aperture measured parallel to the axis of the shell; W, width of final whorl measured between the ribs.

All localities are in Victoria, Australia, unless stated otherwise and have standard grid references taken from the Australian one mile map series.

The species are described in ascending stratigraphical order.

SYSTEMATICS

SUBFAMILY ATHLETINAE PILSBRY AND OLSSON 1954

Genus *Athleta* Conrad 1853

Subgenus *Athleta* s.s.

Athleta Conrad 1853, *Proc. Acad. Nat. Sci. Philad.*, 6 (12): 448-9.

TYPE SPECIES: (Subsequent designation, Dall 1890, p. 75): *Voluta rarispina* Lamarck 1811.

STRATIGRAPHIC RANGE: Upper Cretaceous — Recent.

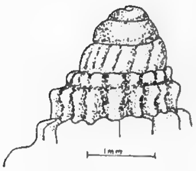
DISTRIBUTION: Europe, Asia, Africa (Upper Cretaceous); Cosmopolitan (Paleogene); Europe, Asia (Neogene); South and East Africa (Recent).

COMMENTS: Because of the complexity of the taxonomy no formal synonomy is presented. Several synonyms of the genus have been listed in the earlier discussion and need not be repeated. A partial synonomy and a description of this taxon can be found in Fischer, Rodda and Dietrich (1964, p. 38).

Athleta (Athleta) wangerrip sp. nov.

Pl. 16, fig. 27-28, 31-32; Fig. A.

DESCRIPTION: Shell broadly fusiform with a subconical spire and tumid body whorl tapering rapidly to the anterior canal. Protoconch small, turbinate, of about three smooth whorls which merge with the juvenile whorls of the spire, first juvenile spire whorl with oblique narrow axial costae which at the ninth costa or so show signs of a groove which cuts the costae close to the anterior suture, forming a series of spinose nodules against the suture and an anterior set of axial costae which are spinose on the shoulder. The groove broadens on the adult whorls to form the ramp of the posterior portion of the shoulder.



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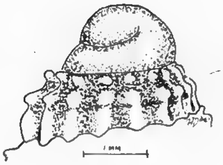

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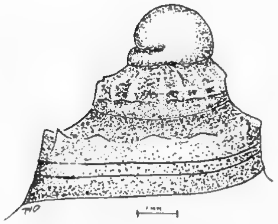

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Figure A. *Athleta (A.) wangerrip* sp. nov., P28032. Protoconch of holotype. Compares with that of *A. (A.) rarispina* (Lamarck) figured by Fischer et al. (1964 p. 40).

Figure B. *Athleta (Ternivoluta) antiscalaris antiscalaris* (McCoy), P22486, protoconch of paralectotype. Typical of all the fossil species.

Figure C. *Athleta (Ternivoluta) studeri* (Martens), F27420 protoconch of hypotype, 100 fathoms off Cape Morton, Qld.

Body whorl with about twelve axial costae which extend over about half of the anterior whorl slope and on mature specimens tend to lose their spinose character at the shoulder. Spiral sculpture absent from the spire whorls but fine lirae are present on the anterior slope of the body whorl and are either weakly developed or absent near the shoulder of the whorl. Columella with two major plaits and a thin posterior minor plait.

DIMENSIONS:

Holotype	P28032	L25	HA17	W12
Paratype	P22474	26	18	12
Paratype	P22475		18	11 spire incomplete

LOCATION OF TYPES: National Museum of Victoria. Holotype P28032, collected T. A. Darragh 19 Nov. 1970; Paratype P22474, J. Dennant Collection; Paratype P22475, G. S. V. Collection, collected C. S. Wilkinson 1865.

TYPE LOCALITY: Geological Survey of Victoria locality Aw7, Rivernook, black silt beneath an outcrop of indurated siltstone one mile SE. of Point Ronald, Princetown. Grid Ref. Princetown 063250. "*Trochocyathus band*", Dilwyn Formation, Wangerripian, Upper Paleocene.

STRATIGRAPHIC RANGE: Wangerripian, Upper Paleocene.

OCCURRENCE: Type locality only.

MATERIAL: Holotype, four reasonably complete individuals and many fragments.

COMMENTS: This species is the only representative of the subgenus as yet recorded from Australia. It is not uncommon at the type locality but is usually in the form of large fragments of body whorl rather than complete specimens. In overall morphology it can be compared with *A. (A.) bicorona* (Lamarck) and *A. (A.) elevata* (Sowerby) but it lacks the cancellation on the early spire whorls present in these two species. It bears no obvious relationship with any American *Athleta*.

Subgenus *Ternivoluta* Martens 1897

Voluta (Ternivoluta) Martens 1897, *Arch. Naturgesch.*, 63 (1) (2): 177.

Volutocorbis (Ternivoluta) Thiele 1929, *Handbuch der Systematischen Weichtierkunde*, 1 (1): 345.
Smith 1942, *A review of the Volutidae*, p. 15.
Wenz 1943, *Handbuch der Paläozoologie*, 6 (1) (6): 1319.

Ternivoluta Weaver & du Pont, 1970, *Living Volutes*. p. 13.

Austrovoluta Cotton 1949, *Rec. S. Aust. Mus.*, 9 (2): 185. (Type species (original designation): *Voluta antiscalaris* McCoy 1866).

TYPE SPECIES: (Subsequent Designation, Sykes, Smith and Crick 1898, p. 61): *Voluta (Ternivoluta) studeri* Martens 1897.

DESCRIPTION: Shell fusiform to subfusiform and usually with a gradate spire about one third the length of the shell. Protoconch of one and half smooth whorls, the first globose, deviated at right angles to the axis of the spire, the second half whorl merging rapidly into the juvenile spire whorls. Juvenile spire whorls grooved adjacent to the suture and on the adult whorls the groove frequently develops into an angular shoulder with a cingulum or row of nodules on it adjacent to the suture.

Axial costae usually prominent, with nodules and spines on the shoulder. Spiral lirae present on the anterior portion of the body whorl and frequently entirely covering it and the anterior whorl slope of the spire whorls.

Aperture elongately elliptical with a very shallow anterior siphonal notch and with a few faint denticulations coincident with lirae on the edge of the outer lip. Interior of outer lip smooth. Columella with three or four major and three or four minor plaits which on mature specimens are set on a prominent shelly plate. Siphonal fasciole absent. Parietal callus thin, confined to the ventral portion of the body whorl.

STRATIGRAPHIC RANGE: Upper Eocene — Recent.

DISTRIBUTION: South-eastern Australia (Upper Eocene — Upper Miocene), Eastern Australia (Recent).

COMMENTS: The deviated protoconch and the smooth inner surface of the outer lip of the aperture distinguish this genus from others in the subfamily. McMichael (1959) accepted Smith (1942) as the earliest designation of the type species of the genus overlooking the prior designation of Sykes et al. in the *Zoological Record* for 1897.

Vredenburg (1925, p. 132) has compared certain Pakistani Oligocene and Miocene species of *Athleta* with *A. (Ternivoluta) antiscalaris* (McCoy). The principal similarity appears to be the form of the protoconch but the outer lip of the aperture of the Pakistani species has a denticulate or even ribbed inner surface. Judging from illustrations of these species

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PLATE 14.

Fig. 1, 3. *Athleta (Ternivoluta) curvicostata* sp. nov., P22477, paratype, Point Flinders, Vict.

Fig. 2, 4. *A. (T.) anticingulata craticula* subsp. nov., P22479, holotype, Jan Juc Beach, Torquay, Vict.

Fig. 5, 6. *A. (T.) curvicostata* sp. nov., P22476, holotype, Point Flinders, Vict.

Fig. 7. *A. (T.) anticingulata craticula* subsp. nov., P22480, paratype, Jan Juc Beach, Torquay, Vict.

Fig. 8. *A. (T.) anticingulata anticingulata* (McCoy), P12156, paralectotype, Ad 22, Bird Rock Cliff, Torquay, Vict.

Fig. 9. *Ibid.*, P12161, syntype of variety *indivisa*, Ad 22, Bird Rock Cliff, Torquay, Vict.

Fig. 10. *Ibid.*, P12160, syntype of variety *indivisa*, Ad 22, Bird Rock Cliff, Torquay Vict.

Fig. 11, 14. *Ibid.*, P12159, syntype of variety *persulcata*, Ad 21, Bird Rock Cliff, Torquay, Vict.

Fig. 12, 13. *Ibid.*, P12157, lectotype, Ad 22, Bird Rock Cliff, Torquay, Vict.

PLATE 14


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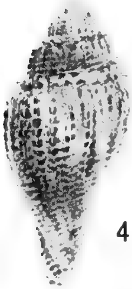
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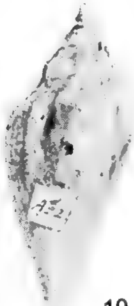
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they are derived from Pakistani Eocene *Athleta* and probably have no direct relationship with the Australian species, the deviated protoconch probably having developed independently.

Athleta (Ternivoluta) curvicostata sp. nov.

Pl. 14, fig. 1, 3, 5-6.

DESCRIPTION: Shell narrowly fusiform with a gradate spire and rounded body whorl gently tapering to the anterior canal. Protoconch large (1.7 mm), of about one and one half whorls merging with the juvenile spire whorls, the first whorl globose, deviated, the second smooth for a quarter of a whorl then for the next quarter bearing axial costae which at the fifth or sixth are cut by the sutural groove. Sutural nodules subspinose set on a prominent sutural cingulum. Axial costae thin, numerous (18-27 on the body whorl), sigmoidal, rounded on the shoulder, and extending anteriorly over about two thirds of the anterior whorl slope of the body whorl. Spiral lirae generally confined to the remaining anterior third of the body whorl. Columella with two or three major plaits and one or two minor.

DIMENSIONS:

Holotype	P22476	L39	HA26	W17
Paratype	P22477	46	30	20
Paratype	P22478	34	24	14

LOCATION OF TYPES: National Museum of Victoria. Holotype P22476, collected T. A. Darragh and H. E. Wilkinson, 5 Dec. 1968. Paratype P22477, collected C. S. Wilkinson 1865. Paratype P22478, F. A. Cudmore Collection.

TYPE LOCALITY: Geological Survey locality Aw1, NW. outcrop, 0.6 miles N. of Point Flinders, Grid Ref. Aire 367098. Glen Aire Clay, Upper? Aldingan, Uppermost Eocene.

STRATIGRAPHIC RANGE: Upper Aldingan, Uppermost Eocene.

OCCURRENCE: GLEN AIRE CLAY: Type locality; G. S. V. loc. Aw4, Aire coast, 1.1 miles NW of the mouth of the Aire River. Grid Ref. Aire 323 147.

MATERIAL: Types and numerous topotypes.

COMMENTS: In gross morphology this species bears a striking resemblance to *Volutocorbis boswellae* Rehder. It appears to be related to the Paleocene *Athleta (A.) wangerrip* sp. nov. but the costae are not spinose on the shoulder and are more slender and elongate, also there is no suggestion of a shoulder but merely a deep groove and the protoconch is larger deviated and globose. It is the direct ancestor of *A. (T.) anticingulata anticingulata* (McCoy) which has fewer and shorter costae and a more inflated body whorl.

On a few well preserved specimens there is a suggestion of dark narrow spiral bands which are probably traces of original colour banding.

Athleta (Ternivoluta) anticingulata anticingulata (McCoy, 1866)

Pl. 14, fig 8-14.

Voluta anticingulata. McCoy 1866, *Ann. Mag. Nat. Hist.* Ser. 3, 18 (107) : 379.
Voluta anticingulata var. b *indivisa* McCoy 1866, Op. cit. p. 380.
Voluta anticingulata var. a *perstriata* McCoy 1866, Op. cit. p. 380 (lapsus for *persulcata*).
Voluta anticingulata. McCoy 1874, *Prod. Pal. Vict.* 1: 24, pl. 6, fig. 2-4.
Voluta anticingulata var. b *indivisa*. McCoy 1874, *Op. cit.* p. 25.
Voluta anticingulata var. a *persulcata*. McCoy 1874, *Op. cit.* p. 25.
Voluta antiscalaris. Johnston 1888, *Geology of Tasmania*. pl. 30, fig. 5, 5a-b. non McCoy 1866.
Voluta anticingulata. Tate 1889, *Trans. R. Soc. S. Aust.* 11: 133.
Voluta anticingulata. Pritchard 1896, *Proc. R. Soc. Vict.* 8: 92.
Voluta anticingulata var. *indivisa*. Pritchard 1896, *Op. cit.* p. 93.
Voluta anticingulata var. *persulcata*. Pritchard 1896, *Op. cit.* p. 93.
Volutilithes anticingulatus. Harris 1897, *Catalogue of Tertiary Mollusca*. p. 98.
Voluta anticingulata. Pritchard 1913, *Proc. R. Soc. Vict.* 26 (1) : 192.
Voluta anticingulata var. *indivisa*. Pritchard 1913, *Op. cit.* p. 193.
Voluta anticingulata var. *persulcata*. Pritchard 1913, *Op. cit.* p. 193.
Austrovoluta anticingulata. Cotton 1949, *Rec. S. Aust. Mus.* 9 (2) : 185, pl. 15.

DESCRIPTION: Shell broadly fusiform with tumid body whorl tapering abruptly to the anterior canal. Protoconch as in *A. (T.) antiscalaris*. Sutural nodules subspinose when present and the sutural groove is narrow, when absent the sutural groove is broad so that the whorls are shouldered. Axial costae sigmoidal (15 - 19 on the body whorl) extending anteriorly over one third to one half of the body whorl. Spiral lirae generally restricted to the anterior third of the body whorl but occasionally extending over the whole whorl and very rarely present on the spire whorls. Columella with three or four major and occasionally one or two minor plaits.

DIMENSIONS:

Lectotype	P12157	L41	HA28	W18	McCoy 1874, pl. 6, fig. 2a.
Paralectotype	P12156	45	32	20	Op. cit. fig. 2, specimen distorted.
Paralectotype	P12158	22	15	10	Op. cit. fig. 3.
	P12160	43	30	18	G. S. V. loc. Ad 22.
	P12161	49	33	21	G. S. V. loc. Ad 22, specimen distorted.
	P12162	49	32	20	G. S. V. loc. Ad 22, specimen broken.
	P12159	42	28	20	Ad 21.

LOCATION OF TYPES: National Museum of Victoria. Lectotype P12157, Paralectotypes P12156, P12158. Holotype of variety *persulcata* P12159, syntypes of variety *indivisa* P12160-2. Collected Richard Daintree 1861.

TYPE LOCALITY: Geological Survey of Victoria locality Ad 22, Bird Rock Cliffs. This locality is a set of strata from about 17′ - 37′ below the cap of Bird Rock. Grid Ref. Anglesea 355676. Jan Juc Formation, Janjukian, Upper Oligocene.

STRATIGRAPHIC RANGE: Janjukian, Upper Oligocene.

OCCURRENCE: JAN JUC FORMATION (Janjukian): Type locality and all Jan Juc strata in Bird Rock Cliffs, Torquay; Bed B100, clay immediately beneath the Point Addis Limestone, SW side of Bells Headland, Grid Ref. Anglesea 356676; left bank, Barwon River 3½ miles S. of Birregurra, Grid Ref. Colac 864646. FREESTONE COVE SANDSTONE (Janjukian): Lowermost part of cliff section between Fossil Bluff and Table Cape, N. of Wynyard, Tas. FOSSIL BLUFF SANDSTONE (Janjukian): Upper part of cliff section between Fossil Bluff and Table Cape.

MATERIAL: Types and numerous topotypes.

COMMENTS: This is the most variable of the species in the genus. The variation is probably at least partly connected with ecological conditions at the time of deposition. At Torquay the population is dimorphic with very few specimens connecting the *indivisa* form with the typical *anticingulata,* whereas at Table Cape there is every gradation between the two and the *persulcata* form which is quite rare at Torquay is more common, particularly in the upper bed. On the other hand the *indivisa* form is found only in the coarser lower bed, the Freestone Cove Sandstone.

Athleta (Ternivoluta) anticingulata craticula subsp. nov.

Pl. 14, fig. 2, 4, 7.

DESCRIPTION: Shell broadly fusiform with a tumid bodywhorl tapering abruptly to the anterior canal. Protoconch as in *A. (T.) antiscalaris.* Sutural nodules subspinose, set on a prominent sutural cingulum. Whorls slightly shouldered. Axial costae numerous (about 20 - 28 on the body whorl), somewhat nodulate on the shoulder, extending anteriorly over half the body whorl. Spiral lirae prominent over the whole of the body whorl and with three lirae present on the spire whorls, subnodulate where they cross the axial costae. Columella with four major and two or three minor plaits.

DIMENSIONS:

Holotype	P22479	L44	HA29	W19
Paratype	P22480	45	29	18

LOCATION OF TYPES: National Museum of Victoria. Holotype P22479, collected T. A. Darragh and H. E. Wilkinson, 14 Dec. 1968. Paratype P22480, coll. T. A. Darragh 1965.

TYPE LOCALITY: Cliff section at SW end of Jan Juc beach about 100 yds. NE of Bird Rock, Torquay. Grid Ref. Anglesea 379706. Puebla Clay, Longfordian, Lower Miocene.

STRATIGRAPHIC RANGE: Lower part of Longfordian, Lower Miocene.

PLATE 15.

Fig. 15, 16. *A. (T.) antiscalaris levior* (McCoy), P12166, lectotype, Fossil Beach, Mornington, Vict.

Fig. 17, 20. *A. (T.) antiscalaris antiscalaris* (McCoy), P12164, lectotype, Curlewis, Vict.

Fig. 18, 22. *A. (T.) subcrenulifera* sp. nov., P22481, holotype, S. bank of Lake Costin, Hordern Vale, Vict.

Fig. 19. *Ibid.*, P22483, paratype, S. bank of Lake Costin, Hordern Vale, Vict.

Fig. 21, 23. *A. (T.) antiscalaris antiscalaris* (McCoy), P22484, hypotype, Kennedys Creek Cutting, Vict.

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OCCURRENCE: PUEBLA CLAY (Longfordian); Type locality. GELLIBRAND CLAY (Longfordian); Left bank, Barwon River at Birregurra. FORMATION UNKNOWN; 70 feet in a well on J. Keyte's farm, 3 miles E. of Mt. Arapiles.

MATERIAL: Types and eight topotypes; twelve specimens from Birregurra.

COMMENTS: The presence of spiral lirae over the whole of the spire and body whorl distinguishes this species from *A. (T.) anticingula* s.s., however, as a few individuals of the population of that species in the Jan Juc Formation, the *persulcata* form, approach this subspecies in morphology, it seems proper to treat this taxon as a subspecies of *A. (T.) anticingulata* from which it has evolved by the development of consistant overall spiral ribbing.

This subspecies gives rise to *A. (T.) antiscalaris antiscalaris* (McCoy) and *A. (T.) subcrenulifera* sp. nov. which replace it in the younger horizon of the Longfordian.

Athleta (Ternivoluta) subcrenulifera sp. nov.

Pl. 15, fig. 18-19, 22.

DESCRIPTION: Shell elongately fusiform with a high gradate spire and rounded gently tapering bodywhorl. Protoconch and early whorls as in *A. (T.) antiscalaris.* Sutural nodules narrow, spinose, set on a prominent sutural cingulum, well separated from the suture itself by a channel which on the adult whorl is as wide as the sutural groove anterior to the cingulum. Axial costae thin, erect and numerous (40 - 45 on the body whorl), subspinose on the shoulder and extending anteriorly over half the body whorl. Spiral lirae strongly developed over the whole spire and body whorl, weakly nodulate on crossing the axial costae. Columella with two or three major and two or three minor plaits.

DIMENSIONS:

Holotype	P22481	L56	HA37	W22
Paratype	P22482	46	30	19
Paratype	P22483	51	32	19

LOCATION OF TYPES: National Museum of Victoria. Holotype P22481, Paratype P22482, Paratype P22483 collected T. A. Darragh and K. Bell, 24 Feb. 1970.

TYPE LOCALITY: Slip on S. bank of Lake Costin, 0.3 miles W. of Horden Vale-Red Hill Rd., Horden Vale. Grid Ref. Aire 363163. Fishing Point Marl, lower mollusc horizon. Longfordian.

STRATIGRAPHIC RANGE: Longfordian, Lower Miocene.

OCCURRENCE: FISHING POINT MARL, lower mollusc horizon, (Longfordian): Type locality; Cliff 100 feet above Lake Craven, Aire River, quarter mile NW. of Red Hill, Horden Vale, Grid Ref. Aire 359149.

MATERIAL: Types and seven other complete specimens.

COMMENTS: The finely cancellate appearance and elongate shape distinguish this species from others in the subgenus. The name alludes to its resemblance to *Volutocorbis crenulifera* (Bayan) of the French Eocene. *A. (T.) antiscalaris antiscalaris* (McCoy), its closest ally, is more inflated, has few axial costae and a more prominently shouldered body whorl. They occur together in the lower part of the Fishing Point Marl and both seem to be derived from the early Longfordian *A. (T.) anticingulata craticula* sp. nov., however, unlike *A. (T.) antiscalaris* which has a wide distribution, it is restricted to the Aire district and does not give rise to any subsequent species. Why it should have evolved at all is not obvious from the data in hand.

Athleta (Ternivoluta) antiscalaris antiscalaris (McCoy, 1866)

Pl. 15, fig. 17, 20 - 21, 23; Pl. 16, fig. 25; Fig. B.

Voluta antiscalaris. McCoy 1866, *Ann. Mag. Nat. Hist.* ser. 3, 18 (107) : 378.
McCoy 1874, *Prod. Pal. Vict.* 1: 26, pl. 6, fig. 5.
Tate 1889, *Trans. R. Soc. S. Aust.* 11; 133.
Volutilithes antiscalaris. Harris 1897, *Catalogue of Tertiary Mollusca* p. 97 partim.
Austrovoluta antiscalaris. Cotton 1949, *Rec. S. Aust. Mus.* 9 (2) : 185, pl. 15.
Ludbrook 1961, *Bull. Geol. Surv. S. Aust.* 36, pl. 7, fig. 5.
Ludbrook in Parkin 1969, *S. Aust. Geology*. fig. 96-7.

DESCRIPTION: Shell broadly fusiform with a tumid body whorl tapering rapidly to the anterior canal. Protoconch of about one and one half whorls which merge imperceptably with the juvenile spire whorls, first whorl smooth, globose, deviated, the next quarter whorl smooth followed by a quarter whorl bearing sharp axial costae which at the eighth or so are cut by a sutural groove which widens rapidly to form a concave posterior ramp or shoulder on the adult whorls. Sutural nodules spinose and on the body whorl are separated from the suture by a narrow channel. Axial costae sharp, slightly sigmoidal, spinose to subspinose on the shoulder and extending anteriorly over about a third of the body whorl, there are from 16 to 21 on the body whorl. Spiral lirae well developed over the whole spire and body whorl and nodulose where they cross the axial costae. Columella with two or three major and two or three minor plaits.

DIMENSIONS:

Lectotype	P12164	L50	HA34	W22	McCoy 1874, pl. 6, fig. 5, 5a.
Paralectotype	P12163	39	25	16	Op. cit. unnumbered figure.
Paralectotype	P22486				Op. cit. unnumbered figure.
Hypotype	P22484	55	36	26	Kennedys Creek cutting.

LOCATION OF TYPES: National Museum of Victoria. Lectotype P12164, Paralectotype P12163, Paralectotype P22486, collected R. Daintree G. S. V. April 1861. Hypotype P22484, coll. T. A. Darragh and H. E. Wilkinson 8 Dec. 1968.

TYPE LOCALITY: Geological Survey of Victoria locality Ad 14, Section 24, block 1, Parish of Moolap, 1.5 miles N. of Curlewis railway crossing. Grid Ref. Portarlington 578937. Fyansford Clay, Batesfordian.

STRATIGRAPHIC RANGE: Upper Longfordian — Batesfordian, Lower Miocene.

OCCURRENCE: (Batesfordian.) FYANSFORD CLAY: Type locality; Belmont shaft; Bed 7, G.S.V. Fc 20, 60 feet up section, Amphitheatre, Leigh River. GELLIBRAND CLAY: Cutting, Cobden — Lavers Hill Rd., 0.8 miles S. of Kennedys Creek, Grid Ref. Princetown 155390; Chapple's locality, landslips on Latrobe Creek, ¾ mile NW. of Princetwon; Cutting on Princetown-Simpson Rd., 1.7 miles S. of Melrose Rd., Grid Ref. Princetown 033346; Cutting on Bornung Road at top of hill, 1.3 miles N. of Coriemungle Rd., Grid Ref. Princetown 982485. MYARING BEDS: Limestone Creek, Glenelg River. CADELL MARL LENS: Left bank, Murray River at gully 3.0 miles S. of Morgan — Cadell Rd., Grid Ref. Renmark (1:250,000) 268789, South Australia.

(Longfordian). FISHING POINT MARL: Cliff about 100 feet above Lake Craven, quarter mile NW. of Red Hill, Horden Vale, Grid Ref. Aire 359149; 20-30 ft. above Lake Craven SE. side Fischers Point, Horden Vale, Grid Ref. Aire 359158; Slips on S. side of Lake Costin, 0.3 miles W. of Horden Vale - Red Hill Rd., Horden Vale, Grid Ref. Aire 363163.

MATERIAL: Types and fifteen topotypes.

COMMENTS: The broad fusiform shape, spinose axial costae and strongly developed spiral sculpture distinguish this subspecies. It has evolved from the Puebla Clay *A. (T.) anticingulata craticula* by the development of shoulder spines on the costae and by widening of the shoulder. The specimen chosen as lectotype is the larger and better preserved of the three syntypes.

Athleta (Ternivoluta) antiscalaris levior (McCoy, 1866)

Pl. 15, fig. 15-16; Pl. 16, fig. 35-36.

Voluta antiscalaris levior. McCoy 1866, *Ann. Mag. Nat. Hist.* ser. 3, 18 (107): 379.
McCoy 1874, *Prod. Pal. Vict.* 1: 28.
Volutilithes antiscalaris. Harris 1897, *Catalogue of Tertiary Mollusca,* p. 97, pl. 4, fig. 8a - b.
Cossmann 1899, *Essais de Paléoconchologie Comparée* 3, pl. 5, fig. 4.

DESCRIPTION: Shell fusiform with a gradate spire and slenderly tapering body whorl. Protoconch and early whorls as in *A. (T.) antiscalaris* s.s. Sutural groove widening rapidly to form a prominent shoulder on the body whorl. Sutural nodules spinose, prominent and separated from the suture by a narrow channel so that the shoulder is double stepped. Axial costae, short, prominent, spinose on the shoulder extending anteriorly over about a quarter of the body whorl, 14 - 16 on the body whorl. Spiral lirae absent from the spire whorls, feebly developed immediately anterior to the shoulder or in some cases confined to the anterior third of

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PLATE 16.

Fig. 24, 26. *A. (T.) studeri* (Martens), 22678, holotype, off Cape Moreton, Qld.
Fig. 25. *A. (T.) antiscalaris* (McCoy), P12163, paralectotype, Curlewis, Vict.
Fig. 27, 32. *A. (Athleta) wangerrip* sp. nov., P22474, paratype, Aw7, Rivernook, Vict., X 1½.
Fig. 28, 31. *Ibid.*, P28032, holotype, Aw7, Rivernook, Vict., X 1½.
Fig. 29. *A. (Ternivoluta) antiscalaris antispinosa* (Tate), T1449, holotype, "Murray Desert."
Fig. 30, 33. *A. (T.) bungae* sp. nov., P22485, holotype, Bunga Creek Cutting, Vict.
Fig. 34. *A. (T.) antiscalaris antispinosa* (Tate), P22487, hypotype, Lake Bullenmerri, Vict.
Fig. 35, 36. *A. (T.) antiscalaris levior* (McCoy), P12165, paralectotype, Fossil Beach, Mornington?, Vict.
Fig. 37. *A. (T.) antiscalaris antispinosa* (Tate), P22488, hypotype, Wiridgil, Camperdown, Vict.


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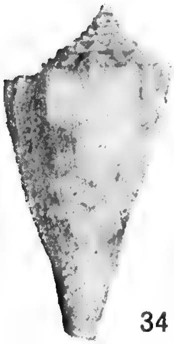
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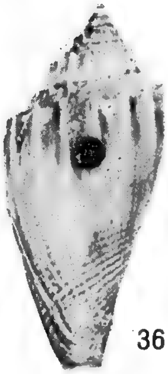
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the body whorl. Columella with three or four major and two or three minor plaits.

DIMENSIONS:

Lectotype	P12166	L48	HA36	W23	
Paralectotype	P12165	51	39	23	
Paralectotype	P12167			21	Specimen broken.
Paralectotype	P12168	10			Juvenile.

LOCATION OF TYPES: National Museum of Victoria, Lectotype P12166, Paralectotypes P12165, P12167, P12168 collected W. Kershaw prior to 1864.

TYPE LOCALITY: Mount Martha, i.e. Fossil Beach, Balcombe Bay, 1½ miles S. of Mornington. Grid. Ref. Cranbourne 072845. Balcombe Clay, Balcombian, Middle Miocene.

STRATIGRAPHIC RANGE: Balcombian — Bairnsdalian, Middle Miocene.

OCCURRENCE: BALCOMBE CLAY (Balcombian): Type locality; 200 yds. S. of Gunyoung (= Grices) Creek; Kackeroboite (= Dennant) Creek about 50 yds. from the older volcanics, Grid Ref. Cranbourne 120928. (Bairnsdalian): Cliff section to the S. of Manyung Rocks and N. of sewer pipe and jetty, bed 10Ba, Grid Ref. Cranbourne 106903; Downstream section Grices Creek, beds 8 Ba-g, Grid Ref. Cranbourne 111910. NEWPORT FORMATION (Balcombian): Southeastern Trunk Sewer between Braeside shaft and shaft at corner of Boundary and Centre Dandenong Rds., Dingley. (Horizon not known): Altona Bay Coal Shaft. FYANSFORD CLAY (Balcombian): Red Hill, Shelford-Inverleigh Rd., Grid Ref. Beeac 064066; Left bank, Native Hut Creek, SW. of Glenleigh, Grid Ref. Geelong 173034. (Bairnsdalian): Right Bank, Native Hut Creek, 100 yds. S. of Hamilton Highway, Grid Ref. Geelong 181009; Junction of Native Hut Creek and Barwon River, Grid Ref. Geelong 184003; Left bank, Barwon River, section 2B, Parish of Murgheboluc, Grid Ref. Geelong 197988; Left bank, Barwon River near junction with Bruces Creek, section 4A, Parish of Murgheboluc, Grid Ref. Geelong 229982. GELLIBRAND CLAY (Bairnsdalian): Cliff at NW. end of Gibson Beach, Princetown, Grid Ref. Princetown 022298; Clay immediately beneath limestone on track to V.A.L. quarry, Curdies, Grid Ref. Panmure 871589; Cutting Timboon-Port Campbell Rd., 100 yds. S. of Timboon shops, Grid Ref. Panmure 892534. MUDDY CREEK FORMATION (Balcombian): Clifton Bank, Muddy Creek, Hamilton. (Bairnsdalian): Grange Burn, ¾ mile above Henty's House, Hamilton.

MATERIAL: Types and twenty topotypes.

COMMENTS: This subspecies is distinguished from *A. (T.) antiscalaris antiscalaris* generally by its less tumid body whorl, more prominent shoulder spines, shorter and bolder axial costae and by the decrease in prominence of the spiral lirae. However as some specimens of *A. (T.) antiscalaris* s.s. are somewhat similar in morphology to the stratigraphically older specimens of *A. (T.) antiscalaris levior*, it is felt that subspecific rather than specific separation is warranted. Similarly stratigraphically younger specimens of *A. (T.) antiscalaris levior* show afinity with *A. (T.) antiscalaris antispinosus* (Tate).

The specimen chosen as lectotype is a typical representative of the Fossil Beach population but the paralectotype P12165 is closely akin to those found at Grices Creek (= Mt. Eliza) and is probably incorrectly located.

Athleta (Ternivoluta) antiscalaris antispinosa (Tate, 1899)

Pl. 16, fig. 29, 34, 37

Volutilithes antispinosus. Tate 1899, *Trans. R. Soc. S. Aust.* 23 (1): 107, pl. 1, fig. 5a, b.
Austrovoluta antispinosa. Cotton 1949, *Rec. S. Aust. Mus.* 9 (2): pl. 15.

DESCRIPTION: Shell pyriform with a short squat subconical spire and tumid bodywhorl, abruptly tapering to the anterior canal. Sutural groove of early spire whorls widening rapidly and forming a prominent shoulder on the body whorl. Sutural nodules spinose when present but much reduced and absent in stratigraphically younger specimens. Anterior whorl slope of spire completely covered by succeeding whorl. Axial costae spinose on the shoulder, broad and short extending anteriorly over one quarter to one third of the body whorl (eleven or so present on the body whorl). Spiral lirae developed only on the anterior portion of the body whorl and the anterior canal. Columella with three or four major and two or three minor plaits.

DIMENSIONS:

Holotype T1449	L47	HA—	W24	
Hypotype P22487	47	38	22	NW. corner Lake Bullenmerri.
Hypotype P22488	47	35	23	Wiridgil.

LOCATION OF TYPES: Tate Museum, Geology Department, Adelaide University, Holotype T1449. National Museum of Victoria, Hypotype P22487; coll. E. D. Gill, 5 June 1957; Hypotype P22488, coll. W. A. H., T. S. Hall in F. A. Cudmore collection.

TYPE LOCALITY: Well sinking, Murray Desert. Tate (1899) states that his Murray Desert material comes from two wells, one at Mindarie, South Australia and the other at Tareena, New South Wales. From comments in the paper and because at least three other species described or recorded in the paper come from Mindarie it seems probable that this is the type locality.? Bookpurnong Beds, Cheltenhamian, Upper Miocene.

STRATIGRAPHIC RANGE: Bairnsdalian, Middle Miocene — Cheltenhamian, Upper Miocene.

OCCURRENCE: ? BOOKPURNONG BEDS (Cheltenhamian): Type locality. RUTLEDGES CREEK MEMBER, Port Campbell Limestone (Bairnsdalian): G. S. V. Aw10, cliff at Rutledge Beach, Grid Ref. Princetown 954345. BULLENMERRI CLAY (Bairnsdalian): NW. shore of Lake Bullenmerri, Camperdown; Well at Wiridgil, Camperdown. GOODWOOD FORMATION (Cheltenhamian) Bed of Spring Creek, half mile NE. of Spring Creek Homestead, Minhamite, Grid Ref. Hawkesdale 367129. ROSE HILL MARL MEMBER, Tambo River Formation (Mitchellian): Rose Hill near Bairnsdale. JEMMYS POINT FORMATION (Cheltenhamian): Sample 1, 66 - 120 feet, Bore 12, Parish of Stradbroke, Grid Ref. Stradbroke 966777.

COMMENTS: This subspecies is characterised by the very low spire. Some stratigraphically older specimens such as those from Lake Bullenmerri match the type specimen closely in overall morphology but as other specimens approach *A. (T.) antiscalaris levior* in shape and also have a row of subspinose sutural nodules, showing that they are derived from that subspecies, it seems preferable to regard this taxon as a subspecies of *A. (T.) antiscalaris.*

Athleta (Ternivoluta) bungae sp. nov.

Pl. 16, fig. 30, 33.

DESCRIPTION: Shell pyriform with a squat conical spire. Protoconch as in *A. (T.) antiscalaris.* Posterior whorl slope without sutural groove except on the first one or two juvenile whorls so that the posterior whorl slope of the spire whorls is flat and the spire conical rather than gradate. Axial costae numerous (about 25 on the body whorl), thin, extending from the posterior suture over half the body whorl, and raised into slight nodes where they are crossed by the spiral lirae of the posterior whorl slope. Spiral lirae present over the whole of the anterior whorl slope of the body whorl. Columella with four major and three or more minor plaits.

DIMENSIONS:

Holotype	P22485	L48	HA38	W21

LOCATION OF TYPE: National Museum of Victoria. Holotype P22485, F. A. Cudmore Collection, collected 1936 or 1939.

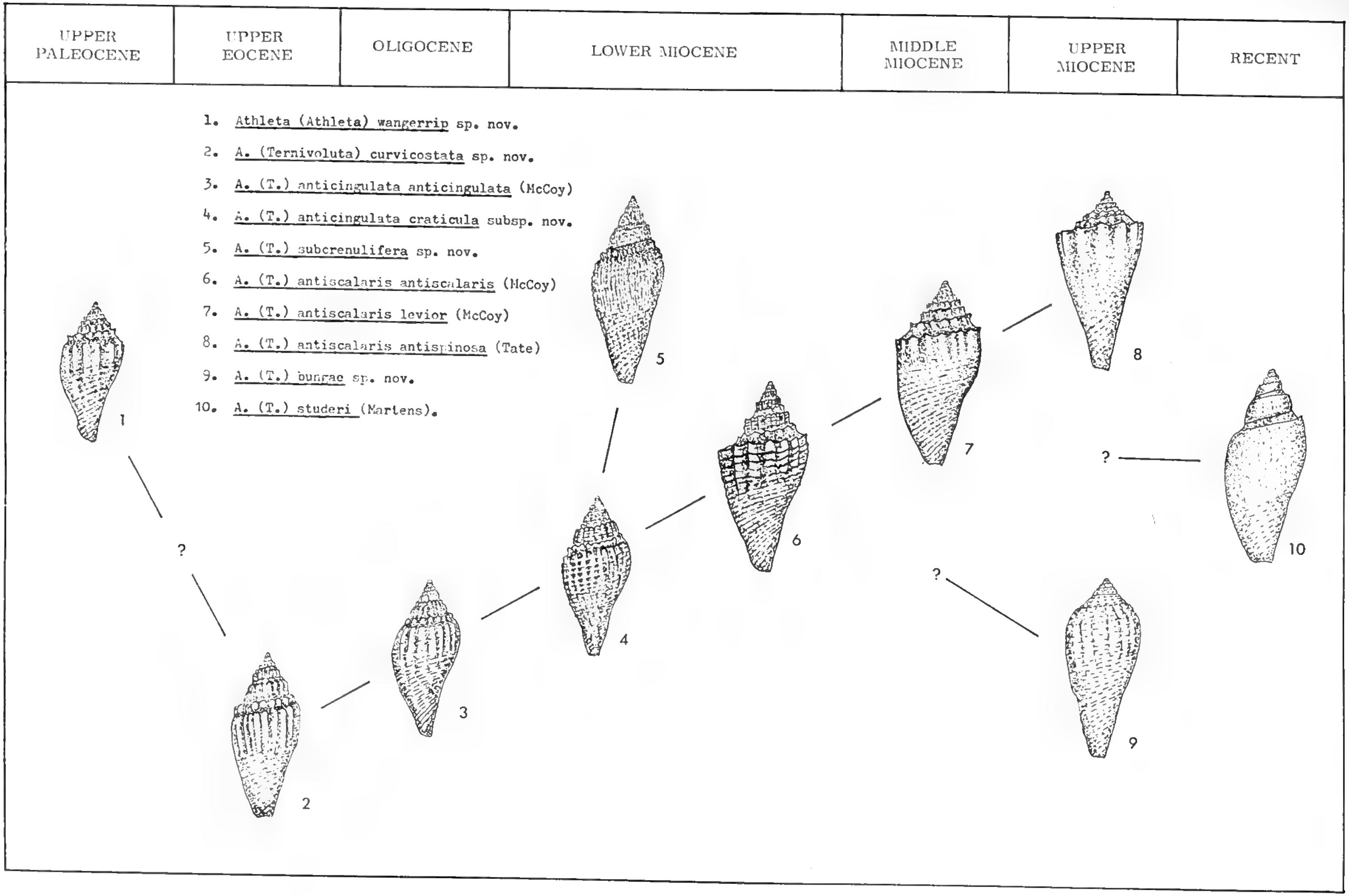
TYPE LOCALITY: Cutting on Princes Highway, left bank, Bunga Creek, Lakes Entrance, Grid Ref. Hartland 961302. Up until the widening of the cutting in 1961 the only shell bed outcropping was bed (b) of Wilkins (1963). The collections of mollusca associated with the type are all typical of this bed rather than the younger shell beds exposed near the top of the cutting. Jemmys Point Formation, Cheltenhamian, Upper Miocene.

STRATIGRAPHIC RANGE: Cheltenhamian, Upper Miocene.

OCCURRENCE: JEMMYS POINT FORMATION (Cheltenhamian): Type locality; Ritchies Cutting, Scrivenors Rd., right bank, Mississippi Creek, G. S. V. loc. Fl., Grid. Ref. Bairnsdale 878329; Lake Bunga Crossing; Lowest shell bed in cutting on Nyerimalang Rd. about 12 feet above and on the left bank of Meringa Creek, Grid Ref. Bairnsdale 866283; Bluff on W. side of North Arm, S. of Hunter Gully, Lakes Entrance, Grid Ref. Bairnsdale 909276; just below nigh tide level on E. side of North Arm on Point at end of Ferndale Parade, Lakes Entrance, Grid Ref. Bairnsdale 913276.

MATERIAL: Type specimen, five fragmentary topotypes and several other fragmentary specimens.

COMMENTS: The species is distinguished by the lack of spines, the conical spire and hence lack of a shoulder and by the fine cancellate appearance of the sculpture. It is not possible to directly derive this species from any other presently known. The only other species known from Gippsland, *A. (T.) antiscalaris antispinosa* (Tate) does not appear to have any obvious connection with it.



Schematic representation of the evolution of *Ternivoluta* in Australia.

Athleta (Ternivoluta) studeri (Martens, 1897)

Pl. 16, fig. 24, 26; Fig. C.

Voluta (Psephaea) concinna. Schacko 1881, *Conchologische Mittheilungen.* 2 (1 & 2): 126, pl. 24, fig. 5, (radula), (non Broderip 1836).

Voluta (Ternivoluta) studeri. Martens 1897, *Arch. Naturgesch.* 63 (1): 177, pl. 17, fig. 2.

Ternivoluta studeri. McMichael 1959, *Proc. R. Zool. Soc. N.S.W.* for 1957-58: 60, fig. 1.
McMichael 1960, *J. Malac. Soc. Aust.* 4: 4, Text fig. 1A (radula).

Volutocorbis (Ternivoluta) studeri. Shikama & Horikoshi 1963, *Selected shells of the World.* 1: 97, pl. 79, fig. 1.

Ternivoluta studeri. Weaver & du Pont 1970, *Living Volutes*, p. 13, pl. 3A, 3B; fig. 3.

DESCRIPTION: Shell elongately fusiform with a high gradate spire and rounded body whorl tapering gently to the anterior canal. Sutural groove narrow but forming a prominent shoulder on the adult whorls. No sutural nodules. Thin axial costae present only on the first whorl, absent from the succeeding whorls. Shoulder nodules developed on the costae and persisting to the adult whorls but irregularly developed and much reduced in size. Spiral lirae weakly developed and confined to the anterior portion of the body whorl. Four major and three or four minor plaits. Colour pattern of thin axial chestnut bands and three interrupted thicker spiral bands on the body whorl, one of which is also present on the spire.

DIMENSIONS:

Holotype 26678	L50	HA35	W22

LOCATION OF TYPES: Zoologisches Museum, Museum für Naturkunde der Humboldt-Universität zu Berlin. Holotype. 26678.

TYPE LOCALITY: "Gazelle" station 40, Lat. 26° 51.1′ S, Long. 153° 29.6′ E, 76 fathoms (139 metres), 12 miles N. by NNW. from Cape Moreton, Queensland. 27 Sept. 1879.

OCCURRENCE: QUEENSLAND: 60 - 100 fathoms off Cape Moreton; 15 fathoms, Tin Can Bay (Wide Bay); South of Double Pt. Is.; NEW SOUTH WALES: 68 fathoms NNE. of Cape Byron.

MATERIAL: Numerous topotypes.

COMMENTS: This species is distinguished from the others in the genus by the overall smoothness of the whorls. McMichael (1960) has commented on the similarity of the radula and gross anatomy to that of *Athleta (A.) abyssicola* (Adams & Reeve). Detailed anatomical studies are currently being undertaken by Dr. W. F. Ponder of the Australian Museum. Of the species in the Victorian Tertiary, *A. (T.) studeri* is closest to the Bairnsdalian *A. (T.) antiscalaris levior* (McCoy).

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ACKNOWLEDGEMENTS FOR PHOTOGRAPHS

Fig. 1 - 23, 25, 27 - 28, 30 - 37 are from photographs by Mr. Frank Guy. Fig. 24, 26 are from Museum für Naturkunde, Berlin photographs. Fig 29 is from a Geology Department, University of Adelaide photograph. All figures natural size unless stated otherwise.

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ON A NEW GENUS FOR "*TORNATINA*" *MURDOCHI* SUTER, 1913 (RETUSIDAE, OPISTHOBRANCHIA)

W. B. RUDMAN

Dept. of Zoology, University of Auckland, Auckland, New Zealand.

Plate 17

ABSTRACT

Relichna n. gen. is erected for the species previously described as *Tornatina murdochi* Suter, 1913. A study of the alimentary canal, reproductive system, mantle cavity and nervous system show the relationship of the new genus to *Retusa* and *Rhizorus*. It is suggested that the Retusidae represent an independent evolutionary line within the Lower Opisthobranchia.

INTRODUCTION

Shells, similar in shape to *Cylichna* and *Retusa* were described by Murdoch and Suter (1906) as *Cylichna simplex*. Later, Suter renamed this species *Tornatina murdochi* (Suter, 1913), *Cylichna simplex* being preoccupied. Subsequent authors have placed this species in the genus *Retusa* (Powell, 1946; Dell, 1956).

A study of the anatomy of specimens from mud at 54 m off Deep Water Cove, Bay of Islands, show that this species is closely related to *Retusa*. However, because of differences in the form of the gizzard plates, it is more satisfactorily placed in a separate genus, newly created.

Relichna n.gen.

Type species: *Tornatina murdochi* Suter, 1913.

Shell small, cylindrical, involute, imperforate, thin and glossy. Sculpture absent, except for fine irregular growth lines. Colour, white. Spire sunken, deep and broad. Aperture as long as shell, narrow above, expanded below. Outer lip almost straight, slightly concave, rounded at both ends. Columella thin, rounded, slightly reflected at upper end.

Animal white, foot narrow, headshield bearing pair of small posterior lobes. No jaws or radula. Gizzard with three brown, unequal plates, concave on inner surface. No gill.

Relichna murdochi (Suter, 1913)

Synonymy: *Cylichna simplex* Murdoch and Suter, 1906: (non A. Adams, 1850).
Tornatina murdochi Suter, 1913: p. 526.
Retusa murdochi Powell, 1946 et seq.: p. 88.
Retusa aff *murdochi* Dell, 1956: p. 154.

Shell: A study of the holotype and paratypes from the Dominion Museum and N.Z. Geological Survey Collections respectively, show some variations in shell shape (Pl. 17, A, E). Specimens collected at the Bay of Islands, were not as variable in shape as the paratypes but were very similar in shape to the holotype. In Plate 17, B, the most extreme variant from Dell's Chatham Rise material, is illustrated. In the living animal, the shell appears quite transparent.

PLATE 17

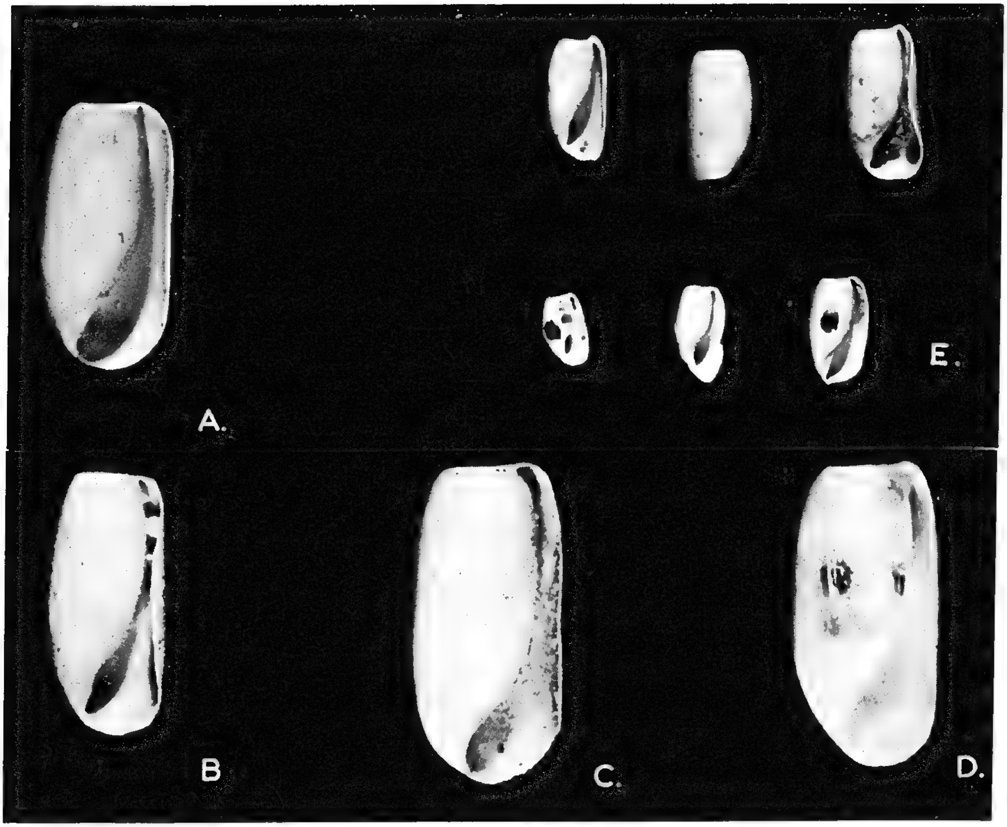

PLATE 17. *Relichna murdochi* n.gen. A, Holotype, Dom. Mus. Coll. M.1739, coll. 200 m off Great Barrier Is., 5 x 2.5 mm. B, ? *Retusa* aff. *murdochi* (Dell, 1956), coll. East of Forty Fours (Chatham Rise) in 234 m Station 34, Chatham Is. Expedition, 1954. Dom. Mus. Coll. M.10651, 5 x 2.5 mm. C, Dead shell, coll. Bay of Islands, 5 x 2.5 mm. D, Showing gizzard plates, and gizzard packed with foraminiferans, coll. Bay of Islands, 4.2 x 2.1 mm. E, Paratypes, N.Z. Geological Survey Coll., T.M. 1176 - 1181, coll. 200 m off Great Barrier Is., largest specimen 5 x 2.5 mm.

Photo — G. W. Batt.

Alimentary Canal: The buccal bulb, although shaped somewhat similarly to that of *Cylichna* (see Lemche, 1956), is without either jaw plates or radula. There are no extrinsic muscles. A thin walled, ciliated, mid-dorsal channel runs the length of the buccal bulb and it is histologically similar to the oesophageal lining with which it communicates. The rest of the lining of the buccal cavity is unciliated and has large subepithelial mucous gland cells (Fig. 2C). At the posterior end of the cavity is a ventral mound which is possibly a remnant of an odontophore.

The oesophagus, thin and lined with a simple ciliated epithelium, quickly enlarges to form a thin walled distensible crop or gizzard, which contains three large, brown chitinous plates at the posterior end (Fig. 1C). The " crop " was often distended with six or seven foraminiferans of an undescribed species of the genus *Notorotalia* Finlay. The gizzard plates are unequal, one being slightly larger than the other two (Fig. 1D). In section, (Fig. 2A) we can see that the gizzard plates are formed of closely packed chitinous rods. The plates are concave on their inner

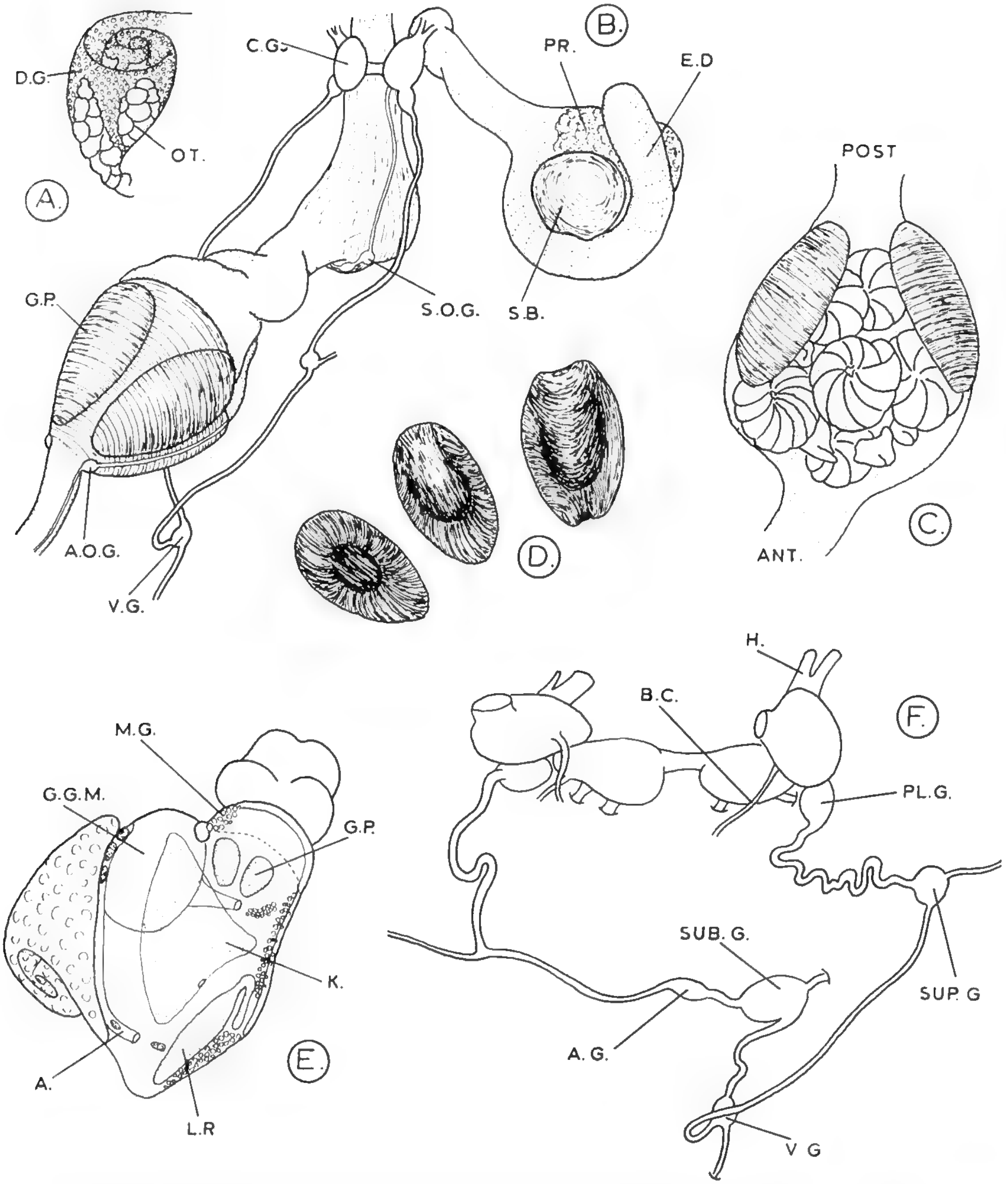

Fig. 1. A., visceral mass; B., foregut and penis; C., gizzard packed with foraminiferans; D., gizzard plates — showing inner side; E., showing mantle cavity; F., nervous system; A., anus; A.G., accessory gland; ANT., anterior end of gizzard; A.O.G., accessory oesophageal ganglion; B.C., cerebro-buccal connective; C.G., cerebral ganglion; D.G., digestive gland; E.D., ejaculatory duct; G.G.M., genital gland mass; G.P., gizzard plate; K., kidney; L.R., lower raphe; M.G., mantle glands; H., nerve to Hancock's Organ; O.T., ovitestis; PL.G., pleural ganglion; POST., posterior end of gizzard; PL.G., pleural ganglion; S.B., spermatic bulb; S.O.G., buccal ganglion; SUB.G., suboesophageal ganglion; SUP.G., supraoesophageal ganglion; V.G., visceral ganglion.

surface and apparently block the posterior end of the crop. Although the musculature of the " gizzard " or posterior region of the crop, is only slight, the broken tests of foraminiferans found in the intestine suggest that they have been crushed by the gizzard plates.

From the gizzard, the posterior oesophagus runs back to the stomach, which is only distinguishable because of the openings of the ducts to the digestive gland. The ciliated intestine runs behind the genital gland mass (Fig. 1E), along the back of the mantle cavity, to open near the ventral raphe. The digestive gland, greeny-brown in life, occupies the dorsal half of the visceral whorls (Fig. 1A).

The muddy bottom, where this species was found alive, contained many foraminiferans of a large variety of genera. Ten or eleven specimens had crops filled with food; this consisted solely of *Notorotalia* specimens. It is possible that *Relichna murdochi* feeds specifically on this animal.

Mantle Cavity: The mantle cavity is large (Fig. 1E) and the kidney occupies a major portion of the roof. The gill has been lost, but the upper and lower raphae are well developed. The loss of the gill has been supplemented by the development of extensive blood sinuses in the roof and floor of the mantle cavity (Fig. 2B).

Three or four glandular areas (M.G.) produce a white mucoid secretion similar to that of the repugnatorial glands of the Acteonidae (Fretter & Graham, 1954). These are situated above the mantle opening, along the raphal region and at the left anterior corner of the mantle flap, outside the mantle cavity.

The opening of the mantle cavity is relatively small, being only half the width of the cavity itself. The lower raphe is large and from the right edge of the mantle opening, it runs to the anterior right corner of the mantle cavity.

Reproductive System: The yellow ovitestis occupies the ventral half of the visceral whorls. From this the ovitestis duct, often distended with endogenous sperm, runs down to the fertilisation chamber (Fig. 2D). A small sac opens into the ovitestis duct just before it enters the genital gland mass and this is possibly an endogenous sperm sac. Opening off the fertilisation chamber, is a large exogenous sperm sac, (often distended with sperm), an albumen gland, and a posterior mucous gland, staining dark grey in Weigert's iron haemotoxylin and van Gieson. The anterior end of the fertilisation chamber is lined with a glandular epithelium which may be the capsule gland. From the fertilisation chamber, the anterior mucous gland, forming the pallial gonoduct, and staining lightly in Weigert's iron haemotoxylin, runs forward to open near the left edge of the mantle opening. Near the genital opening a duct runs off to the gametolytic sac, a large brown sac alongside the genital gland mass. The external, ciliated, endogenous sperm groove runs from the genital opening, forward, along the side of the body to the opening of the penis sac on the right of the mouth.

The penis is large, and lies alongside, and to the right, of the fore-gut (Fig. 1B). A wide ciliated duct runs back from the penial opening to a large, unciliated, spermatic bulb; at the entrance of the bulb is a large muscular papilla. Also opening off the duct are a large, short prostate gland, and a long sac which may be an ejaculatory duct. This " ejaculatory duct " is muscular and is also lined with glandular tissue staining brown in both Mallory and Heidenhain and Weigert's iron haemotoxylin and van Gieson.

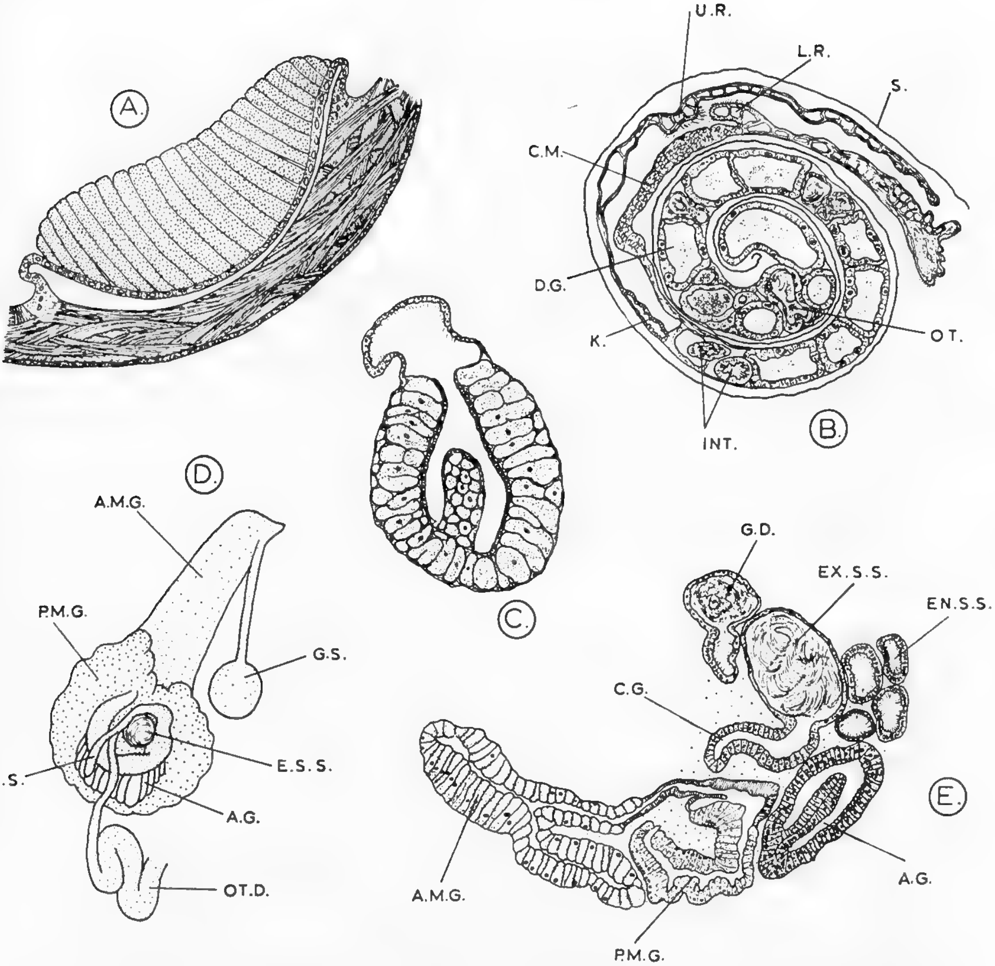

Fig. 2. A., section through gizzard plate showing rod-like formation; B., transverse section through whole animal; C., transverse section through the posterior buccal bulb; D., reproductive system; E., longitudinal section through genital gland mass; A.G., albumen gland; A.M.G., anterior mucous gland; C.G., capsule gland; C.M., columellar muscle; D.G., digestive gland; E.S.S., exogenous sperm sac; EN.S.S., endogenous sperm sac; G.D. gonoduct; G.S., gametolytic sac; INT., intestine; K., kidney; L.R., lower raphe; OT., ovotestis; OT.D., ovitestis duct; P.M.G., posterior mucous gland; S., shell; S.S., endogenous sperm sac; U.R., upper raphe.

Nervous System: The illustration of the nervous system (Fig. 1F) shows the supra-oesophageal ganglion positioned to the right of the visceral and sub-oesophageal ganglion. Before dissection however, it lies left of these ganglia. On casual examination, *Relichna* appears to exhibit a streptoneurous condition. However, since the connective between the left pleural ganglion and the suboesophageal ganglion is the only cord pass under the alimentary canal, the system is basically euthyneurous. Minichev (1967) described a similar situation in *Retusa operculata* Minichev, 1966, but in that species, the pleural ganglia are fused to the cerebral ganglia.

DISCUSSION

The Retusidae, like many other groups of shelled opisthobranchs, is ill-defined. Descriptions of the animals are few, and these are rarely more than statements describing the shape of the gizzard plates and the presence or absence of radular teeth.

A study of *Rhizorus persimilis* (Morch, 1875) by Marcus and Marcus (1960) shows that this genus, which is usually placed in a separate family Rhizoridae, should really be considered as belonging to the Retusidae. The three genera, *Rhizorus, Retusa* and *Relichna* are typified by the small cylindrical shell, the lack of a gill and the loss of the radular. The gizzard plates of a number of species of *Retusa* have been described; those of the type species *R. obtusa* by Hurst (1965), *R. operculata* by Minichev (1967), *R. nitidula* by Sars (1878), *R. sosa* by Marcus & Marcus (1969); I have examined *R. oruaensis*. In all cases, the three plates have raised blunt denticles on the inner surface. The constant nature of this feature suggests that it can be considered to be characteristic of the genus.

Rhizorus persimilis can be typified by the pointed upper end of the shell and the lack of gizzard plates, which are also a characteristic of the New Zealand species *Rhizorus nesentus* Finlay, 1926 (personal observations).

Relichna differs from both these genera in the form of the gizzard plates. From the illustrations of Minichev (1967) and Sars (1878) we can see that the gizzard plates of *Retusa* are formed, as in *Relichna,* by closely packed vertical rods. In *Retusa* some of these rods are extended into large protuberances while in *Relichna* the inner rods are much shorter forming a concavity. Because of the constancy of the denticulate gizzard plates in *Retusa* I feel justified in erecting a new genus for *Relichna murdochi.*

The relationship of the Retusidae to other opisthobranchs is not clear. The reproductive system is monaulic (Marcus & Marcus, 1960) and the penis is complex (Minichev, 1967). The monaulic system, the external sperm groove and invaginable penis are also typical of the Philinidae and Scaphandridae, while the loss of the gill and radula are certainly specialisations. The interesting discovery of an operculate species of *Retusa* by Minichev (1966) however, shows that this group must be considered to be as primitive as the Acteonidae and to represent an independent line, quite separate from any other opisthobranch at present studied.

ACKNOWLEDGEMENTS

I would like to thank Dr C. A. Fleming, F.R.S., of the N.Z. Geological Survey, Lower Hutt, and Dr F. Climo of the Dominion Museum, Wellington, for making type material available. I am also grateful to Mr & Mrs M. Hancock for their assistance in dredging live material from the Bay of Islands, and to Dr M. C. Miller of the Zoology Dept., University of Auckland for his assistance and advice.

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THE GENUS *BULLINA* (OPISTHOBRANCHIA, GASTROPODA) IN NEW ZEALAND

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PLATE 18

ABSTRACT

A study of shells of the genus *Bullina* from collections in New Zealand, show that there are a number of species in local waters. The shell, radula, jaw-plates and external features of *Bullina lineata* (Gray, 1825) and a new species, *Bullina roseana*, are described. The shells of two other species, most probably *Bullina melior* Iredale, 1929 and *Bullina lauta* Pease, 1860 are described. Shells of other specimens collected in New Zealand are described and illustrated, but the author did not feel an attempt at identification, or description as new species, was warranted at this stage.

INTRODUCTION

Until now, *Bullina lineata* was the only recorded species of the genus from New Zealand. Since the first record (Hutton, 1873), a number of recordings of the species have been made from the north of the country. These records are restricted to the east coast of the North Island, all except two, being north of the Hauraki Gulf and Great Barrier Island. Although shells have been washed up on beaches, it would seem that this species is restricted to the sub-littoral in New Zealand. *Bullina lineata,* a common Indo-Pacific species, is found inter-tidally in south-eastern Australia (Allan, 1959; Iredale, 1929), but at the northern limit of its geographical range, Honshu, Japan, it is restricted to the sub-littoral zone (Kira, 1962).

While dredging in the Bay of Islands for this species, a live animal of a new species of *Bullina* was discovered. A consequent study of the shells of *Bullina,* collected from New Zealand, has shown that other species of *Bullina* also occur in these waters. The following study considers both identifiable specimens and those which do not fit any described species. Although some of these are most probably new species, it was considered undesirable to compound the confusion which already exists within the genus. All species have been described from shells alone, and their descriptions range from adequate to most inadequate.

Genus *Bullina* Ferussac, 1822

Type species: *Bulla lineata* Gray, 1825, (subsequent designation, Gray, 1847).
Synonym: *Bullinula* Swainson, 1840.

Bullina lineata (Gray, 1825).

Pl. 18, I - J; Fig. 2, A - D.

Synonymy: *Voluta scabra* Gmelin, 1791, p. 3434; non Muller, 1874.
Voluta ziczac Muhlfeldt, 1818, p. 5, pl. 1, fig. 4; non Schroter, 1804.
Bulla lineata Gray, 1825, p. 408.
Aplustrum lineatum Hutton, 1873, p. 52.
Bullina lineata Hutton, 1880, p. 120.
Aplustrum scabrum Watson, 1886, p. 633 - 4.
Bullinula ziczac Iredale, 1915, p. 477.
Bullinula lineata Powell, 1946, p. 88., et. seq.

Shell ovate, sides almost straight; white with two distinct red spiral lines dividing each whorl into three approximately equal parts. A diffuse red spiral line usually exists, running around base of shell. Eight to ten equi-spaced, sinuous, red axial lines run across body whorl. Spire approximately one seventh of shell height, protoconch large, whorls shouldered. Sculpture distinct; wide, smooth spiral ridges, separated by punctate grooves, half width of ridges, transverse bars across grooves forming small rectangular hollows. Aperture large, narrowing at both ends; outer lip thin, joining body whorl either at, or below, the upper red spiral line. Suture shallowly channelled. Columella straight, slightly truncated at base, free edge recurved forming small umbilical opening. Inner lip forming thin glaze over aperture region of body whorl.

Operculum chitinous and thin, nucleus distinct at lower left (inner) corner; long thin muscle scar runs up inner side.

Radula formula 11.1.11; central tooth small, elongate plate; lateral teeth all of similar shape, having long basal plate, outer edge rising to form an incurved posteriorly facing flange, bearing four denticles on posterior edge. Inner nine rows of laterals of same size, outer two rows approximately half of this size.

Jaw plates consist of individual triangular denticulate elements.

Animal blue, foot and headshield bordered by brilliant iridescent greeny-blue edge. Headshield extends posteriorly to form a large posterior process on each side, partly lying over shell. On each side of the head, headshield can fold to form a pair of temporary funnels leading water back over sensory Hancock's organs. Posterior end of mantle forms process lying alongside right side of spire, directing exhalant water current from mantle.

Small pair of black eyes visible on head between posterior processes of the headshield. Foot large and thin, extending behind shell and to each side. Anterior edge of foot forms lateral triangular processes, so forming a wide blunt leading edge. The full anatomy and functional morphology of this, and the following species, will be discussed separately.

NEW ZEALAND OCCURRENCES:

Bland Bay, Whangaruru; Matapouri, Tutukaka Harpour; Whangapoua, East Coast — Gt. Barrier Is.; Oruawharo, East Coast — Gt. Barrier Island; Port Fitzroy, Gt. Barrier Is.; Spirits Bay; Houhora Heads; Tokerau Beach, Doubtless Bay; Whangaroa Heads, 32 m; Little Barrier Is.; 36 m; Buffalo Beach, Whitianga; Mt. Maunganui, Tauranga; Bay of Islands.

The live specimens studied in this paper were dredged in the Bay of Island, S.W. of Waewaetorea Is. in 11-14 m.

DISTRIUTION:

This species is probably widely distributed throughout the Indo-West Pacific. There are many references in the literature to *Bullina lineata* or to one of its many synonyms. The accuracy of these identifications must however remain in some doubt, as in most cases, only the shell was found. Reliable records do exist for all the main islands of Japan (Habe, 1955), for the east coast of Australia (Allan, 1959; Iredale & McMichael, 1962; Macpherson, 1958), and New Zealand. Specimens from Norfolk

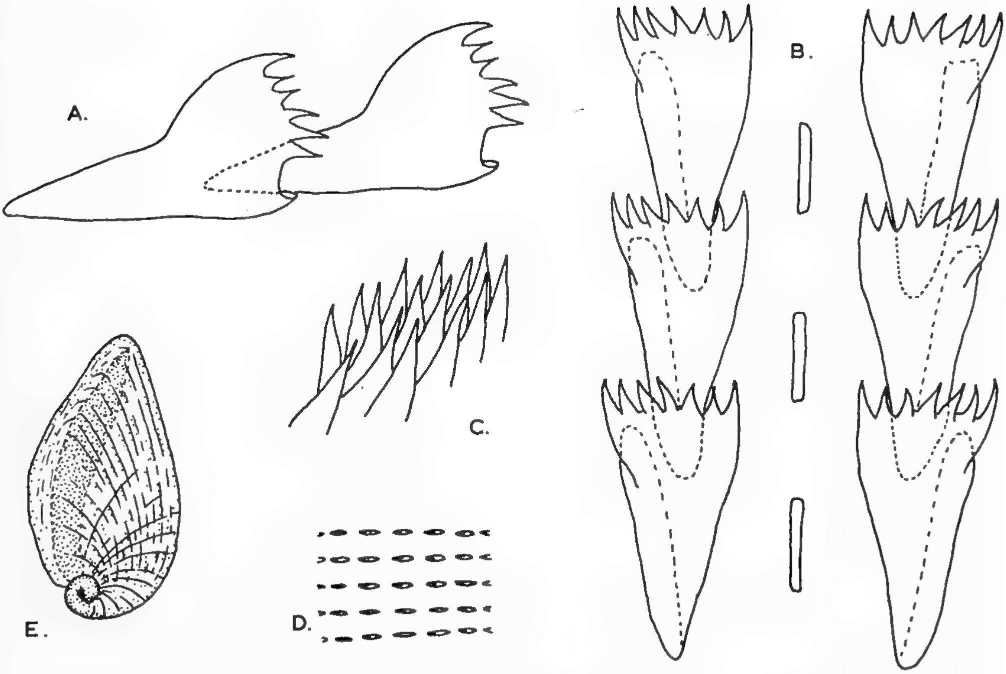

Fig. 1. *Bullina roseana* n.sp.
A, radula teeth, lateral view; B, radula, dorsal view of central and inner laterals; C, part of jaw plates, showing rods; D, sculpture of shell; E, operculum.

Is.; Lifu, Loyalty Is.; New Caledonia and Lord Howe Is. are in the collection of the Australian Museum, Sydney (W. F. Ponder — pers. comm.). Watson lists other occurrences at Java and Mauritius (Watson, 1886), and there are many reports of it occurring in Hawaii.

Bullina roseana n.sp.

Pl. 18, H; Fig. 1, A - E.

Shell ovate, globose, umbilicate; pinkish white with two pink spiral lines dividing whorl into 3 parts, the middle one being twice the width of the outer two. A diffuse spiral band runs around base of shell. Axial red lines not well marked except for short lines running down from suture halfway to upper pink spiral line. Approximately 7 axial lines on body whorl. Spire low, approximately one ninth of shell height, protoconch large, whorls rounded. Sculptured with wide smooth spiral ridges, separated by narrow punctate grooves, approximately one third to one quarter the width of ridges. Transverse bars across grooves, wide, forming strings of oval pits. Aperture large, narrowing at upper end and slightly at lower end; outer lip thin, joining body whorl just above upper red spiral line. Suture channelled. Columella white, straight, broad, slightly truncated at base, free edge slightly recurved to form umbilical opening. Inner lip forming calcified layer over lower half of aperture region of body whorl.

Operculum similar to *Bullina lineata.*

Radula formula 18.1.18; central tooth small elongate plate; lateral teeth all of similar shape and size, having long triangular basal plate, outer edge rising, as in *B. lineata*, to form high, wide incurved flange, bearing six or usually seven, denticles on the posteriorly facing edge. Outer denticle on each side usually larger than inner denticles.

Jaw plate appears to consist of individual rods. (It is possible that compound plates as in *B. lineata* occur in this species. These plates may have been broken into individual rods during the extraction process which requires chemical maceration of the surrounding tissues).

Animal white, slight brown area above mouth. Headshield extending posteriorly on each side to form large pair of flaps partly covering shell. On either side of the headshield, at anterior end, a permanent funnel is formed, leading water down over chemosensory Hancock's organs. As in *B. lineata*, the posterior edge of the mantle is developed into an exhalant siphon. Foot large and thin, extending posteriorly to limit of shell, and extending laterally at anterior end.

LOCALITY:

One specimen dredged alive from 15 m south west of Waewaetorea Is., Bay of Islands, September 1969.

HOLOTYPE:

The shell, unfortunately damaged in removing animal, and radula mount are deposited in the collection of the Dominion Museum, Wellington, Reference No. M24090. Height of shell 12.5 mm; diameter 8 mm.

REMARKS:

A study of references to all other described species show that this species is quite distinct from them. Points of difference will be fully discussed in the concluding discussion. The external features of the animal immediately distinguish it from *Bullina lineata.* Whereas *B. lineata* is brilliantly coloured, *B. roseana* is pure white; the foot of the former extends behind the shell when the animal is moving while in the latter the foot does not. In *B. roseana* a siphon on either side of the head forms a permanent channel to the Hancock's organ whereas in *B. lineata* no such permanent siphon exists. The radula also shows considerable differences. As will be shown separately, there are considerable anatomical differences between the two species. Unfortunately no information is available concerning the animal or anatomy of other species of the genus. This species is named after my mother.

Bullina cf. *melior* Iredale, 1929.

Pl. 18, A - B, F - G.

Iredale described *B. melior* from a specimen dredged in Sydney Harbour from 4 fathoms. In his description he states that, " it is broader

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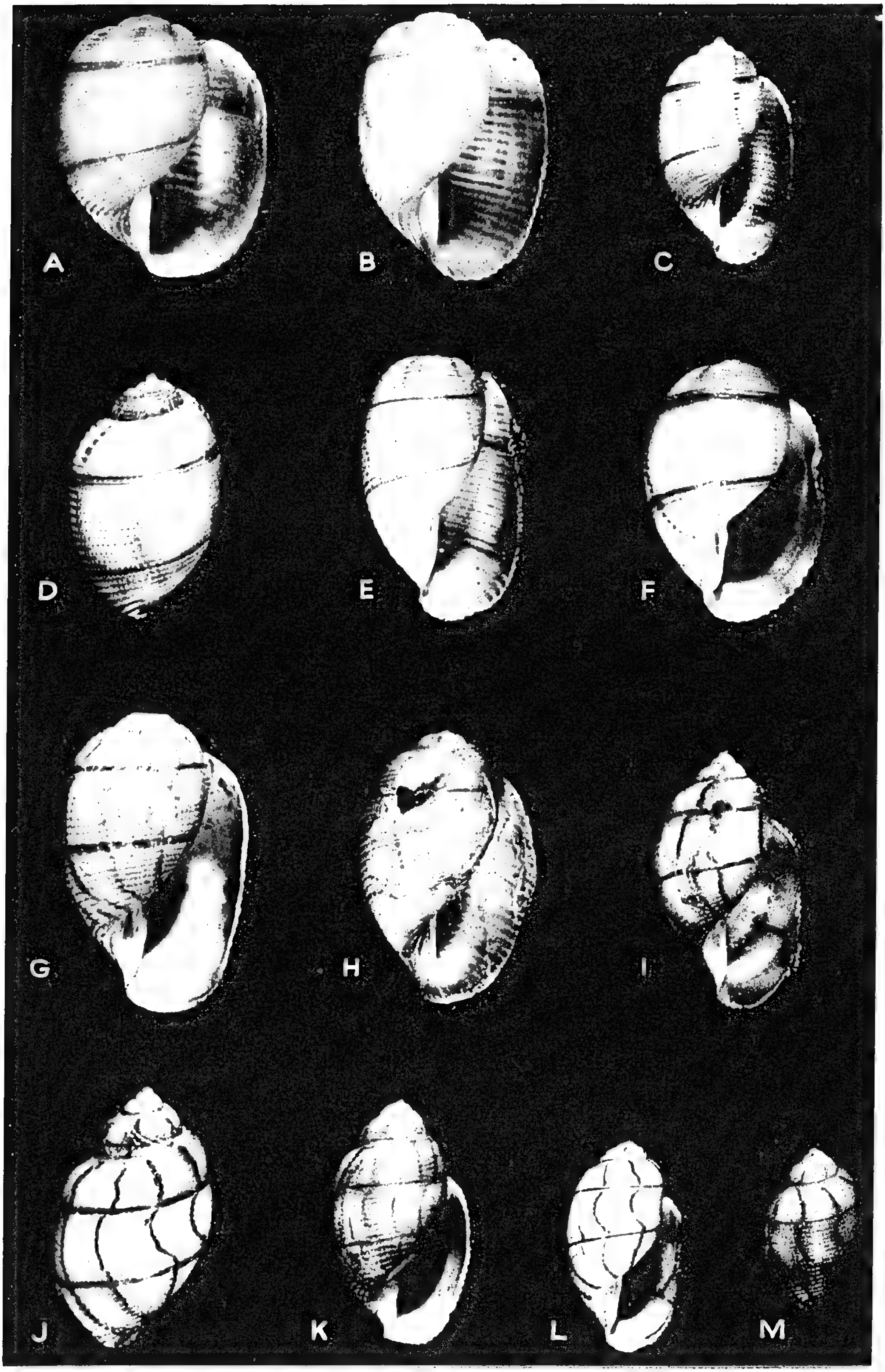
PLATE 18. A, *Bullina melior?*, coll. Tokerau Beach, Doubtless Bay, 14 x 11 mm. B, *Bullina melior?*, coll. Okiwi, Gt. Barrier Island, 15 x 10.5 mm. C, D, *Bullina* sp., coll. between Sydney and Cronulla, New South Wales, in 80 m, 8 x 5 mm. E, *Bullina* sp., coll. Bay of Islands, 12 x 8 mm. F, *Bullina melior?*, coll. Okiwi, Gt. Barrier Island, 12.5 x 9 mm. G, *Bullina melior?*, Dom. Mus. Coll. M.709. No locality data, 20 x 12.5 mm. H, *Bullina roseana* n.sp. Holotype, coll. Bay of Islands, 12.5 x 8 mm. I, J, *Bullina lineata*, coll. Bay of Islands, 15 x 8.5 mm. K, *Bullina* cf. *lauta*, from N.W. Gardner Collection, no locality data, 12 x 7 mm. L, M, *Bullina* cf. *lineata*, coll. Collaroy, New South Wales. Dom. Mus. No. M.F. 8299. Axial coloured lines are brown. 11.5 x 6; 9.5 x 5.

Photo — G. W. Batt.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(than *B. lineata*) with a more depressed spire and stronger sculpture, apical whorls apparently white. Shell broadly ovate, spire depressed, thin, columella truncate ".

From the full description and illustration it is most probable that a number of specimens I have seen from New Zealand collections belong to this species. Four of these specimens are illustrated in Plate 18. They will be discussed separately.

Specimen a. Pl. 18, A.

From the collection of Mr and Mrs N. W. Gardner, Auckland. Collected from Tokerau Beach, Doubtless Bay. Upper lip of shell joins just above upper red spiral line. Suture deeply canaliculate. Columella is only slightly truncated. Sculpture similar to Fig. 2E. Shell solid, spire depressed.

Specimen b. Pl. 18, B.

From Gardner collection, collected Okiwi, Gt. Barrier Is., June 1963. Upper lip joins at upper red line. Suture deeply channelled. No lower red spiral line. Sculpture similar to specimen " a " but spiral channels only half width of ridges. Columella straight.

Specimen c. Pl. 18, F.

Collected with specimen " b ". Upper lip joins at upper red spiral, sculpture similar to Fig. 2 E. Columella truncated.

Specimen d. Pl. 18, G.

Dominion Museum collection M.709. No locality record other than " N.Z.". Upper lip joins at upper red spiral, sculpture as in specimen " b ". Columella truncated.

REMARKS:

These four specimens are larger and more heavily calcified than either *B. lineata* or *B. roseana*, the spire is depressed, the red spiral lines are more diffuse, and in some cases are double. All these features and the sculpturing are consistent with Iredale's description of *B. melior*. In two cases, specimens " c " and " d ", there is a truncated columella consistent with *B. melior*, but in the other two cases the columella is straight. These specimens are definitely neither *B. lineata* nor *B. roseana* and it is probable that they belong to *Bullina melior*.

Bullina lauta Pease, 1860

Pl. 18, K

Synonymy: *Bullina scabra solida* Pilsbry, 1920, p. 362-3.

The original description of *Bullina lauta*, a species from Hawaii, is not very adequate. However a study of photographs of the holotype, kindly provided by Dr J. D. Taylor of the British Museum (Natural History) and of published information of Pease's types (Kay, 1965) show that this species can be typified by the shell, more heavily calcified than in *B. lineata*, and the axial red lines, which are much more numerous than in *B. lineata*.

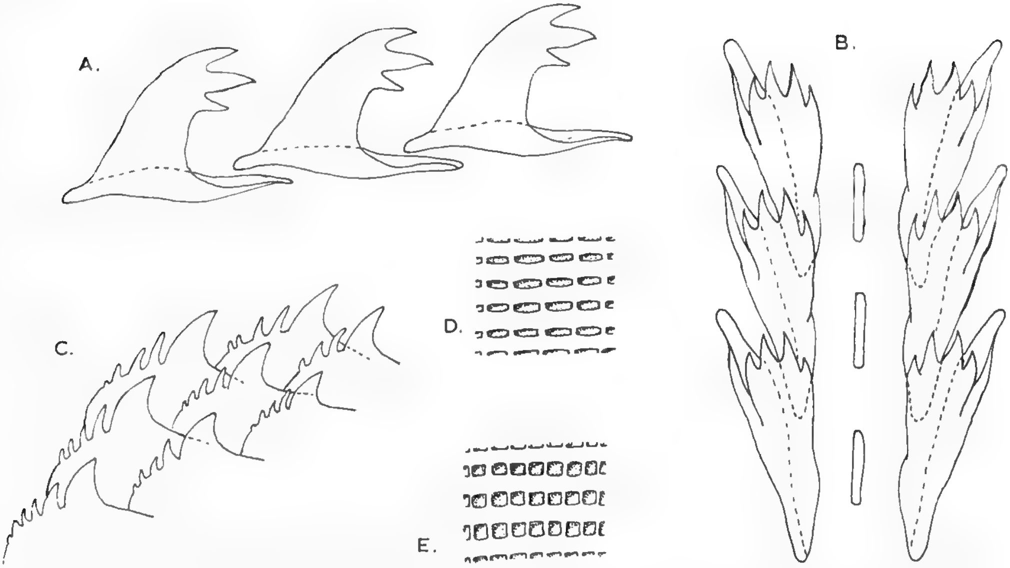

Fig. 2. A - D, *Bullina lineata* (Gray), E, *Bullina* sp.
A, radula teeth, lateral view; B, radula, dorsal view of central and inner laterals; C, part of jaw plate: D, sculpture of shell; E, sculpture of shell of *Bullina* sp. (see text).

It is most probable that the specimen illustrated here from New Zealand, belongs to this species. Pilsbry (1920) described a subspecies, *B. scabra solida,* as " differing from *B. scabra* (ie. *B. lineata*) by it solidity, the lip being far thicker. The fold near the upper end of the straight columella is much stronger ". Although Pilsbry does not specifically mention the numerous wavy axial red lines, the illustration accompanying his description shows that this subspecies is conspecific with *B. lauta.*

The specimen illustrated, from the Gardner collection, unfortunately has no locality information other than that it is from New Zealand. A broken specimen was found in the Dominion Museum collection and was collected from the Cavalli Islands, Whangaroa, (J. E. McDonald, November 1952).

This species differs from *B. lineata* in being heavily calcified and in having many more axial red lines. In *B. lineata* there are usually eight to ten axial lines on the body whorl, whereas in this species there are seventeen to eighteen.

As with *B. melior* lack of information on the soft parts prevented certain identification of this species.

Bullina sp.

Pl. 18, E; Fig. 2 E

Shell, ovate, bulloid; white with two double red spiral lines, the double lines breaking each whorl into three approximately equal parts. No markings around base of shell. In each pair of spiral lines, the lower is more dominant. Seven equi-spaced axial red lines present, running from suture to upper red spiral, and from there to lower red spiral. No axial lines on basal third of whorl. Spire completely suppressed, but not sunken. Sculpture differing markedly from *B. lineata* and *B. roseana;* strong smooth spiral ridges, separated by deep punctate grooves of same width as ridges. Grooves crossed by transverse ridges forming rows of hollow squares.

Aperture large, narrowing at upper end but not at base; outer lip joins body whorl mid-way between suture and upper red spiral line. Suture deeply channelled. Columella weak, straight, truncated at base, only weakly recurved. Umbilicus indistinct. Inner lip forming glaze over aperture region of body whorl. Animal unknown.

REMARKS:

The specimen was collected from the Bay of Islands by Mr and Mrs M. Hancock. It is now deposited in the Dominion Museum collection, Reference No. M24091.

Shell height 12 mm; width 8 mm.

REMARKS:

This specimen may well prove to be a new species. It is easily distinguished by the flattened spire and the high point of attachment of the upper lip. The thin shell and sculpturing are also distinctive. However, until more is known about the range of variation within the described species of this genus it would be undesirable to describe this as a new species. The number of species of the genus *Bullina* which have been erected on such little evidence are reason enough for my conservative attitude.

DISCUSSION

All existing species of the genus *Bullina* other than *B. roseana* have been described from the features of the shell alone. Since most species have a white shell, with red markings, difficulties in identification have been experienced by some authors.

Bullina lineata and the synonyms *B. scabra* and *B. ziczac* have had a confused history in the literature. This has arisen through nomenclatural problems rather than conchological differences; both *Voluta scabra* and *Voluta ziczac* being preoccupied. It would appear however, that Gray did not nominate a holotype for *Bullina lineata.* Nineteen specimens are in the J. E. Gray collection of the British Museum and were collected from New Holland (Australia). It is possible that more than one species could be present in this collection (J. D. Taylor — pers. comm.).

Bullina lauta Pease, 1860 was separated on vague conchological grounds, Pease considering that microscopic lines crossing the spiral ridges were significant. These were no doubt the normal microscopic growth lines. Pilsbry (1893) considers *B. lauta* to be a synonym of *B. lineata* and his copy of Sowerby's drawing (Conch. Icon. xviii, f.5) shows little variation from specimens of *B. lineata* I have seen. Watson (1886), after studying specimens in the British Museum came to the same conclusion. However, as mentioned earlier, photographs of the holotype of *B. lauta* show a feature apparently missed by the early workers. The red axial lines, 8-10 in *B. lineata,* are much more numerous.

Of the other described species, two are yellow, *Bullina callizona* Sakurai and Habe, 1961 with two narrow red spiral stripes and *B. virgo* Habe 1950, with broad red spiral bands.

B. melior has been described earlier; *B. vitrea* Pease, 1860 has two or three fine black spiral lines and *B. deshayesii* Pilsbry, 1894 has a pair of black brown lines.

Only two other species are white with red markings: of these, *B. nobilis* Habe, 1950 has a pair of broad red bands and very heavy axial lines; the shape of the shell is also different. The only other described species, *B. brugierii* A. Adams, 1855 has a tall spire and broad spiral bands.

It is possible that some of these species are synonymous, but until more is known of their anatomy, attempts at erecting new species or synonymising existing species on shell characters alone, will only lead to further confusion.

ACKNOWLEDGEMENTS

I am very grateful to Mr and Mrs M. Hancock of Whangarei for making material available and for the use of their yacht for dredging in the Bay of Islands. I would also like to thank Mr and Mrs N. W. Gardner, Dr F. Climo, of the Dominion Museum, Dr W. F. Ponder of the Australian Museum, Sydney, and Dr J. D. Taylor of the British Museum (Nat. Hist.) for their assistance. To Dr M. C. Miller of the Zoology Dept., University of Auckland, who read this manuscript and offered suggestions, I offer my deepest appreciation.

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THE FAMILY ACTEONIDAE (OPISTHOBRANCHIA, GASTROPODA) IN NEW ZEALAND

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Plate 19

SUMMARY

The New Zealand species of the genus *Pupa* are discussed. The radula of *Pupa kirki* (Hutton, 1873), a New Zealand species, is described and compared with those of *Pupa sulcata* (Gmelin, 1791) and *Pupa suturalis* (A. Adams, 1854) collected from Fiji and Queensland respectively.

A new genus, *Maxacteon*, is erected for *Acteon cratericulatus* Hedley, 1906 and two new species are also described. The shells of two probable new species are described but not named.

INTRODUCTION

During a study of the biology of the bullomorph opisthobranchs many specimens of acteonid opisthobranchs were collected. The most commonly found species in Northern New Zealand is *Pupa kirki,* which shows a wide variation of colour pattern, columellar design and of spiral sculpture. My investigations also throw considerable doubt on the validity of the species *Pupa alba.*

A thorough examination of the anatomy of *Acteon cratericulatus* Hedley, 1906 and two closely related new species, has shown that a new genus must be created for this group of species.

Shells of two other undescribed species of the Acteonidae were seen but, because anatomical information is not available, it is impossible to satisfactorily place these species in an appropriate genus. Although these shells are illustrated, I have refrained from naming them.

TAXONOMY

Genus *Pupa* Roeding, 1798

Type species: *Pupa grisebia* Roeding (= *Bulla solidula* Linné, 1758) designated by Suter, 1913. Synonymy: see Habe, 1955.

Shell thick, solid, ovate, transversely sulcate; spire elevated, acute; aperture longitudinal, narrow and basally rounded; inner lip thickened, callous; columella with large double fold, with or without an upper thin single plait.

Animal with large headshield, with a deep median slit separating shield into two posteriorly projecting lobes. Radula formula usually 5-6.0.5-6. Teeth having large base bearing long recurved denticulate flange arising from outer side. Posteriorly projecting, pointed flange being longer in outer than inner rows and inner rows usually bearing more denticles. Operculate.

Pupa kirki (Hutton, 1873)

Pl. 19, A - C; Fig. 1B, 2A

Synonymy: *Buccinulus kirki* Hutton, 1873.
Buccinulus gracilis Kirk, 1882.
Pupa affinis (A. Adams); Suter, 1913 (in part not of Adams).
Pupa kirki Finlay, 1927.

The shell is well described by Suter (1913:519) as *Pupa affinis.* A large series of shells studied by the author shows that the colour is extremely variable even within one population. The three specimens illustrated show a range from the Bay of Islands, where specimens differ from pure white to those tesselated with black markings. The brown spiral lines, often present in varying degrees, are caused by pigments associated with the periostracum, whereas the black pigment lies within the calcareous part of the shell.

The spiral sculpturing of the shell is variable; some specimens are only grooved at the extremities of the body whorl while others are regularly sculptured. Similarly, in some specimens, a thin upper plait is present above the bifid columellar fold (Pl. 19, B).

The radula is constant in form. Radulae from over fifty specimens, ranging in size, colour and sculpture were examined. The radular formula is 5.0.5. The teeth consist of a large basal plate with an inwardly recurving denticulate flange. On the inner two teeth the flange is about the size of the basal plate and projects posteriorly as a pointed spine over the preceding row of teeth. Five or six large denticles extend from the outer base of the spine.

On the outer three teeth the posterior spine is much longer, extending back over two or three rows of radular teeth. The denticles at the base of the spine are smaller and decrease in number from the third to fifth tooth. The radular teeth of *Pupa sulcata* and *P. suturalis,* from Fiji and Queensland respectively, are illustrated. The radulae of *Pupa solidula* and *Pupa strigosa* Gould, 1859 are very similar and are illustrated by Habe (Habe, 1950).

Pupa alba (Hutton, 1873)

The original description, which was without an illustration, is most inadequate.

> " Ovate, whorls seven, rather deeply equidistantly spirally grooved, and lightly transversely striated; columella with a broad double anterior fold, and a smaller posterior one. White. Length, .35; breadth, .15."

No locality was mentioned but in a subsequent publication it is given as " Auckland " (Hutton, 1880).

This description is totally inadequate and would fit a number of species. Suter (1913) presents a fuller description of the shell but as he notes that the type was lost it is impossible to know whether his specimen was in fact Hutton's species. Finlay (1927) chose a neotype on the following grounds: " For the small *Acteon*-like form common in northern deep-water dredgings, Hutton's *Buccinulus albus* is suitable; the type is lost, but there is only one small New Zealand species, and sufficient data is given in Hutton's diagnosis and measurements to indicate that he des-

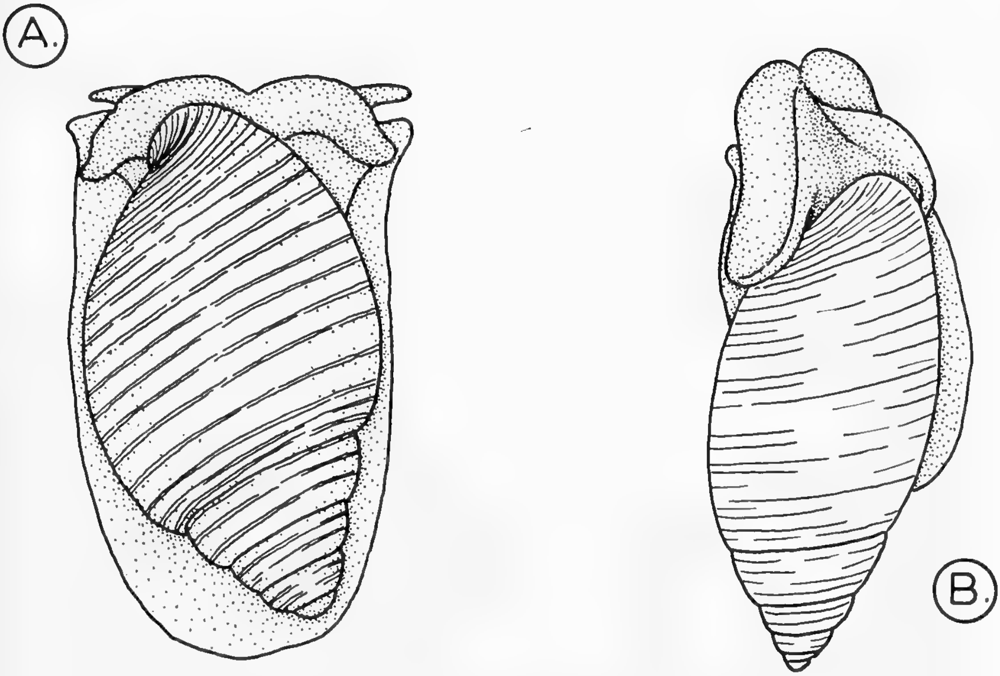

Fig. 1. A, *Maxacteon hancocki* n. sp.; B, *Pupa kirki* (Hutton).

cribed this; as the shell occurs all round the Hauraki Gulf and its precincts, and it is advisable to have a type specimen, I chose as neotype a specimen in the Finlay collection, dredged in the Hauraki Gulf in 25 fathoms."

Neither Suter nor Finlay had seen the type specimen and, as opposed to Finlay, I consider Hutton's description to be quite inadequate. These grounds alone are sufficient to have *Pupa alba* (Hutton, 1873) declared a *nomen nudum.*

Furthermore, a study of specimens labelled *Pupa alba* in private collections and the Dominion Museum, Wellington, indicates that the name has been used as a convenient label for dead deep water specimens of *Pupa kirki.* Specimens of *Pupa kirki* dredged in over 30 fathoms off the entrance to the Bay of Islands show similar shell characters to *Pupa alba* as characterised by Finlay and Suter, but are identical in anatomical and radular features to *Pupa kirki* from shallower water. It would seem therefore that those shells usually identified as *P. alba* are in fact deep water *Pupa kirki,* empty and without a periostracum. The most satisfactory course to follow, therefore, will be to submit to the International Commission on Zoological Nomenclature a request that the taxon *Buccinulus albus* Hutton, 1873 be declared a *nomen nudum.*

Genus *Maxacteon* n. gen.

Type species: *Maxacteon hancocki* n.sp.

Shell oval, more inflated than *Pupa,* aperture longitudinal, more open than *Pupa,* columella truncate bearing single fold, inner lip forming thin callous; spire conical, less than half length of shell. Sculpture consists of regular spiral punctate grooves.

Radula of thirteen or less lateral teeth in each half row. No central tooth. Teeth consist of large basal plate with incurved posteriorly pointing flange, extending into pointed spine. Usually one or two denticles extending from the outer base of the spine.

Animal having headshield bearing a large pair of posteriorly projected fleshy lobes and a small pair of laterally projecting anterior extensions. Foot extending slightly behind the spire of shell. Operculate.

This genus is named after Mr Max Hancock of Whangarei, whose dredging activities from his keeler " Olwen " provided me with much of the material from the Bay of Islands.

Maxacteon hancocki n.sp.

Pl. 19, E - F; Fig. 1A, 2D.

Shell white with orange brown periostracal markings at base and on spire, inflated; spire half height of body whorl; aperture open, upper lip joining halfway up body whorl, basal lip rounded. Columella bearing single fold; inner lip forming slight callous. Sculptured with regular, deeply punctate, spiral grooves. Shell moderately thin. Height not exceeding 6 mm.

Animal as for genus.

Radula formula 8.0.8. Inner two teeth on each side having large basal plate and a large incurving flange bearing one large denticle at the base of a short thick posteriorly projecting spine. The next three teeth have a progressively stouter and longer posterior spine and two basal denticles. The outer three teeth become progressively smaller, the posterior spine becoming shorter and the outer tooth has only one denticle. The outermost tooth has a longer spine than the innermost tooth but is otherwise smaller. Operculum as for *Maxacteon the cratericulatus.*

TYPE MATERIAL: Holotype: a shell measuring 6 mm x 3.2 mm, deposited at the Dominion Museum, Wellington, Reference No. M. 24085. Paratypes: six other shells, Reference No. M. 24086. All specimens were collected from 67 m, west of Deep Water Cove at the entrance to the Bay of Islands, March 15th, 1969.

REMARKS: This species is named after Mr M. Hancock of Whangarei who dredged the first specimens. This species is compared with the others in the final discussion.

Maxacteon cratericulatus (Hedley, 1906)

Pl. 19, G; Fig. 2F.

Synonymy: *Acteon cratericulatus* Hedley, 1906.
Actcon craticulatus Murdoch and Suter, 1906.

As Finlay (1927) has observed, Hedley inadvertedly gave a valid name to this species two months before Murdoch & Suter published their description. A full description of the shell was given by Murdoch & Suter (1906) and was repeated later (Suter, 1913). The salient points of the

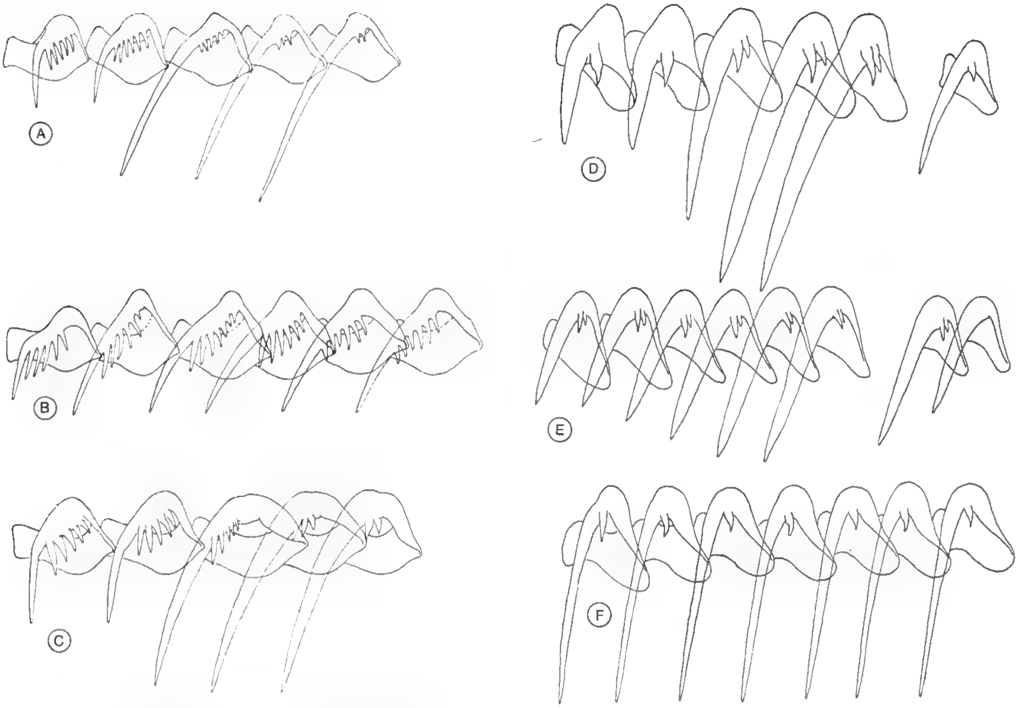

Fig. 2. Radulae. A, *Pupa kirki* (Hutton), 5.0.5; B, *Pupa sulcata* (Gmelin), 6.0.6; C, *Pupa suturalis* (A. Adams), 5.0.5; D, *Maxacteon hancocki* n. sp., 8.0.8; E, *Maxacteon milleri* n. sp. 13.0.13; F, *Maxacteon cratericulatus* (Hedley), 11.0.11.

shell of this species are: Sculpture; numerous narrow, deep punctate spiral grooves; Colour: purple tinge on shell often present on the body whorl, with a clear white region just below the suture, periostracum brown. The shell is less inflated than *M. hancocki* and the other new species, and approaches *Pupa kirki* in general outline. Columella bears a light fold.

Radula formula 11.0.11. Teeth being all of the same shape, having a large basal plate and an incurving flange extended into a long slender posteriorly projecting spine. Each tooth bears a single denticle at base of spine. All the teeth are of similar size except for the outermost which are slightly smaller.

The alimentary canal and operculum have been described (Rudman, 1971).

REMARKS: Only two preserved animals were available for study. One was dredged off Port Fitzroy, Gt. Barrier Is. and the other from the entrance to the Firth of Thames.

Maxacteon milleri n.sp

Pl. 19, I - K; Fig. 2E.

Shell white, with diffuse orange-brown axial markings; inflated, spire depressed, less than one third of the height of body whorl. Sculpture of widely spaced broad punctate grooves; columella thin with single spiral fold. Aperture wide.

Animals as for genus. Radula formula 13.0.13. Teeth having large basal plate with recurved flange extended posteriorly into thick pointed spine. In all but the outermost tooth a pair of denticles extend out at base of spine. Spine increases in length along the row from inner tooth to the sixth, then decreases in size to outermost tooth. Outermost tooth bears no denticles at base of spine. Operculum as for *M. cratericulatus*.

TYPE MATERIAL: Holotype: shell measuring 11 mm x 7 mm is deposited in the Dominion Museum, Wellington, Reference No. M. 24087. The holotype was dredged in 54 m off Cape Brett, Bay of Islands, 8 February, 1970.

REMARKS: This species is quite distinct from any other recorded from either the recent or fossil fauna of New Zealand. Another live specimen of this species was recently collected at the Poor Knight's Islands off the east coast of Northland. *Maxacteon milleri* is named after Dr M. C. Miller of the Zoology Department, University of Auckland, in recognition of his interest and assistance in this work.

Maxacteon ? sp.

Pl. 19, D.

One shell, collected by Mr R. Grace off Ti Point, at the entrance to Whangateau Harbour, north of Auckland, in 3.6 m of water, March 1967, is quite unlike any described species.

Shell inflated, spire high, whorls shouldered, covered with brown periostracum. Sculptured with regularly spaced, narrow, punctate, spiral grooves. Columella bearing single fold.

Animal unknown.

REMARKS: This specimen has been deposited in the Dominion Museum, Wellington, Reference No. M.24088. It is 16 mm in length and 10 mm in width. I consider it unwise to name this species until the animal is available and the radula, at least, examined. The placing of this species in a genus can be no more than provisional, but it is most probably a new species of *Maxacteon*.

Acteon ? sp.

Pl. 19, H

A number of specimens of this small pink species were made available by Mrs D. Greene of Napier. They were washed up at the Mahia Peninsula, Hawke Bay in May 1968.

Shell small, narrow, pink with white subsutural band. Sculpture consisting of widely spaced punctate grooves. Shell solid with polished appearance. Columella with single spiral fold.

REMARKS: As with the last species, this is also most probably a new species. The form of the shell is quite unlike that of *Maxacteon*. As no animals were available it is not possible to either adequately describe the species or to place it in a genus. Two shells have been deposited in the Dominion Museum, Wellington, Reference No. M. 24089.

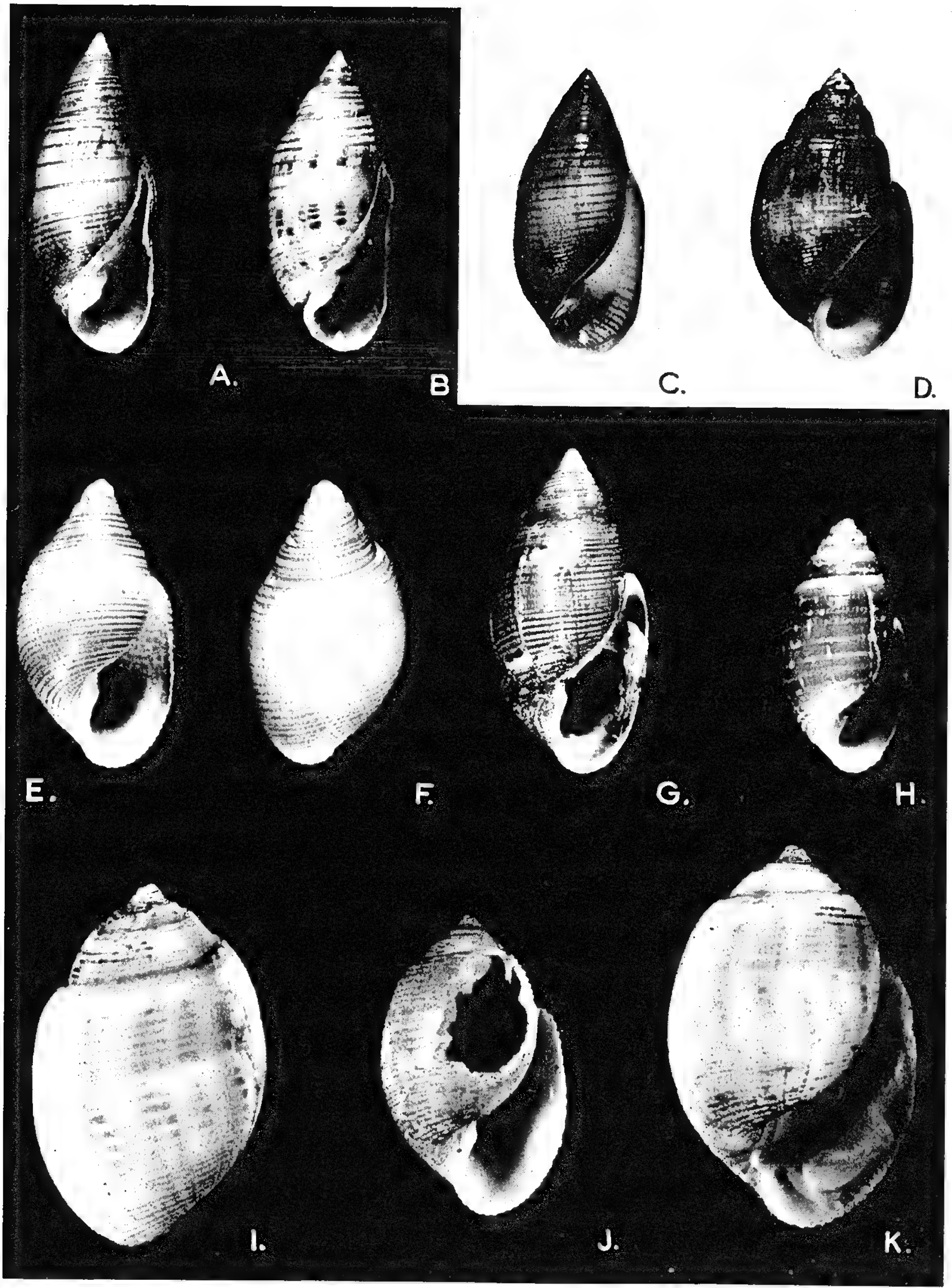

PLATE 19. A-C, *Pupa kirki*. A, white shell, with orange-brown spiral lines, Bay of Islands; 15 x 7 mm; B, white shell with black markings, Bay of Islands, 12 x 5.5 mm; C, dark orange-brown periostracum, Bay of Islands, 13 x 6 mm; D, *Maxacteon?* sp., coll. off Ti Point, Whangateau Harbour, 16 x 10 mm; E-F, *Maxacteon hancocki* n. sp., Holotype. coll. 67 m off Deep Water Cove, Bay of Islands, 6 x 3.2 mm; G, *Maxacteon cratericulatus*, coll. Port Fitzroy, Gt. Barrier Island, 17 x 8.5 mm; H, *Acteon?* sp., coll. Mahia Peninsula, Hawke Bay, 6.5 x 3.5 mm; I-K, *Maxacteon milleri* n. sp., Holotype, coll. off Cape Brett, Bay of Islands, 11 x 7 mm.

Photo — G. W. Batt.

DISCUSSION

In the Acteonidae, as in many other groups of shelled opisthobranchs, most species have been described from the shell alone. While in some cases this has proved adequate for identification, in many instances it is not sufficient.

Similarly, at the generic level adequate definitions are not available. In a study of the literature I have found over seventy species of *Acteon* and *Pupa* described from the shell alone, the distinction between the two genera being simply whether they have a bifid or a simple columellar fold. It is not surprising therefore that authors who have studied the radulae of some species have felt the need to erect new genera. In most cases, these genera have remained monotypic. The simple definition of *Pupa* and *Acteon* on the form of the columellar fold is not adequate.

The anatomy of *Acteon tornatilis* (Linné, 1766), the type species of *Acteon* Montfort, 1810, has been fully studied (Sars, 1878; Fretter, 1939; Fretter & Graham, 1954; Johannson, 1956) and it is possible to define this genus adequately. The shell is similar to *Maxacteon* in having a simple columellar fold, but the two genera differ considerably in anatomical features. The headshield, as in *Pupa,* has a pair of posterior lobes covering the extreme anterior end of the shell. The radula is quite distinct, consisting of countless minute hook-shaped teeth. Although it is not within the scope of this study, my studies of the reproductive system of the Acteonidae show that *Acteon tornatilis* has a quite different system to that of *Pupa* and *Maxacteon.*

Of the genera placed in the Acteonidae, a few have no fold on the columella, and as there is no information on their anatomy, they will not be considered in this discussion. *Pupa* alone has a bifid columellar fold. Excluding *Acteon* and *Maxacteon* the following genera have been erected for species with a simple columellar fold:

Pseudacteon Thiele, 1925, type species *P. albus* (Sowerby, 1873)
Rictaxis Dall, 1871, type species *R. punctocaelatus* (Carpenter, 1864).
Japonacteon Taki, 1956, type species *J. nipponensis* (Yamakawa, 1911).
Punctacteon Habe, 1961, type species (?) *P. fabraeus* (Crosse, 1874).

The radula of *P. albus*, illustrated by Thiele (1925), shows little difference to the illustration of Habe (1956) of *R. punctocaelatus.* The radular formula is 5.0.5. The inner three teeth have a large triangular flange, denticulate along the posterior and outer borders. In the fourth tooth the flange is more elongate and denticulate along the outer edge, while in the outer tooth the flange has become a long, non-denticulate spine. I therefore consider that *Pseudacteon* Thiele, 1925 is a probable junior synonym of *Rictaxis* Dall, 1871.

Japonacteon Taki, 1956 is the subject of a lengthy paper (Taki, 1956). In *J. nipponensis* the radular formula is 6.0.6, the inner lateral tooth consists of a large base and a small denticulate flange. The next four teeth have a large base and a long, broad, posteriorly projecting spine with two or three denticles at the base. The outermost tooth is degenerate. The headshield, unlike that of *Maxacteon,* has only a pair of large posterior lobes. The structure of the stomach and the reproductive system, as described by Taki, are greatly different to those in *Acteon,* or the other genera of the Acteonidae that I have studied, and would suggest that *Japonacteon nipponensis* is either an extremely interesting animal or that Taki is in error.

The final genus to be considered is *Punctacteon* Habe, 1961 described in two lines, in Japanese (Habe, 1961). A subsequent English translation (Habe, 1964) shows that this description is quite inadequate. Habe simply uses this name in an entry describing the shell of *Acteon fabraeus.* This indication does not fulfil the requirements of the International Code of Zoological Nomenclature (1961) on at least two grounds. Article 13 (a) (i) states that for a name to be considered available it must be " accompanied by a statement that purports to give characters differentiating the taxon . . . " and 13 (b) " a genus-group name published after 1930 must . . . be accompanied by a definite fixation of a type-species." *Punctacteon* should therefore be declared a *nomen nudum.*

Maxacteon n.gen. is easily recognisable from other valid genera. It differs from *Pupa* in having a single columellar fold on the shell, in having lateral extensions to the headshield and in the general form of the radula. It differs from *Acteon* s.str. in the shape of the headshield, in the form of the radula and in the structure of the reproductive system. The reproductive system of the Acteonidae is to be discussed in a separate paper.

Unfortunately, as discussed earlier, the other acteonid genera with single columellar folds, are not well defined but *Maxacteon* can be distinguished by the distinctive form of the radula.

The three species of *Maxacteon* are easily separated from one another especially in regard to the shape of the shell and the radula. The shell of *M. cratericulatus* can grow to 17 mm in height and there is often a purple tinge to the body whorl of the shell, with a white subsutural band. The shell is similar to *P. kirki,* the sides of the body whorl being nearly parallel. In contrast, the shell of *M. hancocki* rarely exceeds 6 mm in height in fully mature animals, and the only colouration present is due to the orange-brown of the periostracum. The shell is slightly thinner than either of the other two species and is slightly inflated.

In the case of *M. milleri* the shell of the two specimens that have been found have been 11 and 12 mm in height and thus are much larger than *M. hancocki.* The shell is coloured with diffuse orange-brown axial markings and it is much more inflated than the other two.

As I have described earlier, the radular formulae of the three species are quite distinct. At present the geographical range of each species is distinct, but this is probably a result of the small amount of off-shore collecting that has been done in New Zealand waters. *M. cratericulatus* has only been collected in the Great Barrier Island — Firth of Thames region and *M. hancocki* only from deep-water at the entrance to the Bay of Islands. All that can be said of *M. milleri* is that one specimen has been found at the entrance to the Bay of Islands and another east of the Bay of Islands at the off-shore Poor Knights Island.

It is intended to make a formal submission on *Pupa alba* and *Punctacteon* to the International Commission on Zoological Nomenclature.

ACKNOWLEDGEMENTS

I would like to thank Mr and Mrs M. Hancock, Dr W. F. Ponder and Mrs D. Greene for making specimens available. I must make special mention of Mr and Mrs M. Hancock for their dredging activities in the Bay of Islands and of Dr M. C. Miller of the Zoology Dept., University of Auckland, for critically reading this paper.

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ERRATA SLIP

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W. F. PONDER. Notes on some Australian genera and species of the family Muricidae (Neogastropoda), pp. 215-248: errata.

p. 217, third para. *Jaton decussatus* (Gmelin) is a West African species, not Californian as indicated.

p. 231, third para. Substitute *pumilus* for *pumillus* (also p. 240, fig. 10).

p. 237, 6 lines from bottom of page. Substitute "outer" for "inner".

p. 218, fig. 3. Substitute *Pterotyphis* for *Pterynotus*.

p. 223, fig. 2. Substitute *Pterynotus (Pterochelus)* for *Pterynotus (Pterynotus)*.

p. 240, fig. 10. Substitute *Murexiella* for *Muricopsis*.

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NOTES ON SOME AUSTRALIAN GENERA AND SPECIES OF THE FAMILY MURICIDAE (NEOGASTROPODA)

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Plates 20 - 23.

ABSTRACT

Various genera and Australian species of the Muricidae are discussed and their taxonomic status reviewed, particularly in relation to the structure of their radulae and opercula.

The genus *Pterynotus* and its subgenera are discussed and the Australian occurrences of some species are noted. *Nothotyphis* Fleming is reduced to a synonym of *Tripterotyphis* Pilsbry and Lowe, a subgenus of *Pterotyphis* Jousseaume, and a new subspecies of this group is described. *Galfridus* Iredale is found to be only subgenerically distinct from *Phyllocoma* Tapparone-Canefri and the southern Australian *eburneus* (Petterd) is shown to be a subspecies of the East Coast P. *(G.) speciosa* (Angas). *Tritonidea petterdi* Brazier is a synonym of *Maculotriton bracteatus* (Hinds). Two species of *Aspella; anceps* (Lamarck) and *producta* (Pease), are recognised from Australia. The relationships of *Favartia* are discussed and *Murex confusus* Brazier is placed in this genus. *Murexiella* Clench and Fartante is reduced to a subgenus of *Favartia* and 5 Australian species are included, three of these being new. *Murexsul* Iredale is shown to be a synonym of *Muricopsis* Bucquoy et al and four Australian species are discussed, one being described as new. *Spinidrupa* Habe & Kosuge is probably a subgenus of *Muricopsis*. Several species are recorded from Australia for the first time.

INTRODUCTION

The Muricidae contains some of the more attractive and popular species of neogastropods yet very little is known of their habits, reproductive biology or anatomy. Their classification is based on shell, radular and opercular features but only the shell is known for the vast majority of species. The systematics of this family have suffered, in many instances, from over enthusiastic "splitters" basing taxa on minor shell features. Many species and genera in this family appear to exhibit considerable variation in shell features so that "lumping" will often prove to be a necessity. Before some of the more complex genera can be effectively worked out the examination of large series of specimens will be required. A number of genera containing fewer, sometimes rather inconspicuous (and hence often overlooked) species, are particularly in need of revision and it is to attempt to clarify the status of a few of these genera that is the primary purpose of this paper.

During the course of this work a few new species were encountered and these have been described. In addition, because the Australian occurrences of some of the less common Indo-Pacific species have never been well tabulated, the localities of specimens in the Australian Museum are listed and their registered numbers given so that these species can be recognized as definite members of the Australian fauna.

TAXONOMY

Genus *Pterynotus* Swainson, 1833

Type species: (s.d. Swainson, 1833) *Murex pinnatus* Swainson, 1822 = *alatus* Röding, 1798.

Vokes (1964) described and figured a radula said to be that of *P. pinnatus* (=*alatus*) the central tooth of which had three long cusps on a simple short basal plate. A small specimen from Warrior Reef, north Queensland, in the Australian Museum (Plate 20, fig. 1) contained a dried animal from which a radula was extracted. This proved to be different from Vokes' radula in having a long basal plate and 3 short cusps with small intermediate denticles between them (Text fig. 1:1). The operculum is elongate, with a terminal nucleus.

The radula of *Pterynotus (Pterochelus) acanthopterus* (Lamarck, 1816), (Text fig. 1: 2a, b), the type species of the subgenus *Pterochelus* Jousseaume, 1880, is like that of the Warrior Reef *P. alatus* but the shell differs in having a long spine at the posterior corner of the aperture. The operculae of species of this group (Text fig. 4: 32, 33) are also similar to those of typical *Pterynotus* species.

The recent species of the *acanthopterus* group in Australia *(triformis* Reeve, 1845 and *duffusi* Iredale, 1936) appear to grade into one another and may possibly prove to be all one species. Any attempt at a revision of this group should await the accumulation of much more material than is available at present.

P. (P.) triformis often has a very short posterior spine so that the commonly cited differences between *Pterynotus* and *Pterochelus* are not particularly clear-cut. Examination of the protoconchs, however, shows that the type species of *Pterynotus* has a conical multispiral protoconch, whereas that of *P. (P.) acanthopterus* and its associated " species " is paucispiral with a strongly tilted nucleus. The only other species attributable to typical *Pterynotus* available to the writer that had a partially intact protoconch was *P. patagiatus* (Hedley, 1912). This species agrees with *alatus* in its solid white shell, crisp scabrose sculpture, multispiral protoconch, single inter-variceal nodule, rather long anterior canal and lack of a posterior canal.

Pterynotus tripterus (Born, 1778), a species placed in *Naquetia* by Cernohorsky (1967), also agrees in teleoconch features with *P. alatus*. Cernohorsky describes the protoconch of this species as having " 2 calcified (nuclear) whorls " which suggests that the protoconch was probably eroded. Placement in *Pterynotus* (s.s) seems a much better location for this species, particularly as the type species of *Naquetia* Jousseaume, 1880, *Murex triqueter* Born, 1778, has very different sculpture. Cernohorsky (1967) figured the radula of *triqueter* which appears to be basically like those of *Pterynotus* and *Pterochelus* but differs in the middle cusp of the central tooth being relatively longer, the intermediate cusps vestigial and the outer cusps very short.

Vokes (1964) includes *Rhizophorimurex* Oyama, 1950 (type species *Murex capucinus* Lamarck, 1822) in the synonymy of *Naquetia* but Cernohorsky (1967) correctly includes the species usually interpreted as *capucinus* Röding, 1798 (=*capucinus* Lamarck, = *permaestus* Hedley, 1914) in *Chicoreus* Montfort, 1810 (type species *Murex ramosus* Linnaeus, 1758). Vokes (1970b) has discussed the nomenclature of this species in detail.

Vokes (1964) reduced *Marchia* Jousseaume, 1880 (type species (o.d.) *Murex clavus* Kiener, 1843 = *M. elongatus* Lightfoot, 1786) to a synonym of *Pterynotus* and on teleoconch characters this seems to be a reasonable judgement.

Beu (1970) transferred *Murex bednalli* Brazier, 1877 from *Pterynotus* to *Pteropurpura* Jousseaume, 1880. The operculum (Text fig. 4: 30) and radula (Text fig. 1: 3) of *M. bednalli* were examined and found to be similar to those of *alatus* and *acanthopterus*. The protoconch of this northern Australian species resembles that of *acanthopterus* but there is only a vestige of a posterior canal present. The shell sculpture, light build, and sometimes dark coloured shell all suggest placement in *Pterochelus*.

The radulae of two species attributed to *Pteropurpura* are illustrated (Text figs. 2: 14, 15) for comparison with those of *Pterynotus*. Vokes (1964) has figured the operculum of the West American *P. carpenteri* Dall, 1899 (=*macropterus* Deshayes, 1839, as shown by Emerson, 1964) the type species of the genus. The operculae of the two species from which the radula is figured, is similar in having a latero-terminal nucleus, one being figured here (Text fig. 4: 34). In shell features *Pteropurpura* and *Pterochelus* are almost indistinguishable, species in the two groups even having similar protoconchs. The relationship of *Pteropurpura* to its subgenus *Ocinebrellus* Jousseaume, 1880 is obviously very close and their radulae are also similar (c.f. Text figs. 2: 14, 15) and that of *O. aduncus* (Sowerby, 1834) figured by Vokes (1964). The radulae and operculae of two Californian species, *Jaton decussatus* (Gmelin) and *Shaskyus festivus* (Hinds), have recently been figured (Burch and Campbell, 1963), these species being the types of their respective genera. Both are closely related to *Pteropurpura* and may be only subgenerically distinct.

The Australian occurrences of *Pterynotus* (s.s.) species have been poorly documented. An attempt to list the known records is made below. This is based on material in the Australian Museum and on published information. McMichael (1961) has recently discussed the records of *P. patagiatus* (Hedley).

Pterynotus (Pterynotus) alatus (Röding)

Plate 20, fig. 1; Text fig. 1: 1

1798 *Purpura alata* Röding, *Mus. Bolten.*: 144 (no. 1085) (ref. Martini, 1777, 3, t. 111, figs. 1036, 1037).
1822 *Murex pinnatus* Swainson, *Cat. Coll. Bligh*, App.: 17.
1845 *Murex pellucidus* Reeve, *Conch. Icon. Murex.* pl. 14, sp. 54.

Vokes (1970b) has suggested that an appeal be made to the Internation Commission for Zoological Nomenclature to " conserve the well-known *pinnatus* ". In a clear cut case of unconfused priority such as this, an application probably should not be made, particularly as the name *alatus* is now gaining general usage.

Reeve's illustration of *Murex pellucidus* has a wider variceal flange than most specimens of *alatus* encountered. Dredged specimens usually have this delicate flange developed whereas specimens obtained from shallow water have the solid varices normally associated with *alatus*. The two forms intergrade and are clearly the same species.

Although previously recorded from 30 fathoms, Darnley Island, Torres Strait by Brazier (1877), the specimen cannot now be located in the Macleay Museum. There are specimens in the Australian Museum from the following Australian localities: Warrior Reef, North Queensland (C. 76626); Port Darwin, Northern Territory (C. 55056); vicinity of Cape Moreton, Queensland, trawled (C. 74904).

Pterynotus (Pterynotus) tripterus (Born, 1778)

1778 *Murex tripterus* Born; *Ind. Rer. Nat. Mus. Caes. Vindob.*: 287.
1780 *Murex tripterus* Born; *Test. Mus. Caes. Vindob.*: 291, t. 10, figs. 18, 19.
1967 *Pterynotus (Naquetia) tripterus*. Cernohorsky, *Veliger*, 10 (2): 124, pl. 15, fig. 14.

This species is not uncommon on the Great Barrier Reef, Queensland but was not recorded from Australia by Hedley (1910). Cotton (1956) records the species from Queensland and Northern Australia. There are specimens in the Australian Museum from the following localities in Queensland: Fairfax Island, Bunker Group (C. 69053, C. 77016); Tryon Island, Capricorn Group (C. 76868) (specimen recorded by Kerslake, 1957); Lady Elliot Island, Bunker Group (C. 69173); Mackerel Bay, Hook Island, Whitsunday Group (C. 68998).

Pterynotus (Pterynotus) elongatus (Lightfoot, 1786)

1786 *Murex elongatus* Lightfoot, *Cat. Port. Mus.*: 65 (no. 1479) (ref. Favanne, 1780, pl. 79, fig. H).
1842 *Murex clavus* Kiener, *Spéc. Gen. Icon. Coq. Viv., Murex*: 111 - 112, pl. 37, figs. 2, 2 (non Michelotti, 1841).
1967 *Pterynotus elongatus*. Cernohorsky, *Veliger*, 10 (2): 123, pl. 15, fig. 13.

This very characteristic, elongate species has been reported from Queensland by Cotton (1956) and Kerslake (1957) reported it from Tryon Island. Her specimen is now in the Australian Museum (C. 75770) along with a specimen from Fairfax Island in the Bunker Group (C. 68519).

Pterynotus (Naquetia) triqueter (Born, 1778)

1778 *Murex triqueter* Born, *Ind. Rer. Nat. Mus. Caes. Vindob.*: 288.
1780 *Murex triqueter* Born, *Test. Mus. Caes. Vindob.*: 291, t. 11, figs. 1 - 2.
1967 *Pterynotus (Naquetia) triqueter*. Cernohorsky, *Veliger*, 10 (2): 124, pl. 15, fig. 15; text fig. 6.

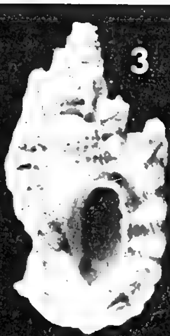
Neither Hedley (1910) nor Cotton (1956) recorded this species from Queensland but Kerslake (1957) reports it from Tryon Island, Queensland, this specimen now being held in the Australian Museum (C. 77007). Other specimens in the Australian Museum are from the following Queensland localities: Fairfax Island, Bunker Group (C. 69053); Brampton Island (C. 77005); West Cay, Diamond Islets, Coral Sea (C. 69165); Herald Cays, Coral Sea (C. 69064; C. 77011).

PLATE 20.

1. *Pterynotus (Pterynotus) alatus* (Röding). Warrior Reef, North Queensland (C. 76626). *
2. *Pterynotus (Pterochelus) acanthopterus* (Lamarck). Broome, North West Australia (C. 76582). *
3. *Pterynotus (Tripterotyphis) lowei norfolkensis* (Fleming). Norfolk Island (C. 59390). *
4. *Pterotyphis (Tripterotyphis) lowei colemani* subsp. nov. Tryon Island, Queensland, holotype, (C. 77189).
5. *Pterotyphis (Prototyphis) zelandicus iredalei* (Fleming). Norfolk Island (C. 59391). *
6. *Pterotyphis (Prototyphis) angasi angasi* (Crosse). Camp Cove, Sydney Harbour, N.S.W. (C. 77139). *
7. *Pterotyphis (Tripterotyphis) robustus* (Verco). Backstairs Passage, South Australia, paratype. (C. 41864).

Scale A: fig. 1 - 2; Scale B: fig. 3 - 7.
* Specimens from which figured radulae obtained.


1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Genus *Pterotyphis* Jousseaume, 1880

Type species: (o.d.) *Typhis pinnatus* Broderip, 1833.

Two subgenera, *Tripterotyphis,* Pilsbry and Lowe and *Prototyphis* subgen. nov. are recognised in the Australian fauna.

Subgenus *Tripterotyphis* Pilsbry and Lowe, 1932

Type species: (o.d.) *Typhis lowei* Pilsbry, 1931.

Synonym: *Nothotyphis* Fleming, 1962 (type species: (o.d.) *Pterynotus (Nothotyphis) norfolkensis* Fleming, 1962).

Keen (1944) and Vella (1961) allow *Pterotyphis* full generic rank and make *Tripterotyphis* a subgenus. The only apparent difference between the two type species is the position of the posterior siphonal tubes. In *Tripterotyphis* they are " wholly concrescent " with the varices, whereas in *Pterotyphis* they lie slightly behind the varices.

Fleming (1962) distinguished a new subgenus (of *Pterynotus*), *Nothotyphis,* from the otherwise almost identical West American species, *Pterotyphis (Tripterotyphis) lowei,* by the " variceal origin " of the siphonal tube. The variceal origin of this tube is shown by the " closure of opposing shell lips over a canal on the front of the varix, leaving a suture to mark the line of closure ". Keen and Campbell (1964) have described the mode of formation of the tube in another West American species, *Pterotyphis (Tripterotyphis) fayae* Keen and Campbell. This description clearly shows a similar formation of the tube to that seen in *Typhis angasi* Crosse, 1863 (see below) and in *norfolkensis.* I would agree with Gertman (1969) that *Tripterotyphis* and *Nothotyphis* should not be retained as separate groups, let alone placed in different " subfamilies ". *P. (T.) lowei* hardly differs at all from *norfolkensis* in shell features and is even closer to the new subspecies described below. These three forms are here regarded as conspecific.

The radula of *Pterotyphis (Tripterotyphis) lowei norfolkensis* (Text fig. 2: 18) is similar to that of " *Typhis* " *angasi* Crosse (Text fig. 2: 16), but the central tooth has a stouter, relatively shorter median cusp and larger lateral denticles.

Pterotyphis (Tripterotyphis) lowei colemani subsp nov.

Plate 20, fig. 4

Shell: Small, yellowish-white, solid, spire about 5/12 height of body whorl and canal. Protoconch of $1\frac{3}{4}$ rounded whorls, the first whorl slightly tilted (from Murray Island specimen). Teleoconch with about 6 very lightly convex whorls, 3 rather thin varices per whorl, each slightly behind that of the previous whorl giving each line of varices a slight twist. Posterior canal enclosed in a tube-like extension of the aperture which protrudes from the upper part of the terminal varix. This siphonal tube is twisted dorsally and orientated posteriorly. It has a line of closure on its ventral (apertural) face, a circular opening and is continued into a buttress-like basal portion behind the varix. Sculpture of low, rather flat, spiral cords, 4 on body whorl and 1 on base, with traces of 4 additional semiobsolete cords on base. The spirals become prominent only where they pass over the varices where they form thick ridges which have deep pits between them on the apertural face of each varix. The cords correspond to the pits between the labial denticles. The whole surface is crossed by irregular axial growth lines and weak, often indistinct, spiral threads. The growth lines become scaly in the pits on the varices. Aperture with raised peristome, anterior siphonal canal closed, straight except for the terminal portion which opens as a narrow tube dorsally. Posterior siphonal canal communicating with aperture by a small hole lying just behind peristome. Inner lip smooth, outer lip with 5 denticles, the 2nd and 3rd being bifid in the holotype.

Dimensions:	Height:	16.86 mm.	Diameter:	8.62 mm.	(holotype)
		15.80 mm.		8.00 mm.	(paratype)

Locality: Tryon Island, Capricorn Group, Southern Queensland, subtidal on reef, collected by N. Coleman, July, 1969 (holotype C. 77189). Paratype in N. Coleman collection.

Additional material examined: Under stone, low tide on reef, Murray Island, Torres Strait, C. Hedley (one juvenile) (C. 29504); on beach, Murray Island, Torres Strait, C. Hedley (one juvenile) (C. 29390); 9-15 metres Murray Island, Torres Strait, C. Hedley (5 juveniles and one subadult) (C. 77278).

Remarks: The holotype of *lowei colemani* differs from *lowei norfolkensis* (Plate 20, fig. 3) in its much larger size (the holotype of *norfolkensis* is 9.5 x 5 mm) and weaker spiral cords. The whorls of the Norfolk Island subspecies are more convex and more impressed at the sutures compared with *colemani*. The varices in *norfolkensis* are thicker, with prominent swellings where the spiral cords cross. In *colemani* they are thin-edged and only slightly crenulated by the cords. There are 4 specimens of *P. (T.) lowei norfolkensis* from Lord Howe Island (collected R. Bell) in the Australian Museum (C. 59576, C. 59577) and these agree very well with Norfolk Island specimens except that they are larger in size, one adult measuring 12.2 x 6.5 mm. *P. (T.) lowei norfolkensis* appears to be restricted to Norfolk and Lord Howe Islands.

Pterotyphis (Tripterotyphis) lowei lowei is similar in size, colour and shape and in most details of sculpture to *colemani*. The siphonal tubes are bent more acutely dorsally in *lowei colemani*. If it were not for the fact that *lowei* is a Central west American species, the Queensland form would hardly be worthy of separation.

Pterotyphis (Tripterotyphis) robustus (Verco, 1895) (Plate 20, fig. 7) which was included in *Nothotyphis* by Fleming (1962), has the spiral cords visible only at the varices where they form strong pillars. The aperture has no prominent denticles and the variceal tubes are much longer, twisted posteriorly and only slightly dorsally.

Subgenus *Prototyphis* subgen. nov.

Type species: *Typhis angasi* Crosse, 1863.

Subgeneric diagnosis: SHELL: small, with medium to long posterior siphonal spines which are wholely or partly closed. Anterior canal rather long, tilted dorsally, almost closed but not completely fused. Varices 3 per whorl, with weak scaly sculpture, bearing the siphonal spines and few, if any, accessory spines. Aperture with smooth margins, peristome extended beyond varix and parietal wall. Protoconch flat-topped with strongly angled periphery; paucispiral. OPERCULUM: simple, with terminal nucleus. RADULA: with short cental teeth, the cusps bent over the basal plate. 3 cusps on central tooth, with small intermediate cusps between them and strong lateral denticles (Text fig. 2: 16, 17).

Remarks: This subgenus is provided for *Typhis angasi*, a species usually included in *Pterynotus* or *Poropteron* by recent writers. Apart from *angasi* (Plate 20, fig. 6), this subgenus also contains the New Zealand species *Typhis zelandicus* Hutton, 1873. A specimen of the Norfolk Island subspecies of *zelandicus*, *iredalei* Fleming, 1962,* is illustrated (Plate 20, fig. 5). *P. (P.) angasi* has been shown (Fleming, 1962) to have two New Zealand subspecies, the Recent *eos* Hutton, 1873 and the Pleistocene *powelli* Fleming, 1962.

This subgenus is similar to *Pterotyphis (Tripterotyphis)* but differs in the simple, thin, scaly varices, subobsolete spiral sculpture, keeled protoconch and smooth peristome. The exact limits of the genera and subgenera in these groups cannot be satisfactorily defined until, at least, more radulae have been examined. Neither of the West American species *(P. (T.) lowei* and *fayae)* have had their protoconchs described, but examination of a specimen of *lowei* shows that this species has a protoconch like that of *P. (T.) norfolkensis.*

Although superficially similar to *Pterynotus (Pterochelus) triformis*, *Prototyphis* species differ in their smaller size, keeled protoconch and, particularly, in the formation of a posterior siphonal tube. In *P. (Pterochelus) acanthopterus* a long spine is usually developed which is superficially very similar to the siphonal tube of *Prototyphis.* This spine, however, does not seem to serve as a functioning posterior canal because, in mature individuals it is closed off at its base and outer end and bypassed over its base by a short groove. It is thus quite different from the analogous structure in *angasi* and *zelandicus.* In these two species the spine is always open at its proximal and distal ends and obviously functions as a siphonal canal. It is never quite fused in *angasi* but is fused in *zelandicus.* Fleming (1962) and Vokes (1970c) have both argued that the *Typhis* — like tube of *Prototyphis* species was produced by the closure of the *Pterochelus* spine. The radular evidence does not seem to support this view.

The South African genus *Poropteron* Jousseaume, 1880 (type species: (o.d.) *Murex uncinarius* Lamarck, 1822) was thought (Finlay, 1927; Iredale and McMichael, 1962), apparently incorrectly, to have close affinity with the species here placed in *Prototyphis.* Vokes (1964) placed *Poropteron* in the " Tritonaliinae " on the basis of its resemblance to *Purpurellus* Jousseaume, 1880. Emerson and D'Attilio (1969) have discussed the relationships of *Purpurellus* which they show to be a subgenus of *Pterynotus.* It has a very similar radula to that of *Pterynotus alatus* but the operculum has an almost central nucleus.

Most of the shell features of *P. uncinarius* agree rather well with *angasi* and *zelandicus* except that the long, curved, hollow posterior spines that are characteristic of the genus are not open to the aperture and are thus not siphonal structures. Possibly this genus is related to *Pterynotus* but as yet the radula and operculum have not been described.

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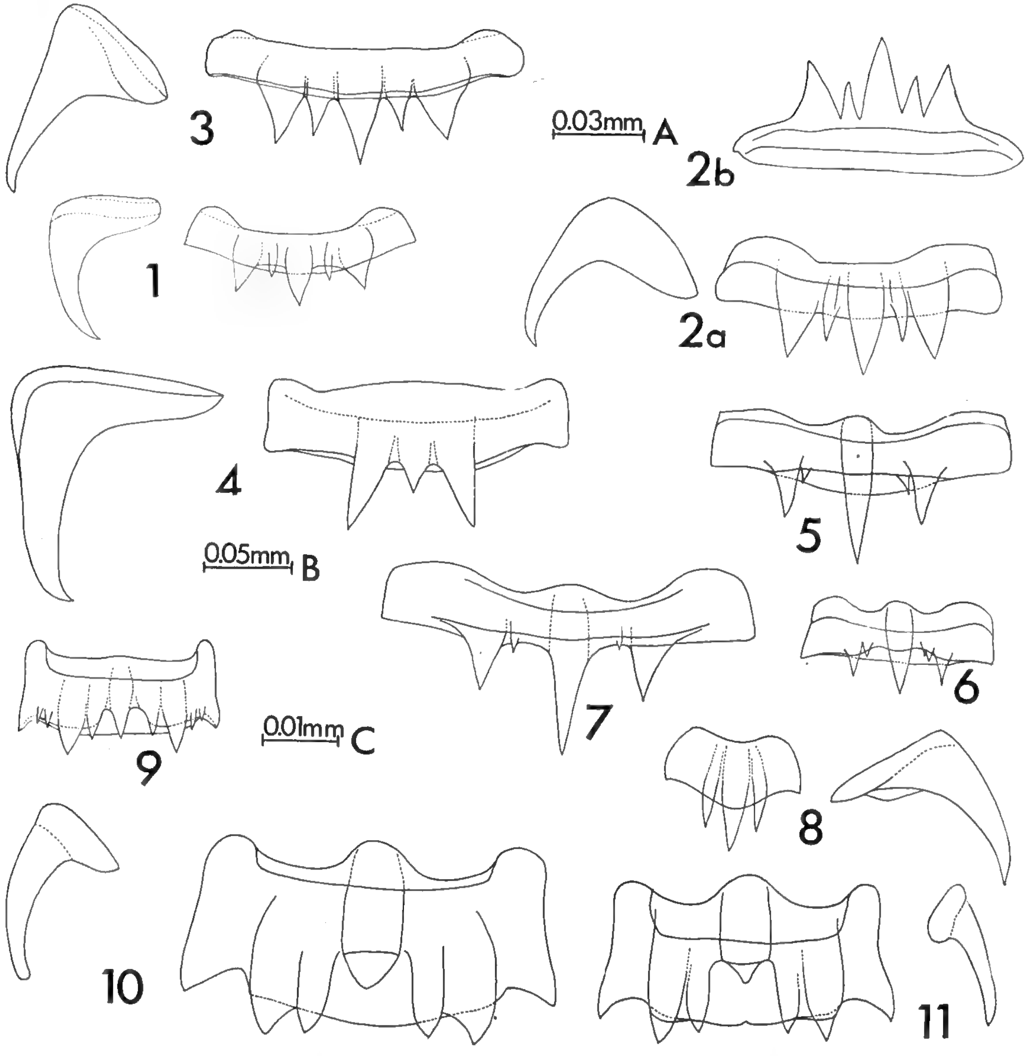
* Gertman (1969) suggests that this subspecies may be *Murex canaliferus* Sowerby, 1841.



TEXT FIG. 1. Radular teeth.

1. *Pterynotus (Pterynotus) alatus* (Röding). Warrior Reef, North Queensland (C. 76626).

2a, b. *Pterynotus (Pterynotus) acanthopterus* (Lamarck). Broome, North West Australia (C. 76582).

3. *Pterynotus (Pterochelus) bednalli* (Brazier). Swires Bluff, Darwin Harbour, Northern Territory (C. 71742).

4. *Phyllocoma (Galfridus) speciosa speciosa* (Angas). Watson's Bay, Sydney, N.S.W. (C. 76669).

5, 6. *Maculotriton bracteatus* (Hinds). Lady Musgrave Island, Bunker Group, Queensland (C. 77187).

7. *Phrygiomurex sculptilis* (Reeve). Funafuti, Ellice Islands (C. 5996).

8. *Phyllocoma (Phyllocoma) convoluta* (Broderip). Suva Harbour, Fiji (C. 67022).

9. *Favartia (Murexiella) brazieri* (Angas). Vaucluse, Sydney, N.S.W. (C. 6379).

10. *Favartia (Murexiella) salmoneus* (Melvill and Standen). 9 - 15 metres, Murray Island, Torres Strait (C. 29961).

11. *Favartia (Murexiella) striasquamosa* sp. nov. Lindeman Island, Queensland, holotype (C. 76670).

Scale A: fig. 1 - 4; Scale B: fig. 5 - 8; Scale C: fig. 9 - 11.

Discussion on the Typhinae

The method of formation of the siphonal tube in the more typical members of the " Typhinae " is like that seen in *Pterotyphis (Tripterotyphis)* and *P. (Prototyphis)* but in the more modified genera the tubes lie between the varices. In *Pterotyphis* s.s. the tube has moved back a little behind the varix and in *Typhis* s.s. lies midway between the varices. In *T. (Typhisopsis)* Jousseaume, 1880 the tube has migrated back to lie in front of the preceding varix. It is thus formed just in advance of each varix. In all cases an indistinct line of fusion is seen running from the edge of the varix to the base of the tube and along its ventral face. Internally the opening of the last tube is seen as a small aperture (these apertures are sealed off behind). Intervariceal specimens of *Typhis* (s.l.) species are rarely seen and it would appear that the growth of the shell between the varices is rapid to avoid a prolonged period with the shell lacking any strengthening at the edge of the aperture. In addition, the relationship of the pallial structures to the narrow posterior siphonal aperture would be upset during growth.

The advantages of the posterior siphonal tube are analogous to the notch of the turrids and bursids which has been developed in the posterior corner of the aperture. Waste material can be disposed of well clear of the head foot and the anterior siphon. In addition the shell can remain partially buried in mud or sand and as long as the anterior siphon has contact with the surface respiration should proceed normally.

Some species of *Typhis* (s.l.) have variceal spines as well as the intervariceal siphonal tubes. These spines however, do not open in to the aperture and are only ornamental. The Typhinae are thus, at least on shell features, rather distinctive, but the radula of *Typhis (Haustellotyphis) cumingii* (Broderip) as figured by Thiele (1929) and described by Vokes (1964) as typical of the Typhinae, is by no means the only type encountered. An Australian species, *Typhis (Typhina) philippensis interpres* (Iredale, 1924) examined by the writer has a radula typical of the Muricinae (Text fig. 2: 19).

The " Typhinae " would appear to represent a specialized off-shoot from the " Muricinae ". As with the other so-called subfamilies of the Muricidae the limits are difficult to define. *Prototyphis* for example is certainly on the borderline of the two subfamilies.

Genus *Phyllocoma* Tapparone-Canefri, 1881

Type species: (monotypy) *Triton convolutus* Broderip, 1833.
Synonym: *Craspedotriton* Dall, 1904 (type species: (o.d.) *Triton convolutus* Broderip).

Subgenus *Phyllocoma* ss.

1833 *Triton convolutus* Broderip, *Proc. Zool. Soc. Lond.*: 7.

Phyllocoma (Phyllocoma) convolutus (Broderip, 1833)

Plate 23, fig. 10; Text fig. 1: 8

Cotton (1956) records *P. (P.) convoluta* from Darwin, northern Australia and there is a juvenile specimen in the Australian Museum found in a fish stomach in the " Capricorn Group ", Queensland (C. 76937). There are specimens in the Australian Museum collections from Mauritius

(C. 77286), Fiji (C. 67022, C. 67460), Lifu, Loyalty Islands (C. 28701) and Santa Cruz Islands, S. Pacific (C. 4210). A specimen from Fiji is figured (Plate 23, fig. 10) for comparison with P. *(Galfridus) speciosa* (Angas).

Subgenus *Galfridus* Iredale, 1924

Type species: (o.d.) *Triton speciosus* Angas, 1871.

Most Australian writers have given *Galfridus* full generic status (Cotton, 1956; Macpherson and Gabriel, 1962, etc.). Thiele (1929) regarded *Galfridus* as a subgenus of *Phyllocoma* and this was followed by Wenz (1941). The shells of the type species of both groups are similar (c.f. Plate 23, figs. 9, 10) being spirally sculptured with distinct, rounded varices, convex whorls, inflated body whorls, and simple apertures with a narrowly open canal of moderate length.* The protoconch of *P. convoluta* has not been described and the species is apparently normally decollate. *G. speciosa* often retains the protoconch, although decollate specimens are not uncommon. The protoconch of *speciosa* (figured by Kesteven, 1902) is of about 1¾ convex whorls with indistinct spiral scratches. Normal specimens of *convoluta* have only 2 varices per whorl, *speciosa* usually has between 2 and 7. Both species have axial striae but this is stronger in *speciosa.*

The operculum of *speciosa* (Text fig. 4: 36) has been previously figured by Kesteven (1902) although his drawing does not depict the position of the nucleus accurately. In both *speciosa* and *convoluta* the reddish operculum has the nucleus in a lateroterminal position and they are nearly identical in all other features.

Thiele's (1929) illustration of the radula of *speciosa,* which is copied from Kesteven (1902), shows the central tooth having 3 almost equal cusps, the middle one being very slightly longer. The radulae of 2 specimens from N.S.W. were examined and these were found to be nearly identical and differ considerably from Kesteven's illustration (Text fig. 1: 4). The central teeth are wide, with the 3 cusps close together, the central cusp being shorter than the lateral cusps — but varying a little in relative length between the two specimens examined. The basal plate bears lateral protruberances and the lateral teeth are large and simple.

The radula of a specimen of *Phyllocoma convoluta* from Fiji was examined (Text fig. 1: 8) and found to have similar central teeth to those of *speciosa* but they have a shorter, relatively deeper base, massive, curved central cusps and smaller lateral cusps. The lateral teeth are relatively very large and there is a peculiar, elongate bulge at the base of the single cusp on each tooth.

In view of the similarity in teleoconch and opercular features and the general similarity of the radula, *Phyllocoma* and *Galfridus* should be regarded as belonging to the one genus-group. The differences in the radula, however, appear to be sufficient to warrant subgeneric separation.

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* Iredale (1924) states that *Phyllocoma convoluta* has a closed canal, but this does not appear to be the case.

Phyllocoma (Galfridus) speciosa (Angas, 1871)

Plate 23, fig. 9; Text fig. 1:4, 4:36

1871 *Triton speciosus* Angas, *Proc. Zool. Soc. Lond.*: 13, pl. 1, fig. 7.

P. (G.) speciosa appears to exist as 3 subspecies. The southern Australian form *eburnea* Petterd, 1884, has been given full specific status but agrees with *speciosa speciosa* from south eastern Australia (N.S.W.) in nearly every way except that it usually has 2-3 varices per whorl, compared with 5-7 in the N.S.W. form. This form extends at least as far north as the Richmond River area (C. 76905, C. 76906) in N.S.W. and there is one broken specimen from 115-124 metres off Cape Moreton, Queensland, in the Australian Museum (C. 73518). 4 specimens from Lindeman Island, Whitsunday Passage, Queensland (C. 77282) are very similar to N.S.W. shells. A specimen from Malacoota, eastern Victoria, is intermediate between *speciosa* and *eburnea* (C. 50552).The similarity between these forms was recognized by Hedley (1913) who discussed the synonyms of this species. *Trophon virginalis* Suter, 1913 from northern New Zealand is probably a third geographic subspecies of *speciosa.*

Genus *Maculotriton* Dall, 1904

Type species: (o.d.) *Triton bracteatus* Hinds, 1844.

Maculotriton is distinguished from other muricoid genera by its small size, tall spire, axial ribs crossed by fine spiral cords that do not form spines or knobs. Usually no additional varices are formed except perhaps for a few on the body whorl. The protoconch is conical and consists of about 4 whorls. In many ways the shell has more the appearance of a small cymatiid or ' triton ' than a muricid.

The radula of *M. bracteatus* (Text figs. 1: 5, 6), previously figured by Pilsbry & Vanatta (1904) shows a strong resemblance to that of *Phrygiomurex sculptilis* (Reeve, 1844) which has been described and figured by Arakawa (1965). The operculum is simple, yellow, with a terminal nucleus.

This genus was considered to be a subgenus of *Drupa* Röding, 1798 by Thiele (1929) and Wenz (1941). The shell, opercular and radular features (see Cernohorsky, 1969) of the type species of *Drupa, D. morum* Röding, 1798, are very different from those of *Maculotriton.*

Cernohorsky (1969) records *M. egregius* (Reeve, 1844) from Fiji. This figure and description do not agree at all with Reeve's shell and it is doubtful if the species figured by Cernohorsky is a *Maculotriton.*

Maculotriton bracteatus (Hinds, 1844).

Plate 23, figs. 1-5; Text fig. 1: 5, 6.

1844 *Triton bracteatus* Hinds, *Proc. Zool. Soc.*: 21.
1848 *Columbella epidelia* Duclos (in Chenu), *Illust. Conch., Columbella* (1843 - 1858) : pl. 25, figs 17-18.
1872 *Tritonidea petterdi* Brazier, *Proc. Zool. Soc.*: 22.
1896 *Clathurella* (?) *waterhouseae* Brazier, *Proc. Linn. Soc. N.S.W.*, 21: 345.
1904 *Maculotriton bracteatus longus* Pilsbry and Vanatta, *Proc. Acad. Natr. Sci. Phil.*: 595.

Hedley (1906) showed that *Cantharus waterhouseae* and *Columbella epidelia* were synonyms of *M. bracteatus*. The specimen figured by Hedley (1906) as the type of *waterhouseae* is actually the specimen mentioned by Brazier in the footnote to his description. The holotype is here figured for the first time (pl. 23, fig. 5).

The holotype of *Tritonidea petterdi* Brazier (Plate 23, fig. 1) has never previously been figured. Tate & May (1901) showed that the type locality given by Brazier as " N.E. Coast of Tasmania " was incorrect and that the holotype was actually found on " Bird Island, N.E. Australia ". This species has been known only from the holotype which proves to be a worn and faded specimen of *M. bracteatus.*

The shell of *M. bracteatus* is rather variable in size, colour and sculpture (c.f. figs. 1-5). It does not develop a varix until reaching maturity but, especially in cooler waters, may continue growing and add additional varices on the body whorl. There is usually a characteristic pattern of black spots on the axial ribs, although these are sometimes sparse or absent. Such unicolored forms resemble *digitale* Reeve, 1844 which may also prove to be a synonym.

M. bracteatus is a relatively common species in the Central Indo-Pacific and extends along the eastern Australian coast from central N.S.W. northwards. It also occurs at Lord Howe Island, New Caledonia, Kermadec Islands (Oliver, 1915), and Japan. The Japanese form has been separated as a subspecies, *longus*, but there are no consistent observable differences between Japanese shells and those from other areas. Cernohorsky (1969) does not record this species from Fiji. There are two specimens in the Australian Museum (C. 70621) from Sovi Bay, Viti Levu, Fiji.

Genus *Phrygiomurex* Dall, 1904

Type species: (o.d.) *Triton sculptilis* Reeve, 1844.

This monotypic genus is close to *Maculotriton* in radular features (cf. Text figs. 1: 5, 6, 7) but there are differences in the shell and operculum between the two type species. The shell has deeply channelled sutures and quite different sculpture from that of *Maculotriton.* The protoconch of *sculptilis* is decollated in all specimens seen by the writer so that this is probably a normal habit of the species. *Maculotriton* species retain the protoconch. The operculum is opaque, deep reddish-brown and has a baso-lateral nucleus.

Phrygiomurex sculptilis (Reeve, 1844)

Text fig. 1: 7

1844 *Triton sculptilis* Reeve, *Conch. Icon.* 2, *Triton*, pl. 18, fig. 76.

P. sculptilis is represented in the Australian Museum collections from Bird Islet, Wreck Reef, Queensland (C. 76998), and Angourie, northern N.S.W. (C. 76999) and has an otherwise wide Indo-Pacific distribution. It has not previously been recorded from Australia.

Genus *Aspella* Mörch, 1877

Type species: (monotypy) *Ranella anceps* Lamarck, 1822.

Subgenus *Aspella* s.s.

Hertlein & Strong (1951) have discussed this genus in some considerable detail. Its relationships are rather obscure. It certainly does not have much in common with *Favartia* Jousseaume, 1880 which is sometimes regarded as a subgenus (Thiele, 1929; Wenz, 1941; Vokes, 1964). Emerson and D'Attilio (1970b) figure the radula and operculum of their *Aspella (Dermomurex) myrakeenae.*

The radula of a specimen of *A. (A.) anceps* from Woolgoolga, N.S.W., is figured (Text fig. 2: 12). It is of the typical muricid pattern with a wide central tooth with 3 main cusps, between which lie two prominent intermediate cusps. The central cusp is largest and there are no accessory denticles. The lateral teeth are simple and normal. The operculum has a terminal nucleus, is yellowish and simple.

Aspella undata Hedley, 1907 belongs to the Turridae (subfamily Mangeliinae), although it does not fit exactly into any of the known genera.

M. Smith (1953) lists "*Aspella australis* Dall Mss. name? Australia" and "*A. ceylonensis* Dall holotype in U. S. N. M. Ceylon". Neither of these names appear to have been published and must be regarded as *nomena nuda.*

Aspella (Aspella) anceps (Lamarck, 1822)

Plate 23, fig. 7; Text fig. 2: 12

1822 *Ranella anceps* Lamarck, *Anim. Sans. Vert.*, 7: 154.
1833 *Ranella pyramidalis* Broderip, *Proc. Comm. Sci. Corres., Zool. Soc. Lond.* (1832), 25: 194.
1835 *Ranella pyramidalis.* Sowerby, *Conch. Illust. (Ranella)*, fig. 2.
1842 *Ranella anceps.* Kiener, *Coq. Viv. (Genre Ranella)*, p. 36, pl. 4, fig. 2.
1844 *Ranella anceps.* Reeve, *Conch. Icon.* 2 *(Ranella)*, pl. 8, fig. 43.
1961 *Aspella (Aspella) anceps.* Warmke & Abbott, *Caribbean Seashells*, p. 108, pl. 19, fig. C.
1964 *Aspella anceps.* Habe, *Shells of the Western Pacific in Colour* 2: 83, pl. 27, fig. 3.

Lamarck's type specimen from unknown locality has apparently not been figured but his brief description and the dimensions he gives suggest that *anceps* is probably the small, smooth species found not uncommonly in N.S.W. and Queensland. Bartsch (1915) has cited the west coast of America as the type locality but Keen (1958) does not record this species.

Hertlein & Strong separate *pyramidalis* Broderip and *anceps*, and Keen (1958) refers to the Central West American species by the former name. Sowerby's figure of Broderip's species shows a shell identical to that of Reeve's and Kiener's figure of *cnceps* in that it has only two axial folds between each of the lateral varices and extremely weak spiral sculpture. *Ranella hastula* Reeve, 1844 *(Conch. Icon.* pl. 8, fig. 42) is similar and may be the same species. Probably, with careful examination of good series of material, this species will be split into several geographic forms. One name, *acuticostata* Turton, 1892, is already available for the South African form.

The Australian Museum has specimens of this species from the following localities: Taboga Island, Panama (C. 79035); Lifu, Loyalty Islands (C. 76872, C. 76871, C. 25705); Port of Noumea, New Caledonia (C. 76875); Akamaru, Paumotus (C. 28273); Pearl Harbour, Hawaiian Islands (C. 48227); Torres Strait, N. Qld. (C. 8066); Murray Is., Torres Strait (C. 29555); off Port Darwin, N.T. (C. 76873); Broome, W.A. (C. 68507); Cottesloe, W.A. (C. 10469); Morris Is., Qld. (C. 69481); Masthead

Reef, Qld. (C. 19019); Lindeman Is., Qld. (C. 76870); Wilsons Beach, Wooli, N.S.W. (C. 76874); Woolgoolga, N.S.W. (C. 76023, C. 76671); Port Stephens, N.S.W. (C. 8469); Catherine Hill Bay, N.S.W. (C. 10441); Collaroy Beach, N.S.W. (C. 48844). Warrior Reef, Torres Strait and Katow, New Guinea specimens (recorded by Brazier, 1877) are in the Macleay Museum, Sydney.

Aspella (Aspella) producta (Pease, 1861)

Plate 4, fig. 8

1861 *Ranella producta* Pease, *Proc. Zool. Soc.*: 397.

1958 *Aspella (Aspella) pyramidalis* Keen, *Seashells of Tropical West America*: 364, fig. 376 (not of Broderip).

1965 *Ranella producta*. Kay, *Bull. Brit. Mus. (Nat. Hist.) Zool. Suppl.* 1: 37, pl. 6, figs. 17, 18 (holotype).

Pease's name appears to be the most satisfactory to use for the species figured by Keen (1958) as *pyramidalis.* It differs from *anceps* in its larger shell (up to 20 mm in length) and its much coarser spiral cords which render the 3 axial ribs, lying between the varices, nodulous.

This species, like *anceps*, has a wide distribution: Hawaiian Islands (type); Central West America and Galapagos Islands (Keen, 1958); Mauritius (C. 76876, C. 76877, C. 4960); New Hebrides (C. 76878); Murray Island, Torres Strait (C. 76879); Low Isles, off Port Douglas, Queensland (C. 76881); Michaelmas Cay, Queensland (C. 76880); Palm Island, Queensland (C. 9653).

Genus *Favartia* Jousseaume, 1880

Type species: (o.d.) *Murex breviculus* Sowerby, 1834.

Subgenus *Favartia* s.s.

Although some authors (see above) regard *Favartia* as a subgenus of *Aspella*, Cernohorsky (1967) gave it full generic status and described the operculum of the type species. *F. brevicula* has very different shell features and a different radula (Text fig. 2: 21) from those of *Aspella.* The opportunity is taken to figure the radula of the common Florida-West Indian *F. cellulosa* (Conrad, 1846) for comparison with the type species (Text fig. 2: 22).

In the North American group *Maxwellia* Baily, 1950 (type species (o.d.) *Murex gemma* Sowerby, 1879) which contains at least one other species *(M. santarosana* Dall, 1905) apart from the type, the shell and opercular features are very similar to those of *Favartia* species. The operculum has become thickened throughout and the concentric ridges are even more conspicuous. *Maxwellia* could probably be regarded as a subgenus of *Favartia*, and although the radula of neither of the species has been described, Vokes (1970a) states that it is identical in both species. She also notes the resemblance of *Maxwellia* to *Murexiella* (see below) and *Favartia.*

F. (F.) tetragona (Broderip, 1833) was recorded from Bet Island, Torres Strait in 11 fathoms by Brazier (1877) but his specimen has been lost and thus this record cannot be confirmed.

Favartia (Favartia) brevicula (Sowerby, 1834)

Plate 22, fig. 1; Text fig. 2: 21

1834 *Murex breviculus* Sowerby, *Conch. Illust.*, Murex, fig. 37.
1967 *Favartia brevicula.* Cernohorsky; *Veliger*, 10(2): 126, pl. 15, fig. 19, text fig. 8.

The operculum of *F. (F.) brevicula* is rather distinctive. It has the lateral borders thinner than the remainder. These borders are sometimes yellowish, becoming, with maturity, red-brown and thickened like the remainder of the operculum. The surface is relatively strongly concentrically ridged and the nucleus is terminal, although the thinner borders make the otherwise leaf-shaped operculum almost circular (Text fig. 4: 35).

F. (F.) brevicula is represented in the Australian Museum collections from Murray Island, Torres Strait (C. 29465); Lady Elliot Island, Queensland (C. 69172); Hazelwood Island, Whitsunday Passage, Queensland (C. 77287); Reef off Kurrimine Beach, near Silkwood, Queensland (C. 79036); and " north west Australia " (exact locality unknown) (C. 49711), as well as specimens from other Indo-Pacific localities.

Favartia (Favartia) confusa (Brazier, 1877)

Plate 22, fig. 5; Text fig. 2: 20a, b

1877 *Murex (Ocinebra) confusa* Brazier, *Proc. Linn. Soc. N.S.W.*, 1: 172.
1901 *Murex confusus.* Hedley, *Rec. Aust. Mus.*, 4: 123, pl. 16, fig. 4.

F. (F.) confusa is a typical *Favartia*, its radula (Text fig. 2: 20a, b) being similar to that of *brevicula*. The operculum is also like that of *brevicula* except that the borders are narrower so that the operculum is more narrowly oval than in *brevicula*, but otherwise they are very similar.

This species is represented by only three specimens in the Australian Museum, one being the holotype (C. 77183) from 55 metres, Darnley Island, Torres Strait. The other specimens are from 9-15 metres, Murray Island, Torres Strait (C. 29965) and Caloundra, Queensland (C. 79037).

Subgenus *Subpterynotus* Olsson and Harbison, 1953

Type species: (o.d.) *Murex textilis* Gabb, 1873.

This subgenus has been discussed by Vokes (1968) in detail. The type species is a Floridian to central American Miocene-Pliocene fossil.

Vokes recognised only one Recent species, *Murex exquisitus* Sowerby, 1904 as a *Subpterynotus*. Sowerby's species was described from unknown habitat and apparently has not been recollected.

The South Australian species *Murex tatei* Verco, 1895 and its Pliocene fore-runner *Homalocantha antecedens* Ludbrook, 1957 appear to be two further species of *Subpterynotus*.

Vokes (1964) made *Subpterynotus* a synonym of *Pterynotus* but later (1968) used it as a subgenus of *Murexiella*. The group seems to be closely related to *Murexiella* and *Favartia* and is retained as a subgenus pending further information. The radula of *F. (S.) tatei* has not been seen but the operculum is like that of *Favartia* and *Murexiella*, being deep red, with prominent external growth ridges and with a terminal nucleus.

Subgenus *Murexiella* Clench and Farfante, 1945

Type species: (o.d.) *Murex hidalgoi* Crosse, 1869.
Synonym: *Minnimurex* Woolacott, 1957, type species: (o.d.) *Minnimurex phantom* Woolacott, 1957.

Murexiella resembles, in many ways, *Favartia*, but some species produce spines and the shells of most species are smaller, lighter in build and more delicately sculptured. Shell features are not consistently different in species ascribed to both groups and because of the similarity in radular structure and opercular features, *Murexiella* can be regarded, at best, as being only subgenerically distinct from *Favartia*.

Vokes (1968, 1970a) discusses the characteristics of this group in detail and she (1968) and Emerson and D'Attilio (1970a) illustrate the radula of the type species which lives in deepwater off the Lesser Antilles. The distinctive features of the genus according to Vokes (1970a) are the " almost circular aperture with no anal notch and from 4 to 10 foliaceous varices, which have the fronds connected by a complex laminated webbing ". The type species has long spines but in many closely related forms these spines are short or rudimentary and the varices rather heavy.

This subgenus appears to be rather wide-spread but many of the species that probably fall within this group have not yet been formally included in it. One such species is *Murex pumillus* A. Adams, 1854, from Mauritius which is figured (Plate 22, fig. 10) for comparison with *F. (M.) salmonea* (Melvill and Standen) which it somewhat resembles. The radula from this specimen is also figured (Text fig. 2: 13).

Favartia (Murexiella) salmonea (Melvill and Standen, 1899)

Plate 21, figs. 1, 2; Text fig. 1: 10

1899 *Murex (Ocinebra) salmoneus* Melvill and Standen, *J. Linn. Soc. Zool.*, 27: 162, pl. 10, fig. 2.

This species is characterised by its relatively thick shell, pink colour, heavy varices (5-6 per whorl) and 7-11 (usually 8) spiral cords on the body whorl and base. The small protoconch has 2½ whorls.

Height:	12.5 mm.	Diameter:	6.0 mm.	(holotype).
	12.90 mm.		7.85 mm.	(Swain Reefs)
	12.80 mm.		7.40 mm.	(Torres Strait)

The radula of a specimen from Torres Strait (Text fig. 1: 10) has relatively deep central teeth which have a short, strong median cusp located above the two pairs of lateral cusps. The lateral teeth are relatively small. This radula is very like that of *Murexiella hidalgoi* (Crosse) illustrated by Emerson and D'Attilio (1970). The operculum of the same specimen is red-brown, oval, with wide non-thickened, yellowish lateral borders, a terminal nucleus and distinct growth lines.

Localities: 9-15 metres, Murray Is., Torres Strait (C. 29961); 64-73 metres, off Gillett Cay, Swain Reefs, Queensland (C. 77193).

Remarks: Melvill and Standen described this species from Torres Strait and the type (in the British Museum) is narrower than the specimens in the Australian Museum but these do not appear to differ in other ways. Specimens in the Australian Museum collection labelled *salmonea* by Hedley are mostly a new species described below.

Favartia (Murexiella) voorwindei sp. nov.

Plate 21, fig. 4.

Shell: Small, rather lightly built, with thin, flaring varices, short spire and broad body whorl. Protoconch rather large, of 1½ whorls, the tip bulbous and strongly tilted. Teleoconch of 4¾ strongly convex whorls, with 2 prominent spiral cords and 6-7 (usually 7) varices per whorl; fewer on the body whorl (5-6). Varices delicate, rather thin when not worn, with short, curved, hollow spines on their edges. Lattice-like sculpture lies between the variceal ribs on the ventral face of each varix. Delicate laminate axials and very minute spiral striae make up the minor sculpture. 7 spirals on body whorl and base, lower 2 just above a conspicuous fasciole. There are no secondary ribs in the rather wide interstices but an extremely weak secondary spine is sometimes found between primary spines on the varices. Anterior canal moderately long, somewhat curved dorsally, narrowly open. Aperture small, with inner lip raised, smooth. Outer lip with shallow grooves running into the aperture which correspond to the external spiral ribs. Colour white (all specimens dead).

Dimensions: Height: 10.75 mm. Diameter: 6.94 mm. (holotype)
9.26 mm. 6.00 mm. (paratype)

Locality: 64-73 metres off Gillett Cay, Swain Reefs, Queensland. Collected by Australian Museum Swain Reefs Expedition, Oct. 1962, (C. 77194) holotype and 8 paratypes (C. 77195).

The new species is closest to *salmonea* from which it differs in its fewer, thinner varices (8 on spire whorl in *salmonea*, 6-7 (usually 7) in *voorwindei*), lighter build, shorter spire and hence relatively broader shell, and different protoconch — *salmonea* has 2½ whorls, *voorwindei* has 1½. The spiral cords are often bifid or trifid in *salmonea* whereas they are simple (single) in *voorwindei* and a small secondary spiral (which forms a weak variceal spine) is seen in the former species. In addition *salmonea* has the anterior canal turned dorsally, more sharply. Two specimens of *salmonea* were found in the same dredging as *voorwindei*, showing that the two species are not ecotypic forms.

The new species is named for Mr. Jacques Voorwinde, an honorary member of the Department of Malacology of the Australian Museum. Mr. Voorwinde tirelessly sorted the Swain Reefs dredgings, although this is but a minor part of his total contribution.

PLATE 21.

1, 2. *Favartia (Murexiella) salmoneus* (Melvill and Standen). 1 — 64 - 73 metres off Gillett Cay, Swain Reefs, Queensland (C. 77193); 2 — 9 - 15 metres, Murray Island, Torres Strait (C. 29961). *

3. *Favartia (Murexiella) iredalei* sp. nov. Lord Howe Island, holotype (C. 77180).

4. *Favartia (Murexiella) voorwindei* sp. nov. 64 - 73 metres off Gillett Cay, Swain Reefs, Queensland, holotype (C. 77194).

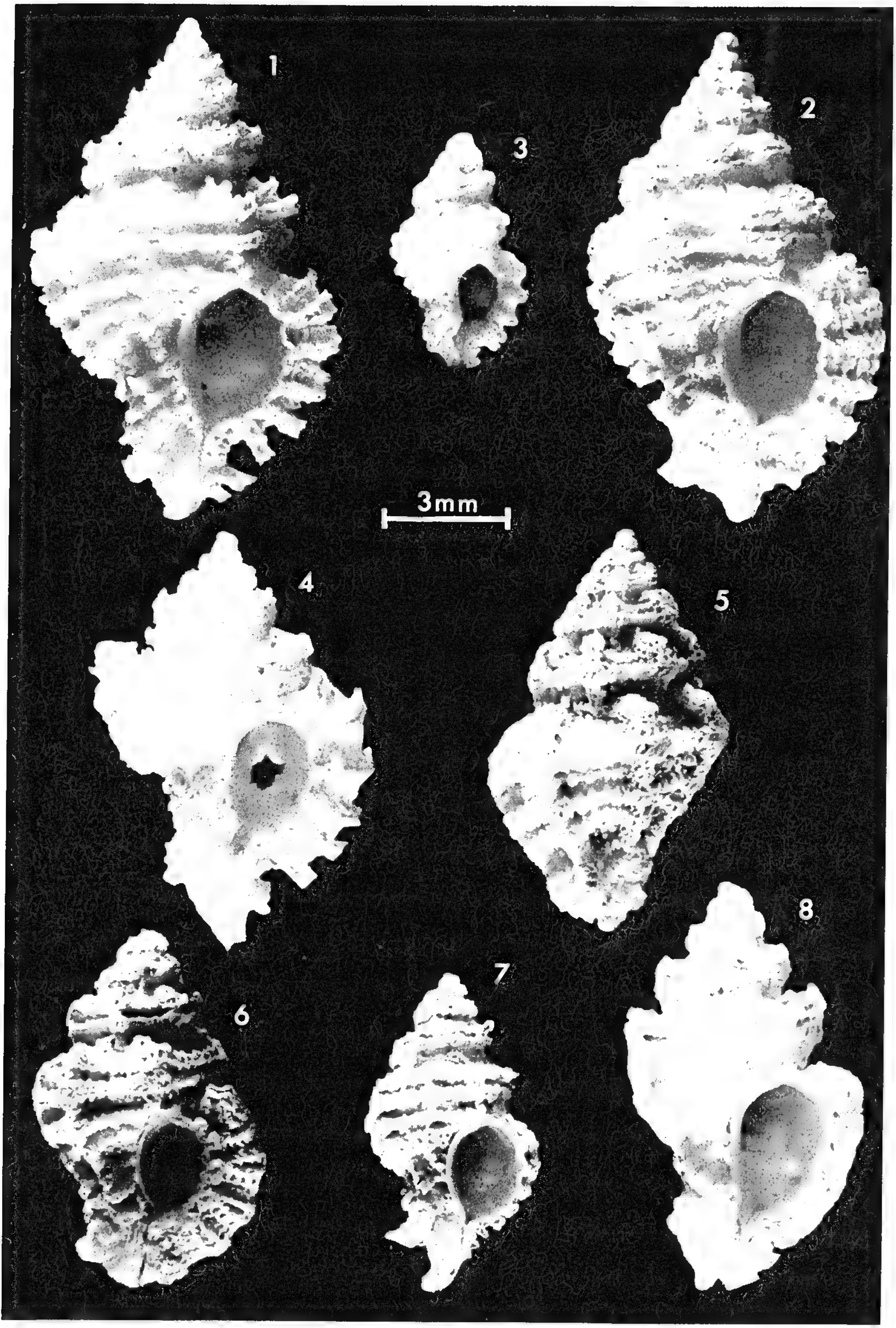
5, 6. *Favartia (Murexiella) striasquamosa* sp. nov. Lindeman Island, Queensland: 5 — holotype (C. 77190) *; 6 — paratype (C. 76670).

7. *Favartia (Murexiella) brazieri* (Angas). Sydney, N.S.W. (C. 59).

8. *Favartia (Murexiella) phantom* (Woolacott). Gerringong, N.S.W., holotype (C. 77171).

All to same scale.
* Specimens from which figured radulae obtained.

Plate 21



Favartia (Murexiella) striasquamosa sp. nov.

Plate 21, figs. 5, 6; Text fig. 1: 11

1877 *Murex (Muricidea) mundus* Brazier, *Proc. Linn. Soc. N.S.W.*, 1: 172 (not of Reeve).

Shell: Small, solid, with rounded, heavy varices. Protoconch minute, of 1½ whorls, tip small, slightly tilted. Teleoconch of approximately 5 convex whorls. 2 strong spiral cords per whorl with 4 additional cords on body whorl and base. Upper spiral sometimes weaker than lower one on spire whorl. Weak intermediate threads lie above and below the sutures on the penultimate whorl, these continuing on to the body whorl which also has 2 threads between the 4th and 5th spiral cords on the base. Axial sculpture of numerous, weak, foliose threads, which are produced into prominent scales on the spiral cords. The scales are flattened so that they lie horizontal to the shell surface and each is individually sculptured with numerous (up to 18) spirally orientated, somewhat irregular, slightly radiating threads. There are approximately 5-7 scales between each varix on the body whorl with 7 varices per whorl on spire whorls and 6 on body whorl. A number of closely packed, wavy axial lamellae give a lattice-like effect between the spiral ribs; these ribs do not form spines. Aperture small, with a rather short, almost closed anterior canal which is sharply twisted dorsally. Colour greyish or yellowish-white, with purplish blotches in the aperture and between the spiral ribs.

Operculum: Oval, yellowish-brown, with distinct concentric growth lines, and wide, non-thickened borders laterally. Nucleus subterminal.

Radula: Central teeth relatively deep, with the strong but short median cusp held higher than the other 4 cusps. Lateral tooth relatively small (Text fig. 1: 11). Very like the radula of *salmonea*.

Dimensions: Height: 10.24 mm. Diameter: 5.90 mm. (holotype)
9.37 mm. 5.66 mm. (figured paratype)

Locality: Lindeman Island, Queensland. Collected M. Ward (C. 77190 holotype, C. 77192 figured paratype, C. 77191 2 additional paratypes).

Additional Material Examined: Lizard Island, south east of Howick Group, Queensland. C. Hedley (C. 41341); Low Isles, near Port Douglas, Queensland. Great Barrier Reef Exped., 1929. T. Iredale (C. 77279); Rocky Isle, 25 miles north east of Cape Flattery, Queensland (C. 76944); outer Barrier Reef, S. Lat. 14, Queensland. C. Hedley (C. 76943); 9-15 metres, Murray Island, Torres Strait. C. Hedley (C. 76942); Torres Strait, 22 metres. J. Brazier (C. 8068); Darnley Island, Torres Strait, 55 metres, Chevert Exped. (Macleay Museum) (Brazier's record of *mundus*); Kapa Kapa, S. E. of Port Moresby, Papua, on sheltered coral flats, low tide. W. F. Ponder and P. H. Colman (C. 80093).

This species is readily separated from *salmonea* and *voorwindei* by the flattened scale-like lamellae, smaller shell, and coloration (*salmonea* is pink). Both *voorwindei* and *salmonea* have simple irregular lamellae which form simple, fragile, upright foliations. In all cases these lamellae, scales etc. are easily worn off. The varices are like those of *salmonea* in general form but the protoconch, although smaller, has the same number of whorls as that of *voorwindei*. *Murex mundus* Reeve, 1845 is larger and has an additional spiral cord on the body whorl. It is not known what the minor sculpture of this species from the Philippines is.

Favartia (Murexiella) phantom (Woolacott, 1957)

Plate 21, fig. 8

1957 *Minnimurex phantom* Woolacott, *Proc. Roy. Zool. Soc. N.S.W.* 1955 - 56: 115, pl. 3, fig. 8.

This species is the type of *Minnimurex* which has been placed in the synonymy of *Murexiella* by Vokes (1964) because of the resemblance of *M. phantom* to the central American species *M. humilis* (Broderip, 1833) and *M. macgintyi* (M. Smith, 1938). Comparison of figures of these species with specimens of *phantom* show some features in common but *phantom* has weaker and fewer varices (only 4 per whorl), a short, open anterior canal and appears to lack variceal spines. Only dead, worn specimens were available for examination.

Localities: Gerringong, N.S.W. (C. 77171) (holotype); Angourie, northern N.S.W. (C. 77280); Catherine Hill Bay, s. of Swansea, N.S.W. (C. 58577); Long Reef, Collaroy, N.S.W. (C. 79038).

Favartia (Murexiella) brazieri (Angas, 1877)

Plate 21, fig. 7; Text fig. 1: 9

1877 *Murex brazieri* Angas, *Proc. Zool. Soc.* (1877): 171, pl. 26, fig. 3.
(1884 *Trophon tumidus* Petterd, *J. Conch., Lond.*, 4: 141).
1962 *Murexsul brazieri*. Macpherson and Gabriel, *Mar. Molluscs Vict.*: 169, fig. 201.

Brazier (1893a; b) has given a detailed synonymy of this species. I have not seen the type specimen of *T. tumidus* Petterd, nor has it been figured, so that this species is tentatively included in the synonymy of *brazieri* on Brazier's authority. The dimensions given by Petterd (12 x 8 mm) are greater than those of any specimen of *brazieri* seen by the writer, the largest examined being 10.5 x 6.7 mm from Bunbury, W. Aust. (C. 37260).

This species has 2 strong, often bifid spiral cords on the spire whorls and 10-13 spiral cords on the body whorl and base. There are 6-7 varices on the body whorl, these being thickened, low, rounded and closely resembling axial ribs. The axial sculpture is lamellate, giving a scaly appearance to the shell which is easily worn off. The protoconch has about 2¼ smooth, lightly convex whorls and is reddish-purple in colour.

The operculum is typical, reddish-brown, with a terminal nucleus.

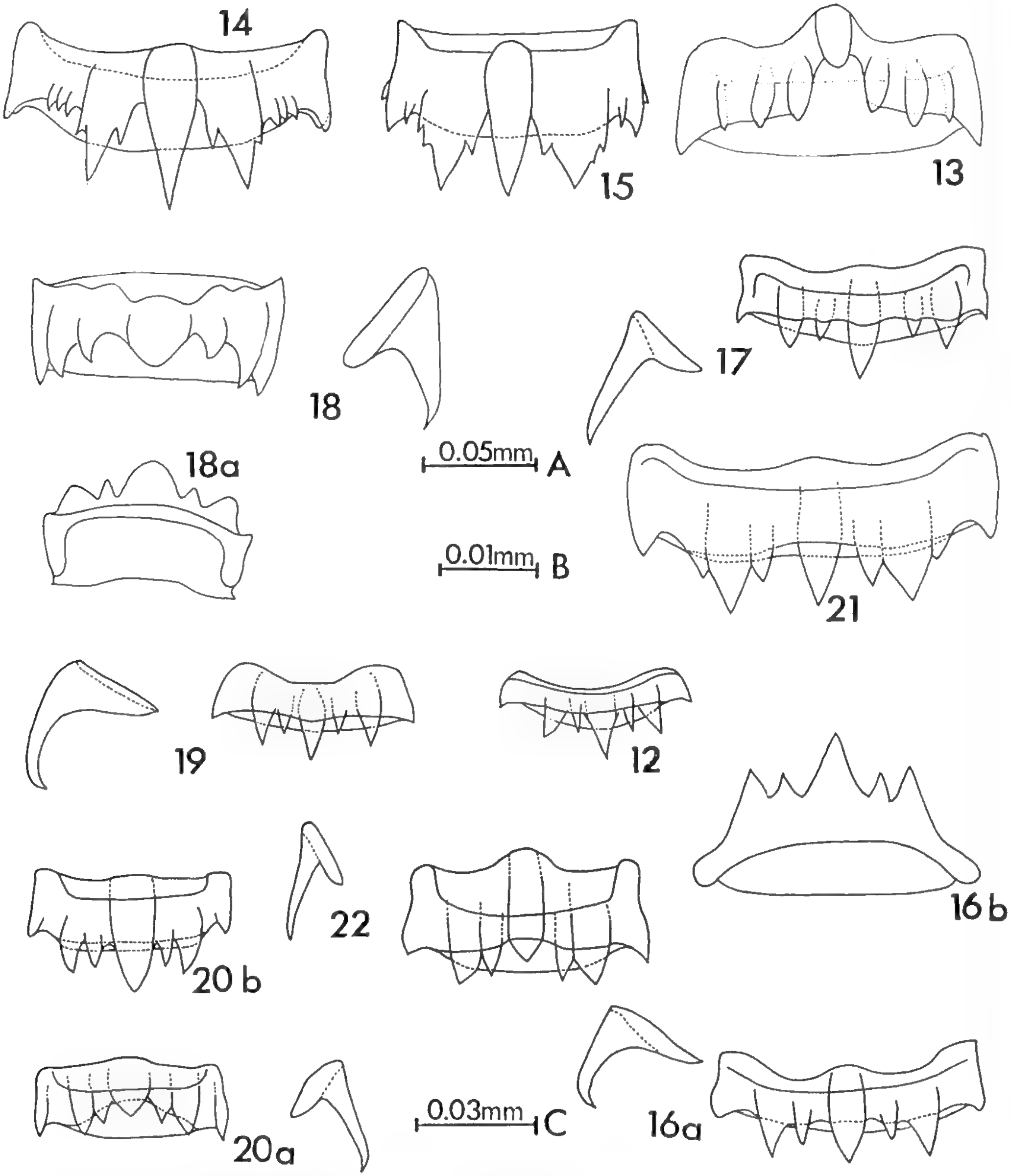
The radula (Text fig. 1: 9) is similar to that of *salmonea* and *striasquamosa* except that there are a pair of small denticles on the outerside of the outermost cusps of the central teeth.

Range: Caoundra, southern Queensland (C. 77281) along the N.S.W. coast, southern Australia and Tasmania to mid Western Australia, at least as far north as Perth (C. 10458).

Favartia (Murexiella) iredalei sp. nov.

Plate 21, fig. 3

Shell: Small, pinkish, with strong spiral cords crossing 8-9 varices and inconspicuous secondary sculpture. Protoconch (from paratypes) of 1½ strongly deviated whorls. Teleoconch of about 4 whorls, varices on



TEXT FIG. 2. Radular teeth.

12. *Aspella (Aspella) anceps* (Lamarck). Woolgoolga, N.S.W. (C. 76671).
13. *Favartia (Murexiella) pumila* (A. Adams). Mauritius (C. 36013).
14. *Pteropurpura festiva* (Hinds). San Pedro, California (C. 76589).
15. *Pteropurpura (Ocinebrellus) falcatus* (Sowerby). Kii, Japan (C. 66915).
16. *Pterotyphis (Prototyphis) angasi angasi* (Crosse). Camp Cove, Sydney, N.S.W. (C. 77139).
17. *Pterotyphis (Prototyphis) zelandicus iredalei* (Fleming). Norfolk Island (C. 59391).
18. *Pterotyphis (Tripterotyphis) lowei norfolkensis* (Fleming). Norfolk Island (C. 59390).
19. *Typhis (Typhina) philippensis interpres* (Iredale). 92 metres off Montague Island, N.S.W. (C. 66931).

20a, b. *Favartia (Favartia) confusa* (Brazier). 9 - 15 metres, Torres Strait (C. 29965).

21. *Favartia (Favartia) brevicula* (Sowerby). New Caledonia (C. 36409).
22. *Favartia (Favartia) cellulosa* (Conrad). Bonefish Key, Florida. (C. 77267).

Scale A: fig. 14 - 15; Scale B: fig. 18; Scale C: fig. 12 - 13, 16 - 17, 19 - 22.

1st whorl extending on to last whorl of protoconch as thin lamellae. 6-8 (8 in holotype) varices on body whorl, 9 on penultimate whorl. Last 1-2 varices stronger (in adults) than rest, and these exhibit webbing between the spiral ribs. Spire whorls with 2 spirals, and a suprasutural cord on the penultimate whorl. 5 spirals on body whorl, uppermost forming a distinctive shoulder, upper 2 strongest and usually bifid on last 1½ whorls. A very weak 6th spiral and a strong 7th lies between the very prominent fasciole and the last basal spiral. A single, short, scale-like spine is formed at each point of intersection with the varices on the lower whorls, sharp nodules being produced on the upper spire whorls. Intervariceal sculpture of fine axial threads, which are very easily worn off. Aperture rounded, canal open (probably closed in well preserved, mature specimens) curved a little dorsally, otherwise straight. Outer lip grooved within, grooves corresponding to the spiral ribs. Inner lip smooth. Colour yellowish-pink, varices and spiral cords paler than remainder of surface.

Dimensions: Height:	6.20 mm.	Diameter:	3.52 mm.	(holotype)
	7.30 mm.		4.10 mm.	(paratype)

Locality: Lord Howe Island, R. Bell, holotype (C. 77180) and 7 paratypes (C. 77181).

All the mature specimens were rather worn. This species appears to be related to *Hexaplex puniceus* Oliver, 1915 from the Kermadec Islands, but Oliver's description and figure show only 4 spiral cords on the body whorl which apparently form nodules on all whorls. It is possible that these two forms may eventually be found to be only subspecifically distinct. *F. (M.) brazieri* is of similar size but has purplish-coloured variceal ribs, a different protoconch and the secondary sculpture is much more scaly. The other species described herein also differ in having better developed secondary sculpture.

This species is named in honour of Mr. Tom Iredale, who was Curator of Molluscs at the Australian Museum from 1924 to 1944. Since his retirement he has, until recently, been actively involved in the Mollusc Department, and is still working with shells at his home in Harbord, Sydney. He turned 91 on the 24th March, 1971.

Genus *Muricopsis* Bucquoy, Dautzenberg & Dollfus, 1882

Type species: (o.d.) *Murex blainvillei* Payraudeau, 1862 (replacement name for *Muricidea* Mörch, 1852, non Swainson, 1840).

Synonym: *Murexsul* Iredale, 1915, type species: (o.d.) *Murex octogonus* Quoy & Gaimard, 1833.

Subgenus *Muricopsis* s.s.

Vokes (1964) commented that " shells of *Muricopsis* are not unlike those of the Australian *Murexsul* group. They may be distinguished by the extreme development of the denticles on the outer lip of *Muricopsis* ". However, all of the Australian species examined by the writer have denticles developed inside the inner lip so that this distinction is not valid. A specimen of *M. blainvillei* is figured (Plate 22, fig. 4) for comparison with the Australian species.

The placement by Vokes (1964, 1968) of *Murexsul* as a subgenus of *Hexaplex* cannot be maintained owing to the very different radulae in both groups. The radula of *octogonus* figured by Ponder (1968), showed the central tooth flattened. The cusps are normally curved over the basal plate (Text fig. 3: 24) and the radula strongly resembles that of *Muricopsis blainvillei* (Text fig. 3: 23) also figured by Radwin and D'Attilio (1970) and Troschel and Thiele (1869).

The radulae of the Australian species of *Muricopsis* are figured for comparison (Text fig. 3) and all are noticeably similar. The protoconch of all examined species is paucispiral, strongly tilted and often keeled. A specimen of *M. blainvillei* with an intact protoconch was not available to the writer. The protoconch of *M. octogonus* is figured by Ponder (1968). The operculae of all examined species are red-brown with a nucleus that tends to become subterminal, that of *M. octogonus octogonus* being shown in (Text fig. 4: 31). Radwin and D'Attilio (1970) figure the operculum of *blainvillei* and *jaliscoensis* Radwin and D'Attilio, 1970. In both of these they show a peculiar process emerging from the inner side of a lateral thickening into the muscle-impression area. This structure is actually a slight irregularity in the edge of the thickening in the two specimens of *blainvillei* examined and is certainly not of any taxonomic significance. Vokes (1968) has stated that the muscle attachment area of the operculum of *M. octogonus* is " entirely different in construction " from that of *Tritonalia.* I can see no differences between the opercula of members of the Ocenebrinae and of the Muricinae apart from the position of the nucleus. Both groups exhibit the same type of muscle attachment area (cf. Text fig. 4: 30-35).

In view of the close similarities in the radula, operculum, protoconch and teleoconch features in species assigned to *Murexsul* and *Muricopsis* there can be little doubt that *Murexsul* can be regarded as a junior synonym of *Muricopsis.*

Vokes (1970a) suggested that *Murexsul* and *Murexiella* intergrade but there appear to be sufficient features separating the two groups to give *Muricopsis* full generic status. Such features include the open anterior canal into which the aperture gradually constricts, the relatively simple, numerous varices and spines and tall spire. The operculum is also rather different from that of *Murexiella* in lacking the broad, non-thickened lateral areas. Although the central teeth of the radulae are similar, the central cusp is situated somewhat higher on the tooth in top view in *Murexiella* and *Favartia* s.s. than in *Muricopsis.* In addition the lateral teeth are relatively smaller in *Murexiella.*

Murexsul conatus McMichael, 1964 is not a *Muricopsis* but can be included in the genus *Hexaplex* Perry, 1810, as far as can be judged on shell features.

Muricopsis (Muricopsis) octogonus umbilicatus (T. - Woods, 1876)

Plate 22, fig. 3, Text fig. 3: 25

1854 *Murex scalaris* A. Adams, *Proc. Zool. Soc.*, 21 (1853): 71 (non Brocchi, 1814).

1865 *Murex scalaris.* Angas, *Proc. Zool. Soc.*, (1865): 157.

(1865 *Murex serotinus* Angas, *Proc. Zool. Soc.*, (1863): 157 (not of A. Adams)).

1876 *Trophon umbilicatus* T.-Woods, *Proc. R. Soc. Tasm.*, (1875): 135

1880 *Murex (Phyllonotus) angasi* Tryon, *Manual of Conchology*, 2: 109 (nom. nov. pro *Murex scalaris* A. Adams, non Brocchi, 1814).

1880 *Urosalpinx umbilicata.* Tryon, *Manual of Conchology*, 2: 155.

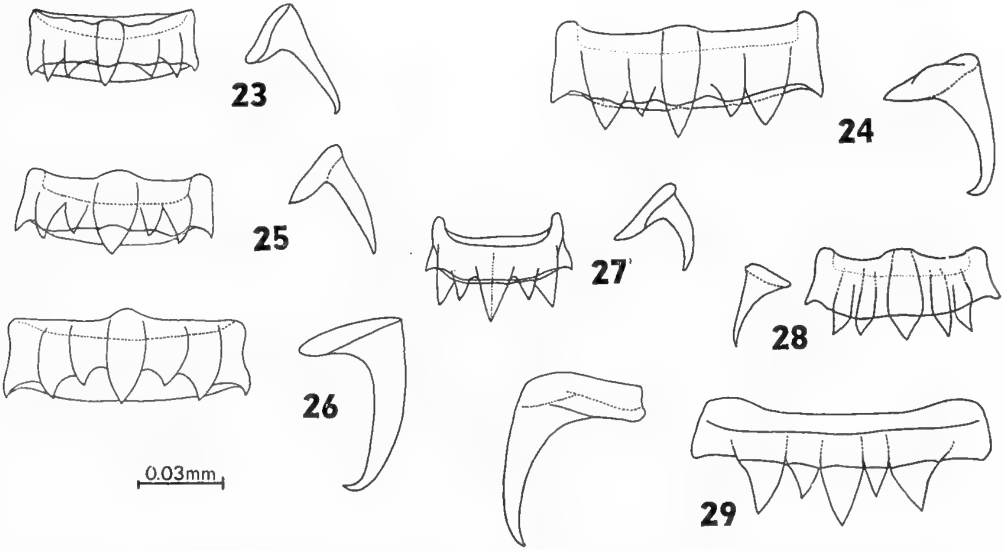
1886 *Murex (Phyllonotus) octogonus* Bednall, *Trans. R. Soc. S. Aust.*, 8 (1884, 1885): 64 (not of Quoy and Gaimard).

1893 *Murex umbilicatus.* Brazier, *Cat. Mar. Shells Aust.*: 64 (full synonymy).

1895 *Murex umbilicatus.* Verco, *Trans. R. Soc. S. Aust.*, 19: 96.
1896 *Murex umbilicatus.* Verco, *Trans. R. Soc. S. Aust.*, 20: 231. pl. 7, figs. 4, a - c.
1962 *Murexsul umbilicatus.* Macpherson and Gabriel, *Mar. Molluscs Vict.*: 169, fig. 202.

A brief synonymy of this subspecies is given because of its complex history. *M. scalaris* A. Adams was described from Moreton Bay (F. Strange) but this was obviously a wrong location as *umbilicatus* does not occur on the East Coast of Australia at all. The type of *scalaris* was examined in the British Museum by Hedley, who confirms in his unpublished notes (2/10/1912) the synonymy already given by Brazier (1893a).

Suter (1901) outlines the history of the published comments on the relationships of *umbilicatus* and *octogonus*. He summarizes his views as follows " After comparing a good many examples from Hauraki Gulf (N.Z.), and also a few from South Australia, I have come to the conclusion that *M. umbilicatus*, T. Woods, is absolutely nothing more than a *variety* of *M. octogonus*, Q. and G." He goes on to discuss the variation in size and sculpture in the two forms and shows that no significant measurable differences could be found. There are, however, differences between Australian and New Zealand specimens which suggest that the two forms are best regarded as subspecies. The umbilical depression is



TEXT FIG. 3. Radular teeth.

23. *Muricopsis (Muricopsis) blainvillei* (Payraudeau). Grand Harbour, Malta, Mediterranean (C. 44572).
24. *Muricopsis (Muricopsis) octogonus octogonus* (Quoy and Gaimard). Westmere Reef, Auckland, New Zealand (Dominion Museum).
25. *Muricopsis (Muricopsis) octogonus umbilicatus* (T. - Woods). Giles Point, near Coobowie, St. Vincent Gulf, South Australia (C. 76256).
26. *Muricopsis (Muricopsis) cuspidatus* (Sowerby). Tryon Island, Capricorn Group, Queensland (C. 77561).
27. *Muricopsis (Muricopsis) planiliratus* (Reeve). St. Francis Island, St. Vincent Gulf, S. Australia (C. 41851).
28. *Muricopsis (Muricopsis) purpurispina* sp. nov. Minnie Waters, Clarence River, N.S.W., holotype (C. 76796).
29. *Muricopsis (Spinidrupa)* cf. *nodulifera* (Sowerby). New Caledonia (C. 36413).

All figures same scale.

usually more pronounced in the Australian shells, and these specimens *usually* have heavier spiral cords and hence more solid, although short, spines. In addition the spiral sculpture is clearly divided into primary and secondary spiral cords. This division is seen in New Zealand specimens obtained from the continental shelf (Ponder, 1968) but littoral shells have the spiral ribs more or less equally developed so that there are more spines on the varices. In addition the denticles within the aperture are generally more strongly developed in the Australian form. These differences, although not always constant, usually allow for the separation of Australian and New Zealand shells. The operculae and radulae (Text fig. 3: 24, 25) are also very similar.

M. (M.) octogonus umbilicatus has been reported from the north coast of Tasmania, western Victoria (probably not east of Wilson's Promontory), and eastern South Australia.

Muricopsis (Muricopsis) planilirata (Reeve, 1845)

Plate 22, fig. 9; Text fig. 3: 27

1822 *Murex fimbriatus* Lamarck, *Anim. S. Vert.*, 7: 176 (non Lightfoot, 1876, non Brocchi, 1814).
1843 *Fusus pallidus* Menke, *Moll. Nov. Holl. Spec.*: 26 (not of Broderip, 1832).
1845 *Murex planiliratus* Reeve, *Conch. Icon.*, 3: pl. 31, fig. 149.
1865 *Murex pumilis* Angas, *Proc. Zool. Soc.*: 158 (not of A. Adams).
1894 *Murex (Pseudomurex) polypleurus* Brazier, *Proc. Linn. Soc. N.S.W.* (2), 7: 179, text figure.

The name *fimbriatus* Lamarck was re-introduced by Hedley (1913) after examining Lamarck's types. Iredale (1916) pointed out that *fimbriatus* Solander (i.e. Lightfoot) invalidates *fimbriatus* Lamarck and Gatliff and Gabriel (1922) re-introduced *planiliratus* Reeve in their catalogue of the Victorian Mollusca. However other Australian writers, including Macpherson and Chapple (1951), Macpherson and Gabriel (1962) and Cotton (1959) continued to use *fimbriatus*. Rehder (1967) has shown that *Murex fimbriatus* Lightfoot = *Trophon geversianus* (Pallus, 1774) and that another prior homonym, *Murex fimbriatus* Brocchi, 1814 is an unidentified species of *Pleuroploca*. The next available name, one that was in regular use until 1913, is *Murex planiliratus* Reeve.

This species somewhat resembles a coralliophilid with its pinkish-white colour, rather delicate, minute scales and short anterior canal. The radular (Text fig. 3: 27) and opercular features are similar to those of other species of *Muricopsis* (s.s.). The protoconch is paucispiral and its 1¾ whorls are rather sharply angled.

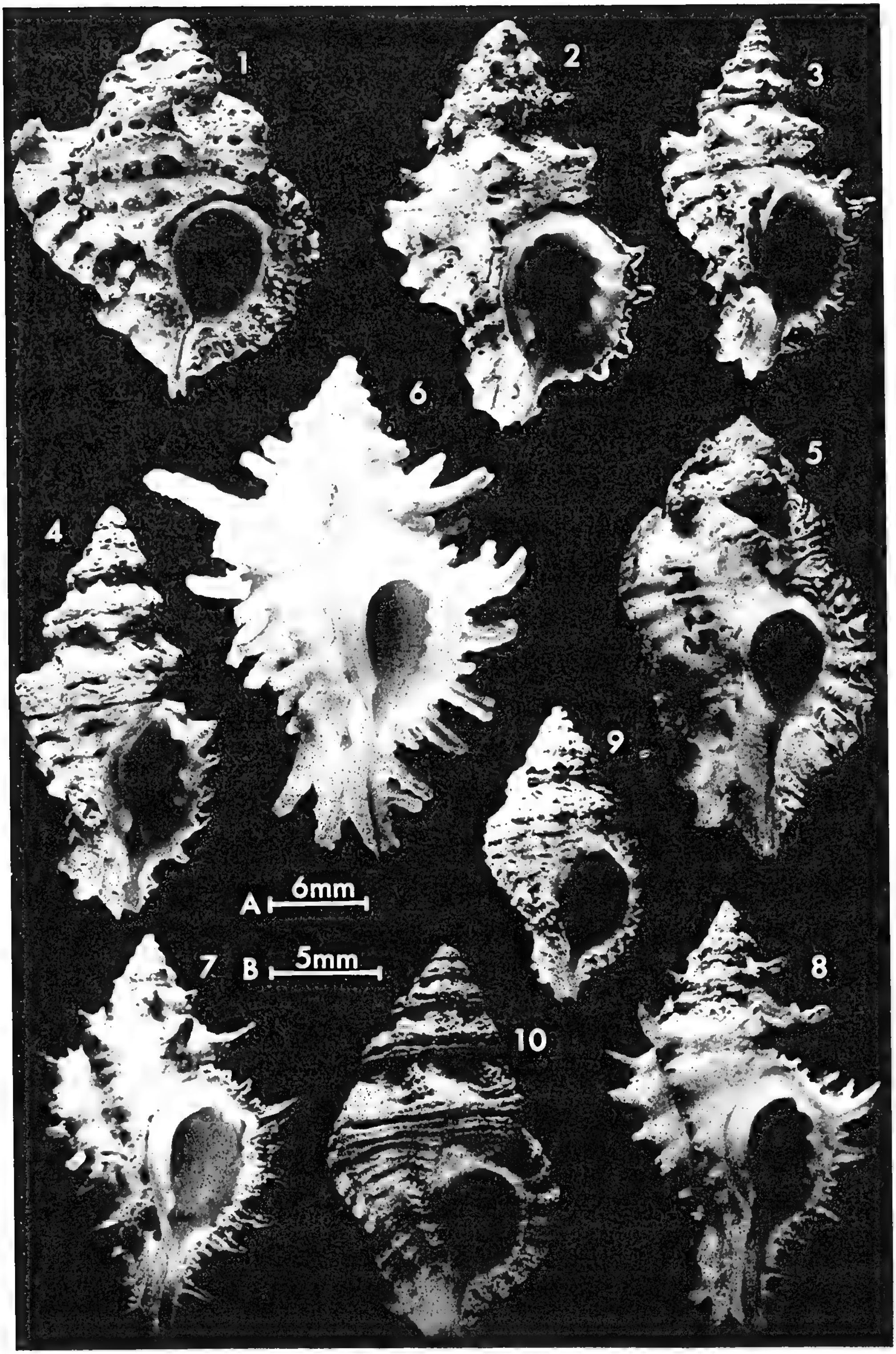
M. (M.) planilirata is distributed around the southern coast of Australia from West of Wilson's Promontory to at least as far north as Perth on the west coast. It has not been recorded from Tasmania.

PLATE 22.

1. *Favartia (Favartia) brevicula* (Sowerby). New Caledonia (C. 36409). *
2. *Muricopsis (Spinidrupa)* cf. *nodulifera* (Sowerby). New Caledonia (C. 36413). *
3. *Muricopsis (Muricopsis) octogonus umbilicatus* (T.-Woods). Giles Point, near Coobowie, St. Vincent Gulf, South Australia (C. 76256). *
4 *Muricopsis (Muricopsis) blainvillei* (Payraudeau). Grand Harbour, Malta (C. 44572). *
5. *Favartia (Favartia) confusa* (Brazier). 55 metres, Darnley Island, Torres Strait, holotype (C. 77183).
6 - 8. *Muricopsis (Muricopsis) cuspidatus* (Sowerby). 6 — 9 metres, Swain Reefs, Queensland (C. 77185); 7 — New Caledonia (C. 77184); 8 — 20 miles north of Herald Prong, No. 1 Reef, Swain Reefs, Queensland (C. 77186).
9. *Muricopsis (Muricopsis) planiliratus* (Reeve). St. Francis Island, St. Vincent Gulf, South Australia (C. 41851). *
10. Favartia *(Muricopsis) pumilla* (A. Adams). Mauritius (C. 36013). *

Scale A: fig. 1 - 8, 10; Scale B: fig. 9.
* Specimens from which figured radulae obtained.

Plate 22



Muricopsis (Muricopsis) cuspidatus (Sowerby, 1879)

Plate 22, figs. 6-8; Text fig. 3: 26

1879 *Murex cuspidatus* Sowerby, *Thes. Conch.*: 36, pl. 21, fig. 203.

This species does not appear to have been re-discovered in Japan since its original description and I cannot find any discussion on it in the literature. A specimen in the Australian Museum collection from New Caledonia (Plate 22, fig. 7) matches Sowerby's illustration and description very well and it is possible that New Caledonia was actually the type locality. Several specimens from Queensland also appear to be this species.

M. (M.) cuspidatus is rather similar to some forms of *M. octogonus* and was considered to be a synonym of that species by Tryon (1880). The varices in specimens that were probably collected in the lower littoral zone are dark brown and the spines short (as in fig. 7). This form best matches the illustration of the type specimen. Others obtained from deeper water are uniformly coloured and usually have longer spines (Plate 22, fig. 6). A similar variation is seen in *octogonus* (Ponder, 1968). All but one (C. 69053) of the Australian specimens seen are of the long-spined form and one small specimen from Noumea (C. 3955) also has long spines.

The shell has 7-8 varices on the body whorl and has 4 primary spines on the body whorl varices plus 2 on the canal. The short-spined form has some intermediate (secondary) spines developed almost to the same extent as the primary spines. There are 6 strong denticles inside the outer lip and 2 on the inner lip just above the neck of the anterior canal. The largest specimen available is 36 mm x 19 mm (excluding spines). The operculum and radula (Text fig. 3: 26) are like those of other species of *Muricopsis* (s.s.).

Australian Localities: Fairfax Island, Bunker Group, off Gladstone, Queensland (C. 69053); Swain Reefs, Queensland (C. 72866); 9 metres, Swain Reefs, Queensland (C. 77185); 28-36 metres, Gillett Cay, Swain Reefs, Queensland (C. 72671); 20 miles N. of Herald Prong, No. 1 Reef, Swain Reefs, Queensland (C. 77186). Several additional specimens in the collection of Neville Coleman, Sydney, have been examined. These are from 9 metres, Swain Reefs, Queensland and Tryon Island, Capricorn Group, Queensland at 8 metres on compacted coral rubble.

Muricopsis (Muricopsis) purpurispina sp. nov.

Plate 23, fig. 6; Text fig. 3: 28

Shell: Small, elongate, with strong varices and short spines. Protoconch of 1½ smooth, tilted, very slightly shouldered whorls. Lamellae continuous with the varices of the 1st whorl of the teleoconch extend on to the protoconch. Whorls of teleoconch 4¼, usually bluntly shouldered, sometimes more acutely. Body whorl with 5-7 varices, 7-8 on penultimate whorl and 8-9 on antepenultimate whorl. Spiral sculpture rather irregular and 5 primary cords on the body whorl commencing at the shoulder, above which lie about 5 weak spirals. A single intermediate cord lies between each primary rib and is about ½ as strong. A single strong cord on the pillar has 3 weaker spirals above it and two below. All spiral cords produced into very short, open spines at the varices, but these are usually worn off. Irregular weak axial lamellae cross the surface giving it a scaly appearance. Some specimens have the 1st primary cord stronger than the others which produces a prominent shoulder. Fasciole with the remnants of the previous anterior canals forming spines. Aperture with inner lip spread beyond columella; outer lip thin, extends beyond varix, with 5 strong denticles on its anterior 2/3rds. Anterior canal rather short, not closed, slightly curved dorsally. Colour pinkish-brown to pale reddish-brown, with the 4th primary spiral cord white, the others sometimes with patches of white. Varices sometimes paler than rest of shell and with at least some of the spines dark purplish as is dorsal part of canal and fasciolar spines.

Operculum: red-brown, rather thin, with a terminal nucleus.

Radula (from holotype): central tooth with 5 cusps, median one strongest, lateral projections and basal, median swelling present. Lateral tooth simple (Text fig. 3: 28).

Animal: Head-food unpigmented, reddish-brown splashes on mantle edge. Holotype a mature female.

Dimensions:	Height:	16.20 mm.	Diameter:	7.72 mm	(holotype)
		16.65 mm.		8.00 mm	(paratype)

Locality: In fish trap, 36 metres off Minnie Waters, northern N.S.W., Collected L. Bale, holotype (C. 76796) and 6 paratypes (C. 76797).

Additional Material Examined: 40 metres, off Manning River, N.S.W., 1 specimen (C. 16819); Angourie, Clarence River, northern N.S.W., many worn shells (C. 77034, C. 77036, C. 77037); Wooli, Northern N.S.W., 1 worn shell (C. 77035); off Moreton Bay, Queensland, 27° 27′22″ S, 153°39′ E, 77 metres, W. F. Ponder on H.M.A.S. *Kimbla.* 1 shell (C. 77065).

Subgenus *Spinidrupa* Habe and Kosuge, 1966

Type species: (o.d.) *Murex eurantha* A. Adams, 1851.

The radula of the type species of this genus has not been described and the generic relationships of its contained species have been the source of some considerable confusion.

Murex nodulifera Sowerby, 1841 is very similar to *eurantha* and may prove to be identical. It is found throughout the tropical Indo-Pacific but is nowhere common. Occasional specimens are found in Queensland, the species being represented in the Australian Museum collections by juvenile shells from two localities (9-15 metres, Murray Island, Torres Strait (C. 77285), Low Isles, Queensland (C. 77283, C. 77284). An adult shell from off Mossman, Queensland, is in Neville Coleman's collection. *Murex (Trophon) fruticosus* Gould, 1849 is a synonym of *nodulifera.* The type is recorded as coming from Sydney, Australia, but this is certainly an error.

Cernohorsky (1967) placed *nodulifera* in *Poirieria* Jousseaume, 1880. I would agree with Vokes (1970b) that Cernohorsky was in error and that *Muricopsis* would be a better location because of the overall teleoconch similarity and the protoconch of *nodulifera* is like that of species of *Muricopsis. S. nodulifera* and *eurantha,* have 2 prominent rows of spines on the body whorl and the radula of a related form is dissimilar (Text fig. 3: 29), although the operculum is very like that of species of *Muricopsis* (s.s.).

This radula was obtained from a specimen from New Caledonia. The shell (Plate 22: 2) agrees with *nodulifera* in most features except that there are 4 rows of spines in place of the 2 rows of swollen knobs usually seen in *nodulifera*. Careful examination of typical *nodulifera* shows that the knobs are formed by the fusion of 2 rows of spines and in some specimens they remain separate, especially in the basal row. In other features the shells are similar. Both typical *nodulifera* and the New Caledonian form illustrated have 3 denticles on the columella near the neck of the anterior canal and about 7-8 on the outer lip. Species of *Muricopsis* (s.s.) normally have 1-2 denticles on the columella.

The radula differs from species of *Muricopsis* in having a wide but shallow basal plate from which the cusps stand upright as in *Murex* and *Pterynotus*. Until a specimen of the type species can be examined the relationships of this puzzling group of species will remain uncertain. Certainly on shell features the New Caledonian cf. *nodulifera* comes very close to *Muricopsis* but the radula features would appear to allow it at least subgeneric distinction.

DISCUSSION

One of the most disturbing aspects of the classification of the Muricidae is the difficulty in placing genera in the various subfamilies recognised. These include the Muricinae, Ocinebrinae (= Tritonaliinae), Typhinae, Trophoninae and Rapaninae. The Thaididae should probably also be regarded at best, as a subfamily of the Muricidae. The question of the validity of these groups on anatomical grounds will be discussed elsewhere. Suffice to say that several genera placed in the Muricinae by Vokes (1964) have since been shown to be better located in the Ocinebrinae and vice versa. This proves that on shell features, and in some cases on opercular features, accurate placement is impossible in these two subfamilies. Powell's (1951) descriptions of the radulae of *Trophon* species would place the species of this genus in 4 different subfamilies. The radulae of species of the Thaidinae also show a similar gradation and certainly on shell features it is impossible to draw a distinct line between any of these groups. It would seem that, until a more satisfactory means of determining subfamilial relationships in the Muricidae (if such subfamilies exist) can be formulated, these should be put aside.

PLATE 23.

1 - 5. *Maculotriton bracteatus* (Hinds). 1 — Holotype of *Tritonidea petterdi* Brazier (Nat. Mus. Vict. F. 649); 2 — Cato Island, Queensland (C. 68582); 3 — Lady Musgrave Island, Capricorn Group, Queensland (C. 77187) *; 4 — Clarence River, northern N.S.W. (C. 77188); 5 — Holotype of *Clathurella* (?) *waterhouseae* Brazier (C. 8668).

6. *Muricopsis (Muricopsis) purpurispina* sp. nov. 33 metres off Minnie Waters, northern N.S.W., holotype (C. 76796). *

7. *Aspella (Aspella) anceps* (Lamarck). Woolgoolga, N.S.W. (C. 76671). *

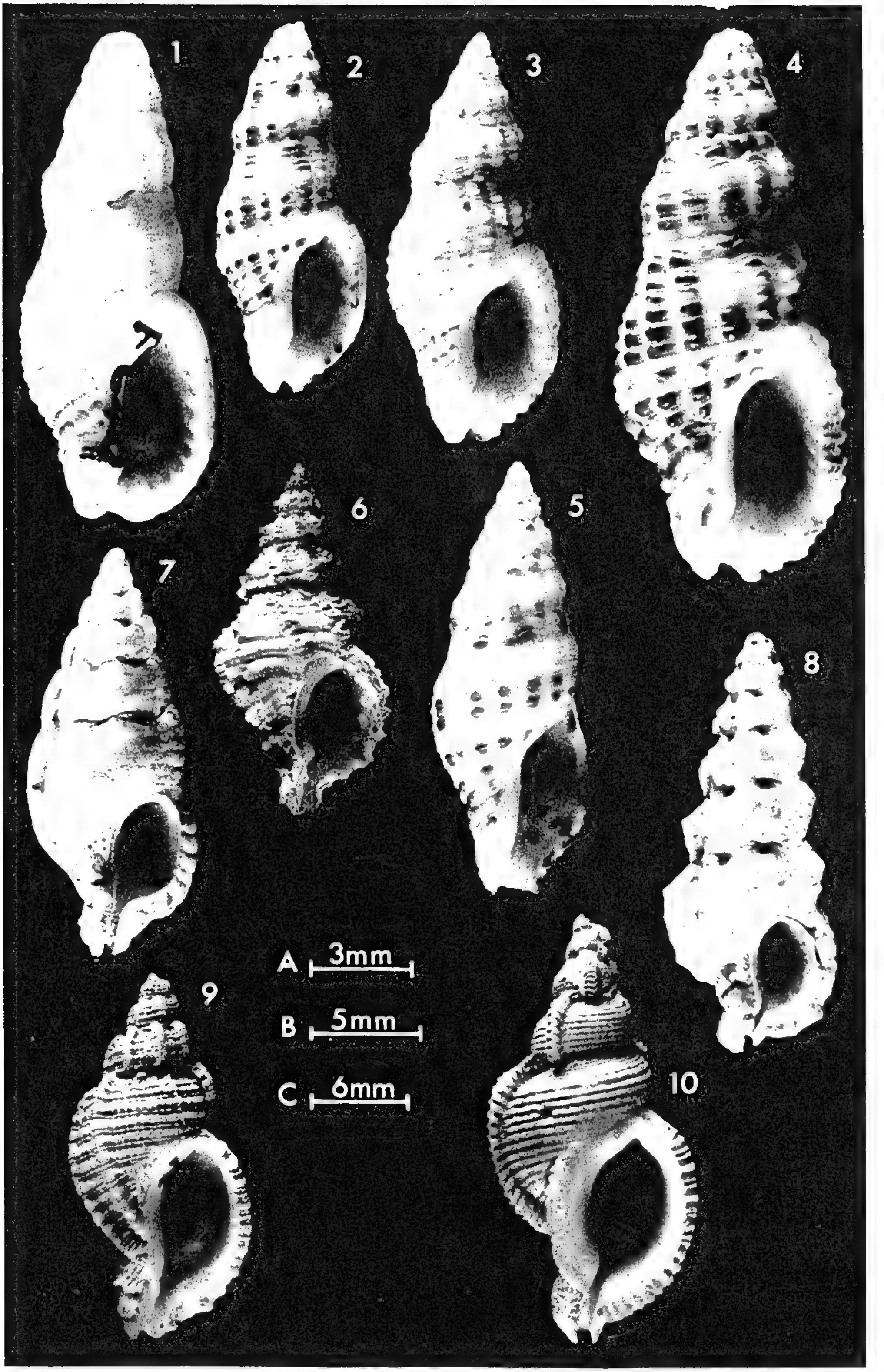
8. *Aspella (Aspella) producta* (Pease). Low Isles, near Port Douglas, Queensland (C. 76881).

9. *Phyllocoma (Galfridus) speciosa speciosa* (Angas). Watson's Bay, Sydney, N.S.W. (C. 76669). *

10. *Phyllocoma (Phyllocoma) convoluta* (Broderip). Suva Harbour, Fiji (C. 67022). *

Scale A: fig. 1 - 5, 7; Scale B: fig. 6, 9, 10; Scale C: fig. 8.

* Specimens from which figured radulae obtained.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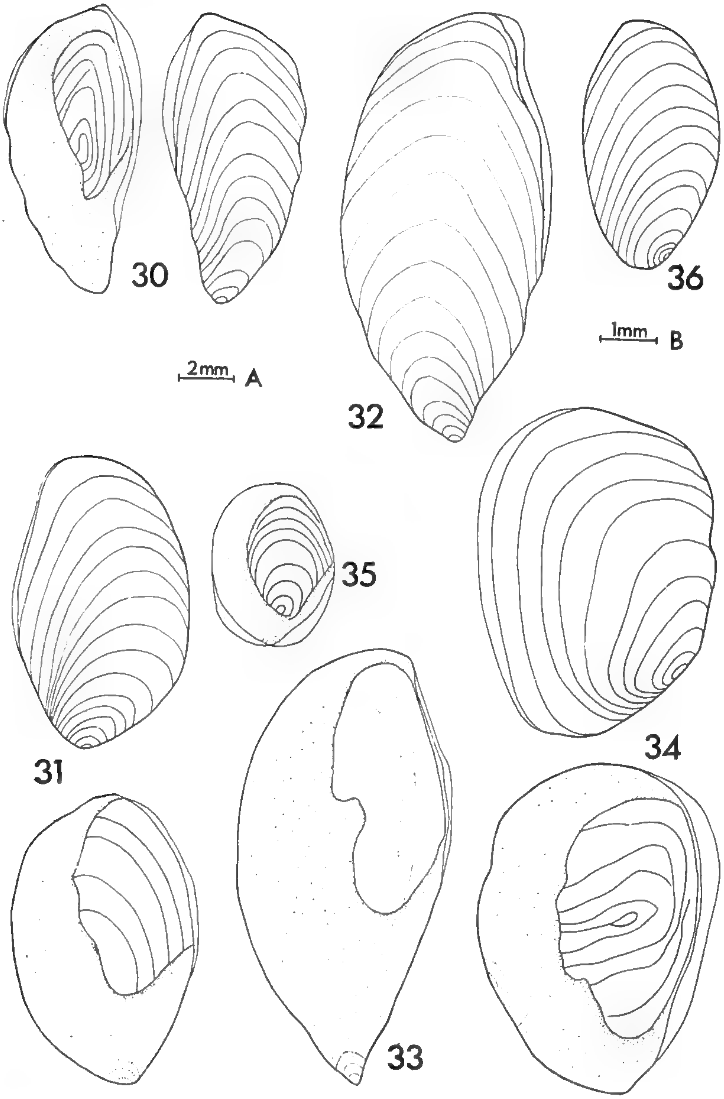

TEXT FIG. 4. Operculae

30. *Pterynotus (Pterochelus) bednalli* (Brazier). Swires Bluff, Darwin Harbour, Northern Territory (C. 71742).

31. *Muricopsis (Muricopsis) octogonus octogonus* (Quoy and Gaimard). Auckland, New Zealand (C. 76323).

32, 33. *Pterynotus (Pterochelus) triformis* (Reeve). 4 - 6 metres, N.W. Arm, Western Port Bay, Victoria (C. 76555).

34. *Pteropurpura (Ocinebrellus) falcatus* (Sowerby). Kii, Japan (C. 66915).

35. *Favartia (Favartia) brevicula* (Sowerby). New Caledonia (C. 36409).

36. *Phyllocoma (Galfridus) speciosa speciosa* (Angas). Watson's Bay, Sydney, N.S.W. (C. 76669).

Scale A: fig. 30 - 35; Scale B: fig. 36

ACKNOWLEDGEMENTS

I am especially grateful to Mr. Neville Coleman, who has provided me with a considerable amount of valuable material, without which some of this work would have been impossible. The staff of the Malacology Department have provided valuable assistance, and Mr. C. Turner, of the Australian Museum Photography Department, took the photographs. I am indebted to Mrs. P. Zylstra who did the final drawings for the text figures and to my wife for her help with checking the manuscript.

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NOTES ON SOME AUSTRALIAN SPECIES AND GENERA OF THE FAMILY BUCCINIDAE (NEOGASTROPODA)

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Plates 24 - 25

ABSTRACT

The genus *Engina* Gray is used for *Tritonidea australis* Pease, which has been included in *Maculotriton* Dall, a genus of the Muricidae. The species *Phos gracilis* Sowerby and *Cantharus unicolor* Angas are tentatively included in *Engina*. Related genera and subgenera are discussed and compared with this genus. *Prodotia* Dall is reduced to a subgenus of *Engina* and the synonymies of the two species in the subgenus and their Australian occurrences are given. *Caducifer* Dall is reduced to a subgenus of *Monostiolum* Dall and Australian records of two species are listed. *Ecmanis* Gistel and *Appisania* Thiele are considered to be synonyms of *Pisania* Bivona-Bernardi. Several previously recognised species appear to fall into the synonymy of *Pisania fasciculata* (Reeve), a common Australian species. *Jeannea* Iredale, *Sukunaia* Cernohorsky and *Taeniola* Dall are here recognised as subgenera of *Pisania*. A new genus and species, *Crassicantharus norfolkensis*, is described and the relationships of *Clivipollia* Iredale are discussed

INTRODUCTION

The buccinids are well represented in temperate latitudes where they often replace the nassariids and fasciolariids which dominate in tropical waters. A few buccinid genera such as *Cantharus* Röding, 1798 and *Engina* Gray, 1839, are conspicuous in warmer seas. In addition some less well known genera occur, some of which are discussed in this account.

This paper is largely the outcome of an attempt to clarify the relationships of a common N.S.W. species, *Tritonidea australis* Pease. This has been only partially successful because generic limits in the Buccinidae are particularly difficult to define. The shells, radulae and opercula have relatively few characters that allow for clear-cut taxonomic divisions. The status of some genera and subordinate taxa as set out below, is based on a combination of all the characters of the " hard parts " including the protoconch, teleoconch, radula and operculum.

There have been few attempts to examine the classification of the smaller species of the tropical Indo-Pacific Buccinidae and none of these have been particularly searching. During the course of this work it was found that a number of much needed changes had to be made and these are either indicated or dealt with where possible. It is not intended that this work be a full revision of any of the groups considered.

TAXONOMY

Hedley (1915) transferred *Phos gracilis* Sowerby, 1859, *Cantharus unicolor* Angas, 1867 and *Tritonidea australis* Pease, 1871 to *Maculotriton* Dall, 1904 and discussed the differences between these three Australian species. Subsequent writers have not questioned this generic placement. *Maculotriton* was introduced for *Triton bracteatus* Hinds, 1844. This genus was included in his Colubrariidae by Dall (1904) as a section of *Colubraria*.

In the same year Pilsbry and Vanatta (1904) showed that the radula of *M. bracteatus* was that of a muricid. Thiele (1929) made *Maculotriton* a subgenus of *Drupa* Röding, 1798, but most recent writers have given it full generic status in the Muricidae.

Hedley (1917) illustrated the radula, operculum and the external features of the head-foot of *M. australis*. Although he did not, at that time, comment on the familial placing of the genus, the radula he described is clearly buccinoid and later (1918) he placed *Maculotriton* in the " Fusidae."

The present investigation indicates that *australis* can be included in *Engina*. The two species that have been historically associated with *australis (gracilis* and *unicolor)* are considered in much less detail because they are known only from their shells.

Genus *Engina* Gray, 1839

Type species: (s.d. Gray, 1847) *E. zonata* Gray, 1839 (= *Purpura turbinella* Kiener, 1836).
Synonym: *Enzinopsis* Iredale, 1940 (type species (o.d.) *Engina gannita* Hedley, 1915).

Engina (Engina) australis (Pease, 1871)

Plate 24, fig. 1 - 2; Text fig. 1: 2; 2: 15 - 16, 24

1867 *Cantharus (Tritonidea) assimilis* Angas, *Proc. Zool. Soc.*, 1867: 187 (not of Reeve).
1871 *Tritonidea australis* Pease, *Amer. J. Conch.*, 7: 21.
1881 *Cantharus australis*. Tryon, *Man. Conch.*, 3: 160, pl. 73, fig. 269.
1917 *Maculotriton australis*. Hedley, *Proc. Linn. Soc. N.S.W.*, 41: 711, pl. 1, figs. 28 - 30.
1962 *Maculotriton australis*. Macpherson and Gabriel, *Mar. Molluscs Vict.*: 176, fig. 211.

As this species has not previously been fully described, a description is offered below.

Shell: Small, rather elongate bucciniform, spire slightly longer than aperture plus canal. Protoconch of 1½ whorls, the first whorl bulbous and slightly inrolled. Sculpture of teleoconch of regular axial folds, sometimes weak or absent on body whorl, these crossed by 8-12 spiral cords which increase in thickness only slightly where they cross the axials. Interstices variable in width, usually with an intermediate cord. Aperture with a short, open, slightly recurved posterior canal. Outer lip dentate within, with an external varix and weakly sinuate anteriorly. Posterior canal bordered by a rather weak labial and parietal denticle, the outer stronger (these are occasionally duplicated). Columella with 3 prominent plaits above neck of anterior canal and two minor ones anterior to these. Inner lip with several accessory wrinkles which do not run into aperture and occur with variable frequency and strength. Periostracum not obvious.

Radula: (Text fig. 1: 12) Central tooth relatively large, squarish, with 5 cusps, the outermost pair smaller than the other 3. Lateral teeth with bases extended outwards beyond outermost cusp. Two large cusps, the outer larger, the inner bearing a denticle on its inner surface. A small median cusp present, sometimes this reduced to a denticle (as in figured specimen).

Operculum: (Text fig. 2: 24) Simple, nucleus terminal, with small, oval muscle scar.

The shells of 2 typical specimens are illustrated (Plate 24, figs. 1 - 2).

This species is known from Port Fairy, Victoria (Pritchard and Gatliff, 1898: 274) and along the south-eastern coast as far north as Byron Bay, northernmost N.S.W. (C. 5293*). Shirley (1913) records this species from Murray Island but, like many of his records, this is obviously based on a misidentification. His (1911) record from Tweed Heads, just south of the northern N.S.W. border is possibly correct.

Discussion on the generic position of Engina australis and on the genus Engina.

The type species of *Engina*, *E. turbinella* (Kiener), a species living in the Caribbean, is a small broad shell (Plate 24, fig 8) that is very different from that of *Tritonidea australis*. Several other species of *Engina* have a more elongate shell and resemble *australis* in most major shell and radular features. The question of generic and specific groups within the *Engina* group will have to be dealt with more fully elsewhere but the following points of difference between *Engina* (sensu lato) and *australis* can be noted. None of the typical species of *Engina* have more than 5 primary spiral cords on the penultimate whorl, and most have less, which usually become strongly nodulous where they cross the axials. There are 9-12 primary cords on the penultimate whorl of *australis* and the axials are not rendered nodulous. Between the primary spirals lie several (up to 6) intermediate threads in most species of *Engina*, this being in sharp contrast to the 0-1 in *australis*.

The apertural features of *E. turbinella* are distinctive in having few (about 5) denticles on the outer lip, the posterior 3 usually fused into a single tooth. The posterior canal has strong labial and parietal denticles at its base but the canal extends out as a shallow groove along the outer edge of the posterior parietal wall.

The anterior canal is short, open and straight and there is a strong external varix on the outer lip, but no sinus. The parietal wall has several conspicuous denticles and the columellar has 2 plaits, the posterior one being very weak. Other species of *Engina* show essentially the same apertural features although these are modified with shell elongation. An extra denticle or two may be added to the outer lip and these do not tend to become fused. The posterior canal (i.e. the posterior edge of the aperture) extends only slightly beyond the denticles at its base and the anterior canal is often lengthened and sometimes slightly recurved. Essentially the same apertural structure is seen in *australis* as in the various elongate species of *Engina* but the denticles and teeth are more numerous and correspondingly weaker.

Only one specimen of *E. turbinella* available to me has a protoconch. This has $1\frac{3}{4}$ whorls, the first whorl smaller than in *australis*. Most other species of *Engina*, however, have an evenly conical protoconch of about $2\frac{1}{2}$ whorls. *Enzinopsis resta* Iredale, 1940 from Lord Howe Island has a protoconch of $1\frac{1}{2}$ whorls which resembles that of *australis* (Text fig. 2: 15, 16). The rest of the shell is very like *australis* in shape and build but has the apertural and sculptural features of *Engina*. The radula is almost identical in these two species and their opercula are very similar

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* Australian Museum registered number.

(cf. Text fig. 2: 23, 24). Whether this is a case of convergence or real relationship can only be decided when additional information is available. The protoconch similarity is probably related to the extralimital position of *resta* and *australis* — the development of the paucispiral protoconch in cooler waters being a well documented phenomenon (Thorson, 1950).

The radulae of a few species of *Engina* have been investigated. Orr (1962) figured the radula of *E. turbinella* and that of another specimen is shown here for comparison with the species under discussion (Text fig. 1: 10). Mörch (1859) (and later Barnard, 1959) described and figured the radula of the common Indo-Pacific species *E. mendicaria* (Linnaeus, 1758), showing that this group was different from otherwise superficially similar species in the family Columbellidae. Pilsbry and Lowe (1932) have described the radula of the West American *Engina strongi* Pilsbry and Lowe, and Habe (1943) described the radula of the Japanese species *E. menkeana* Dunker, (1860) which is shorter than, but otherwise very like, *E. submenkeana* (Pilsbry, 1901). This latter species appears to be a synonym of the common Queensland species *E. concinna* (Reeve, 1846) which is one of the most elongate species of *Engina*. Five radulae of this species were mounted and some variation was observed, one example being illustrated (Text fig. 1: 9). Only one had a minute denticle-like middle cusp on the lateral teeth, the others having only 2 large cusps. The central teeth of all specimens had 3 strong cusps outside of which were placed a pair of short cusps and, in two specimens, an additional pair of small denticles.

All species of *Engina* that have been examined have a radula that is similar to that of *australis* in having squarish, basically tricuspid central teeth, and bicuspid lateral teeth, which in some species develop a third minor cusp. The central teeth have a pair of minor cusps at the outer bases of the outer main cusps. Sometimes a weak denticle is developed on the inside face of the inner cusp on the lateral teeth (as in Orr's figure of *E. turbinella* and in *menkeana*) but this apparently is not a regular feature of the radula of typical *Engina* species.

Engina (Enzinopsis) gannita (Plate 24, fig. 6) is a peculiar species that, at first sight, suggests affinity with species of *Prodotia* (see below). The aperture is, however, like that of other species of *Engina*. *Enzinopsis* could possibly be used (as a subgenus) for most of the elongate species of *Engina* with convex whorls, regular spiral sculpture and simple labial denticles. Such a division would however, be largely artificial, and is thus not recommended, as this series appears to grade into the typical group remarkably well.

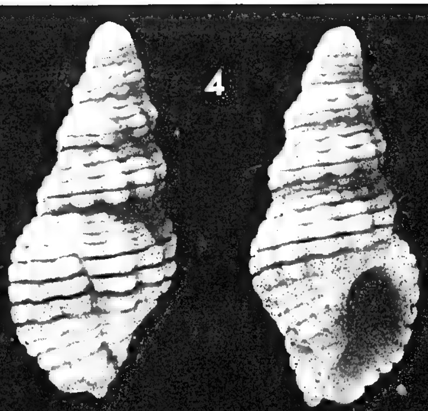
PLATE 24.

Figs. 1, 2. *Engina (Engina) australis* (Pease). Wooli, N.S.W. (C. 77135).
Fig. 3. *Engina ? gracilis* (Sowerby). Cronulla, N.S.W. (C. 77136).
Fig. 4. *Crassicantharus norfolkensis* n.sp. Norfolk Is. Holotype (C. 59418a).
Fig. 5. *Pisania (Jeannea) hedleyi* Iredale. Raoul Is., Kermadec Islands (C. 36693). *
Fig. 6. *Engina (Engina) gannita* Hedley. Darnley Is., Torres Strait. Holotype (C. 7468).
Fig. 7. *Monostiolum (Monostiolum) swifti* (Tryon). Hungry Bay, Paget Parish, S.E. coast, Bermuda, West Indies (Acad. Nat. Sci. Phil. No. 319019). *
Fig. 8. *Engina (Engina) turbinella* (Kiener). Camaricoa, Cuba (C. 77083). *
Fig. 9 *Engina ? unicolor* (Angas). Middle Harbour, Sydney, N.S.W. (C. 32444).
Fig. 10. *Engina (Engina) resta* (Iredale). Lord Howe Is. Paratype (C. 59643b). *

* specimens from which figured radulae obtained.

Plate 24


3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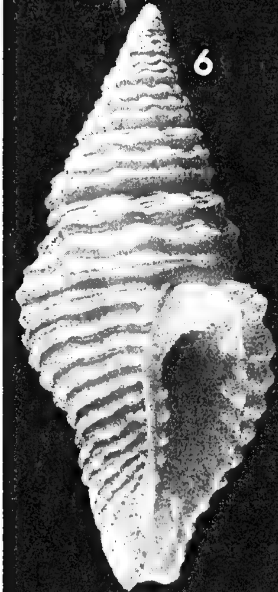
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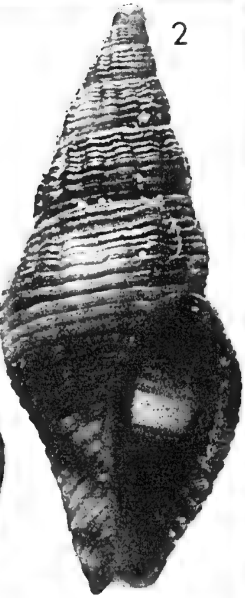
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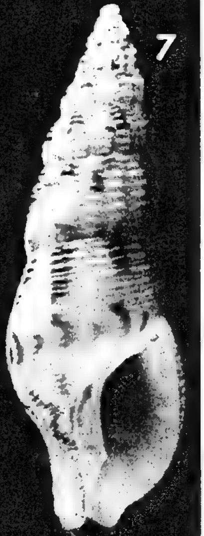
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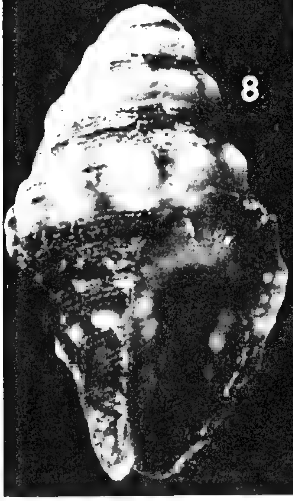
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Trachypollia Woodring, 1928 (type species *T. sclera* Woodring) from the Miocene of Jamaica also appears to belong to *Engina* and may be another name that could be used for the "tall species." The protoconch of *T. sclera* has 3 "rapidly enlarging" whorls.

In conclusion despite the apparent dissimilarity between *australis* and *zonata*, *australis* can be regarded as a species of *Engina*, but cannot be satisfactorily separated in a distinctive subgenus on the information available.

Pusiostoma Swainson, 1840 (type species (s.d. Gray, 1847) *Columbella punctata* Lamarck, 1822 = *Buccinum discors* Gmelin, 1790) is usually cited as a synonym of *Engina* (e.g. Thiele, 1929; Wenz, 1938). The type designation by Gray, however, makes this name a synonym of *Pyrene* Röding, 1798 (type species *P. rhombifera* Röding, 1798 = *discors* Gmelin), both having the same type species. Iredale (1940) gave "*mendicaria* auct., but not of Linné" as the type of *Pusiostoma* and erected a new family name for this genus with which he intended to replace the then obscure *Engina*.

Olsson and McGinty (1958) have described a genus *Risomurex* for *Engina schrammi* Crosse, 1863 and some other species previously included in *Engina*. The apertural features are like those of *Engina* but the protoconch is strongly keeled and the radula is muricoid.

Engina? gracilis (Sowerby, 1859)

Plate 24, fig. 3

1859 *Phos gracilis* Sowerby, *Thes. Conch.*, 3: 91, pl. 222, fig. 33.
1915 *Maculotriton gracilis*. Hedley, *Proc. Linn. Soc. N.S.W.*, 39: 733, pl. 84, fig. 79.

This species is known only from N.S.W., extending from Kurnell, Botany Bay (C. 77270) to Catherine Hill Bay (C. 54153).

Engina? unicolor (Angas, 1867)

Plate 24, fig. 9

1867 *Cantharus (Tritonidea) unicolor* Angas, *Proc. Zool. Soc.* (1867): 110, pl. 13, fig. 2.

E? unicolor is represented in the Australian Museum collections only from N.S.W., extending from Kurnell, Botany Bay (C. 77269) to the Clarence River district (C. 77268).

E.? unicolor can be separated from *gracilis* by its shorter, slightly broader shell, less convex whorls, weaker axial ribs which are usually weak or absent on the body whorl (they are strongly developed in *gracilis*) and more numerous closer spaced spiral cords (9-11 in *unicolor*, 7-8 in *gracilis*). Both species sometimes develop intermediate spiral threads between the main cords, but this is more frequently the case in *gracilis*. Hedley's (1915) figure of *gracilis* shows the penultimate whorl with 9 spiral cords. In fact two of these cords are secondary threads that have been over-emphasised in the drawing.

Discussion on the generic position of E.? gracilis and E.? unicolor.

Phos gracilis and *Cantharus unicolor* closely resemble *australis* in most shell features but have a smooth parietal wall except for a single tubercle. These two species may belong to a distinct genus but until their radulae are described they can be tentatively associated with *australis.*

Monostiolum swifti (Tryon, 1881) (Plate 24, fig. 7) from the West Indies (type species of *Monostiolum* Dall, 1904) has similar teleoconch sculpture and general features to *australis, unicolor* and *gracilis.* The spire is relatively taller (about 1½ x height of aperture plus canal instead of about 1-1⅛ times), and the columella is smooth (as in the latter two species) except for a minute denticle above the canal. Dall (1904) describes the protoconch of *M. swifti* as being axially ribbed and having the tip immersed leaving an apical pit. Dall probably examined a decollated specimen because it actually has 1½ whorls, the last ½ whorl being carinated, the remainder strongly shouldered and oblique. Olsson (1967) describes the protoconch as being " somewhat bulbous of a single smooth whorl ".

The radula of *E. australis* differs from that of *M. swifti* in having the bases of the lateral teeth produced outwards and these teeth vary from being bicuspid to tricuspid. The central tooth of *M. swifti* (Text fig. 1: 8) is relatively smaller and does not have any denticles in addition to the 3 cusps. The radulae of *gracilis* and *unicolor* are not known but their shells differ from *Monostiolum* in having a simpler protoconch and a rather different build.

Subgenus *Prodotia* Dall, 1904.

Type species: (o.d.) *Phos billeheusti* Petit, 1853 = *Buccinum obliquicostatum* Reeve, 1846.

This subgenus is characterised by the peculiar style of the aperture which has a relatively long canal and weakly dentate lips. Like *Engina* s.s. the protoconch is small-tipped and sometimes multispiral and there is moderately strong axial and spiral teleoconch ornament. The operculum is simple, with an apical nucleus and an oval muscle scar.

Peile (1939) described the radula of *Buccinum marmoratum* Reeve, a typical species of *Prodotia,* which he placed in *Engina.* Whereas the shells of species of both *Prodotia* and *Engina* have some features in common, the relatively weaker sculpture and apertural ornament make the two species of *Prodotia* stand apart from typical *Engina.* There is, however, some general similarity with some species, notably *Engina gannita* Hedley as already noted. The radula differs from *Engina* s.s. in the outermost pair of cusps on the central tooth being better developed giving the tooth a true pentacuspid appearance. The lateral teeth each have 2 long cusps, the outermost much longer than the inner.

The radula of three specimens of *E. (P.) marmorata* were examined. Two of them from specimens collected at Taurama, near Port Moresby, Papua, wese identical and normal (Text fig. 1: 5). A specimen from Mauritius had a radula with the median cusp of each central tooth divided into two separate teeth but was otherwise identical. Peile (1939) also, described an aberrant radula in *marmorata* with the central cusp reduced to a vestige.

Only a single radula of *E. (P.) obliquicostata* was available, this being obtained from a specimen named *crosseanus* from Noumea, New Caledonia. This radula (Text fig. 1: 6), which is clearly a freak example, has some of the cusps on the central teeth subdivided, these subdivisions being asymmetrical and varying a little in arrangement along the length of the ribbon. The basic tooth structure is the same as that in *marmorata;* the central teeth with 5 cusps, and bicuspid lateral teeth, their outermost cusps strongest.

Engina (Prodotia) obliquicostata (Reeve, 1846)

Plate 25, fig. 3 - 4; Text fig. 1: 6, 2: 17

1846 *Buccinum obliquicostatum* Reeve, *Conch. Icon.*, 3, *Buccinum*, pl. 12, sp. 91 a, b.
1846 *Buccinum gracile* Reeve, *Conch. Icon.*, 3, *Buccinum*, pl. 12, sp. 96.
1846 *Buccinum crocatum* Reeve, *Conch. Icon.*, 3, *Buccinum*, pl. 12, sp. 97.
1853 *Phos billeheusti* Petit, *J. Conch., Paris*, 4: 244, pl. 8, fig. 5.
1864 *Pisania billeheusti* var *artensis* Souverbie and Montrouzier, *J. Conch., Paris*, 12: 266.
1865 *Fusus crosseanus* Souverbie, *J. Conch., Paris*, 13: 160, pl. 5, fig. 6.

The number of species listed in the synonymy show the variability of this species. Considerable variation in size, colour, sculpture etc. occurs. Shells in the Australian Museum collections can be matched with the figures and descriptions of the type of each of the species names and no reasonable grounds for their separation can be found.

Reeve published three names on the same plate which apparently represent the same species. The first is chosen as the name for the species because it has numerical priority and there are no special reasons why the other figures should be chosen. *Pisania gaskelli* Melvill, 1891 *(J. Conch., Lond.*, 6: 406, pl. 2, fig. 5) and *Tritonidea neglecta* Sowerby, 1894, *(Proc. Malac. Soc.*, 1: 42, pl. 4, fig. 7) are possibly additional synonyms.

This species is distinguished by its protoconch of only 1$\frac{1}{2}$-1$\frac{3}{4}$ whorls (Text fig. 2: 17), and strong axial ribs which extend with more or less equal strength from suture to suture and over the base. The spiral threads tend to be more regular than in *P. marmorata* and are typically stronger. In addition the shell is usually smaller and has a longer canal than *P. marmorata.* It is distributed throughout the tropical Indo-Pacific and in the Australian Museum there are specimens from eastern Queensland (Low Isles (C. 77165, 77166); Fitzroy Island (C. 77169); Hook Island (C. 77170)); and Long Island, Torres Strait (C. 77167, 77168).

Engina (Prodotia) marmorata (Reeve, 1846)

Plate 25, fig. 5; Text figs. 1: 5; 2: 18

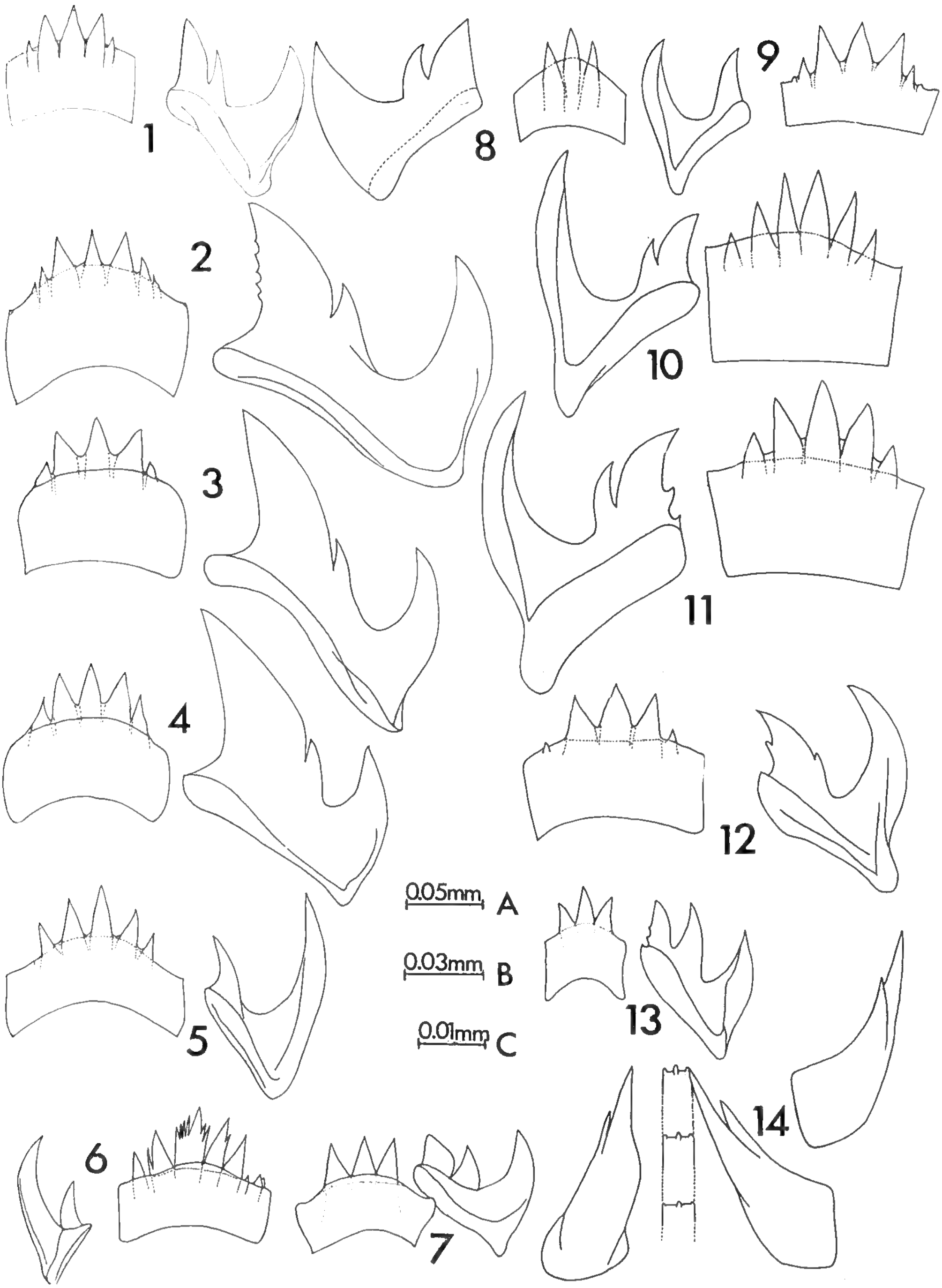
1846 *Buccinum marmoratum* Reeve; *Conch. Icon.*, 3, *Buccinum*, pl. 12, sp. 95.

TEXT FIG. 1. Radular teeth.

1. *Pisania (Pisania) striata* (Gmelin). Marsa Sciroceo Harb., Malta, Mediterranean (C. 44347).
2. *Pisania (Pisania) ignea* (Gmelin). Michaelmas Cay, Queensland (C. 53314).
3. *Pisania (Taeniola) decollata* (Sowerby). Cook Islands, Pacific Ocean (C. 76288).
4. *Pisania (Pisania) fasciculata* (Reeve). Lindeman Island, Queensland (C. 58869).
5. *Engina (Prodotia) marmorata* (Reeve). Tuarama, near Port Moresby, Papua (C. 76287).
6. *Engina (Prodotia) obliquicostata* (Reeve). Noumea, New Caledonia (C. 4306).
7. *Pisania (Jeannea) hedleyi* (Iredale). Raoul Island, Kermadec Islands (C. 36693).
8. *Monostiolum (Monostiolum) swifti* (Tryon). Hungry Bay, Paget Parish, S.E. Coast, Bermuda, West Indies (Acad. Nat. Sci. Phil. No. 319019).
9. *Engina (Engina) armillata* (Reeve). North Keppel Island, Queensland (C. 70451).
10. *Engina (Engina) turbinella* (Kiener). Camaricoa, Cuba (C. 77083).
11. *Engina (Engina) resta* (Iredale). Lord Howe Island. Paratype (C. 59643b).
12. *Engina (Engina) australis* (Pease). Minnie Waters, Clarence River, N.S.W. (C. 72632).
13. *Clivipollia pulchra* (Reeve). Siassi Islands, New Guinea (C. 74829).
14. *Crassicantharus norfolkensis* gen. et sp. nov. Norfolk Island. Paratype (C. 59418b).

Fig. 1 - 5: Scale A; Fig. 6 - 9, 13: Scale B; Fig. 10 - 12, 14: Scale C.

Buccinidae



This species differs from the preceding in having a multispiral protoconch of 3½ whorls (Text fig. 2: 18), and a larger, usually slightly broader shell with the axial ribs much reduced or wanting above the shoulder. The spiral cords are usually alternatively weak and strong and the sculpture is typically weaker than in *obliquicostata.*

This species has a similar distribution to the last. There is a specimen from Minnie Waters, Clarence River, N.S.W. in the Australian Museum collection (C. 70011) and others from eastern Queensland; Low Isles (C. 77163, 77164); Fairfax Island, Bunker Group (C. 69053); North East collection (C. 70011) and others from eastern Queensland; Low Isles Herad Cay, Coral Sea (C. 69064).

Four specimens from Taurama, near Port Moresby, Papua were sexed with the following results.

Shell dimensions (Height x diameter)	Sex
36.0 x 14.2	Female
26.0 x 11.5	Female
24.0 x 10.0	Male
23.0 x 9.5	Male

This result suggests there may be a positive correlation of size with sex as seen in some other Buccinidae (Habe, 1950; Tiba, 1941).

Genus *Monostiolum* Dall, 1904

Subgenus *Caducifer* Dall, 1904

Type species: (o.d.) *Triton truncatum* Hinds, 1844.

This group appears to be closely allied to *Monostiolum* (see p. 255) which has place priority (both genera introduced on p. 136), and is here given subgeneric rank. It mainly differs in the multispiral protoconch and the very tall spire which is normally decollated.

The type species is found in Queensland (Kenn Reef, C. 68578) and is easily recognised by its orange and black mottled coloration, strong axial ribs and decollated spire. A very similar but more weakly sculptured species, *C. decapitatus* (Reeve, 1844) also occurs in much of the tropical Indo-Pacific and is known from Queensland (Two Isles, Cape Flattery (C. 41437), Palm Island (C. 9638), Michaelmas Cay, off Cairns (C. 53526)) and Western Australia (Houtmann Abrolhos Is. (C. 77260)).

The radula of both species (see Pilsbry and Vanatta, 1904) has simple tricuspid central and lateral teeth. The protoconch of the type species is tall and of about 3 whorls.

Genus *Pisania* Bivona — Bernardi, 1832

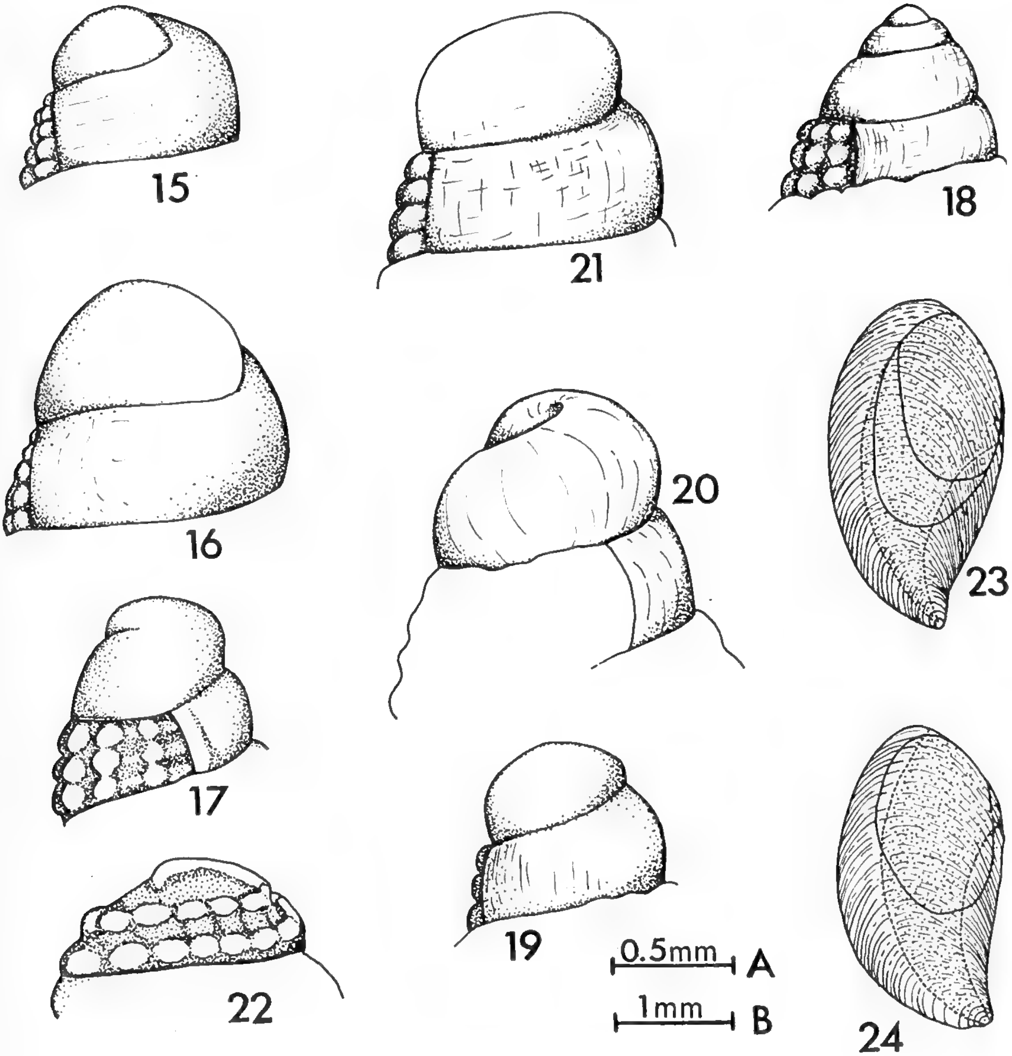
Type species: (s.d. Iredale, 1915), *P. striatula* Bivona, 1832, Opin. 740 *Bull. Zool. Nom.*, 2: 171 - 172 = *Voluta striata* Gmelin, 1790 (not *Murex striata* Gmelin, 1791 as stated by Rehder, 1963).

Synonyms: *Proboscidea* Schmidt (in Möller) 1832 (non Bruguiére, 1791) (type species *Buccinum igneum* Lin. (=Gmelin)).

Ecmanis Gistel, 1848 nom. nov. pro *Proboscidea* Schmidt.

Appisania Thiele, 1929 (type species *Pisania montrouzieri* Crosse, 1862 (= *fasciculata* Reeve, 1846)).

Appisania was introduced by Thiele as a subgenus of *Metula* H. and A. Adams, 1853. *Metula,* however, appears to have little relationship



TEXT FIG. 2. Protoconchs and operculae.

15, 16. *Engina (Engina) australis* (Pease). Wooli, N.S.W. (from specimens figured on Plate 24) (C. 77135).

17. *Engina (Prodotia)* obliquicostata (Reeve). Noumea, New Caledonia (C. 3962).

18. *Engina (Prodotia) marmorata* (Reeve). Low Isles, near Port Douglas, Queensland (C. 77163).

19. *Pisania (Pisania) ignea* (Gmelin). Samoa (C. 61162).

20, 21. *Pisania (Pisania) fasciculata* (Reeve). Palm Island, Queensland (C. 9649). Two views of same specimen.

22. *Crassicantharus norfolkensis* gen. et sp. nov. Norfolk Island. Paratype (C. 59418b).

23. *Engina (Engina) resta* (Iredale). Lord Howe Island. Paratype (C. 59643b).

24. *Engina (Engina) australis* (Pease). Minnie Waters, Clarence River, N.S.W. (C. 72632).

Fig. 15 - 22: Scale A; Fig. 23, 24: Scale B.

with *Pisania* and may belong to the family Colubrariidae. Thiele differentiated *Appisania* largely on radular characters, the lateral teeth having the inner cusp much larger than the outer (Text fig. 1: 4). Cernohorsky (1966) has described the radula of *P. montrouzieri* (= *fasciculata*) and this was originally illustrated by Thiele (1929). The radula of several specimens covering a range of colour forms was examined in the present study and no correlation with colour, or marked variation, was found. The small denticle on the inner cusp (= the medium cusp) varies in size and is occasionally very indistinct. This species is discussed in detail below.

The radula of *Pisania striata* (Text fig. 1: 1) (also figured by Troschel and Thiele, 1867) has 5 cusps on the squarish central tooth, the outer pair small in relation to the others. The lateral teeth have 2 large cusps, with one small cusp between them. Troschel and Thiele's figure shows these cusps subequal, the specimen here illustrated has the outer cusp stronger. Thus the only difference between the radula of *Pisania* and *Appisania* is the relative size of the outer cusps of the lateral teeth. Considering the variation observed in radular features, I can see no valid reason why *Appisania* should be maintained as a distinct genus or subgenus. Certainly there is nothing distinctive in the shell features between *striata* (Plate 25, fig. 1) and *fasciculata* and now that there is only one species of *Appisania* to consider (see below), its recognition as a " group of species " is no longer necessary.

Two specimens of *Pisania ignea* (Gmelin), the type species of *Ecmanis* Gistel, were available for radula extraction. One specimen from Michaelmas Cay, Queensland (Text fig. 1: 2) has serrations along the inside of the inner cusp of each lateral tooth. The central tooth has five main cusps and 2 small denticles at the outer bases of the outermost cusps. These denticles are not present in the radula of the second specimen, which was obtained by trawling off Broome, N.W. Australia; nor are the denticles on the inner cusp of the lateral teeth present. These radulae are very like that of *P. striata.* I cannot find any significant shell features that would allow for subgeneric separation of *ignea,* especially when the range of shell form in species related to *ignea* and *striata* is considered. Both *striata* and *ignea* (Text fig. 2: 19) have a paucispiral protoconch that is relatively smaller than that of *fasciculata.*

There appears to be at least 3 subgeneric groups of *Pisania* in the Pacific area and these are briefly contrasted with *Pisania* below.

Dall (1904) introduced *Taeniola* for *Triton decollatus* Sowerby, 1833 which was considered to be inseparable from *Pisania* by Pilsbry and Vanatta (1904). The sculpture in *T. decollatus* is composed of broad, flat spiral cords with narrow interstices and the early whorls also have axial ribs. This is quite unlike the sculpture seen in species of *Pisania* s.s. as Dall commented and it seems that *Taeniola* could hold subgeneric rank in *Pisania.* Other distinctive features include the markedly decollate spire, convex whorls, very strong varix (this is weak to medium in typical species of *Pisania*) and the inner lip raised over the fasciole.

The radula of *Pisania (Taeniola) decollata* (Text fig. 1: 3) is intermediate between that of *Pisania striata* (and *P. ignea*) and *P. fasciculata* in having the outer cusp of each lateral tooth about ½ the size of the inner. The middle cusp is very small, as in *P. fasciculata. P. (T.) decollata,* although having a wide Pacific distribution, has not been recorded from Australia.

Jeannea Iredale, 1912 (type species *J. hedleyi* Iredale) appears to contain only the type species which is from the Kermadec Islands north-east of New Zealand. *J. hedleyi* (Plate 24, fig. 5) is smaller than species of *Pisania* s.s. and has a barely discernible labial varix. Widely spaced, sharp spiral cords predominate over most of the teleoconch and they are rendered slightly nodulous at the points of intersection with the weak axials. Numerous fine interstitial threads lie between the main spirals. The inner lip and columella are smooth and there are long, weak lirations within the outerlip. The protoconch is rather loosely coiled, of 1½ whorls with the tip inrolled. There is nothing outstandingly different in the shell features that would separate this species from *Pisania* s.s. but the radula (Text fig. 1: 7) which was examined from two topotypes, is like that of *Buccinulum* Swainson, 1837 species (see Powell, 1929) with simple tricuspid central teeth of different shape to those seen in *Pisania* s.s. and the lateral teeth have three cusps of equal size.

The radular features suggest relationship with *Buccinulum* but the protoconch and teleoconch show affinity with *Pisania*. It is more probable that the relatively subtle characters seen in the radula were brought about by convergence than the rather more elaborate shell features. Thus *Jeannea* is here regarded as a subgenus of *Pisania*, from which it can be distinguished on radular features.

Sukunaia Cernohorsky, 1966 (type species *S. jenningsi* Cernohorsky) is very closely related to *Pisania* and barely distinguishable on shell features. The radula, however (see Cernohorsky, 1966) has a central tooth with only rudimentary cusps. As this appears to be the only distinguishing character from *Pisania*, *Sukunaia* should be regarded as a subgenus of *Pisania*. The type species has only been recorded from Fiji.

Pisania (Pisania) fasciculata (Reeve, 1846)

Plate 25, fig. 2; Text figs. 1: 4; 2: 20-21

1846 *Buccinum fasciculatum* Reeve, *Conch. Icon.*, 3, *Buccinum*, pl. 10, fig. 76.
1854 *Pisania crenilabrum* A. Adams, *Proc. Zool. Soc.*, (1854): 138.
1862 *Pisania montrouzieri* Crosse, *J. Conch., Paris*, 10: 251, pl. 10, fig. 5.
1876 *Pisania crenilabrum*. Smith, *J. Linn. Soc.*, 12: 541.
1901 *Pisania delicatula* Sowerby, *J. Malacol.*, 8: 101, pl. 9, fig. 2.
1929 *Jeannea crenilarum* (sic). Iredale, *Mem. Qld. Mus.*, 9: 288.
1962 *Jeannea delicatula*. Iredale and McMichael, *Aust. Mus. Mem.*, 9: 69.
1968 *Appisania sugimoto* Habe, *Venus*, 27 (3): 85, text fig. 1.

This species exhibits considerable colour and size variation between and within populations. I can see no reason why the names in the above synonymy should be considered valid species as they appear to represent mere colour forms which can be found grading into one another, even within a single population.

The adult shell always bears small crenulations on the outer lip which correspond to the weak spiral cords (which form the main sculpture) and within this lip shallow grooves run between the crenulations. There is a labial varix and the inner lip bears a single tooth posteriorly and another immediately above the short canal. The protoconch is asymmetrical, of about 2 whorls (Text fig. 2: 20-21).

This species is common on the Great Barrier Reef and in New Caledonia. It extends throughout the tropical Indo-Pacific to tropical East Africa. The type locality of *Pisania delicatula* Sowerby, was given as

"Bird Island, South Pacific." Hedley (1913) suggested that this may be Bird Island near Newcastle, N.S.W., but there are, he remarks, no less than 10 "Bird Islands" off the Australian coast. Probably, however, the specimens were collected in a more tropical location than the central N.S.W. coast.

Genus *Crassicantharus* gen. nov.

Type species: *C. norfolkensis* sp. nov.

GENERIC DIAGNOSIS: *Shell:* Small, elongate — buccinoid, solid, with strong spiral cords and axial ribs. Protoconch of 1 bicarinate whorl. Inner lip and columella smooth except for a parietal tubercle at the base of the posterior canal. Outer lip without a sinus, thickened and denticulate within. *Operculum:* oval, with an apical nucleus. *Radula:* Relatively small, lateral teeth strong, with small bases consisting of a single bifid cusp. Central teeth vestigial, narrow, with 3 denticles (Text fig. 1: 14).

REMARKS: The radular and protoconch features readily separate the new genus from any other in the Buccinidae.

Chauvetia Monterosato, 1884 (type species *Buccinum candidissima* Philippi) is similar to *Crassicantharus* in shell features (see Tiberi, 1868 for figures of the type species and related species) but *C. brunnea* (Donovan, (1804) has a distinctive radula and operculum (Woodward, 1899). The radula has a single cusp on the central teeth and the tricuspid laterals each have a long latero-basal projection. The operculum is broadly truncated at the apical end. Lebour (1937, p. 156) describes the egg capsules of *C. brunnea* as being lens-shaped and transparent.

Clathranachis Kuroda and Habe, 1954 (type species *Lachesis japonica* A. Adams, 1860) and *Ruthia* Shasky, 1970 (type species *R. mazatlanica* Shasky) are somewhat similar in shell features but have typical columbellid radulae.

Crassicantharus norfolkensis sp. nov.

Plate 24, fig. 4; Text fig. 1: 14; 2: 22

Shell: Small, elongate, solid, with strong spiral cords and axial ribs. Whorls of teleoconch about 5, subshouldered, sutures moderately impressed. Protoconch (Text fig. 2: 22) almost flat, of 1 whorl, tip only slightly raised, with 2 strong spiral ridges continuous with those of first whorl of teleoconch. These ridges are crossed by weak axial riblets which render the spiral cords slightly nodulous on the first $\frac{1}{2}$ whorl. The finer details of protoconch sculpture were not visible due to abrasion (only

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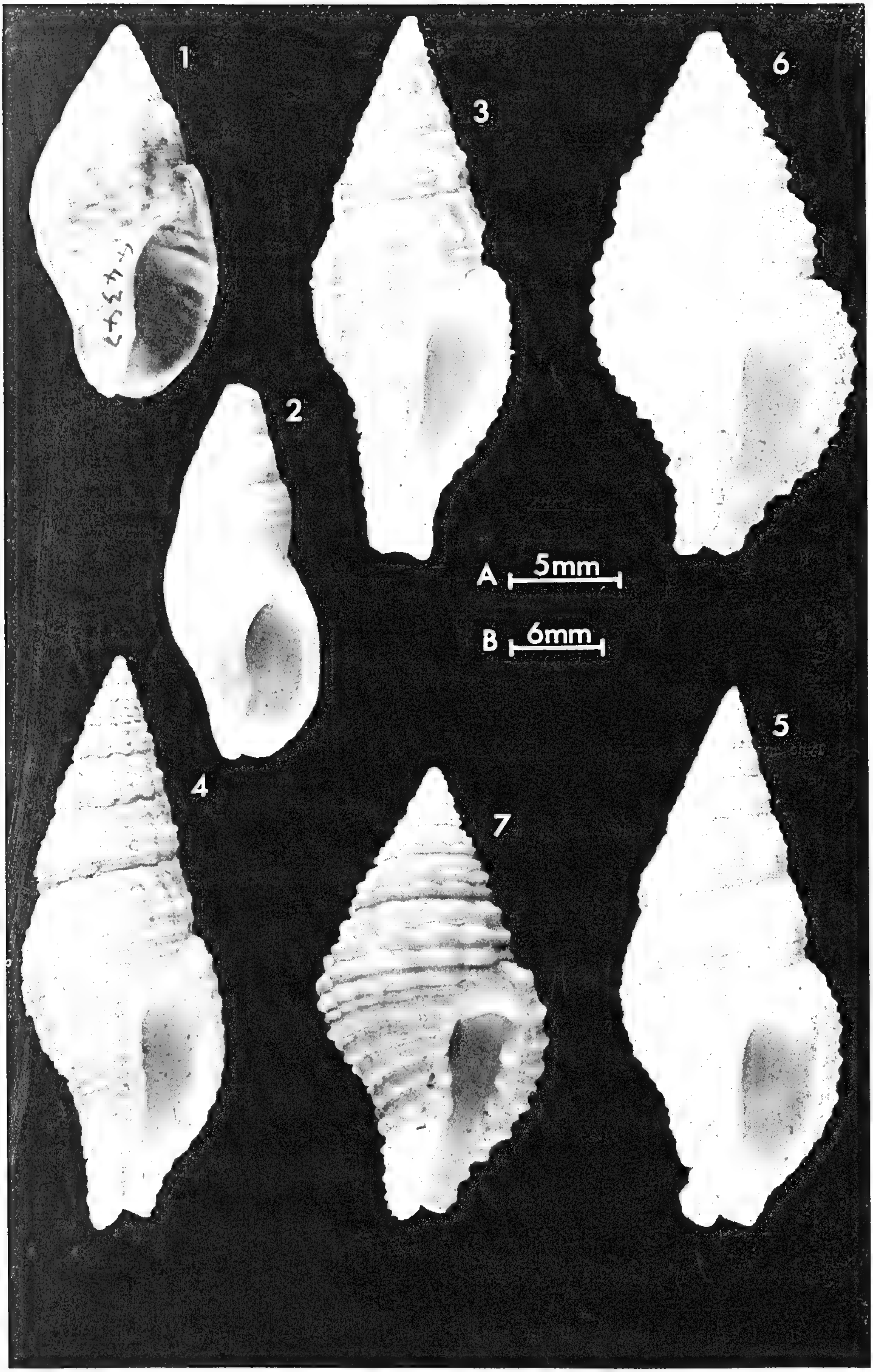
PLATE 25.

Fig. 1. *Pisania striata* (Gmelin). Marsa Sciroceo Harb., Malta, Mediterranean (C. 44347). *
Fig. 2. *Pisania fasciculata* (Reeve). Lady Musgrave Island, Bunker Group, Southern Queensland (C. 77137).
Fig. 3. *Engina (Prodotia) obliquicostata* (Reeve). Noumea, New Caledonia (C. 4306). *
Fig. 4. *Engina (Prodotia) obliquicostata* (Reeve). Long Island, Torres Strait (C. 77167).
Fig. 5. *Engina (Prodotia) marmorata* (Reeve). Low Isles, near Port Douglas, Queensland (C. 77163).
Fig. 6. *Clivipollia imperita* Iredale. Sydney Hr., N.S.W. Holotype (C. 57848).
Fig. 7. *Clivipollia pulchra* (Reeve). Siassi Is., New Guinea (C. 74829). *
Fig. 1, 2: Scale A; Fig. 3 - 7: Scale B.
* specimens from which figured radulae obtained.

Plate 25



1 juvenile has the protoconch intact). Sculpture of teleoconch of white to yellowish, broad, flat, spiral ridges, with narrow, dark reddish-brown interstices. First whorl of teleoconch with 2 spiral cords crossing the axial ribs, the points of intersection slightly nodulous. Spiral increase to 4 on penultimate whorl and there are 11 on the body whorl and base. Sometimes an additional weak cord below periphery on body whorl. Axial ribs strong, 11-12 on body whorl. Fasciole prominent, inner lip and columella smooth, a large parietal tubercle at base of posterior canal. There is no sinus on the outer lip which is thickened with about 8 long denticles. There is no external varix. Anterior canal short, curved to left, and open.

Radula and operculum: As for generic diagnosis.

Head-foot: (from restored dried animal) with no dark pigment, with dense white blotches on foot. Head small; eyes prominent, at the bases of moderately long tentacles.

Height	10.25 mm.	Diameter	4.55 mm.	(holotype)
	10.42 mm.		4.65 mm.	(paratype)
	11.32 mm.		4.70 mm.	(paratype)

Holotype: Norfolk Island; collected R. Bell (Australian Museum, Registered No. C. 59418a).

Paratypes: 8 — with above data (C. 59418b); 14 additional paratypes (specimens presented by C. Hedley) from the same locality (C. 31020).

Genus *Clivipollia* Iredale, 1929

Type species: (monotypy) *C. impertia* Iredale.

This genus was placed in the Fasciolariidae by Wenz, next to *Peristernia* Mörch, 1852, a genus which it closely resembles in most shell features. The type species has, however, an aperture like *Engina* with a row of prominent denticles inside the inner lip. There are a few tropical species which are obviously congeneric with *C. impertia* (Plate 2, fig. 6) which have been variously placed in *Peristernia, Engina* etc. These include *Ricinula pulchra* Reeve, 1846; *Turbinella carolinae* Kiener, 1841 (= *Rincinula bella* Reeve, 1846); and *Turbinella wagneri* Anton, 1838 (= *Turbinella crenulata* Reeve, 1847 (non Kiener, 1841), = *Purpura bucciniformis* Kiener, 1835).

C. impertia is known from only one specimen taken by the Sydney Harbour dredge "Triton". The shell is very faded and may possibly be sub-fossil. It is almost indistinguishable from *R. pulchra,* the radula of which was mounted from a specimen collected from the Siassi Islands, northern New Guinea (Plate 2, fig. 7). This radula (Text fig. 1: 13) has a different structure from that of typical species of *Engina,* a genus in which *pulchra* Reeve is often located. It has narrow central teeth with 3 large cusps and the lateral teeth have 3 cusps decreasing in size from the outer to the inner.

In view of the distinctive radular and shell features, this group appears to be fully worthy of generic status within the Buccinidae. It shares the features of both *Engina* and *Cantharus* Röding, 1798.

ACKNOWLEDGEMENTS

I would like to thank Dr. R. Robertson, Academy of Natural Sciences of Philadelphia and Dr. J. Rosewater, Smithsonian Institution, Washington, for the loan of specimens, and Miss G. Thornley and Mrs. J. Kerslake for providing useful comparative material. I am grateful to Miss C. Robinson and Mr. P. Colman of the Malacology Department for their valuable assistance and to Mr. C. Turner for the photography. I am also indebted to Mrs. P. Zylstra who kindly did the final drawings for the text figures, and to my wife who has tirelessly helped in checking the manuscript.

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A REVISION OF AUSTRALIAN RECENT AND TERTIARY TURRITELLIDAE (GASTROPODA: MOLLUSCA)

T. A. GARRARD

Hon. Associate, Australian Museum, Sydney

Plates 26-30

ABSTRACT

A description is given and comparisons made of all known recent species in the family Turritellidae from Australian waters, together with all known species from the Tertiary of Victoria, South Australia and Tasmania. Four (one new) species are included in *Archimediella*, 19 (7 new) in *Colpospira (Colpospira)*, 4 (one new) in *Colpospira (Acutospira)*, 8 in *Colpospira (Platycolpus)*, 5 in *Colpospira (Ctenocolpus)*, 8 and one new subspecies in *Gazameda*, two in *Haustator (Kurosioia)*, five in *Maoricolpus*, one in *Stiracolpus*, one in *Turritella*, one in *Zeacolpus*, one new species in *Zeacolpus (Stiracolpus)*, one in *Pareora*, one in *Zaria*, 3 in *Glyptozaria*, and 2 in *Kimberia*.

INTRODUCTION

During the present century the recent Australian species of the family Turritellidae have been greatly neglected, due possibly to a lack of material in some instances on which to base any systematic work on the group, and also possibly because of its complexity. What little work has been done, has been in some instances misleading and confusing. Generally speaking the bulk of the species are so variable that a systematic microscopic examination of live-taken specimens is necessary to determine their exact relationship with each other, but in many cases these would be almost impossible to obtain. This paper is therefore designed to clear up a number of misconceptions regarding various species, and chiefly to collate the knowledge regarding all Australian species, both recent and fossil, in the one paper for the first time. A number of recently discovered species, chiefly from deep water, and also two Tertiary fossils are described and named.

Fortunately the dredging carried out by H.M.A.S. " Gascoigne " in 1962 in southern Australian waters, and the results obtained by the " Western Australian — Hawaiian Expedition " in the same year off the coast of Western Australia, have assisted in throwing a great deal of light on a number of species, and brought to notice three new species and a number of new records. Valuable material was also obtained from the Division of Fisheries and Oceanography, C.S.I.R.O., Cronulla, N.S.W., during a survey of the continental shelf down to 100 metres. In addition recent trawling and dredging in the somewhat deeper waters of southern Queensland has brought to light a further seven new species.

The excellent revision of the genera of this family by Marwick (1957) has enabled some order to be restored to the rather haphazard classification of the Australian species previously existing.

No new genera have been introduced as it is considered that all Australian recent and fossil species fit well into existing genera and subgenera. It has been found necessary to pay close attention to geographical limits imposed on most species of such sedentary molluscs, especially those with large paucispiral protoconchs indicating only a benthic existence. Close attention has also been paid to the possible ancestry of recent species which may be evident in the Tertiary of southern Australia and New Zealand, and any temptation to show connection with European or American species avoided without just cause.

Subfamilies, genera and subgenera have been set out in tabular form in the order of Marwick's (1957) classification, with the addition of one new subgenus introduced since that date.

Owing to the discrepancies and terms used in such varied manner by different authors in their description of species, it has proved most difficult in the past to compare species, especially when endeavouring to identify them from descriptions alone. The six to ten words in Latin frequently used by Linnaeus contrast markedly with the voluminous descriptions of Watson in the "Challenger" reports (1886). It was therefore decided that for the sake of clarity it was better to use a brief uniform diagnostic description for each species, except in the case of new species where a fuller description is given. Under the heading "Discussion" each species is compared with its nearest relatives if any in order to simplify recognition.

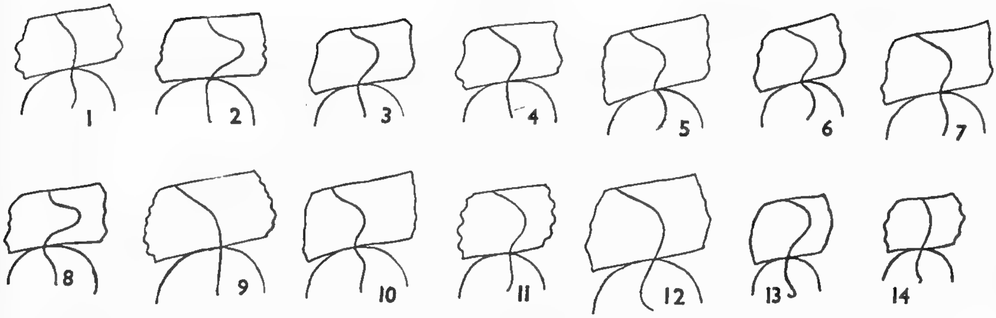
IDENTIFICATION OF GENERA AND SPECIES

Briefly the main points to observe in generic and specific determination in this family are:

1. The protoconch, which remains fairly constant within species (with the exception in Australia of *Gazameda declivis* Adams and Reeve), but may vary to a small extent within a genus. Outlines of various protoconchs applicable to Australian species are shown below. Most genera in which Australian species are placed have paucispiral types of protoconchs, with the nucleus and portion of first whorl deviated at an angle of 20° to 40° from the axis of coiling of the following whorls. These protoconchs are referred to in the descriptions of genera as asymmetric.

2. The lateral sinus in conjunction with the basal sinus, which remain fairly constant within a genus. Drawings of the outer lip of genera and subgenera applicable to Australian species have been adopted from Marwick (1957: 146) with his permission and are shown below. It must be noted that geronticism may cause marked variation in the depth and also to a slight extent in the position of the lateral sinus on the mature whorls, and the outer lip trace on the earlier whorls is a safer guide if visible. In many specimens of *Colpospira* species the lateral sinus narrows and deepens to such an extent on gerontic whorls that it is indistinguishable from that of *Spirocolpus*, and the basal sinus would then assist considerably in determination of the genus.

In accordance with accepted practice, where an arc leans to the left when drawn from the upper suture across the wings of the outer lip, this is described as *prosocline;* where such an arc leans to the right it is described as *opisthocline;* where the line is perpendicular to the suture it is described as *orthocline.* These terms are used under the heading "Generic characteristics."



Figures 1 - 14. Outer lips of type species of Turritellidae.

1. *Archimediella*; 2. *Colpospira* s.s. and *C. (Acutospira)*; 3. *Colpospira (Platycolpus)*; 4. *Colpospira (Ctenocolpus)*; 5. *Gazameda*; 6. *Haustator (Kurosioia)*; 7. *Maoricolpus*; 8. *Spirocolpus*; 9. *Turritella*; 10. *Zeacolpus* s.s.; 11. *Zeacolpus (Stiracolpus)*; 12. *Zaria*; 13. *Pareora*; 14. *Glyptozaria*.

Note: Basal sinus of *Gazameda* amended. J. Marwick del.

3. The order of emergence of the primary spirals. Authors of several monographs in other countries in recent years have adopted various methods of defining the position of the various cords or keels and the combinations of them. The simplest procedure is that of Finlay (1930: 230), as modified by Marwick (1957: 148), naming the medial primary cord as B, and the peribasal one usually involved with the suture as D. (This cord frequently fails to appear in a number of species, or appears only on the last two or three whorls). A is the first to appear adapical to B, and C the first to appear abapical to B, that is between B. and D. The order of emergence of these primary spirals is given with the description of each genus to assist with identification.

4. Sculpture. In relying on sculpture to assist with classification, that of the primary spire whorls is usually much more reliable and less variable than that of the more mature whorls. The shape of the whorls and spiral sculpture in many species is very variable, and gerontic specimens frequently develop on parallel lines in shape and sculpture with closely allied species, which can be very misleading.

These points of determination cannot be taken in any order of precedence, but must be observed conjointly.

ORDER OF PRINTING

The type for each genus is printed first if it occurs in Australian waters, otherwise all are in alphabetical order. Fossil species are placed in order of age at the end of each genus. An index to species is at rear of the paper.

MATERIAL

Although the bulk of material for new species is shown as being held by the Australian Museum, Sydney, a number of specimens where available will be forwarded to other State Museums for reference purposes.

SIZE OF SPECIES

Sizes are shown under "Generic characteristics" according to the following table of Kotaka (1959: 59) as modified by Marwick (1971: 6).

Very large	Over 100 mm.
Large	50 - 100 mm.
Medium	20 - 50 mm.
Small	10 - 20 mm.
Very Small	Under 10 mm.

SPECIES OMITTED

The two following species formerly on record in Australia have been omitted for the reasons stated:

Turritella microscopica May, 1910. Examination of the holotype shows that this has no connection with the Turritellidae but is possibly an *Aclis*, family Aclididae.

Turritella multilirata A. Adams and Reeve, 1848. This species was recorded by Melvill and Standen (1899: 170), from dredgings by Prof. A. C. Haddon, and taken at Boydong Cays, 50 miles south of Cape York Peninsula, off the east coast of Queensland. The specimen was forwarded for inspection by the Manchester Museum, England, but proved to be *Haustator (Kurosioia) cingulifer* Sowerby.

FOSSIL SPECIES

All necessary data regarding Tertiary fossil species has been included, the Formation, Local Stage name and Epoch being cited in each case for the relative type locality. No mention has been made of distribution, as most species are recorded from so many localities, frequently showing localised variations, that a comprehensive separate paper would be required to list them all, by a palaeontologist fully conversant with the geographical and stratigraphical distribution. The description given in each case is that of specimens from the type locality only, together with photographs of suitable specimens, only two being from other than type localities.

ACKNOWLEDGEMENTS

I wish to place on record my sincere thanks to the following: Dr. J. Marwick, Lower Hutt, New Zealand, for considerable assistance with

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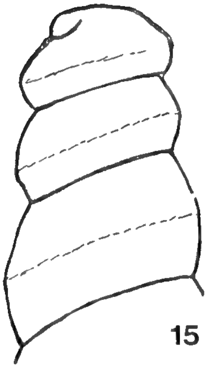
Figures 15 - 32. Protoconchs of Turritellidae.

15. *Gazameda declivis* (Adams and Reeve). 31 - 36 metres off Masthead Is., Q.; 16, 17, 18. *Gazameda declivis* (Adams and Reeve). 58 metres E. of King Is., Bass Strait; 19. *Colpospira (Colpospira) runcinata* (Watson). 63 metres off St. Francis Is., S. Aust.; 20. *Colpospira (Ctenocolpus) australis* (Lamarck). 118 metres off Jervis Bay, N.S.W.; 21. *Colpospira (Platycolpus) quadrata* (Donald). 91 metres off Twofold Bay, N.S.W.; 22. *Spirocolpus aldingae* (Tate). Adelaide Bore, Kent Town, S. Aust.; 23. *Archimediella fastigiata* (Adams and Reeve). Roebucke Bay, W.A.; 24. *Zeacolpus (Zeacolpus) vittatus* (Hutton). Castlecliff, Wanganui, N.Z.; 25. *Zeacolpus (Stiracolpus) symmetricus* (Hutton). 183 metres off Otago Heads, N.Z.; 26. *Glyptozaria opulenta* (Hedley). 9 - 14 metres Twofold Bay, N.S.W.; 27. *Kimberia neptunensis* (Verco). 170 metres S. of Cape Carnot, S. Aust.; 28. *Gazameda gunnii* (Reeve). 137 metres off Broken Bay, N.S.W.; 29. *Haustator (Kurosioia) cingulifer* (Sowerby). 4 metres Keppel Bay, Q.; 30. *Haustator (Kurosioia) leeuwinensis* Garrard. 142 metres W. of Jurien Bay, W.A.; 31. *Colpospira (Acutospira) atkinsoni* (Tate and May). 146 metres off Gabo Is., Vic.; 32. *Pareora stylacris* (Tate). Blanche Point, Aldinga Bay, S. Aust.

Fig. 15 - 18, 28 X. Fig. 19 - 32, 36 X.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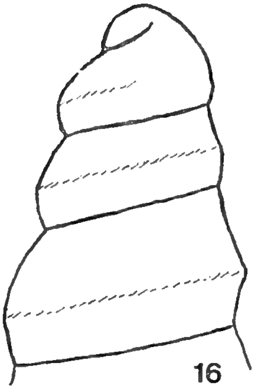
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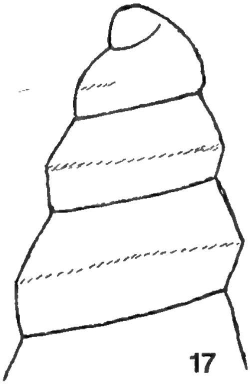
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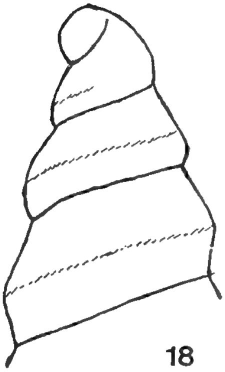
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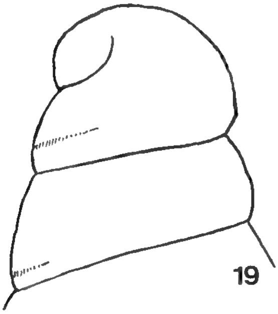
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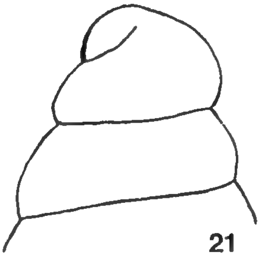
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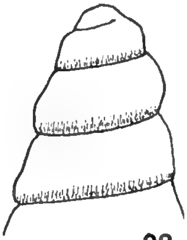
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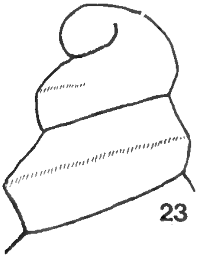
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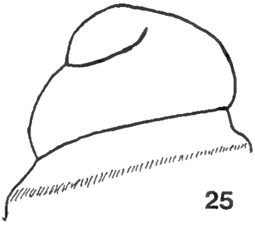
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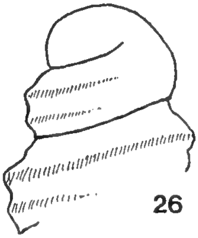
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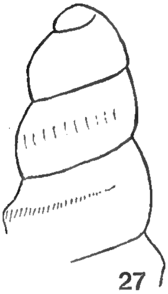
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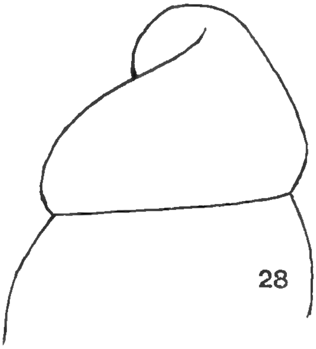
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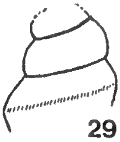
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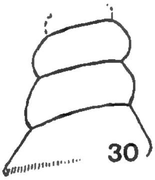
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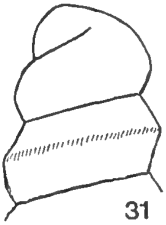
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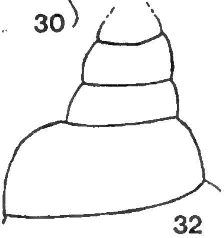
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TABLE OF GENERA AND SUBGENERA

Family TURRITELLIDAE Woodward, 1851

Subfamily TURRITELLINAE Woodward, 1851

Archimediella	*_(Archimediella)_	_Peyrotia_	
	(Torculoidella)	_Sechuritella_	
Callostracum		*_Spirocolpus_	
Colposigma		_Torcula_	_(Torcula)_
Colpospira	*_(Colpospira)_		_(Bactrospira)_
	*_(Acutospira)_		_(Eurytorus)_
	*_(Platycolpus)_	_Torquesia_	_(Torquesia)_
	*_(Ctenocolpus)_		_(Ispharina)_
Colpospirella		_Tropicolpus_	
*_Gazameda_		*_Turritella_	
Haustator	_(Haustator)_	_Zeacolpus_	*_(Zeacolpus)_
	*_(Kurosioia)_		_(Leptocolpus)_
*_Maoricolpus_			*_(Stiracolpus)_
Neohaustator			

Subfamily PROTOMINAE Marwick, 1957

Protoma	_(Protoma)_
	(Protomella)

Subfamily PAREORINAE Finlay and Marwick, 1937

Craiginia
Mesalia
Motyris
*_Pareora_
Sigmesalia
Tachyrhyncus
Woodsalia
*_Zaria_

Subfamily TURRITELLOPSINAE Marwick, 1957

*_Glyptozaria_
*_Kimberia_
Turritellopsis

ORECTOSPIRINAE Habe, 1955

Orectospira

INCERTAE SEDIS

Arcotia

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* Indicates genera and subgenera dealt with in this paper.

SYSTEMATIC SECTION

Subfamily TURRITELLINAE Woodward, 1851

Genus *ARCHIMEDIELLA* Sacco, 1895

ARCHIMEDIELLA Sacco, 1895, *Moll. Terr. Terz. Piemonte Liguria*, 19: 28. Type species by original designation *Turritella archimedis* Brongniart, 1823, *non* Dillwyn, 1817 = *cochlias* Bayan, 1873, Oligocene, Italy.

Generic characteristics: Medium to large, recent species brightly coloured. Whorls flatly convex to convex, spire straight-sided. Aperture sub-circular to sub-quadrate. Base flat to flatly convex. Protoconch paucispiral, asymmetric to axis of coiling, about 1½ whorls, clear and glass-like, nucleus not usually submerged. Labial sinus orthocline, broad and very shallow (Fig. 1). Primary spirals emerge in order, B, C, A. Spiral cords medium to strong.

Archimediella dirkhartogensis sp. nov.

Pl. 26, fig. 1.

Description: PROTOCONCH paucispiral, asymmetric, 1½ whorls, clear and glass-like, nucleus not submerged. TELEOCONCH 14 whorls, strongly convex. SUTURES deeply impressed. SCULPTURE commences with a medium spiral cord a little below centre on first whorl, followed by a second cord on next whorl midway between first cord and lower suture; a further cord follows on about fourth whorl between central cord and upper suture; a number of minor striae are formed from second whorl onwards, gradually becoming more pronounced; on holotype the central and lower main cords retain predominance, the third or posterior cord a little less so; in other specimens from sixth or seventh whorl onwards all are of about equal strength and usually total ten to twelve; between these cords are a number of very fine threads, granulated by the crossing of extremely fine and close packed growth striae. APERTURE sub-circular, columella arcuate, outer lip thin with typical sinus. BASE of shell flatly convex with fifteen or more flatly rounded striae crossed by very fine and densely packed growth striae. COLOUR white with reddish-brown axial flames showing mainly on main cords and giving shell a densely spotted appearance. OPERCULUM unavailable.

Type locality: North of Dirk Hartog Island, Shark Bay, Western Australia, 73 metres.

Dimensions: Holotype, length 30.3 mm, breadth 8.9 mm, Western Australian Museum, Reg'd. No. 834-70, together with four paratypes Reg'd. Nos. 835/6/7/8-70. Two paratypes Australian Museum, Sydney, Reg'd. No. C.77826. Six paratypes Bernice P. Bishop Museum, Honolulu, Reg'd. No. BBM 217609.

Distribution: From Shark Bay southwards, and along southern coastline of Western Australia at least as far as Eucla.

Material: 14 specimens Australian Museum, Sydney, and 30 from Western Australian Museum, Perth, including holotype.

Discussion: This species shows the central and lowest of the three main cords as prominently on many specimens as those of *A. fastigiata* (Adams and Reeve), on other specimens they are more subdued, and on many more they are only of equal importance with all others. However it lacks the wavy axial flames of *A. fastigiata,* which are replaced by dense spotting. The species differs from *A. infraconstricta* (E. A. Smith) from the Andaman Islands in having far fewer and more pronounced striations, consequently more widely spaced, with the spotting far larger and bolder in appearance. It is strange that this species should completely overlap the apparently rather limited area occupied by *A. occidua* (Cotton and Woods), and although of the same genus the two species bear little resemblance to each other.

Archimediella fastigiata (A. Adams and Reeve, 1848)

Pl. 26, fig. 2; Pl. 30, fig. 7-8.

1848 *Turritella fastigiata* A. Adams and Reeve, *Voy. Samarang*, p. 48, pl. 12, fig. 9.
1849 *Turritella fastigiata.* Reeve, *Conch. Icon.*, 5, pl. 10, fig. 48.
1886 *Turritella fastigiata.* Tryon, *Man. Conch.*, 8: 204, pl. 63, fig. 92.

Description: PROTOCONCH paucispiral, asymmetric, 1½ whorls, clear and glass-like, nucleus prominent. TELEOCONCH 18 to 20 whorls, contracted above, rounded below. SUTURES fairly impressed. SCULPTURE — earliest whorls with 2-3 cords, increasing to about 12 cords on later whorls, one central cord and another half-way between it and lower suture always predominant, and the outstanding feature of the sculpture. APERTURE sub-circular; columella arcuate, inner lip reflected; outer lip thin with typical sinus. BASE of shell flatly convex, 18 to 20 irregular raised striae crossed by faint growth lines. COLOUR pale violet and white with oblique brown streaks, occasionally fairly dark brown with white flames. OPERCULUM unavailable.

Type locality: " China Seas."

Dimensions: Holotype — dimensions of original painting — length 56 mm, breadth 12 mm, British Museum (Natural History) Reg'd. No. 1969270.

Distribution: At least as far east as Melville Island, Northern Territory, and south along Western Australian coast as far as Shark Bay.

Material: Numerous specimens from six State Museums.

Discussion: This species in its typical form extends from the Northern Territory along the Western Australian coast to at least as far south as Shark Bay. Apart from other differences, the larger *Turritella terebra* (Linnaeus) can at once be separated from *A. fastigiata* by the presence of a third major cord midway between the other two, which is quite consistent on all specimens examined, and gives the lower part of the whorls of *T. terebra* a somewhat bulbous appearance.

A most extraordinary complex of varieties of this species occurs round the Dampier Archipelago and islands off Onslow, Western Australia. Most specimens show a ridge with a heavier cord about the centre of each whorl, and a further similar corded ridge half-way between this and the lower suture, similar to *A. fastigiata* s.s. Other specimens have the whorls quite convex with no sign of these ridges, with 17 or 18 densely packed cords to each whorl, and all of about equal value. In other half-way specimens the ridges are present in a suppressed form. Some of these specimens with a finer sculpture than others tend to resemble *A. infraconstricta* (E. A. Smith), named from the Andaman Islands, Bay of Bengal. However none possess the dense and very fine spotting of that species. The axial flames tend to disappear entirely on most specimens, the bulk of which assume a general overall colour ranging from pale cream or light yellow to yellow-brown or medium brown.

The large paucispiral protoconch of the species of *Archimediella* strongly suggests that there is either no pelagic stage or at most a very short pelagic stage. This fact, plus the sedentary nature of the adult molluscs, indicate that it is not surprising to find distinct and greatly varied forma occuring in the above rather restricted area (Marwick, 1957: 144-5). What is somewhat inexplicable however, is that the distinct but obviously closely related *A. dirkhartogensis* Garrard should be so widely distributed from Shark Bay round the southern coastline to at least as far east as Eucla, also that *A. fastigiata* s.s. occurs right down the coast, in and amongst the Onslow " forma " to at least as far south as Shark Bay.

Archimediella maculata (Reeve, 1849)

Pl. 26, fig. 3.

1849 *Turritella maculata* Reeve, *Conch. Icon.*, 5, pl. 7, fig. 33.
1886 *Turritella maculata*. Tryon, *Man. Conch.*, 8: 202, pl. 63, fig. 83.
1909 *Turritella maculata* var. *ornata* Schepman, *Siboga Exped.*, pt. 2: 188, pl. 11, fig. 11.

Description: PROTOCONCH paucispiral, asymmetric, of 1½ whorls, nucleus slightly submerged. TELEOCONCH about 18 whorls, flatly convex and strongly bicarinate. SUTURES slightly impressed. SCULPTURE — a heavy cord in centre and towards base of whorls, with a strong cingulum sometimes present below upper suture on last seven or eight whorls; a number of fine striae between cords, growth striae very faint. APERTURE sub-quadrate; columella arcuate, inner lip slightly recurved at base; outer lip thin and crenulated by cords, with typical sinus. BASE of shell flatly convex, some specimens with three heavy cords and several fine striae between each, others with up to 12 strong striae and 3 or 4 finer threads between each. COLOUR off-white, all striae topped with brown, brown spots on all heavy cords, and occasional dark brown axial flames. OPERCULUM unavailable.

Type locality: China Sea.

Dimensions: Holotype — Reeve's painting — length 69 mm, breadth 19 mm, British Museum (Natural History) Reg'd. No. 1969267.

Distribution: In Australia, apparently far northern coastline only.

Material: 6 specimens Australian Museum, Sydney; 3 from Queensland Museum, Brisbane; 2 from National Museum of Victoria, Melbourne.

Discussion: The occurrence of this species on the northern coastline is apparently rather sparse. Three specimens in fair condition are held by the Queensland Museum marked " Queensland," no record of exact locality. Two half-grown specimens in good condition held by National Museum of Victoria, Melbourne, marked from Port Essington, Northern Territory; these are the only specimens from Australia held by Australian Museums. As none of the above specimens were suitable for illustration, a better specimen held by the Australian Museum, Sydney, from Tarrut Bay, Saudi Arabia, has been used to give a better idea of form and colour pattern, being very similar to above two small specimens from Port Essington.

Archimediella occidua (Cotton and Woods, 1935)

Pl. 26, fig. 4.

1935 *Turritella terebra occidua* Cotton and Woods, *Rec. S. Aust. Mus.*, 5: 369, text fig. 7; p. 378.

Description: PROTOCONCH — none available, but almost certainly similar to others in the genus. TELEOCONCH 14 whorls, rounded convex, sides of spire straight. SUTURES slightly impressed. SCULPTURE of first few whorls strongly three-corded, central the strongest, and these three usually remain predominant; further sculpture of finer striae appear at intervals, some increasing in strength, some remaining fairly fine; all are crossed by numerous fine incremental striae conforming to outer lip sinus. APERTURE sub-quadrate; columella a little arcuate, inner lip reflected anteriorly; outer lip thin, crenulated by striae exteriorly, with typical sinus. BASE of shell flat with numerous fine wavy concentric threads crossed by growth lines. COLOUR light to medium brown, occasionally axially flamed with white. OPERCULUM unavailable.

Type locality: King George's Sound, Western Australia, 12-14 fathoms (22-25 metres).

Dimensions: Holotype, length 22 mm, breadth 6 mm, South Australian Museum, Adelaide, Reg'd. No. D.11439. Largest paratype examined, length 30.5 mm, breadth 7.5 mm.

Distribution: Apart from the type locality the only other record appears to be from Hopetoun, Western Australia, 35 fathoms (63 metres).

Material: Holotype and numerous paratypes, South Australian Museum. Three specimens, Australian Museum, Sydney.

Discussion: This species, although obviously closely related to *A. dirkhartogensis* Garrard, is quite distinct, growing to approximately the same size and same number of whorls, but possessing the three dominant keels throughout. It is darker and more evenly coloured and entirely lacks the conspicuous spotting. The three main keels on all whorls separate it from the biangulate whorls of *A. fastigiata* (Adams and Reeve). The species was named by Cotton and Woods as a subspecies of the much larger *Turritella terebra* (Linnaeus), but it has no connection with that genus, and is typical of the genus in which it is now placed.

Genus *COLPOSPIRA* Donald, 1900

Subgenus *COLPOSPIRA* s.s.

COLPOSPIRA Donald. 1900, *Proc. Mal. Soc. Lond.*, 4: 51. Type species by original designation *Turritella runcinata* Watson.

Subgeneric characteristics: Species range from very small and translucent to medium and solid. Whorls mostly flatly convex, some very small species a little concave. Spire mainly straight sided, some concave. Aperture usually sub-quadrate. Base convex to flatly convex. Protoconch of 1½ to 2 whorls, asymmetric, flatly rounded to globose, clear or translucent. Labial sinus orthocline, deep and narrow. Primary spirals emerge in order C, A, B, sometimes C and A only. Spiral cords fairly fine to very strong and coarse.

Turritellidae

Colpospira (Colpospira) runcinata (Watson, 1881)

Pl. 26, fig. 5.

1869 *Torcula tennilirata* Dunker, *Mus. Godeff.*, Cat. 4: 77, No. 3433; *nomen nudum.*

1874 *Murchisonia sutoris* Dunker, *Mus. Godeff.*, Cat. 5: 148, subst. name for *T. tennilirata* referred to *Zaria* on p. 212. Name validated as synonym of *C. runcinata* (Watson) by Donald, 1900, *Proc. Mal. Soc. Lond.*, 4: 50.

1881 *Turritella runcinata* Watson, *Jour. Linn. Soc. Lond.*, Zool., 15: 218.

1884 *Turritella higginsi* Petterd, *J. Conch. Paris*, 4: 135.

1883 *Turritella runcinata.* Watson, *Rep. Sci. Res. Challenger*, Zool., 25: 475, pl. 30, fig. 3.

1900 *Colpospira runcinata.* Donald, *Proc. Mal. Soc. Lond.*, 4: 51.

1924 *Colpospira runcinata.* Iredale, *Proc. Linn. Soc. N.S.W.*, 49: 249.

1962 *Colpospira runcinata.* Macpherson and Gabriel, *Mar. Moll. Vict.*, p. 99.

Description: PROTOCONCH asymmetric, of two flatly globose whorls, nucleus slightly submerged, translucent. TELEOCONCH 15 whorls, all flatly convex, first five smooth. SUTURES fairly impressed. SCULPTURE after first five whorls becoming increasingly strong, consisting of heavy cords and numerous fine striae, of no set pattern, showing considerable variation. APERTURE sub-quadrate, columella arcuate; outer lip thin with typical sinus. BASE of shell flatly convex with 30 or more flat irregular spirals. COLOUR of apex yellow, next few whorls white speckled with yellow, gerontic whorls off-white. OPERCULUM black, approx. 3.5 mm diameter, heavy rounded outer edge, depressed centre, with number of very fine concentric spirals.

Type locality: Bass Strait, off East Moncoeur Island, 38-40 fathoms (69-73 metres).

Dimensions: Holotype, length 31.75 mm, breadth 10.16 mm, British Museum (Natural History) Reg'd. No. 1887.2.9.1495-7. Largest specimen examined, length 39 mm, breadth 12.5 mm.

Distribution: From central New South Wales coast to Victoria, southern Tasmania, South Australia, southern coast of Western Australia and north as far as Rottnest Island.

Material: Numerous specimens from six State Museums, including several topotypes.

Discussion: Sculpture on adult whorls varies considerably, heaviest cords usually towards base of whorls, and frequently parallels that of the closely allied *C. (A.) accisa* (Watson); the latter can easily be separated by the two sharp strong keels on every whorl.

Iredale (1924: 247) went out of his way to denigrate the whole of Watson's work. He stated (p. 249) that he had examined the holotypes of *C. runicinata* and *C. (A.) accisa* and concluded that they were identical, also that *C. cordismei* (Watson) was a juvenile of the same species. However examination of a long series of all three species shows Watson's highly detailed descriptions to be completely accurate. This is one species where most reliance should be placed on the primary whorls for identification, in conjunction with the deep labial sinus and the protoconch. It bears a strong resemblance to the fossil species *C. conspicabilis* (Tate), and is possibly a direct descendant, but that species has flat primary whorls, also a more consistent sculpture of a heavy ridge at base of whorls with three strong cords above.

Colpospira (Colpospira) aquamarina sp. nov.

Pl. 26, fig. 6.

Description: PROTOCONCH paucispiral, asymmetric, of 1½ flatly globose whorls, translucent white, nucleus slightly submerged. TELEOCONCH of 14 flatly convex whorls. SUTURES very slightly impressed. SCULPTURE shows a sharp cord just below centre on first two whorls, tending to fade on third whorl, after which a slight cingulum appears at top and bottom of each whorl from about fourth onwards, becoming progressively more pronounced, with three to six fine striations appearing between cingula. Subsequent development of sculpture varies considerably, whorls in some specimens becoming somewhat flattened, retaining the fine striae; whorls in other specimens become distinctly concave between the two cingula. APERTURE sub-quadrate; columella arcuate, inner lip slightly reflected; outer lip thin with typical sinus. BASE of shell flat, six or seven fine concentric striae, crossed by faint growth lines. COLOUR fawn, usually with purplish band in centre of whorls, colour showing through from inside; a row of more or less distinct white spots immediately below the sutures in some specimens, a few others showing brown and white spots alternately; first three or four teleoconch whorls glass-like, with white interior canal in shell showing through. OPERCULUM unavailable.

Type locality: East of Wooli, New South Wales, 110 metres.

Dimensions: Holotype, length 14.5 mm, breadth 3.8 mm, Australian Museum, Sydney, Reg'd. No. C.72586. Largest paratype, length 17.5 mm, breadth 5.1 mm.

Distribution: Apart from type locality, specimens have so far been obtained from 70 metres, Moreton Bay; 115-122 metres, north-east of Cape Moreton, and 36-55 metres, off Jumpin Pin Bar, all southern Queensland.

Material: Holotype and 15 paratypes, all Australian Museum.

Discussion: Some specimens, more especially those with the flattened whorls and fine striae, could be confused with immature specimens of *Gazameda tasmanica* (Reeve), but completely lack the pitting common to that species, also the distinctive *Gazameda* protoconch and wider and shallower labial sinus. This species also grows only one-third the size of *G. tasmanica.*

Colpospira (Colpospira) bundilla sp. nov.

Pl. 26, fig. 17.

Description: PROTOCONCH asymmetric, of two whorls, flatly globose. TELEOCONCH of 12 whorls, first two slightly concave, central portion of later whorls increasing in concavity, whole of spire decidedly concave. SUTURES at base of deep V-notch but very little impressed. SCULPTURE of two fairly sharp but not pronounced cords on early whorls, lower one slightly higher, with broad concave section between; space above upper cord slopes outward from suture, being either flat or a little concave; space below lower cord either flat or slightly convex; sections above and below sutures in places show vague traces of three or four faint striae; general appearance of whole is smooth and highly polished. APERTURE subquadrate; columella arcuate, inner lip strongly reflected at base, almost forming an open canal at junction with basal portion of outer lip; outer lip thin, with typical sinus between the two ridges; lower edge of outer lip curves downward in an arc to meet the pseudo-canal at junction with inner lip. BASE of shell slightly convex, with five to seven somewhat obscure concentric striae crossed by microscopic growth lines. COLOUR of most specimens a light yellow-brown in the smooth centre section, some lacking any colour and merely translucent white, a few coloured an even reddish-brown over last six or seven whorls. OPERCULUM circular, approx. 0.65 mm diameter, medium brown, shining, with seven concentric ridges, central nucleus deeply depressed, fairly thick and gelatinous in appearance under high magnification.

Type locality: North-east of Cape Moreton, southern Queensland, 114-123 metres.

Dimensions: Holotype, length 5.2 mm, breadth 1.6 mm, Australian Museum, Sydney, Reg'd. No. C.72588. Largest paratype, length 9 mm, breadth 2.4 mm.

Distribution: Apart from type locality the only other records are that from Western Australia below, and one live-taken specimen from 109 metres, east of Wooli, northern New South Wales. This latter specimen features a greatly expanded body whorl, which is also in evidence in a few of the 150 paratypes examined.

Material: Holotype and 150 paratypes, Australian Museum; four specimens from South Australian Museum, Adelaide.

Discussion: Four specimens in the South Australian Museum collection from 300 fathoms (549 metres), 120 miles west of Eucla, Western Australia, and dredged by Verco, are identical in all respects, except that one specimen, after the seventh whorl, shows a distinct nodulation of both cords at top and bottom of each whorl; the nodules are somewhat elongated and oblique, those forming the top cord being inclined to the right and those on the bottom cord to the left. The shells are opaque white, not live taken, and have no sign of the brown colour band as with the Queensland specimens. None of the Queensland specimens examined shows any sign of this nodulation. This species shows some affinity with two other new species described below and the differences are noted in the discussion following both of them. The specific name is a New South Wales Aboriginal noun-in-apposition meaning " Meeting of the waters."

Colpospira (Colpospira) cordismei (Watson, 1881)

Pl. 26, fig. 7.

1881 *Turritella cordismei* Watson, *Jour. Linn. Soc. Lond.*, Zool., 15: 224.
1886 *Turritella cordismei.* Watson, *Rep. Sci. Res. Challenger*, Zool., 25: 469, pl. 29, fig. 1.
1924 *Turritella cordismei.* Iredale, *Proc. Linn. Soc. N.S.W.*, 49: 249.

Description: PROTOCONCH paucispiral, asymmetric, of 1½ flatly convex whorls, nucleus a little submerged. TELEOCONCH 13 flatly convex whorls. SUTURES deeply impressed. SCULPTURE — first four whorls have one central cord, followed by three, sometimes four, strong evenly spaced striae, with a heavy cord at base of whorls, all crossed by numerous sinuate growth striae conforming to shape of labial sinus.

APERTURE sub-quadrate; columella arcuate, inner lip strongly reflected throughout its length; outer lip thin with typical sinus. BASE of shell flatly convex with up to 12 faint flattened striae crossed by numerous growth lines. COLOUR — central New South Wales coast specimens are cream in colour with alternate brown and white spots on all striae, indefinite whitish patches on most whorls; more southerly specimens are mainly overall chestnut with little or no spotting. OPERCULUM light brown, concave with upturned edge, multispiral with central nucleus.

Type locality: Bass Strait, off East Moncoeur Island, 38-40 fathoms (69-73 metres).

Dimensions: Holotype, length 11.17 mm, breadth 3.3 mm, British Museum (Natural History) Reg'd. No. 1887.2.9.1479-82.

Distribution: From New South Wales central north coast southwards to Victoria and Tasmania.

Material: Numerous specimens from Australian Museum, fair number from National Museum of Victoria.

Discussion: Regarded for many years as a synonym of C. *runcinata* (Watson) but is quite distinct and only one-third the size. Several

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PLATE 26

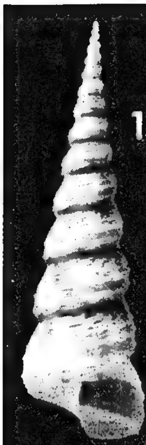
1. *Archimediella dirkhartogensis* Garrard. North of Dirk Hartog Island, Shark Bay, Western Australia, 73 metres. Holotype, X 2.1. W.A.M. No. 834-70.
2. *Archimediella fastigiata* (Adams and Reeve). Off Melville Island, Northern Territory, 45 metres. Figured specimen, X 1.2. A.M. No. C77332.
3. *Archimediella maculata* (Reeve). Tarrut Bay, Saudi Arabia. Figured specimen, X 1.3. A.M. No. C77374.
4. *Archimediella occidua* (Cotton and Woods). King George Sound, Western Australia. Figured specimen (Topotype), X 2.1. A.M. No. C77333.
5. *Colpospira (Colpospira) runcinata* (Watson). Off Neptune Island, South Australia, 73 metres. Figured specimen, X 1.7. A.M. No. C19306.
6. *Colpospira (Colpospira) aquamarina* Garrard. Off Wooli, New South Wales, 110 metres. Holotype, X 4.4. A.M. No. C72586.
7. *Colpospira (Colpospira) cordismei* (Watson). Off Port Hacking, New South Wales, 82 metres. Figured specimen, X 3.5. A.M. No. C77329.
8. *Colpospira (Colpospira) deliciosa* (Watson). Off Raine Island, Torres Strait, 283 metres. Holotype, X 5. B.M.N.H. No. 87. 2. 9. 1488-91.
9. *Colpospira (Colpospira) decoramen* (Iredale). East of Sydney, New South Wales, 457 metres. Figured specimen, X 2.7. A.M. No. C24433.
10. *Colpospira (Colpospira) joannae* Hedley. East of Sydney, New South Wales, 750 metres. Holotype, X 7.2. B.M.N.H. No. 89.10.26.89.
11. *Colpospira (Colpospira) indigena* Garrard. North-east of Cape Moreton, southern Queensland, 114-123 metres. Holotype, X 9.1. A.M. No. C72590.
12. *Colpospira (Colpospira) mediolevis* (Verco). South-west of Cape Adieu, South Australia, 79 metres. Figured specimen, X 11.3. A.M. No. C77331.
13. *Colpospira (Colpospira) moretonensis* Garrard. Off Jumpin Pin Bar, southern Queensland, 36-54 metres. Holotype, X 10.9. A.M. No. C72589.
14. *Colpospira (Colpospira) sinuata* (Reeve). Disaster Bay, New South Wales, 27 metres. Figured specimen, X 4. A.M. No. C77330.
15. *Colpospira (Colpospira) sophiae* (Brazier). North-east of Cape Moreton, southern Queensland, 114-123 metres. Figured specimen, X 7.2. A.M. No. C77381.
16. *Colpospira (Colpospira) translucida* Garrard. South-west of Eucla, Western Australia, 79-140 metres. Holotype, X 10.9. A.M. No. C72587.
17. *Colpospira (Colpospira) bundilla* Garrard. North-east of Cape Moreton, Southern Queensland, 114-123 metres. Holotype, X 12.1. A.M. No. C72588.

Abbreviations used for various Museums are as under:

A.M. Australian Museum, Sydney, New South Wales.
B.M.N.H. British Museum (Natural History), London.
N.M.V. National Museum of Victoria, Melbourne.
S.A.M. South Australian Museum, Adelaide.
T.M. Tate Museum, Geology Dept., University of Adelaide, South Australia.
W.A.M. Western Australian Museum, Perth.

Photographs: All photographs are by Mr. Charles V. Turner, Photography Dept., Australian Museum, Sydney, with the following exceptions: Pl. 26, fig. 8 and 10 — British Museum (Natural History), London; Pl. 27, fig. 2 — T. A. Darragh and K. N. Bell, National Museum of Victoria; Pl. 30, fig. 7 - 9 — Commercial photographer.

Plate 26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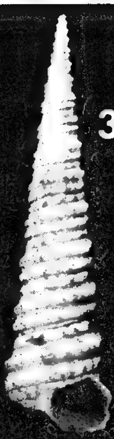
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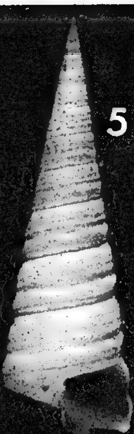
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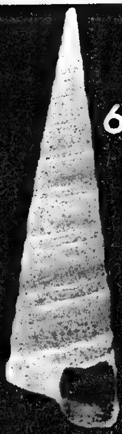
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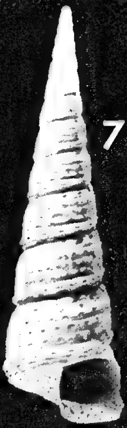
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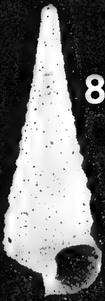
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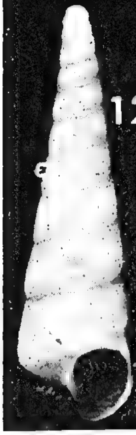
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specimens have been checked with the holotype in the British Museum (Natural History). It changes considerably in appearance from north to south in its range. The more southerly specimens nearer the type locality, in addition to the change in colour as above, also tend to have decidedly heavier striations. The species is quite distinct and does not appear to have any close relatives.

Colpospira (Colpospira) decoramen (Iredale, 1936)

Pl. 26, fig. 9.

1936 *Gazameda decoramen* Iredale, *Rec. Aust. Mus.*, 10: 292, pl. 21, fig. 20.

Description: PROTOCONCH paucispiral, asymmetric, of 1½ flatly globose whorls, nucleus a little submerged, translucent. TELEOCONCH up to 14 whorls, first four or five a little convex, balance flat with concave centre. SUTURES moderately impressed. SCULPTURE — first four or five convex whorls are almost smooth; sculpture commences gradually with a medium sharp cord above suture about fifth or sixth whorl, a further strong sharp cord below upper suture one or two whorls later; cord above lower suture frequently becomes strongly bifurcate on gerontic whorls; four to ten fine striae in concave section between cords, often up to five more between lower cord and adjoining suture; fine to coarse growth striae cross cords and threads in an irregular manner, conforming to deep labial sinus. APERTURE sub-quadrate; columella arcuate, inner lip strongly reflected on to body-whorl; outer lip thin with deep narrow central sinus. BASE of shell flatly convex with numerous irregular concentric striae, crossed by very fine growth lines. COLOUR — apex and primary whorls white, balance mottled brown and white with somewhat curved vertical flames; red and white alternate spots on both ridges. OPERCULUM circular, black-brown, central nucleus, concave, with about 12 concentric overlapping lines of growth.

Type locality: Off Sydney, New South Wales, 65-70 fathoms (118-128 metres).

Dimensions: Holotype. length 18 mm, breadth 6.5 mm. Australian Museum, Reg'd. No. C.60635.

Distribution: Eastern Victoria through New South Wales to southern Queensland, in depths from 73 to 549 metres.

Material: Large quantity of specimens from a number of localities, Australian Museum.

Discussion: Examination of many specimens from a number of localities shows this species to be more variable in sculpture than expected from examination of those near the type locality. Some from off Montague Island, southern New South Wales, are considerably flatter and smoother, the two strong ridges giving way to one small one at base of whorls, the sub-sutural ridge being almost non-existent, and intermediate striae are microscopic. Some specimens from off Botany Bay, whilst conforming generally, have two very strong striations in centre of each whorl, finely decussated by growth lines. This feature is even more pronounced and fairly constant in numerous specimens from deep water north-east of Cape Moreton, southern Queensland. Specimens vary in length from that of the holotype, 18 mm, up to 24 mm, whilst one from 549 metres east of Sydney measures 30.5 mm. This species has no close relatives and is easily distinguished by the extremely fine apex, followed by the rapidly expanding later whorls, which gives the spire a greater concavity than any other species in the genus.

Colpospira (Colpospira) deliciosa (Watson, 1881)

Pl. 26, fig. 8.

1881 *Turritella deliciosa* Watson, *Jour. Linn. Soc. Lond.*, Zool., 15: 226.
1886 *Turritella deliciosa.* Watson, *Rep. Sci. Res. Challenger, Zool.*, 25: 471, pl. 29, fig. 3.

Description: PROTOCONCH asymmetric, of two flatly rounded whorls, nucleus not depressed, slightly tumid, hyaline. TELEOCONCH of 12 whorls, flat in appearance, but contracted above, below and between the two main cords. SUTURES fine and inconspicuous but impressed. SCULPTURE — two strong, broad, rounded cords; area between cords a little concave with a somewhat smaller striation in centre of depression; above each cord a minute thread. APERTURE rectangularly triangular, right-angle being at base of columella; columella straight, with slight swelling towards upper end, reflected as a thin glaze on to body-whorl; outer lip thin, slightly crenulate, with typical sinus; basal lip patulous and prominent, meeting columella almost at right-angles, where it forms a slight narrow canal. COLOUR porcellanous glossy white. OPERCULUM unavailable.

Type locality: Off Raine Island, Torres Strait, 155 fathoms (283 metres).

Dimensions: Holotype, length 8.88 mm, breadth 2.14 mm, British Museum (Natural History), Reg'd. No. 87.2.9.1488-91.

Distribution: At present only recorded from the type locality.

Material: Photographs of 3 specimens supplied by British Museum (Natural History).

Discussion: Reliance has had to be placed on Watson's drawing of the outer lip for inclusion of this species in the genus *Colpospira,* although the possibility that its affinities lie with either of the subgenera *(Kurosioia)* or *(Platycolpus)* cannot be dismissed. Only a later examination of both labial and basal sinuses of the holotype coupled with other features will prove this point. The photograph illustrated, by courtesy of the British Museum (Natural History), shows the holotype very clearly, and unfortunately a search through recent extensive dredgings from the Arafura Sea in somewhat similar depths to that in which the holotype and paratypes were found, has failed to produce further specimens. The species is quite distinct and has no near relatives in Australian waters.

Colpospira (Colpospira) indigena sp. nov.

Pl. 26, fig. 11.

Description: Protoconch paucispiral, asymmetric, clear and glass-like, of 1½ flatly globose whorls, nucleus slightly submerged. TELEOCONCH 12 whorls, flatly concave, sides of spire straight. SUTURES a little impressed at base of deep V-notch. SCULPTURE commences as a slight cord a little below centre of first main whorl, gradually "moving" abapically until by sixth or seventh whorl it is one-fourth of whorl height above lower suture; a second cord commences on second whorl one-third of the height of whorl below the upper suture, and becomes of equal prominence with the first cord on the next whorl; space between upper suture and upper cord slightly concave, sometimes with one or two faint striae; space between cords smooth and very concave; lower cord bifurcate from about centre of shell to body-whorl, and space below this and lower suture usually flat; a strong liration is present below the bifurcate cord on the body-whorl. APERTURE sub-quadrate; columella arcuate, inner lip a little reflected; outer lip thin with sinus typical of genus. BASE of shell flat with four or five medium but depressed lirae, crossed by numerous growth lines. COLOUR off-white or cream, translucent, with interior spiral canal clearly visible in good specimens. OPERCULUM unavailable.

Type locality: North-east of Cape Moreton, southern Queensland, 114-123 metres.

Dimensions: Holotype, length 6.9 mm, breadth 2.1 mm, Australian Museum, Sydney, Reg'd. No. C.72590. Largest paratype, length 8.6 mm, breadth 2.7 mm.

Distribution: In addition to type locality, other records are from 70 metres two miles north-east of Gillet Cay, and 54 metres off One Tree Island, both southern Queensland.

Material: Holotype and six paratypes, all Australian Museum, Sydney.

Discussion: This species differs from *C. bundilla* Garrard in being a little wider for its length, also larger and a little more heavily built. It is one colour only and lacks the central colour band, the ridges are bolder, the lower one bifurcate, which does not occur in *C. bundilla*. The differences are somewhat slight but distinct and consistent.

Colpospira (Colpospira) joannae Hedley, 1923

Pl. 26, fig. 10.

1900 *Turritella (Colpospira) crenulata* Donald, *Proc. Mal. Soc. Lond.*, 4: 52, pl. 5, figs. 2a, b.
1912 *Turritella reevei* Cossmann, *Ess. Pal. Comp.*, 9: 119, (*non* Dautzenberg and Fischer, 1907).
1923 *Colpospira joannae* Hedley. *Proc. Linn. Soc. N.S.W.*, 48: 311. (New name for *T. crenulata* Donald, 1900, *non* Nyst, 1843).

Description: PROTOCONCH asymmetric, of about two flatly globose whorls, nucleus a little submerged. TELEOCONCH ten whorls, quadrate in form, flattened, spire straight-sided. SUTURES incised within a pronounced V-notch. SCULPTURE — first whorl with strong crenulate cord at base, followed by a second at top of fourth whorl, and a third crenulate cord between these on next whorl, all three increasing in strength, the third or anterior cord being the strongest; a few sinuate growth lines cross the cords at intervals. APERTURE imperfectly known, appears to be somewhat triangular in shape; columella arcuate, inner lip reflected on to body-whorl; outer lip with typical sinus. COLOUR creamy-white. BASE of shell almost flat with numerous fine concentric threads. OPERCULUM unavailable.

Type locality: Off Sydney, New South Wales, 410 fathoms (750 metres).

Dimensions: Holotype, length 6.5 mm, breadth 2 mm, British Museum (Natural History), Reg'd. No. 89.10.26.89.

Distribution: The holotype is the only known specimen.

Material: Photograph supplied by courtesy of the British Museum (Natural History).

Discussion: The description given by Donald states that there are four keels on each whorl, three uppermost strongly and lowest but slightly crenulate. However the two excellent enlarged photographs of the holotype received show no sign of a fourth keel except at the base of the body-whorl. The specimen came from the disputed "Challenger" station 164B in 410 fathoms east of Sydney, New South Wales, and has been shown as a doubtful record ever since. However the presence of the deep labial sinus described by the author leaves little doubt that the locality is genuine, such a sinus being quite unknown amongst Atlantic species which were allegedly mixed with those from the above station. None of the other minute deep-water Australian forms approach at all closely to this species.

Colpospira (Colpospira) mediolevis (Verco, 1910)

Pl. 26, fig. 12.

1910 *Turritella mediolevis* Verco, *Trans. Roy. Soc. S. Aust.*, 34: 121, pl. 30, figs. 5, 6.

Description: PROTOCONCH paucispiral, asymmetric, of 1½ flatly convex whorls, nucleus a little submerged. TELEOCONCH of nine flattish whorls becoming a little more convex with age. SUTURES well impressed within a prominent V-notch. SCULPTURE commences on third or fourth whorl, of 2 or 3 weak flatly rounded threads at top and bottom of each whorl, central area usually smooth. APERTURE sub-quadrate; columella arcuate, inner lip strongly reflected on to body-whorl; outer lip thin with typical sinus. BASE of shell convex with up to eight flat irregular concentric striae crossed by strong growth lines. COLOUR translucent creamy-white, fawn round sutures, also on base and columella. OPERCULUM unavailable.

Type locality: Cape Borda, South Australia, 62 fathoms (112 metres).

Dimensions: Holotype, length 5.2 mm, breadth 1.5 mm, South Australian Museum, Adelaide, Reg'd. No. D.13430.

Distribution: South Australia and southern Western Australia generally, in depths from 63 to 183 metres.

Material: Holotype and several paratypes, South Australian Museum; co-type and several others Australian Museum; several specimens National Museum of Victoria.

Discussion: In this species, as in *C. sophiae* (Brazier), the labial sinus tends to become deeper and narrower with age, until in many cases it corresponds with that of the genus *Spirocolpus*, however the basal sinus remains constant. The primary spiral threads are very vague and indefinite, but the protoconch and general shape of the early whorls are very similar to immature specimens of the much larger *C. runcinata* (Watson), the type for the genus. If studied carefully under medium magnification it would not be possible to confuse this minute species with any other, and it does not appear to have any close relatives.

Colpospira (Colpospira) moretonensis sp. nov.

Pl. 26, fig. 13.

Description: PROTOCONCH paucispiral, asymmetric, of 1½ glass-like whorls, flatly globose, nucleus partly submerged. TELEOCONCH of at least 8 whorls, flatly convex, spire straight sided. SUTURES lightly impressed. SCULPTURE commences on first whorl with a decidedly sharp cord towards the base, which becomes depressed on second or third whorl, thereafter remaining as a slight shouldered ledge, occupying one-fourth of each whorl immediately above the lower suture and sloping convexly towards it; usually on third whorl a further slight cord appears from one-fourth to one-third of whorl's depth below upper suture, becoming gradually a little sharper and more prominent, by about the fifth whorl the space between these cords becomes a little concave, a little more so at the base than above; apart from the two cords and a single fine striation which may appear in the centre of the lower flattened cord in some specimens, the whorls are devoid of spiral striae; fine closely packed sinuous axial striations follow the lines of the labial sinus. APERTURE sub-quadrate; columella arcuate, inner lip strongly reflected at base; outer lip thin with deep and narrow medial sinus, typical of genus. BASE of shell flatly convex with five or six flattish but prominent striae crossed by densely packed lines of growth. COLOUR translucent light cream to amber, with yellowish interior spiral canal clearly visible in good specimens. OPERCULUM unavailable.

Type locality: Off Jumpin Pin Bar, southern Queensland, 36-54 metres.

Dimensions: Holotype, length 5.8 mm, breadth 2 mm, Australian Museum, Sydney, Reg'd. No. C.72589. Largest paratype, length 6.6 mm, breadth 2.1 mm.

Distribution: Apart from type locality, other records are 73 metres, off Moreton Bay, and 114-123 metres, north-east of Cape Moreton, both southern Queensland.

Material: Holotype and 35 paratypes, all Australian Museum, Sydney.

Discussion: This species differs from *C. aquamarina* Garrard chiefly in its somewhat similar but more depressed protoconch, the lack of transverse striations, and the concave central section of each whorl. From *C. bundilla* Garrard it may be separated by its straight and not concave spire, the lack of contrasting colour band in the central concave section of each whorl, and the greater convexity of the whorls. The ratio of width to length and the depressed protoconch in this species is similar to *C. sinuata* (Reeve), but it is distinguished by the lack of transverse striae, the concave central section of each whorl, and the much smaller size.

Colpospira (Colpospira) sinuata (Reeve, 1849)

Pl. 26, fig. 14.

1849 *Turritella sinuata* Reeve, *Conch. Icon.*, 5, pl. 11, fig. 62.
1867 *Turritella sinuata*. Angas, *Proc. Zool. Soc. Lond.*, p. 210, sp. 151.
1886 *Turritella sinuata*. Tryon, *Man. Conch.*, 8: 200, pl. 61, fig. 60.
1924 *Colpospira sinuata*. Iredale, *Proc. Linn. Soc. N.S.W.*, 49: 249.
1962 *Colpospira sinuata*. Macpherson and Gabriel, *Mar. Moll. Vict.*, p. 99.

Description: PROTOCONCH paucispiral, asymmetric, of 1½ flatly globose whorls, nucleus a little submerged. TELEOCONCH 12 flatly convex whorls. SUTURES deeply impressed. SCULPTURE — first four whorls almost smooth; up to 20 flatly compressed threads commence imperceptibly after fourth whorl, variable in size and importance and never strong, crossed by numerous, close-packed growth lines conforming to shape of labial sinus. APERTURE sub-quadrate; columella straight, inner lip very little reflected; outer lip thin with typical sinus. BASE of shell flatly convex, with numerous concentric striae crossed by faint growth lines. COLOUR of apex white, main whorls and base off-white suffused with vertical, faint fawn patches; alternate brown and white spots below sutures. OPERCULUM dark brown, circular, consisting of numerous spiral layers of extremely thin and ragged-edged horny material, rising to a central light-brown solid nucleus, with small central depression.

Type locality: Port Jackson, New South Wales.

Dimensions: Holotype, Reeve's painting, length and breadth are out of proportion and exact measurements are unknown. Size of an average mature specimen is, length 17 mm, breadth 6 mm. Holotype deposited with British Museum (Natural History), Reg'd. No. 1969268.

Distribution: Southern Queensland, throughout New South Wales to Victoria.

Material: Numerous specimens from six State Museums.

Discussion: This species remains constant in its main characters throughout its range, and little variation takes place in its adult length of about 17 mm. The row of red and white spots below the sutures serves as a good guide to its identity. For some reason it is frequently confused with C. *(Platycolpus) quadrata* (Donald), but the deep clean-cut V-notch at the sutures of that species together with its concave whorls sets it apart without difficulty. Immature specimens of C. *runcinata* (Watson) resemble this species to a certain extent, but the yellow apex of C. *runcinata* followed by yellow-spotted white whorls readily set it apart.

Colpospira (Colpospira) sophiae (Brazier, 1883)

Pl. 26, fig. 15.

1878 *Turritella incisa* Tenison-Woods, *Proc. Linn. Soc. N.S.W.* (1877), 2: 262.

1883 *Turritella sophiae* Brazier, *Proc. Linn. Soc. N.S.W.*, 8: 227. (New name for *T. incisa* Tenison-Woods, non Reeve, 1849).

1903 *Turritella sophiae*. Hedley, *Mem. Aust. Mus.*, 4: 348.

1925 *Turritella sophiae*. Iredale, *Rec. Aust. Mus.*, 14: 267.

Description: PROTOCONCH paucispiral, asymmetric, of 1½ clear glass-like whorls, flatly globose, nucleus a little submerged. TELEOCONCH 13 whorls, first four or five slightly convex, rest flat and a little shouldered. SUTURES deeply impressed. SCULPTURE — first three or four whorls smooth; a sharp cord commences on fourth or fifth whorl below the suture, and another at base of whorl, which usually bifurcates; three or four strong striations in flat space between cords, all crossed by occasional microscopic sinuate growth lines. APERTURE sub-quadrate; columella slightly arcuate, inner lip strongly recurved on to body-whorl; outer lip thin with typical sinus. BASE of shell convex with seven or eight strong flat lirae, flat spaces between, and crossed by fine growth lines. COLOUR — apex and primary whorls translucent white, balance cream to chestnut, somewhat translucent, large irregular red-brown patches on upper ridge. OPERCULUM circular, 0.8 mm diameter, reddish-brown, flat, six fine concentric ridges, central nucleus; inner side concave, five broadly rounded concentric ridges, small round raised central nucleus, the whole covered by a thick transparent gelatinous coating.

Type locality: " Off Sydney Heads."

Dimensions: Holotype, length 11 mm, breadth 3 mm, Australian Museum, Sydney, Reg'd. No. C.2470.

Distribution: 76-154 metres, east of Port Jackson, New South Wales, and 114-124 metres, north-east of Cape Moreton, southern Queensland, are the only localities on record.

Material: Holotype and 10 topotypes, also 150 specimens from the Queensland locality, all Australian Museum, Sydney.

Discussion: Iredale (1925: 267) stated: " The type of this species, preserved in the Australian Museum, has been carefully examined and proves to be a young specimen of *T. sinuata* Reeve . . . . . " This statement is extraordinary, as the two species do not resemble each other in any way, apart from a vague similarity in colour pattern. Compared with *C. sinuata*, this species is only half the length and width, the protoconch is decidedly smaller, the spire is a little concave and not straight, and the transverse striae are more pronounced. The holotype was apparently the only specimen held by any Australian museum from 1878 until 1962, when several more specimens were obtained from the type locality, later followed by numerous specimens from off Cape Moreton, southern Queensland.

Colpospira (Colpospira) translucida sp. nov.

Pl. 26, fig. 16.

Description: PROTOCONCH paucispiral, asymmetric, of $1\frac{1}{2}$ flatly globose whorls, nucleus slightly submerged, clear and transparent. TELEOCONCH of ten whorls, some flatly convex to commence, increasing in convexity until quite globose, others with whorls quite convex from commencement. SUTURES well impressed. SCULPTURE — base of primary whorls slopes in sharply to suture, upper part of whorls consists of a slightly shouldered and somewhat flattened cord; slight grooves appear on third or fourth whorl, leaving central one-third of each whorl as a convexly flattened clear space; in most cases a strong broad flatly-rounded cord appears in the central space at about fourth or fifth whorl; cords above and below this cord may also increase in prominence, some specimens having the appearance of possessing three fairly prominent cords in centre of each whorl; striations vary considerably, some specimens with only five of unequal strength on penultimate whorl, others with up to 14. APERTURE sub-circular; columella arcuate, inner lip reflected at base; outer lip thin with deep and narrow medial sinus, typical of genus. BASE of shell convex with five or six flattened but clearly visible concentric striations, crossed by densely packed growth lines. COLOUR slightly translucent white or clear and glass-like. OPERCULUM unavailable.

Type locality: South-west of Eucla, Western Australia, 79-140 metres.

Dimensions: Holotype, length 5.8 mm, breadth 1.9 mm, Australian Museum, Sydney, Reg'd. No. C.72587.

Distribution: The only other record apart from the type locality is 183 metres, 40 miles south of Cape Wiles, South Australia.

Material: Holotype and 20 paratypes from above localities, all Australian Museum, Sydney.

Discussion: As with other species in the genus *Colpospira,* gerontic whorls in this species tend to develop traces of the labial sinus conforming to *Spirocolpus,* and reliance must be placed on traces in the earlier whorls and the basal sinus, which remain constant. The main differences between this species and C. *mediolevis* (Verco), are the consistently clear and glass-like appearance as opposed to the opaque cream coloured whorls of C. *mediolevis* with the yellow-brown band beneath the sutures. The whorls on this new species are decidedly more convex, with the sutures consequently deeper, and the spirals are more prominent. Twenty specimens have been examined from the two localities and nothing resembling an intergrade with C. *mediolevis* has been seen, the two species being quite distinct.

Colpospira (Colpospira) wollumbi sp. nov.

Pl. 27, fig. 1.

Description: PROTOCONCH paucispiral, asymmetric, of 1½ flatly globose whorls, glassy, nucleus not submerged. TELEOCONCH of nine whorls, convex throughout. SUTURES well impressed. SCULPTURE of four prominent cords, centre two usually a little more pronounced, sometimes the lowest two; several striations tend to appear between the cords in an irregular manner. APERTURE sub-circular; columella slightly arcuate, inner lip reflected; outer lip with deep and narrow medial sinus typical of the genus, and crenulated by cords on body-whorl. BASE of shell convex with five to seven fairly strong striations crossed by numerous fine growth lines. COLOUR, when in good condition, is translucent pure white or chestnut, mostly off-white with chestnut band below sutures; a similar coloured patch on centre of base. OPERCULUM circular, approx. .3 mm, thin, flat, translucent light brown, depressed central nucleus and five irregular ill-defined concentric ridges.

Type locality: East of Port Jackson, New South Wales, 77-154 metres.

Dimensions: Holotype, length 5.1 mm, breadth 1.6 mm, Australian Museum, Sydney, Reg'd. No. C.72585.

Distribution: From north of Cape Moreton, southern Queensland, through New South Wales, Tasmania, Victoria, South Australia to at least as far as Wilson Inlet, Western Australia, in depths from as little as 9 metres down to 237 metres.

Material: Holotype and large quantity of specimens from six State Museums.

Discussion: This is the species shown by May in his "*Illustrated Index of Tasmanian Shells,*" 1923 (Pl. 28, fig. 10, *Stiracolpus smithianus* Donald), apparently due to the poor, or transposed, drawing of that species at pl. 5, fig. 3, *Proc. Mal. Soc. Lond.,* 1900. The species is very widespread, occurring in six States as above, and probably in large quantities in moderately deep water. *C. (Acutospira) smithiana* (Donald) can be confused with this small species unless studied under magnification, but the four flatly rounded cords on this species commence almost simultaneously, whereas *C. (A.) Smithiana* has sharp keels commencing on successive whorls. The specific name is a New South Wales Aboriginal noun-in-apposition meaning " Meeting of the Waters."

FOSSIL SPECIES

Colpospira (Colpospira) tristira (Tate, 1885)

Pl. 27, fig. 2.

1885 *Turritella tristira* Tate, *Pap. Proc. R. Soc. Tas.*, (1884): 227.
1893 *Turritella tristira.* Tate, *Trans. R. Soc. S. Aust.*, 17: 338, pl. 8, fig. 8; pl. 9, fig. 7.
1935 *Turritella tristira.* Cotton and Woods, *Rec. S. Aust. Mus.*, 5: 380.

Description: PROTOCONCH paucispiral, asymmetric, of 1½ globose whorls, nucleus a little submerged. TELEOCONCH 17 whorls, first four or five flatly convex, next three or four medially concave, mature whorls again a little convex, sides of spire slightly concave. SUTURES a clear fine line, slightly impressed. SCULPTURE — a slight cord appears towards the base of the whorl on the third whorl, followed by a second cord on about seventh whorl, centrally situated, and a further cord towards top of ninth whorl; all develop into medium keels right to the body-whorl; microscopic striations commence about ninth whorl above, below, and between keels; incremental striae difficult to detect until about eleventh whorl; a sharp keel appears on acutely angular periphery of body-whorl. APERTURE sub-quadrate; columella arcuate; inner lip reflected anteriorly; outer lip thin, crenulated exteriorly by keels, with typical sinus. BASE of shell flat with numerous fine concentric striae crossed by very fine densely packed growth lines.

Type locality: Fossil Bluff, Table Cape, near Wynyard, Tasmania. Table Cape Group: Janjukian/Longfordian: Upper Oligocene/Lower Miocene.

Dimensions: Holotype, length originally 46 mm, now 41.5 mm due to breakage, breadth 12 mm, Tate Museum, Geology Dept., University of Adelaide, South Australia, Reg'd. No. T.1419 B.

Material: 24 specimens, Australian Museum, Sydney, from Maringa Creek, near Lakes Entrance, Victoria. Holotype is only known specimen from type locality.

Discussion: See notes by Tate under *C. (C.) conspicabilis* (Tate). The sculpture on that species never appears to have developed on the same lines as *C. (C.) tristira*, with its three strong keels throughout most of the length of the shell, and there is no doubt that it is a distinct species. The species bearing the closest resemblance to *C. (C.) tristira* amongst recent species is *C. (Acutospira) accisa* (Watson), which also has three sharp strong keels throughout most of the length of the shell, but whether *C. (C.) tristira* is directly ancestral is a matter of conjecture.

This species is extremely rare at the type locality, the holotype apparently being unique. However this has been examined and the matrix present is not inconsistent with that from the upper beds at Fossil Bluff,

Table Cape, i.e. the Fossil Bluff Sandstone (T. A. Darragh, pers. comm.). As further proof of the validity of the type locality being in N.W. Tasmania, five specimens agreeing well with the holotype were found near Burnie, 15 miles east of Table Cape, in 1970 by Darragh. One specimen forwarded for examination has a finely gemmate central cord.

Gippsland specimens differ from the holotype mainly by the late appearance of the central cord, usually on the tenth to twelfth whorl; this seldom becomes as prominent as the other two cords until the last two or three whorls. The spaces between the cords, also between the upper and lower cords and the adjacent sutures, also vary in width compared with the Tasmanian specimens.

Colpospira (Colpospira) calcaria sp. nov.

Pl. 27, fig. 3.

Description: PROTOCONCH asymmetric, of two flatly convex smooth whorls, nucleus free or very slightly submerged. TELEOCONCH 14 whorls, first four smooth and convex, balance flat and strongly striated; spire noticeably concave. SUTURES finely incised. SCULPTURE — an indefinite sub-central swelling on first three whorls; about fourth whorl a rounded spiral appears towards base, closely followed by others at top and centre; one to three minor cords appear irregularly later but first three predominate, either centre or lowest cord the stronger; growth striae fine and difficult to detect until last two or three whorls; whole shell smooth and polished. APERTURE sub-quadrate; columella arcuate, inner lip a little reflected at base; outer lip thin, crenulated by cords exteriorly, with deep and narrow medial sinus, typical of the genus. BASE of shell flat, with peripheral ridge and five flatly rounded concentric cords crossed by fine and densely packed growth striae.

Type locality: Blue Clays at Fossil Beach, Balcombe Bay, Mornington Peninsula, Victoria; Grid Ref. Cranbourne 072845. Balcombe Clay: Balcombian: Middle Miocene.

Dimensions: Holotype, length 7.9 mm, breadth 1.9 mm, National Museum of Victoria, Melbourne, Reg'd. No. P.27458.

Material: 35 paratypes, Australian Museum, Sydney, from type locality.

Discussion: The protoconch, primary whorls and concave spire of this very small species bear a slight resemblance to *C. (C.) platyspira,* but the keels of this new species are decidedly heavier and it grows to only half the length. It is quite common at the type locality, and also occurs in the cliff-face south of Manyung Rocks a little further north (Bairnsdalian Stage). The closest recent species as far as general shape and sculpture are concerned would be *C. decoramen* (Iredale), which is decidedly larger, but whether this new species is directly ancestral to *C. decoramen* is a matter of conjecture.

Colpospira (Colpospira) platyspira (Tenison-Woods, 1879)

Pl. 27, fig. 4.

1879 *Turritella platyspira* Tenison-Woods, *Proc. Linn. Soc. N.S.W.*, 3: 234, pl. 20, fig. 13.
1893 *Turritella platyspira.* Tate, *Trans. R. Soc. S. Aust.*, 17: 341, pl. 8, fig. 9.
1941 *Colpospira platyspira.* Ludbrook, *Trans. R. Soc. S. Aust.*, 65: 100.

Description: PROTOCONCH asymmetric, of two smooth inflated whorls, nucleus not submerged. TELEOCONCH 15 whorls, first five or so smooth and convex, followed by several whorls usually flat, last three or four again convex. SUTURES vary from lightly impressed to decidedly incised. SCULPTURE usually of three suppressed cords, evenly spaced between sutures, obsolete in some specimens, space between anterior and medial cords concave; faint threads usually present in interstices; incremental striae deeply flexuous but barely visible. APERTURE sub-quadrate; columella slightly arcuate, inner lip a little reflected at base; outer lip thin with typical sinus. BASE of shell flat with strong peripheral ridge, four or five medium spiral striations crossed by extremely fine growth lines.

Type locality: Muddy Creek, west of Hamilton, Victoria. Muddy Creek formation: Balcombian: Middle Miocene.

Dimensions: Holotype, length 13 mm, breadth 3.75 mm, Australian Museum, Sydney, Reg'd. No. F.1781.

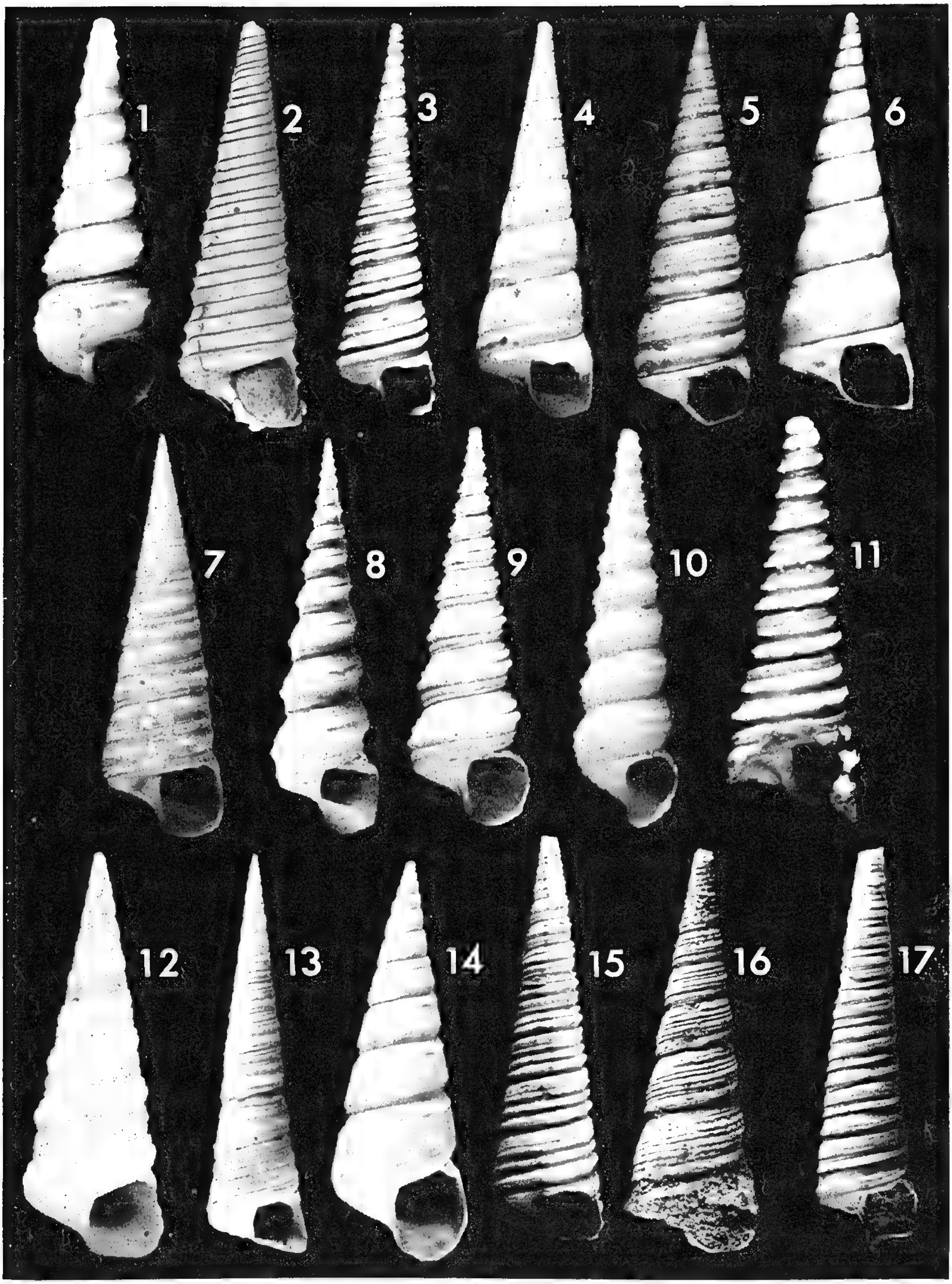
Material: Six topotypes, National Museum of Victoria, Melbourne; two topotypes, Australian Museum, Sydney.

Discussion: The recent *C. aquamarina* Garrard bears a strong general resemblance to this species, however the protoconch of *C. aquamarina* whilst almost identical, is decidedly larger. It also has two medium cingula almost adjoining the sutures as opposed to the three evenly spaced striae of *C. platyspira*, and more even and evenly spaced striations.

PLATE 27

1. *Colpospira (Colpospira) wollumbi* Garrard. East of Port Jackson, New South Wales, 77 - 154 metres. Holotype, X 12.4. A.M. No. C72585.
2. *Colpospira (Colpospira) tristira* (Tate). Fossil Bluff, Table Cape, near Wynyard, Tasmania. Holotype, X 1.2. Tate Museum, University of Adelaide, Geology Dept., Reg'd No. T.1419B.
3. *Colpospira (Colpospira) calcaria* Garrard. Fossil Beach, Balcombe Bay, Mornington Peninsula, Victoria. Holotype, X 8. N.M.V. No. P27458.
4. *Colpospira (Colpospira) platyspira* (Tenison-Woods). Clifton Bank, Muddy Creek, west of Hamilton, Victoria. Topotype, X 5.1. N.M.V. No. P26986.
5. *Colpospira (Colpospira) conspicabilis* (Tate). Bed b, Cutting on Prince's Highway, North-east side of Bunga Creek, Lakes Entrance, Victoria. Figured specimen, X 1.9. N.M.V. No. P26997.
6. *Colpospira (Colpospira) platyspiroides* Ludbrook. Abattoirs Bore, Adelaide, South Australia. Paratype, X 6.8. T.M. No. F15156.
7. *Colpospira (Acutospira) accisa* (Watson). Off Twofold Bay, New South Wales, 73 metres. Figured specimen, X 2.5. A.M. No. C77376.
8. *Colpospira (Acutospira) atkinsoni* (Tate and May). East of Babel Island, Bass Strait, 118 metres. Figured specimen, X 2.9. A.M. No. C77378.
9. *Colpospira (Acutospira) smithiana* (Donald). 27½ miles east of Sydney, New South Wales, 457-549 metres. Figured specimen, X 6.4. A.M. No. C24430.
10. *Colpospira (Acutospira) yarramundi* Garrard. South-east of Lakes Entrance, Victoria, 154 metres. Holotype, X 11.7. A.M. No. C72591.
11. *Colpospira (Platycolpus) acinella* (Chapman and Crespin). Sorrento Bore (Nepean No. 1)., Victoria, 1,400 feet. Topotype, X 19.7. N.M.V. No.
12. *Colpospira (Platycolpus) circumligata* (Verco). East of King Island, Bass Strait, 58 metres. Figured specimen, X 4. A.M. No. C77382.
13. *Colpospira (Platycolpus) congelata* (Adams and Reeve). 7 miles north of Long Island, near Onslow, Western Australia, 50 metres. Figured specimen, X 3.1. W.A.M. No. 365-69.
14. *Colpospira (Platycolpus) quadrata* (Donald). Off Twofold Bay, New South Wales, 45-54 metres. Figured specimen, X 3.9. A.M. No. C77380.
15. *Colpospira (Platycolpus) warburtonii* (Tenison-Woods). Topotype, X 2.5. N.M.V. No. P27454.
16. *Colpospira (Platycolpus) warburtonii* (Tenison-Woods). Topotype, X 2.9. N.M.V No. P27006.
17. *Colpospira (Platycolpus) warburtonii* (Tenison-Woods). Topotype, X 3. N.M.V. No. P27453. Above three Topotypes from Fossil Bluff, Table Cape, near Wynyard, north-west Tasmania.

Plate 27



Colpospira (Colpospira) conspicabilis (Tate, 1893)

Pl. 27, fig. 5.

1893 *Turritella conspicabilis* Tate, *Trans. R. Soc. S. Aust.*, 17: 339, pl. 8, fig. 7.
1935 *Turritella conspicabilis.* Cotton and Woods, *Rec. S. Aust. Mus.*, 5: 380.
1957 *Turritella conspicabilis.* Marwick, *Proc. Mal. Soc. Lond.*, 32: 153.

Description: PROTOCONCH paucispiral, asymmetric, of 1½ smooth globose whorls, nucleus not submerged. TELEOCONCH 13 whorls, all flatly convex. SUTURES well impressed. SCULPTURE — first four whorls smooth with indefinite cord at base which becomes increasingly heavy with age; usually three strong striations develop above the basal cord, with a number of very fine striae over the whole whorl, all crossed by fine, dense lines of growth. APERTURE sub-quadrate; columella arcuate, inner lip a little reflected at base; outer lip thin and crenulated exteriorly by cords, typical sinus. BASE of shell with numerous strong but fine lirae crossed by numerous growth lines.

Type locality: "Gippsland Lakes", precise locality not known. Mitchellian-Cheltenhamian: Upper Miocene. (T. A. Darragh, pers. comm., 29/10/69).

Dimensions: Holotype, length 41.1 mm, breadth 10.9 mm, Tate Museum, Geology Dept., University of Adelaide, South Australia, Reg'd. No. T.1416C.

Material: 4 topotypes, National Museum of Victoria, Melbourne.

Discussion: Notes by the author (Tate): " Though associated with *T. tristira* at Gippsland Lakes, and not with it elsewhere, as there are no decided intermediate stages, I have somewhat reluctantly considered it a distinct species. A varietal form, if not a distinct species, occurs abundantly at Spring Creek, which differs by less prominent keel. It makes some approach to that variety of *T. runcinata,* in which the front keel is conspicuously elevated, but the whorls are more quadrate, the keel truncated on the edge, whilst the spiral striae are fewer and not wavy interrupted." My own comments are that this species could well be the direct ancestor of *C. runcinata.* The primary whorls in this species are flat and not flatly convex as in *C. runcinata,* but general whorl structure and spirals are very similar.

Colpospira (Colpospira) platyspiroides Ludbrook, 1957

Pl. 27, fig. 6.

1957 *Colpospira platyspiroides* Ludbrook, *Trans. R. Soc. S. Aust.*, 80: 19, pl. 2, fig. 12.

Description: PROTOCONCH paucispiral, asymmetric, of 1½ smooth globose whorls, shining, nucleus not submerged. TELEOCONCH approx. 17 whorls, smooth, shining, flattish, rather restricted posteriorly. SUTURES a little impressed. SCULPTURE — early whorls slightly carinate in anterior quarter, a second keel later developing in posterior quarter, area between is flat and smooth except for occasional very fine spiral threads, crossed by fine flexuous growth lines. APERTURE sub-quadrate; columella slightly arcuate, inner lip a little reflected at base; outer lip thin with typical sinus. BASE of shell with sharply angulate periphery, flattish, six fine spiral lirae crossed by fine growth lines.

Type locality: Abattoirs Bore, Adelaide, South Australia. Dry Creek Sands: Yatalan: Upper Pliocene.

Dimensions: Holotype, length — estimated total 18.5 mm, breadth 5 mm, Tate Museum, Geology Dept., University of Adelaide, South Australia, Reg'd. No. F.15156.

Material: 2 paratypes from type locality, Tate Museum, as above.

Discussion: Observations by the author: " The four examples of this species were previously referred to *C. platyspira* Tenison-Woods, from which the species differs in being larger and thicker, with a wider spire more gradually tapering than that of *C. platyspira.* The sculpture also differs."

Subgenus *ACUTOSPIRA* Kotaka, 1959

ACUTOSPIRA Kotaka, 1959, *Sci. Rep. Tohoku Univ.*, (2). 31: 101. Type species by original designation *Turritella okadai* Nagao, 1928.

Subgeneric characteristics. Similar in nearly all respects to main genus *Colpospira,* except that spiral cords are replaced by sharp-edged prominent keels. In the five species now included in this subgenus, B is always the first spiral to emerge, followed by either A, C or C, A. This contrasts with the main genus *Colpospira,* where the spiral C, if visible, emerges first, and confirms the necessity for the introduction of this subgenus. Whether this also applies to species outside Australia is unknown.

Colpospira (Acutospira) accisa (Watson, 1881)

Pl. 27, fig. 7.

1881 *Turritella accisa* Watson, *Jour. Linn. Soc. Lond.*, 15: 220.
1886 *Turritella accisa.* Watson, *Rep. Sci. Res. Challenger, Zool.*, 25: 476, pl. 30, fig. 4.
1924 *Colpospira accisa.* Iredale, *Proc. Linn. Soc. N.S.W.*, 49: 249.
1931 *Colpospira accisa.* Cotton and Godfrey, *S. Aust. Naturalist*, 12: 57.

Description: PROTOCONCH asymmetric, of two smooth globose whorls, nucleus not submerged. TELEOCONCH 16 whorls, convex towards base of whorls, spire straight sided. SUTURES sharply impressed. SCULPTURE — a strong keel in centre and another towards base, commencing on first whorl, a smaller at top commencing on first or second whorl; from about fourth whorl onwards various striations commence above, below and between the keels, but three main keels remain dominant throughout, the lowest tending to bifurcate on gerontic whorls. APERTURE sub-quadrate; columella fairly straight, inner lip strongly reflected at base; outer lip thin and crenulate with typical sinus. BASE of shell flatly convex with strong peripheral cord; numerous fine, even concentric striations crossed by faint growth lines. COLOUR an overall cream, fawn or light reddish-brown; some specimens with reddish irregular spotting on keels and striations. OPERCULUM from a half-grown specimen is circular, approx. 2 mm diameter, dark brown, gelatinous, four rough heavy concentric ridges inwards from edge, several finer ones surrounding solid, slightly raised central nucleus.

Type locality: Bass Strait, off East Moncoeur Island, 38-40 fathoms (69-73 metres).

Dimensions: Holotype, length 29.2 mm, breadth 8.6 mm, British Museum (Natural History), Reg'd No. 1887.2.9.1498-1500.

Distribution: Central New South Wales coast southward to Victoria, Tasmania, South Australia and southern Western Australia.

Material: Large quantity of specimens from six State Museums.

Discussion: Specimens examined from southern New South Wales and Victoria follow Watson's description quite well, the central and lower main cords being strong and sharp, the upper tending usually to be a little broader and more flattened. Specimens from 70 metres off Cape Borda, South Australia, tend to have the strongest keel at the base, the central keel replaced by two or even three lesser keels, accompanied by the numerous fine striae as usual. No difficulty should be experienced in separating this strongly keeled species from the closely allied *C. runcinata* (Watson), with its almost smooth golden-yellow and then white primary whorls.

Colpospira (Acutospira) atkinsoni (Tate and May, 1900)

Pl. 27, fig. 8.

1876 *Turritella tasmanica* Tenison-Woods, *Proc. R. Soc. Tas.*, (1875), p. 140.
1900 *Turritella atkinsoni* Tate and May, *Trans. R. Soc. S. Aust.*, 24: 95. (New name for *T. tasmanica* Tenison-Woods, 1876, *non* Reeve, 1849).
1900 *Turritella (Colpospira) godeffroyana* Donald, *Proc. Mal. Soc. Lond.*, 4: 53, pl. 5, figs. 6, 6a.
1901 *Turritella atkinsoni*. Tate and May, *Proc. Linn. Soc. N.S.W.*, 26: 378, pl. 23, figs. 15-17.
1910 *Colpospira atkinsoni medioangulata* Verco, *Trans. R. Soc. S. Aust.*, 34: 125, pl. 30, figs. 8, 9.
1962 *Stiracolpus atkinsoni*. Macpherson and Gabriel, *Mar. Moll. Vict.*, p. 97, text fig. 122.

Description: PROTOCONCH paucispiral, asymmetric, of 1½ glassy convex whorls, nucleus slightly submerged. TELEOCONCH 14 whorls, all medially angulate and inflated. SUTURES lightly impressed. SCULPTURE — a strong, sharp and heavy keel emerges in centre of first whorl, followed by a further keel towards base of second whorl, and a third above central keel on about fifth whorl; the central keel always remains strongly predominant; further striations develop at intervals, of varying strength and in an irregular manner. APERTURE sub-circular; columella arcuate, inner lip reflected at base; outer lip thin with typical sinus. BASE of shell a little convex, periphery strongly keeled, up to 10 rather vague and irregular concentric striae crossed by numerous growth lines. COLOUR off-white, cream or medium brown. OPERCULUM circular, approx. 2.2 mm diameter, medium brown, thin and papery, with numerous overlapping irregular concentric ridges; central nucleus solid and strongly elevated.

Type locality: Tasmania.

Dimensions: Holotype ("*tasmanica*" of Tenison-Woods), length 14.8 mm, breadth 4 mm, Tasmanian Museum, Hobart, Reg'd. No. 7879/E538.

Distribution: Off Port Jackson, New South Wales, southwards to Victoria and Tasmania.

Material: Large quantity from five State Museums.

Discussion: In line with the suggestion by Tate and May (1901: 378) that the species named *C. (A.) godeffroyana* Donald, 1900, was an individual variation of *C. (A.) atkinsoni*, I support their contention and hereby designate a neotype of *C. (A.) godeffroyana* for the following reasons:

(1) No other recent Australian species in the family has the sharp and boldly prominent medial keel on each whorl, persisting throughout the length of the shell and setting it quite apart.

(2) The description and other data given above for the species *C. (A.) atkinsoni* ensure recognition of the specimen designated without difficulty, and conform also to the original description and other data given for *C. (A.) godeffroyana* Donald.

(3) The holotype of *C. (A.) godeffroyana* in the Godeffroy collection was a unique specimen, which was destroyed during the loss of the Hamburg Museum by bombing in January 1943. This has been verified by enquiries from the present Director of the Museum.

(4) The neotype has been carefully chosen from a quantity of material available, and conforms as closely as practicable to the measurements, number of whorls and other description of the lost holotype.

(5) The neotype has been selected from dredgings made by "Endeavour" in 1912, from 65 fathoms east of Babel Island, Bass Strait, which is as close as practicable to the original type locality, designated merely as Bass Strait.

(6) The neotype is the property of, and is preserved in, the Australian Museum, Sydney, where it is registered No. C.78948.

Colpospira (Acutospira) smithiana (Donald, 1900)

Pl. 27, fig. 9.

1900 *Turritella (Colpospira) smithiana* Donald, *Proc. Mal. Soc. Lond.*, 4: 52, pl. 3, fig. 1.
1931 *Stiracolpus smithianus*. Cotton and Godfrey, *S. Aust. Naturalist*, 12: 58.

Description: PROTOCONCH asymmetric, of two glassy globose whorls, nucleus not submerged. TELEOCONCH 12 angularly convex whorls, spire straight sided. SUTURES well impressed. SCULPTURE — one extremely strong and sharp keel commences in centre of first whorl with a smaller keel above; a third keel develops on third whorl towards the base, and a fourth keel at top of fourth whorl; a few microscopic striae develop in places on last two or three whorls. APERTURE sub-circular; columella rather strongly arcuate, inner lip reflected as a glaze on to body-whorl and strongly at base; outer lip thin, crenulated exteriorly by cords, with typical sinus. BASE of shell convex, six or seven strong irregular concentric striations crossed by numerous growth lines. COLOUR translucent white when live-taken, later becoming opaque white. OPERCULUM circular, approx. 1.4 mm diameter, medium brown, thin and papery with numerous overlapping irregular concentric ridges; central nucleus solid and slightly elevated.

Type locality: Off Sydney, New South Wales, 410 fathoms (750 metres).

Dimensions: Holotype, length 9.5 mm, breadth 3 mm, British Museum (Natural History), Reg'd. No. 1889.10.26.56-88.

Distribution: From southern Queensland through New South Wales to Victoria, Tasmania, South Australia and the southern coast of Western Australia, in depths from fairly shallow water down to 1,464 metres.

Material: Large quantities from six State Museums.

Discussion: This species was described from the disputed "Challenger" station 164B in 410 fathoms off Sydney Harbour, and was consequently on the doubtful list for some years. However it has proved to be a widespread species as shown above. The sculpture of four equally strong keels is not constant, this applying to only say 60% of specimens; others have the central two considerably stronger, whilst others again have the first central keel to emerge predominant throughout. Hedley had specimens from 800 fathoms east of Sydney confirmed by Mrs. Longstaff (née Donald), and I have since had further specimens compared with the holotype. The original drawing of this species at pl. 5, fig 1 is decidedly misleading, the keels being shown as far weaker than they actually are, whilst the drawing of "*godeffroyanus*" at fig. 6 is extremely like *C. (A.) smithiana*. Specimens from 300 fathoms 120 miles west of Eucla, Western Australia, tend to have all keels of equal strength, with more space above and below the sutures. This species bears a superficial resemblance to the new species next described, the differences being shown under discussion of that species.

Colpospira (Acutospira) yarramundi sp. nov.

Pl. 27, fig. 10.

Description: PROTOCONCH paucispiral, asymmetric of 1½ convexly rounded whorls, translucent white, nucleus not submerged. TELEOCONCH ten whorls, flatly convex to commence, increasing in convexity later, sides of spire straight. SUTURES very lightly impressed. SCULPTURE commences on first main whorl in form of a strong keel a little below centre, followed on second whorl by a fine keel above it which gradually increases in strength, until nearly equal to first keel by time fifth whorl is reached; a further keel commences below main keel on about fifth whorl, usually becoming about half-way in prominence between the other two; a fourth weak keel emerges above lower suture about ninth whorl. APERTURE sub-circular; columella arcuate, inner lip strongly reflected; outer lip crenulated exteriorly by keels and striations, labial sinus deep and narrow, and typical of the genus; basal portion of outer lip curves downward to form a slight canal at junction with base of inner lip. BASE of shell a little convex with three or four fine concentric threads crossed by faint growth striae. COLOUR — whole shell usually pure white and shining, some specimens tinged light to medium chestnut. OPERCULUM unavailable.

Type locality: 154 metres south-east of Lakes Entrance, Victoria.

Dimensions: Holotype, length 5.4 mm, breadth 1.4 mm, Australian Museum, Sydney, Reg'd. No. C.72591.

Distribution: From north of Cape Moreton, southern Queensland, through New South Wales to south-east of Lakes Entrance, Victoria, in depths ranging from 75 to 550 metres, the last being 27½ miles east of Port Jackson, New South Wales.

Material: Large quantity from five State Museums.

Discussion: This widespread small species bears a superficial resemblance to the larger *C. (A.) smithiana* (Donald), in the number and disposition of the sharp keels on the last three or four whorls. However, whereas the three main keels of *C. (A.) smithiana* are prominent from the second or third whorl, the three main keels of this species appear one at a time, and achieve somewhat equal prominence only from about the sixth whorl onwards. A weak thread appears above the uppermost keel and another between the two lowest keels in a number of specimens on the body-whorl and penultimate. The appearance of the three sharp keels on this species also separates it without difficulty from *C. wollumbi* Garrard, which has four rounded cords commencing almost simultaneously. The specific name is a New South Wales aboriginal noun meaning " Deep water."

Subgenus *PLATYCOLPUS* Donald, 1900

PLATYCOLPUS Donald, 1900, *Proc. Mal. Soc. Lond.*, 4: 54. Type species by original designation *Turritella (Colpospira) quadrata* Donald, 1900.

Subgeneric characteristics. Very small to medium. General characteristics as for main genus *Colpospira*, except that labial sinus is broader and shallower, medial, and orthocline (Fig. 3). Primary spirals emerge in order B, C, A or B, A, C; quite clear as former in fossil *C. (P.) warburtonii* and as the latter in *C. (P.) multicincturalis;* difficult to detect in recent *C. (P.) quadrata* (type) and *C. (P.) circumligata.*

Colpospira (Platycolpus) quadrata (Donald, 1900)

Pl. 27, fig. 14.

1900 *Turritella (Colpospira) quadrata* Donald, *Proc. Mal. Soc. Lond.*, 4: 53, pl. 5, fig. 8, 8a, 8b.
1900 *Turritella (Colpospira) quadrata* subsp. *scitula* Donald, *Proc. Mal. Soc. Lond.*, 4: 54, pl. 5, fig. 9.
1924 *Colpospira quadrata.* Iredale, *Proc. Linn. Soc. N.S.W.*, 49: 249.
1931 *Platycolpus quadratus.* Cotton and Godfrey, *S. Aust. Naturalist*, 12: 58, pl. 2, fig. 3.
1950 *Platycolpus quadratus.* Allan, *Aust. Shells*, p. 92, text fig. 2.
1957 *Platycolpus quadratus.* Marwick, *Proc. Mal. Soc. Lond.*, 32: 157, text fig. 51.
1962 *Colpospira quadrata.* Macpherson and Gabriel, *Mar. Moll. Vict.*, p. 99.

Description: PROTOCONCH asymmetric, two smooth white convex whorls, nucleus not submerged. TELEOCONCH 11 whorls, first three or four slightly convex, balance a little concave between ridges, spire straight sided. SUTURES slightly impressed at base of deep V-notch. SCULPTURE commences with several fine spiral striae on third whorl, followed by a strong cord above suture near base of whorl and another below suture towards top of whorl; cords continue to increase in strength, and intervening space increases in concavity; striations continue as fine threads, increasing in number above, below and between the ridges. APERTURE sub-circular; columella strongly arcuate, inner lip strongly reflected on to body-whorl and at base; outer lip thin, curving strongly round base, and with typical sinus. BASE of shell strongly convex with numerous slightly gemmate flat striae, due to intersection with closely packed growth lines. COLOUR light yellow, lightly flamed with brown, with deeper brown spots on both ridges; protoconch translucent white. OPERCULUM circular with black-brown base, elevated central nucleus having central depression, 16 or more cream concentric overlapping incremental ridges, extremely thin and papery.

Type locality: Bass Strait, 45 fathoms (82 metres).

Dimensions: The author states that the length of a medium sized specimen is 19 mm, and breadth 6.5 mm. The Holotype is in the British Museum (Natural History), Reg'd. No. 1969271.

Distribution: Victoria, Tasmania, South Australia and New South Wales northwards to mid-coast, in varying depths from a few metres to 860 metres (" Endeavour " 1912, off Green Cape, New South Wales).

Material: Large quantity from six State Museums.

Discussion: Although this species appears to be confused quite frequently with *Colpospira sinuata* (Reeve), it can be separated on sight by the clean-cut and deep V-notch at the sutures, and the central concavity between the ridges on each whorl after about the first four. The species varies very little throughout its range. The subspecies C. *(P.) scitula* (Donald) is obviously only a specimen with slightly brighter markings and the whorls a little more concave, which can be seen many times over in a long series of specimens. The fine transverse striae vary a little in intensity, and the angle of the spire can vary from 4.5° to 5.5°, otherwise it is a constant species.

Colpospira (Platycolpus) circumligata (Verco, 1910)

Pl. 27, fig. 12.

1910 *Turritella circumligata* Verco, *Trans. R. Soc. S. Aust.*, 34: 123, pl. 30, figs. 3, 4.
1931 *Colpospira circumligata*. Cotton and Godfrey, *S. Aust. Naturalist*, 12: 57.

Description: PROTOCONCH paucispiral, asymmetric, 1½ to 2 smooth globose translucent whorls, nucleus prominent. TELEOCONCH 11 whorls, a little convex. SUTURES linear, very slightly canaliculate in early whorls. SCULPTURE becomes prominent about fifth whorl, consisting of a broad heavy rounded cord below suture, below which are two similar but smaller cords with flat space of equal width between them; largest cord is below these, higher and more rounded than the large posterior one, sloping inwards towards lower suture; the whole is crossed by densely packed prominent growth striae. APERTURE sub-quadrate; columella arcuate, inner lip strongly reflected towards base; outer lip thin, crenulated exteriorly by cords, and with typical sinus. BASE of shell roundly convex, with up to 9 broad flat striae crossed by numerous growth lines. COLOUR pale yellow-brown with darker brown spirals between cords, a broad brown spiral over centre of base. OPERCULUM unavailable.

Type locality: Off Beachport, South Australia, 110 fathoms (200 metres).

Dimensions: Holotype, length 17mm, breadth 6 mm, South Australian Museum, Reg'd. No. D.13429.

Distribution: South Australia and Bass Strait.

Material: Holotype and several paratypes, South Australian Museum; two paratypes and one other, Australian Museum, Sydney.

Discussion: This beautifully sculptured small species is quite rare in dredgings. The only specimen obtained by " Gascoigne " in 1962 and given to the Australian Museum came from 58 metres east of King Island, Bass Strait, and is a clear translucent white. Examination of the holotype in the South Australian Museum shows it now to be a uniform pale cream in colour, due to fading since the original description. The species does not appear to have any close relatives.

This species was recorded by Chapman and Gabriel (1914: 323) from 3,226 feet in the Mallee Bore, but was a case of mis-identification.

Colpospira (Platycolpus) congelata (A. Adams and Reeve, 1848)

Pl. 27, fig. 13.

1848 *Turritella congelata* A. Adams and Reeve, *Voy. Samarang*, Zool., p. 47, pl. 12, fig. 2.
1849 *Turritella congelata.* Reeve, *Conch. Icon.*, 5, pl. 11, fig. 59.
1886 *Turritella congelata.* Tryon, *Man. Conch.*, 8: 204, pl. 64, fig. 94.

Description: PROTOCONCH asymmetric, of two whorls, flatly rounded, nucleus prominent. TELEOCONCH 16 whorls, convex, first four strongly centrally carinate, balance becoming flatter with maturity. SUTURES impressed. SCULPTURE — one strong cord just below centre on first four whorls, becoming a raised striation from then on; a further striation both above and below this on succeeding whorls; three or four striae follow, but first three remain predominant, all crossed by sinuous densely packed but faint growth lines. APERTURE sub-quadrate, columella straight, inner lip slightly recurved at base; outer lip thin with typical sinus. BASE of shell flatly convex, three strong striae next to peripheral edge, further six or seven indistinct striae towards centre, crossed by faint growth lines. COLOUR opaque white, mature whorls somewhat translucent, three main spirals tipped with yellow-brown. OPERCULUM unavailable.

Type locality: China Sea.

Dimensions: Figured specimen — holotype, length 36.5 mm, breadth 10.5 mm, British Museum (Natural History), Reg'd. No. unavailable.

Distribution: The only specimens now recorded from the Australian coast are: 7 miles north of Long Is., Onslow, 47 metres, 4 specimens; 20 miles north of Delambre, Dampier Archipelago, 42 metres, 1 specimen; both localities in Western Australia.

Material: Five specimens in Western Australian Museum as above.

Discussion: Although only five specimens of this species have been examined from the collection of " Western Australian — Hawaiian Expedition " as above, one specimen in particular is almost fully grown and in very good condition. The illustration and description of the species leaves no room for doubt as to its identity. The thin, frail construction of the shell sets it apart from any other species in Australian waters.

FOSSIL SPECIES

Colpospira (Platycolpus) warburtonii (Tenison-Woods, 1877)

Pl. 27, fig. 15-17; Pl. 30, fig. 9.

1877 *Turritella warburtonii* Tenison-Woods, *Pap. Proc. R. Soc. Tas.*, (1876), p. 99; *ibid* = *T. sturtii* Tenison-Woods, 1877.
1893 *Turritella warburtonii.* Tate, *Trans. R. Soc. S. Aust.*, 17: 337, pl. 8, fig. 2; *ibid.* = *T. sturtii* Tenison-Woods, 1877, p. 338, pl. 8, fig. 6.
1896 *Turritella warburtoni.* Pritchard, *Proc. R. Soc. Vict.*, 8: 113-4; *ibid.* = *T. sturtii* Tenison-Woods, 1877.
1935 *Turritella (Ctenocolpus) warburtonii.* Cotton and Woods, *Rec. S. Aust. Mus.*, 5: 377-80; *ibid.* = *T. (C). sturtii* Tenison-Woods, 1877.
1957 *Ctenocolpus warburtoni.* Marwick, *Proc. Mal. Soc. Lond.*, 32: 153; *ibid.* = *C. sturti* Tenison-Woods, 1877.

Description: PROTOCONCH asymmetric, of 2½ smooth convex whorls, nucleus slightly submerged. TELEOCONCH 15 whorls, varying from flatly convex to a little concave, sides of spire flat to slightly concave. SUTURES deeply impressed. SCULPTURE varies considerably, from three to eight cords and striations, some granulose, some smooth: the commonest form taken by the sculpture is two heavy cords towards the base of each whorl, one or both smooth or granulose, a further lighter cord just below the upper suture, with intervening space concave, sometimes with minor striae, sometimes completely smooth; other specimens with flatly convex whorls, up to eight striations of varying importance; other specimens fall between these extremes. APERTURE sub-quadrate; columella almost straight, inner lip a little reflected at base; outer lip crenulated exteriorly by cords, with typical sinus. BASE of shell flat with up to ten concentric striae of varying prominence, crossed by numerous growth lines.

Type locality: Fossil Bluff, Table Cape, near Wynyard, Tasmania. Table Cape Group: Janjukian/Longfordian: Upper Oligocene/Lower Miocene.

Dimensions: Holotype, length 14 mm, breadth 4 mm. (Holotype of *C. (P.) sturtii*, length 22 mm, breadth 5.25 mm). Both holotypes should be in the Tasmanian Museum, Hobart, but are reported to be lost.

Material: 11 topotypes National Museum of Victoria, Melbourne. Large quantity of topotypes Australian Museum, Sydney.

Discussion: This most variable species appears to have been the subject of a great deal of argument and speculation since it was named as two distinct species by Tenison-Woods in 1877. Cotton and Woods (1935: 377-9) commented on a number of specimens from the Singleton collection and finally adopted an arbitrary method of separation. They declared that all specimens with two prominent keels at the base of each whorl, either smooth or granulose, were *C. (P.) warburtonii*, and all those with more than two ribs, except where the anterior pair are very strongly developed, were to be placed in *C. (P.) sturtii*. An argument such as this, where no distinct dividing line is given, cannot be sustained; furthermore the fact that they placed all specimens with two strong keels, either smooth or granulose, under *C. (P.) warburtonii*, is directly in conflict with Tenison-Woods' original description of that species, where he placed the words " two smooth " ,(ribs) in italics to emphasise one manner in which it differed from *C. (P.) sturtii*.

I have carefully examined a long series of this species, from the type locality, in the Australian Museum collection. Specimens agreeing well with both the original descriptions are included, in addition to every possible intergrade; the protoconchs and primary whorls of all specimens are identical, and no clear-cut dividing line is evident. I conclude that there is only one species having a most variable sculpture, and with whorls varying from a little convex to fairly concave, and the two names must be considered synonymous.

Colpospira (Platycolpus) acinella (Chapman and Crespin, 1928)

Pl. 27, fig. 11

1928 *Turritella acinella* Chapman and Crespin, *Rec. Geol. Surv. Vict.*, 5: 115, pl. 8, fig. 45.

Description: PROTOCONCH asymmetric, of two smooth flatly globose whorls, nucleus slightly submerged. TELEOCONCH 8 flat whorls. SUT-

URES a fine impressed line. SCULPTURE — first whorl strongly centrally unicarinate, on second or third whorl further strong cords develop at both top and bottom, all persisting strongly on to body-whorl; whorls are otherwise smooth with growth striae barely discernible. APERTURE sub-circular; columella slightly arcuate, inner lip reflected at base; outer lip thin, crenulated exteriorly by cords, with typical sinus. BASE of shell flat with strong peripheral cord and three or four smaller striations, crossed by numerous growth lines.

Type locality: Sorrento Bore (Nepean No. 1), Victoria, 1,310 feet. Fyansford Formation: Bairnsdalian: Middle Miocene.

Dimensions: Holotype, length 4.5 mm, breadth 1.7 mm, National Museum of Victoria, Melbourne — reported lost.

Material: Four topotypes, National Museum of Victoria.

Discussion: The original description states that the median rib in this species is the strongest; it emerges first but the anterior rib (or cord) is often of equal strength after about fourth whorl. In others the posterior cord can become equal to the median by about sixth whorl whilst the anterior cord remains depressed. Strength of cords in relation to each other is a variable feature. This very small species resembles *C. (P.) medioplicatilis* (Chapman and Crespin), and is of the same age and from same type locality, however that species lacks the posterior cord, and the cords are less acute and more rounded.

Colpospira (Platycolpus) medioplicatilis (Chapman and Crespin, 1928)

Pl. 30, fig. 6.

1928 *Turritella medioplicatilis* Chapman and Crespin, *Rec. Geol. Surv. Vict.*, 5: 116, pl. 8, fig. 47.

Description: PROTOCONCH paucispiral, asymmetric, of 1½ flatly convex whorls, nucleus a little submerged. TELEOCONCH 11 whorls, flatly convex, spire straight sided. SUTURES well impressed. SCULPTURE — first five whorls strongly centrally unicarinate, further strong cord develops at base on about sixth whorl, later " moving " a little adapically, with smooth area between cords, also area above upper cord, strongly concave; one or two striations form below upper suture on later whorls; growth striae very faint. APERTURE sub-circular; columella slightly arcuate; outer lip thin with typical sinus. BASE of shell a little concave with three or four vague striations crossed by fine growth lines.

Type locality: Sorrento Bore (Nepean No. 1), Victoria, 1,461 feet. Fyansford Formation: Bairnsdalian: Middle Miocene.

Dimensions: Holotype, length 3.25 mm, breadth at base 1 mm, National Museum of Victoria, Melbourne, Reg'd. No. P. 14465.

Material: One paratype National Museum of Victoria, Melbourne.

Discussion: This minute species appears difficult to obtain at the type locality, the amount of material available for study apparently being very limited. However the specimen available is quite distinct from its closest relative, *C. (P.) acinella* as shown above.

Colpospira (Platycolpus) multicincturalis (Chapman and Crespin, 1928)

Pl. 28, fig. 1.

1928 *Turritella multicincturalis* Chapman and Crespin, *Rec. Geol. Surv. Vict.*, 5: 116, pl. 8, fig. 46.

Description: PROTOCONCH asymmetric, of two globose whorls, nucleus not submerged. TELEOCONCH 14 whorls, flat and depressed, sides of spire straight. SUTURES moderately impressed. SCULPTURE of primary whorls strongly bicarinate, lower cord the stronger, two or three other cords later developing with a few finer striations in a somewhat irregular manner; sub-central cord is always predominant; growth striae extremely faint even on mature whorls. APERTURE sub-circular; columella arcuate, inner lip a little reflected at base; outer lip a little thickened and crenulated by cords, with typical sinus. BASE of shell flat with up to six fine flattened striae crossed by fine growth lines.

Type locality: Sorrento Bore (Nepean No. 1), Victoria, 741 feet. Fyansford Formation: probably Cheltenhamian: Upper Miocene.

Dimensions: Holotype, length 7 mm, breadth 2.25 mm, National Museum of Victoria, Melbourne, Reg'd. No. P.14464.

Material: 3 paratypes National Museum of Victoria, Melbourne.

Discussion: The order of emergence of the primary spirals for the recent C. *(P.) quadrata* (Donald), the type for this subgenus, is very vague and difficult to detect, but B is the first to emerge, quickly becoming submerged again with other fine striations. The within species differs from the fossil C. *(P.) warburtonii* (Tenison-Woods) in that the order of emergence is B, A, C as against B, C, A for C. *(P.) warburtonii.* However the labial and basal sinuses together with the protoconch show that *(Platycolpus)* is the only available subgenus for this species. It does not appear to have any near relatives in the Miocene or Pliocene.

Colpospira (Platycolpus) trilix (Cotton and Woods, 1935)

Pl. 28, fig. 2.

1935 *Turritella (Ctenocolpus) trilix* Cotton and Woods, *Rec. S. Aust. Mus.*, 5: 377, text fig. 4.
1952 *Ctenocolpus trilix.* Cotton, *Geol. Surv. S. Aust., Bull.*, 27, Append. 4: 245.
1954 *Turritella (Ctenocolpus) trilix.* Ludbrook, *Trans. R. Soc. S. Aust.*, 77: 59.
1957 *Ctenocolpus trilix.* Ludbrook, *Trans. R. Soc. S. Aust.*, 80: 18.

Description: PROTOCONCH paucispiral, asymmetric, of 1½ smooth globose whorls, nucleus prominent. TELEOCONCH 10 flat whorls, spire straight sided. SUTURES deeply incised. SCULPTURE (specimens from type locality) — one heavy broad cord at top and bottom of each whorl, both of which commence to bifurate after second whorl; the upper pair remain equal in strength, the lower two usually finish with the anterior cord decidedly heavier than the other; space between the two pairs is decidedly concave; one or two very fine striations appear irregularly; incremental striae difficult to detect. APERTURE sub-circular; columella arcuate, inner lip reflected at base; outer lip thin with typical sinus. BASE of shell convex with up to 12 irregular sized striae crossed by almost straight lines of growth.

Type locality: Abattoirs Bore, Adelaide, South Australia, 300-500 feet. Dry Creek Sands: Yatalan: Upper Pliocene.

Dimensions: Holotype, length 6.5 mm, breadth 2.5 mm, Tate Museum, Geology Dept., University of Adelaide, South Australia, Reg'd. No. T.1675.

Material: Four topotypes, National Museum of Victoria.

Discussion: The disposition of the cords on specimens examined from the type locality as described above, is somewhat at variance with the original description, which was rather loosely worded and not specific. Specimens examined from other localities also fit the above description well and the species is apparently a lot less variable than many others in the family. It does not appear to have any near relatives.

Subgenus *CTENOCOLPUS* Iredale, 1925

CTENOCOLPUS Iredale, 1925, *Rec. Aust. Mus.*, 14: 266. Type species by original designation *Turritella australis* Lamarck.

Subgeneric characteristics: Shells very small to medium. It is considered that *Ctenocolpus* can only be regarded as a further subgenus of *Colpospira;* the basal sinus compared with that of the subgenus *Platycolpus* is very similar but the labial sinus is prosocline to a small extent (fig. 4). Also the primary spiral C emerges first in this subgenus in lieu of B as in *Platycolpus,* and the spiral cords are frequently gemmate.

Colpospira (Ctenocolpus) australis (Lamarck, 1822)

Pl. 28, fig. 3.

1822 *Turritella australis* Lamarck, *Hist. Anim. s. Vert.*, 7: 59.
1873 *Turritella australis.* Kiener and Fischer, *Coq. Viv.*, 9: 36, pl. 4, fig. 3.
1876 *Turritella granulifera* Tenison-Woods, *Pap. Proc. R. Soc. Tas.*, (1875), p. 143.
1886 *Turritella australis.* Tryon, *Man. Conch.*, 8: 207, pl. 65, fig. 23.
1893 *Turritella terebellata* Tate, *Trans. R. Soc. S. Aust.*, 17: 336, (*non* Lamarck, 1804).
1900 *Turritella australis.* Randles, *Proc. Mal. Soc. Lond.*, 4: 58.
1925 *Turritella australis.* Iredale, *Rec. Aust. Mus.*, 14: 266.
1925 *Turritella australis diffidens* Iredale, *Rec. Aust. Mus.*, 14: 267, pl. 43, fig. 17.
1935 *Ctenocolpus terebellatus.* Cotton and Woods, *Rec. S. Aust. Mus.*, 5: 376 (*non* Lamarck, 1804).
1962 *Ctenocolpus australis.* Macpherson and Gabriel, *Mar. Moll. Vict.*, p. 97, text fig. 121.

Description: PROTOCONCH paucispiral, asymmetric, of 1½ globose whorls, nucleus a little submerged. TELEOCONCH 13 whorls, early whorls flatly globose, later becoming concave medially, spire straight sided. SUTURES deeply incised. SCULPTURE — a crenulated cord develops at base of fourth whorl, closely followed by a lesser crenulated cord at top; both gradually increase in strength, becoming bold, prominent and gemmate, and causing a decidedly concave space between;; lower cord remains predominant; specimens from type locality, southern Tasmania, develop a third smooth minor cord between lower main cord and suture, which is absent on those from Victoria and New South Wales, but not of subspecific significance. APERTURE sub-circular; columella arcuate with inner lip strongly reflected at base; outer lip thin, crenulated exteriorly by cords, and with typical sinus. BASE of shell convex with about seven flat indefinite concentric striations crossed by numerous growth lines. COLOUR yellowish-brown, darker pinkish-brown round sutures, brown band round centre of base, protoconch translucent white. OPERCULUM described by Iredale (1925: 266) as simple, concave exteriorly, horny and multispiral.

Type locality: Southern Tasmania.

Dimensions: Holotype, length 20.24 mm, breadth not stated. Information not available but understood to be held by Museum d'Histoire Naturelle, Geneva, Switzerland.

Distribution: Tasmania, South Australia, Victoria and New South Wales to central coast.

Material: Large quantity from six State Museums.

Fossil. Type locality of T. terebellata Tate: Limestone Creek, Glenelg River, Victoria. Werrikoo Member, Whalers Bluff Formation: Werrikooian: Upper Pliocene/Lower Pleistocene.

Discussion: Examination of many specimens from three States shows that incidence of nodules on the two keels varies considerably, even on different whorls in the same specimen, and many heavily noduled specimens can be found living with others almost devoid of them. The subspecies *C. australis diffidens* Iredale therefore cannot be regarded as valid. The fossil species *T. terebellata* Tate cannot be separated from Victorian and New South Wales specimens of the recent *C. (C.) australis* (Lamarck), and is therefore a further synonym.

Smaller specimens of the smooth form of this species could bear a superficial resemblance to *C. (C.) guillaumei* (Iredale), and also to some specimens of the fossil *C. (C.) pagodula* (Tate) but differences between the three are fairly well marked and consistent.

Colpospira (Ctenocolpus) curialis (Hedley, 1907)

Pl. 28, fig. 4-5.

1907 *Turritella curialis* Hedley, *Rec. Aust. Mus.*, 6: 357, pl. 67, fig. 19.

Description: PROTOCONCH asymmetric, of two round, dome-shaped whorls, nucleus a little submerged. TELEOCONCH of nine slightly con-

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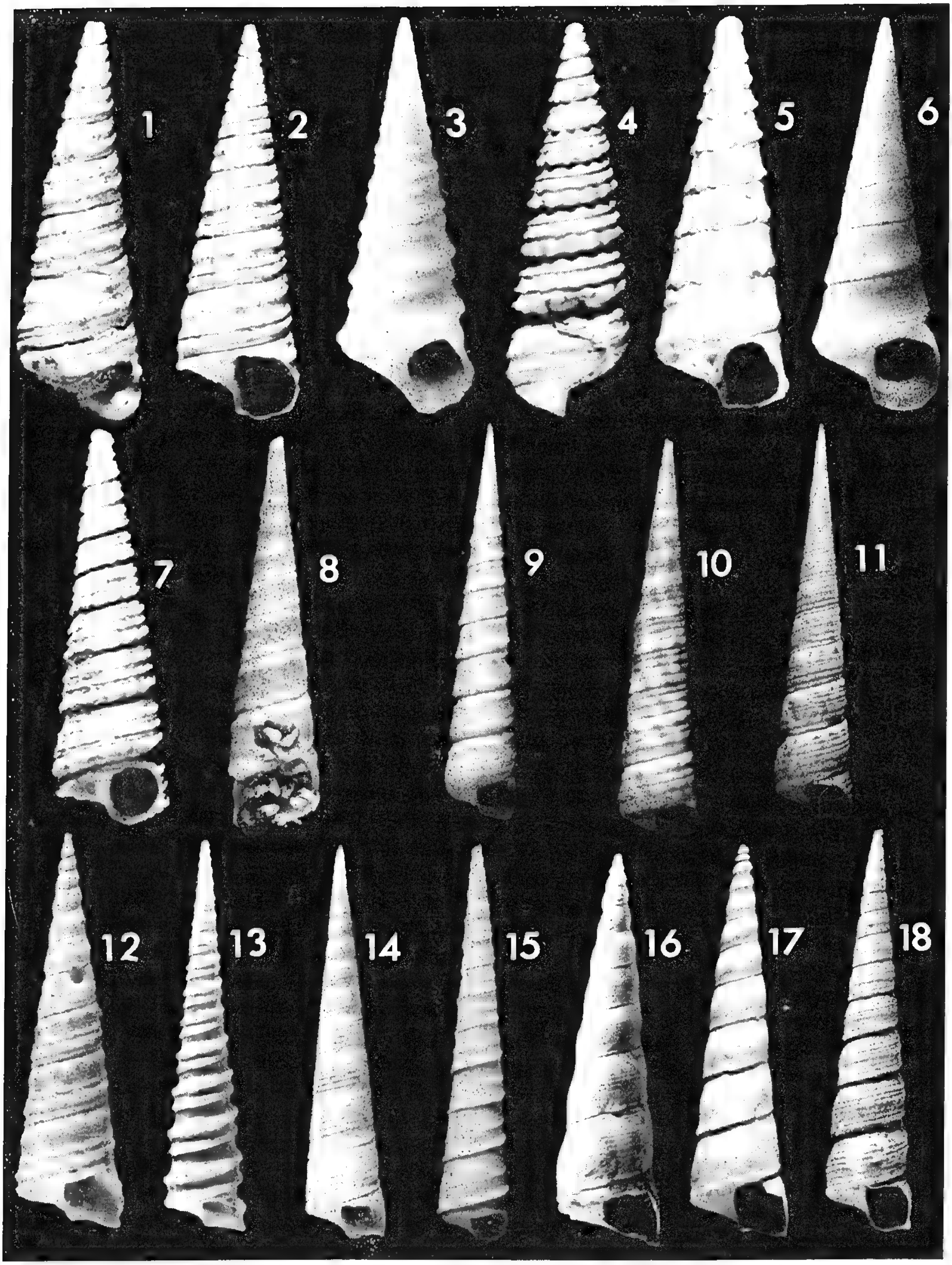
PLATE 28

1. *Colpospira (Platycolpus) multicincturalis* (Chapman and Crespin). Sorrento Bore (Nepean No. 1), Victoria, 741 feet. Paratype, X 8.4. N.M.V. No. P27002.
2. *Colpospira (Platycolpus) trilix* (Cotton and Woods). Abattoirs Bore, Adelaide. Topotype, X 7.3. N.M.V. No. P26992.
3. *Colpospira (Ctenocolpus) australis* (Lamarck). Off Merimbula, New South Wales, 45 metres. Figured specimen, X 3.7. A.M. No. C77384.
4. *Colpospira (Ctenocolpus) curialis* (Hedley). 35 miles east of Sydney, New South Wales, 1,464 metres. Paratype, X 10. A.M. No. C26623.
5. *Colpospira (Ctenocolpus) curialis* (Hedley). 23 miles east of Sydney, New South Wales, 457 metres. Figured specimen, X 12. A.M. No. C24434.
6. *Colpospira (Ctenocolpus) guillaumei* (Iredale). Off Sow and Pigs Reef, Port Jackson, New South Wales, 16 metres. Figured specimen, X 4. A.M. No. C77383.
7. *Colpospira (Ctenocolpus) gemmulata* (Tate). Clifton Bank, Muddy Creek, west of Hamilton, Victoria. Topotype, X 11. N.M.V. No. P26988.
8. *Gazameda gunnii* (Reeve). Twofold Bay, New South Wales, 18 metres. Figured specimen, X 1.7, broken open to show embryos *in situ*. A.M. No. C77372.
9. *Gazameda gunnii* (Reeve). Stanley, north-west Tasmania. Figured specimen, X 1.1. A.M. No. C69777.
10. *Gazameda gunnii* (Reeve). Off Southport, southern Queensland, 68 metres. Figured specimen, X 1.1. A.M. No. C77369.
11. *Gazameda gunnii* (Reeve). Off Twofold Bay, New South Wales, 18 metres. Figured specimen, X 1.1 A.M. No. C77371.
12. *Gazameda declivis* (Adams and Reeve). Half-mile south-west of Doc Can Island, Sulu Archipelago, P.I. Figured specimen, X 1.2. W.A.M. No. 173-69.
13. *Gazameda iredalei* (Finlay). Glenelg Beach, South Australia. Figured specimen, X 2.7. A.M. No. C77373.
14. *Gazameda tasmanica* (Reeve). Off Port Hacking, New South Wales, 82 metres. Figured specimen, X 1.9. A.M. No. C77370.
15. *Gazameda acricula* (Tate). Murray River cliffs, 4 miles south of Morgan, South Australia. Topotype, X 1.7. A.M. No. C77389.
16. *Gazameda victoriensis victoriensis* (Cotton and Woods). 2.1 miles north-west of Point Ronald, Victoria. Grid Ref. Princetown 027, 2915. Figured specimen, X 2.9. N.M.V. No. P26993.
17. *Gazameda victoriensis manyung* Garrard. Cliff-face south of Manyung Rocks, Mornington Peninslla, Victoria. Grid Ref. Cranbourne, 106, 903. Holotype, X 3.3. N.M.V. No. P27457.
18. *Gazameda adelaidensis* (Cotton and Woods). Abattoirs Bore, Adelaide, South Australia. Topotype, X 1.9. N.M.V. No. P26991.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cave whorls, spire straight sided. SUTURES lightly impressed and crenulate, due to proximity of gemmate keel above. SCULPTURE — a cord a little below centre on first whorl, becoming crenulate from second whorl (from sixth whorl on holotype); cord " moves " abapically until it adjoins lower suture; further gemmate cord develops immediately below upper suture on last three whorls; two narrow widely spaced smooth striae on last three whorls a little above lower cord on holotype, absent on some other specimens. APERTURE sub-quadrate; columella arcuate, inner lip strongly reflected on to body-whorl; outer lip thin with typical sinus. BASE of shell flatly convex, five broad flat lirae, barely discernible, crossed by numerous growth lines. COLOUR light cream. OPERCULUM unavailable.

Type locality: 35 miles east of Sydney, New South Wales, 800 fathoms (1,464 metres).

Dimensions: Holotype, length 7 mm, breadth 2.95 mm, Australian Museum, Sydney, Reg'd. No. C.26623.

Distribution: At present only recorded from 457 and 1,464 metres, east of Sydney, New South Wales.

Material: Holotype, 5 paratypes and 2 others, all Australian Museum.

Discussion: Two specimens from 457 metres east of Sydney, New South Wales, have no sign of the two spiral lirae in evidence on the holotype and paratypes, but are definitely the same species. Evidently an archibenthal species as extensive dredgings in shallower water near the same area have failed to produce further specimens. The species does not appear to have any close relatives.

Colpospira (Ctenocolpus) guillaumei (Iredale, 1924)

Pl. 28, fig. 6.

1924 *Colpospira guillaumei* Iredale, *Proc. Linn. Soc. N.S.W.*, 49: 248, pl. 36, fig. 4, 15.

Description: PROTOCONCH paucispiral, asymmetric, of 1½ round, dome-shaped whorls, nucleus a little submerged. TELEOCONCH 11 whorls, first four a little convex, next five or six flat, later whorls a little concave. SUTURES a little impressed within a shallow V-notch. SCULPTURE mainly of numerous incremental striae following line of outer lip; a cingulum develops at top and bottom of each whorl from about sixth onwards, increasing in strength, lower cingulum the stronger, imbricating over whorl below and producing a pagoda-like effect. APERTURE sub-quadrate; columella almost straight, inner lip reflected strongly on to body-whorl and at base; outer lip thin with typical sinus. BASE of shell convex, devoid of any discernible striae but crossed by strong growth lines. COLOUR pinkish-white suffused with light brown; brown and white spots alternately on both ridges. OPERCULUM circular, approx. 1.6 mm diameter, dark brown, horny, outer side a little convex with raised central nucleus having a depressed centre, about 12 raised concentric lamellae, thin and papery; underside smooth, concave and gelatinous in appearance.

Type locality: Twofold Bay, New South Wales, 15 fathoms (27 metres).

Dimensions: Holotype, length 15 mm, breadth 5 mm, Australian Museum, Sydney, Reg'd. No. C.71638.

Distribution: New South Wales, Victoria and Tasmania.

Material: Large quantity from four State Museums.

Discussion: This well marked small species can be readily distinguished from C. *(P.) quadrata* (Donald), which is rather similar in appearance, by its far shallower V-notch at the sutures, the lack of development of the posterior ridge compared with the well developed anterior ridge, whilst the centre of whorls is less concave than those of C. *(P.) quadrata.* This species has a strong general resemblance to the fossil C. *(C.) pagodula* (Tate), which is possibly ancestral. However the posterior cingulum in C. *(C.) pagodula,* if present at all, is far less pronounced, whilst the bifurcated lower cingulum does not imbricate over the lower whorl in the pronounced fashion of C. *(C.) guillaumei.*

FOSSIL SPECIES

Colpospira (Ctenocolpus) gemmulata (Tate, 1893)

Pl. 28, fig. 7.

1893 *Turritella gemmulata* Tate, *Trans. R. Soc. S. Aust.,* 17: 338, pl. 8, fig. 11.

Description: PROTOCONCH paucispiral, asymmetric, of 1½ round dome-shaped whorls, nucleus a little submerged. TELEOCONCH 9 whorls, flatly concave, spire straight sided. SUTURES fairly deeply impressed. SCULPTURE of beaded cords, firstly at base of whorl, followed by another at top and then in centre; two or three others follow at intervals making five or six on body-whorl, next but one to lower suture usually the most prominent. APERTURE sub-circular; columella arcuate, inner lip slightly reflected; outer lip with typical sinus. BASE of shell flatly convex, about five fine threads crossed by numerous growth lines.

Type locality: Muddy Creek, west of Hamilton, Victoria. Lower beds. Muddy Creek Formation: Balcombian: Middle Miocene.

Dimensions: Holotype, length 6.5 mm, breadth 1.75 mm, Tate Museum, Geology Dept., University of Adelaide, South Australia, Reg'd. No. T.1413 C, D.

Material: 4 topotypes National Museum of Victoria, Melbourne.

Discussion: This species bears a fairly strong resemblance to the unique specimen of the recent *Colpospira joannae* (Hedley), being almost identical in size and shape of whorls, but the strongly gemmate whorls of this species sets it apart from the crenulated ribbing of C. *joannae.*

Colpospira (Ctenocolpus) pagodula (Tate, 1893)

Pl. 30, fig. 4.

1893 *Turritella pagodula* Tate, *Trans. R. Soc. S. Aust.,* 17: 336, pl. 8, fig. 10.

1914 *Turritella pagodula.* Chapman and Gabriel, *Proc. R. Soc. Vict.,* 26: 323.

Description: PROTOCONCH paucispiral, asymmetric, of 1½ round, dome-shaped whorls, nucleus a little submerged. TELEOCONCH 14 whorls, medially concave, spire straight sided. SUTURES well impressed within a shallow V-notch. SCULPTURE — a heavy cingulum at base of each whorl which frequently bifurcates in the more mature whorls, and occasionally a narrower cingulum at top, area between decidedly concave;

several very faint transverse threads in concave area in some specimens, crossed by numerous sinuate incremental striae. APERTURE sub-circular; columella strongly arcuate, inner lip reflected on to body-whorl and at base; outer lip a little thickened with typical sinus. BASE of shell convex with about ten indeterminate concentric striae crossed by numerous growth lines.

Type locality: Gippsland Lakes, Victoria. Jemmys Point Formation: Kalimnan: Upper Miocene/Lower Pliocene.

Dimensions: Holotype, length 12.5 mm, breadth 4,25 mm, Tate Museum, Geology Dept., University of Adelaide, South Australia, Reg'd. No. T. 1421 D.

Material: 4 topotypes National Museum of Victoria, Melbourne.

Discussion: This species is quite possibly directly ancestral to the recent C. *(C.) guillaumei* (Iredale), and the more mature whorls are almost identical. However the earlier whorls of C. *(C.) guillaumei* are flatly convex, the concave appearance not commencing until about the sixth whorl, and it is also devoid of basal striations; other differences are very minor.

Genus *GAZAMEDA* Iredale, 1924

GAZAMEDA Iredale, 1924, *Proc. Linn. Soc. N.S.W.*, 49: 247. Type species by original designation *Turritella gunnii* Reeve.

Generic characteristics: Medium to large. Recent species mainly maculated or spotted with brown. Whorls flatly convex to concave, spire usually straight sided. Aperture sub-quadrate. Base flat to a little concave. Protoconch paucispiral, asymmetric, 1½ to 2 convex whorls, expanding rapidly in size, nucleus raised and prominent (excepting *G. declivis* Adams and Reeve). Labial sinus proscocline, broad and moderately deep (Fig. 5). B is first primary spiral to emerge weakly, followed by a number of faint secondaries. Later spiral cords medium to strong.

Gazameda gunnii (Reeve, 1849)

Pl. 28, fig. 8-11.

1849 *Turritella gunnii* Reeve, *Conch. Icon.*, 5, pl. 9, fig. 45.
1881 *Turritella philippensis* Watson, *Jour. Linn. Soc. Lond.*, Zool., 15: 223.
1886 *Turritella philippensis.* Watson, *Rep. Sci. Res. Challenger*, Zool., 25: 479, pl. 30, fig. 6.
1886 *Turritella gunnii.* Tryon, *Man. Conch.*, 8: 203, pl. 63, fig. 86.
1924 *Gazameda gunnii.* Iredale, *Proc. Linn. Soc. N.S.W.*, 49: 247.
1950 *Gazameda gunnii.* Allan, *Aust. Shells*, p. 92, text fig. 3.
1957 *Gazameda gunnii.* Marwick, *Proc. Mal. Soc. Lond.*, 32: 154, fig. 52.
1962 *Gazameda gunnii.* Macpherson and Gabriel, *Mar. Moll. Vict.*, p. 98, text fig. 123.

Description: PROTOCONCH asymmetric, of two whorls, flatly convex, expanding rapidly in diameter, nucleus erect and prominent. TELEOCONCH 18 whorls, flat, frequently contracted a little posteriorly, spire straight sided. SUTURES deeply incised. SCULPTURE very variable, a weak cingulum at base of whorls becoming heavier with maturity, from three to six striations above it, varying considerably in importance, often accompanied by several microscopic threads. APERTURE sub-quadrate; columella arcuate, inner lip a little reflected at base; outer lip thin with typical sinus. BASE of shell flat with a few rather vague concentric striae, crossed by very fine densely packed growth lines.

COLOUR, apex translucent white, main whorls off-white with brown or purple-brown bands round centre of whorls, brown wavy flames, pale fawn on base. OPERCULUM circular, light horn colour, central nucleus and concentric growth ridges.

Type locality: Tasmania.

Dimensions: Holotype — Reeve's figured painting — length 56 mm, breadth 12.5 mm, British Museum (Natural History), Reg'd. No. 1969272.

Distribution: Tasmania, Victoria, New South Wales and southern Queensland, in depth from about 8 metres to at least 140 metres.

Material: Large quantities from six State Museums.

Discussion: A very variable species so far as sculpture of main whorls is concerned. Transverse cords vary from four to six, usually fairly strong, whilst many from Tasmania tend to be very faint, giving quite a smooth appearance. In some, especially from deeper water, the anterior cingulum is so strongly developed that it imbricates well over the succeeding whorl. Those from northern New South Wales and southern Queensland usually have four cords only, all equal and strongly developed and also brighter in colour than more southerly specimens. A series from off Merimbula, New South Wales, shows the anterior cingulum strongly developed and quite nodulose, whilst those from Disaster Bay, a little further south, are decidedly broader for their length.

Gazameda declivis (A. Adams and Reeve, 1848)

Pl. 28, fig. 12; Pl. 30, fig. 5.

1848 *Turritella declivis* A. Adams and Reeve, *Voy. Samarang, Zool.*, p. 48, pl. 12, fig. 10.
1849 *Turritella declivis.* Reeve, *Conch. Icon.*, 5, pl. 10, fig. 52.
1886 *Turritella declivis.* Tryon, *Man. Conch.*, 8: 200, pl. 62, fig. 70.
1907 *Turritella captiva* Hedley, *Proc. Linn. Soc. N.S.W.*, 32: 500, pl. 17, fig. 26.

Description: PROTOCONCH asymmetric, two convex whorls, expanding rapidly in diameter, nucleus varying from depressed to rather erect and prominent. TELEOCONCH 18 whorls, convex to commence, later flattening, becoming a little concave medially with maturity, spire straight sided. SUTURES lightly impressed. SCULPTURE — first six or seven whorls strongly centrally corded, becoming flattened with age; from about thirteenth whorl onwards a heavy cingulum develops at top of each whorl, followed by a concave space with two lirae, the lower decidedly stronger; this is followed by two heavy cords at base of each whorl with a fine thread between; all more mature whorls are crossed by densely packed fine sinuate lines of growth, following line of outer lip. APERTURE subquadrate; columella arcuate, inner lip reflected at base; outer lip thin with typical sinus. BASE of shell concave, ten or twelve fine lirae crossed by fine growth lines. COLOUR off-white with small red-brown spots immediately below the suture, often commencing as early as third whorl, becoming increasingly larger on succeeding whorls, irregular in outline and extending vertically down the whorls. OPERCULUM from a 40 mm specimen is circular, 3.3 mm diameter, light brown, very thin and translucent, slightly depressed central nucleus, numerous fine concentric lamellate growth lines.

Type locality: China sea.

Dimensions: Painting of holotype, length 70 mm, breadth 18 mm, British Museum (Natural History) Reg'd. No. 1874.12.11.165.

Distribution: Recorded from Gillett Cay, off Masthead Island, North-west Island and north of Cape Moreton in southern Queensland. One specimen off Rottnest Island, one immature specimen off Cape Leeuwin, both Western Australia. Five immature specimens east of King Island, Bass Strait. This species was recorded from Bass Strait by Schmeltz (1874, *Mus. Godeff. Cat.*, 5, p. 197) but was succeeded by the name *T. subsquamosa* in italics, and may have been mis-identified. This cannot now be verified owing to the destruction of the Godeffroy collection in the Hamburg Museum in 1943.

Material: Holotype, several paratypes and a number of more mature specimens from Queensland (Hedley's *T. captiva*), all Australian Museum. Six specimens Bass Strait and Western Australia, Australian Museum. One specimen Western Australia, in Western Australian Museum.

Discussion: The order in which the upper and lower cords on this species come into prominence is somewhat variable, especially in Queensland specimens (*T. captiva* Hedley). The primary spire whorls, also labial and basal sinuses from all localities where found so far in Australian waters, agree well with the type for the genus, *G. gunnii* Reeve. However the protoconch shows remarkable differences, that on all Queensland specimens examined, although expanding rapidly in the usual manner for the genus, has the nucleus almost totally submerged. The two specimens from off Rottnest Island and Cape Leeuwin in Western Australia unfortunately have the protoconch missing, but the five immature specimens from off King Island, Bass Strait, show remarkable differences for shells from the same locality. A typical protoconch for Queensland specimens is shown at Fig. 15 in the Introduction, whilst three of the Bass Strait specimens are shown at Fig. 16-18. This is the only species in all those included in this paper where the protoconch has failed as one of the guides to generic determination. The Queensland specimens grow to a far larger size than any noted by Hedley, the largest examined so far from North-east of Cape Moreton would have measured approx. 60 mm in length with 19 whorls if complete.

Gazameda iredalei Finlay, 1927

Pl. 28, fig. 13.

1873 *Turritella clathrata* Kiener and Fischer, *Coq. Viv.*, 139-40: 38, pl. 14, fig. 4.
1886 *Turritella clathrata.* Tryon, *Man. Conch.*, 8: 206, pl. 64, figs. 2, 16.
1927 *Gazameda iredalei* Finlav. *Trans. New Zeal. Inst.*, 57: 496 (New name for *T. clathrata* Kiener, 1873, *non* Deshayes, 1833).
1931 *Stiracolpus iredalei.* Cotton and Godfrey, *S. Aust. Naturalist*, 12: 59, pl. 2, fig. 4.
1950 *Gazameda iredalei.* Allan, *Aust. Shells*, p. 92, text fig. 1.
1962 *Gazameda iredalei.* Macpherson and Gabriel, *Mar. Moll. Vict.*, p. 98, text fig. 124.

Description: PROTOCONCH asymmetric, of two flatly convex whorls, expanding rapidly in diameter, nucleus erect and prominent. TELEOCONCH 18 whorls, each with two concave sections, spire slightly concave. SUTURES lightly impressed in early whorls, overshadowed by lower keel in later whorls and difficult to detect. SCULPTURE of one strong keel from first whorl onwards, developing into a prominent central keel, followed by a second prominent keel from about fifth whorl, situated at base of whorls and overshadowing the lower suture; five to seven fine transverse striations develop in later whorls both above and below central keel, crossed by very fine densely packed growth lines, causing a roughened and slightly punctate appearance. APERTURE sub-quadrate; columella arcuate, inner lip strongly reflected on to body-whorl at maturity; outer lip thin with typical sinus. BASE of shell flat, devoid of striae and crossed by extremely fine sinuous growth lines. COLOUR of primary whorls off-white, other whorls purple-brown between the keels, which remain whitish with brown spots. OPERCULUM simple, circular, dark brown, central slightly raised nucleus and concentric growth rings.

Type locality: South Australia.

Dimensions: Kiener's holotype, length 48 mm, believed to be held by Museum d'Histoire Naturelle, Paris, Reg'd. No. not available.

Distribution: South coast of Western Australia, South Australia, Victoria and Tasmania.

Material: Large quantity from four State Museums.

Discussion: The species appears to live in fairly shallow to medium depths, being washed up on beaches in fair quantity but difficult to obtain alive. The shell has the appearance of a sharply tapered wood-screw, and its two bold sharp ridges on each whorl separate it without difficulty from any other species, either recent or fossil.

Gazameda tasmanica (Reeve, 1849)

Pl. 28, fig. 14.

1849 *Turritella tasmanica* Reeve, *Conch. Icon.*, 5, pl. 9, fig. 42.
1871 *Turritella subsquamosa* Dunker, *Mal. Blätt.*, 18: 152.
1876 *Turritella acuta* Tenison-Woods, *Pap. Proc. R. Soc. Tas.*, (1875), p. 143.
1881 *Turritella lamellosa* Watson, *Jour. Linn. Soc. Lond.*, Zool., 15: 229.
1886 *Turritella lamellosa.* Watson, *Rep. Sci. Res. Challenger*, Zool., 25: 474, pl. 29, fig. 6.
1886 *Turritella tasmanica.* Tryon, *Man. Conch.*, 8: 203, pl. 63, fig. 87.
1897 *Turritella oxyacris* Tate, *Trans. R. Soc. S. Aust.*, 21: 41 (new name for *T. acuta* Tenison-Woods, 1876, *non* Mayer, 1859).
1924 *Turritella subsquamosa.* Iredale, *Proc. Linn. Soc. N.S.W.*, 49: 250.
1931 *Gazameda tasmanica.* Cotton and Godfrey, *S. Aust., Naturalist*, 12: 57.
1962 *Gazameda subsquamosa.* Macpherson and Gabriel, *Mar. Moll. Vict.*, p. 98, text fig. 125.

Description: PROTOCONCH asymmetric, of two whorls, flatly convex, expanding rapidly in diameter, nucleus rather erect and prominent. TELEOCONCH 15 whorls, first six or seven a little convex, remainder flat; sides of spire straight. SUTURES moderately impressed. SCULPTURE — primary whorls centrally corded, becoming flattened and joined by numerous striations of varying importance with finer threads between, and with cingula developing at top and bottom of each whorl from about the sixth onwards; lower cingulum the stronger and frequently imbricates over lower suture. APERTURE sub-quadrate; columella arcuate, inner lip strongly reflected on to body-whorl and a little at base; outer lip thin with typical sinus. BASE of shell flat with numerous fine concentric striations crossed by densely packed fine growth lines. COLOUR of protoconch and first three or four primary whorls translucent white, usually a wide purple-brown band round centre of all other whorls, brown spots on cingula and brown wavy axial flames crossing the colour band; some specimens very pale with brown spots only. OPERCULUM is similar in all respects to that of *G. gunnii* (Reeve).

Type Locality: Tasmania.

Dimensions: Holotype — Reeve's figure — length 42 mm, breadth 9.5 mm, British Museum (Natural History), Reg'd. No. 1969269.

Distribution: South-western Western Australia to South Australia, Tasmania, Victoria, New South Wales and southern Queensland, in depths from about 8 metres to 90 metres.

Material: Large quantity from six State Museums.

Discussion: It is unfortunate that Reeve chose to name this species from one old worn and colourless specimen, which led to the subsequent naming of several synonyms by other workers. In his description the words " ridged at the lower edge, encircled with two ridges with intermediate striae above " are somewhat misleading, as the two main ridges or cingula occur at top and bottom of each whorl with the intermediate striations between. Worn, immature or broken specimens are frequently difficult to separate from *G. gunnii* Reeve, but a good mature specimen is fairly easily separated by the flatter appearance of the whorls, the more numerous and regular striations, and chiefly by the finely punctate appearance of the whorls due to crossing of the striations by numerous and densely packed growth lines.

FOSSIL SPECIES

Gazameda acricula (Tate, 1893)

Pl. 28, fig. 15.

1893 *Turritella acricula* Tate, *Trans. R. Soc. S. Aust.*, 17: 339.
1935 *Turritella (Gazameda) acricula.* Cotton and Woods, *Rec. S. Aust. Mus.*, 3: 373.

Description: PROTOCONCH paucispiral, asymmetric, of 1½ smooth globose whorls, nucleus erect and prominent. TELEOCONCH 18 whorls, first four convexly ridged medially, balance a little concave; spire straight sided. SUTURES strongly incised. SCULPTURE — a strong median keel on all whorls, a heavy cingulum at base, sometimes a finer cingulum at top, with several striations developing above and below the central keel after about sixth whorl; lower cingulum expands and imbricates over whorl below from about tenth onwards. APERTURE sub-quadrate; columella straight, inner lip slightly reflected at base; outer lip thin with typical sinus. BASE of shell flat with numerous concentric striae of varying strength crossed by fine growth lines.

Type locality: River Murray cliffs, South Australia. (Actual locality has been determined as four miles downstream from Morgan, South Australia, on left bank of River Murray). Cadell Marl Lens of Morgan Limestone: Batesfordian: Lower Miocene.

Dimensions: Holotype, length 38 mm, breadth 6.25 mm, Tate Museum, Geology Dept., University of Adelaide, South Australia, Reg'd. No. T.1410 C.

Material: Six topotypes National Museum of Victoria, Melbourne. Numerous topotypes Australian Museum, Sydney.

Discussion: The placing of this species in the genus *Gazameda* is to a certain extent a matter of expediency, but it is the closest available.

The recognition points agree reasonably well with the main exception of the protoconch. This shows a slight divergence in some specimens from the common somewhat turbinate protoconch with a large globose nucleus, towards the unusual slightly scaphelloid protoconch of the recent *G. gunnii* (Reeve), and may well represent the early beginnings of the *Gazameda* protoconch as we know it to-day. This earlier form of protoconch however, is decidedly narrower at the base than that of the recent species. The protoconchs of some recent species tend to show intraspecific differences in specimens taken from the same locality (see Figures 16-18 at end of Introduction — *Gazameda declivis* (Adams and Reeve)).

Gazameda victoriensis victoriensis (Cotton and Woods, 1935)

Pl. 28, fig. 16.

1893 *Turritella acricula* var. Tate, *Trans. R. Soc. S. Aust.*, 17: 340, pl. 9, figs. 4, 4a.

1935 *Turritella (Gazameda) acricula victoriensis*. Cotton and Woods, *Rec. S. Aust. Mus.*, 5: 374, 376. Not figured.

Description: PROTOCONCH paucispiral, asymmetric, of 1½ smooth globose whorls, expanding rapidly, nucleus erect and prominent. TELEOCONCH 11 whorls, first three medially angulate, balance a little convex, spire slightly convex. SUTURES deeply impressed first four whorls, then a little canaliculate. SCULPTURE — a basal cingulum forms from fourth or fifth whorl, together with numerous striations, increasing in number on mature whorls; cingulum tends to imbricate over lower whorls from about seventh onwards; numerous incremental striae visible on mature whorls. APERTURE sub-quadrate; columella fairly straight, inner lip reflected at base; outer lip thin with typical sinus. BASE of shell flat, bordered by a strong peripheral ridge with fairly deep groove adjoining, then several indefinite concentric striae crossed by irregular growth lines.

Type locality: Gellibrand River, Victoria. (Cliffs 2-3 miles north-west of mouth of Gellibrand River). Gellibrand Marl: Balcombian: Middle Miocene. (Specimens from type locality at National Museum of Victoria are of Balcombian age, and it appears unlikely that this species ranges into the Bairnsdalian on the Gellibrand Coast — T. A. Darragh, pers. comm.)

Dimensions: Holotype, length 25 mm, breadth 5.5 mm, Tate Museum, Geology Dept., University of Adelaide, South Australia, Reg'd. No. T.1411 E.

Material: 5 topotypes National Museum of Victoria, Melbourne.

Discussion: Similar remarks apply in the case of this species to those under *G. acricula* (Tate), especially with regard to the protoconch, also the general formation of the neanic and mature whorls sets it quite apart from *G. acricula* and it is accorded full specific rank.

Gazameda victoriensis manyung subsp. nov.

Pl. 28, fig. 17.

Description: PROTOCONCH paucispiral, asymmetric, 1½ smooth globose whorls, expanding rapidly, nucleus erect. TELEOCONCH 12 whorls, first three convex and strongly sub-centrally unicarinate; balance less convex, smooth and imbricating at base over whorl below; spire straight sided. SUTURES strongly incised first five or six whorls, later becoming strongly canaliculate. SCULPTURE — after subsidence of sub-central carination on about fourth whorl, microscopic finely punctate lines gradually appear, increasing to about 18 on last whorl, intervening spaces flat and smooth; a basal cingulum develops on all whorls after about fourth whorl, becoming more pronounced and imbricating strongly over whorl below; growth striations fairly numerous and prominent under magnification on all mature whorls. APERTURE sub-quadrate; columella arcuate, inner lip strongly reflected at base; outer lip thin with broad and deep medial sinus, typical of the genus. BASE of shell a little concave with up to ten microscopic finely punctate concentric lines, crossed by numerous growth striae.

Type locality: Cliff-face south of Manyung Rocks, Mornington Peninsula, Victoria; Bed 10B a of Gostin, 1966, Grid. Ref. Cranbourne 106903. Upper Balcombe Clay: Bairnsdalian: Middle Miocene.

Dimensions: Holotype, length 19.2 mm, breadth 4.9 mm, National Museum of Victoria, Reg'd. No. P.27457. Largest paratype, length 23.8 mm, breadth 5.9 mm.

Material: Holotype as above, 30 paratypes Australian Museum, Sydney.

Discussion: This subspecies differs from the nominal subspecies *G. v. victoriensis* chiefly by the perfectly flat interspaces between the finely punctate lines on all whorls, as compared with the flatly rounded striations between the punctate lines on *G. v. victoriensis*. In addition the canaliculate sutures on this subspecies commence earlier and are far more pronounced.

Gazameda adelaidensis (Cotton and Woods, 1935).

Pl. 28, fig. 18.

1935 *Turritella (Gazameda) acricula adelaidensis* Cotton and Woods, *Rec. S. Aust. Mus.*, 5: 374, 376, text fig. 2, p. 371.

1952 *Gazameda adelaidensis*. Cotton, *Geol. Surv. S. Aust.*, Bull. 27, Append. 4: 245.

1954 *Turritella (Haustator) acricula adelaidensis*. Ludbrook, *Trans. R. Soc. S. Aust.*, 77: 59.

1957 *Turritella (Gazameda) acricula adelaidensis*. Ludbrook, *Trans. R. Soc. S. Aust.*, 80: 17.

Description: PROTOCONCH asymmetric, of two flatly convex whorls, expanding rapidly in diameter, nucleus erect and prominent. TELEOCONCH 15 whorls, first four strongly medially ridged, balance flatly convex, spire slightly convex. SUTURES strongly impressed for first seven whorls, then progressively more excavate, imbricating over lower whorls. SCULPTURE consists of strong medial cord for first four whorls, the cord then becoming a strong keel and persisting to body-whorl; a basal cingulum develops about fourth whorl, accentuating the degree of imbrication over lower whorls; three or four strong striations commence about fourth whorl both above and below central keel, increasing to as many as twelve, crossed by dense and prominent sinuous growth lines, giving a latticed appearance to shell. APERTURE sub-quadrate; columella straight, inner lip slightly reflected at base; outer lip thin with typical sinus. BASE of shell flat with heavy peripheral ridge, a deep groove adjoining, several fine concentric striae crossed by dense growth lines, giving a latticed appearance similar to whorls.

Type locality: Abattoirs Bore, Adelaide, South Australia, 300-500 feet. Dry Creek Sands: Yatalan: Upper Pliocene.

Dimensions: Holotype, length 37 mm, breadth 7 mm, Tate Museum, Geology Dept., University of Adelaide, South Australia, Reg'd. No. T. 1681.

Material: 4 topotypes National Museum of Victoria, Melbourne.

Discussion: The protoconch of this species approaches more closely the typical *Gazameda* protoconch of the type species, the recent *G. gunnii* Reeve, than does that of *G. acricula* Tate, and even though it exhibits the strong central keel of *G. acricula,* owing to the differences in protoconch and sculpture, it cannot be regarded as a subspecies and is therefore accorded full specific rank.

Gazameda subacricula (Cotton and Woods, 1935)

Pl. 29, fig. 1.

1935 *Turritella (Gazameda) subacricula* Cotton and Woods, *Rec. S. Aust. Mus.*, 5: 376, text fig. 3, p. 371.
1952 *Gazameda subacricula.* Cotton, *Geol. Surv. S. Aust.*, Bull. 27, append. 4: 245.
1954 *Turritella (Haustator) subacricula.* Ludbrook, *Trans. R. Soc. S. Aust.*, 77: 59.
1957 *Turritella (Gazameda) subacricula.* Ludbrook, *Trans. R. Soc. S. Aust.*, 80: 18.

Description: PROTOCONCH paucispiral, asymmetric, 1½ smooth globose whorls, nucleus erect and prominent. TELEOCONCH 14 whorls, first two convexly centrally keeled, remainder flatly convex, spire straight sided. SUTURES finely but strongly incised. SCULPTURE — median keel on first two whorls which continues in subdued form throughout; a bifurcated basal cingulum commences on third whorl; two further keels above central keel commence on fourth whorl, often with a finer striation between them from about tenth whorl onwards; densely packed growth striae become progressively stronger, giving a pitted appearance generally. APERTURE sub-quadrate; columella straight, inner lip reflected at base; outer lip thin with typical sinus. BASE of shell flatly concave, heavy peripheral ridge, about 8 concentric lirae crossed by coarse densely packed growth lines.

Type locality: Abattoirs Bore, Adelaide, South Australia, 300-500 feet. Dry Creek Sands: Yatalan: Upper Pliocene.

Dimensions: Holotype, length 40.5 mm, breadth 7.8 mm, Tate Museum, Geology Dept., University of Adelaide, South Australia, Reg'd. No. T.1686.

Material: 4 topotypes National Museum of Victoria, Melbourne.

Discussion: This species is the same age and from the same type locality as *G. adelaidensis*, but the fairly substantial differences in the two warrant separation. The whorls of this species are flatter than those of *G. adelaidensis,* they do not show the same strong imbricating tendency in the lower part of the whorls, and the spiral striations are decidedly coarser. No intermediate specimens have been found in any of the material examined and it is considered that the two species are distinct.

Genus *HAUSTATOR* Montfort, 1810

HAUSTATOR Montfort, 1810, *Conchyl. Syst.*, 2: 183. Type species by subsequent designation *Turritella imbricataria* Lamarck. (Guillaume, 1925, *Bull. Soc. Geol. France,* (4), 24: 290).

Subgenus *KUROSIOIA* Ida, 1952

KUROSIOIA Ida, 1952, *Geol. Surv. Japan,* Rep. 150: 43. Type species by original designation *Turritella kurosio* Ida.

Subgeneric characteristics: Small to medium, thin, light in weight. Whorls flatly convex, spire straight sided. Aperture sub-circular. Base flatly convex. Protoconch of three minute flatly globose whorls, nucleus unavailable. Labial sinus a little prosocline, fairly deep and moderately broad (Fig.6). Primary spirals emerge in order C, B, A. Spiral cords rather weak, some nodulose.

Haustator (Kurosioia) cingulifer (Sowerby, 1825)

Pl. 29, fig. 2-3.

1825 *Turritella cingulifera* Sowerby, *Cat. Tankerville*, Append., p. 14, no. 1442.

1830 *Turritella fascialis* Menke, *Synop. Meth. Moll.*, p. 83, ed. 2, (1828), p. 45, no. 138.

1832 *Turritella tricarinata* King, *Zool. Journ.*, 5: 346, no. 55.

1843 *Turritella tricarinata*. Deshayes, *Hist. Anim. s. Vert.*, 9: 262, sp. 20.

1848 *Turritella bicolor* A. Adams and Reeve, *Voy. Samarang*, Zool., p. 47, pl. 12, fig. 1.

1849 *Turritella fascialis*. Reeve, *Conch. Icon.*, 5, pl. 10, fig. 47; *ibid. T. cingulifera* Sowerby, pl. 11, fig. 64.

1853 *Turritella fusco-tincta* Pettit, *J. Conch. Paris*, 4: 368, pl. 11, fig. 3.

1861 *Turritella gracillima* Gould, *Proc. Boston Soc. Nat. Hist.*, 7: 386.

1862 *Turritella gracillima*. Gould, *Otia Conch.*, p. 140.

1873 *Turritella fragilis* Kiener, *Coq. Viv.*, 9: 34, pl. 8, fig. 3.

1875 *Turritella fascialis*. E. A. Smith, *Japan Gasteropoda*, p. 19, no. 69.

1877 *Torcula parva* Angas, *Proc. Zool. Soc. Lond.*, p. 174, pl. 26, fig. 17.

1878 *Turritella cingulifera*. Brazier, *Proc. Linn. Soc. N.S.W.*, 12: 1, no. 1.

1886 *Turritella fascialis*. Watson, *Rep. Sci. Res. Challenger*, Zool., 25: 468.

1886 *Turritella cingulifera*. Tryon, *Man. Conch.*, 8: 193, pl. 59, figs. 38-41; *ibid.*, *T. fascialis*, p. 197, pl. 59, figs. 36-37.

1897 *Turritella fascialis*. Kobelt, *Conch. Cab.*, Bd. 1, Abt. 27, sp. 12 - 13; Taf. 4, Abt. 5.

1938 *Turritella fascialis*. Otuka, *Jap. Journ. Mal.* 8: 38, text fig. 5.

1941 *Turritella fascialis*. Merriam, *Univ. Cal. Bull.*, Geol. Sc. 26: 16.

1952 *Kurosioia fascialis*. Ida, *Geol. Surv. Japan, Rep.*, 150: 45, pl. 1, fig. 11; *ibid.*, *K. fascialis gracillima*. Pp. 46 - 47, pl. 1, fig. 10.

1959 *Kurosioia fascialis*. Kotaka, *Sci. Rep. Tohoku Univ.*, (2), 31: 86.

Description: PROTOCONCH mamillate, of three minute flatly globose whorls, 0.2 mm diameter, nucleus unavailable. TELEOCONCH 18 whorls, flatly convex, sides of spire straight. SUTURES moderately impressed. SCULPTURE — a primary spiral cord appears towards base of first whorl, closely followed by another centrally, then another towards top of whorls; as early as sixth whorl other fine spirals may appear, some increasing in importance, some crenulated and some smooth, and body-whorl may carry as many as 18. APERTURE almost circular, a little higher than wide, columella straight and very thin, inner lip not reflected; outer lip thin and fragile, with typical sinus. BASE of shell a little convex, with numerous uneven fine spirals crossed by very fine lines of growth. COLOUR off-white or cream to light brown; a deep chestnut band above, below or on both sides of sutures; base often has sinuate chestnut bands. OPERCULUM circular, light brown, central nucleus, surface dull and somewhat rough, about seven concentric lamellations, thickening towards centre, soft and gelatinous in appearance.

Type locality: East Indies. (Indonesia).

Dimensions: Specimens may measure up to 25 mm in length and 5 mm in breadth; average specimen at maturity 21 mm in length, 4.5 mm in breadth. I have been unable to trace the whereabouts of the holotype from the Tankerville collection.

Distribution: In Australia across the whole of the northern coastline, southwards along west coast at least as far as Onslow, southwards along east coast at least as far as Port Jackson, New South Wales.

Material: Large quantity from six State Museums.

Discussion: Both the species *H. (K.) cingulifer* (Sowerby) and *H. (K.) fascialis* (Menke) were shown by Hedley (1909: 357-8) as living in Queensland, also Kuroda and Habe (1952: 95-6) show both species living in Japan, possibly through traditional usage, as no serious attempt appears to have been made to decide whether in fact two distinct species exist. The type locality of *H. (K.) fascialis* is unknown, the type specimen unknown, and as far as can be seen no good basis exists for retention of the name. Reeve, on the authority of Cuming, gave a Central American locality as the type locality, which has proved to be erroneous. The original descriptions were rather similar, no important details were given, and in view of present knowledge the descriptions were totally inadequate. When the variability in length, width, sculpture and height of whorls is taken into account, the impressive synonymy is understandable. The species is washed up on Queensland beaches in huge drifts, one of which I estimated to contain 1,200 cubic feet of shells, and a very wide range of form, colour and sculpture is exhibited. The minute three-whorled protoconch calcifies and disintegrates in stages as it is vacated by the mollusc, exposing an internal septum. This can quite easily be mistaken for the protoconch nucleus if the fractured edges become worn and it is not viewed under sufficiently high power. This has possibly misled some workers in the past into believing that several styles of protoconch are involved, indicating more than one species when coupled with the great variation in sculpture.

I have shown both *H. (K.) fascialis* and *H. (K.) gracillima* as synonyms of *H. (K.) cingulifer*, although Ida (1952: 46) gives reasons for considering *H. (K.) gracillima* a good subspecies of *H. (K.) fascialis* (= *cingulifer*). However examination of a number of specimens from various parts of Japan, Philippine Islands and Papua-New Guinea shows them all to fall within the range of variation exhibited by the one species from such a large area of the Australian coastline.

Haustator (Kurosioia) leeuwinensis sp. nov.

Pl. 29, fig. 6.

Description: PROTOCONCH — last 2½ whorls of protoconch remaining on 3 specimens are microscopic and flatly globose, nucleus unknown. TELEOCONCH eleven whorls, possibly immature, all roundly convex; spire straight sided. SUTURES faintly impressed. SCULPTURE of one strong cord on first whorl, immediately below centre, gradually fading until only a faint striation about fourth whorl, accompanied by a further four above and four below; main whorls otherwise smooth except for faint growth striae conforming to outer lip. APERTURE sub-quadrate; columella slightly arcuate, inner lip a little reflected at base; outer lip thin with typical medial sinus. BASE of shell flat with faint growth lines only. COLOUR of top half of each whorl a faint yellow, lower half chestnut, commencing gradually and becoming darker with each succeeding whorl; the two bands of colour are divided by a fine brown line in centre of each whorl; a fine hair-line of brown just visible on top of each fine striation in lower colour band. OPERCULUM unknown.

Type locality: West of Jurien Bay, Western Australia, 142 metres.

Dimensions: Holotype, length 9 mm, breadth 2.7 mm, Australian Museum, Sydney, Reg'd. No. C.72592. Six paratypes from type locality.

Distribution: Localities recorded other than type locality are: 156 metres west of Bunbury, W.A. (3 specimens); 77-144 metres south of Cape Leeuwin, W.A. (1 specimen), both lots Australian Museum, Sydney; 128-132 metres west of Dongara, W.A. (2 specimens), 109 metres west of Rottnest Is. (11 specimens), Western Australian Museum.

Material: 24 specimens as above.

Discussion: Although 11 specimens of this new species are held by the Australian Museum, Sydney, from dredgings taken by H.M.A.S. "Gascoigne" in 1962, and 13 by the Western Australian Museum, none are mature. The holotype has nine main whorls and one paratype 11 whorls, and it could grow to a decidedly larger shell; it is quite distinct from any other Australian species.

Genus *MAORICOLPUS* Finlay, 1927

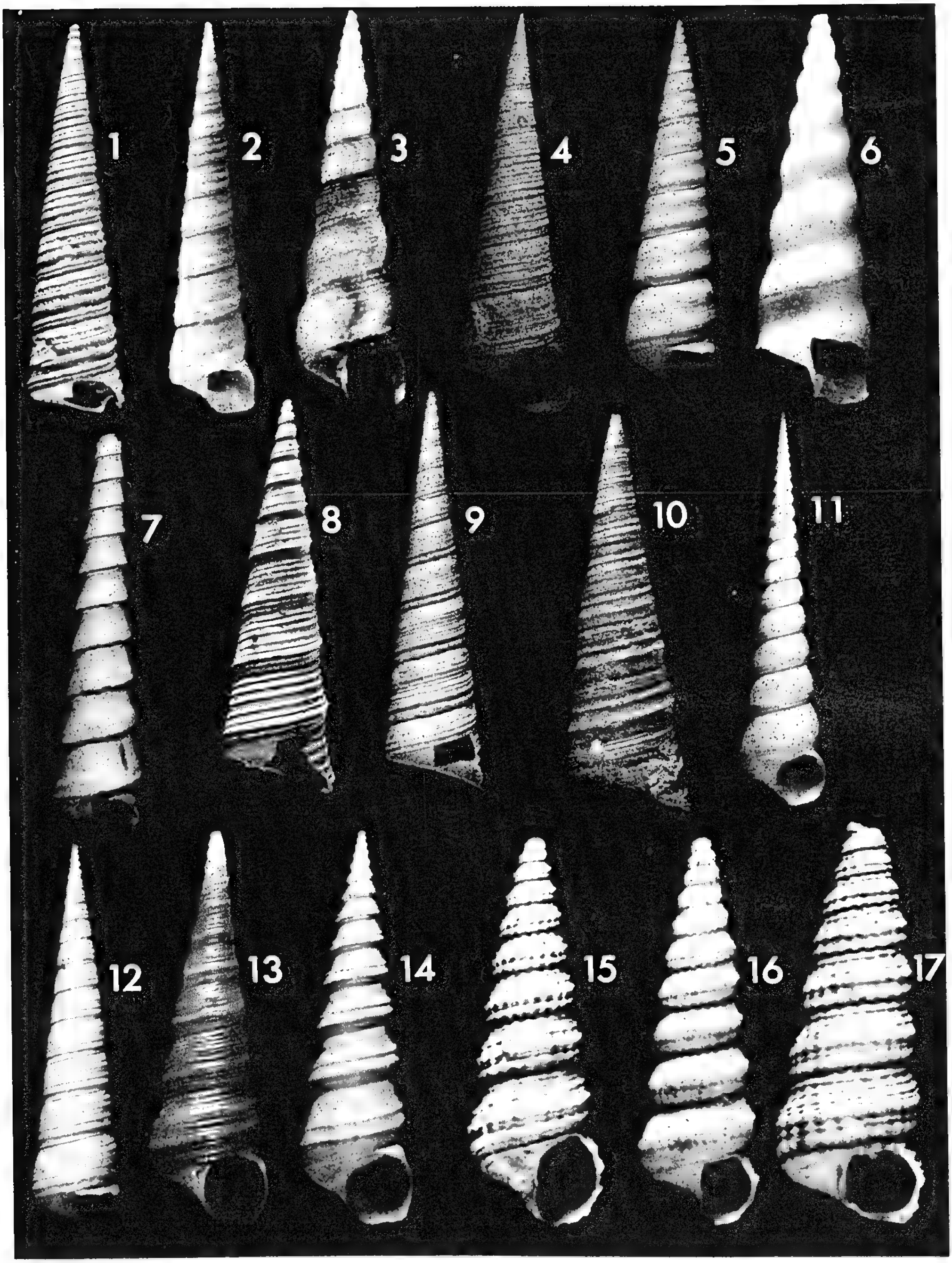
MAORICOLPUS Finlay, 1927, *Trans. New Zeal. Inst.*, 57: 389. Type species by original designation *Turritella rosea* Quoy and Gaimard.

Generic characteristics: Small to very large. Whorls initially convex then flatly concave, spire straight sided. Aperture sub-quadrate. Base flat to slightly concave. Protoconch of three or four microscopic flatly globose whorls. Labial sinus prosocline, broad and moderately deep (Fig. 7). Primary spirals emerge in order B, C, A. Spiral cords fine to strong.

PLATE 29

1. *Gazameda subacricula* (Cotton and Woods). Abattoirs Bore, Adelaide, South Australia. Topotype, X 2.5. N.M.V. No. P26990.
2. *Haustator (Kurosioia) cingulifer* (Sowerby). Lindeman Island, Queensland. Figured specimen, X 2.6. A.M. No. C77377.
3. *Haustator (Kurosioia) cingulifer* (Sowerby). Off Yeppoon, Queensland, 4 metres. Figured specimen, X 4.1. A.M. No. C58408.
4. *Maoricolpus roseus* (Quoy and Gaimard). Porto Bello Beach, New Zealand. Figured specimen, X 1. A.M. No. C43889.
5. *Maoricolpus murrayanus* (Tate). Murray River cliffs, 4 miles south of Morgan, South Australia. Topotype, X 1.3. A.M. No. C77390.
6. *Haustator (Kurosioia) leeuwinensis* Garrard. West of Jurien Bay, Western Australia, 142 metres. Holotype, X 7. A.M. No. C72592.
7. *Maoricolpus septifragus* (Tate). Zone 4, above ledge, Bird Rock Cliffs, Torquay, Victoria. Topotype, X 0.9. N.M.V. No. P27001.
8. *Maoricolpus tasmaniensis* (Cotton and Woods). Fossil Bluff, Table Cape, near Wynyard, Tasmania. Topotype, X 2.4. N.M.V. No. P27008.
9. *Maoricolpus roseus subrudis* (Cotton and Woods). Abattoirs Bore, Adelaide, South Australia. Topotype, X 1.7. N.M.V. No. P26989.
10. *Spirocolpus aldingae* (Tate). Blanche Point, Aldinga Bay, South Australia. Figured specimen, X 2.2. N.M.V. No. P26999.
11. *Turritella terebra* (Linnaeus). Cape York Peninsula, Queensland. Figured specimen, X .65. A.M. No. C77368.
12. *Zeacolpus (Zeacolpus) vittatus* (Hutton). Lower beds, Castlecliff, New Zealand. Figured specimen, X 1.2. A.M. No. C77375.
13. *Zeacolpus (Stiracolpus) capricornius* Garrard. Dundowron Beach, north of Hervey Bay, Queensland. Holotype, X 4.4. A.M. No. C72584.
14. *Zaria duplicata* (Linnaeus). Colombo Harbour, Ceylon. Figured specimen, X .59. A.M. No. C52564.
15. *Glyptozaria opulenta* (Hedley). Off Port Jackson, New South Wales, 91 metres. Figured specimen, X 10. A.M. No. C77386.
16. *Glyptozaria columnaria* Cotton and Woods. Off Cape Pillar, southern Tasmania, 183 metres. Holotype, X 14.4. S.A.M. No. D11438.
17. *Glyptozaria transenna* (Tenison-Woods). Clifton Bank, Muddy Creek, west of Hamilton, Victoria. (Lower beds). Topotype, X 10. N.M.V. No. P26987.

Plate 29



Maoricolpus roseus (Quoy and Gaimard, 1834)

Pl. 29, fig. 4.

1834 *Turritella rosea* Quoy and Gaimard, *Voy. Astrolabe*, p. 136, pl. 55, figs. 24-26.
1843 *Turritella rosea*. Deshayes, *Hist. Anim. s. Vert.*, 9: 260, sp. 16.
1849 *Turritella rosea*. Reeve, *Conch. Icon.*, 5, pl. 8, sp. 41.
1873 *Turritella rosea*. Kiener, *Coq. Viv.*, 9: 32, sp. 25; pl. 12, fig. 2.
1873 *Turritella rosea*. Hutton, *Cat. Mar. Moll. New Zeal.*, p. 29, no. 119.
1873 *Turritella rosea*. Martens, *Crit. List Moll. New Zeal.*, p. 27.
1880 *Turritella rosea*. Hutton, *Man. New Zeal. Moll.*, p. 83.
1886 *Turritella rosea*. Tryon, *Man. Conch.*, 8: 199, pl. 62, figs. 67, 68; pl. 61, fig. 59.
1927 *Maoricolpus roseus*. Finlay, *Trans. New Zeal. Inst.*, 57: 389.
1965 *Maoricolpus roseus*. Greenhill, *Pap. Proc. R. Soc. Tas.*, 99: 67-8.

Description: PROTOCONCH multispiral, three to four microscopic flatly globose whorls, apparently sinusigeroid, nucleus not observed. TELEOCONCH 18 whorls, biangulate with slightly concave centre; spire straight sided. SUTURES fine but deeply incised. SCULPTURE of three strong cords on early whorls, central first to emerge, closely followed by lower, and upper cord emerges on about fourth whorl; central cord gradually subsides, upper remains prominent, lower cord dominates throughout after about seventh whorl; numerous fine and coarse striations develop at intervals, often up to 25 on penultimate whorl. APERTURE sub-circular, higher than wide; columella straight, inner lip reflected on to body-whorl as glazed callus; outer lip thin with typical sinus. BASE of shell flat with numerous strong striae crossed by numerous growth lines. COLOUR light creamy-pink, striae reddish-brown, often with wavy longitudinal flames. OPERCULUM circular, thin, central nucleus, reddish-brown, multi-lamellate, flat in centre, raised glossy red outer edge.

Type locality: New Zealand.

Dimensions: Holotype, length 2 pouces 3 lignes (60.75 mm), breadth 8 lignes (18 mm). Information not available, but probably in Museum d'Histoire Naturelle, Paris.

Distribution: New Zealand generally; southern and western Tasmania, 4-18 metres; southern Queensland, 110-150 metres.

Material: Large quantity from Australian Museum, Sydney; National Museum of Victoria, Melbourne; Tasmanian Museum, Hobart.

Discussion: Sculpture of this species is very variable, and the apical angle varies considerably, however the protoconch and sculpture of the neanic whorls are both quite constant. It is common and widespread throughout New Zealand, where it has a long history dating well back into the Tertiary. It would appear that it has only arrived in Australia, but possibly for the second time, during the past 40 years, and is now abundant in southern Tasmania, but was not recorded by May (1921: 60-61 and 1923: 60-61). Two dead specimens are also on record from Macquarie Harbour on the west coast of Tasmania. During the past five years a number of dead specimens have also been trawled north of Cape Moreton in southern Queensland, in depths down to 150 metres. The multispiral protoconch, indicating a long pelagic existence in the veliger stage, could account for possible transport of the species in the bilge or ballast water of ships, but not by the trans-Tasman currents, which all flow from west to east.

The possibility is strong that during the Tertiary era this species formerly existed in Australia in the form now known as *M. murrayanus* (Tate), but apparently died out during the Miocene epoch (see further notes under latter species).

FOSSIL SPECIES

Maoricolpus septifragus (Tate, 1893)

Pl. 29, fig. 7.

1893 *Turritella septifraga* Tate, *Trans. R. Soc. S. Aust.*, 17: 336, pl. 8, fig. 5.

Description: PROTOCONCH unknown. TELEOCONCH at least 18 whorls, first few flat or slightly concave, all later whorls concave, imbricating over lower suture; spire concave. SUTURES well impressed in early whorls, in later whorls canaliculate. SCULPTURE consists of a slight cord on all whorls towards the base, a flatly rounded cingulum at top, usually developing on more mature whorls, two or three fine striae between lower cord and suture; concave area above lower cord has a few faint and distant striae. APERTURE sub-quadrate; columella slightly arcuate, outer lip with typical sinus. BASE of shell flat with several vague and indefinite striae crossed by numerous strong growth lines, which are also very pronounced on all whorls.

Type locality: Bird-rock Bluff, near Geelong, Victoria. Jan-Juc Formation: Janjukian: Upper Oligocene.

Dimensions: Holotype, length (incomplete) 100 mm, breadth 17 mm, Tate Museum, Geology Dept., University of Adelaide, South Australia, Reg'd. No. T.1409 A.

Material: Two topotypes from National Museum of Victoria.

Discussion: This very large heavy species can be recognised on sight by its almost smooth concave whorls with a cingulum towards the base, and the pagoda-like effect of the imbricating base of each whorl. Although the protoconch is unknown, the size of the shell in conjunction with the labial and basal sinus and the general whorl shape place it in the genus *Maoricolpus*. It has no affinities with other fossil or recent species in Australia.

Maoricolpus murrayanus (Tate, 1885)

Pl. 29, fig. 5.

1885 *Torcula murrayana* Tate, *Pap. Proc. R. Soc. Tas.*, (1884), p. 227.

1893 *Turritella murrayana.* Tate, *Trans. R. Soc. S. Aust.*, 17: 340, pl. 8, fig. 3.

1896 *Turritella murrayana.* Pritchard, *Proc. R. Soc. Vict.*, 8: 113 - 4.

1935 *Turritella (Maoricolpus) latissima* Cotton and Woods, *Rec. S. Aust. Mus.*, 5: 372, text fig. 6, p. 377.

Description: PROTOCONCH multispiral, three to four microscopic flatly globose whorls, apparently sinusigeroid, nucleus not observed. TELEOCONCH 18 whorls, biangulate with slightly concave area between; spire straight sided. SUTURES deeply incised. SCULPTURE of three strong cords on early whorls, central first to emerge, closely followed by lower, and upper cord emerges on about fourth whorl; central cord gradually subsides, upper remains prominent, lower cord dominates throughout after about seventh whorl; numerous fine and coarse striations develop at intervals, often up to 25 on penultimate whorl. APERTURE subcircular, higher than wide; columella straight, inner lip reflected on to body-whorl as glazed callus; outer lip thin with typical sinus. BASE of shell flat with numerous strong striae crossed by numerous growth lines.

Type locality: River Murray Cliffs, 4 miles downstream from Morgan, South Australia.

Dimensions: Holotype, length 60 mm, breadth 17 mm, Tate Museum, Geology Dept., University of Adelaide, South Australia, Reg'd. No. T.830 C.

Material: Large quantity from Australian Museum, Sydney; National Museum of Victoria, Melbourne; Tasmanian Museum, Hobart.

Discussion: This species has quite a long history in the Australian Tertiary, and may be found in quantity in many parts of Victoria and South Australia, and at Table Cape, Tasmania. I have compared many specimens from a number of localities with recent *M. roseus* (Quoy and Gaimard) from various parts of New Zealand, also with the few New Zealand fossil specimens available to me. The sculpture is decidedly variable, and the apical angle varies from 14° to as much as 24°. However the protoconch, the primary whorls with three strong keels, also the labial and basal sinus are quite constant throughout all specimens examined. There are strong grounds for considering *M. murrayanus* to be a synonym of *M. roseus,* however it would be necessary to examine a large quantity of specimens of both species of fossils, comparing each stage progressively to determine the matter, and the New Zealand specimens are not available to me. This is a study which could well be undertaken by a palaeontologist at a later date.

Maoricolpus tasmaniensis (Cotton and Woods, 1935)

Pl. 29, fig. 8.

1893 *Turritella acricula* var. Tate, *Trans. R. Soc. S. Aust.,* 17: 340, pl. 9, fig. 12.

1935 *Turritella (Gazameda) acricula tasmaniensis* Cotton and Woods, *Rec. S. Aust. Mus.,* 5: 374, 376. Not figured.

Description: PROTOCONCH of 3 to 4 microscopic flatly globose whorls, apparently sinusigeroid, nucleus not seen. TELEOCONCH at least 13 whorls, first seven convex, balance flatly concave, ridged towards anterior end, spire straight sided. SUTURES finely but strongly incised. SCULPTURE — first whorl centrally corded, which later becomes a strong striation, second whorl develops another cord towards base, third whorl develops a third cord towards top, lowest of three remains dominant throughout; others follow until 7 or 8 cords of various sizes on penultimate with finer threads between; all are crossed by fine incremental striae. APERTURE sub-quadrate; columella slightly arcuate, inner lip slightly reflected at base; outer lip thin with typical sinus. BASE of shell slightly concave, with 9 or 10 strong concentric lirae, one or two finer threads between each, growth lines fine and numerous.

Type locality: Fossil Bluff, Table Cape, near Wynyard, Tasmania. Table Cape Group: Janjukian/Longfordian: Upper Oligocene/Lower Miocene.

Dimensions: Holotype, length 34 mm, breadth 8.3 mm, Tate Museum, Geology Dept., University of Adelaide, South Australia, Regd. No. T. 1414B.

Material: Three topotypes from National Museum of Victoria.

Discussion: This is one of the five species shown by Cotton and Woods (1935: 374, 376) under the genus *Gazameda*, with which it has no relationship. It is obviously related to *M. murrayanus* but cannot be classed as a subspecies owing to its smaller size, far bolder sculpture, and decidedly narrower length/width ratio, all points being consistent.

Maoricolpus subrudis (Cotton and Woods, 1935)

Pl. 29, fig. 9.

1935 *Turritella (Maoricolpus) murrayana subrudis* Cotton and Woods, *Rec. S. Aust. Mus.*, 5: 371, text fig. 1.

1952 *Maoricolpus subrudis.* Crespin and Cotton, *Geol. Surv. S. Aust.*, Bull. 27, append. 4: 245.

1954 *Turritella (Peyrotia) murrayana subrudis.* Ludbrook, *Trans. R. Soc. S. Aust.*, 77: 59.

1957 *Turritella (Maoricolpus) murrayana subrudis.* Ludbrook, *Trans. R. Soc. S. Aust.*, 80: 19.

Description: PROTOCONCH unavailable, presumed to be as for the genus. TELEOCONCH 14 whorls, first five convex and medially angulate, balance flat or slightly medially concave, spire straight sided. SUTURES strongly incised, in places a little canaliculate. SCULPTURE commences gradually after first whorl, of densely packed and prominent striae, increasing to 16 on penultimate and with finer threads between; two stronger cords usually more prominent than others towards base of whorls. APERTURE sub-quadrate; columella slightly arcuate; outer lip thin with typical sinus. BASE of shell concave with numerous concentric striae, strong and fine alternating, crossed by numerous growth lines.

Type locality: Abattoirs Bore, near Adelaide, South Australia, 300-500 feet. Dry Creek Sands: Yatalan: Upper Pliocene.

Dimensions: Holotype, length 49 mm, breadth 12 mm, Tate Museum, Geology Dept., University of Adelaide, South Australia, Reg'd. No. T. 1688.

Material: Four topotypes from National Museum of Victoria; one topotype from Australian Museum, Sydney.

Discussion: This species was shown by Cotton and Woods (1935: 371), as a subspecies of the larger *M. murrayanus* (Tate). Specimens available for study have the protoconch and first two or three primary whorls missing, but the following whorls do not conform to the sculpture of *M. murrayanus*, the usual three strong striae of that species being replaced by densely packed numerous striations, the different form of sculpture being quite consistent on all specimens examined. The prominent cord towards the base of whorls in *M. murrayanus* is also replaced in this species by two finer cords. It is considered that the differences are sufficient to warrant separation as a full species.

Genus *SPIROCOLPUS* Finlay, 1927

SPIROCOLPUS Finlay, 1927, *Trans. New Zeal. Inst.*, 57: 388. Type species by original designation *Turritella waihaoensis* Marwick.

Generic characteristics: Medium, broad for length, fairly solid. Whorls flatly convex, spire straight sided. Aperture sub-circular to sub-quadrate. Base flat to slightly concave. Protoconch multispiral, conic, 2¼ flatly convex whorls, nucleus a little submerged. Labial sinus opisthocline, medial, extremely deep and narrow (Fig. 8). Primary spirals emerge in order B, C, A. Spiral cords fairly strong.

FOSSIL SPECIES

Spirocolpus aldingae (Tate, 1882)

Pl. 29, fig. 10.

1882 *Turritella aldingae* Tate, *Trans. R. Soc. S. Aust.*, 5: 45.
1893 *Turritella aldingae.* Tate, *Trans. R. Soc. S. Aust.*, 17: 336, pl. 8, fig. 1.
1912 *Turritella (Zaria) pritchardi* Cossmann, *Essais. de Paleo. Comp.*, 9: 199, pl. 8, fig. 6.

Description: PROTOCONCH of 2½ flatly convex whorls, nucleus a little submerged, slightly asymmetric. TELEOCONCH 14 whorls, flatly convex, spire straight sided. SUTURES finely but deeply incised. SCULPTURE of three fine striae on primary whorls, which become progressively stronger cords with age, lowest the strongest, central becoming beaded; upper cord frequently divides into three closely packed smaller cords; several fine striations also develop on whorls in various positions; growth striae very faint on early whorls but show up strongly on last two or three. APERTURE sub-quadrate; columella arcuate, inner lip reflected at base; outer lip thin and crenulated exteriorly by cords, with typical sinus. BASE of shell flat, with heavy peripheral ridge, and a number of striae of various sizes crossed by faint growth lines. COLOUR — most specimens are chocolate in colour with a fairly high glaze.

Type locality: Adelaide Bore, Kent Town, South Australia. Blanche Point Marl: Aldingan: Upper Eocene.

Dimensions: Holotype, length 36 mm, breadth 10.5 mm, Tate Museum, Geology Dept., University of Adelaide, South Australia, Reg'd. No. T.1406 B & G.

Material: 9 specimens, National Museum of Victoria, Melbourne, from Blanche Point Marl, Aldinga Bay, South Australia.

Discussion: This species has a somewhat similar sculpture on the mature whorls and a general similar facies to the recent *Colpospira (Acutospira) accisa* (Watson), but the far deeper labial sinus is an outstanding feature and sets it quite apart.

Genus *TURRITELLA* Lamarck, 1799

TURRITELLA Lamarck, 1799, *Soc. Hist. Nat.*, Paris, p. 74. Type species by original designation *Turbo terebra* Linnaeus.

Generic characteristics: Very large, heavy and solid. Whorls convex, spire straight sided. Aperture almost circular. Base roundly convex. Protoconch not known. Labial sinus a broad and very shallow curve, opisthocyrt or arched backward, continued as a straight line across base (Fig. 9). Primary spirals emerge in order B, A, C, with a secondary, soon rivalling B, commencing between A and B before C begins. Spiral cords medium to fairly strong.

Turritella terebra (Linnaeus, 1758)

Pl. 29, fig. 11.

1758 *Turbo terebra* Linnaeus, *Syst. Nat.*, ed. 12, p. 766.
1849 *Turritella terebra.* Reeve, *Conch. Icon.*, 5, pl. 1, fig. 3.
1849 *Turritella cerea* Reeve, *Conch. Icon.*, 5, pl. 6, fig. 25.
1849 *Turritella spectrum* Reeve, *Conch. Icon.*, 5, pl. 8, fig. 40.

1873 *Turritella terebra.* Kiener, *Coq. Viv.*, 9: 4, pl. 3, fig. 4.
1886 *Turritella terebra.* Tryon, *Man. Conch.*, 8: 195, pl. 59, fig. 32.
1950 *Turritella cerea.* Allan, *Aust. Shells*, p. 91, pl. 17, fig. 17.
1957 *Turritella terebra.* Marwick, *Proc. Mal. Soc. Lond.*, 52: 161, text figs. 48, 49.

Description: PROTOCONCH unavailable. TELEOCONCH about 25 whorls, contracted above, bulbous toward base, spire straight sided. SUTURES fairly strongly incised. SCULPTURE commences with a sub-central cord on first whorl, followed by a second at top of whorl, another between these, then a fourth towards base; others follow at intervals, reaching about 14 on body whorl with a few fine threads between; three equal and strongest cords towards base, producing a broadly pear-shaped whorl. APERTURE almost circular, a little deeper than broad; columella arcuate, inner lip strongly reflected on to body-whorl as a glazed callus; outer lip together with base form one wide shallow sinus, moving in a shallow arc from upper suture, then across base of shell to columella. BASE of shell roundly convex with 6 or 7 strong lirae and 2 or 3 fine threads between each, crossed by straight growth lines. COLOUR light cream or fawn, often with darker axial flames; some tend to be quite dark in colour, commencing with light reddish-tinged whorls and finishing with body-whorl almost black. OPERCULUM simple, circular, black and polished, with a number of concentric growth ridges and sub-central nucleus.

Type locality: Generally accepted as Philippine Islands.

Dimensions: Maximum length of a fully mature specimen approx. 170 mm, maximum breadth approx. 44 mm. Holotype understood to be in possession of the Linnaean Society of London.

Distribution: Across the whole northern Australian coastline, and a short distance southwards along both east and west coasts.

Material: Numerous specimens from six State Museums.

Discussion: The wide shallow primitive type of sinus in this large species, which was widespread in the Cretaceous and early Tertiary, is by no means representative of the subfamily Turritellinae, but places it towards its outer limits. It is frequently confused with *Archimediella fastigiata* (Adams and Reeve), but the three strong cords towards the base of the whorls in *T. terebra* easily separate it from the two strong cords of *A. fastigiata* with the somewhat shallow concave section between. A feature noticed in many specimens is that the cords tend to disappear on the body-whorl of light coloured specimens, whilst they continue strongly on the bulk of those with very dark colouring.

Genus *ZEACOLPUS* Finlay, 1927

ZEACOLPUS Finlay, 1927, *Trans. New Zeal. Inst.*, 57: 388. Type species by original designation *Turritella vittata* Hutton.

Subgenus *ZEACOLPUS* ss.

Subgeneric characteristics: Medium to large in size and solid. Whorls flat, spire straight. Aperture sub-quadrate. Base flatly convex. Protoconch little more than one whorl, nucleus slightly submerged. Labial sinus prosocline, broad and moderately deep (Fig. 10). Primary spirals emerge in order B, C, A. Spiral cords fine to fairly strong.

Zeacolpus (Zeacolpus) vittatus (Hutton, 1873)

Pl. 29, fig. 12.

1873 *Turritella (Haustator) vittata* Hutton, *Cat. Mar. Moll. New Zeal.*, p. 29.
1880 *Turritella (Haustator) vittata.* Hutton, *Man. New Zeal. Moll.*, p. 84.
1881 *Turritella carlottae* Watson, *Jour. Linn. Soc. Lond.*, 15: 222.
1886 *Turritella carlottae.* Watson, *Rep. Sci. Res. Challenger*, Zool., 25: 478, pl. 30, fig. 5.
1905 *Turritella carlottae.* Murdoch and Suter, *Trans. New Zeal. Inst.*, 38: 292.
1913 *Turritella carlottae.* Hedley, *Proc. Linn. Soc. N.S.W.*, 38: 292.
1913 *Turritella carlottae.* Suter, *Man. New Zeal. Moll.*, p. 266, pl. 39, fig. 19.
1915 *Turritella vittata.* E. A. Smith, *Brit. Antarc. (Terra Nova) Exp.*, 1910, Vol. 2: 80.
1957 *Zeacolpus vittatus.* Marwick, *Proc. Mal. Soc. Lond.*, 32: 161, text fig. 5, 56 - 59.

Description: PROTOCONCH paucispiral, asymmetric, little more than one whorl, nucleus erect. TELEOCONCH 12 whorls, flat, contracted at sutures, spire straight. SUTURES strongly incised. SCULPTURE of two strong cords on lower half of first whorl, upper the stronger, closely followed by two finer cords above; numerous finer striae develop at intervals some becoming prominent; body-whorl with six strong cords and up to 12 finer. APERTURE sub-quadrate; columella straight, inner lip reflected on to body-whorl; outer lip thin with typical sinus. BASE of shell flatly convex with several strong flat concentric striae and finer threads between, crossed by numerous growth lines. COLOUR yellowish-white to light reddish-brown with brown-topped major cords both on whorls and base. OPERCULUM circular, thin, flat, light yellow-brown, central nucleus, about 12 concentric growth lamellae.

Type locality: North Island, New Zealand.

Dimensions: Holotype, length 46 mm, breadth 12.7 mm, Dominion Museum, Wellington, New Zealand, Reg'd. No. 137.

Distribution: New Zealand generally. (?) Bass Strait.

Material: 15 specimens from various New Zealand localities in Australian Museum, Sydney.

Discussion: It is interesting to note that Watson mentions several mature specimens of "*carlottae*" from his type locality in 38-40 fathoms east of East Moncoeur Island, Bass Strait, and yet further specimens do not appear to have come to notice since that date. The species has been omitted from the Tasmanian Check-list, and Hedley (1913: 292) expressed doubts regarding its existence in Australian waters. No further specimens were obtained by H.M.A.S. "Gascoigne" in Bass Strait in 1962, which does not however prove its non-existence. As Watson obtained other specimens from Queen Charlotte Sound, New Zealand, the possibility cannot be overlooked that these were later mixed with other species of shells from the Bass Strait locality. In these circumstances its existence as an Australian species must still be regarded with doubt.

Subgenus *STIRACOLPUS* Finlay, 1927

STIRACOLPUS Finlay, 1927, *Trans. New Zeal. Inst.*, 57: 339. Type species by original designation *Turritella symmetrica* Hutton.

Subgeneric characteristics: Medium in size, light to heavy in weight. Whorls convex, spire straight. Aperture sub-circular. Base flatly convex. Protoconch of one to 1½ flatly convex whorls, asymmetric, nucleus a little submerged. Labial sinus prosocline, broad and moderately deep (fig. 11).

Primary spirals emerge in order B followed by A and C simultaneously. Spiral cords fine to very strong.

Zeacolpus (Stiracolpus) capricornius sp. nov.

Pl. 29, fig. 13.

Description: PROTOCONCH paucispiral, asymmetric, of 1½ flatly convex white or translucent whorls, nucleus a little submerged. TELEOCONCH ten convex whorls, shining, spire straight. SUTURES slightly impressed. SCULPTURE of three main cords, commencing almost simultaneously on first whorl, central the strongest, followed by lowest, with uppermost the weakest; spirals continue in this strength until fifth or sixth whorl, when upper and lower become equal; one, two or three finer spirals between main cords commence about fourth whorl, and penultimate has about 12 of varied importance, all crossed by fine growth lines. APERTURE sub-circular; columella strongly arcuate, inner lip reflected at base; outer lip thin with broad, moderately deep medial sinus, typical of the genus. BASE of shell flatly convex with seven or eight strong but flat lirae crossed by numerous lines of growth. COLOUR light brown or chocolate, apart from white protoconch; there are no other markings. OPERCULUM unavailable.

Type locality: Dundowron Beach, north of Hervey Bay, southern Queensland.

Dimensions: Holotype, length 14.5 mm, breadth 4.5 mm, Australian Museum, Sydney, Reg'd. No. C.72584. Largest paratype, length 20 mm, breadth 6.2 mm.

Distribution: Type locality only.

Material: Holotype and five paratypes.

Discussion: This species has no near relatives in Australian waters, and its origins probably lie with one or other of the many New Zealand species or subspecies in the subgenus. It has been compared with several others from New Zealand which it appeared to resemble. However all New Zealand members of the group are more solidly constructed with decidedly heavier and coarser keels and striations, and this new species appears to be quite distinct. Although only six specimens are known to me from the type locality, they were collected, three personally, over a period of some five years, which appears to be definite proof that the species lives in the area. The tremendous distance that the tide recedes at the type locality owing to the almost flat and horizontal sea-bed in the area would account for the fact that so few of this small species would normally be washed up to the high tide mark or thereabouts.

Subfamily PAREORINAE Finlay and Marwick, 1937

Genus *PAREORA* Marwick, 1931

PAREORA Marwick, 1931, *New Zeal. Geol. Surv., Palaeon. Bull.*, 13: 94. Type species by original designation *Eglisia striolata* Hutton.

Generic characteristics: Very small and elongate. Whorls convex, spire convex. Aperture oval and oblique. Base flat or slightly convex. Protoconch conic and polygyrate. Labial sinus slightly opisthocline, broad but deep, and above centre of whorl (Fig. 13). Primary spirals emerge in order B, C, A. Spiral cords flat and narrow.

FOSSIL SPECIES

Pareora stylacris (Tate, 1893)

Pl. 30, fig. 3.

1893 *Mesalia stylacris* Tate, *Trans. R. Soc. S. Aust.*, 17: 341, pl. 9, fig. 2.
1935 *Pareora stylacris*. Cotton and Woods, *Rec. S. Aust. Mus.*, 5: 382.

Description: PROTOCONCH multispiral, mamillate, microscopic, of four narrow convex whorls, nucleus slightly submerged. TELEOCONCH five whorls, convex and slightly medially angulated, spire slightly convex. SUTURES strongly impressed. SCULPTURE of four to seven flat narrow striae, mainly confined to anterior portion of whorls, crossed by microscopic somewhat sigmoid growth lines. APERTURE oval; columella thick, arched and flattened, joined by callus to outer lip, which is thin with typical sinus. BASE of shell flat or slightly convex, smooth except for incremental growth striae.

Type locality: Blanche Point, Aldinga Bay, South Australia. Blanche Point Marl: Aldingan: Upper Eocene.

Dimensions: Holotype, length 4 mm, breadth 2 mm, Tate Museum, Geology Dept., University of Adelaide, South Australia, Reg'd. No. T.1442.

Material: 4 topotypes National Museum of Victoria, Melbourne.

Discussion: This unusually shaped species, more reminiscent in general facies of some Pyramidellidae or Melanellidae groups, is the only known Australian member of the genus, its polygyrate protoconch and aperture continuous with the columella being consistent with the original generic description. It does not appear to have any recent descendants.

Genus *ZARIA* Gray, 1847

ZARIA Gray, 1847, *Syn. Cont. Brit. Mus.*, ed. 42: 147. Type species by original designation *Turbo duplicatus* Linnaeus.

Generic characteristics: Very large, heavy and solid. Whorls convex, spire straight sided. Aperture sub-circular, inclined to pyriform. Base convex and withdrawn in to columella. Protoconch unknown. Labial sinus prosocline, formed of wide arc from upper suture round edge of base (Fig. 12). Primary spirals emerge in order C, B, A. Mature spirals consist of strong sharp keels.

Zaria duplicata (Linnaeus, 1758)

Pl. 29, fig. 14.

1758 *Turbo acutangulus* Linnaeus, *Syst. Nat.*, ed. 10: 766, sp. 559; *ibid.*, *T. duplicatus* Linnaeus, p. 766, sp. 560.
1767 *Turbo acutangulus*. Linnaeus, *Syst. Nat.*, ed. 12, sp. 642; *ibid.*, *T. duplicatus* Linnaeus, sp. 643.
1843 *Turritella duplicata*. Lamarck, *Hist. Anim. s. Vert.*, 9: 251.
1847 *Zaria duplicata*. Gray, *Syn. Cont. Brit. Mus.*, ed. 42: 147.
1849 *Turritella duplicata*. Reeve, *Conch. Icon.*, 5, pl. 1, fig. 2; *ibid.*, *T. acutangulus*, pl. 1, fig. 2. (Ref. as synonym).
1873 *Turritella duplicata*. Kiener, *Coq. Viv.*, 9: 3, pl. 1, 3 figs.; pl. 2, figs. 2a, 2b.
1886 *Turritella duplicata*. Tryon, *Man. Conch.*, 8: 207, pl. 65, figs. 20 - 22.
1957 *Zaria duplicata*. Marwick, *Proc. Mal. Soc. Lond.*, 32: 164, text figs. 40, 47.

Description: PROTOCONCH unavailable. TELEOCONCH 16 whorls, contracted above, bulbous towards base, spire slightly convex. SUTURES deeply impressed. SCULPTURE of three strong sharp spiral keels towards base and three finer above for about first ten whorls, after which anterior of the three strong spirals tends to fade, other two decidedly stronger and more sharply ridged, but these often fade out on body-whorl. APERTURE sub-circular, inclined to pyriform; columella strongly arcuate; outer lip sweeps in wide arc from upper suture to base, then reverses direction and swings in further wide arc to columella, where it forms a spiral ridge crossing it towards top of aperture. BASE of shell smooth, convex and withdrawn in towards the columella. COLOUR light reddish-cream, upper part of whorls somewhat darker. OPERCULUM circular, dark brown to black, about 12 mm diameter in fully grown specimens, sub-central nucleus, up to seven concentric lamellae with raised edges, each lamellation showing oblique growth lines.

Type locality: " Eastern Seas."

Dimensions: Reeve's figured specimen measures 171 mm, length, 42 mm breadth, which appears to be the maximum to which the species grows. Holotype understood to be in possession of the Linnaean Society of London.

Distribution: In Australia the species occurs across the north of the continent, from the far north of Western Australia to Cape York Peninsula, Queensland.

Material: Large number of specimens from five State Museums.

Discussion: This very large, heavy and massive species cannot be confused with any other in the family, and little variation is apparent except the greater or lesser prominence of one or two of the main keels. In the original description of *T. acutangulus* Linnaeus and *T. duplicatus* Linnaeus, (1758: 766) the former name takes page precedence. However the description of *T. acutangulus* is that of an aberrant specimen, is misleading and not indicative of the species. This was apparently realised by Linnaeus and the numbers 642 and 643 were both marked on the one specimen in his collection, the numbers referring to the two species. The above specimen, which is the *T. duplicata* of modern writers, was well presented by Chemnitz (*Conch. Cab.*, 4, pl. 151, fig. 1414). This observation was made by Hanley (1855: 347).

Subfamily TURRITELLOPSINAE Marwick, 1957

Genus *GLYPTOZARIA* Iredale, 1924

GLYPTOZARIA Iredale, 1924, *Proc. Linn. Soc. N.S.W.*, 49: 248. Type species by original designation *Turritella opulenta* Hedley.

Generic characteristics: Very small and frail. Whorls convex, spire straight sided. Aperture sub-circular to pear shaped. Base flatly convex to flatly concave. Protoconch slightly asymmetric, 1½ whorls, flatly convex, nucleus submerged. Labial sinus a wide shallow arc slightly opisthocline (Fig. 14). Primary spirals — B and C emerge simultaneously from junction of first main whorl with protoconch, B being the stronger, and C emerges about fourth whorl. Sculpture of spiral and axial cords of about equal strength, forming a cancellated sculpture.

Glyptozaria opulenta (Hedley, 1907)

Pl. 29, fig. 15.

1907 *Turritella opulenta* Hedley, *Rec. Aust. Mus.*, 6:292, pl. 54, fig. 9.
1924 *Glyptozaria opulenta.* Iredale, *Proc. Linn. Soc. N.S.W.*, 49: 248.
1925 *Glyptozaria opulenta.* Iredale, *Rec. Aust. Mus.*, 14: 267.
1931 *Glyptozaria opulenta.* Cotton and Godfrey, *S. Aust. Naturalist*, 12: 59, pl. 2, fig. 5.
1950 *Glyptozaria opulenta.* Allan, *Aust. Shells*, p. 92.
1951 *Glyptozaria opulenta.* Laseron, *Rec. Aust. Mus.*, 22: 333, fig. 91.
1957 *Glyptozaria opulenta.* Marwick, *Proc. Mal. Soc. Lond.*, 32: 164, text figs. 69, 70.

Description: PROTOCONCH paucispiral, a little asymmetric, of 1½ whorls, with large but well submerged nucleus. TELEOCONCH eight whorls, convex, deeply indented at sutures, spire straight. SUTURES lightly impressed within a deep channel between whorls, often with a fine thread on one or both sides. SCULPTURE — two strong spiral cords on first whorl, three from fourth whorl onwards, central the most prominent; a fine thread frequently present between spirals; all are crossed by fairly closely packed axial ribs forming gemmulations on spirals; axial ribs follow slight curve of outer lip. APERTURE almost pear-shaped; columella and inner lip strongly arcuate; outer lip, crenulated by cords, flares outwards at base, then curves inwards to form an open canal at junction with base of columella. BASE of shell flatly convex, bordered by a strong peripheral rib, about five concentric striae crossed by faint growth lines. COLOUR off-white to light fawn, somewhat translucent when in good condition; irregular light brown marbling visible in places on some specimens. OPERCULUM not available.

Type locality: Off Cape Three Points, New South Wales, 41-50 fathoms (72-92 metres).

Dimensions: Holotype, length 6 mm, breadth 2 mm, Australian Museum, Sydney, Reg'd. No. C.16764.

Distribution: From Broken Bay, New South Wales, southwards to Victoria, Tasmania and South Australia, in known depths from 115 to 155 metres.

Material: Fair quantity from four State Museums.

Discussion: The sculpture of this species is subject to variation, the axial ribbing predominating in some specimens and the spiral in others. The placing of this species and other *Glyptozaria* species in the family Turritellidae is open to doubt. The outer lip at maturity is strongly reminiscent of certain Cerithiidae, and the short open canal at its junction with the base of the columella is often half-way to the typical anterior canal of that family. The genus is very close to the border line, and discovery of other similar species in future may warrant the establishment of a separate family between the two.

Glyptozaria columnaria Cotton and Woods, 1935.

Pl. 29, fig. 16.

1935 *Glyptozaria columnaria* Cotton and Woods, *Rec. S. Aust. Mus.*, 5: 382, text fig. 5 (p. 377).

Description: PROTOCONCH paucispiral, slightly asymmetric, of 1½ depressed globose whorls, nucleus submerged. TELEOCONCH ten whorls,

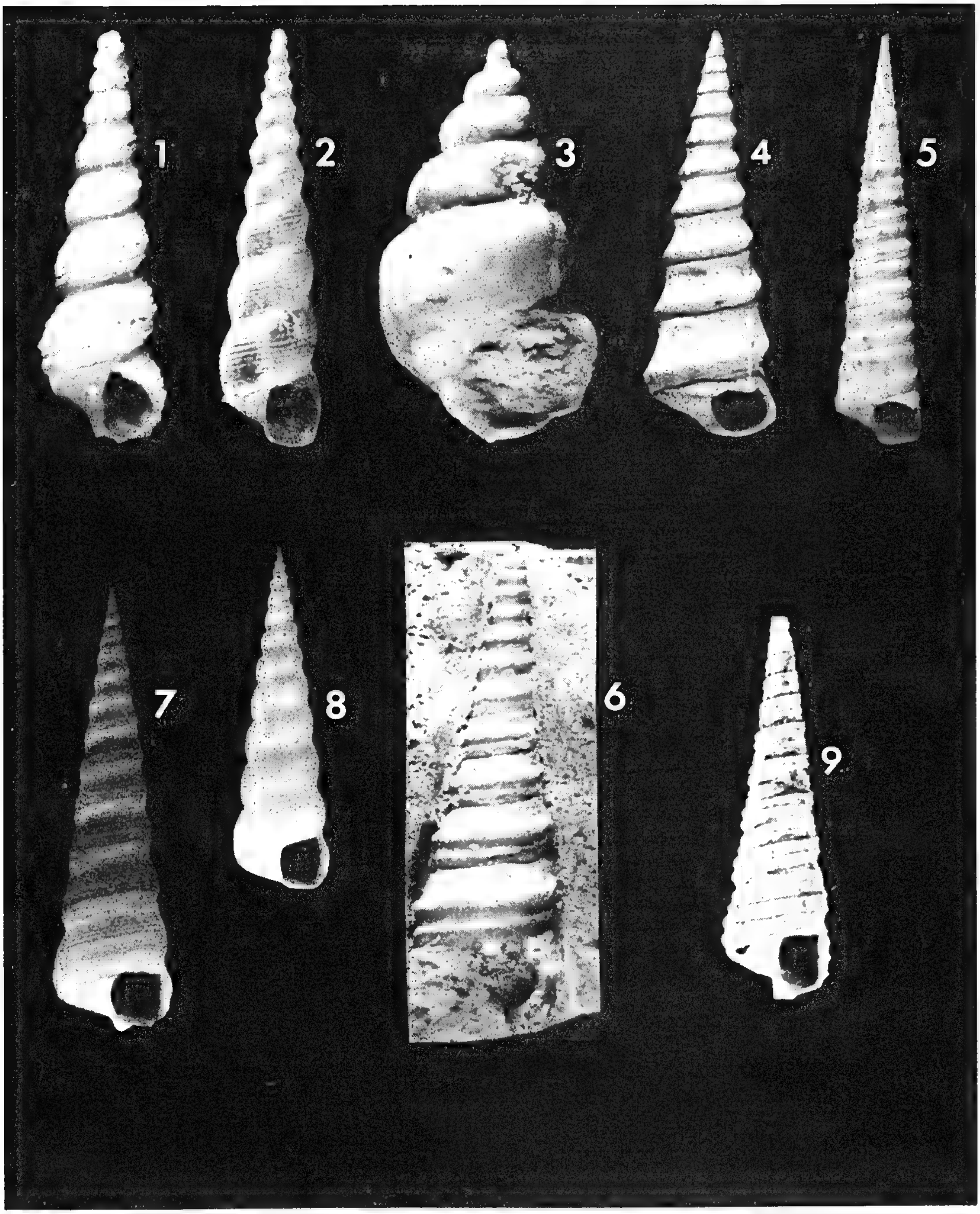


PLATE 30

1. *Kimberia kimberi* (Verco). South of Cape Carnot, South Australia, 170 metres. Figured specimen, X 21. A.M. No. C77387.
2. *Kimberia neptunensis* (Verco). Off Cape Everard, Victoria, 54 metres. Figured specimen, X 8.9. A.M. No. C77388.
3. *Pareora stylacris* (Tate). Lower 6-15 feet of cliffs, Blanche Point, Aldinga Bay, South Australia. Topotype, X 15.3. N.M.V. No. P27000.
4. *Colpospira (Ctenocolpus) pagodula* (Tate). Cutting on Prince's Highway, Jemmys Point, Kalimna, Victoria. Figured specimen, X 5.8. N.M.V. No. P26998.
5. *Gazameda declivis* (Adams and Reeve). (*G. "captiva"* (Hedley)). North-east of Cape Moreton, southern Queensland, 114-123 metres. Figured specimen, X 1.2. A.M. No. C77379.
6. *Colpospira (Platycolpus) medioplicatilis* (Chapman and Crespin). Sorrento Bore (Nepean No. 1), Victoria, 1,461 feet. Paratype, X 11.9. N.M.V. No. P27003.
7. *Archimediella fastigiata* (Adams and Reeve). West of Flat Island, near Onslow, Western Australia, 11-18 metres. "Onslow forma," intermediate form. Figured specimen, X 2.2. A.M. No. C77385.
8. *Archimediella fastigiata* (Adams and Reeve). West of Flat Island, near Onslow, Western Australia, 11-18 metres. "Onslow forma," extreme form. Figured specimen, X 2.1. A.M. No. C77385.
9. *Colpospira (Platycolpus) warburtonii* (Tenison-Woods). Lower bed, Fossil Bluff, Table Cape, near Wynyard, Tasmania. Topotype, X 4.3. A.M. No. C77410.

convex, constricted posteriorly, spire slightly convex. SUTURES slightly canaliculate. SCULPTURE of two prominent cords commencing on first whorl, crossed by numerous rather faint axial riblets, about 24 on body whorl, rendering cords somewhat nodular; cords situated sub-centrally at anterior end of whorls, with a third cord at base of body-whorl. APERTURE sub-circular; columella straight; outer lip thin, a little crenulated exteriorly. BASE of shell smooth. COLOUR light cream. OPERCULUM unknown.

Type locality: 100 fathoms (182 metres) off Cape Pillar, southern Tasmania.

Dimensions: Holotype, length 4.5 mm, breadth 1.5 mm, South Australian Museum, Adelaide, Reg'd. No. D.11438.

Distribution: The only other known record apart from the type locality is 77 metres, south of Wilson Inlet, Western Australia.

Material: Two specimens only as mentioned above.

Discussion: Dredging undertaken by the author in many parts of southern Tasmania in recent years in depths down to about 50 metres has failed to produce a single specimen of this small species, which is apparently confined to deeper water. However the one other record from Western Australia indicates that its occurrence is fairly widespread.

FOSSIL SPECIES

Glyptozaria transenna (Tenison-Woods, 1879)

Pl. 29, fig. 17.

1879 *Turritella transenna* Tenison-Woods, *Proc. Linn. Soc. N.S.W.*, 3: 234, pl. 20, fig. 8.
1893 *Turritella transenna*. Tate, *Trans. R. Soc. S. Aust.*, 17: 335.

Description: PROTOCONCH paucispiral, slightly asymmetric, of 1½ convex flatly compressed whorls, nucleus well submerged. TELEOCONCH nine whorls, slightly convex, spire straight. SUTURES finely incised. SCULPTURE of two or three strong spiral cords on each whorl, other minor cords later forming between, crossed by numerous almost vertical axial riblets forming gemmulations. APERTURE sub-circular; columella arcuate, inner lip strongly reflected and forming umbilical chink below columella; outer lip with gently curved shallow arc from upper suture to base. BASE of shell fairly concave, bordered by gemmate cord and with six or seven strong lirae crossed by fine densely packed growth lines.

Type locality: Muddy Creek, west of Hamilton, Victoria. Lower beds. Muddy Creek Formation: Balcombian: Middle Miocene.

Dimensions: Holotype, length 8.5 mm, breadth 3 mm, Australian Museum, Sydney, Reg'd. No. F.1701.

Material: Holotype as above, 3 topotypes National Museum of Victoria, Melbourne.

Discussion: Tenison-Woods' original description is rather misleading, stating of the cords " two large and three small alternating," whereas specimens have major and minor cords in different order on each of four specimens examined, which includes the holotype. In addition the axial riblets were mentioned as somewhat sloping and not passing over the cords, whereas they are practically vertical and pass over all spiral cords, large and small, rendering them decidedly gemmulate. The periphery was also mentioned as " margined with double line of small keels " but has one large cord only. The four specimens examined were all from the type locality.

The possibility exists that this species could be directly ancestral to *G. opulenta* Hedley. The main points of difference are that *G. opulenta* is a little narrower for its length, is more deeply channelled at the sutures, and has a pear-shaped aperture instead of sub-circular.

Genus *KIMBERIA* Cotton and Woods, 1935

KIMBERIA Cotton and Woods, 1935, *Rec. S. Aust. Mus.*, 5: 370. Type species by original designation *Turritella kimberi* Verco.

Generic characteristics: Very small, frail and translucent or clear. Whorls convex, spire straight or slightly convex. Aperture elongate-oval to sub-quadrate. Base convex and smooth. Protoconch three to four minute whorls, nucleus not submerged. Labial sinus absent. Primary spirals emerge in order B, C, A, spiral B remaining dominant throughout. Sculpture of fairly strong keels, becoming flatter with age.

Kimberia kimberi (Verco, 1908)

Pl. 30, fig. 1.

1908 *Turritella kimberi* Verco, *Trans. R. Soc. S. Aust.*, 32: 342, pl. 15, figs. 14, 15.
1931 *Stiracolpus kimberi*. Cotton and Godfrey, *S. Aust. Naturalist*, 12: 59.
1935 *Kimberia kimberi*. Cotton and Woods, *Rec. S. Aust. Mus.*, 5: 370.
1957 *Kimberia kimberi*. Marwick, *Proc. Mal. Soc. Lond.*, 32: 164, text fig. 53.

Description: Protoconch narrowly conic with four tall whorls and small deviated emergent nucleus. TELEOCONCH eight convex whorls, spire straight sided. SUTURES lightly impressed. SCULPTURE — three spiral cords commence simultaneously after junction with protoconch on specimens examined; two others follow later making five on penultimate; extremely fine growth lines barely visible. APERTURE elongate oval; columella arcuate, inner lip reflected as callus on body-whorl; outer lip curves in an arc from upper suture to form a narrowly patulous base to aperture. BASE of shell convex and smooth. COLOUR translucent white. OPERCULUM unavailable.

Type locality: Backstairs Passage, South Australia, 20 fathoms (36 metres).

Dimensions: Holotype, length 7.7 mm, breadth 1.7 mm, South Australian Museum, Adelaide, Reg'd. No. 13427.

Distribution: Appears to be confined to South Australia.

Material: Holotype and several paratypes South Australian Museum, several paratypes National Museum of Victoria, six specimens Australian Museum, Sydney.

Discussion: This small species is a little variable, the type possessing six spiral ribs on penultimate whorl, the co-type in the National Museum of Victoria has five, a specimen from 170 metres south of Cape Carnot, South Australia, has nine. The protoconch of the last specimen has about 22 narrow ribs on all whorls of protoconch, more or less vertical above, inclined to right below, which gradually disappear on first main whorl and which are not present on holotype.

Kimberia neptunensis (Verco, 1910)

Pl. 30, fig. 2.

1910 *Turritella neptunensis* Verco, *Trans. R. Soc. S. Aust.*, 34: 120, pl. 30, fig. 7.
1931 *Stiracolpus neptunensis.* Cotton and Godfrey, *S. Aust. Naturalist*, 12: 59.
1935 *Kimberia neptunensis.* Cotton and Woods, *Rec. S. Aust. Mus.*, 5: 370.

Description: PROTOCONCH minute, narrowly conic, three flatly convex whorls, nucleus slightly submerged, first two whorls smooth, third faintly axially striate. TELEOCONCH nine whorls, first six medially angulate, next two convex, spire slightly convex. SUTURES lightly impressed, faintly margined. SCULPTURE of strong medial cord on first six whorls, accompanied by several minute lirae, which flatten out to become rather obsolete, mostly towards centre of whorls, and show through shell into aperture. APERTURE sub-quadrate, columella straight, inner lip reflected at base; outer lip thin with a slight overall concavity. BASE of shell smooth and rounded. COLOUR transparent to translucent white. OPERCULUM if any unavailable.

Type locality: Neptune Island, South Australia, 35 miles south-west, 104 fathoms (190 metres).

Dimensions: Holotype, length 6 mm, breadth 1.4 mm, South Australian Museum, Adelaide, Reg'd. No. D.13428.

Distribution: From north of Cape Moreton, southern Queensland, through New South Wales and Victoria to South Australia, in depths ranging from 115 to 550 metres.

Material: Holotype, several paratypes and a number of other specimens from three State Museums.

Discussion: The resemblance of this species to *K. kimberi,* as noted by the author in his original diagnosis, is further emphasized by the presence of axial striations on the third whorl of the protoconch. This feature has been noted in discussion of a specimen of *K. kimberi* which precedes this species. Although *K. kimberi,* so far as known at present, appears to be confined to South Australia, the within species is far more widespread as shown above.

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INDEX TO SPECIES

Valid names are in italics.

Fossil species and synonyms are preceded by an asterisk.

NEW SPECIES AND RECORDS OF VOLUTIDAE (GASTROPODA) FROM WESTERN AUSTRALIA

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Plates 31 - 33

ABSTRACT

Four new deep water species of volutid genera *Amoria*, *Notovoluta*, *Notopeplum* and *Volutoconus* are described from the central west coast of Western Australia. Another species of *Notovoluta*, previously described as a south eastern Australian Miocene fossil, is recorded living on the outer part of the continental shelf, also off the central west coast of Western Australia. The relationships and temporal and geographic distributions of all five species are discussed.

Notovoluta occidua Cotton, 1946 is removed from synonymy with *N. verconis* Tate, 1892; but *Notovoluta rossiteri* (Brazier, 1898) is considered to be a junior subjective synonym of *N. kreuslerae* Angas, 1865.

INTRODUCTION

Biological exploration of the long and varied coastline of Western Australia began in the 17th century with the visit of William Dampier to the northern shores in 1699. Subsequently many new marine species of molluscs and other animals were described by European scientists from specimens collected by British, French and German exploratory expeditions. (For a historical summary see Alexander, 1916.) Some Western Australian material has been described by conchologists of the eastern states of Australia in more recent years, but no comprehensive collection of the molluscan fauna of this large State has ever been made. It is not surprising then that recent field activity in the region has already produced a large number of undescribed species and unexpected locality records. This is especially true of the fauna from deeper water on the outer edge of the Western Australian continental shelf. Even in a family as well studied as the Volutidae many new discoveries have been made, so that in this paper it is possible to describe no less than 4 new species. More may be expected as field activities continue.

Zoogeographers studying shallow water marine faunas have shown that the central Western Australian coast from North West Cape to Cape Leeuwin is a zone of overlap between the tropical ("Indo-West Pacific") fauna of the north and the temperate ("Flindersian") fauna of the south (Kott, 1952; Wilson & Gillett, 1971). In the vicinity of Perth the shallow water molluscan fauna is composed of almost equal numbers of northern and southern species (Wilson & Hodgkin, 1967; Wilson & Gillett, 1971). My unpublished observations on the fast-growing collections of the Western Australian Museum suggest that the benthic fauna of the outer part of the continental shelf in the same region has a similar proportion of northern and southern representatives (although the species concerned are mostly different from those of the shallows). One surprise, however, is the number of deep water west coast species which have their ancestral affinities with ancient autochthonous Tertiary groups of south-eastern

Australia. In the Volutidae, the species of *Notovoluta, Notopeplum* and *Volutoconus* described here have such affinities. It is hoped that future opportunities will arise to describe other groups which have similar affinities and to discuss this matter more fully. In the meantime the following data and descriptions are given in the hope that they may stimulate and facilitate interest in the subject and in the taxonomy and zoogeography of Australian Volutidae.

The abbreviation WAM used in this paper stands for Western Australian Museum.

DESCRIPTIONS

Genus *AMORIA* Gray, 1855

1855 *Amoria* Gray, *Proc. Zool. Soc. Lond. 1855*: 64. Type species (subsequent designation, Harris, 1897): *Voluta turneri* Griffith and Pidgeon, 1834.

DISTRIBUTION: The genus is confined to the continental shelves of Australia except for two species which extend to the islands of eastern Indonesia i.e. Tanimbar, Kai and Aru (Wilson, unpublished data). A fossil species is known from Pliocene rocks of South Australia.

REMARKS: The taxonomy of the genus has been discussed in detail by Ludbrook (1953), McMichael (1964), and Weaver and du Pont (1970). The most important diagnostic characters are a smooth and glossy elongate ovate shell and smooth multispiral obtusely conical protoconch, and a uniserial radula with Y-shaped unicuspid teeth. Weaver and du Pont (1970) list 13 species as members of the subgenus *Amoria* s.s. Of these 5 are found in Queensland waters, 4 are found only in Western Australia and Northern Territory waters, 2 are common to the north west and north east coasts, and 2 *(A. jamrachi* Gray, 1864; *A. praetexta Reeve,* 1849) live on the coasts of North Western Australia, Northern Territory and the south eastern islands of Indonesia (Wilson, unpublished data).

Most of these species are confined to the tropical waters of the northern coast of the continent, although two of them, *A. grayi* Ludbrook (1953), and *A. damonii* Gray (1864), range well south into the warm temperate waters of the west coast of Western Australia. The new species described here makes the total in the subgenus 14, and is the only one confined to subtropical and temperate waters.

Amoria (Amoria) diamantina sp. nov.

Pl. 31, fig. 1-4.

Type locality: CSIRO station 208, 27°40'S, 113°20'E, west of Bluff Point, Geraldton, Western Australia, depth 130 m, associated organisms in trawl net "sponge, bryozoa, molluscs and crustacea"; bottom water temp. 19.83°C.

Type series: Holotype: Adult shell with body preserved, WAM. 142-64, taken in a beam trawl by CSIRO aboard HMAS "Diamantina", cruise DM 6/63, 10th Oct. 1963.

Paratypes: All from Western Australia and lodged in the collection of the Western Australian Museum.

WAM.N4454, piece, NNW of Rottnest I., 114 m, sponge and sand, B. R. Wilson on "Bluefin", 15.VIII.62

WAM.4685-68, adult shell, SW of Rottnest I., 146 — 154 m, B. R. Wilson on "Bluefin", 17.IX.65

WAM.663-71, adult shell, W of West End, RottnestI., 146 m, B. R. Wilson on "Bluefin", 16.IX.65

WAM.N4331, 3 pieces, NW of Rottnest I., 183 — 189 m, sponges and sand, B. R. Wilson on "Bluefin", 14.VII.62

WAM.664-71, adult shell, W of West End, Rottnest I., 178 — 183 m, B. R. Wilson on "Bluefin", 16.IX.65

WAM.665-71, juv. shell, NW of Rottnest I., 146 m, sand, bryozoa and sponge, B. R. Wilson on "Bluefin", 15.IX.65

WAM.N4356, 2 juv. shells, NW of Rottnest I., 156 m, sponge and sand, B. R. Wilson on "Bluefin", 15.VIII.62

WAM.N4303, adult shell, WNW of Rottnest I., 173 — 175 m, sponge and sand, B. R. Wilson on "Bluefin", 14.VIII.62

WAM.144-64, adult shell, W of Rottnest I., 32°00'S : 115°116'E, 137 — 142 m, with fish and shells, no sponges, bottom water temp. 17.74°C, CSIRO Stn 225, HMAS "Diamantina" cruise DM 6/63, 12.X.63

WAM.626-71, adult shell and body preserved, W of West End, Rottnest I., 178 — 185 m, B. R. Wilson on "Bluefin", 12.VIII.62

WAM.133-64, adult shell and body preserved. W of Rottnest I., 32°S : 115°16'E. 137 — 143 m, with fish and shells, no sponge, bottom water temp. 17.34°C, CSIRO Stn 225, HMAS "Diamantina" cruise DM 6/63, 12.X.63

WAM.666-71, adult shell. NW of Green I., 30°38'S : 114°46'E, 146 m, CSIRO Stn 41, HMAS "Diamantina" cruise DM 1/70, 27.XI.70

WAM.141-64, adult shell and body preserved. W of Dirk Hartogs I., 25°31'S : 112°20'E, 133 m, bottom water temp. 19.52°C, CSIRO Stn 200, HMAS "Diamantina" cruise DM 6/63, 9.X.63

WAM.147-64 and 148-64, 3 juv. and 2 adult shells. W of N.W. Cape, 21°49'S : 113°56'E, 122 — 128 m, bottom water temp. 23.18°C, CSIRO Stn 24, HMAS "Diamantina" cruise DM 1/64, 1.II.64.

Distribution: At depths from 119-188 metres between North West Cape and Rottnest Island, Western Australia (between latitudes 21°48'S and 32°S).

Description of the holotype shell: Shell elongate-ovate; spire of moderate height (ratio spire height to total height 0.27), conical, with a blunt apex; protoconch of 4 smooth glossy whorls with slightly convex sides; teleoconch of 2½ smooth glossy whorls; sutures narrow and very shallow; outerlip rather straight, strong and slightly thickened; aperture elongate and rather narrow; anterior siphon canal rather narrow, deep, U-shaped and only slightly oblique; parietal wall and columella almost straight, columella with 4 strong flat-topped oblique plaits; anterior fasciole very low but well defined by change of pattern of the growth lines and demarcated by a weak obliquely spiral ridge which is a continuation of the most posterior columellar plait, similar weak obliquely spiral ridges on the fasciole represent continuations of the second and third columellar plaits; protoconch whorls pale pink to grey with a faint whitish line in the sutures; teleoconch whorls light apricot (pink) with a spiral row of small distinct V-shaped brown marks in the sutures, a pale brown spiral band immediately behind the sutures, and two central spiral bands of short thin, rather straight brown lines around the body whorl; interior white. Measurements: total shell height 55.2 mm, spire height 14.6 mm, width 22.0 mm.

Variations of shell characters: There is little variation in the paratypic series. Colour and markings are quite consistent except for a few cases where some adjacent axial lines coalesce. Data on measurements and number of whorls for the type series of the new species and for *A. grayi* are given in Table 2.

Anatomy: The radula and soft parts of the holotype remain intact and have not been examined. Nor have detailed anatomical notes on the preserved paratypes been attempted. The preserved specimens in the paratype series have all faded and little colour remains. From colour slides of living specimens it is evident that the pattern is very like that of *A. grayi*, i.e. ground colour cream or pinkish with radial red lines on the foot and transverse red bands around the siphon and eye stalks. But the lines and bands in *A. diamantina* are much narrower than they are in *A. grayi.*

Radula (of paratype WAM.626-71): Uniserial with Y-shaped teeth. No significant differences were observed between this radula (Fig. 1-E) and one taken from a specimen of *A. grayi* (WAM.625-71). (See also the figure of an *A. grayi* radula in Weaver and du Pont, 1970, p. 153, Fig. 34.)

Differential diagnosis: The shape of the nucleus, number of protoconch whorls, and colour pattern of the body whorl are the most useful characters differentiating between *A. diamantina* and its sympatric congeners *A. grayi* Ludbrook, 1953 and *A. damonii* Gray, 1864 (Table 1).

TABLE 1.

Diagnostic characters of *A. diamantina, A. grayi* and *A. damonii.*

Species	Nucleus	Body whorl colour and pattern
A. diamantina	blunt	Uniformly pale apricot except for two spiral zones of short, thin, rather straight, regularly spaced, brown axial lines.
A. grayi	pointed	Ground colour variable, cream, white, buff or dun, sometimes with two central brown spiral bands, axial lines when present zigzag, irregularly spaced, and not confined within the spiral bands in adults.
A. damonii	blunt	Ground colour variable, pink, ivory, cream, white or fawn, with a pattern of reticulate chocolate or chestnut brown lines and usually two central spiral zones of blotches or crowded reticulate lines.

Remarks: This new species has the large, smooth, and conical protoconch of the subgenus *Amoria* s.s. Two other species of this group, *A. grayi* and *A. damonii,* live in the same region of the Western Australian coast as the new species although both have a much wider range than *A. diamantina. A. grayi* extends from Geographe Bay in the south west of Western Australia to Cambridge Gulf, Northern Territory (Weaver & du Pont, 1970: 154). In past times this species reached as far east as South Australia, for it is recorded from Pliocene fossil beds in that State (Ludbrook, 1958: 75-76) thus representing a significant penetration of

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PLATE 31.

Fig. 1. *Amoria diamantina* sp. nov. Holotype; WAM.142-64, west of Bluff Point, Geraldton, W.A., 146 m.

Fig. 2-4. *Amoria diamantina* sp. nov. Paratype; WAM.4685-68, southwest of Rottnest I., W.A., 146-154 m.

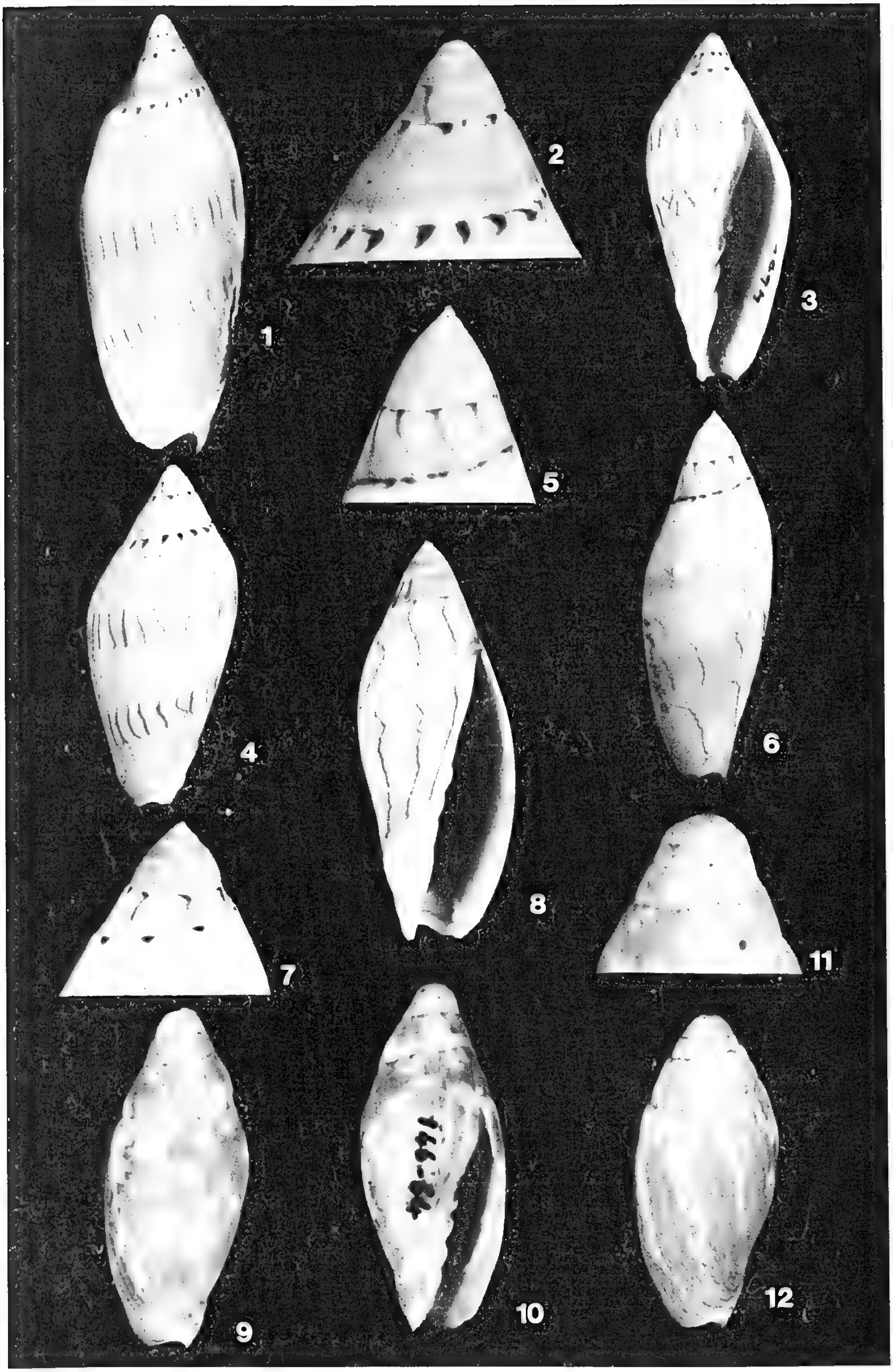
Fig. 5-6. *Amoria grayi* Ludbrook, 1953; WAM.649-71, northwest of Rottnest I., W.A., 146 m.

Fig. 7-8. *Amoria grayi* Ludbrook, 1953; WAM.658-71, Rosemary I., Dampier Archipelago, W.A., intertidal.

Fig. 9-11. *Volutoconus capricorneus* sp. nov. Holotype; WAM.146-64, west of Point Cloates, W.A., 133 m.

Fig. 12. *Volutoconus capricorneus* sp. nov. Paratype; WAM.774-71, west of Point Cloates, W.A., 133 m.

Whole shells approximately x 1½, spires approximately x 3.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a tropical northern species into southern Australian waters. *A. damonii* ranges from Fremantle, Western Australia to North Queensland.

A. diamantina tends to occupy a different depth zone to *A. damonii* and *A. grayi* which live in relatively shallow water, even on intertidal sand flats, and rarely occur below 128 metres. *A. diamantina* appears to be confined to the outer part of the continental shelf, 114 metres being the shallowest record.

A. damonii is a variable species (Weaver & du Pont, 1970: 151-152), but the colour patterns of the species are characteristic and the shells cannot be confused with *A. diamantina.* The nucleus of *A. damonii* is blunt like that of *A. diamantina,* but the protoconch is much larger and consists of about 5 whorls.

A. grayi is also a variable species, especially in shell coloration. For some time it was considered hat *A. diamantina* might be only a deepwater ecomorph of *A. grayi,* but this was difficult to reconcile with the consistency of the colour pattern and protoconch characters, the absence of intermediate forms in intermediate depths, and the wide distribution of the deepwater form from North West Cape to Rottnest Island. Doubts were dispelled by the discovery of two specimens of typical *A. grayi* within the depth zone of *A. diamantina,* one of these (WAM 649-71, Pl. 31, figs. 5-6) taken in the same dredge haul as a typical *A. diamantina* (WAM 665-71). It is now confidently concluded that *A. grayi* and *A. diamantina* are two very closely related but distinct species generally occupying different depth zones on the mid western continental shelf, but occasionally occurring together in the 114 to 146 metre zone.

The two primary characters which differentiate between *A. diamantina* and *A. grayi,* i.e. the shape of the protoconch nucleus and the colour and markings on the body whorl, are summarized in the differential diagnosis.

In *A. diamantina* the protoconch is conical but blunt at the apex like most other species of the genus. *A. grayi* is exceptional in that the protoconch terminates in a sharp, pointed apex. This character is quite consistent. There also tend to be slightly fewer protoconch whorls in *A. diamantina* (Table 2).

The ground colour of the teleoconch whorls varies in *A. grayi* (Table 1). While adults in northern populations tend to have rather uniformly coloured shells, southern specimens (from the Fremantle and Geographe Bay areas) consistently have two wide spiral brown bands (Pl. 31, fig. 6). In juvenile specimens throughout the species range there are usually wavy axial brown lines (Pl. 31, fig. 8) and, in southern juvenile specimens, these may be broken with irregular axial lines concentrated within the two spiral brown bands (Pl. 31, fig. 6). But such axial markings rarely persist on the adult body whorl and when they do they are sparse and irregular. In *A. diamantina* the body whorl is always uniformly apricot pink with two spiral zones of short, rather straight and regularly spaced brown axial lines.

Other differentiating characters are less consistent. The brown V-shaped sutural marks tend to be distinct and regular in *A. diamantina* and often indistinct and irregular in *A. grayi.* The light brown subsutural band on the teleoconch whorls is usually strongly developed in *A. grayi* but always very weak in *A. diamantina.*

TABLE 2.

Comparison of meristic data for *A. grayi* and *A. diamantina.*

	Total Shell Height (adult)		Total no. of whorls (adult)	No. Protoconch whorls	$\frac{\text{Spire height}}{\text{Total height}}$		Protoconch height	
	Mean cm	Range cm			Mean	Range	Mean cm	Range cm
A. grayi								
(a) Maud Landing populations (10 specimens)	4.78	4.50-5.70	6-6½	4-4¼	0.27	0.22-0.32	0.53	0.41-0.66
(b) Other populations (15 specimens)	7.42	6.25-8.88	6-7	4-4½	0.27	0.25-0.29	0.71	0.56-0.81
A. diamantina (16 specimens)	4.66	3.78-5.51	5½-6¼	3½-4	0.27	0.26-0.29	0.45	0.35-0.49

A summary of meristic data for these two species is given in Table 2. In the Maud Landing area, about 120 miles north of Carnarvon, specimens of *A. grayi are* "dwarf" (see also Weaver & du Pont, 1970: 154) and it is convenient for these to be considered separately when making comparisons with *A. diamantina.* The adult size range of the new species is comparable to that of the Maud Landing *A. grayi* dwarfs.

Protoconch height in *A. diamantina* throughout its whole geographic range is considerably less than that of *A. grayi* throughout its range, with the exception of the abnormal Maud Landing *A. grayi* population. The ratio of spire height to total shell height, however, is similar and consistent in the two species (Table 2).

There is no other described species of *Amoria* with which *A. diamantina* may be confused (see descriptions and illustrations in Weaver & du Pont, 1970.) I am pleased to name the new species after HMAS "Diamantina," the vessel responsible for securing a great amount of new and interesting material from the outer part of the Western Australian continental shelf.

Abbreviated list of *A. grayi* specimens examined and compared with the new species (only adult shells used for measurements):

WAM.N1986, Busselton; WAM.N1950, Busselton; WAM.N2338, Dunsborough; WAM.N2339, Quindalup; WAM.N4190, off Garden I., 18 m; WAM.9857 and 122-65/7, Cottesloe; WAM.647-71, Kwinana, Cockburn Sound; WAM.43-60, Jervoise Groyne, Cockburn Sound, 5.5 m; WAM.648-71, NE of Rottnest I., 36 m; WAM.N4418, piece, NW of Rottnest I., 155-163 m; WAM.649-71, NW of Rottnest I., 146 m; WAM.651-71, Cervantes I., 110 m; WAM.625-71, [illegible] preserved specimens, radula examined, 22 ml N of Maud Landing, intertidal; WAM.653-71, 10 shells, 1 ml S of Maud Landing, intertidal; WAM.145-64, W of Pt Cloates, 129 m; WAM.812-71, Thevenard I., intertidal; WAM.658-71 and 659-71, Rosemary I., intertidal; WAM.1-61, off Delambre I., 37 m; WAM.811-71, Port Hedland, intertidal; WAM.662-71, Broome, intertidal.

Genus *VOLUTOCONUS* Crosse, 1871

1871 *Voluta (Volutoconus)* Crosse, *J. de Conch.* (3), *19*: 306. Type species (by monotypy) *Voluta coniformis* Cox, 1871.

Distribution: Living species occur in Northern Australia from about latitude 31°S in Western Australia to Port Macquarie in N.S.W., the islands of south eastern Indonesia, and the south coasts of West Irian and Papua. Two fossil (Miocene) species considered to belong to this genus occur in Victoria.

Remarks: Shells of the four described living species are moderately large, solid, with 4 or more strong columellar plaits. The most characteristic feature is a small spine-like structure called a "calcarella" on the protoconch. The radula, where known, is uniserial with large tricuspid teeth on which cusps are strongly arched (Abbott, 1958, Figs. 1-2). Sculpture and spire height vary between the species.

For a full account of the genus see Weaver and du Pont (1970: 133-138, pls. 61-62), and Wilson and Gillett (1971: 134-136, pls. 89-90).

Tate (1888) described two Miocene fossil volutes from Victoria and suggested that they may be the ancestors of modern *Volutoconus*. Finlay (1930: 44) and Darragh (1970: 178, 191) have since used that generic name for them. The two species are now known as *Volutoconus limbata* (Tate, 1888) and *Volutoconus ralphi* Finlay, 1930 (=*Voluta conoidea* Tate, 1888). Both are small species which lack a protoconch calcarella and their relationship to the modern *Volutoconus* species rests on their similarity in shape, columella, and solidarity.

The new species described here is provisionally assigned to *Volutoconus*, mainly because of its close resemblance to the fossil "ancestral" species.

Volutoconus capricorneus sp. nov.

Pl. 31, fig. 9 - 12

Type locality: CSIRO station 17; 22°59'S : 113°25'E; W of Point Cloates, W.A.; 133 m; associated organisms "sponges, crabs, etc.", bottom water temp. 21.88°C.

Type series: Two "dead" shell specimens taken in the same beam trawl haul by CSIRO aboard HMAS "Diamantina" cruise DM 1/64, 31st Jan. 1964. HOLOTYPE WAM. 146-64; PARATYPE WAM. 774-71.

Description of the holotype: Shell small, unusually solid, elongate-ovate, with 4 protoconch and 3 teleoconch whorls. Spire rather high (ratio spire height to total shell height 0.38); protoconch smooth large dome-shaped with a central nucleus; sutures well defined but not deeply indented. Teleoconch whorls rounded with only weakly developed shoulders; first teleoconch whorl with very weak axial folds, penultimate whorl with 11 low axial folds which tend to form weak nodules at the shoulder, body whorl with 5 weak axial folds at the shoulder on the ventral and left sides but lacking these on the dorsal and right sides; teleoconch whorls smooth except for fine growth lines and minute wavy spiral striae. Aperture narrow, elongate-elliptical; anterior canal moderately broad and deep, oblique, U-shaped; anterior fasciole short and low but well developed; columella calloused, with 4 strong, oblique plaits, of which the first and second are stout rounded and the third and last are rather more angulate and narrow; a prominent spiral cord on the parietal wall may represent a fifth columellar plait. Protoconch cream, teleoconch pale orange with numerous tent-shaped pinkish white markings of varing size, with a few thin short wispy orange-brown lines on the sutural ramp of the body whorl arising from the sutures, columella tawny, especially at the anterior end, columellar plaits white, deep interior pinkish white becoming pale orange toward the lip and tawny toward the anterior end.

Measurements:

	Total Shell Height	Spire Height	Width
Holotype (WAM. 146-64)	3.72 cm	1.43 cm	1.60 cm
Paratype (WAM. 774-71)	3.42 cm	1.12 cm	1.56 cm

Paratype: The single paratype resembles the holotype except for the following small differences. It has only 6½ whorls, the spire is lower (spire height : total shell height ratio 0.33), and there is a shallow sulcus around the sutural ramp of the body and penultimate whorls making the shoulders slightly more pronounced. The wispy sutural lines and axial folds on the teleoconch whorls are rather more numerous than in the holotype.

Remarks: At first glance the type specimens might be taken for juvenile *V. hargreavesi* (Angas, 1872) or *V. coniformis* (Cox, 1871). The known geographic range of *V. hargreavesi* is from Wedge Island to the Dampier Archipelago, Western Australia and the type locality of the new species lies within this range. *V. coniformis* is found further north (Nickol Bay to Broome). Both species are much larger than *V. capricorneus,* minimum recorded shell height of adults being 6 cm in *V. coniformis* and 7.5 cm in *V. hargreavesi.* The protoconch is much smaller in *V. capricorneus* although the number of protoconch whorls is about 4 in all three species. A calcarella is usually prominent in *V. hargreavesi,* very small in *V. coniformis,* and absent in *V. capricorneus.* The protoconch is smooth in *V. capricorneus,* smooth or axially lirate in *V. hargreavesi,* and axially lirate in *V. coniformis.* The teleoconch whorls are weakly axially lirate and spirally striate in *V. capricorneus,* smooth or axially lirate in *V. hargreavesi,* and very finely striate both axially and spirally in *V. coniformis.*

Apart from these differences the shell characters of the new species match those of the Recent species of *Volutoconus* quite well, but because of the lack of a calcarella its assignment to that genus must remain provisional. Lack of a calcarella in the two similarly small Miocene species *V. ralphi* and *V. limbata* lends support to the placement of *V. capricorneus* in *Volutoconus,* although the generic position of all three species may well be questioned. Study of the soft parts of *V. capricorneus* may do much to resolve this matter when living specimens are discovered.

The specific name of this new species alludes to the proximity of the type locality to the Tropic of Capricorn.

Genus *NOTOVOLUTA* Cotton, 1946

1946 *Notovoluta* Cotton, *S. Aust. Nat. 24* (1): 15. Type species (by original designation.): *Voluta kreuslerae* Angas, 1865.

Distribution: Living on the continental shelf of southern Australia from Victoria and South Australia to the south coast of Western Australia, and here also recorded from the mid west coast of Western Australia as far north as Geraldton. Fossil species known from the Miocene of Victoria.

Remarks: The original diagnosis of *Notovoluta* given by Cotton (1946: 15-16) and the slightly amplified version given by Weaver and du Pont (1970: 167-168) are adequate to characterize the genus. The most useful diagsostic characters are the high spire with a smooth, dome-shaped ("papilliform") protoconch and axially plicate early teleoconch whorls, and the 4 strong, oblique, columellar plaits.

In addition to the type species, Cotton (1946) included the Victorian species *rossiteri* Brazier, 1898, the South Australian species *verconis* Tate, 1892 and the Western Australian species *occidua* Cotton, 1946 in the genus *Notovoluta.* Subsequently, Cotton (1949, 1957) added the Queensland and south west Pacific species *thatcheri* McCoy, 1868 and *perplicata* Hedley, 1902 but Weaver and du Pont (1970) pointed to the small, radially ribbed, conical protoconchs and the numerous columellar plaits of these tropical species and concluded that they are not congeneric with the southern Australian species of *Notovoluta.* This conclusion seems reasonable, although the relocation of *perplicata* and *thatcheri* to *Cymbiolacca* Iredale, 1929 may need further consideration. Weaver and du Pont (1970) accept *rossiteri* as a distinct species but the unique holotype is certainly only a large specimen of *N. kreuslerae.*

For comparison with the species described and recorded here the protoconchs and early teleoconch whorls of *thatcheri, kreuslerae, verconis* and *occidua* are illustrated (Pl. 32).

Weaver and du Pont (1970) placed *occidua* into the synonymy of *verconis* on the grounds that "the only apparent differences between it and the more easterly *Notovoluta verconis* are that the shell is somewhat narrower with a longer spire". After examination of the holotype (Pl. 32, Figs. 8-9) I disagree with that opinion for, in addition to these differences, the type has strong axial costae, a smaller protoconch, and lacks the angulate shoulders characteristic of *verconis. Notovoluta occidua* seems to be closely related to *N. pseudolirata* and may later prove to be a subspecies of it. *Notovoluta occidua* is known from 64 metres off Hopetoun (type locality) and 137-183 metres west of Eucla (Verco, 1912: 224), both localities on the south coast of Western Australia.

Several Tertiary fossil species of *Notovoluta* are known. Two of them, *pseudolirata* Tate, 1888, and *cathedralis* Tate, 1888 occur in the Middle Miocene (Balcombian) of Victoria. A third Victorian Miocene fossil species, *sarissa* Tate, 1889, is sometimes referred to *Notovoluta* but it has a large conical protoconch and Darragh (1970: 193) placed this species in *Alcithoe.* Another fossil species of *Notovoluta,* as yet undescribed, occurs in the rich early Pleistocene shell beds of the Roe Plain on the south east coast of Western Australia (pers. comm. Dr N. H. Ludbrook).

The discovery of *N. pseudolirata* and the related new species of *Notovoluta* living off the central west coast of Western Australia considerably extends the known distribution of the genus. The survival of *N. pseudolirata* from the Miocene to the present is also of great interest.

Volutidae

Notovoluta pseudolirata Tate, 1888

Pl. 32, fig. 4 - 7.

1888 *Voluta pseudo-lirata* Tate, *Trans. R. Soc. S. Aust.*, 10: 176, pl. 13, fig. 6; 1889, *ibid.*, 11: 131.

Type locality: "lower beds at Muddy Creek", Victoria (Middle Miocene). Holotype: South Australian Museum, Adelaide, Tate Collection (ex Geology Department, University of Adelaide) regn no. T 608 specimen C.

Description: Shell rather solid, elongate, fusiformly cylindrical. Protoconch dome-shaped with 2½ smooth whorls and a central nucleus; teleoconch of 5 whorls. Sutures prominent but not deeply excavated. Spire height about or slightly less than half the total shell height. Anterior fasciole usually weak, anterior canal short, moderately broad and shallow, oblique. Aperture narrow, outer lip sharp, slightly patulous anteriorly, elliptical; columella nearly straight, bearing 4 strong, vertical plaits which cross the columella at a slight angle, the anterior plait is the smallest of the 4; there may be an additional spiral cord or very weak 5th plait posteriorly on the parietal wall. First to fourth teleoconch whorls with convex sides, ornamented with strong axial costae, 18-21 on the first teleoconch whorl, 17-23 on the on the second, 13-18 on the third, and 11-14 on the fourth; body whorl with up to 12 axially elongate angular nodules or short axial costae at the shoulders or on the posterior 1/3 of the whorl excluding the sutural ramp (nodules sometimes confined to the ventral and left sides of the body whorl). External surface smooth except for minute spiral striae, glossy, cream with a pale pink or orange band around the sutural ramp, a spiral row of small orange-brown spots in the sutures, usually another spiral row of orange-brown spots just anterior to the centre of the body whorl, and sometimes two wide spiral bands of very faint orange-brown reticulate markings. There is a tiny light brown spot at the nucleus of the protoconch. Interior cream.

Measurements:

	Total height cm	Width cm	Spire height cm	Spire height / Total height
WAM.131-64	5.98	2.06	2.90	0.49
WAM.130-64	6.14	2.22	3.08	0.50
WAM.471-71 (juv.)	4.55	1.60	2.22	0.48
WAM.470-71	5.40	1.91	2.37	0.44

Fossil records: Middle Miocene (Balcombian) at Muddy Creek, Hamilton, and Schnapper Point, Mornington, Victoria.

Recent records:

WAM.130-64 (1 adult shell) and WAM.131-64 (1 adult shell), beau trawl 137—143 m. west of Rottnest I., Western Australia, lat. 32°00'S, long. 115°16'E, CSIRO Cruise DM 6/63, HMAS "Diamantina", stn 225, 12.X.63; WAM.471-71 (1 whole juv., 1 piece adult), dredged, 146 m, sand/bryozoa/sponge, North West of Rottnest I., Western Australia, B. R. Wilson on "Bluefin", 15.IX.65; WAM.N4351 (1 spire of juv.) dredged, 156 m, sand and sponges, North West of Rottnest I., Western Australia, B. R. Wilson on "Bluefin", 15.VIII.62; WAM.N4259 (1 broken piece), dredged 200 — 214 m, sand and sponge, North West of Rottnest I., Western Australia, B. R. Wilson on "Bluefin", 14.VIII.62; WAM.N4192 (4 broken pieces), dredged at various depths 146 — 189 m, N.N. West of Rottnest I., Western Australia, B. R. Wilson, 14.VIII.62; WAM.470-71 (1 whole adult shell), dredged, 146 m, sand/sponge/bryozoa, North West of Rottnest I., Western Australia, B. R. Wilson on "Bluefin", 15.IX.65.

Remarks: The number of axial costae on the early teleoconch whorls and the development of nodules or short costae on the body whorls are rather variable in this species. Also there is some variation in the development of the anterior fasciole. In one Rottnest I. specimen (Pl. 32, Fig. 7, WAM 470-71) the anterior fasciole is quite strong, the spire is relatively low, and the shell is more cylindrical than fusiform, although in other characters it fits the rest of the Recent series.

Use of the name *pseudolirata* Tate, 1888 for these Recent specimens from the outer part of the western continental shelf may be regarded as dubious by some in view of the 12 million years and 2 thousand miles which separate them from the type material. But, having compared the Western Australian Recent series with fossil material in the National Museum of Victoria, I can find no morphological characters by which they can be differentiated. Since neither temporal nor geographical distance is an acceptable taxonomic character there is no alternative but to consider the fossil and Recent specimens conspecific.

The facies of the type locality is that of a deepwater muddy or silty environment (Mr T. A. Darragh, pers. comm.). The habitat from which the Recent specimens were taken is similar depthwise although the substrate consists of fine sand. The fact that *N. pseudolirata* is not recorded from Pliocene or Pleistocene shell beds may be because most southern Australian shell beds of those periods represent shallow water facies. More curious is the apparent absence of the species at the present time from the outer continental shelf of the southern Australian coast where considerable dredging has been done by Sir Joseph Verco and others. Future dredging in that region may yet prove the presence of the species there but the indications so far are that, some time since the Miocene, *N. pseudolirata* has become restricted to the outer continental shelf off the mid west coast of Western Australia.

The nearest fossil relative of *N. pseudolirata* is *N. cathedralis* Tate, 1888 which is also found in the lower beds at Muddy Creek. It is more slender than *N. pseudolirata*, the posterior slope is spirally lined and the whorls bear tubercles not costae at the shoulders.

Of the living species of *Notovoluta*, the nearest relative of *N. pseudolirata* may be the new species *N. baconi* which lives in similar depths a little further north. Distinguishing characters are given in the discussion of *N. baconi*. Another close relative is *N. kreuslerae*. That species has similar markings including sutural spots and a tiny spot on the protoconch nucleus, but the shell is much larger, broader, with a strongly developed anterior fasciole and angulate shoulders bearing prominent pointed nodules, and the axial costae on the early teleoconch whorls are poorly developed (Pl. 32, fig. 13). The south coast species *N. occidua* is also similar but may be distinguished by the even narrower shell, very strong axial costae, and smaller protoconch (Pl. 32, fig. 8-9). Further study may show that *N. occidua* is merely a southern subspecies of *N. pseudolirata*. *N. verconis* from South Australia is quite distinctive for it has a rather small, stout, fusiform shell with broad angulate shoulders, heavy shoulder nodules, and a small protoconch (Pl. 32, fig. 10). It may be noted that the faint reticulate pattern on *N. pseudolirata* is very like that of *N. ver-*

PLATE 32.

Fig. 1-3. *Notovoluta baconi* sp. nov. Holotype; WAM.1565-70, west of Wedge I., W.A., 128-146 m.

Fig. 4-6. *Notovoluta pseudolirata* Tate, 1888; WAM.131-64, west of Rottnest I., W.A., 137-143 m.

Fig. 7. *Notovoluta pseudolirata* Tate, 1888; WAM.470-71, northwest of Rottnest I., W.A., 146 m.

Fig. 8-9. *Notovoluta occidua* Cotton, 1946, Holotype, South Australian Museum Reg. No. D 14500, Hopetoun, 54 m.

Fig. 10-12 *Notovoluta verconis* Tate, 1892; WAM.776-69, Yankalilla Bay, St Vincent's Gulf, S.A., 24 m.

Fig. 13. *Notovoluta kreuslerae* Angas, 1865; South Australian Museum Reg. No. D 440, Backstairs Passage, S.A.

Fig. 14. *Cymbiolacca thatcheri* McCoy, 1868; WAM.786-71, Bampton Reef, Qld.

Whole shells and Figures 13-14 approximately x 1½, spires approximately x 4.


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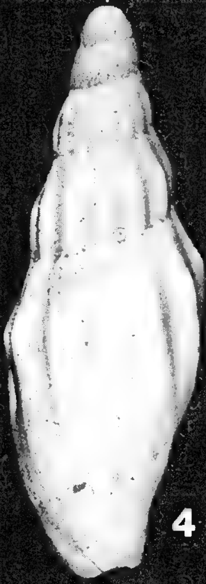
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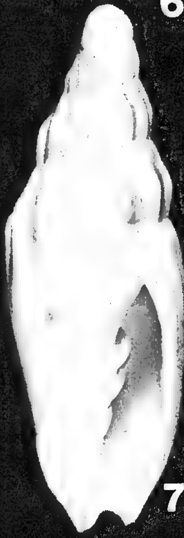
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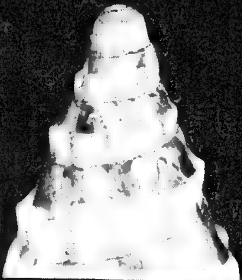
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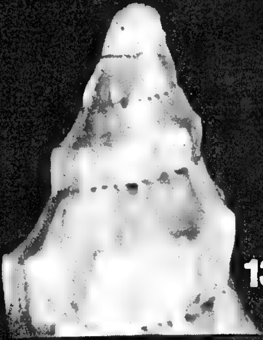
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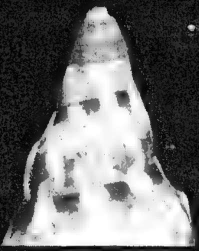
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conis, although the latter species lacks sutural spots and the brown spot on the protoconch nucleus.

Notovoluta baconi sp. nov.

Pl. 32, fig. 1 - 3.

Type locality: 128-146 m west of Wedge Island, Western Australia (approx. lat. 30°50'S, long. 114°55'E).

Type series: Holotype: A whole but "dead" shell taken from a rock lobster pot by Mr Al Bacon; now in the collection of the Western Australian Museum, WAM.1565-70.

Paratype: A single broken paratype dredged by the Hawaiian-W.A. Expedition, 146 m, 10 miles N.W. Zeewyck Channel, Houtman Abrolhos [Islands], Western Australia, May 12, 1960; WAM.41-60.

Description of the holotype: Shell solid, elongate, fusiform to cylindrical. Protoconch dome-shaped and broad, smooth, consisting of 2½ whorls. Spire height slightly less than half the total shell height. Teleoconch consisting of 5 axially plicate whorls including the body whorl, plicae on first teleoconch whorl too indistinct to be counted, 14 plicae on second teleoconch whorl, 18 on the third, 19 on the fourth and 12 plus on the body whorl; axial plicae on the ventral and left sides of the body whorl strong and extend as far anteriorly as the columellar callus, those on the right side near the lip are weak and indistinct; body whorl with numerous axial plicae on the ventral and left sides extending as far anteriorly as the columellar callus, plicae much reduced on the right side near the lip. Whorls slightly convex, lacking shoulders. Aperture elongate, broad anteriorly, narrowing to an acute angle posteriorly; lip sharp-edged, slightly patulate anteriorly. Anterior canal rather deep, broad and obliquely U-shaped; anterior fasciole moderately broad and strong. Columella almost straight, bearing 4 thick and high oblique plaits of which the first (most anterior) is the smallest and the third and fourth the largest, an additional thin oblique spiral cord present on the parietal wall may represent a fifth plait. Exterior cream with a few small and faint orange-brown spots in the sutures, a spiral band of large orange-brown squarish blotches around the sutural ramps of all the teleoconch whorls, a spiral band of similar blotches around the anterior part of the body whorl, and a spiral band of small irregular orange-brown blotches around the centre of the body whorl; interior white.

Variations: The single paratype is a broken specimen lacking most of the body whorl. The axial plicae on the first teleoconch whorl are too indistinct to be counted, there are 15 on the second teleoconch whorl, 16 on the third, 15 on the fourth, 12 plus on the body whorl. Colour pattern like that of the holotype. Columellar plaits like those of the holotype, except for the parietal cord which is much stronger.

Measurements:

	Total height mm	Width mm	Spire height mm	Spire height / Total height
Holotype WAM.1565-70	63.9	22.9	30.3	0.48
Paratype WAM. 41-60	—	—	29.4	—

Records: As only the two specimens of the type series are known, the range lies between about latitudes 29° and 31° South, at depths from 128 — 146 m.

Remarks: The shell is rather more solid than that of *N. pseudolirata*, the sides of the whorls are straighter, the columellar plaits thicker, the anterior fasciole much stronger, and the axial costae are longer and less nodulose, especially on the body whorl. The axial costae are less numerous on the first and second teleoconch whorls of *N. baconi* than in *N. pseudolirata*, but more numerous on the third and fourth whorls, and on the ventral and right sides of the body whorl. In the two specimens available for study there is no trace of reticulate patterns on the external surface. The spiral bands of large squarish blotches on the sutural ramp and around the anterior part of the body whorl, and the central band of spots, also serve to distinguish this species from *N. pseudolirata*.

The only other Recent species which resembles *N. baconi* is the south coast *N. occidua*. That species is much narrower and has a small protoconch (Pl. 32, fig. 8-9). Although it has strong and long axial costae they are less numerous than in *N. baconi*.

Although there are only two "dead" specimens of *N. baconi* known to me, they are sufficient to demonstrate that they represent a hitherto undescribed species. Of considerable interest for the future will be the determination of the geographic and depth ranges of *N. baconi* and *N. pseudolirata*. At present their known ranges do not overlap with each other, or with the ranges of other species of the genus.

The species is named after the collector Mr Al Bacon who generously donated the holotype to the Western Australian Museum.

Genus *NOTOPEPLUM* Finlay, 1927

1927 *Notopeplum* Finlay, *Trans. N.Z Inst.*, *57*: 514. Type species (original designation): *Scaphella victoriensis* Cossmann, 1899, [= *Voluta polita* Tate, 1889].

Distribution: Recorded living on the continental shelf of southern and south western Australia from South Australia to the Fremantle region, Western Australia at depths from 12 to 200 metres. Fossil species are known from Miocene sediments of Victoria and Tasmania.

Remarks: Until now the southern Australian volute *N. translucidum* (Verco, 1896) was the only Recent species of *Notopeplum* known, and that only from a few "dead" shells. There are four described fossil species in the Tertiary (Miocene) sediments of south eastern Australia (pers. comm. Mr T. A. Darragh) viz. *N. polita* (Tate, 1889) (= *victoriensis* Cossmann, 1899); *N. balcombensis* Finlay, 1930 (= *maccoyi* Tate, 1889, *non* Ten. Woods, 1877); *N. maccoyi* (Ten. Woods, 1877); *N. protorhysum* (Tate, 1889). In addition Mr Darragh advises me that there is a fifth fossil species which is unnamed.

All five fossil species, and *N. translucidum* are characterized by rather small, elongate-ovate, very thin, smooth shells, which have a smooth, broad, dome-shaped, and often slightly deviated protoconch of only about 1½ whorls. The protoconch is not sharply differentiated in any way from the teleoconch whorls. Often the second teleoconch whorl encroaches upon the first. There are 4 oblique columellar plaits, a rather shallow anterior canal, and shoulders and anterior fasciole are weak or lacking.

N. translucidum is said to have a thin deciduous white periostracum (Weaver & du Pont, 1970: 170).

Although these species form an easily distinguishable generic group on shell characters their relationship to other genera is uncertain. The discovery of another living species is, therefore, of special interest. The observations on the new species reported below suggest that the position of *Notopeplum* in the subfamily Scaphellinae (see Weaver and du Pont, 1970) may need reconsideration in favour of the Fulgorarinae. Comparable anatomical data on Australian Fulgorarinae and Scaphellinae are much needed.

Notopeplum annulatum sp. nov.

Pl. 33, fig. 1 - 4.

Type locality: CSIRO station 225; 32°00'S : 115°16'E; W of Rottnest Island, W.A.; 141 — 146 m, with modest catch of fish and shells, no sponges, bottom water temp. 17.74°C.

Type series. Holotype: A "dead" adult shell taken with a hermit crab in a beam trawl by CSIRO aboard HMAS "Diamantina," cruise DM 6/63, 12th Oct. 1963, WAM.132-64.

Paratypes: 1. One sub-adult specimen with body preserved, radula mounted, shell with lip not fully formed and slightly broken; from same locality and trawl haul as the holotype; WAM. 134-64. 2. One "dead" juvenile shell, from CSIRO station 144, 32°00'S : 115°08'E, W of Rottnest Island, HMAS "Diamantina" cruise DM 4/63, 28th Aug. 1963; 141 m; beam trawl with starfish, sponge and bryozoa; WAM. 472-71.

There is also a fragment not designated as a paratype from NW of Rottnest Island, 156 m; dredged, with sponges; B. R. Wilson on "Bluefin", 15th Aug. 1962; WAM cat. no. N4355.

Description of the holotype: Shell fusiform, with a total of 6 whorls, thin and translucent, surface very smooth and glossy, lacking sculpture of any kind. Spire high, spire height to total shell height ratio 0.41. Protoconch smooth, opaque, glassy, calloused, slightly deviated, broad and dome-shaped, not sharply differentiated from teleoconch so that number of protoconch whorls is not determinable. Second whorl with a diagonal flaw resembling a suture line. Coiling normal except for a difference of about 15° between the suture slopes of the first-second and second-third whorls (Pl. 33, fig. 4). Whorls convex, lacking shoulders, sutures weakly incised. Outer lip convex, slightly flared out anteriorly, columellar and parietal walls gently curved, aperture widens anteriorly. Columella weak, not calloused, bearing 4 oblique plaits of which the central two are moderately strong, straight sided and flat topped, the posterior one is weak and bifid, and the anterior one is moderately strong and forms the almost axial lip of the anterior part of the columella. Anterior canal broad, moderately deep; anterior fasciole weak. Early whorls cream merging into fawn to

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PLATE 33.

Fig. 1-2. *Notopeplum annulatum* sp. nov., Holotype; WAM.132-64, west of Rottnest I., W.A., 141-146 m.

Fig. 3. *Notopeplum annulatum* sp. nov., Paratype; juvenile, WAM.472-71, X-ray, west of Rottnest I., W.A., 137 m.

Fig. 4. *Notopeplum annulatum* sp. nov., Holotype; WAM.132-64, X-ray.

Fig. 5-6. *Notopeplum translucidum* (Verco, 1896), Holotype; S.A.M. Reg. No. 13614, Newlands Head, 36 m.

Figures 1 - 3, 5 - 6 approximately x 1½, Figure 4 x 3.

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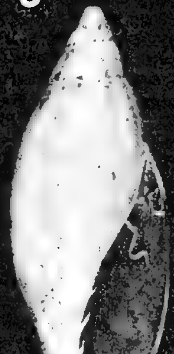

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apricot on the later whorls. Body whorl with a wide pale central spiral band bordered by two poorly defined thick white spiral lines on each side, and with another thick white spiral line below the suture. Small regularly spaced orange-brown rings enclosing pale orange spots lie on the two central white lines; confluent orange brown blotches lie on the subsutural line. The most posterior of the central lines and its rings are evident above the sutures of the 4th and 5th whorls. Columellar teeth white, anterior fasciole off-white, lip margin white, interior takes the colour of the exterior although the spiral lines and rings do not show through. Measurements: total shell height 53.4 mm, spire height 21.9 mm, width 20.2 mm.

Anatomy (of Paratype 1, WAM.134-64): Foot and head of a rose ground colour, with large, approximately round pale yellowish green blotches encircled by rings of small, round white spots at their peripheries and containing numerous irregular, smaller white spots in their centres, and with numerous round white spots of varying size on the rose ground colour between the yellowish green blotches. Tentacles and siphon pale green to white with blotches of dark rose.

Head typically volutid, with 3 flap-like lobes, the central one undivided and separated from the lateral lobes by the tentacles which are of moderate length and blunt in the preserved specimen but longer and attenuated in a photograph of the same specimen when alive. Eyes small, located on the edge of the lateral head lobes adjacent to the tentacles. Siphon with a pair of flat, square-ended lateral lobes of approx. equal size. Foot lacking metapodial lobes, anterior part of foot more densely pigmented than remainder and demarcated from it by a shallow marginal indentation on each side; anterior pedal groove present around the entire margin of the anterior part of the foot. Penis tubular not grooved, crescent-shaped with a short terminal "spike", sperm duct closed and terminates proximally in a spongy glandular organ, presumably prostate, at the back of the mantle cavity behind the hypobranchial gland. Arrangement of mantle cavity organs otherwise typical for the family (see Clench & Turner, 1964, p. 133, Pl. 81).

Oesophagus wide and lying medially over the buccal mass which it totally obscures from above. Accessory salivary glands long, convoluted, and lie over the rather compact salivary glands (the "racemose salivary glands" of Clench & Turner, 1964) which are thus partially obscured; both pairs of salivary glands loosely bound together with connective tissue and lie over the nerve ring. Ducts of both pairs of salivary glands were not followed beyond their junction with the oesophagus.

Unpaired fore-gut gland (see Hyman, 1967: 221) consists of two distinct parts; the anterior part is a compact, rather solid, roughly spherical mass situated on top of the oesophagus just behind the nerve ring; the

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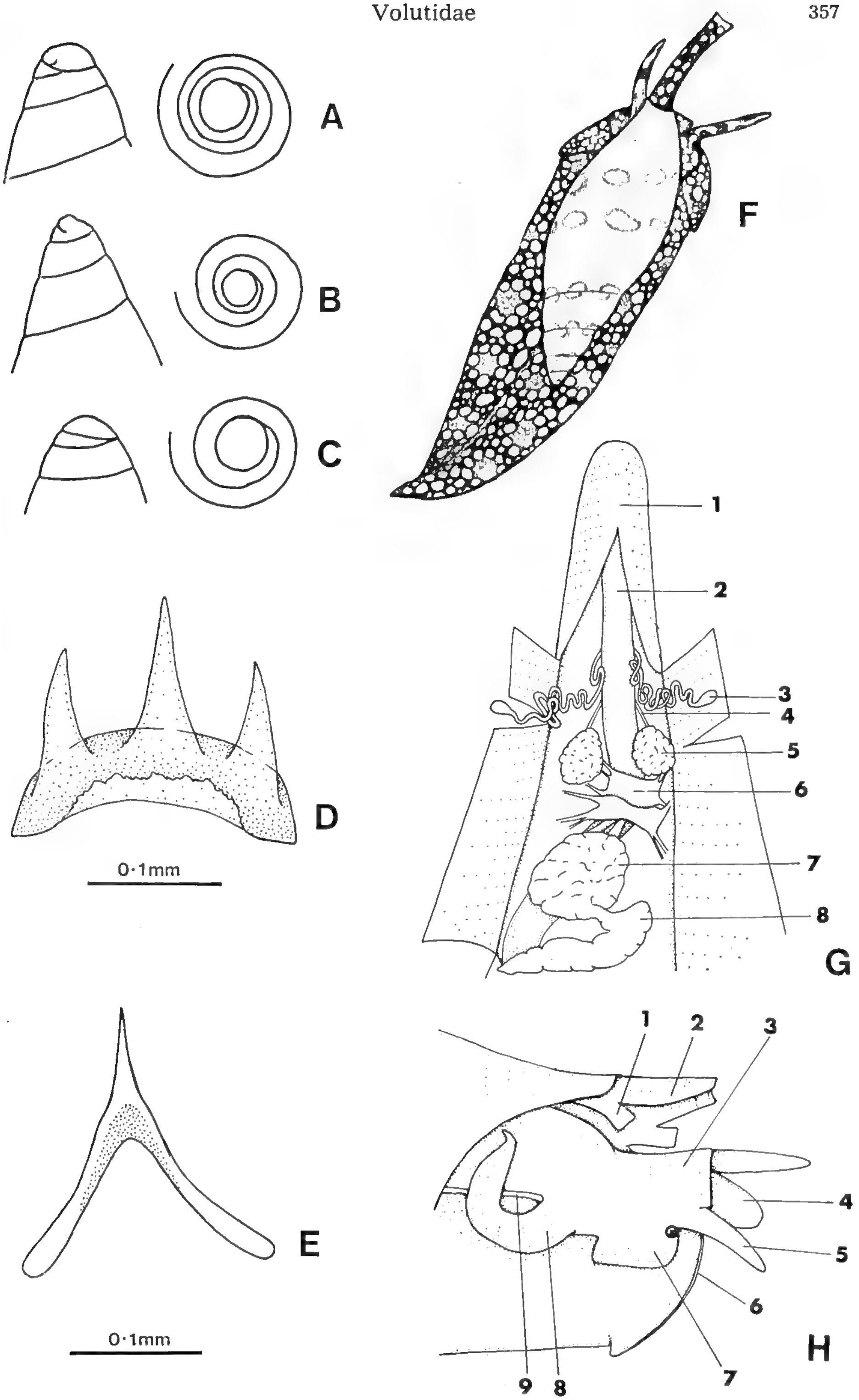
Fig. A, *Notopeplum annulatum* sp. nov. Holotype protoconch, WAM.132-64. B, *Notopeplum annulatum* sp. nov. Paratype protoconch, WAM.134-64. C, *Notopeplum politum* Tate, 1889. Holotype protoconch (drawing by courtesy Dr N. Ludbrook). D, *Notopeplum annulatum* sp. nov. Radula tooth of paratype, WAM.134-64. E, *Amoria diamantina* sp. nov. Radula tooth of a paratype, WAM. 626-71. F, *Notopeplum annulatum* sp. nov. Paratype WAM.134-64: Living animal drawn from a colour slide. G, *Notopeplum annulatum* sp. nov. Paratype WAM.134-64: Organs of the anterior digestive system. 1 — Proboscis, 2 — Oesophagus, 3 — Accessory salivary gland, 4 — Duct of salivary gland, 5 — Salivary gland, 6 — Nerve ring, 7 — Anterior part of un-paired fore-gut gland, 8 — Posterior part of un-paired fore-gut gland (Gland of Leiblein). H, *Notopeplum annulatum* sp. nov. Paratype WAM.134-64: External morphology of the anterior part of the body drawn from the preserved specimen. 1 — Basal lobe of siphon, 2 — Siphon, 3 — Central head lobe, 4 — Proboscis, 5 — Eye stalk, 6 — Transverse anterior pedal groove, 7 — Lateral head lobe, 8 — Penis, 9 — Seminal duct.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posterior part, the Gland of Leiblein, is a large, rather solid, lobulate sac which is not bound by connective tissue within the anterior mass.

Nervous system, vascular system, internal reproductive system, and the mid and hind parts of the alimentary system not examined.

Radula: Uniserial; teeth tricuspid; central cusp narrow, attenuate, with slightly concave sides; lateral cusps slightly shorter than the central cusp, attenuate, with concave inner and convex outer sides, base broad and shaped like a very wide and shallow, inverted U. (Text fig. 1D).

Remarks: The extremely high gloss, delicate colour, and spiral rows of orange-brown circles, render the shell of this species striking and unusual. There is no living species known to me with which it could be confused. That it belongs to the genus *Notopeplum* seems assured by the thin, smooth shell and the broad, heavily calloused, dome-shaped protoconch of few whorls. Apart from its unique colour pattern, *N. annulatum* differs from the only other known living species of the genus, *N. translucidum,* in its more elongate, slightly fusiform shell with higher spire and less convex whorls. The aperture is less ovate and wider at the anterior end, and the columellar plaits are weak.

Of particular interest is the variation in the protoconch within the type series. From the X-rays (Pl. 33, figs. 3-4) it appears that in some specimens (e.g. the holotype) there is a change in the rate of descent between the protoconch whorl and what is taken to be the first teleoconch whorl. The results are that there is a change in the slopes of the sutures between the first-second and second-third whorls, and the second teleoconch whorl encroaches over the first (Pl. 33, fig. 4). This gives the impression that the protoconch is slightly deviated. In other specimens (e.g. paratype 2, WAM. 472-71) the change in rate of descent is less, the second teleoconch whorl does not encroach markedly upon the first, and the protoconch is not deviated (Pl. 33, fig. 3). It is curious to note that similar protoconch variation occurs in the fossil species *N. polita.*

Having only one preserved specimen to dissect, the anatomical observations made on this species are incomplete. Special attention was paid to the organs of the anterior digestive system for these provided the characters used by Clench and Turner (1964) for their grouping of genera into subfamilies. Several features are worthy of note.

The "fluffy" salivary glands and the accessory salivary glands are not bound together by connective tissue and in this condition the species resembles the Scaphellinae and Volutinae (see Clench and Turner, 1964). The gland of Leiblein also resembles the condition described in the Scaphellinae by Clench and Turner. On the other hand, there are two siphonal lobes of equal size in *N. annulatum* while Clench and Turner (1964) state that there is only a single basal lobe on the left side of the siphon in the species of Scaphellinae which they examined. (But note that there are two equal lobes in the genus *Amoria* which is also at present placed in Scaphellinae.) The radula resembles that of *Ericusa* (Fulgorarinae) in having a broad base and a prominent pointed cusp on each side of the central cusp

The only conclusion to be made is that *N. annulatum* has some anatomical characters which ally it to the subfamily Scaphellinae but others which do not. Much more anatomical work is needed on Australian volutes before generic affinities of this and other groups can be properly assessed.

ACKNOWLEDGEMENTS

I am most grateful to Dr D. F. McMichael who first drew my attention to the fact that the species described here were new and later made many helpful suggestions and criticisms. Special thanks are also due to Mr T. Darragh and Dr N. Ludbrook who freely gave information on fossil species, together with their stimulating ideas and observations on the evolution and palaeogeography of the southern Australian Tertiary and Recent faunas. Dr Winston Ponder made helpful comments on the manuscript, especially regarding the anatomical observations. Mr Frank Abbottsmith's remarks were also helpful. Mrs Shirley Slack-Smith gave much assistance in reading the manuscript and selecting the species' names. Miss Anne Paterson assisted with the photography. The X-ray photographs were taken by Mr H. Klavins through the courtesy of Mr R. Plummer at Sir Charles Gairdner Hospital, W.A. Dr Graham Chittleborough and Mr Barry Scott of C.S.I.R.O. collected many of the specimens taken during oceanographic cruises of H.M.A.S. "Diamantina" and their cooperation is greatly appreciated.

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OBITUARY

TOM IREDALE (1880 - 1972)

GILBERT P. WHITLEY AND WINSTON F. PONDER

The Australian Museum, Sydney.

Plate 34

Tom Iredale, who had been Conchologist at the Australian Museum, Sydney, for twenty years, died at Curl Curl, New South Wales, on 12th April 1972 at the age of 92.

Almost every important work on molluscan systematics now mentions his name, for he enjoyed solving taxonomic problems and he had written more than 170 papers on mollusca (apart from many other subjects) and proposed well over two thousand new scientific names. He was an early exponent of ecology in zoology; he coined new words such as ecomorphs and nannomorphs, and proposed a method of naming living molluscs to indicate their relationship to fossil ancestors. Most of his molluscan type-specimens are in the Canterbury Museum, Christchurch, New Zealand, the British Museum (Natural History), London, and the Australian Museum, Sydney.

As long ago as 1914, William H. Dall of the Smithsonian Institution wrote to Iredale who was then working at the British Museum:

"I am just back from my summering on Mt. Monadnock and looking over the Mal. Soc. numbers for the summer find your papers on nomenclature. I think some millionaire ought to endow a chair of molluscan nomenclature with a view to getting a perfect Nomenclator, and nominate you as incumbent for life. You certainly have a genius for that line of work . . ."

Iredale was born in Cumberland, England, on 24th March 1880. He was always interested in birds and general natural history, but when he was 21 years old, he sailed to New Zealand for health reasons, where he was introduced to the study of Mollusca by his friend, W. R. B. Oliver, a botanist and ecologist. The two men visited the Kermadec Islands for ten months in 1908 where they met Roy Bell who was later to collect large quantities of specimens for Iredale on Lord Howe and Norfolk Islands, in Victoria and southern New South Wales.

Iredale left New Zealand in 1908 for England but, on the way, Charles Hedley persuaded him to stay for the Australian Association for the Advancement of Science Congress in Brisbane. Thus in February 1909 Iredale had a first hand experience with Queensland molluscs by collecting at Caloundra (where he examined the G. Gross collection); he also visited Port Curtis.

Tom Iredale's name first appeared in the registers of conchology in the Australian Museum as early as 1906, when he had sent two *Cyclostrema* from Lyttleton, New Zealand. Other gifts of New Zealand shells followed, and in 1909 and in later years, shells from the Kermadec Islands arrived. In 1913, shells which had been collected by Iredale at Caloundra are noticed and a year later (probably after comparative study at the British Museum) further Caloundra and Kermadecs shells are registered. These are but the first-fruits of many years of further collecting by Tom Iredale, in Victoria, New South Wales, Lord Howe Island and Queensland.

From 1909 to 1923, Iredale spent a great deal of time at the British Museum in Kensington assisting Gregory Mathews in the production of *The Birds of Australia*, identifying molluscs and writing papers on molluscan nomenclature and bibliographic problems. One of his finest efforts was his critical commentary, published in 1915, on Suter's *Manual of the New Zealand Mollusca*. He collaborated with C. D. O'Donoghue to produce a *List of British Nudibranchiate Mollusca*, published in 1923 and he helped C. D. Sherborn compile his great *Index Animalium*. Iredale considered his most spectacular discovery to be *Sherbornia mirabilis*, a gastropod he named from the Indian Ocean in 1917. As a result of his work on the shells of the Kermadecs, Iredale was offered collections from Fiji, New Zealand, Christmas Island, the Monte Bello Islands and elsewhere, but he declined a proffered museum appointment in Honolulu. Instead, he came to Sydney in 1923 for the Pan Pacific Science Congress and went on a collecting trip with Henry A. Pilsbry of Philadelphia who was also in Australia for the Congress.

Iredale was to cause a lot of controversy with his philosophy on genera and species. His explanations for proposing new names were often excessively brief and only those who had watched him at work realised that hours of observation and research were often condensed into a line or two. As early as 1924 he erected 111 new names in a paper based on Roy Bell's collections from south-eastern Australia and was always a 'splitter' rather than a 'lumper'.

Although Iredale was basically a museum worker, he loved field work and considered this very important to gain a proper understanding of the animals he was studying.

He was acutely aware of the importance of history and geography in zoology and was meticulously accurate in bibliographical matters. He wrote many papers on the old-time naturalists, generally to establish their type-localities and to ensure that proper credit was given to them for the scientific names they had bestowed.

After working as a freelance worker with Hedley at the Australian Museum, Iredale was appointed as an Assistant in the Conchology Department, becoming Conchologist in 1924, with Miss Joyce Allan as assistant, when Hedley left to become Director of the Great Barrier Reef Committee. In those days, two other well known conchologists, John Brazier and Thomas Whitelegge, who had been retrenched during the 1893 depression, visited the Museum from time to time. From 1923, Iredale worked consistently on the monograph of loricates with Basset Hull, Miss Allan producing the illustrations. His other molluscan work during his employment

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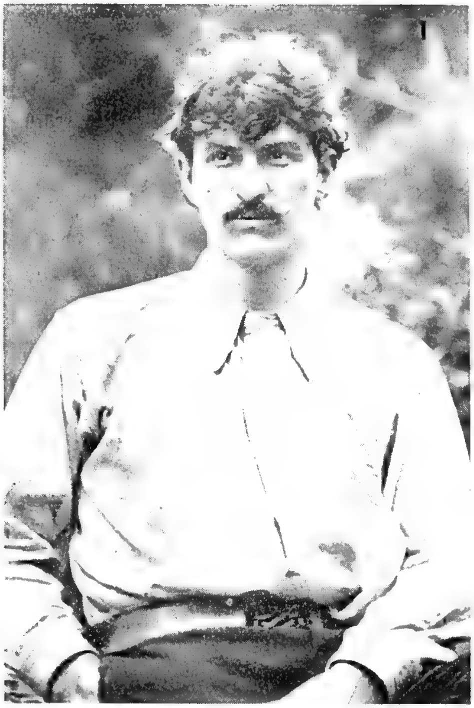
PLATE 34. Tom Iredale

1. November 1908. Taken on Sunday (= Raoul) Island, Kermadec Group.
2. July 1932. Taken in Sydney.
3. September 1938. Taken at the Annual Meeting of the Royal Zoological Society of N.S.W., when he became President.
4. March 1964. (Photograph by Keith Hindwood).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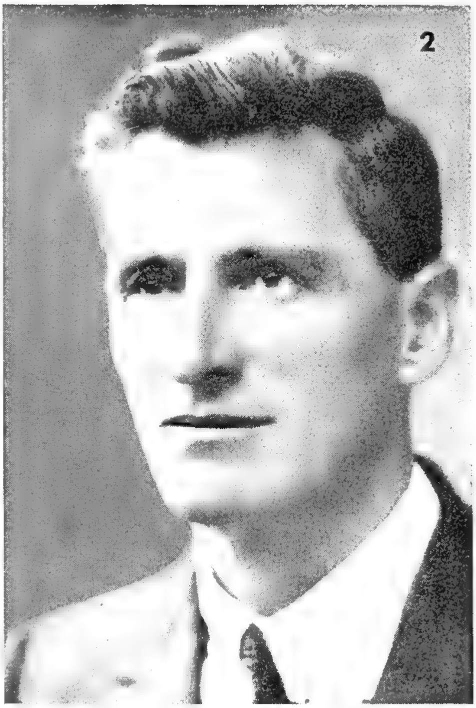
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as conchologist included papers on "cuttle-bones," reports on shells from the New South Wales continental shelf and from the Sydney area, notes on Queensland shells, shipworms (Teredinidae), land snails and freshwater mussels. Iredale took part in the Great Barrier Reef Expedition to Low Isles, Queensland, in 1928 - 1929. In 1939 he published the first part of the Report, which dealt with the lower bivalves, but the other parts of this controversial report were never published, although some of the partially completed manuscript is in the Australian Museum.

Amongst his important molluscan reference works, we may mention his lists of the Australian, Lord Howe and Norfolk Islands and Papuan land shells, the freshwater molluscs of Australia and the marine ones of New South Wales (the latter with D. F. McMichael, a trainee who joined the museum staff in 1948, became assistant curator under Joyce Allan and Curator of Molluscs in 1957). He also had in train a review of Indo-Pacific Strombidae, illustrated by Charles Laseron, but, like another review of the genus *Janthina*, it was never published. A bibliography and index of his scientific names has been published by McMichael and Whitley (1956), and one of us (G.P.W.) has recently prepared a full account of Iredale's life and works, bringing his bibliography and index up to date.

He was most generous in putting information at his colleagues' disposal and encouraged many younger zoologists to publish their findings. He was a member of the Malacological Society and the Zoological Society in London and other societies in England and Australia. He was President and a Fellow of the Royal Zoological Society of New South Wales and was awarded the Clarke Medal by the Royal Society of New South Wales in 1959. He was an Honorary Associate of the Australian Museum until his death which deprived us of a cheerful, witty friend and a revered colleague.

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HISTOLOGY OF THE MANTLE AND PEARL SAC OF THE PEARL OYSTER *PINCTADA MAXIMA* (LAMELLIBRANCHIA)

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Plates 35-36

SUMMARY

The mantle of *Pinctada maxima* is covered by a single layer of epithelium with associated secretory cells. It shows regional differentiation mainly in epithelial cell height, pigmentation, ciliation and nucleus position, and in the distribution and type of secretory cells. Such differentiation relates to variation in the function of different mantle areas, mainly in the secretion of different shell components, and corresponds closely to differentiation found in *Pinctada martensii.*

INTRODUCTION

Extensive studies on the general biology, pearl culture and pearls have been made on the Japanese pearl oyster, *Pinctada martensii* (Dunker). These include investigations of mantle and pearl sac histology and electron microscopy (Aoki, 1966; Ojima, 1952; Nakahara and Machii, 1956; Tsujii, 1960, 1968 a & b). Comparative studies are wanting for the South Seas pearl oyster *Pinctada maxima* (Jameson) a species also of considerable economic importance in pearl culture.

The mantle plays an integral part in pearl culture as a small mantle transplant together with a spherical pearl 'nucleus' are inserted into the visceral tissue of a host pearl oyster during seeding operations. Ideally, the mantle transplant proliferates to form a pearl sac which secretes nacre around the pearl nucleus but in many cases gem quality pearls are not formed. The host pearl oyster may die soon after the transplant operation or, if it survives irregular shaped 'baroque' pearls are often formed. In other animals only organic layer or other low value pearls form.

In view of the frequent occurrence of these undesirable results, investigations of several aspects of pearl culture are being undertaken in *Pinctada maxima.* The present paper forms the basis for investigation of normal mantle processes, the response of the pearl oyster to transplanted mantle and to wounds and the changes occurring in transplanted mantle tissue. It has also proved invaluable for subsequent investigations of histopathological changes accompanying disease.

MATERIAL AND METHODS

For mantle histology eight adult *P. maxima* (dorso-ventral measurement 15.9 - 18.7 cm) were collected in December 1969 from the Old Ground pearling area in the Torres Straits, North Queensland (for locality see Minaur, 1969). A further six pearl oyster collected in this area in August

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1968 had had one nucleus and mantle transplant inserted by skilled Japanese technicians in September 1968 and were cultivated until March 1970. Living pearl oysters were airfreighted to Townsville and maintained in a recirculating seawater system for no more than one month prior to dissection and fixation.

After animals were relaxed using propylene phenoxetol (Rosewater, 1963) or magnesium ions (Pantin, 1964) mantle pieces were excised from the following areas and placed is fixative (Fig. 1):

(1) marginal mantle; (a) folds, anterior, posterior and ventral, and (b) isthmus;

(2) pallial mantle immediately inside the fold samples;

(3) central mantle; (a) inside the line of gill attachment and near the adductor muscle; (b) overlying the heart, and (c) overlying the gonad, digestive diverticula and stomach.

Fixatives used were normal Bouins, 10% neutral formalin (Lillie, 1954) and Baker's formol-calcium. In animals containing pearls the visceral mass with pearl *in situ* was removed and placed in fixative. After 20-24 hrs the pearls were removed and the viscera containing pearl sacs were re-immersed in fresh fixative for a further 24 hrs.

Fixed mantle and visceral tissue was routinely dehydrated in alcohol, Paraplast-embedded, sectioned at 5 - 8 μ and stained with Ehrlich's haematoxylin and eosin or Mallory Heidenhain.

RESULTS

MANTLE HISTOLOGY

The gross form of the mantle is relatively unspecialised and consists of two apron-like lobes united dorsally along the mantle isthmus (Fig. 1). Mantle fusion is not present.

Marked regional differentiation, however, was found in the mantle histology and each area will be treated separately.

MARGINAL ZONE

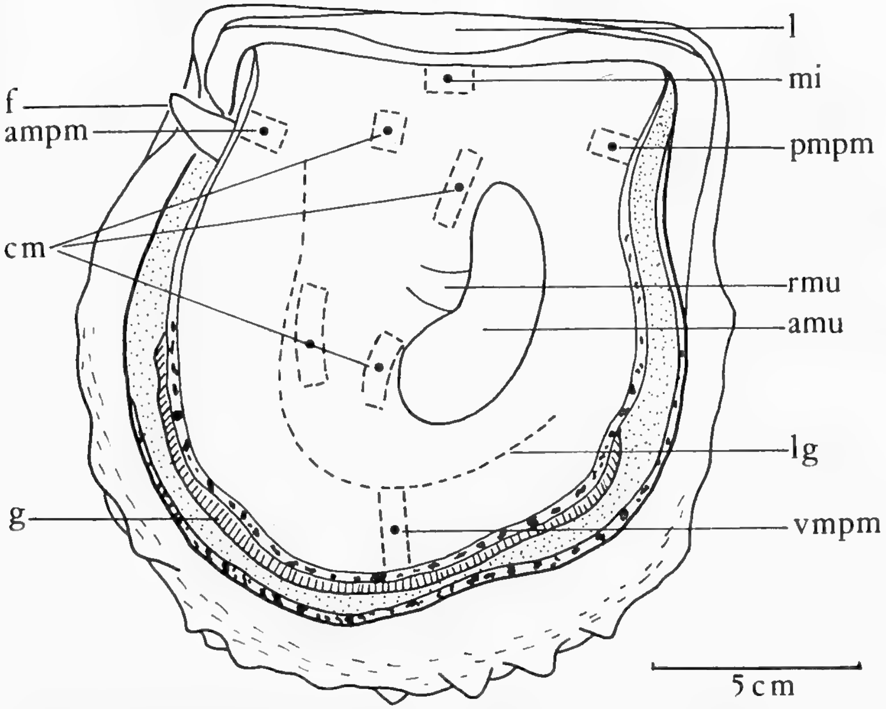
MANTLE FOLDS (Plate 35, Figs. 1-6)

The typical bivalve condition of three marginal folds was found in *Pinctada maxima;* the middle and outer folds are separated by the periostracal groove (Fig. 2). The folds were morphologically similar in anterior, ventral and posterior regions but marked differences occurred between folds.

Inner Fold

A single layer of ciliated columnar epithelium 15 - 20 μ high with basal nuclei covered the largest mantle fold (Pl. 35, Figs. 2 and 3). The distal epithelial cytoplasm was typically pigmented with fine granules which gave a melanin reaction with Lillie's (1957) ferrous ion method and were bleached by the permanganate method (Pearse 1960). At the fold tip ciliation was more conspicuous and pigmentation was reduced.

Conspicuous longitudinal and transverse muscles characterised the inner fold and large numbers of acidophylic secretory cells were scattered through the connective tissue (Pl. 35, Fig. 1). These cells have an amoe-



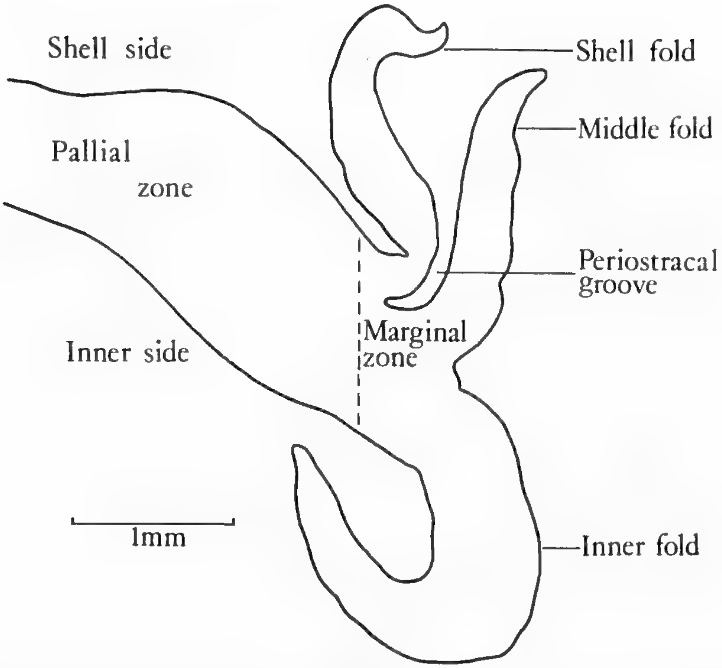
Text Fig. 1: *Pinctada maxima* with the right valve removed to show the mantle regions fixed for investigation. Semidiagrammatic.

boid-like outline, a finely granular cytoplasm and a small but conspicuous nucleus. Although they were most concentrated toward the outer border of the fold they showed little connection with the fold surface. Few secretory cells were found in the epithelium of the inner surface but goblet shaped granular acidophylic cells with large (1 - 5 μ) granules and basophilic mucous cells were common in the outer epithelium and subepithelium, particularly towards the proximal end.

Middle Fold

The middle fold epithelium showed regional differentiation. Cells proximal to the inner fold were similar to those of the latter but the remainder were non-pigmented with lightly basophilic cytoplasm. Non-pigmented epithelial cells of the outer surface were ciliated and similar in size to the pigmented cells (Pl. 35, Fig. 3). A strongly ciliated columnar epithelium reaching a height of 35 μ lined the inner surface of the fold (periostracal groove) apart from near the base which was lined with non-ciliated almost cuboidal cells 8 - 10 μ high, with central muclei and a brush border (Pl. 35, Fig. 4 & 6).

Wandering acidophilic secretory cells which were very abundant in the inner fold were common but less abundant in the middle fold (Pl. 35, Fig. 5). Basophilic mucous cells, however, were extremely abundant



Text Fig. 2: Transverse section through the ventral marginal mantle of *Pinctada maxima* showing the three mantle folds and part of the pallial mantle. Drawn from a histological section.

subepithelially, particularly near the fold tip; they showed clear connections with the fold exterior (Pl. 35, Fig. 3). A few acidophilic cells with large secretory granules were found scattered among the outer epithelial cells although a cluster generally occurred in the subepithelium towards the bottom of the periostracal groove.

Outer fold

The outer (shell) fold showed similar marked regional differentiation to the middle fold but the epithelial cells were neither ciliated nor pigmented.

A clearly demarcated group of tall (40 - 50 μ) stratified columnar epithelial cells occurred at the bottom of the periostracal groove and secreted material on the surface of these cells was continuous with the periostracum in the groove (Pl. 35, Fig. 6). Distally to this group of cells a low columnar epithelium 10 - 15 μ high with lightly basophilic cytoplasm gave way to a taller columnar epithelium (25 - 45 μ high) towards the fold tip. The epithelium of the shell surface of the outer fold was similar although cell height decreased to 10 - 15 μ near the base of the fold.

A group of large lightly basophilic mucous cells occurred below the tall epithelium at the bottom of the periostracal groove. Goblet shaped mucous cells were common along the inner and outer fold surfaces but they were more numerous on the inner surface, particularly towards the tip where acidophilic secretory cells with large granules were also present on the outer fold surface.

MANTLE ISTHMUS (Pl. 35, Fig. 7)

Lying immediately inside the shell hinge line the dorsal marginal mantle or mantle isthmus consisted of a cap of very tall (up to 50 μ) non-ciliated columnar epithelium which rested on connective tissle containing scattered muscle fibres. Several features differentiated the mantle isthmus from other mantle areas. These included strong cytoplasmic basophilia with Ehrlich's haematoxylin, elongation of the cells, and the absence of either epithelial or subepithelial secretory cells.

An abrupt change separated the isthmus cap epithelium from that of the inner isthmus. The latter was similar to that of the central mantle although secretory cells were less numerous near the isthmus.

PALLIAL MANTLE (Pl. 35, Fig. 8; Pl. 36, Fig. 9)

Inner and outer low columnar epithelial layers enclosed muscular connective tissue in the pallial mantle. Although their cells were of similar size (10 - 15 μ x 4 - 6 μ) marked differences occurred between the inner and outer epithelia.

The inner epithelium was characterised by dense cilia, melanin pigment in the cytoplasm and deeply staining basal ovoid muclei. Cilia and cytoplasmic pigmentation were absent in the outer epithelium and the ovoid nuclei were placed basally to centrally with clearly distinguishable chromatin.

Basophilic mucous and coarsely granular acidophilic secretory cells were found on both sides of the pallial mantle but they were small and restricted to the epithelium of the inner surface. The larger secretory cells of the outer surface occurred in the subepithelium as well as the epithelium.

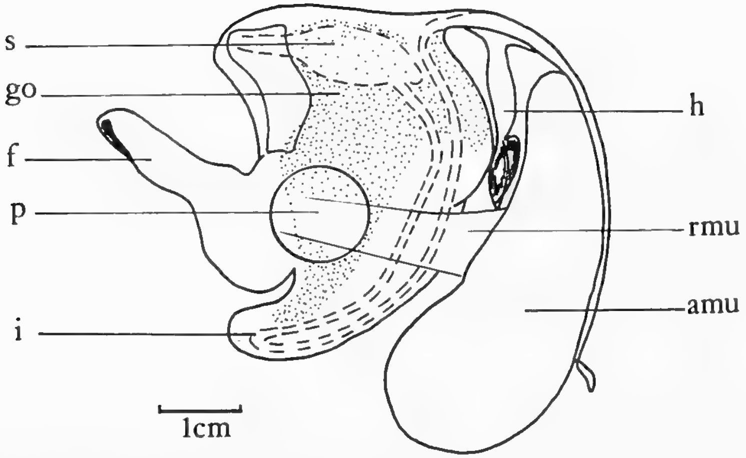
CENTRAL MANTLE (Pl. 36, Fig. 10)

The outer (shell) side of the three sampled central mantle areas consisted of a simple, low columnar epithelium 8 - 10 μ high beneath which and opening through was a characteristic layer of very concentrated secretory cells. The layer consisted of goblet shaped basophilic mucous cells overlying coarsely granular acidophilic cells. The connective tissue containing some muscle cells separated this layer from the gonad and digestive diverticula in the stomach region and from the inner, non-pigmented low columnar epithelium in the heart and adductor muscle regions. Secretory cells in the inner epithelium of the latter central mantle areas were histologically similar to those of the inner pallial mantle.

PEARL SAC HISTOLOGY

All pearls were found in the visceral tissue between the base of the foot and the intestine; they were enclosed by pearl sacs surrounded by gonad, connective and muscular tissue (text Fig. 3).

The following pearl formations were found in the specimens examined: spherical nacreous pearl (2); irregular nacreous pearl without nucleus (4), and irregular periostracal or organic layer pearl without nucleus (1). Prismatic layer pearls were not found in this study.



Text Fig. 3: Viscera of *Pinctada maxima* showing the positon of a spherical pearl. Semidiagrammatic. ABBREVIATIONS: amu — adductor muscle; ampm — anterior marginal and pallial mantle; cm — central mantle; f — foot; g — gill; go — gonad; h — heart; i — intestine; l — ligament; lg — line of gill attachment; mi — mantle isthmus; p — pearl; pmpm — posterior marginal and pallial mantle; rmu — retractor muscle; s — stomach; vmpm — ventral marginal and pallial mantle.

NACREOUS PEARL SAC (Pl. 36, Fig. 11)

Pearl sacs surrounding irregular and spherical nacreous pearls did not differ histologically. They consisted of a single uniform layer of non-ciliated, cuboidal or flattened epithelium 3 - 8 μ high lying in close contact with gonad, connective or muscular tissues. The epithelial cytoplasm was non-granular or very finely granular and slightly basophilic. Nuclei were rounded, centrally placed and occupied much of the cell space.

Two types of secretory cells were found scattered within and immediately below the pearl sac epithelium; these were acidophilic with large secretory granules and less numerous basophilic mucous cells.

PLATE 35

Fig. 1: Inner fold of the marginal mantle of *Pinctada maxima* showing pigmented epithelium (pe), numerous wandering secretory cells (ws) and strong band of muscles (mu). Mallory—Heidenhain x20.

Fig. 2: Pigmented columnar epithelium and secretory cells (sc) of the outer surface of the inner mantle fold in *Pinctada maxima*. Haematoxylin-eosin x325.

Fig. 3: Ciliated, non-pigmented columnar epithelium and subepithelial mucous cells (bs) near the tip of the middle mantle fold of *Pinctada maxima*. Haematoxylin-eosin x325.

Fig. 4: Epithelia lining the periostracal groove in *Pinctada maxima*. Secreted periostracum (p) is visible in the groove. Outer fold to the top and middle fold to the bottom. Haematoxlyin-eosin x130.

Fig. 5: Middle and outer marginal folds of the mantle of*Pinctada maxima* showing the pigmented epithelium (pe) and wandering secretory cells (ws) of the inner middle fold and non-pigmented epithelium of the outer fold and outer surface of the middle fold. Haematoxylin-eosin x20.

Fig. 6: Stratified columnar epithelium (st) and secreted periostracum (p) at the bottom of the periostracal groove in *Pinctada maxima*. Outer fold to the top. Haematoxylin-eosin x325.

Fig. 7: Strongly basophilic non-ciliated columnar epithelium of the mantle isthmus in *Pinctada maxima*. Haematoxylin-eosin x50.

Fig. 8: Outer, non-ciliated low columnar epithelium and subepithelial secretory cells (sc) of the pallial mantle of *Pinctada maxima*. Haematoxylin-eosin x325.

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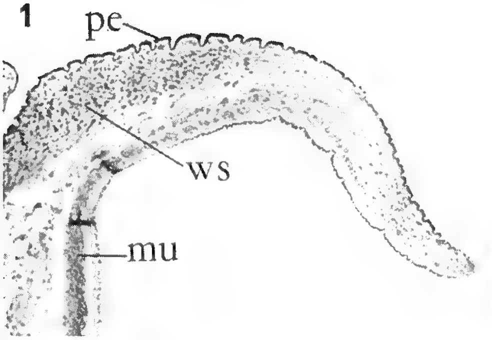

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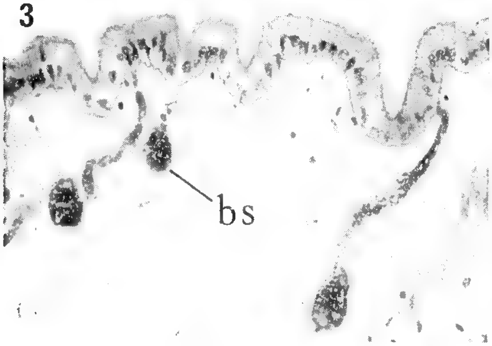

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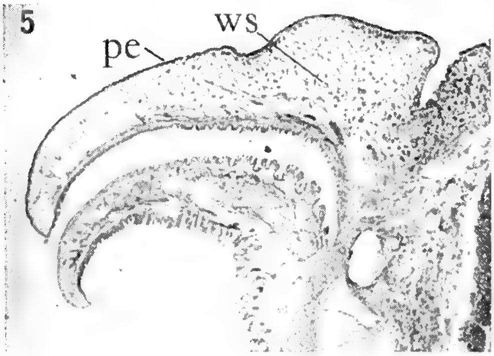

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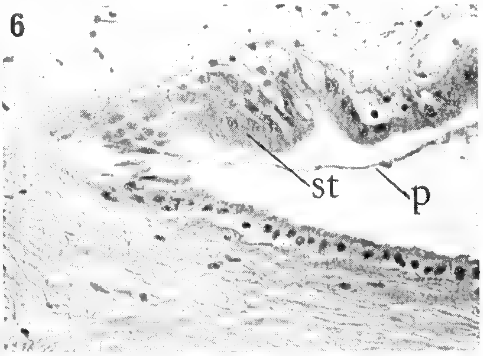

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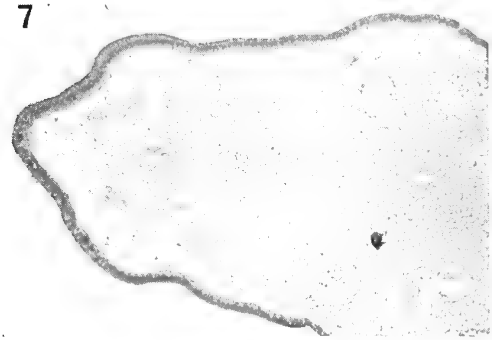

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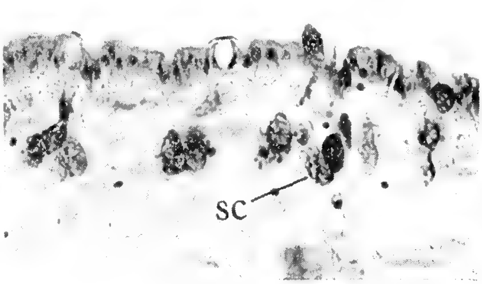

PERIOSTRACAL PEARL SAC (Pl. 36, Figs. 12-14)

Most of the periostracal pearl sac constisted of a single layer of tall (30 - 50 μ) ciliated columnar epithelium with basal nuclei and finely granular, slightly acidophilic cytoplasm, but regional differences were evident. Some parts showed a stratified epithelium while others were hyperplastic with extreme proliferation of small (up to 9 x 5 μ) irregularly arranged cells; these cells, which were also concentrated in parts of the pearl sac subepithelium, were probably haemocytes.

Basophilic mucous cells with fine granular inclusions were common in the subepithelium of the pearl sac and acidophilic cells with large secretory granules were present in one marked concentration.

DISCUSSION

The regional differentiation of histological features found in the mantle of *Pinctada maxima* appears typical for bivalves. Examples include *P. martensii* (Tsujii, 1960), *Anodonta cygnea, Mytilus edulis* and *Ostrea edulis* (Beedham, 1958), *Pinna carnea* (Yonge, 1953), *Crassinella mactracea* (Allen, 1968) and *Mercenaria mercenaria* (Hillman and Shuster, 1962).

In *P. maxima* the most marked differentiation occurred in the marginal mantle (folds and isthmus). These areas were not only quite different from other parts of the mantle but differentiation was found also between and within the folds.

Most of the structural differentiation may be related to function. It is believed generally that the inner, middle and shell folds in bivalves primarily are muscular, sensory and secretory respectively (Beedham 1958; Jorgensen, 1966). This appears true of *Pinctada maxima.* It seems clear that the distinctive tall stratified columnar epithelium on the outer fold at the base of the periostracal groove secretes at least part of the periostracum, particularly in view of the continuity between these cells and newly formed periostracum. A similar group of cells was found in *O. edulis* (Beedham, 1958) while homologous cells extended further along the inner surface of the outer mantle fold in *A. cygnea* and *M. edulis* (Beedham, 1958) and *Mercenaria mercenaria* (Hillman, 1961). Tsujii (1960) suggested that cells of the middle fold secreted periostracum in *P. martensii* although he later (1968a) described a group of cells in the outer fold similar to those found in *P. maxima.*

Part of the outer fold probably also secretes the inner calcereous (prismatic) layer of the shell as suggested for *P. martensii* (Tsujii 1968a) and *P. radiata* (Nakahara and Bevelander (1971)). The non-ciliated, non-pigmented columnar epithelium over most of the outer fold differs from that of the other folds and suggests a difference in function.

While the inner fold is larger and more muscular than the middle fold both are similarly innervated and may have a sensory function. The inner and middle folds also have ciliated and pigmented epithelia and abundant subepithelial secretory cells further suggesting functional similarity. Conversely, more abundant muscular tissue in the inner fold and more frequent mucous cells in the middle suggest functional differences. The clarification of these must await further study.

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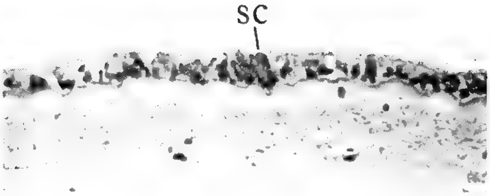

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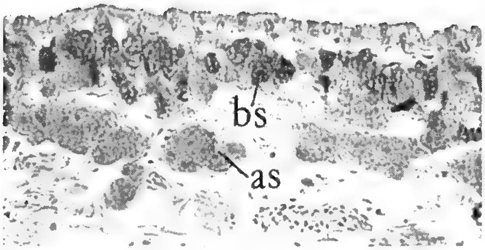

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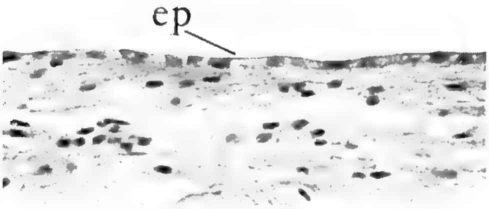

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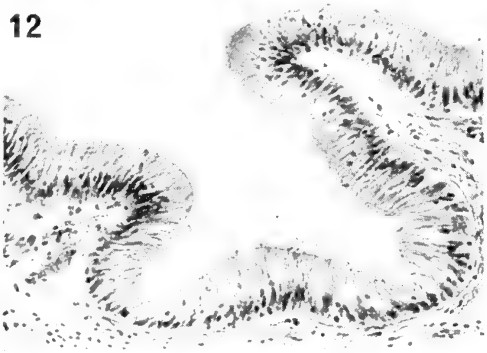

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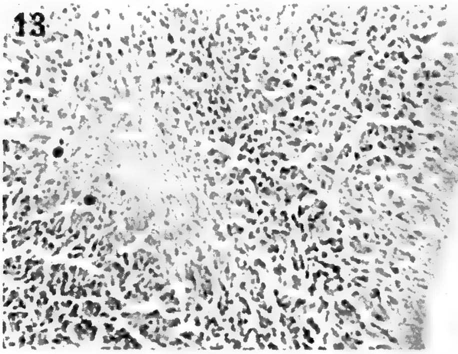

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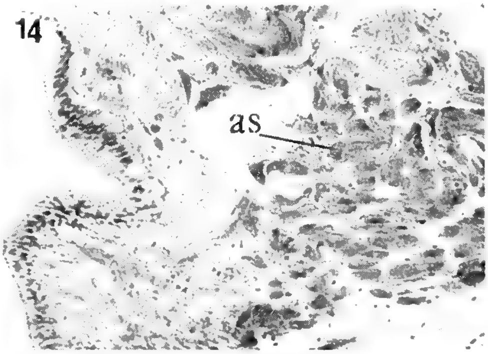

PLATE 36

Fig. 9: Inner, ciliated, pigmented low columnar epithelium and epithelial secretory cells (sc) of the pallial mantle of *Pinctada maxima*. Haematoxylin-eosin x325.

Fig. 10: The outer central mantle of *Pinctada maxima* showing concentrations of mucous cells (bs) and acidophilic granular secretory cells (as) below the low columnar epithelium. Haematoxylin-eosin x210.

Fig. 11: Cuboidal to flattened epithelium (ep) of the nacreous pearl sac in *Pinctada maxima*. The pearl sac is adhered to surrounding connective tissue. Haematoxylin-eosin x500.

Fig. 12: Tall, columnar, ciliated epithelium of a periostracal pearl sac in *Pinctada maxima*. Haematoxylin-eosin x210.

Fig. 13: Proliferated cells (haemocytes) which have replaced part of the periostracal pearl sac epithelium in *Pinctada maxima*. Haematoxylin-eosin x210.

Fig. 14: Concentration of granular acidophilic secretory cells (as) in the subepithelium of the periostracal pearl sac in *Pinctada maxima*. Haematoxylin-eosin x210.

The distinctive columnar epithelium of the dorsal marginal mantle or mantle isthmus *P. maxima* is probably responsible for secretion of at least part of the shell ligament in view of the relationship between shell and mantle in this area. Ligament secretion has been attributed to similar cells as shown by an electron microscope study of *P. radiata* (Bevelander and Nakahara, 1969) and histological studies of *O. edulis* and *M. edulis* (Beedham, 1958).

Because of their relationship to the shell, the outer layers of the central and pallial mantle are likely to contribute to the secretion of the inner calcified layer (nacre). The uniform, low simple epithelium and subepithelial secretory cells in these outer mantle areas differ from corresponding tissues in the marginal and inner mantle areas. The latter, with ciliated epithelium and epithelial secretory cells, may carry out cleansing and rejection of deposited particles as suggested for bivalves in general by Jorgensen (1966).

The marked differences between pearl sacs surrounding nacreous and periostracal materials parallel closely those found in the Japanese pearl oyster *P. martensii* (Aoki, 1966; Nakahara and Machii, 1956; Tsujii, 1960, 1968b). Comparing pearl sacs with mantle areas, the nacreous pearl sac shows general similarity with the outer central mantle although secretory cells are less abundant in the pearl sac. This similarity is expected as both epithelia are concerned with nacre secretion. The periostracal pearl sac shows slight similarity with the tall cells which secrete periostracum at the base of the periostracal groove although these mantle cells are not ciliated. Other differences include the large numbers of haemocytes in the subepithelium and epithelium of the pearl sac and also the extensive folding of the sac. These features may indicate an inflammatory response as suggested for periostracal pearl sacs in *P. martensii* (Aoki, 1966). It is noteable that mantle areas which normally secrete nacre may secrete periostracum under abnormal conditions (e.g. disease or during shell repair). Under these circumstances the mantle shows remarkable similarity to the periostracal pearl sac in the development of elongate cells, cilia and the infiltration of haemocytes (Dix, unpublished observations and Tsujii, 1960).

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CRATERODISCUS McMICHAEL, 1959, A CAMAENID LAND SNAIL FROM QUEENSLAND

ALAN SOLEM
Curator of Invertebrates, Field Museum of Natural History
Chicago, U.S.A.

Plate 37

SUMMARY

Dissection of *Craterodiscus pricei* McMichael, 1959 shows that it cannot be classified in the Helicarionidae as originally suggested. It appears to be the most primitive species of the helicacean land snails yet dissected and is referred tentatively to the Camaenidae, s.l. Scanning electron microscope studies of the radula revealed that it has one of the most remarkable cusp structures found in a pulmonate snail.

INTRODUCTION

McMichael (1959) described a new species and genus of land snail from Hypipamee Crater, Atherton Tableland, North Queensland, Australia as *Craterodiscus pricei.* On the basic shell structure he compared it with the Queensland endemic *Theskelomensor* and temporarily placed it in the Helicarionidae. Through the courtesy of Mr. Laurie Price of Kaitaia, New Zealand, I obtained preserved topotypes of this species that were collected in August 1964 (Field Museum of Natural History number 135141).

As part of a long range review of endodontid genera from the Pacific Islands and the Austro-Zelandic region, *Craterodiscus* was dissected in order to check on the possibility that it was an aberrant endodontoid derivative. Much to my surprise this turned out to be a member of the Helicacea with several quite primitive anatomical features.

This report attempts both to record its unusual structure and to place it within generally recognized family limits. There is no agreement concerning family level units for Australian land snails. A very conservative course is followed here by placing it in the Camaenidae, *s.l.* When anatomical knowledge of the Australian Helicacea is more advanced, an alteration of family units may be required.

SHELL STRUCTURE

Specimens ranged from 4.9 - 5.2 mm. in diameter with 6 to 6½ whorls. The whorls show only modest increase in width from the first whorl (0.33 mm. wide) to the body whorl (0.58 mm. wide). Since this is coupled with a quite widely open umbilicus (contained 2.2 - 2.5 times in the diameter), there is very little cross-sectional area difference between the early post-nuclear whorls and body whorl (see figures in McMichael, 1959). Compared with more typical Australian helicoid shells such as *Hadra, Austrochloritis, Sinumelon* or even *Pedinogyra,* where the whorls rapidly enlarge in cross-sectional area, it seems very atypical in form. When combined with the absence of any lip reflection or callus formation to indicate terminal growth or slowing of growth upon becoming reproductively mature, reference to the Helicarionidae was a logical suggestion. Many taxa in this family have a comparatively high number of whorls that are tightly coiled, lack any positive indication of adult shell growth changes, and also lack any marked surface sculpture on the shell.

Both the relatively high whorl count and the small cross-sectional area increment in *Craterodiscus* have affected anatomical structures. Hence emphasis on the somewhat unusual shell form is necessary preamble to a discussion of the anatomy.

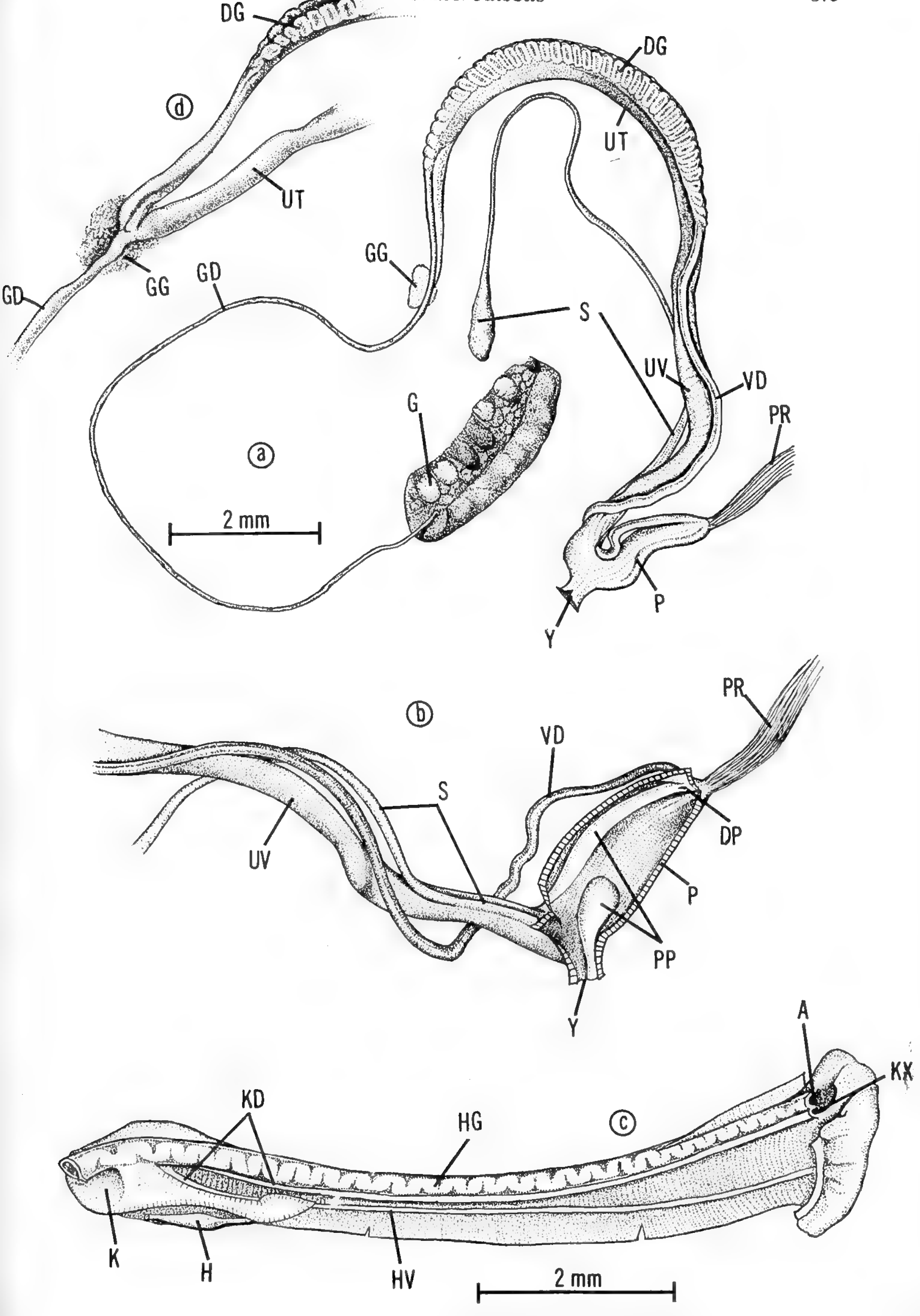
DESCRIPTION OF GROSS ANATOMY

Externally the body is colorless, except for grey speckling on the ommatophores and relatively large black eyespots. Foot and tail truncated anteriorly, bluntly rounded at posterior end with noticable transverse corrugations in most examples. Slime network irregular on head and sides of foot, becoming relatively elongated and rectangular just above foot margin. The character of the foot is holopod, not aulacopod. Gonopore location is below right ommatophore and behind right rhinophore.

Pallial region (Fig. 1, c) extending apically about one whorl in expanded specimens. Kidney (K) extending as dished posterior portion well over intestinal loop, quite narrow, reaching hindgut for posterior third of length, not bilobed, anterior end partly lying under primary ureter and pulmonary vein (HV). Latter extending anteriorly to edge of mantle collar, well removed from hindgut and markedly diverging from same in anterior half. Heart (H) very narow, almost two-thirds length of kidney. Ureter (KD) angled backwards along upper edge of kidney to hindgut, then reflexing forward to external ureteric pore (KX) directly alongside anal pore (A) at pneumostome.

Genitalia (Fig. 1, a, b, d) characterized by elongation and narrowing of parts together with little fusion of the male and female tracts. Ovotestis (G) of weakly divided lobes imbedded in digestive gland at upper palatal margin from one-eighth to one-quarter whorl above stomach, connecting to single tubule that leads into a very long hermaphroditic duct (GD). Latter following the prolonged stomach at parietal-palatal margin for almost one and one-half whorls, no major change in size or texture. Albumen gland (GG) variable in size, nestled between loops of intestine, with very fine acinar structure. No differentiation (Fig. 1, d) of a talon or distinct carrefour structure. Details of union between hermaphroditic duct (GD), albumen gland (GG) and separation into prostatic gonoduct (DG) and uterine gonoduct (UT) requiring histological study for elucidation. Split into totally separated male and female tracts (Fig. 1, d) occurs above pallial cavity apex. Prostatic and uterine gonoducts appressed together along pallial passage, but not at all connected. Free oviduct (UV) and uterine oviduct (UT) not externally differentiated, arbitrarily distinguishable in labelling at point where prostatic acini end and simple vas deferens (VD) continues down to peni-oviducal angle.

Text Fig. 1. Anatomy of *Craterodiscus pricei* McMichael (FMNH 135141). (a) genitalia showing origins and insertions of organs, (b) details of terminal genitalia and interior of penis, (c) pallial region, and (d) details of postpallial and early pallial genitalia showing complete separation of pallial gonoducts. Figures (b) and (d) enlarged over the scales shown for (a). Drawings (a-c) by Miss Claire Vanderslice, (d) by Miss Nelva Bonucchi.


DG
d
UT
GG
GD
DG
UT
GG
GD
S
UV
VD
PR
G
a
2 mm
P
Y
b
PR
VD
S
DP
UV
P
PP
Y
A
KX
KD
HG
c
K
H
HV
2 mm

Penial retractor (PR) inserting on head of penis, arising on lower part of pallial diaphragm. Vas deferens (Fig. 1, b) entering penis (P) near apex through a simple pore (DP) that lies in middle of a longitudinal pilaster (PP) that continues to atrium (Y). On lower third of penis interior, a second, higher, drop-shaped pilaster originates and continues down to base of atrium. Spermathecal head (S) slightly and elongately expanded, lying next to albumen gland, very slender shaft gradually fusing with free oviduct (Fig. 37, b) just above atrium so that no vaginal area differentiated.

Radula (Pl. 37) very distinctive with development of extraordinary endoconal cusp extensions on outer lateral and marginal teeth. Central tooth (Pl. 37 a, b, identified by "C") tricuspid, mesocone extending to level of ectoconal base on tooth in posterior row, ectocones variable, but usually coequal in size. First laterals with endocone distinctly narrower and shorter than ectocone, mesocone often noticably slenderer than mesocone of central tooth. Second lateral with ectocone split, endocone narrowed and slightly elongated. Third lateral with endocone extended into a slender lance-like prolongation (Pl. 37, c). Subsequent laterals with greater elongation of the endocone (Pl. 37, d). Transition to marginals involving progressive reduction of the mesocone, elongation of endoconal prolongation and finally increased splitting of the ectocone. Marginal teeth (Pl. 37, e, f) presenting a forest of endoconal prolongations, subsidiary cusps prolonged and elevated. In Pl. 37, figs. a-d are from the left anterior side of a radula, figs. e-f from the right posterior side of the same radular mount. Hence the difference in wear and cusp loss between the teeth in the two series of photographs.

Based on four specimens from Field Museum of Natural History number 135141.

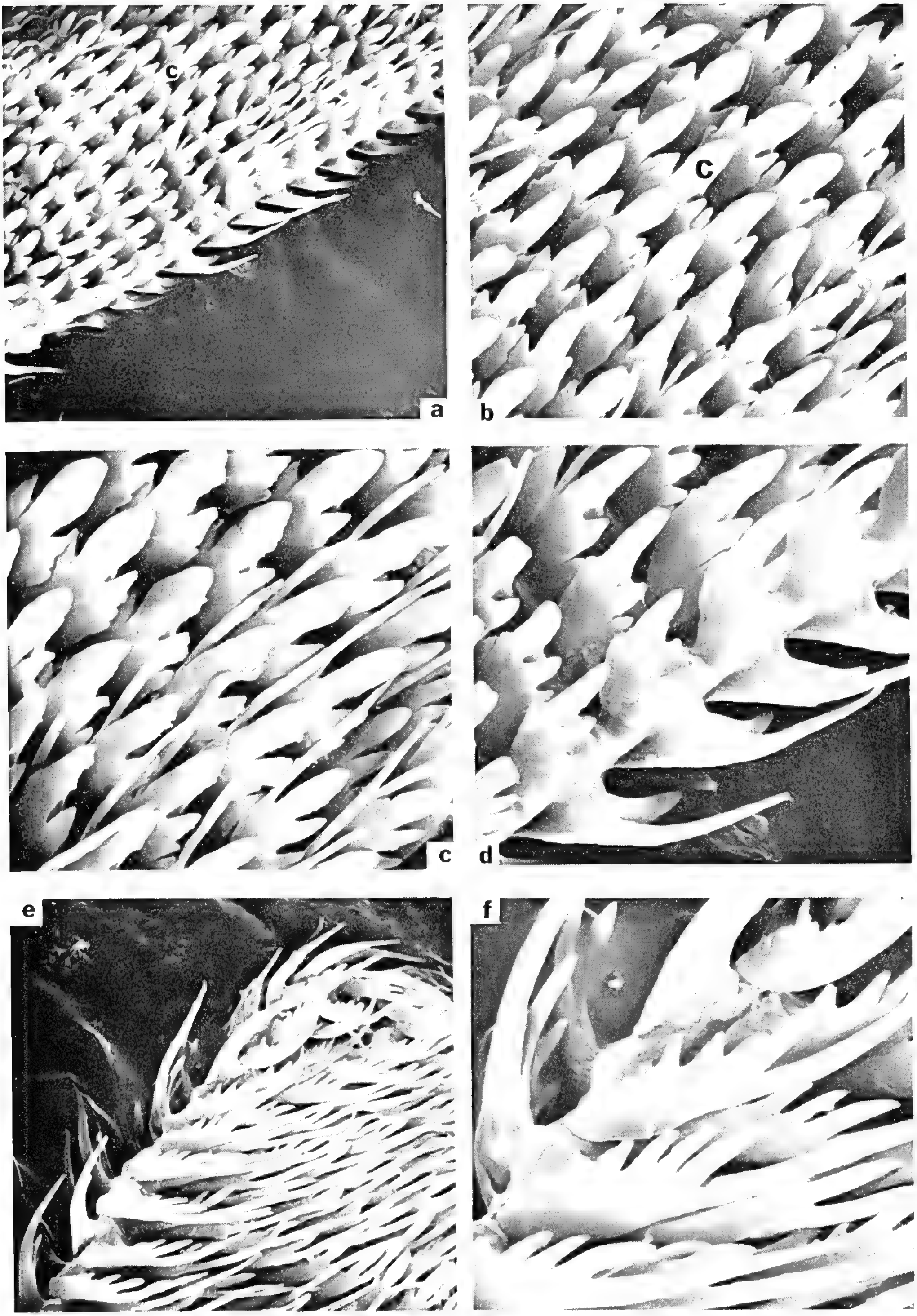
DISCUSSION OF ANATOMICAL FEATURES

As is common in many taxa having increased whorl counts, the apex of the soft parts was located 2½ whorls below the shell apex. The apical whorl space was filled with solidified mucous. As growth proceeded the apex of the digestive gland would have to be gradually withdrawn from the shell apex leaving empty space behind. Whether this is used by the snail for water storage or is simply an unutilized area is unknown. An unusually heavy amount of mucous was found alongside the soft parts at every level of the visceral hump. Probably this relates to the withdrawal of soft parts from the early whorls. Although whorl expansion is minimal, as pointed out above, there still is more cross-sectional area lower in the spire than at the apex. Withdrawal of the soft parts from a "fitted space" into a wider area leaves room around the body that the mucous partly fills.

Several features of the anatomy probably relate to the narrow whorl cross-section and can be assigned no phyletic significance. The narrowing and elongation of the kidney, the very long hermaphroditic duct, and peculiar path of the pulmonary vein on the lower part of the pallial roof, are all adaptations to narrow whorls. In order to allow full retraction of

PLATE 37. *Craterodiscus pricei* McMichael. Radular denticles (FMNH 135141) showing (a) partial row at 750x, (b) details of central (marked "C") and lateral teeth at 1,675x, (c) zone of transition between lateral and marginal teeth at 2,250x, (d) details of early marginal teeth at 2,250x, (e) outer marginal teeth at 1,365x, (f) outer marginal teeth at 4,100x. Photographs made at the Franklin Institute Research Laboratories, Philadelphia on a Jeolco JSM-U2 scanning electron microscope.

PLATE 37



the head and foot into a shell with narrow whorls, the kidney often is narrowed, extended apicad over the intestinal loop, and squeezed up into the parietal-palatal margin. This maximizes the area in the pallial cavity and allows more complete body contraction. The kidney form and position in *Craterodiscus* is typical of this alteration in pattern. Thus the position of the pulmonary vein relative to the hindgut in the anterior portion of the pallial roof probably is a relict from a "normal" shelled ancestor, while its close approach posteriorly, the shape of the kidney, and the vein-ureter-kidney overlap represent a space accomodation of recent origin. Narrowing of the whorls requires elongation of the stomach to maintain equivalent stomach volume to body volume ratio. With this, the hermaphroditic duct, a space saving tube connecting the ovotestis with the fertilization area, simply elongates equally.

Other anatomical features are not space correlated and hence can be given greater phyletic weight. The absence of fusion between the prostatic and uterine gonoducts throughout the pallial region is a primitive character in land snails. In such aulacopod taxa as the Helicarionidae, the Microcystinae have split pallial gonoducts, while the more advanced Helicarioninae, for example, have fusion of pallial gonoducts into a "spermoviduct." Primitive Orthurethra, such as the Tornatellinidae, have split pallial gonoducts, while in the more advanced Pupillidae there is partial fusion of the pallial ducts. The change from split to fused has occurred several times independently. Lack of any differentiation into an epiphallic section by the vas deferens also generally is a primitive character, although of much less phyletic significance. In cases of whorl reduction, a preliminary stage in evolution of slugs from shell-bearing taxa, then secondary reduction of the epiphallus or morphological infolding of this into the penis is of common occurence. In cases of whorl increment, I have seen no evidence for changes in the epiphallic structures occuring. Hence the lack of an epiphallic section in *Craterodiscus* may well be a primitive feature. This also suggests that sperm transfer is not by use of a spermatophore or sperm packet. Finally, there is the holopod nature of the foot. While in a few genera, such as the Bermudan *Poecilozonites*, aulacopod snails have developed a holopod foot situation, details of genital and radular structures leave no question as to the actual affinities.

Radular structures of the central and early lateral teeth are not unusual, but I know of nothing in the stylommatophoran pulmonates comparable to the endoconal prolongations found in *Craterodiscus*. Temporarily ignoring these, the basic characteristics of the radular teeth are the rather squarish to rectangular basal plates of the teeth, and the multicuspid nature of the marginals. In the marginals, the basal plates are shortened, but still square in form (Pl. 37, e), and the cusps inclined centrally.

AFFINITIES OF *CRATERODISCUS*

Consideration of the currently accepted diagnostic features for stylommatophoran classification immediately excludes *Craterodiscus* from several major groupings. The pallial configuration with secondary ureter places this within the Sigmurethra. Both the holopod foot and the confirmatory structures of the radular marginal teeth exclude classifying it with the aulacopod superfamilies Limacacea and Arionacea. Radular basal plate structures in the Limacacea are elongately rectangular with generally bicuspid (Zonitidae) to multi-cuspid (Helicarionidae) marginal configurations. In the Arionacea, the marginal teeth basal plates, with very few exceptions, are much wider than they are long, although retaining a rectangular shape. The small, square marginal basal plates with multi-cuspid denticles of *Craterodiscus* are quite different.

Thus *Craterodiscus* should be grouped with the holopod sub-group of the Sigmurethra. The various carnivorous taxa plus such herbivorous groups as the Bulimulacea, Achatinacea, and the sigmurethrous acavacean genera show such major differences in pallial structures, genitalia and radular characters that no discussion of detailed differences seems necessary. When added to the gross discrepancy in size (acavaceans) and totally different shell form (Achatinacea and Bulimulacea), these possibilities can be dismissed.

This leaves three superfamily groupings for consideration, the Polygyracea (including the Corillidae), the Camaenacea, and the Helicacea. In the first, the radular structure is basically bicuspid with the marginal basal plates tending to become rectangular with their width greater than their length. In the Helicacea, the radula is basically tricuspid with squarish basal plates. In the Polygyracea there is usually a short spermatheca and a very characteristic talon structure. Since the vast majority of the Polygyracea in the under 20 mm. size range have prominent apertural barriers, either formed at the lip edge in adults (Polygyridae) or sequentially at approximately quarter to half-whorl intervals (Corillidae), the absence of any such structures in *Craterodiscus* is another feature weighing against associating it with that superfamily.

The remaining superfamilies, the Camaenacea and Helicacea, contain a minimum of four families, the Camaenidae, Bradybaenidae, Helminthoglyptidae, and Helicidae. The last three taxa are basically Palearctic and Nearctic in distribution. They are characterized by developing various types of accessory mucous and/or dart glands on the genitalia. The Camaenidae, in the sense of Pilsbry, Thiele and Zilch, lack such accessory glands and, at most, develop a simple flagellum on the penis or epiphallus. Following Wurtz (1955), two North American taxa usually associated with the Camaenidae, the Oreohelicidae and Ammonitellidae, are considered to be distinct families, but retained within a new superfamily grouping, Camaenacea. The Camaenidae, *s.s.*, has a disjunctive distribution. Several genera are found on the West Indian islands, while two genera, *Labyrinthus* and *Isomeria*, range from Costa Rica to Madre de Dios, Peru. In the Old World, possibly camaenid genera are known from southeastern China *(Traumatophora, Stegodera, Moellendorffia, Grabauia)*, while definitely camaenid genera range from the Himalayan foothills of India and southern China with a few species reaching southern Japan through most of Indonesia to New Guinea, Northern Australia and the Solomon Islands. Coastal Queensland has several generic groupings that are terminal extensions of the Indonesian-Melanesian taxa, while Northern, Central and Western Australia have a major radiation of camaenid derivatives.

Unfortunately very little has been published concerning the anatomy of Indo-Australian helicoid taxa. Charles Hedley (1896, p. 224) recognized two series of genera: one *(Thersites)* with a long spermathecal duct and an epiphallic section of the male system extending above the penial retractor insertion; the other *(Xanthomelon)* with a very short spermathecal duct and the epiphallus section folded into the penis sac below the penial retractor insertion. Wurtz (1955, p. 105) has shown that in the New World camaenids there is every variation between long and short spermathecae, while the penial complex varies even more widely. The known anatomical range for the Indo-Australian camaenid taxa does not exceed that known for the New World genera. Hence the actions of Iredale (1937, 1938) in proposing the families Hadridae, Chloritidae, Papuinidae, Xanthomelontidae and Rhagadidae for Australian genera is not accepted here. All are considered to belong to the Camaenidae, *s.l.*. I do not consider sufficient data available to allow subfamily recognition.

Camaenids agree with *Craterodiscus* in usually having a single mass of ovotestis tissue, frequently lacking a talon, having a closed secondary ureter, no differentiation of the mantle collar, and a pallial configuration that is consistent with being the condition from which that of *Craterodiscus* was derived. There are significant differences. All previously dissected taxa appear to have a fused sperm-oviduct and an epiphallic section differentiated from the vas deferens. Many have a flagellum on the epiphallius, although this is reduced in some taxa. Hence the separated spermiduct and oviduct, absence of an epiphallus, and no trace of any flagellar structures readily distinguish *Craterodiscus* from any dissected camaenid genera. With its long spermatheca and comparatively simple internal penial ornamentation, comparisons with the various xanthomelontid genera does not seem necessary, while the much greater size and different shape of the chloritid and hadrid stocks make conchological differences obvious. It is worth noting that the genera grouped as hadrids by Iredale average 5 - 7 whorls in adult shells, while the chloritids average 4¾ whorls and rarely reach 5½, and the xanthomelontids are well under 5 whorls. The 6 - 6½ whorls of *Craterodiscus* thus provide an immediate conchological separation from most genera. It should not be assumed that these whorl count differences have phyletic significance. I suspect that when enough genera have been dissected, the hadrid-xanthomelontid- chloritid groupings will be proved invalid. Most families of land snails have a rather wide range in whorl counts and these neat isolates of different whorl counts probably are artificial.

The lack of any thickening or lip reflection in *Craterodiscus* is also unusual for a camaenid and serves to differentiate it from any Australian genera. The only extralimital genus that bears close conchological resemblence is the Indian to Indonesian *Landouria*, which differs obviously in having a slightly reflected lip, many more radular teeth and a prominent epiphallus with flagellum.

Craterodiscus and Theskelomensor may be closely related, but until the latter has been dissected, this cannot be determined. At present, it seems best to consider *Craterodiscus* a very primitive camaenid, possibly representing character states close to the ancestral condition for the family.

ACKNOWLEDGEMENTS

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B. C. COTTON: ADDITIONS TO THE INDEX OF HIS NEW SCIENTIFIC NAMES

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Since publication of the Bibliography and Index to New Names of B. C. Cotton (Laws and Mincham, 1968) a number of friends and co-workers have drawn my attention to several omissions in the list of new names. The first editions of Cotton's handbooks covering the bivalves and chitons were inadvertently omitted from the publications as they were checked for new names. Publications involved are listed below, numbered as in the original bibliography, and the additional list of new names follows.

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THE CHROMOSOMES OF *SUCCINEA AUSTRALIS* (FÉRUSSAC)

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SUMMARY

The chromosomes number of *Succinea australis* (Férussac) from four localities in South Australia is n=18; the largest chromosome pair of the complement is metacentric.

INTRODUCTION

During the past few years a number of studies of the chromosomes of the Succineidae have been published. Haploid chromosome numbers of n=5 and n=6 have been demonstrated for the anatomically more primitive Catinellinae (Burch, 1964a, 1964b; Butot & Kiauta, 1967) and of n=12 to n=22 for the more advanced Succineinae (Natarajan, Hubright & Burch, 1966; Burch, Patterson and Natarajan, 1966; Burch, 1967) apparently supporting a correlation of low chromosome number with "primitiveness." However, Patterson's reports (1968, 1970) of n=25 in the primitive genus *Quickia* question either the validity of a primitive—low chromosome number correlation in the Succineidae, or the position of *Quickia* in the family. The wide range of chromosome number known for the family, the karyotype information which is available for a number of species, and the problems of relating anatomical and cytological information, make this an extremely interesting group for which any further observations are of value. *Succinea australis* (Férussac) has already been studied anatomically (Quick, 1941) and this paper describes the cytology of this southern Australian species,

MATERIALS AND METHODS

Succinea australis is the common amber snail of South Australia and Victoria. The species was studied anatomically by Quick (1941) and is a member of the Succineinae, being closely allied to *S. striata* Krauss. Chromosome counts were made from snails taken at the localities given in Table 1, and duplicate voucher specimens are in the collections of the South Australian Museum. Specimens from Blanchtown were dissected and found to agree with Quick's description for the species.

Pieces of ovotestis were squashed in aceto-orcein, no prior fixation being used. A selection of slides was made permanent by inverting in absolute alcohol to soak off the coverslips which were then replaced with Euparal.

RESULTS

The chromosome number of *Succinea australis* from all localities in Table 1 was n=18 (Figure 1).

In this species, as in other land snails, large-nucleate cells are associated with the spermatogenic tissues. In Port Gawler specimens of *S. australis* these large nuclei were highly polyploid (figure 2). A number of mitotic divisions showed triploid, tetraploid and hexaploid chromosome complements (figures 3, 4 and 5); the mitotic metaphase of the tetraploid cell of figure 5 shows the largest chromosome of the complement to be metacentric. In the cell shown in figure 4 some daughter chromosomes have already separated and in that in figure 3 separation is complete but a number of pairs of daughter chromosomes can still be identified. It appears that in these cells chromosome number is being built up at mitosis by failure of spindle formation and of normal anaphase separation, i.e. endomitosis.

DISCUSSION

The haploid numbers 17, 18, 19, 21 and 22 have been previously reported for the genus *Succinea* (Burch, 1967). The species *S. concordialis, S. greeri, S. urbana, S. campestris* and *S. luteola,* all of which are native to the United States of America, have n=18 as shown here for *S. australis.* In *S. greeri* and *S. urbana* the largest chromosome pair is submetacentric and in *S. concordialis* (Natarajan, Hubright and Burch, 1966, fig. 2) it is apparently metacentric as in *S. australis.* At present, subgeneric groupings in *Succinea* are not well understood and a thorough anatomical study of members of the genus is necessary. It will be of interest to see if groupings made on the basis of chromosome morphology and number correspond to those established on an anatomical and morphological basis.

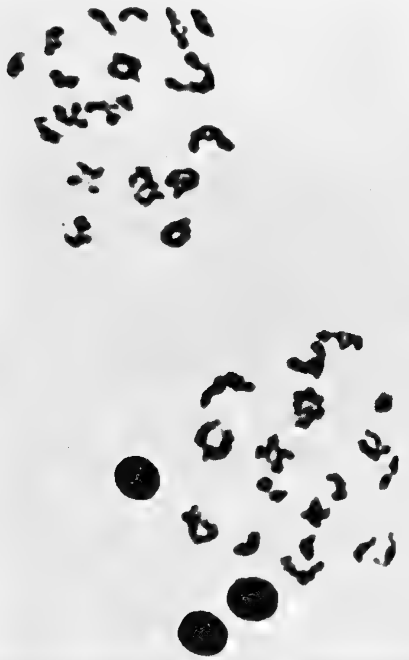
Table 1

COLLECTIONS OF *SUCCINEA AUSTRALIS* USED FOR CHROMOSOME STUDIES

Locality	South Aust. Museum Registered number
Rosetta Head, Encounter Bay	D.14820
Kingston, South-east of S.A.	destroyed in dissection
Port Gawler	D.14870
Blanchetown	D.15010

TEXT Figure 1 - 5

1. Meiotic diakinesis chromosomes of two cells in *Succinea australis;* the larger densely stained bodies are sperm heads.
2. The large polyploid nucleus of a cell associated with the spermatogenic tissues.
3. A hexaploid cell; recent chromosome division and separation has occurred and some pairs of daughter chromosomes can still be identified.
4. Endomitotic metaphase in a triploid cell; some daughter chromosomes have separated.
5. Endomitotic metaphase in a tetraploid cell.



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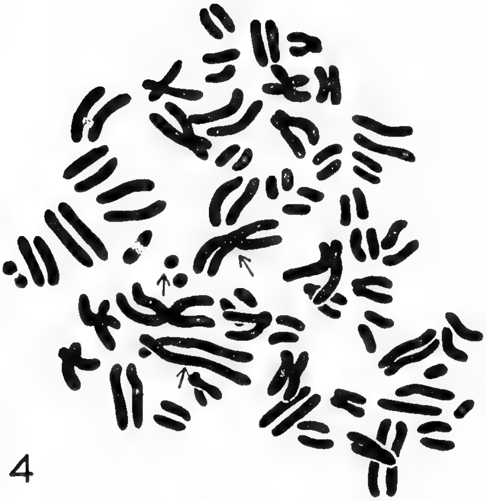

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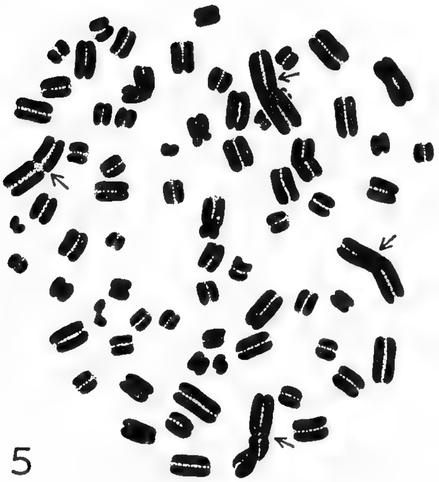

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NOTE ON A THAISID GASTROPOD WITH AN ABNORMAL TENTACLE

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Plate 38

Lepsiella scobina (Quoy and Gaimard, 1833) (Thaisidae, Stenoglossa), commonly known as the oyster-borer, occurs in the intertidal area throughout New Zealand. In the northern parts of the North Island it is an important predator on the New Zealand rock oyster, *Crassostrea glomerata* (Gould, 1850). The biology of the oyster-borer, as well as its control in oyster beds, is part of a general study on the biology of the rock oyster.

During an examination of a batch of *L. scobina*, collected from the Bay of Islands area in the North Island on 16 July 1971, one specimen was found to possess an unusual set of tentacles and eyes. The specimen, a female (shell height 19 mm, diameter of body whorl 11.8 mm), had the right cephalic tentacle bifid at the tip, with 2 well-formed eyes on it (Fig.1);
right cephalic tentacle bifid at the tip, with 2 well-formed eyes on it (Fig.1);
normal tentacle with a single eye on its outer aspect was present on the left side of the head. In the same batch, 346 specimens of *L. scobina* were collected (representing the population in a m^2 area).

The stub-like median process in the head is probably the result of an injury; the reduced eye on the stub suggests that it was perhaps the original right tentacle. The fully developed bifid appendage in the specimen may therefore represent the regenerated right tentacle. Hanko (1914) has demonstrated remarkable powers of regeneration of soft parts, including that of tentacles and eyes, in another stenoglossan, *Nassarius mutabilis*. However, the bifid nature of the tentacle and the double eye on it are very peculiar to the present specimen, and are probably different from simple duplication of tentacles in species of *Oncomelania*, noted by Wong and Wagner (1956).

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Fisheries Research Publication No. 184.

Plate 38. *Lepsiella scobina.* Dorsal view of head, showing abnormal right tentacle and double eyes, and the median lobe with its reduced eye. The irregular blotches are pigments in the skin.

A NEW SPECIES OF *PTERYNOTUS* (GASTROPODA : MURICIDAE) FROM WESTERN AUSTRALIA

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Plate 39

SUMMARY

A new species, *Pterynotus (Pterochelus) westralis*, is described from the south-western continental shelf of Australia. The radulae of two other species of *Pterynotus* are described.

INTRODUCTION

Recent dredging and trawling operations undertaken by the Western Australian Museum off the southern half of the Western Australian coast have brought to light a number of new species, one of which, a species of *Pterynotus*, is described below.

TAXONOMY

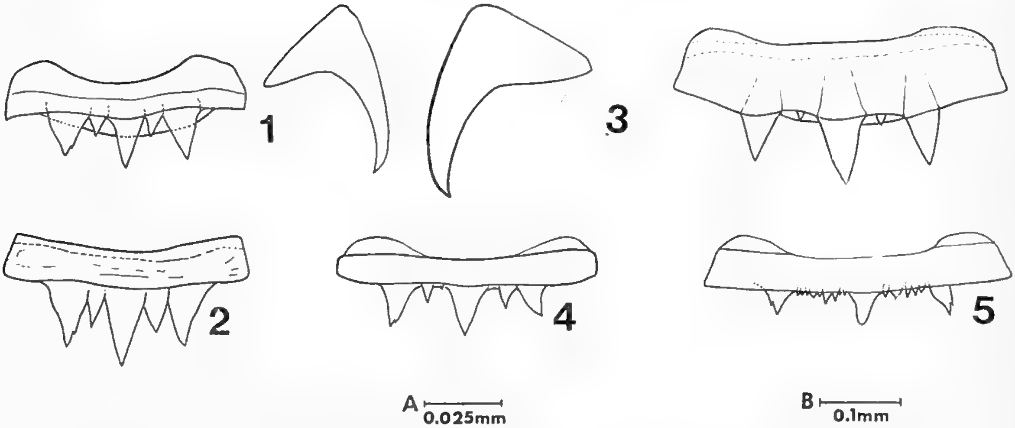
Family Muricidae

Genus *Pterynotus* Swainson, 1833.

Type species: (s.d. Swainson, 1833) *Murex pinnatus* Swainson, 1822 = *alatus* Röding, 1798.

Ponder (1972: 216) suggested that *Pterynotus* (s.s.) be retained for species without a posterior spine and having crisp, scabrose sculpture and a multispiral protoconch, whereas the subgenus *Pterochelus* has a posterior spine, does not develop the scabrose sculpture as intricately as in *Pterynotus* (s.s.) and has a paucispiral protoconch. The radulae of the species of these two groups are quite similar. The new species has shell characteristics of both of these groups. It has a rather weak posterior spine, intricate scabrose sculpture and a paucispiral protoconch. Thus the new species best fits *Pterochelus* and it would appear that scabrose sculpture can occur in both subgenera. It is quite probable that *Pterochelus* is not worthy of recognition even as a subgenus. The status of *Pterochelus* can only be more accurately assessed when the protoconchs of more species of *Pterynotus* (s.l.) are described.

The opportunity is taken to figure the radulae of two species of *Pterynotus* (s.s.) which were previously undescribed. These are: *Pterynotus (Pterynotus) bipinnatus* (Reeve, 1845), shown in Text Fig. 3, from Sandoval Point, Catanaun, Bondoc Peninsula, S. Quezon, Philippines (13°35′ N, 122°



TEXT FIGURES. 1-5. Radular teeth.
1, 2. *Pterynotus (Pterochelus) westralis* sp. nov. (fig. 2 shows central tooth flattened).
3. *Pterynotus (Pterynotus) bipinnatus* (Reeve). Sandoval Point, S. Quezon, Philippines (WAM 132-72).
4, 5. *Pterynotus (Pterynotus) tripterus* (Born). Pala Point, S. Quezon, Philippines (WAM 112-72).
Scale A: fig. 1, 2, 4, 5, Scale B: fig. 3.

16′ E), under dead coral in 1.8 metres. Collected Western Australian Museum Luzon Expedition, 18 August 1965. W.A. Mus. reg. no. 132-72. *Pterynotus (Pterynotus) tripterus* (Born, 1778), shown in Text Figs. 4 and 5 from Pala Point, Catanaun, Bondoc Peninsula, S. Quezon, Phillippines (13°34′ N, 122°20′ E). Collected Western Australian Museum Luzon Expedition, July-August, 1965. W.A. Mus. reg. no. 112-72.

The radulae of both these species are similar to those of *P. (Pterynotus) alatus* (Röding, 1798) and *P. (Pterochelus) acanthopterus* (Lamarck, 1816) (Ponder, 1972: text figs. 1 and 2 respectively) and to the new species described below. One of the specimens of *P. tripterus* (text fig. 5) shows a freak condition with several accessory denticles.

Subgenus *Pterochelus* Jousseaume, 1880.

Type species: (o.d.) *Murex acanthopterus* Lamarck, 1816.

Pterynotus (Pterochelus) westralis sp. nov.

Plate 39, figures 1, 2. Text Figs. 1, 2.

Description. Shell: small, solid, with rather short spire and long anterior canal and short posterior spine. Protoconch yellow-brown to purple, rather large, of one whorl with tip slightly inrolled, terminated with a varix, smooth and shining. Teleoconch with up to 4 whorls, 3 varices on all whorls, arranged in almost straight lines. First 1⅓ whorls of teleoconch convex, smooth and shining, and like the protoconch whorls except for the presence of thin varices and a few very weak spirals. Later whorls angled, with wider varices bearing a short process at the shoulder which forms a spine, hardly protruding beyond the varices, on penultimate and body whorls. Spine thickened behind varix, not hollow but formed from an open channel which is filled in with minute axial lamellae. These lamellae over whole surface, especially well developed on front side of

Pterynotus

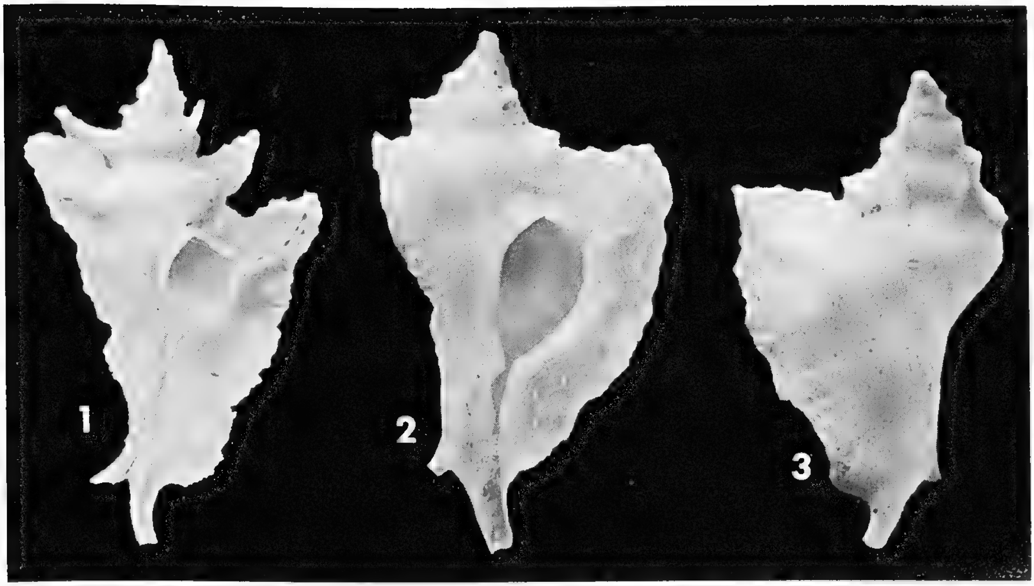


PLATE 39.

1. *Pterynotus (Pterochelus) acanthopterus* (Lamarck). N.W. of Rottnest Island, Western Australia in 146 metres.

2, 3. *Pterynotus (Pterochelus) westralis* sp. nov. 2. holotype, 3. paratype.

Figures not to same scale. For dimensions see Table 1.

varix; forming rows of scales between the spiral cords. Spirals weak, about 11 on penultimate whorl, peripheral spiral not noticeably stronger than others but runs into a prominent rib on the back of each varix which forms the posterior (shoulder) spine. Each varix formed from a thin lamella which is thickened and strengthened by the development of the axial lamellae on front surface, ultimately becoming rather thick and solid. Variceal flange extending from suture to about two thirds along the anterior canal as a slightly crenulated wing of almost equal width along its entire length. A single prominent rounded knob on shoulder between each pair of varices. Aperture moderately large, almost round, inner lip smooth, outer lip with about 6 weak denticles within and outer edge crenulate; both lips somewhat extended. Anterior canal slightly curved to right. Posterior canal short, V-shaped when varix mature, extended as variceal spine when varix immature, this forming a narrowly open groove. Color white or sometimes pale pink when fresh, the first few whorls purplish to brownish, anterior canal sometimes stained very pale brown.

Operculum: rather thin, pale yellow-brown, with terminal nucleus (obtained from specimen WAM. 169-72).

Radula: (Text Figs. 1, 2) central teeth broad, with 3 prominent cusps, the middle one the largest, between which lie short intermediate cusps. Lower part of base of each central tooth flanged laterally. A minute denticle on inside of one lateral cusp in the specimen examined is probably atypical. Lateral teeth simple, cusp narrow, slightly curved, base broad (obtained from specimen WAM. 169-72).

Dimensions: see Table 1.

Type series. Four specimens from one original lot dredged on L. F. B. "Bluefin" by B. R. Wilson, 14 August, 1962 viz: holotype in the W.A. Museum reg. no. 438-72; 2 paratypes in the W.A. Museum reg. nos. 439-72 and 440-72; 1 paratype in the Australian Museum, Sydney reg. no. C. 89039. *Type locality.* 146 metres, NW of Rottnest Island, Western Australia, fine calcareous sand substrate.

Range and habitat. Off the central west coast of Western Australia from Point Cloates (lat. 22°52′ S) to Bunbury (lat. 33°00′ S), at depths from 115 to 221 metres. Fine calcareous sand substrate, usually with sponges and bryozoans.

Other material examined. (The number of specimens is indicated in parenthesis at the end of each record and the Western Australian Museum registered numbers precede each record): 170-72. 22°52′ S, 112°29′ E, W of Point Cloates, 6 Oct. 1963, 134m, DM 6/63, Stn. 178 (1); 176-72. 27°18′ S, 113°16′ E, NW of Bluff Point, 9 Oct. 1963, 99m, DM 6/63, Stn. 204 (1); 121-66. 27°40′ S, 113°03′ E, NW of Bluff Point, 22 Aug. 1963, 128m, DM 4/63, Stn. 131 (1); 120-66. 27°40′ S, 112°03′ E, NW of Bluff Point, 22 Aug. 1963, 128m, DM 4/63, Stn. 131 (1); 118-66. 29°05′ S, 113°56′ E, SW of Geraldton, 16 Feb. 1964, 130-148m, DM 1/64, Stn. 54 (1); 372/3-72. 29°15′ S, 114°01′ E, W of Dongara, 20 Mar. 1972, 139-146m, DM 1/72, Stn. 55 (2); 172-72. 30°00′ S, 114°32′ E, NW of Jurien Bay, 28 Jan. 1964, 128-137m, DM 1/64, Stn. 3 (1); 374/5-72. 30°37′ S, 114°44′ E, NW of Green I., 22 Mar. 1972, 146-139m, bottom temp. 19.71°C, DM 1/72, Stn. 68 (2); 376-72. 31°00′ S, 114°52.5′ E, W of Lancelin, 23 Mar. 1972, 146-150m, bottom temp. 19.12°C, DM 1/72, Stn. 70 (1); 377/8-72. 41°30′-34′ S, 114°56′ - 115°06′ E, W of Guilderton, 23 Mar. 1972, 146m, bottom temp. 19.84°C, DM 1/72, Stn. 76 (2); N4353. NW of Rottnest I., 15 Aug. 1962, 155m, L. F. B. "Bluefin" (1); N4332. NW of Rottnest I., 14 Aug. 1962, 183-188m, L. F. B. "Bluefin" (1); 169-72. W of Westend, Rottnest I., 12 Aug. 1962, 139-144m, L. F. B. "Bluefin" (1); 379/80-72. 32°00′ S, 115°15′ E, W of Rottnest I., 23 Mar. 1972, 146-150m, bottom temp. 19.78°C, DM 1/72, Stn. 78 (2); 173-72. W of West End, Rottnest I., 16 Sept. 1965, 128m, L. F. B. "Bluefin" (2); 171-72. W of West End, Rottnest I., 16 Sept. 1965, 177-183m, L. F. B. "Bluefin" (1); 174-72. SW of Rottnest I., 7 Sept. 1965, 146-152m, L. F. B. "Bluefin" (1); 175-72. 33°00′ S, 114°52′ E, NW of Bunbury, 17 Feb. 1964, 115-123m, DM 1/64, Stn. 59 (1); 381-72. 33°00′ S, 114°37′ E, NW of Bunbury, 17 Mar. 1972, 219-221m, bottom temp. 14.57°C, DM 1/72, Stn. 6 (1).

Remarks. The new species occurs sympatrically with its relative *P. (P.) acanthopterus* along the outer part of the continental shelf of the central Western Australian coast but, unlike its congener, *P. (P.) westralis is* confined to this deeper zone. The two species have sometimes been collected together in the same dredge haul (e.g. WAM N4431 *(acanthopterus)* and WAM N4353 *(westralis)* dredged from 155 metres, N.W. of Rottnest Island).

Specimens of *P. (Pterochelus) acanthopterus* (plate 39, fig. 1) differ from *P. (P.) westralis* in having a much longer posterior spine, about twice the width of the variceal flange, thinner varices, a strong shoulder spiral rib and another somewhat prominent spiral rib on the upper base. All whorls are more distinctly shouldered in *acanthopterus* and all the varices bear distinct shoulder spines. The shell is also larger and lighter in weight and has a relatively taller spire. The anterior $\frac{1}{3}$ of the anterior canal is twisted dorsally and is not bent to the right. The scaly sculpture seen in the new species is much more indistinct in *acanthopterus* and the scales do not fill the posterior canal in *acanthopterus* as they do in *westralis*. The outer lip is crenulated in *acanthopterus* but does not form the denticles usually seen in *westralis*. The two species are thus readily distinguishable and *westralis* is very constant in nearly all its characters.

Murex (Pterynotus) exquisitus Sowerby (1904: 176) is similar to the new species. Sowerby's species was described from unknown habitat and has apparently not been dealt with in the literature since its introduction. It differs from the new species (as far as can be judged from the description and a photograph of the type obtained from the British Museum) in having a relatively smaller aperture, a straight anterior canal on which the varix is replaced by 4 spines and in having 2 brown bands. In most other respects the two species appear to agree closely.

ACKNOWLEDGMENTS

Dr. J. Taylor of the British Museum (Nat. Hist.) kindly supplied photographs of the type specimen of *Murex exquisitus* Sowerby. Mr, C. Turner of the Australian Museum produced the other photographs and Mrs. J. Ponder did the drawings of the radular teeth.

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Appendix

Locality data for measured *Pterynotus (Pterochelus) acanthopterus* in Table 1. All specimens in the Western Australian Museum. 67-66. NW of Rottnest I., W.A., 15 Sept. 1965, 146m; N4211. W of West End, Rottnest I., W.A., 12 Aug. 1962, 139-144m; 123-66. 28°14′ S, 113°28′ E, SW of Bluff Point, W.A., 4 Nov. 1964, 110m; 338-67. 11 Km. N of Long I., Onslow, W.A., 17 June 1960, 51m; 125-66. 29°49′ S, 114°24′ E, W of Dongara, W.A., 11 Oct. 1963, 128-132m.

TABLE 1. Comparison of shell dimensions of *P. (P.) westralis* and *P. (P.) acanthopterus*. (All specimens in the W.A. Museum).

P. (P.) westralis

Reg. No.	Height	Width	Height of aperture & canal	Length of posterior spine on last varix
438-72 (holotype)	28.02mm	15.40mm	18.62mm	6.05mm
439-72 (figured paratype)	25.00	14.56	16.94	6.24
172-72	31.29	18.40	20.25	6.93
120-66	27.00	16.87	18.60	7.27
N4332	30.26	18.36	19.76	7.10
173-72	28.21	16.86	18.30	6.68
169-72	27.30	15.05	18.24	5.85

P. (P.) acanthopterus

Reg. No.	Height	Width	Height of aperture & canal	Length of posterior spine on last varix
67-66 (figured specimen)	53.40	29.83	33.60	11.37
N4211	49.85	27.64	32.12	11.74
123-66	46.46	26.88	29.00	9.90
3388-67	29.50	21.50	19.25	10.13
125-66	32.87	19.50	20.90	8.62

(see Appendix)

A REVIEW OF THE AUSTRALIAN SPECIES OF *PENION* FISCHER (NEOGASTROPODA: BUCCINIDAE)

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ABSTRACT

The Australian Recent and Tertiary species of *Penion* Fischer are reviewed. *Penion* is shown to be properly used for the Southern Hemisphere species previously referred to a number of genera including *Siphonalia, Austrosipho* and *Verconella*. *Penion* is contrasted with related Australian genera and is also shown to be closely allied to the Northern Hemisphere genera *Neptunea* Röding and *Kelletia* Fischer. The Recent Australian species are reduced to two, *P. mandarinus* (Duclos) and *P. maximus* (Tryon). The New Zealand *P. mandarinus* auct. is referred to *P. sulcatus* (Lamarck). Three fossil species and one subspecies are recognised.

INTRODUCTION

A group of large, fusiform buccinid gastropods found in temperate Australia, New Zealand and as fossils in South America have been variously referred to genera such as *Siphonalia* A. Adams, 1863, *Austrosipho* Cossmann, 1906 and *Verconella* Iredale, 1914. Cossmann (1901), Thiele (1929) and Wenz (1941) recognised the close relationship between this Southern Hemisphere group and the Northern Hemisphere genus *Kelletia* Fischer, 1884.

The large degree of variation observed in the Recent Australian species of *Penion* and the confusion over the application of genus and species names resulted in this study being undertaken.

The only genus represented in southern Australia that could be confused with *Penion* is *Pleuroploca* Fischer, 1884 (?=*Pleia* Finlay), which is placed in the Fasciolariidae. This genus has an entirely different radula and external coloration of the head-foot, and plaits on the anterior part of the columella.

The relatively large, paucispiral protoconchs seen in the New Zealand species of this genus are evidence of the retention of the veliger in the egg capsule until it reaches the crawling stage. Only 4-6 embryos emerge from each egg capsule in *P. adustus* (Philippi) (Powwell, 1929). This type of development usually results in some population variation which, in the case of semi-isolated populations, can be marked. The smaller protoconchs of the Australian species suggests that a short larval life may possibly occur.

Careful examination of large series of shells from numerous locations has shown that only 2 Recent species of *Penion* can be distinguished in Australian waters. The large number of species and subspecies currently recognised in New Zealand will also undoubtedly be reduced when new revisionary work is attempted using the larger samples now available.

Probable South American species include *P. subreflexa* (Sowerby), a fossil species from Chile and *P. domeykoana* (Philippi) and *P. subrecta* (v.Ihering), both Patagonian fossils. Cossmann (1901) included *Siphonalia dentifera* Martin and *S. tjibalungensis* Martin, both from the Tertiary of Java, in *Penion* and *Kelletia* respectively. Neither of these species appear to belong to *Kelletia* or *Penion* as far as can be judged from Martin's illustrations. The species described as *Verconella* by Palmer (1937) are not congeneric with *Penion* or *Kelletia*, as they show a number of differences including a protoconch having keeled whorls. A species wrongly assigned to *Penion* (as now interpreted) by Tate (1888) and Darragh (1970) is the fossil species *Siphonalia lamellifera* Tate (1888: 142) from the Miocene of Schnapper Point (=Fossil Beach), Port Phillip Bay, Victoria. This species can tentatively be placed in *Pleuroploca* as it has 2 folds on the columella.

ABBREVIATIONS

STATES		MUSEUMS	
N.S.W.	New South Wales	N.M.V.	National Museum of Victoria
S. Aust.	South Australia	S.A.M.	South Australian Museum (registered numbers given without abbreviations refer to Australian Museum specimens).
Vict.	Victoria		
W. Aust.	Western Australia		

TAXONOMY

Family BUCCINIDAE (= Buccinulidae, Austrosiphonidae etc.)

Genus *Penion* Fischer, 1884: 625.

Type species: (o.d.) *Siphonalia dilatata* (Quoy & Gaimard) = *Fusus dilatatus* Quoy & Gaimard, 1833. Recent, New Zealand.

SYNONYMS:

Austrosipho Cossmann, 1906: 229. Type species: (o.d.) *Siphonalia roblini* Tate, 1888. Lower Miocene, Tasmania.

Verconella Iredale, 1914: 175. Type species: (o.d.) *Fusus dilatatus* Quoy & Gaimard, 1833. Recent, New Zealand.

Berylsma Iredale, 1924: 267. Type species: (o.d.) *Fusus waitei* Hedley, 1903. Recent, Australia.

Largisipho Iredale, 1929: 182. Type species: (o.d.) *Largisipho (oligostira) spectanda* Iredale, 1929. Recent, Australia.

Generic Diagnosis.

Shell: Protoconch small to large, of $1\frac{1}{2}$-4 smooth, convex whorls. Teleoconch large, spire about equal in height to the aperture plus canal, sculpture of primary to quarternary spiral cords or riblets, axials often form prominent knobs on shoulder of whorls. Aperture ovate, with moderately long anterior canal which can be strongly twisted to almost straight. Outer lip not much thickened, with internal lirations; inner lip smooth, with sharply delineated callous deposit. Columella long, somewhat sinuous, tapering towards the end; siphonal fasciole weak to prominent.

Operculum: Leaf shaped, with a terminal nucleus. A shallow median furrow visible externally. Muscle scar large, occupying most of the central area. A raised rim present on the inside of the outer edge (i.e. that edge opposite the outer lip when the animal is retracted).

Radula: Each transverse row with a large central tricuspid tooth, the cusps short and almost equal in size and the base narrow. Two lateral teeth usually with 3 subequal cusps (4 in *P. benthicolus* Dell (Dell, 1956: 97, text fig. B 1)). Powell (1929) has figured the radulae of some New Zealand species and Dell (1956) has discussed radular variation in some New Zealand species.

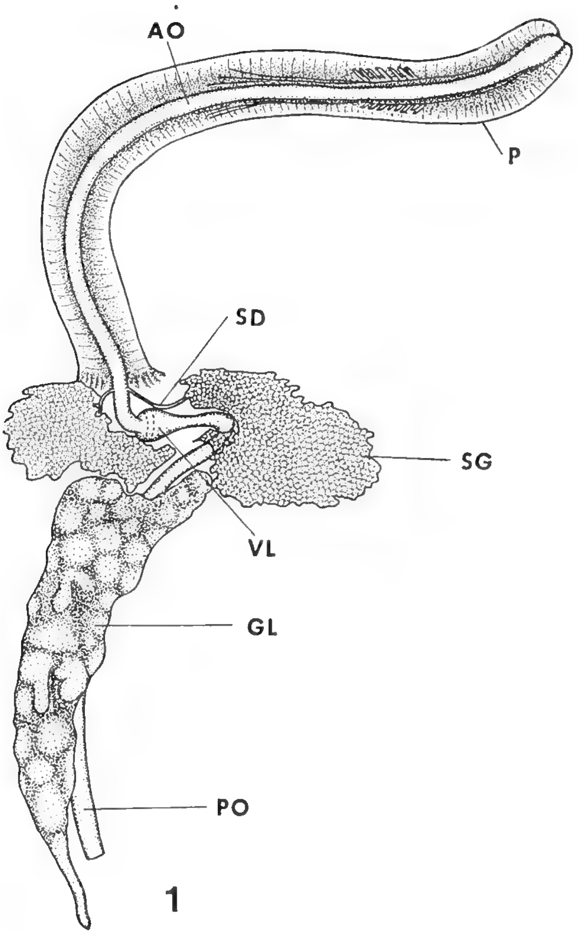
Anatomy: The New Zealand *P. adustus* (Philippi) was studied in some detail and *P. dilatatus* (Quoy & Gaimard) and *P. mandarinus* (Duclos) were also investigated. Most of the detailed points are taken from *P. adustus*. The majority of the following features, as far as can be judged from the material at my disposal, are common to the 3 species examined, and to *P. maximus* investigated by Kesteven (1904).

Head foot: Foot relatively small, simple, usually pigmented in irregular patches. Tentacles short, eyes on bulges at outer bases.

Pallial Cavity: Bipectinate osphradium about equal in length to the large ctenidium and about half of its width in *P. adustus* to about equal in width in *P. maximus*.

Alimentary Canal: (text fig. 1) Proboscis (text fig. 1: 1; P) large, long, with a muscular sheath capable of being fully incorporated into the proboscis. Buccal mass (text fig. 1: 2) elongate, narrow. Radular sac (RS) protruding posteriorly for a distance equivalent to about half the length of the odontophore where it lies amongst a mass of odontophoral retractor muscles (OR). Radular retractor muscle (RR) prominent, attached to the distal end of radular sac. Anterior two thirds of dorsal half of odontophore covered by a thin sheet of transverse muscle. Beneath this lie weak radular protractor and powerful retractor muscles. Beneath the odontophore are the odontophoral protractor muscles (OP). Anterior oesophagus (AO) with 2 low folds ("dorsal folds") lying latero-ventrally, and within these folds are embedded the salivary ducts (SD). Valve of Leiblein (text fig. 1: 1; VL) a little in front of the nerve ring, small but distinct, distinguished by a white collar and a sudden swelling of the oesophagus. Salivary glands (SG) large, irregular, and lie in front of the gland of Leiblein (mid gut gland) (GL). Mid-oesophagus short, with the irregular, brown gland of Leiblein opening into it. The dorsal folds, which disappear just before the valve of Leiblein, reappear in the mid-oesophagus as prominent mid-dorsal structures which terminate just behind the opening to the gland of Leiblein, this point marking the commencement of the posterior oesophagus (PO). Gland of Leiblein (GL) moderately large, dorsal to the posterior oesophagus and narrows at the posterior limit of the cephalic haemocoel to a finger-like outgrowth which extends into the "cephalic vein."

Stomach a simple U-shaped structure with a similar external shape in all species examined. Only *P. adustus* has been examined in detail and its morphology is shown in Text fig. 1: 3. Essential features are:— the widely separated openings of the digestive gland ducts (AG, PG), oesophagus (O) and intestine (I); the overall simplicity of the structure which has become little more than a slightly expanded portion of a continuous



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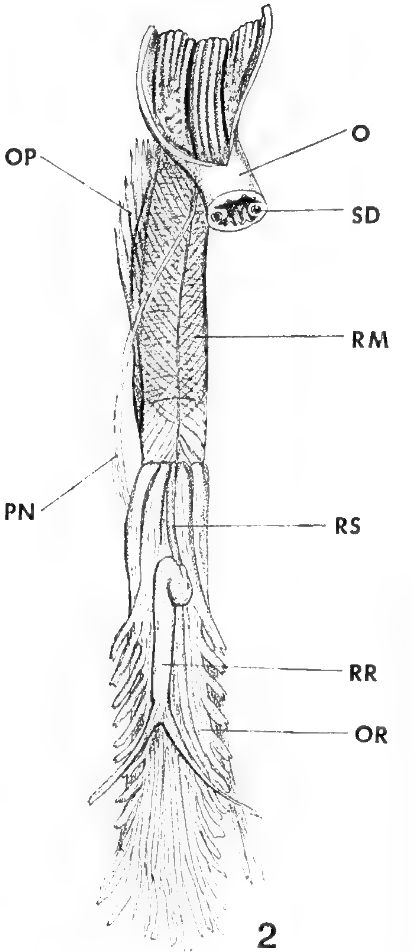

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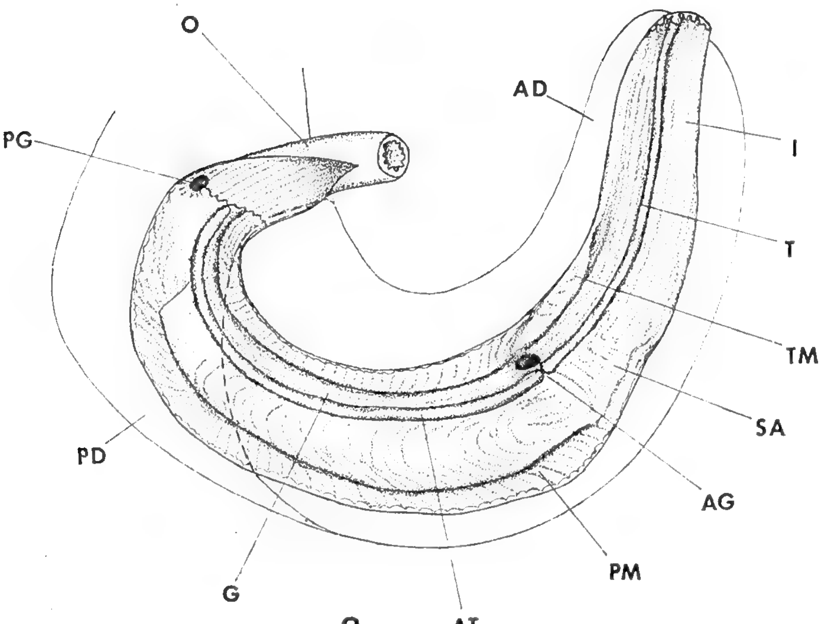

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conducting tube; and a long typhlosole (AT, T) which runs throughout the stomach and continues into the intestine where it lies ventrally. Intestine and rectum simple, the anus extended well forward in the pallial cavity, lying next to the terminal opening of the pallial genital duct in the female. There is no anal gland.

Reproductive System: Only the pallial ducts were studied.
Male: Penis very large, long, flattened dorso-ventrally, more or less parallel-sided and truncated distally, often with a terminal papilla; about $\frac{3}{4}$ length of mantle cavity in *P. maximus* and about $\frac{1}{2}$ the length in the other species. Ejaculatory duct and prostate narrow, as in *Buccinum* (Fretter, 1941).

Female: Pallial oviduct massive, the albumen gland large, slightly shorter than the capsule gland. Bursa copulatrix a muscular bulb at anterior end of duct.

Details of the nervous, renal and circulatory systems of *P. maximus* have been described by Kesteven (1904).

Remarks: Fleming (1955: 1057) has pointed out that *Penion* can be used despite the prior *Penium* Philippi, 1865. *Verconella* Iredale was erected as a replacement name for *Penion* and consequently falls as an absolute synonym.

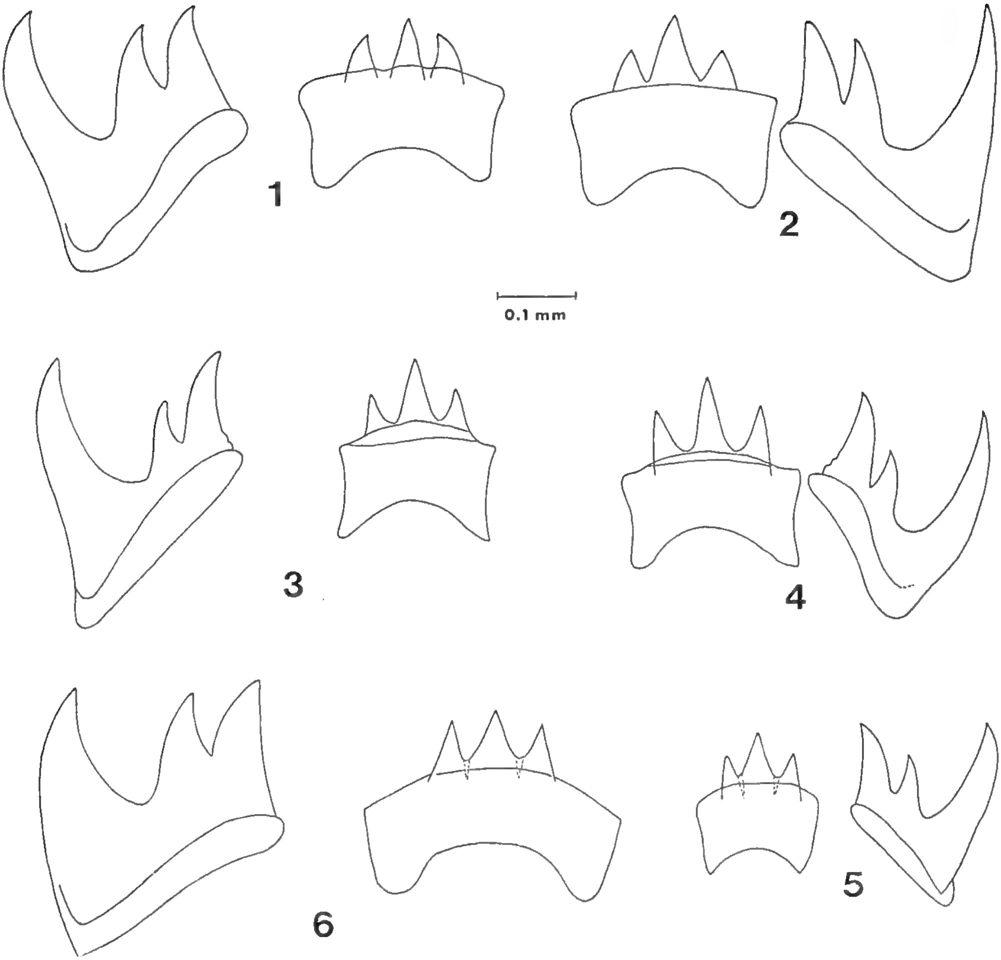
As shown below the Australian species of *Austrosipho* (=*Berylsma* and *Largisipho*) have no distinctive teleoconch, radular or opercular differences from the New Zealand species *Penion dilatatus*, the type species of *Penion*, and the protoconch differences (compare text figures 3: 1 and 3: 9) seen in the two species are not considered to be sufficient evidence to separate them even as subgenera. The teleoconch similarities are so striking that New Zealand and Australian species have frequently been misidentified as one another. The present revision shows *waitei* and *spectanda*, the type species of *Berylsma* and *Largisipho* respectively, to be the same species, *mandarinus* (Duclos).

Powell (1947) reviewed the New Zealand Recent and fossil species of *Verconella*. In an earlier paper (1927) he showed that there were two groups within the genus in New Zealand — these he called the "*dilatata* group (A)" and the "*adusta* group (B)." These were separated on the basis of very minor differences in the protoconch, on the relative thickness of the teleoconch and the presence or absence of a white marking on the inside of the operculum. Powell (1947) agreed with Finlay (1927) that the Australian *Austrosipho* and the New Zealand *Verconella* were separable on protoconch characters.

TEXT FIG. 1. Alimentary canal of *Penion adustus* (Philippi).

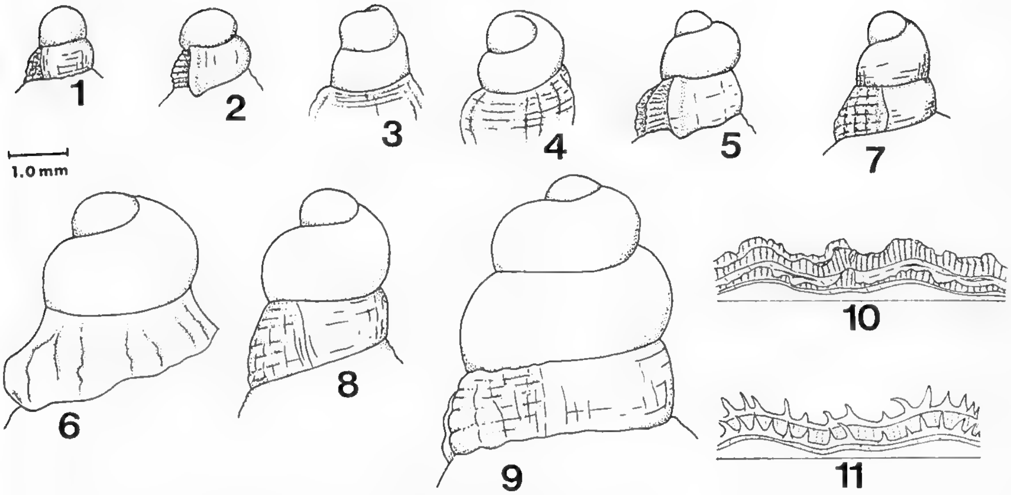
1. Anterior alimentary canal showing opened, everted proboscis, salivary glands, gland of Leiblein and oesophagus.
2. Dorsal view of buccal mass. Anterior oesophagus opened anteriorly, removed posteriorly.
3. Stomach opened along mid-line of external wall.

AD — anterior digestive gland; AG — opening to anterior digestive gland; AO — anterior oesophagus; AT — extension of typhlosole; DP — opening to posterior digestive gland; G — groove; GL — gland of Leiblein; I — intestine; O — oesophagus; OP — odontophoral protractor muscles; OR — odontophoral retractor muscles; P — proboscis; PD — posterior digestive gland; PG — opening to posterior digestive gland; PM — posterior mixing area; PN — proboscis nerve; PO — posterior oesophagus; RM — radular muscles; RR — radular retractor muscle; RS — radular sac; SA — sorting area; SD — salivary duct; SG — salivary gland; T — major typhlosole; TM — minor typhlosole; VL — valve of Leiblein.



TEXT FIG. 2. Radulae. All to the same scale.
1. *Penion adustus* (Philippi). Westmere Reef, Auckland Harbour, New Zealand (C. 88716).
2. *P. dilatatus* (Quoy and Gaimard). Trawled off Cape Colville, New Zealand (C. 88723).
3. *P. mandarinus* (Duclos). E. of Sydney, N.S.W., 357-453 metres (C. 86731).
4. *P. mandarinus* (Duclos). Merricks, Western Port, Vict. (C. 86730).
5. *P. maximus* (Tyron). Off Shell Harbour, N.S.W. (C. 65458).
6. *Kelletia kelletii* (Forbes). California (C. 88714).

Powell (1947) has shown that the *adustus* group, which gave rise to the *dilatatus* group in the Middle Miocene, is represented as far back in the New Zealand Tertiary as the Middle Oligocene, although there is also an earlier species (*proavitus* Finlay and Marwick, 1937) which occurs in the Paleocene, although the protoconch in this species is not known. The oldest New Zealand species that I have been able to study is *P. marwicki* (Finlay) from the Awamoan (Miocene) of Target Gully, Oamaru. This species has a tall protoconch of $3\frac{1}{4}$ whorls which is relatively smaller than the Recent counterparts in New Zealand. In Australia the earliest known



TEXT FIG. 3. Protoconchs. All to the same scale.
1. P. *roblini roblini* (T. Woods). Table Cape, Tasmania (N.M.V., P. 2538-43).
2. P. *longirostris* (Tate). Fossil Beach, Balcombe Bay, Mornington, Vict. (C. 74895).
3. P. *roblini simulans* (Tate). Lectotype. Tate Coll. (S.A.M., T.501).
4. P. *roblini simulans* (Tate). Paralectotype. Tate Coll. (S.A.M., T. 501).
5. P. *roblini simulans* (Tate). Fossil Beach, Balcombe Bay, Mornington, Vict. (C. 74895).
6. P. *spatiosus* (Tate). Holotype of *Fusus henicus* Tate. Tate Coll. (S.A.M., T. 494).
7. P. *mandarinus* (Duclos). Off Port MacDonnell, S. Aust. (C. 71690).
8. P. *maximus* (Tryon). N.E. of Montague Island, N.S.W., 128-146 metres (C. 76063).
9. P. *dilatatus* (Quoy and Gaimard). Trawled, Bay of Plenty, New Zealand, 73 metres (C. 75792).
Periostraca.
10. P. *mandarinus* (Duclos).
11. P. *maximus* (Tryon).

species is *roblini* (T. Woods) from the Lower Miocene of Table Cape, Tasmania. This species has a protoconch similar to those of the two recognised living Australian species, and as Finlay (1927) has pointed out, of fewer whorls than those seen in the New Zealand species.

An exception is *P. bartrumi* (Laws) from the Altonian (Miocene) of Pakaurangi Point, Kaipara Harbour, New Zealand. This species has a protoconch like that of the Australian species of *Penion*, being of only 2 whorls, and only 2 mm at its greatest diameter. The Pakaurangi Point fauna is subtropical in nature and consequently it is probable that *bartrumi*, living in a warm environment like its Australian counterparts, had no need for long larval development within the egg capsule.

The examination and comparison of shell features and anatomy of *Kelletia kelletii* (Forbes) (Plate 43: 5), the type species of the genus *Kelletia*, and *Penion* species, has not revealed any major differences. However, the protoconch of *Kelletia kelletii* is rather elongate, of 2½ whorls and smaller than that of any known species of *Penion*. *Neptunea* Röding, 1798 (type species *Murex contrarius* Linnaeus, 1771) is very closely related to *Kelletia* and the two groups may only be subgenerically distinct. *Kelletia* differs from *Neptunea* s.s. in its more solid shell, elongate spire and heavy, rounded axial knobs. It would appear that *Penion* is the Southern Hemisphere equivalent of *Neptunea*, although the two groups have been separate since the early Tertiary.

The egg capsules in the 3 genera are similar and show considerable specific variation. Those of *Kelletia kelletii* are simple, ovoid, flattened structures which are attached to the substrate (Rosenthal, 1970). The egg capsules of *Penion mandarinus* (Plate 40: 1) are also attached to the substrate but have the large, circular openings in the middle of the flattened side, whereas in *Kelletia* the slit-like openings are on the upper edge. In *Penion adustus* (Plate 40: 2) the capsules are bent over one another and although the first laid capsules are attached to the substrate, subsequent capsules are piled on top to form a higher cluster. In *P. adustus* each capsule is sculptured with weak vertical ridges on the convex face, whereas in *P. mandarinus* there are two strong vertical ridges and weak reticulate sculpture over the whole surface. The slit-like opening in *P. adustus* is situated just below the upper edge on the concave side. Similar specific variation has been observed in *Neptunea* by Golikov (1961). Only one sample of each of the two species of *Penion* has been available for examination.

The three genera are contrasted in Table 1.

Although *Kelletia kelletii* appears to agree with *Penion* species in its superficial anatomy, only 1 specimen (a female) was available for examination. The stomach of *Neptunea antiqua* (Linnaeus) has a caecum and there is only one digestive gland opening (Smith, 1967). The external form of the stomach of the other examined species of *Penion* and of *Kelletia,* the material available not being well enough preserved for more detailed examination, was like that of *Penion adustus.* I have been unable to find a reference to the nature of the salivary gland ducts in *Neptunea* in the literature. In all examined species of *Penion* they are embedded in the wall of the anterior oesophagus, a feature also seen in *Kelletia* but not in *Buccinum undatum* (Linnaeus) (Dakin, 1912) or in *Cominella* species (W. F. P. personal observation).

Most buccinids have a large penis, so that this feature is not necessarily diagnostic for a genus. The related New Zealand genus *Aneator* Finlay, 1927 (type species *Verconella marshalli* Murdoch, 1924) as shown from a study of *Aneator compta* (Finlay), differs in several respects from *Penion.* The swollen penis tapers to a point and there is no papilla. The male pallial duct is thick and clearly separated into a prostate which runs the full length of the pallial cavity, and a narrow, short, ejaculatory duct. In addition the proboscis sac is thin walled, not thickly muscular as in *Penion* species. The type species of *Austrofusus* Kobelt, 1879 (type species *Drupa glans* Röding, 1798) has a stomach very like that of *Neptunea antiqua* with the digestive gland ducts relatively close together and a very short caecum.

In *Buccinulum* Deshayes, 1830 (type species *Murex lineatus* Martyn, 1784), as shown from a study of *B. vittatum vittatum* (Quoy and Gaimard), the penis is relatively small and tapers to a point. The prostate is a broad, rather flat strip which continues to the base of the penis. The stomach is very like that of *Penion. Buccinulum* and *Penion* are obviously related but there are several important shell differences, such as *Buccinulum* species being much smaller, having short anterior canals and different apertural ornament.

PLATE 40

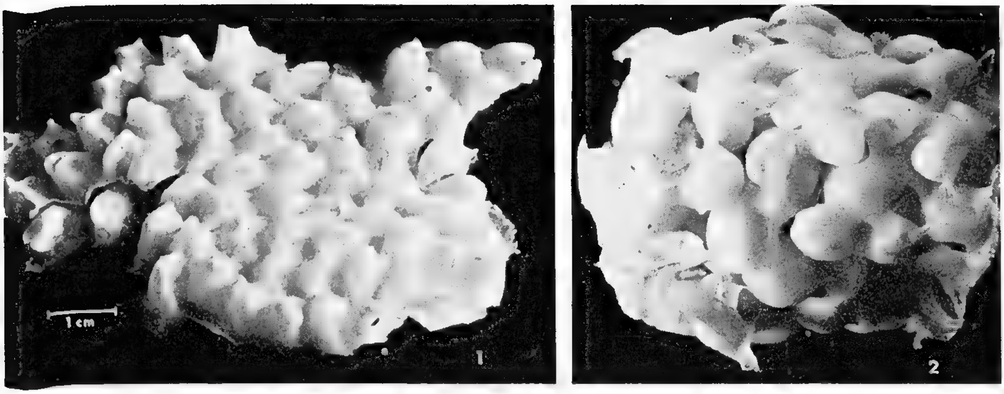


PLATE 40. Egg capsules. To same scale.

1. *Penion mandarinus* (Duclos). Near pier at Cowes, Victoria, in 8 metres. Collected E. Ireland, 22 August, 1966 (ex F. V. Murray Coll.) N.M.V.
2. *Penion adustus* (Philippi). Off Taupu, Thames, New Zealand, in 11 metres. F.R.V. "Ikatere". Collected W. F. Ponder, 11 September, 1965. Dominion Museum, Wellington.

Penion mandarinus (Duclos, 1831).

Plates 40: 1; 41: 1-6; 42. Text figures 2: 3, 4; 3: 7, 10.

Fusus mandarinus Duclos, 1831: pl. 8.

Fusus grandis Gray, 1839: 116. (Type: loc.?).

Fusus dilatatus; Reeve, 1847: pl. 13, fig. 49c (non Quoy and Gaimard, 1833).

Fusus pastinacea Reeve, 1848: pl. 16, fig. 64; Sowerby, 1880: 82, pl. 411, fig. 75. (Type: "Australia" (=Circular Head, Tasmania)).

Fusus tasmaniensis Adams and Angas, 1864: 421, pl. 37, fig. 1; Angas, 1865: 159, T. Woods, 1877: 27. (Type: Spencer Gulf, S. Aust.).

Fusus (Neptunea) dilatatus; Angas, 1865: 159; T. Woods, 1877: 27 (non Quoy and Gaimard, 1833).

Neptunea (Austrofusus) tasmaniensis; Kobelt, 1881: 132, pl. 43, fig. 3.

Neptunea (Austrofusus) pastinacea; Kobelt, 1881: 137, pl. 45, fig. 4.

Hemifusus pastinacea; Tryon, 1881: 112, pl. 44, fig. 234.

Siphonalia tasmaniensis; Tryon, 1881: 135, pl. 54, fig. 360; Tate, 1891: 257.

Siphonalia dilatata; Tate, 1891: 257; Tate and May, 1901: 356; Pritchard and Gatliff, 1898: 272; Pritchard and Gatliff, 1906: 44; Verco, 1895: 94, pl. 3, fig. 9 (radula); Verco, 1912: 221 (non Quoy and Gaimard, 1833).

Siphonalia oligostira Tate, 1891: 258, pl. 11, fig. 6. (Type: Guichen Bay, S. Aust.).

Fusus waitei Hedley, 1903: 373, pl. 37. (Type: 144-146 m. off Botany Bay, N.S.W.).

Verconella oligostira; Hedley, 1916: 208; Serventy, 1936: 78.

Verconella tasmaniensis; May, 1921: 79; May, 1923: pl. 37, fig. 7.

Verconella dilatata; Gatliff and Gabriel, 1922: 133 (non Quoy and Gaimard, 1833).

Berylsma waitei; Iredale, 1924: 267; Iredale, 1925: 261; Mayblom, 1951: 282; Garrard, 1961: 24; Iredale and McMichael, 1962: 69.

Berylsma grandis; Iredale, 1924: 267, pl. 35, fig. 10; Iredale, 1925: 261; Mayblom, 1951: 282; Allan, 1950: 156, pl. 23, fig. 20; Cotton, 1956: fig. 8; Iredale and McMichael, 1962: 69.

Berylsma grandis levifida Iredale, 1925: 261. (Type: off Twofold Bay, N.S.W., shallow water).

Berlysma grandis waitei; Iredale, 1925: 261.

Largisipho oligostira spectanda Iredale, 1929: 182, pl. 41, fig. 6. (Type: 91-110m. off Montague Is., N.S.W.).

Berylsma levifida; Mayblom, 1951: 282.

Largisipho oligostira; Cotton, 1956: fig. 7.

Penion maxima; Cotton, 1956: fig. 7 (not of Tryon, 1881).

Largisipho spectandus; Iredale and McMichael, 1962: 69.

Berylsma levifida; Iredale and McMichael, 1962: 69.

Austrosipho grandis; Macpherson and Gabriel, 1962; 187, fig. 223.

Austrosipho grandis tasmaniensis; Macpherson and Gabriel, 1962: 189; Macpherson, 1966: 225.

Austrosipho oligostira; Macpherson and Gabriel, 1962: 189.

Austrosipho waitei; Macpherson and Gabriel, 1962: 189, fig. 224.

Penion waitei; Wilson and Gillett, 1971: 96, pl. 63, fig. 2.

Penion oligostira; Wilson and Gillett, 1971: 96, pl. 63, fig. 3.

Penion grandis; Wilson and Gillett, 1971: 96, pl. 63, fig. 4.

TABLE 1 Comparison of *Penion*, *Kelletia* and *Neptunea*.

	Penion	*Kelletia*	*Neptunea*
Spire	Usually tall.	Tall.	Usually short.
Anterior canal	Long.	Moderately short.	Usually short.
Spiral sculpture	Spiral lirae, primary spirals predominate, usually only a single secondary spiral between primary spirals. Tertiary spirals usually few.	Primary spirals not readily distinguished from secondary spirals. Few tertiary spirals.	Very strong carinae to subobsolete threads. Often not readily distinguishable into primary secondary and tertiary spirals.
Axial sculpture	Rounded ribs or peripheral knobs, sometimes only on early whorls.	Strong folds, strongest on periphery.	Typically absent, or as rather narrow folds or lamellae when present.
Protoconch	Small to large (1½ to 4 whorls) usually not eroded.	Small, 2½ whorls, usually eroded.	Moderately large to very large, of two or more whorls. Usually eroded.
Operculum	Pointed with median furrow.	Pointed, with median furrow.	Pointed, with or without median furrow.
Radula	3 cusps on central teeth, 3-4 on lateral teeth. Central teeth narrow.	3 cusps on lateral and central teeth. Central teeth wide.	Typically 3 (sometimes 4) cusps on lateral and central teeth. Central teeth wide.
Development	Probably direct but not demonstrated.	Short pelagic phase (Rosenthal, 1970).	Direct (Golikov, 1961; Pearce and Thorson, 1967).

Protoconch: (text fig. 3: 7) rather small, 2¼ smooth, convex whorls. Some surface irregularities on last ½ whorl. Varix moderately distinct.

Teleoconch: Large, generally rather heavy, fusiform, usually with angled periphery, although this is sometimes rounded. Axial knobs (when present) extending below periphery. Whorls about 8. Sculpture of 12-15 primary spirals on penultimate whorl, these rounded, raised, narrow, simple. Secondary cords typically much weaker than primary cords. Tertiary and quarternary spirals usually not present. Axial ribs form weak swellings at periphery on early whorls and these may become strong, forming knobs which result in a strongly angled periphery and concave to almost flat shoulder on the penultimate whorl and body whorl. In some specimens the axials disappear on the last whorls and, occasionally, they reappear on the latter part of the body whorl. Axials 11-14 (usually 12-13) on penultimate whorl, typically rounded, and extend below suture on penultimate whorl. A series from off Eucla (Plate 42: 2, 3) has the axial knobs sharp and more-or-less confined to the periphery as in *maximus* (see also Verco, 1912: 221). Aperture large to medium, shoulder area weakly to strongly concave, dentate within outer lip. No varix present. Columella and inner lip smooth, glazed. Fasciole weak to moderately strong. Anterior canal equal to about ½ height of spire in length, slightly twisted dorsally. Colour variable, ranging from uniform white to almost uniform red-brown. The darkest pigmentation is on the spiral cords and is sometimes arranged in bands or longitudinal streaks. A three banded colour form parallels the pattern seen in *maximus* except that the peripheral band is indistinct and is generally placed just below the peaks of the knobs rather than between them as in *maximus.* Periostracum forming axial lamellae which are easily worn off, their edges simple or forming low undulations (text fig. 3: 10).

Operculum: As for genus; uniform brown.

Radula: (text fig. 2: 3, 4) As for genus. Central tooth narrow, lateral cusps ½-⅔ length of middle cusp. Base and sides of each central tooth concave. Lateral teeth each with middle cusp considerably shorter than the outer (which is the longest) and the inner cusp. Inner cusp with minute denticle-like irregularities on its inner base in some teeth of both specimens examined.

Dimensions: Neotype (=holotype of *oligostira*): Height 89.05 mm. Diameter 43.15 mm. (the dimensions of the original type were 96 mm x 40 mm).

Small specimen with weak spire nodules and smooth body whorl from between Cape Schanck and Wilsons Promontory, Vict. (C.87188). Height: 67 mm. Diameter: 29.2 mm. Height of aperture + canal: 40.2 mm.

Heavily noduled, large specimen, 110 metres off S. coast of Kangaroo Island, S. Aust. (C.81988). Height: 155 mm. Diameter: 79 mm. Height of aperture plus canal: 83.8 mm.

Large specimen with moderate nodules, 91 metres off Wollongong, N.S.W. (C.87202). Height: 179 mm. Diameter: 74 mm. Height of aperture plus canal: 97.7 mm.

Holotype of *grandis*: Length: 127 mm (from original description) (British Museum (Natural History)).

Holotype of *tasmaniensis*: Height: 72 mm. Diameter: 38 mm (from original description) (British Museum (Natural History)).

Holotype of *waitei*: Height: 156 mm. Diameter 61.7 mm. Height of aperture plus canal: 85 mm (C. 16383).

Holotype of *spectanda*: Height: 139 mm. Diameter: 63 mm. Height of aperture plus canal: 75 mm (C. 57724).

S.W. of Eucla, Great Australian Bight, W. Aust. (E. 3875). Height: 99.5 mm. Diameter: 44.0 mm. Height of aperture plus canal: 53.2 mm.

Neotype: Living on rocks at extreme low tides, Guichen Bay, South Australia. S.A.M. (D. 13501) (original type locality "China Seas").

Other Material Examined: A large number of specimens in the South Australian Museum, National Museum of Victoria, and the Australian Museum.

Fossil Material: Upper Pliocene: Cameron Inlet Formation, Flinders Island, dam (50) on Lot 50 (Andrews), Furneaux Sect. B., 1 km. E.S.E. of junction of No. 3 and No. 8 roads (Brid Ref. Flinders Island 029 592), coll. T. A. Darragh, D. M. Shanks and H. E. Wilkinson, N.M.V. (P. 30773) (1 specimen).

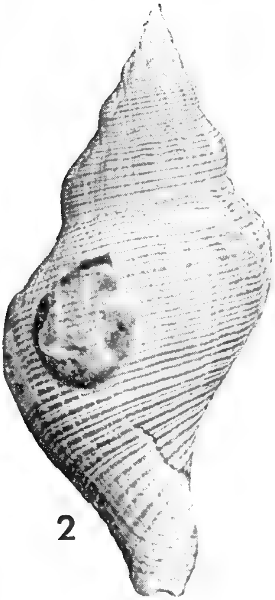
Distribution: Trial Bay, northern N.S.W. (C. 87205-7) to the western half of the Great Australian Bight (C. 35599). It appears to be restricted to the continental shelf in the Great Australian Bight (146-220 metres) and in N.S.W. (18-594 metres) but is also found in the lower littoral and shallow sublittoral in Victoria, Tasmania and South Australia where it occurs rather uncommonly on open coasts. Upper Pliocene, Flinders Island.

Breeding: A note on a label in the National Museum of Victoria states that this species lays egg capsules every year at Richardsons Reef, Victoria, in September. The egg mass figured was collected in August at Cowes, Victoria.

Remarks: An examination of the original figure (Plate 41: 1) given by Duclos shows this to be the smooth form of "*grandis*" usually known as *oligostina* Tate. The figure is almost photographic in its detail and specimens from South Australia can readily be matched with it whereas it has not been possible to match New Zealand shells, except in a superficial manner (independently confirmed by Dr. F. M. Climo, Dominion Museum, Wellington. The figured specimen (Plate 41: 7) is the nearest match from the Dominion Museum collections). The main points that show the figure to represent a South Australian specimen are:— 1. the swollen base — New Zealand shells tend to have the base cut away more rapidly; 2. the lirations on the outer lip extend well within the aperture; 3. there is no suggestion of tertiary spirals in the figure, although these are usually obvious in New Zealand shells; 4. the axial ribs on the spire whorls are heavy and few in number, only 6 visible in the figure on the upper part of the penultimate whorl. In the New Zealand species there are usually about 8 visible when these are present.

PLATE 41. 1-6. *Penion mandarinus* (Duclos). All to same scale.
1. Figure from Duclos, 1831.
2, 3. Neotype (S.A.M., D. 13501).
4. Craypots off Port MacDonnell, S. Aust. (ex T. A. Garrard Coll.) (C. 71690).
5. Port MacDonnell, S. Aust. (ex J. Verco Coll.) (C. 41847).
6. Tasmania (ex Cox Coll.) (C. 87183).
7. *Penion sulcatus* (Lamarck) 15-18 metres off Kapiti Island, W. Coast, North Island, New Zealand (Dominion Museum, M. 1376).

PLATE 41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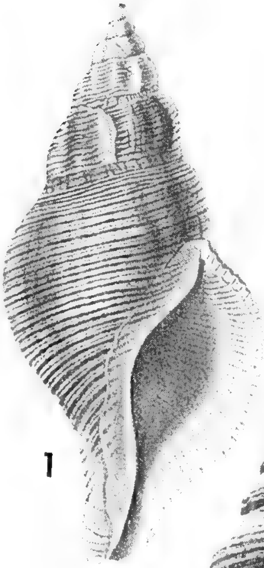
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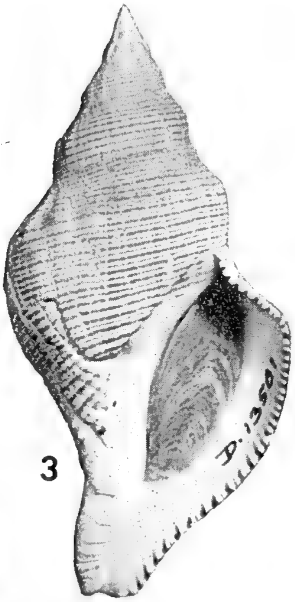
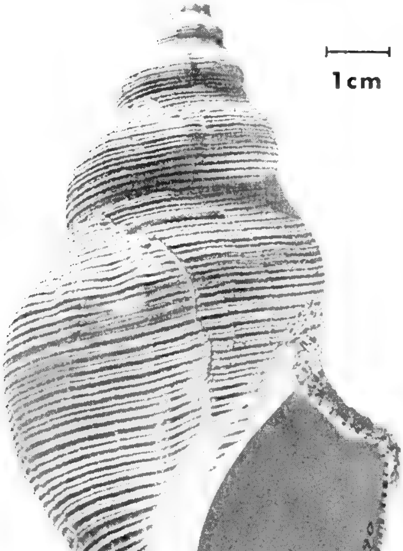


3

1cm


7


4


5


6

It therefore appears as though the specimen figured by Duclos is an Australian shell. Unfortunately the type specimen cannot be located despite requests for its whereabouts being sent to the major Museums in Europe. Because of the difficult taxonomic situation surrounding this species name it is considered necessary to erect a neotype. The specimen chosen is the holotype of *oligostira* which agrees fairly closely with the original type of the species in accordance with Article 75 c (4) of the International Code of Zoological Nomenclature (1961) (compare Plate 41: 1 with 41: 2, 3). In the original description Duclos erroneously gave the locality as the China Sea so that Article 75 c(5) cannot be fulfilled. A description of the neotype is given by Tate (1891: 258) and the type locality is Guichen Bay, South Australia.

A number of writers, including Pritchard and Gatliff (1898), Iredale (1924) and Mayblom (1951) have commented on the change of shape undergone by specimens of "*Austrosipho grandis*" with increasing depth. The shell is narrower, the canal longer and the colour absent in deepwater (110-146 metres) shells (=*waitei*) compared with shallow water (37 metres or less) populations (=*grandis*) (compare Plate 42: 6 with 42: 1, 5). Between 37 - 110 metres the shells are intermediate in form and colour (=*levifida*) (Plate 42: 4, 7, 8). A colour banded form (=*tasmaniensis*) is common in shallow water in southern Australia (Plate 42: 1, 5).

Comparison of large series shows that it is impossible to draw consistent distinctions between any of these varieties and thus it is concluded that they are conspecific.

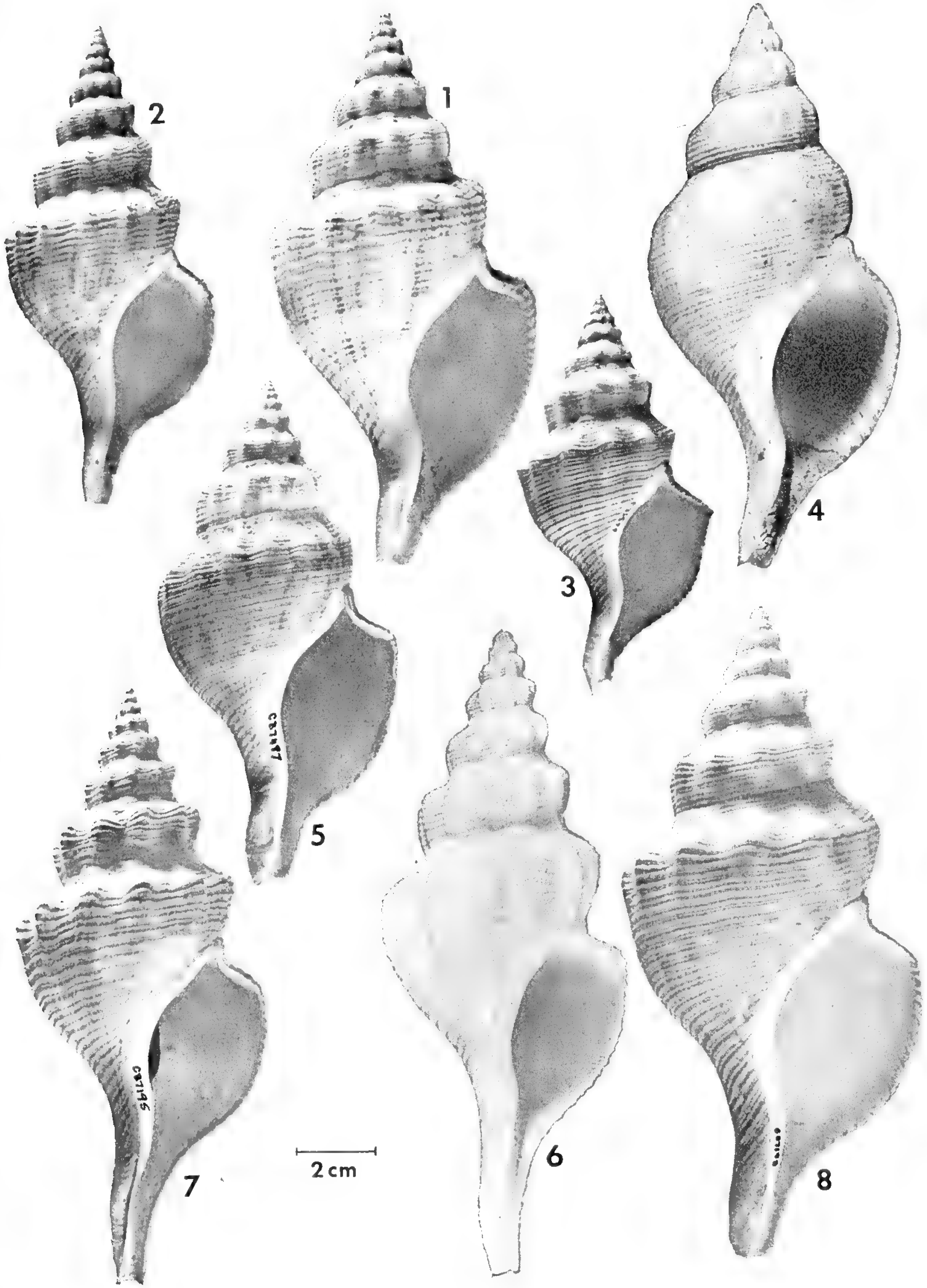
Pritchard and Gatliff (1898) showed that *oligostira* Tate is only a non-costate variety of "*dilatata*" (=*mandarinus*). The specimens at my disposal certainly show this to be the case, although the smooth form (Plate 41: 1-3, 5) seems to occur only in South Australia and western Victoria. Intermediate forms are common (Plate 41: 4, 6).

The type specimen of *grandis* was figured by Iredale (1924) for the first time and is a specimen of the shallow water form of the species. The holotype of *levifida* Iredale is missing but topotypes that agree well with Iredale's meagre characters are available (plate 42: 8).

A few specimens from the northern half of N.S.W. show characters intermediate between *mandarinus* and *maximus* (Plate 45: 3). These depart from the normal *mandarinus* pattern in the lighter and narrower shell, sharper axials on the periphery, the fold below each peripheral knob reduced in strength, and the 3 banded colour pattern which is of the *maximus* type (the 3 banded pattern does not often occur in normal *mandarinus* in northern N.S.W.). The spiral cords are intermediate between those of *mandarinus* and *maximus* and the periostracum (on the one specimen in which it remains) is of the *maximus* type. It is assumed that these specimens are hybrids although no explanation can be given as to why hybridisation does not appear to take place in other parts of the east coast.

PLATE 42. *Penion mandarinus* (Duclos). All to same scale.

1. Craypots off Port MacDonnell, S. Aust. (ex T. A. Garrard Coll.) (C. 87175).
2. 183 metres, 145 km. W. of Eucla, Great Australian Bight. "Endeavour', (S.A.M., D. 6989).
3. Great Australian Bight, latitude 126°-129°E, 146-220 metres. "Endeavour" (C. 35599).
4. Holotype of *Largisipho (oligostira) spectanda* Iredale (C. 57724).
5. North coast of Tasmania (ex M. Ward Coll.) (C. 87497).
6. Holotype of *Fusus waitei* Hedley (C. 16383).
7. 91 metres, 11km., N. of Montague Island, N.S.W. (ex T. A. Garrard Coll.) (C. 87195).
8. Dredged off Eden N.S.W. (ex N. Jackson Coll.) (C. 87198).


2
1
4
3
5
C87197
7
C87195
6
8
2 cm

Supposed hybrid specimens are in the Australian Museum from: Trial Bay, N.S.W. (taken from fish traps) (C. 87207, C. 81945) both lots presented by J. Kerslake (3 specimens), together with *mandarinus* and *maximus*. Off Moreton Bay, S. Qld. 27° 27′ 22″ S, 153° 39′ E, H.M.A.S. "Kimbla", 77 metres, coll. W. F. Ponder (C. 77065) (1 specimen); Off Port Kembla, N.S.W., coll. F. V. "Challenge", pres. T. A. Garrard (C. 63405) (1 specimen).

The usage of the name *mandarinus* for an Australian species, instead of the New Zealand species with which it is normally associated, requires a new name for the New Zealand species. Consequently the synonymy of the New Zealand species previously known as *mandarinus* is given below.

Penion sulcatus (Lamarck, 1816).

Plates 41: 7; 43: 2, 3.

Fusus sulcatus Lamarck, 1816: 130, pl. 424, fig. 3; Lamarck, 1822: 125; Kiener, 1840: 26, pl. 13, fig. 1; (Type: Loc.?) Deshayes and Milne-Edwards, 1843: 447; Sowerby, 1880: 94, pl. 417, fig. 173.

Fusus zelandicus Quoy and Gaimard, 1833: 500, pl. 34, figs. 4, 5; Kiener, 1840: 27, pl. 14, fig. 1. (Type: Tasman Bay, New Zealand).

Fusus mandarinus; Deshayes and Milne-Edwards, 1843: 471 (in part); Reeve, 1847: pl. 2, fig. 8 (non Duclos, 1831).

Neptunea (Austrofusus) sulcata; Kobelt, 1881: 136, pl. 44, fig. 1.

Neptunea (Austrofusus) mandarinus; Kobelt, 1881: 137, pl. 44, fig. 2, 3 (in part) (non Duclos, 1831).

Siphonalia (Austrofusus) sulcata; Tryon, 1881: 138, pl. 56, fig. 380.

Siphonalia (Austrofusus) mandarina; Tryon, 1881: 138, pl. 56, fig. 382, pl. 57, fig. 385; Suter, 1913: 372, pl. 43, fig. 7 (non Duclos, 1831).

Verconella mandarina; Powell, 1927: 556, pl, 31, fig. 33 (non Duclos, 1831).

Suter (1913) lists as synonyms of "*mandarinus*", *Fusus cinnamoneus* Reeve (1847: pl. 5, fig. 16) and *Fusus rudolphi* Dunker (1871: 128, pl. 43, figs. 3, 4), both described from unknown habitat. Both of these species have the general appearance of *sulcatus* but differ in having the spiral cords ornamented with several close spiral threads. Owing to the lack of suitable comparative material it is difficult to suggest where these species were actually collected. *Fasciolaria lugubris* Reeve, 1847, from South Africa, has similar spiral ornament and some specimens closely resemble the illustrations of both *rudolphi* and *cinnamoneus*. Barnard (1959) makes no mention of either species name in his revision of the South African rachiglossate Mollusca.

Suter (1913) erroneously states that "*mandarinus*" also occurs in South Africa (see Barnard (1959: 144) for further comment). Suter (1913) also gives as a synonym of "*mandarinus*", "*Cominella prolongata* Sowerby, 1899" (=*Cominella* (?) *prolongata* Smith, 1889, a synonym of the South African *Afrocominella elongata* (Dunker, 1857) according to Barnard (1959: 153)).

Tryon (1881) and Tate (1891) cite *sulcatus* Lamarck as southern Australian and Dall (1915: 54) records it from Panama. Keen (1958: 418) considers it an unlikely west American species. There is little doubt, judging from the photograph of the holotype of *sulcatus* (Plate 43: 2, 3), that this is the New Zealand species known as *mandarinus*, although it has not previously been associated with it, except by Sowerby (1880).

Holotype: Museum d'Histoire Naturelle, Geneva. No. 1098/15. Dimensions of Holotype: Height 119 mm. Diameter 51 mm.

Penion maximus (Tryon, 1881).

Plate 43: 1. Text figures 2: 5; 3: 8, 11.

Fusus tasmaniensis; Sowerby, 1880: 70, pl. 409, fig. 43 (not of Adams and Angas, 1863).

Siphonalia maxima Tryon, 1881: 135, pl. 54, fig. 355; Cox, 1885: 245; Hedley, 1903: 374, pl. 38.

Megalatractus maxima; Kesteven, 1904: 419, pls. 39, 40.

Penion maxima; Iredale, 1912: 224; Wilson and Gillett, 1971: 96, pl. 63, figs. 1, 1a.

Verconella maxima; Iredale, 1914: 175; Iredale, 1915; 465; Hedley, 1918: M. 85; May, 1921: 79; May, 1923: pl. 37, fig. 5; Gatliff and Gabriel, 1922: 133; Iredale, 1924: 266; Allan, 1950: 155, pl. 22, fig. 9.

Austrosipho maxima; Macpherson and Gabriel, 1962: 189, fig. 225.

Largisipho maxima; McMichael, 1960: 108, fig. 238; Garrard, 1961: 24; Iredale and McMichael, 1962: 69.

Protoconch: (text fig. 3: 8) of moderate size for genus, 2¼ smooth, convex whorls. Some indistinct surface irregularities on last ½ whorl. Varix moderately distinct.

Teleoconch: large, rather light in weight, fusiform, with sharp nodules restricted to the strongly angled peripheral area. Whorls 8½-9. Sculpture of 14-20 primary spirals on penultimate whorl, these rounded, usually rather low and wide, typically with several (up to 8) minute quarternary spiral threads on each cord. Secondary cords usually present, often with a few fine spiral threads upon them. Tertiary spiral cords sometimes present. Axial sculpture restricted to the periphery (except in first 2-5 whorls) where it forms an angulation as a series of sharp knobs, of which there are about 14 on the penultimate whorl. A few large specimens lose the peripheral knobs on the body whorl. Aperture large, weakly concave "shoulder area" in posterior part, lirate within outer lip. No varix present. Columella and inner lip smooth, glazed. Fasciole not distinct. Anterior canal equal to about ½ height of spire in length, slightly twisted dorsally. Colour uniform yellowish-white or orange-brown, sometimes with 3 colour bands on body whorl; one across nodules on periphery (which is also visible on spire whorls), another emerging from the suture and the third low on the base. Anterior end of canal also sometimes darkly coloured. Spiral cords orange brown outside limits of colour bands in a few individuals. The peripheral colour band is the strongest, and a single strong spiral cord running across the main angle of the periphery is usually darker than the remainder of the band. In most specimens the points of the peripheral knobs are not pigmented. Periostracum of axial lamellae which are easily worn off, their edges produced into numerous sharp spikes which correspond to the quarternary spiral threads (text fig. 3: 11).

Operculum: As for the genus; uniform brown.

Radula: (text fig. 2: 5). As for genus. Lateral edges of central teeth almost straight, lateral cusps of central teeth about half height of central cusp.

Dimensions: Holotype: Length: 126 mm (from Tryon) (the figure shows that this is immature).

Large specimen: 220 mm. Diameter: 98.2 mm (146-183 m., off Cape Moreton, Qld. (C. 87203)).

Small specimen: 152 mm. Diameter: 60 mm (Cloudy Bay Lagoon, D'Entrecasteaux Channel, Tasmania (C. 56893)).

Holotype: Tasmania (in the Academy of Natural Sciences, Philadelphia).

Material examined: Many specimens in the Australian Museum, National Museum of Victoria and the South Australian Museum.

Fossil Material: Upper Pliocene: Cameron Inlet Formation, Flinders Island, dam (64) on Block 22, Furneaux Section A (Lees), 4 km. E.N.E. of junction of No. 3 and No. 4 roads (Grid Ref. Flinders Is. 016 713), N.M.V. (P. 30774). Also dam (65) same data. Grid Ref. 011 717. Both lots coll. T. A. Darragh, D. M. Shanks and H. E. Wilkinson, N.M.V.. Cox (1885) recorded "subfossil" specimens from 7-18 metres at Stockton, near Newcastle. These specimens are in the Australian Museum (F. 32267, F. 32414).

Distribution: Caloundra, southern Queensland, south to S.E. Tasmania, Bass Strait and eastern Victoria, the most westerly locality being from off Waratah Bay, on the W. side of Wilsons Promontory (N.M.V. F.24246). South Australian records refer to *P. mandarinus.* Not uncommon on the continental shelf in depths ranging from 18-549 metres. Specimens from below about 200 metres have only been taken as dead shells so that the species is probably confined to the shelf proper. Upper Pliocene, Flinders Island.

Penion roblini (T. Woods, 1876).

This species is known from Miocene strata in Victoria, South Australia and Tasmania. The type is from the Lower Miocene of Fossil Bluff (Table Cape), Tasmania. The Victorian and South Australian specimens are from the Middle Miocene and show minor but consistent differences and are separated as a subspecies, *simulans* (Tate).

Penion roblini roblini (T. Woods, 1876).

Plate 44: 1, 2. Text figure 3: 1.

Fusus roblini T. Woods, 1876: 22, pl. 1, fig. 7.
Siphonalia roblini; Tate, 1888: 143; Pritchard, 1896: 86.
Austrosipho roblini; Cossmann, 1906: 229, pl. 5, fig. 5; Darragh, 1970: 192.

Protoconch: (text fig. 3: 1) small, $1\frac{1}{2}$ - $1\frac{3}{4}$ smooth, weakly convex whorls. Some indistinct spiral and axial sculpture on last half whorl; first $\frac{1}{2}$ whorl broad, flattened. About 1.05 mm - 1.10 mm in diameter.

Teleoconch: rather small, solid, with blunt nodules on the distinctly angled periphery. Sculpture of fine, sharp, closely spaced spiral lirae, 17-20 (2 specimens) on the penultimate whorl usually with distinct secondary spirals between. Tertiary spiral threads occasionally present. Axial growth lines moderately distinct and are raised over the spirals, often forming minute gemmules. Axial folds prominent, tending to angulate the early whorls, becoming distinctly nodulose on the penultimate and body whorls, although they continue as weak folds to the sutures. There are 12 axials on the penultimate whorl. The axial folds terminate in the middle part of the base and fade rapidly this giving a slightly biangled appearance to the body whorl. Primary spirals on base tend to be more

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PLATE 43.

1. *Penion maximus* (Tryon). 146-183 metres off Cape Moreton, S. Qld. (ex T. A. Garrard Coll.) (C. 87203).

2, 3. *Penion sulcatus* (Lamarck). Holotype (Photo courtesy of Natural History Museum, Geneva).

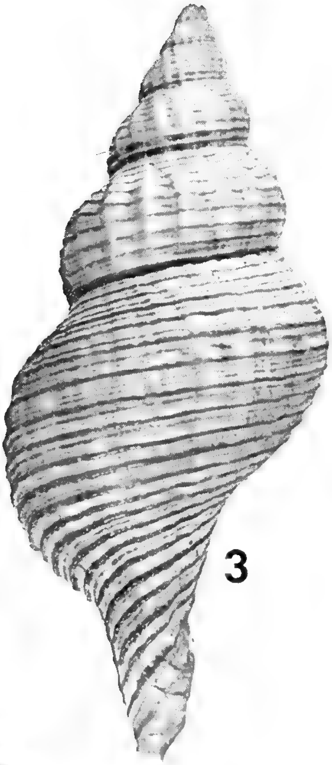
4. *Penion spatiosus* (Tate). Holotype (S.A.M., T. 494).

5. *Kelletia kelletii* (Forbes). 46 metres off Redondo Beach, California, U.S.A. (ex M. Ward Coll.) (C. 87505).

Figure 1 scale A; figures 2-5 scale B.


2

A 4 cm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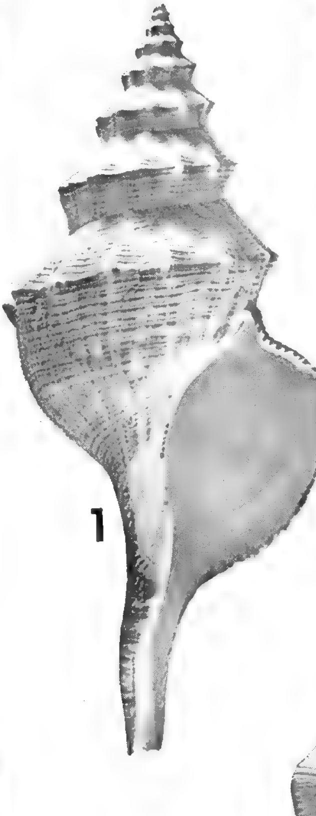
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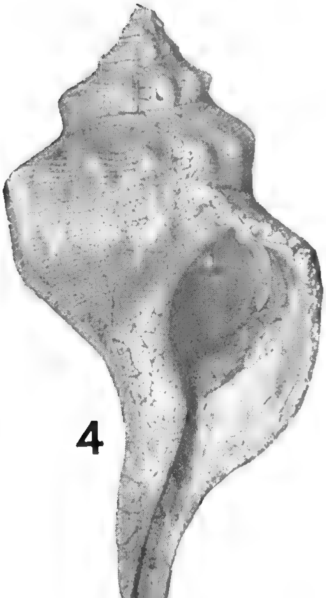
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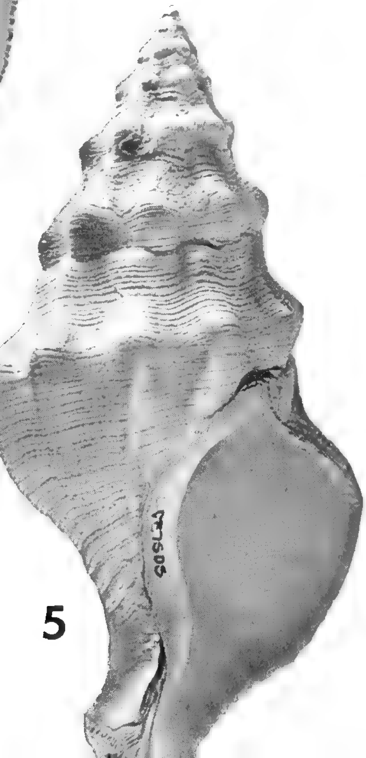
5

B 2 cm

prominent than those on shoulder and fasciole. Aperture moderate, shoulder area slightly convex, outer lip broken or hidden in all specimens examined but appears to have a weakly crenulate edge, lirate within but behind edge. Inner lip simple, with spiral sculpture showing through the glaze. Canal broken in all specimens but appears to be rather short (as judged from juveniles and position of fasciole), curved to left and then back to mid-line and dorsally. Fasciole rather weak.

Dimensions: Holotype: Height: 75 mm. Width: 37 mm (from original description).

Topotypes (N.M.V. P. 2538-43): Height: 58.2 mm (actual), 65 mm (estimated). Diameter: 39.2 mm.

F. 14395: Height 63.15 mm (actual), 73 mm (estimated). Diameter: 32.85 mm.

Holotype: Table Cape, Tasmania. Probably lost. Not recorded by Ludbrook (1967) as being in the Tasmanian Museum.

Other Material Examined: Longfordian: lower bed (=Freestone Cove Sandstone), Table Cape (=Fossil Bluff), N. of Wynyard, Tasmania (F. 14395), and N.M.V. (P. 2538-43) (Both lots collected by E. D. Atkinson); upper beds, Table Cape (=Fossil Bluff Sandstone, Fossil Bluff, N. of Wynyard, Tasmania) F. A. Cudmore Coll., N.M.V. (1 broken juvenile).

Distribution: Longfordian (Lower Miocene) of Fossil Bluff, Tasmania.

Remarks: The same comments apply to this subspecies in its relationships to allied species as to the subspecies described below.

This subspecies occurs at Fossil Bluff with a very similar, fusiform fasciolariid, *Fusinus johnstoni* (T. Woods). The two can easily be confused but *F. johnstoni* is different in having stronger spiral sculpture (although the spirals are not consistently fewer in number), a more solid shell and almost straight canal which is much longer than in *P. roblini roblini.*

Penion roblini simulans (Tate, 1888).

Plates 44: 7, 8; 45: 1, 2. Text figures 3: 3, 4, 5.

Fusus simulans Tate, 1888; 137, pl. 10, figs. 2a, 2b.
Siphonalia subreflexa; Tate, 1888: 142 (non Sowerby, 1844).

No adult specimens are available from the type locality so that the following description is based on specimens from Balcombe Bay, Victoria.

Protoconch: (text fig. 3: 3, 4, 5) small, of 2¼ smooth, convex whorls; terminated by a distinct varix. About 1.5 mm in diameter.

Teleoconch: medium size for genus, rather fragile, sculptured with rather weak spiral threads and sharp peripheral knobs which make all but the first whorl sharply angled. Whorls 8. Sculpture of narrow, rather

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PLATE 44. All to same scale.

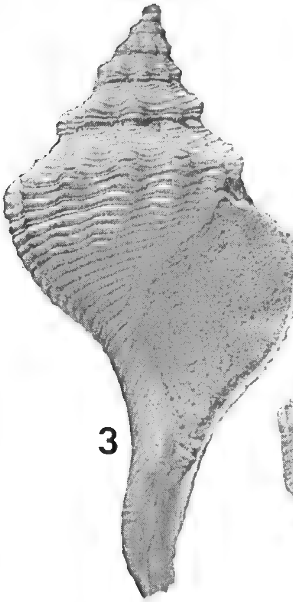
1, 2. *Penion roblini roblini* (T. Woods). Table Cape, Tasmania (F. 14395).

3, 4. *Penion spatiosus* (Tate). 3. Cutting on Princes Highway, S.W. side of Bunga Creek, Gippsland, Vict. (N.M.V., P. 30701); 4. McDonald's Bank, Muddy Creek, near Hamilton, Vict. (N.M.V., P. 30739).

5. *Penion* cf. *spatiosus* (Tate). Lowest shell bed in cutting on Princes Highway, N.E. of Bunga Creek, Gippsland, Vict. (N.M.V., P. 30704).

6. *Penion longirostris* (Tate). Fossil Beach, Mornington, Vict. (C. 74895).

7, 8. *Penion roblini simulans* (Tate). 7. Lectotype (S.A.M., T. 501). 8. River Murray Cliffs, 6 km. below Morgan, S. Aust. (ex F. A. Cudmore Coll.) (N.M.V., P. 30742).


3


1


2


8

1 cm


5


6


7


4

sharp primary spiral threads, 13 on penultimate whorl, most with weak secondary threads present between them. Microscopic tertiary lirae and quarternary striations are present. Two spirals are stronger and sharper than the others, one running across the median point of the peripheral knobs and the other, visible only on the body whorl, runs across the base from the lower suture. This latter cord terminates the axial ribs and gives a somewhat biangled appearance to the outline of the body whorl. There are 12 sharp, axial knobs on the penultimate whorl, which extend anteriorly as weak folds to the lower suture on all whorls and, more weakly, across the shoulder to the upper suture on the spire whorls. Shoulder almost devoid of axial undulations on body whorl. Very fine, crisp, closely packed growth lines present which cross the whole surface. Aperture moderately small, with a thin, smooth outer lip, lirate behind the edge; shoulder area convex. Inner lip smooth except for the spiral sculpture showing through the glaze. Canal long, slender, curved to the left, then recurved slightly to the right and dorsally. Fasciole hardly differentiated, the area sculptured with spiral lirae.

Dimensions: Lectotype: Height: 22.5 mm. Diameter: 12.8 mm. Balcombe Bay specimen: Height: 96.5 mm. Diameter: 38.4 mm. Height of aperture plus canal: 54.3 mm. A body whorl fragment from Grices Creek, Vict. is 47.15 mm in diam..

Type locality: "Murray River Cliffs" = Cadell Marl lens, Morgan Limestone, River Murray cliffs, 6 km. below Morgan, S. Aust..

Lectotype: Tate Coll., S.A.M. (T.501). Chosen from a series of 9 specimens on the type tablet, 2 of which were figured by Tate. The larger figured specimen is here designated the lectotype.

Other Material Examined: Batesfordian: Topotypes, F. A. Cudmore Coll., N.M.V. (P. 30742). Balcombian: Balcombe Clay, Fossil Beach, Balcombe Bay, Mornington, Vic. (Grid Ref. Cranbourne 072 845), coll. J. Kerslake and T. A. Garrard (C. 74895 (part)); Muddy Creek Marl, lower beds (=Clifton Bank), Muddy Creek, near Hamilton, Vict. (Tate Coll., S.A.M. = Tate's record of *Siphonalia subreflexa*) and F. A. Cudmore Coll., N.M.V.; Muddy Creek, near Hamilton, Vict. (=Clifton Bank), coll. North, 1889 (F. 573 (part)). Bairnsdalian: Balcombe Clay, cliff S. of Manyung Rocks, Mornington Peninsula, Vict. (Grid Ref. Cranbourne 106 903) coll. J. Kerslake and T. A. Garrard (C. 74896). Horizon?: "Grice's Creek," Vict. F. A. Cudmore Coll., N.M.V. (several specimens); coastal section, 2½ miles W. of mouth of Gellibrand River, Vict., F. A. Cudmore Coll., N.M.V. (fragments and juveniles).

Distribution: Batesfordian to Bairnsdalian (Miocene) of eastern South Australian and Victoria.

Remarks: There is little doubt that the juveniles from the Murray River cliffs (plate 44: 7, 8) are consubspecific with the Balcombe Bay and Muddy Creek (Plate 45: 1, 2) specimens. The long shoulder slope, sharply angled periphery and weak spiral sculpture are nearly indentical in similar sized specimens from the three localities. The only important difference is that the spire angle is narrower in the Murray River cliff specimens (44°) than in Muddy Creek and Balcombe Bay shells 52°-56°).

This is the species Tate recorded as *Siphonalia subreflexa* (Sowerby) (Plate 45: 1, 2), a species which was originally described from the Chilean

Tertiary. As far as can be judged from the figure the Chilean species agrees superficially but has blunter nodules, a distinctly concave shoulder, stronger spiral sculpture, and the axial ribs do not form a weak second angulation on the body whorl.

This subspecies differs from *P. roblini roblini* in its larger size, sharper peripheral knobs and more distinct biangulation of the body whorl. The protoconch is smaller and of fewer whorls in *roblini roblini* (compare text figures 3: 1 and 3: 3, 4, 5).

Although *P. roblini simulans* occurs together with *P. longirostris* (Tate) the latter species is easily differentiated by its subangled whorls, much coarser spiral sculpture, blunt axial knobs and distinct axial growth-lamellae. This subspecies is superficially similar to *P. maximus* from which it differs in size and the nature of the spiral ornament. It also has the general appearance of the New Zealand species *P. dilatatus* (Quoy and Gaimard) which has a much larger, 4 whorled protoconch.

Penion longirostris (Tate, 1888).

Plate 44: 6. Text figure 3:2.

Siphonalia longirostris Tate, 1888: 143, pl. 11, fig. 8; Harris, 1897: 154.
Austrosipho longirostris; Cossmann, 1906: 229; Darragh, 1970: 178.

Protoconch: (text fig. 3: 2) small, of 1½-1¾ smooth, convex whorls; terminated by a distinct varix; first ½ whorl large, flattened. About 1.2 mm in diameter.

Teleoconch: medium size for genus, of rather light build, sculptured with strong, widely spaced spiral lines crossed by distinct lamellate growth lines, and rounded axial knobs; whorls bluntly angled and about 8½ in number. Spiral cords high, narrow, strong, and widely spaced, 10-11 on penultimate whorl, secondary threads absent to subequal in strength, no other spiral sculpture present. Distinct, close axial lamellae cross the spirals, giving the whole surface a rugose appearance. Axial folds strong from suture to suture on upper whorls, peripheral angulation slight or absent. Axials more-or-less restricted to periphery on penultimate and body whorls, with only weak folds above and below and peripheral angulation weak to moderate; knobs becoming obsolete on last ¼ of body whorl in mature shells; 13-14 knobs on penultimate whorl. Aperture moderate, with a somewhat thickened crenulate outer lip which is strongly lirate immediately within; shoulder area weakly convex. Inner lip with spiral sculpture showing through the glaze, otherwise smooth. Canal long, slender, curved to the left, then curved back into the mid-line and dorsally. Fasciole weak, sculptured with spiral cords.

Dimensions: (Holotype) Height: 79.8 mm. Diameter: 28.95 mm. Fossil Beach (figured specimen): Height: 94.8 mm. Diameter: 32.2 mm. Height of aperture plus canal: 58.2 mm.
Holotype: Blue clays, Schnapper Point, Port Phillip, Victoria. Tate Coll., S.A.M. (T. 552) (=Balcombe Clay, Fossil Beach, Balcombian).

Other Material Examined: Balcombian: Balcombe Clay, Mornington, Hobson's Bay, Vict., ex Worcester, 1889 (F. 773, F. 769); Balcombe Clay, Schnapper Point, Vict., coll. Bailey, 1892 (F. 1927); Muddy Creek Marl, Clifton Bank, Muddy Creek, Vict., coll. C. Hedley, 1900 (C. 88715), and F. A. Cudmore Coll., N.M.V.; Gellibrand Marl, S.E. side of rocks at S.E. end of Gibson Beach, N.W. of Point Ronald, Princetown, Vict. (Grid Ref.

Princetown 0272 915), coll. K. Bell and T. A. Darragh, N.M.V. (P. 30808); same, coll. T. A. Darragh and H. E. Wilkinson, N.M.V. (P. 30807); Balcombe Clay, Fossil Beach, Balcombe Bay, Mornington, Vict. (grid Ref. Cranbourne 072 845), coll. J. Kerslake and T. A. Garrard (C. 74895 (part)). Bairnsdalian: Balcombe Clay, cliff S. of Manyung Rocks, Mornington Peninsula, Vict. (Grid Ref. Cranbourne 106 903), coll. J. Kerslake and T. A. Garrard (C. 74896 (part)); Fyansford Clay, left bank of Barwon River, sect. 2B, Parish of Murgheboluc, Vict. (Grid Ref. Geelong 197 988), F. A. Cudmore Coll., N.M.V. (P. 30804); same, coll. T. A. Darragh, N.M.V. (P. 30806); same, cliff on left bank, 0-3 metres above water, sect. 4B (Grid Ref. Geelong 229 983), coll. T. A. Darragh, N.M.V. (P. 30805); Inverleigh, Vict., T. S. Hall Coll. in F. A. Cudmore Coll., N.M.V. (1 specimen). Horizon?: "Grice's Creek," Vict., F. A. Cudmore Coll., N.M.V..

Distribution: Balcombian to Bairnsdalian (Miocene) of Victoria.

Remarks: This species is readily distinguishable by its tall spire, subangled whorls, strong axial folds and widely spaced, strong spirals.

Penion cf. *longirostris* (Tate).

There is a paucity of material available that is older than Balcombian (Middle Miocene). The few specimens that have been examined apart from *roblini roblini* appear to be ancestral to *longirostris.* Typical *roblini* is characterised by its strong peripheral angle and rather fine, regular spiral sculpture and weak axial growth lines. A series of specimens from Hordern Vale are about the same age as specimens from Table Cape (Longfordian) and have evenly convex whorls and rather distinct axial growth lines which render the primary and secondary spiral cords distinctly gemmate. These shells resemble specimens from Curlewis and one from the River Murray cliffs (both Batesfordian in age) except that in these younger shells the secondary spiral cords are weak and the primary spirals further apart. The Batesfordian specimens are very similar to *longirostris* which differs in having stronger spirals which are even more widely spaced, and stronger axial growth lamellae.

The Hordern Vale specimens also agree closely with *roblini* in most details of sculpture and in size and form of the protoconch. It is probable that *longirostris* and *roblini* had a common ancestor in the lowermost Miocene or Oligocene.

Localities: Longfordian: Fishing Point Marl, lower mollusc horizon, surface material from slips on S. side of Lake Costin, ½ km. W. of Hordern Vale Road, Hordern Vale, W. Vict. (Grid Ref. Aire 363 163), coll. K. Bell and T. A. Darragh, N.M.V. (P. 30745) (3 juveniles, one subadult and one broken subadult). Batesfordian: Fyansford Formation, Curlewis, F. A. Cudmore Coll., N.M.V. (P. 30732) (6 juveniles and 1 subadult); same locality, F. S. Colliver Coll., N.M.V. (P. 30733); Cadell Marl lens, River Murray cliffs, 6.4 km below Morgan, S. Aust., F. A. Cudmore Coll., N.M.V. (P. 30741).

Penion spatiosus (Tate, 1888).

Plates 43: 4; 44: 3-5. Text figure 3: 6.

Siphonalia spatiosa Tate, 1888: 143, pl. 4, fig. 5.
Fusus henicus Tate, 1889: 116, pl. 6, fig. 11.
Austrosipho spatiosa; Darragh, 1970: 195.
Fusinus henicus; Darragh, 1970: 173.

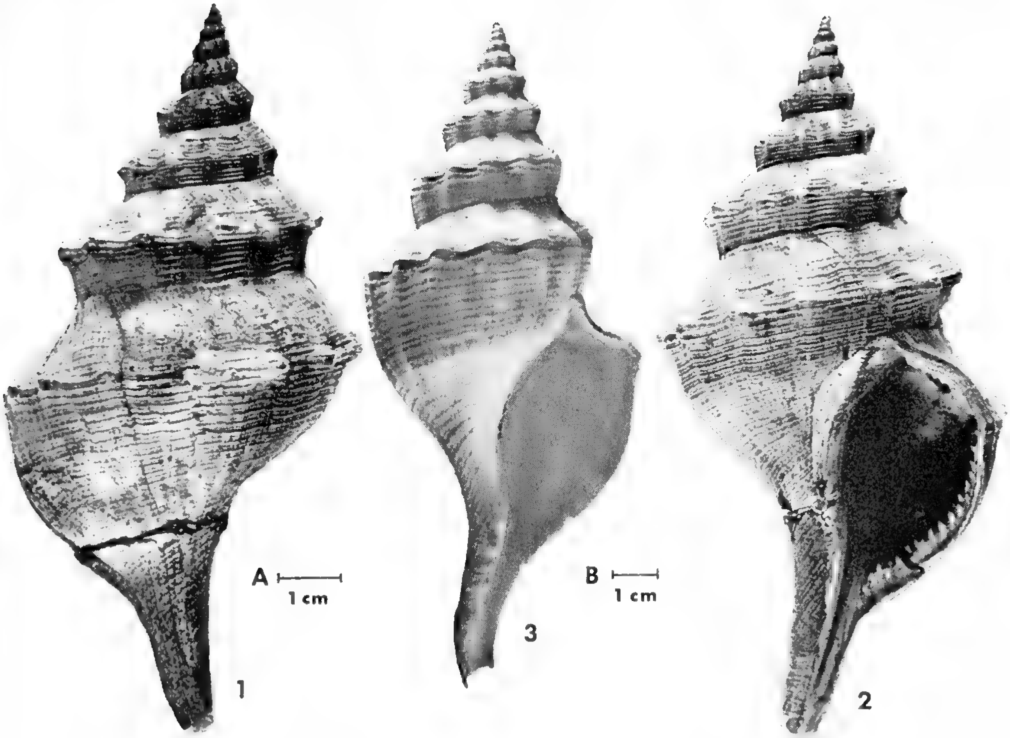


PLATE 45.

1, 2. *Penion roblini simulans* (Tate). "Lower beds, Muddv Creek", near Hamilton, Vict. (S.A.M., T. 553) (Photo courtesy of South Australian Museum). Scale A.

3. *Penion mandarinus* X *maximus*. Off Port Kembla, N.S.W., "Challenge" (ex T. A. Garrard Coll.) (C. 63405). Scale B.

Protoconch: (text fig. 3: 6) of 2 whorls, globose, smooth, bulging beyond first teleoconch whorl. About 2.43-2.65 mm in diameter.

Teleoconch: of about 5 whorls, spire short, body whorl broad. Spire whorls strongly angled but periphery very close to suture. Axials produce rounded knobs on periphery, 12 on penultimate whorl, a second weak angulation on middle of base where the very weak axials which extend from periphery, terminate. Canal slightly recurved and twisted, to almost straight. Spirals moderately strong; 14-15 on penultimate whorl. Intermediate threads weak to strong, not always present. Canal with very weak fasciole and subobsolete spiral sculpture. Inner lip and outer lip smooth. Shoulder very weakly concave.

Specimens from Gippsland (Plate 44: 3) are smaller than Muddy Creek shells (Plate 44: 4) and have stronger spirals, especially on the anterior canal and a smaller protoconch (1.65-1.80 mm).

Dimensions: Holotype: Height: 98.5 mm. Diameter: 47.65 mm.

Type of *henicus:* Height: 24.5 mm. Diameter: 12.5 mm.
Figured Gippsland specimen (P. 30694): Height: 53.25 mm.
Diameter: 27.27 mm.

Holotype: (Plate 43: 4) "Miocene, Muddy Creek" (=upper beds, Muddy Creek = Grange Burn Formation), Tate Coll., S.A.M. (T. 494). The type of *Fusus henicus* Tate is also in the Tate Coll. (T. 499).

Other Material Examined: Kalimnan: Grange Burn Formation, McDonald's Bank, Muddy Creek, near Hamilton, Vict., F. S. Colliver Coll., N.M.V. (P. 30739, P. 30744) and G. B. Pritchard Coll., N.M.V. (P. 30738).

Jemmys Point Formation (all Gippsland, Vict., N.M.V.): left bank of Nowa Nowa arm of Lake Tyers (Grid Ref. Hartland 056 337), coll. K. N. Bell and T. A. Darragh (P. 30696); Jemmys Point, Kalimna, F. S. Colliver Coll. (P. 30690); cutting on Nyerimalang Estates Road on right bank of Meringa Creek, just S. of Kalimna (Grid Ref. Bairnsdale 866 279), coll. K. N. Bell and T. A. Darragh (P. 30693); cutting on Princes Highway, S.W. side of Bunga Creek (Grid Ref. Hartland 956 300), coll. E. D. Gill (P. 30701, P. 30699). Cheltenhamian: large cutting on right bank of Meringa Creek from base of cliff near creek level (Grid Ref. Bairnsdale 866 279), coll. T. A. Darragh.

Distribution: Kalimnan to Cheltenhamian (Lower Pliocene) of Victoria.

Remarks: Fusus henicus Tate is a juvenile of *spatiosus*, as shown by a comparison of the types. Tate's locality for *henicus* is "Lower Beds at Muddy Creek (J. Dennant)". However, the species has only been recollected in the "Upper Beds" (=Grange Burn Formation).

One other specimen in the Dennant Collection (N.M.V.) is labelled as coming from the lower beds. This specimen and the type were probably collected together and it seems likely that both are erroneously located.

A few poorly preserved small specimens from the Cheltenhamian of Gippsland (plate 44: 5) have a relatively narrower spire angle (48°-56°) than that of typical *spatiosus* (70°-90°) and subangled whorls. These are tentatively associated with *spatiosus* because in other features they agree closely, including possessing a similar protoconch. These tall-spired shells are known from the following localities (all N.M.V.): lowest shell bed in cutting on Princes Highway, N.E. side of Bunga Creek, coll. E. D. Gill (P. 30703) and H. E. Wilkinson (P. 30704); large cutting on right bank of Meringa Creek at base of cliff near creek level (Grid Ref. Bairnsdale 866 279), coll. T. A. Darragh (P. 30689).

A large fragment, possibly of an adult of the narrow form has an estimated spire angle of 55° and, although worn, somewhat resembles *maximus* in details of sculpture and shape. This specimen was collected from Jemmys Point, Kalimna (F. S. Colliver Coll., N.M.V., P. 30687).

It is possible that *P. spatiosus* gave rise to both *mandarinus* and *maximus*, although there is little evidence to support this. Both of the Recent species were present in the Upper Pliocene in Bass Strait. The general shell-features and protoconch of *spatiosus* are closer to *maximus* than those of *mandarinus*.

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Museum, Wellington, and Dr. E. Binder of the Natural History Museum, Geneva, for the supply of photographs, access to collections and for the loan of material. Mr. C. Turner of the Australian Museum produced the majority of the photographs and my wife produced the line drawings and assisted in checking the manuscript.

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A NEW SPECIES OF SNAIL FROM LAKE PEDDER, TASMANIA, POSSIBLY BELONGING TO THE FAMILY VALVATIDAE

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ABSTRACT

A new species of freshwater snail, *Valvata (?) pedderi* sp. nov. is described from Lake Pedder, Tasmania. It is tentatively referred to the Family Valvatidae and constitutes the second record of this family for Australia. The structure of the radula and the anatomy are described.

INTRODUCTION

During a survey of the Lake Pedder area of Southern Tasmania, several specimens of a minute gastropod were collected from weed in shallow water by Mr. A. J. Dartnall of the Tasmanian Museum. These were recognised as new to the fauna of Tasmania by Mr. R. C. Kershaw of the Queen Victoria Museum, Launceston, and passed on to me for description and further study. Subsequently, further specimens were obtained by Dr. P. Tyler of the University of Tasmania, which allowed anatomical studies to be carried out.

Notwithstanding the availability of about 10 specimens, these studies are still inconclusive with regard to family and generic placement of the species. This is due to the small size of the animal which makes anatomical study extremely difficult, and the lack of comparative material from the group concerned. However, it was decided that the species should be described and that such findings as have been made, should be recorded.

Abbreviations: TM — Tasmanian Museum; NMV — National Museum of Victoria.

FAMILY AND GENERIC PLACEMENT

The species has a thin, horny, almost colourless operculum with a central nucleus, and a very small, thin, planispiral shell with pronounced spiral ridges on the dorsal and ventral surfaces. The radula consists of a few large units with many denticles. All these characters suggest the Family Valvatidae. However this family is reported as confined to the northern hemisphere (Wenz, 1939; Fretter & Graham, 1962) with only one questionable record in South America (Wenz, 1939); also the radula differs from any other valvatids for which such information is known, possessing only a single large, multicuspid central tooth of a highly modified nature. Nevertheless, I am provisionally referring this species to the Family Valvatidae as it most closely approaches this family in many of its characters. I am also including it in the genus *Valvata* sensu lato because of the paucity of anatomical knowledge. The external characters of the living animal have not been recorded and the few animals which have been dissected or sectioned all proved to be immature so that important features of the reproductive system could not be fully elucidated. Although the structure of the radula was readily seen and proved to be different from any other valvatid, it was thought that, because this could be a function of the animal's small size and because comparative radula information was not available for many of the existing valvatid genera, the erection of a new higher taxon on such evidence would be premature. It is proposed to continue this study in the near future.

Valvata (?) pedderi sp. nov.

Text figures 1-9.

Diagnosis: Shell (Figs. 1-5) dextral, minute, planispiral with sunken spire, whorls strongly keeled dorsally and ventrally, periphery rounded, 3 whorls, with faint growth lines visible, surface of shell composed of irregular lattice of crystal elements. Aperture oval, pointed dorsally and ventrally. Umbilicus wide and deep. Operculum very thin, horny, pale yellow, paucispiral with 1½ turns and central nucleus. Radula of a large curved spoon-shaped central tooth bearing two rows of 7 denticles, lateral and marginal teeth absent. Eyes at outer base of tentacles, little or no modified ctenidial structure, reproductive aperture on right anterior side of head posterior to tentacles.

Type Material: Holotype in Tasmanian Museum, E8543, complete specimen with animal preserved in 70% alcohol.

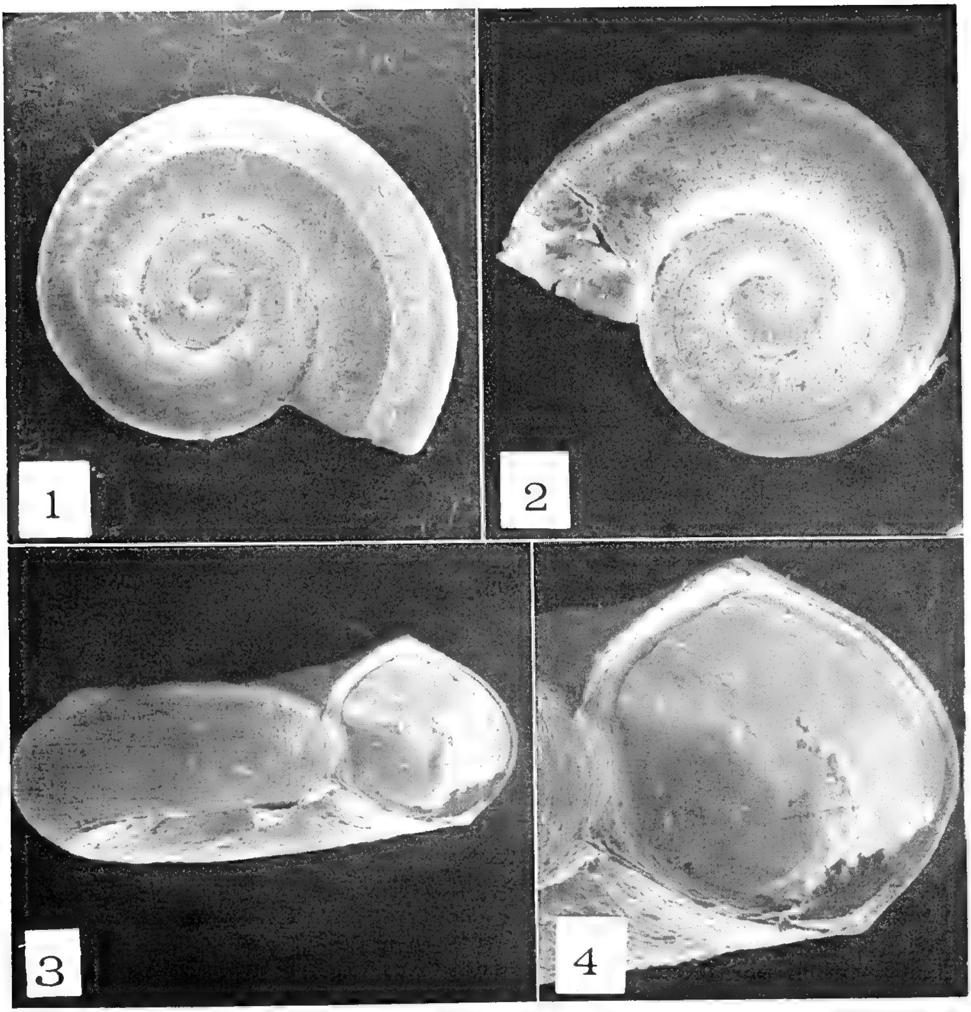
Seven paratypes: Paratypes 1 and 2 in Tasmanian Museum, E6443 with animals preserved in 70% alcohol. Paratype 3 in National Museum of Victoria, F27937, complete serial sections on three slides. Paratype 4 in Tasmanian Museum, E8544, shell only. Paratype 5 in National Museum of Victoria, F27938, shell only. Paratypes 6 and 7 in National Museum of Victoria, F27939, shells only mounted on SEM stud and coated with gold.

Dimensions:

Holotype	E 8543	Max. 1.96 mm.	Min. 1.61 mm.	H 0.88 mm.
Paratype 1	E 6443	Broken	Broken	Broken
Paratype 2	E 6443	1.23 mm.	1.00 mm.	0.42 mm.
Paratype 3	F 27937	———	———	———
Paratype 4	E 8544	1.23 mm.	1.00 mm.	0.58 mm.
Paratype 5	F 27938	1.11 mm.	0.85 mm.	0.58 mm.
Paratype 6	F 27939	1.35 mm.	1.04 mm.	———
Paratype 7	F 27939	1.65 mm.	1.31 mm.	———

Type Locality: Lake Pedder, Lake Maria and Lake Edgar, Southern Tasmania, now all part of the new Lake Pedder, enlarged artificially. The holotype was collected by J. L. Hickman in a small hole in the plain just south of Lake Edgar on 17 May, 1972. The remainder of the type series was collected by Mr. A. J. Dartnall in shallow water on weed and rushes with a net on 12 February, 1967.

Other Material: Lake Maria, A. J. Dartnall, 10 February, 1967, 3 spec. (TM); Lake Edgar, P. Tyler 17 May, 1972, 2 spec. (NMV).



Figures 1-4. *Valvata (?) pedderi* sp. nov.
1. Dorsal view of Paratype 6, F27939, X 90.
2. Ventral view of Paratype 7, F27939, X 90
3-4. Aperture views — specimen lost subsequently, 3 — X 93, 4 — 240.

Radula: The radula (Figs. 6-9) of one specimen was extracted by macerating in 10% sodium hydroxide. It was then mounted on a stud, evaporated with gold and examined with a J.S.M. U-3 Scanning Electron Microscope.

The radula consists of a ribbon of highly modified single central teeth with enlarged basal regions so that each tooth articulates in the plane of the ribbon with the teeth on either end of it. There are no lateral or marginal teeth. Each tooth consists of a solid base plate with short anteriorly pointing protuberances which appear to form ball-and-socket-

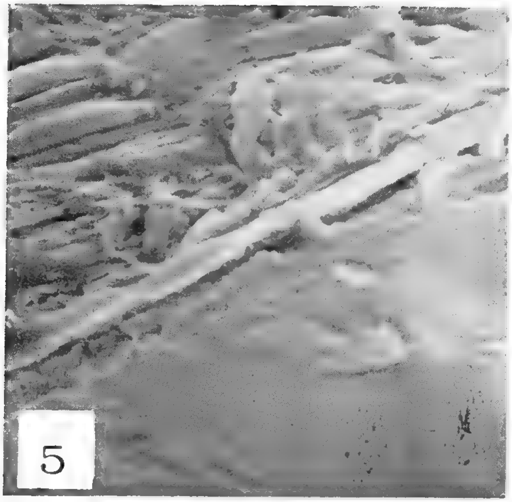


Figure 5. *Valvata (?) pedderi* sp. nov.
Surface of shell, X 2850

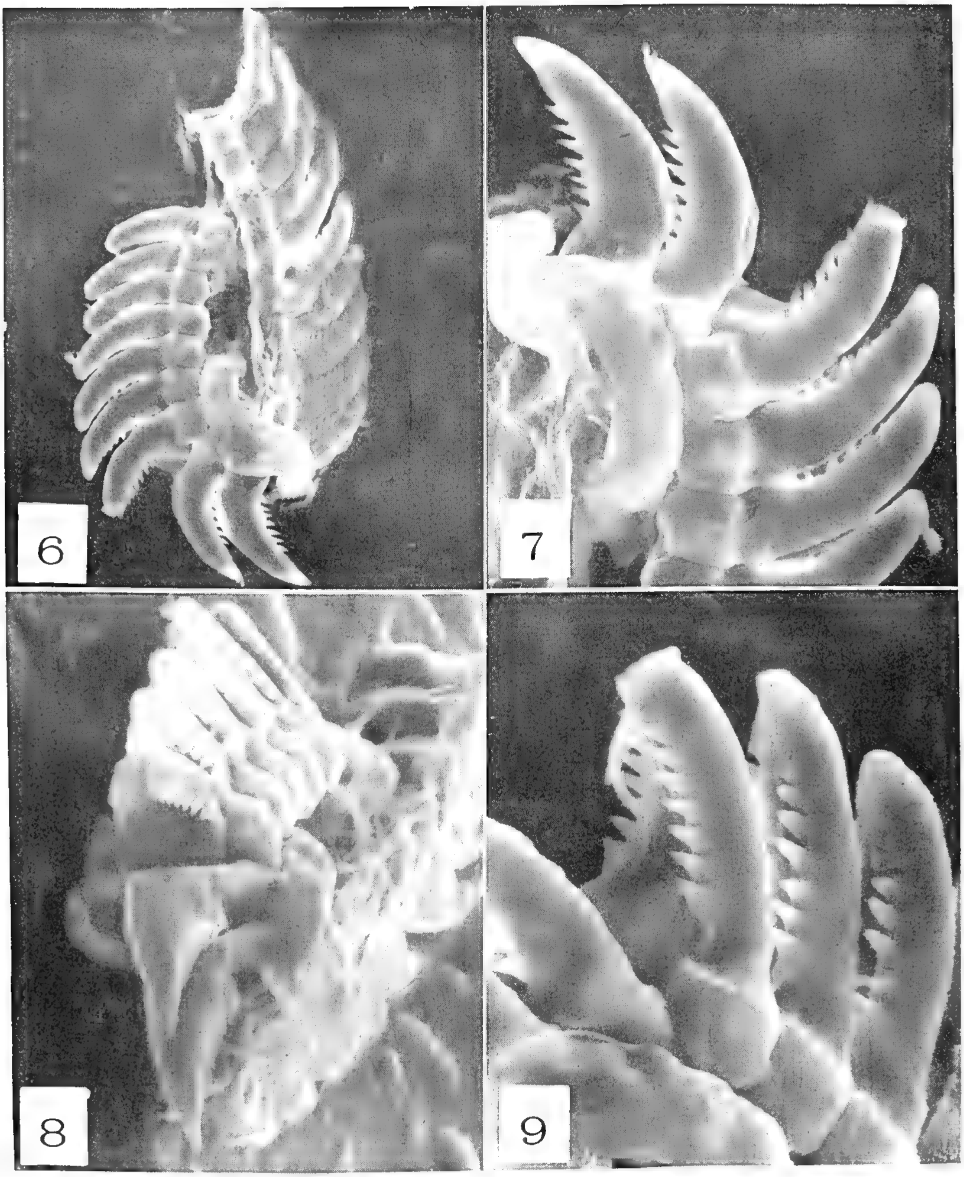
like articulation with the tooth anterior to it. The body of the tooth is extended as an acute, triangular spoon-shaped structure, concave anteriorly. Each side of the tooth bears seven anteriorly pointing small sharply pointed denticles. The pointed tip is easily worn down.

Anatomy: Two specimens were serially sectioned and two were dissected. However, because of the smallness of the specimens, and the fact that none of the specimens were reproductively mature, many of the anatomical features will have to await further collections for elucidation.

The eyes are situated at the outer base of the tentacles. No ctenidia could be detected in the pallial cavity although a long flap-like structure was found attached posteriorly to the left side of the cavity. There also appears to be a structure similar to a pallial tentacle attached at the right margin of the cavity. The anterior part of the reproductive tract extends anteriorly to level with the right side of the buccal mass where it presumably opens to the exterior. A hollow penal organ appears to be present but the specimens were not mature. The oesophagus arises from the mid-dorsal surface of the large buccal mass and runs to the large simple stomach. There appears to be no oesophageal or salivary glands.

Discussion: There is no minute planispiral freshwater operculate remotely similar to this species recorded anywhere in the Australian fauna. The species differs from all other valvatids in its planispiral shell with the two spiral ridges and its radula consisting of a much enlarged central tooth only with no lateral or marginal teeth. A species *Valvata tasmanica* was described by Tenison Woods in 1876. However, it was described as globosely turbinate and was transferred to the Hydrobidae by Iredale 1943 under the genus *Valvatasma.*

The referring of this species to the family Valvatidae constitutes the second record of the family for Australia, and only the third record from the southern hemisphere. This creates considerable zoogeographical problems but these will not be solved by erecting a new family for this species. The species will have to remain an enigma until more collecting can be carried out in Tasmania and comparative collections can be obtained from



Figures 6-9. *Valvata (?) pedderi* sp. nov.

6. X 600.
7. X 2520.
8. X 1848.
9. X 3360.

South America and South Africa, as well as from Europe and North America. Similar species could have been overlooked in remote mountain areas of other parts of the southern hemisphere due to their small size and to lack of collections. This collection was stimulated by the projected hydro-electric work in the area. All the localities where the species was collected are now inundated by a new artificial lake. It is not known what effect this flooding will have on the populations.

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Post scriptum. Recent correspondence with a worker in Germany indicates a similarity of radulae between this species and an undescribed species from southern Chile. It is felt that both these species, because of the unusual radular structure, should be referred to the family Hydrobiidae, possibly to a new genus. It is hoped to publish further on this in the near future.

INDEX OF NEW TAXA PROPOSED IN VOLUME 2

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