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		
Vict.	Victoria	S.A.M.	South Australian Museum (registered numbers given without abbreviations refer to Australian Museum specimens).
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 1½-4 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.

Penion

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.

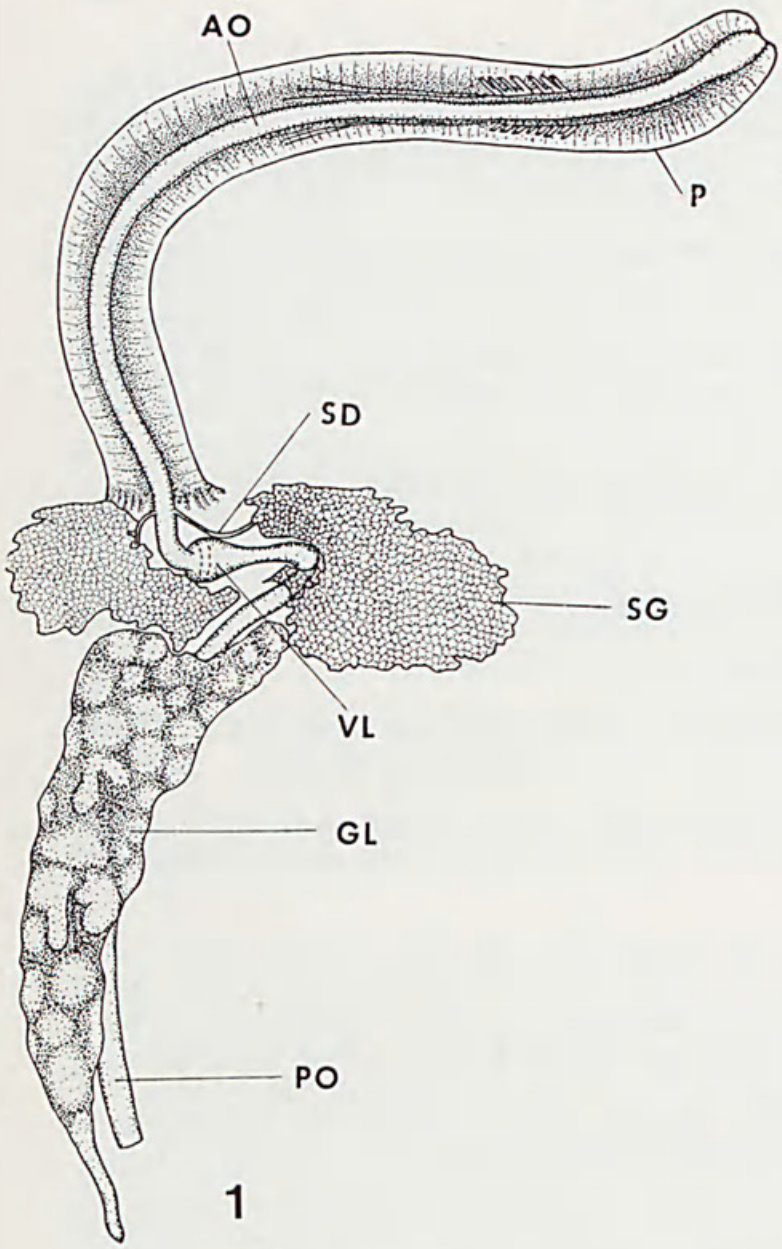
Anatomy: The New Zealand *P. adustus* (Philippi) was studied in some detail and *P. dilatatus* (Quoy & Gaimard) and *P. mandarinus* (Duclos) were also investigated. Most of the detailed points are taken from *P. adustus.* The majority of the following features, as far as can be judged from the material 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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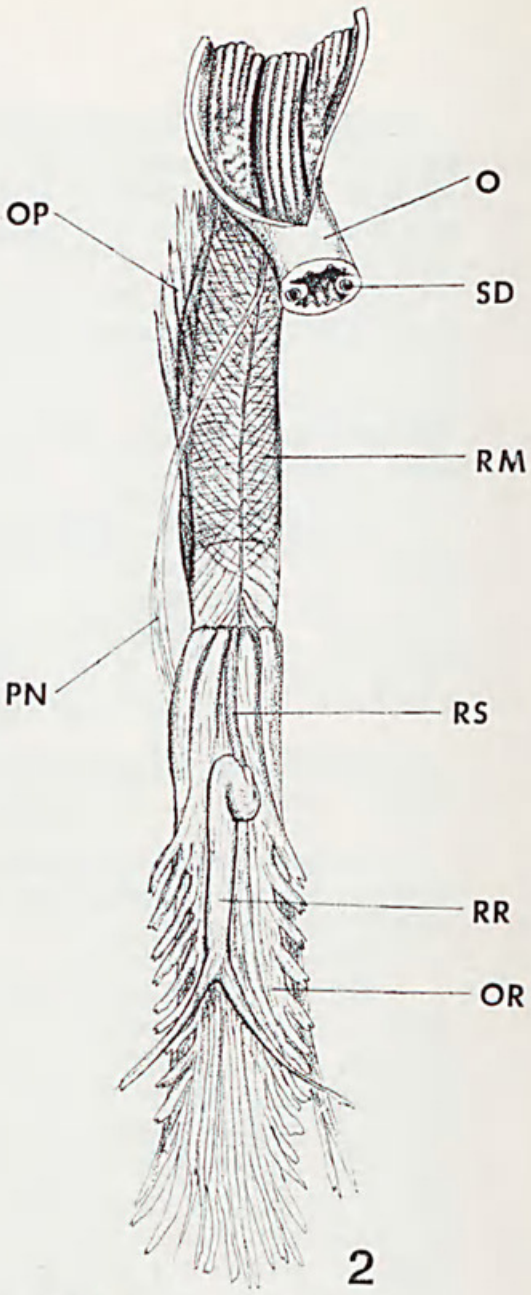

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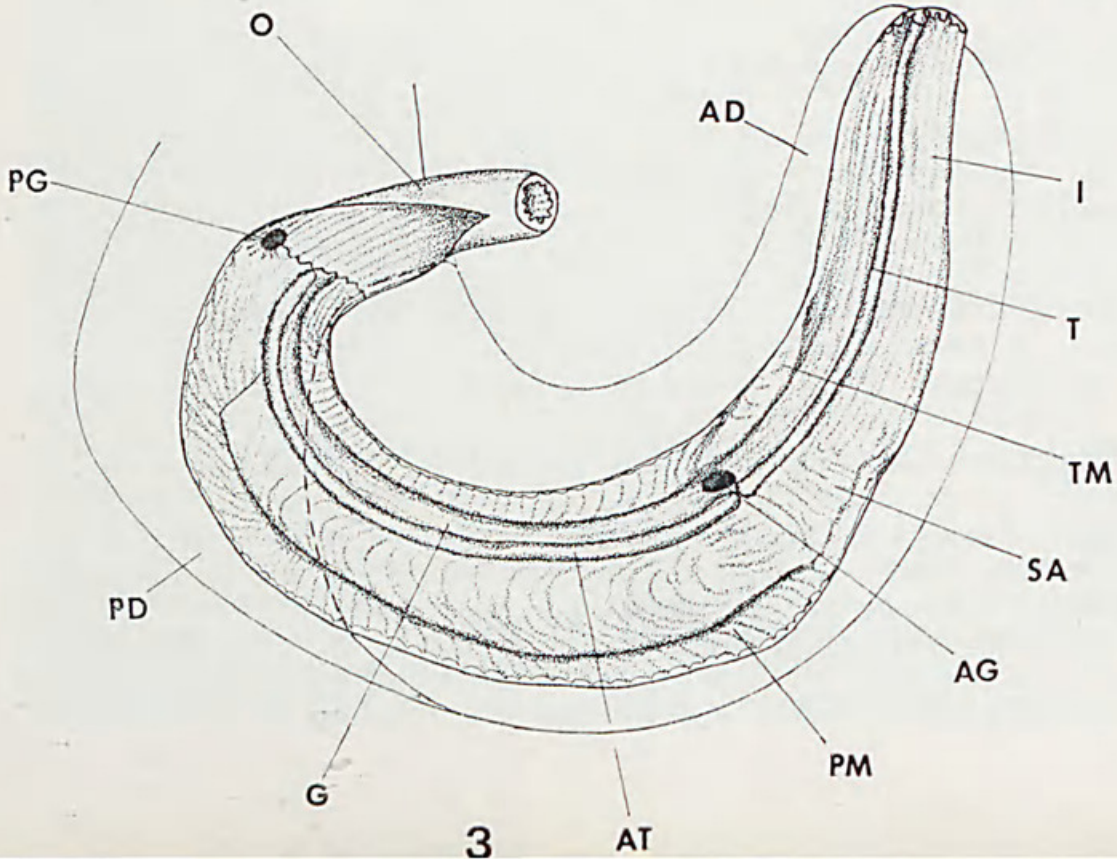

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conducting tube; and a long typhlosole (AT, T) which runs throughout the stomach and continues into the intestine where it lies ventrally. Intestine and rectum simple, the anus extended well forward in the pallial cavity, lying next to the terminal 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).

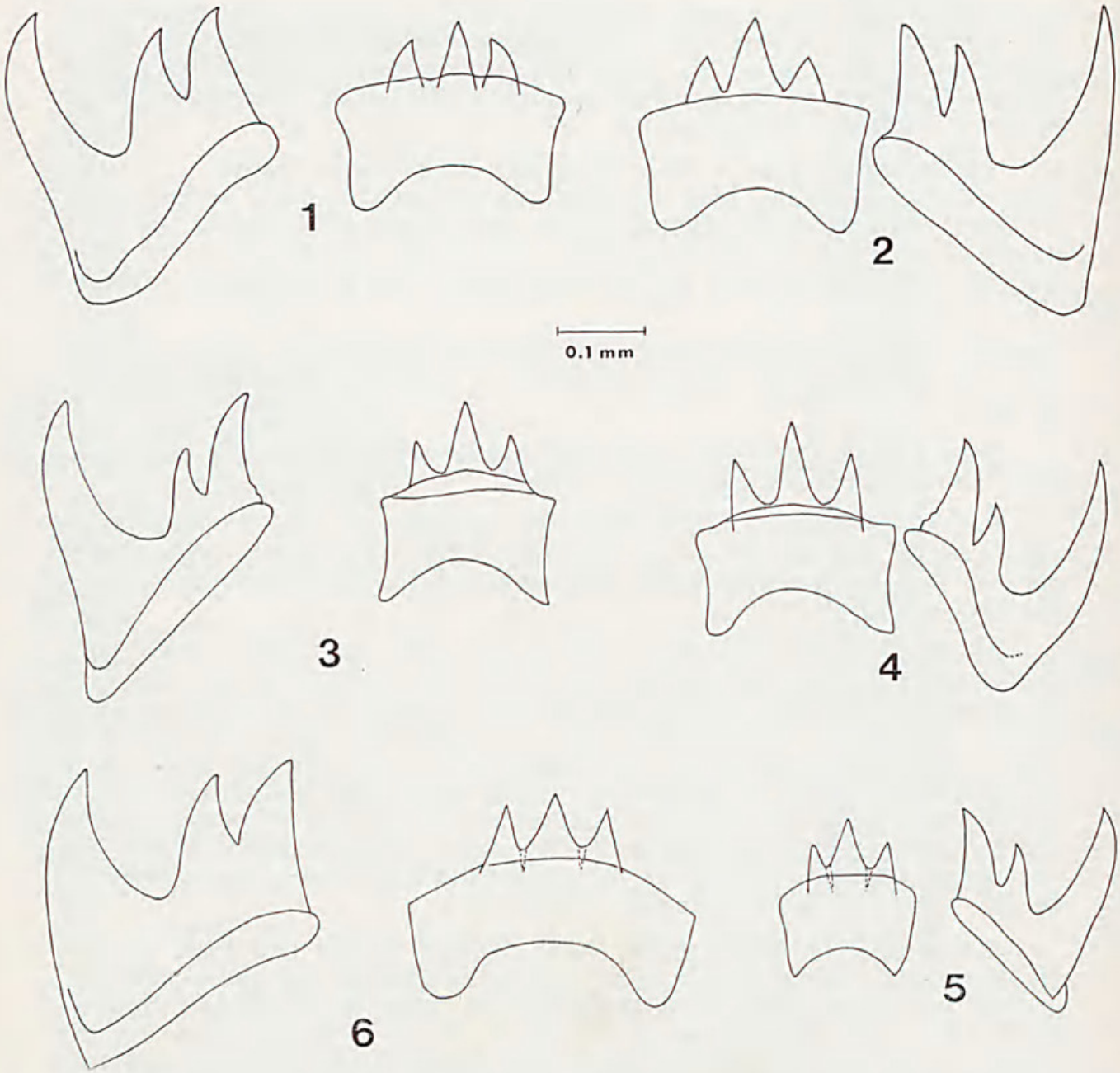
Remarks: Fleming (1955: 1057) has pointed out that *Penion* can be used despite the prior *Penium* Philippi, 1865. *Verconella* Iredale was erected as a replacement name for *Penion* and consequently falls as an absolute synonym.

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.

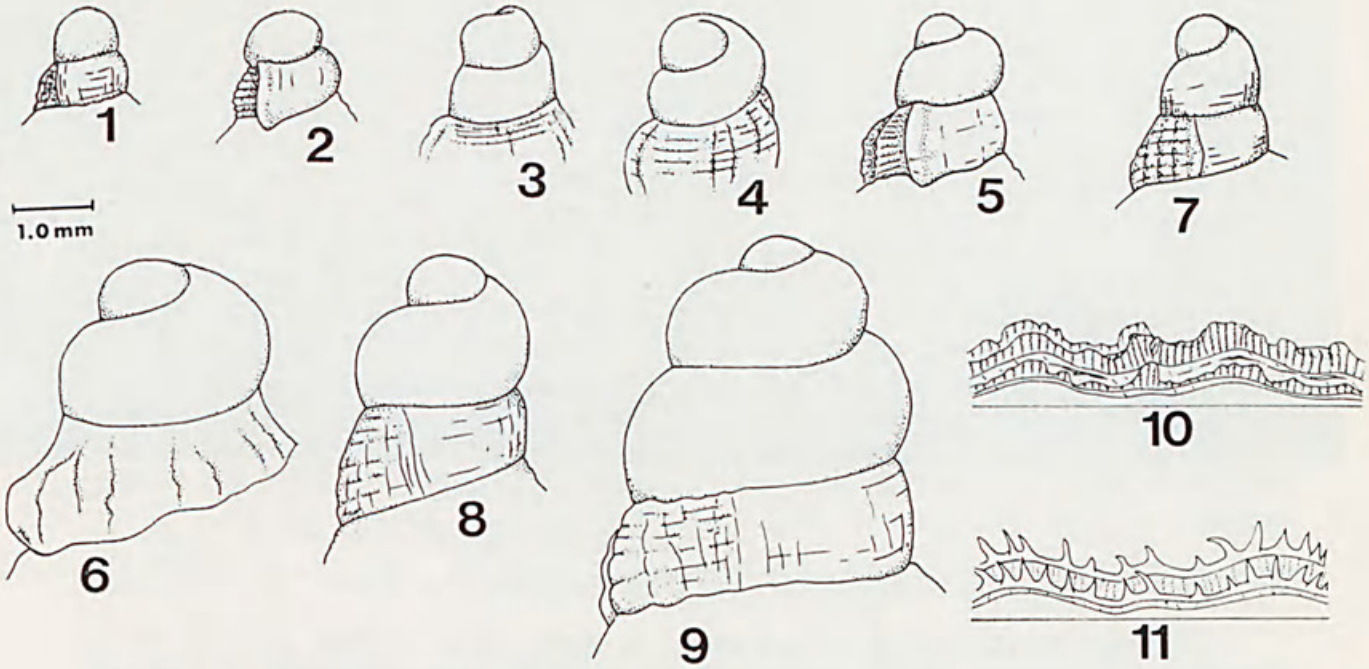
TEXT FIG. 1. Alimentary canal of *Penion adustus* (Philippi).
1. Anterior alimentary canal showing opened, everted proboscis, salivary glands, gland of Leiblein and oesophagus.
2. Dorsal view of buccal mass. Anterior oesophagus opened anteriorly, removed posteriorly.
3. Stomach opened along mid-line 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 $2\frac{1}{2}$ 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.

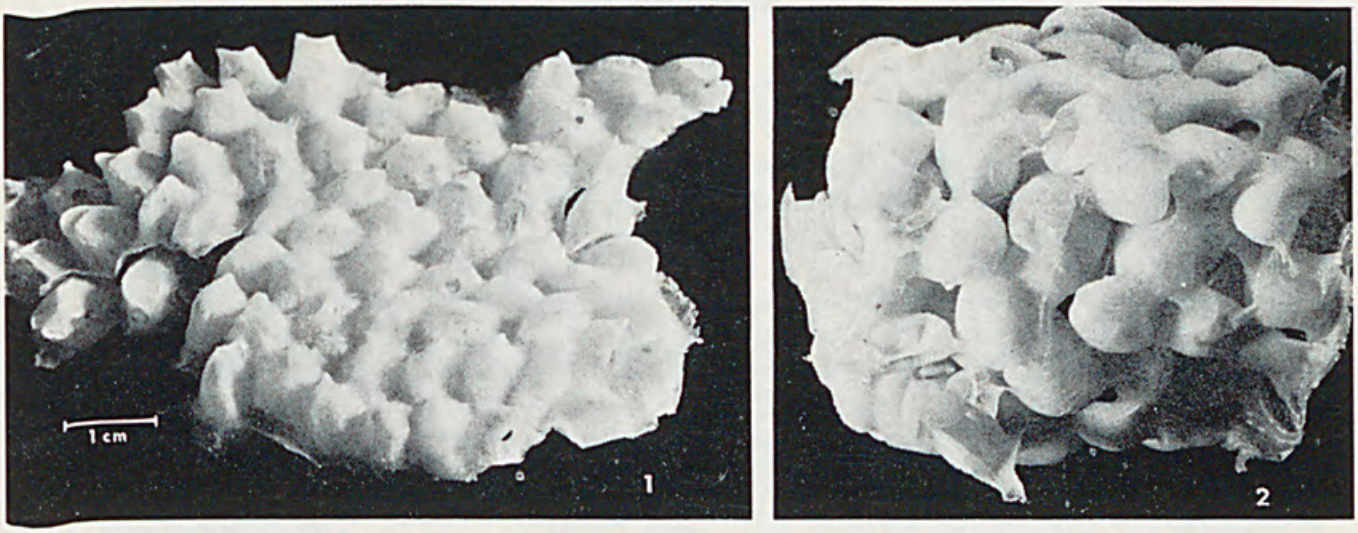


PLATE 40. Egg capsules. To same scale.

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 ($1\frac{1}{2}$ to 4 whorls) usually not eroded.	Small, $2\frac{1}{2}$ 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).

Penion

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).

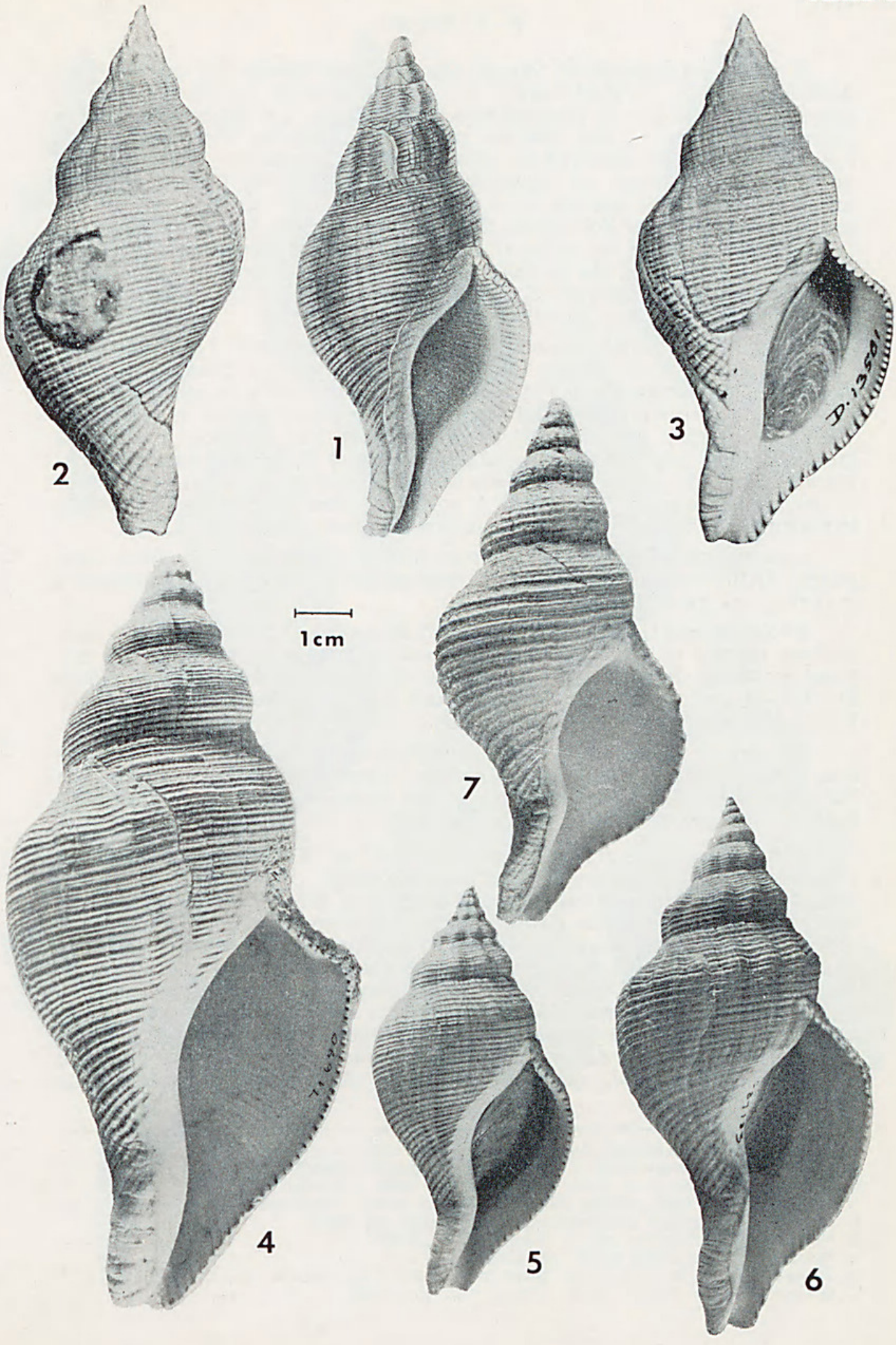
Distribution: Trial Bay, northern N.S.W. (C. 87205-7) to the western half of the Great Australian Bight (C. 35599). It appears to be restricted to the continental shelf in the Great Australian Bight (146-220 metres) and in N.S.W. (18-594 metres) but is also found in the lower littoral and shallow sublittoral 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).


2
1
3
P. 13501
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.

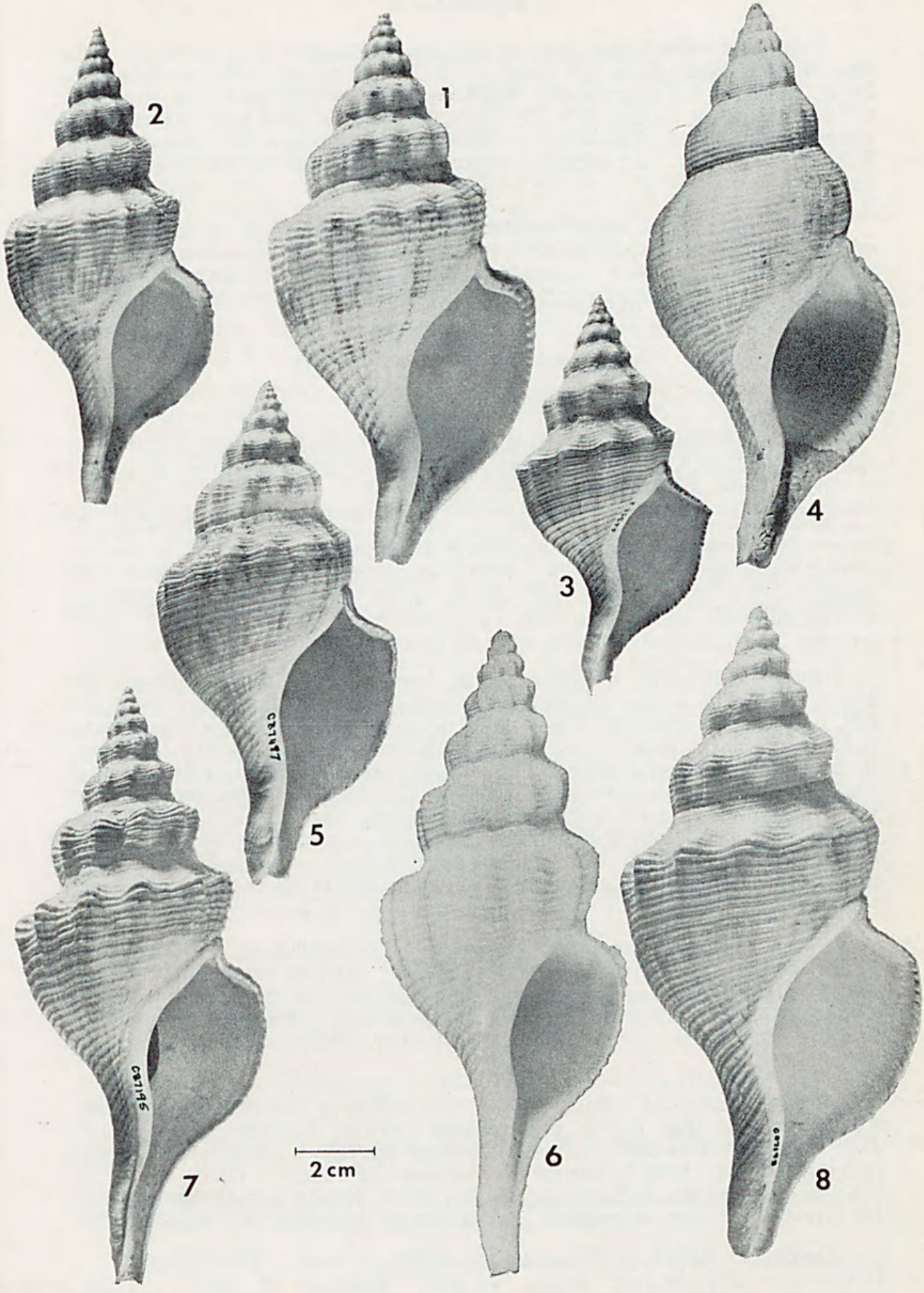
Pritchard and Gatliff (1898) showed that *oligostira* Tate is only a non-costate variety of *"dilatata"* (=*mandarinus*). The specimens at my disposal certainly show this to be the case, although the smooth form (Plate 41: 1-3, 5) seems to occur only in South Australia and western Victoria. Intermediate 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
7
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

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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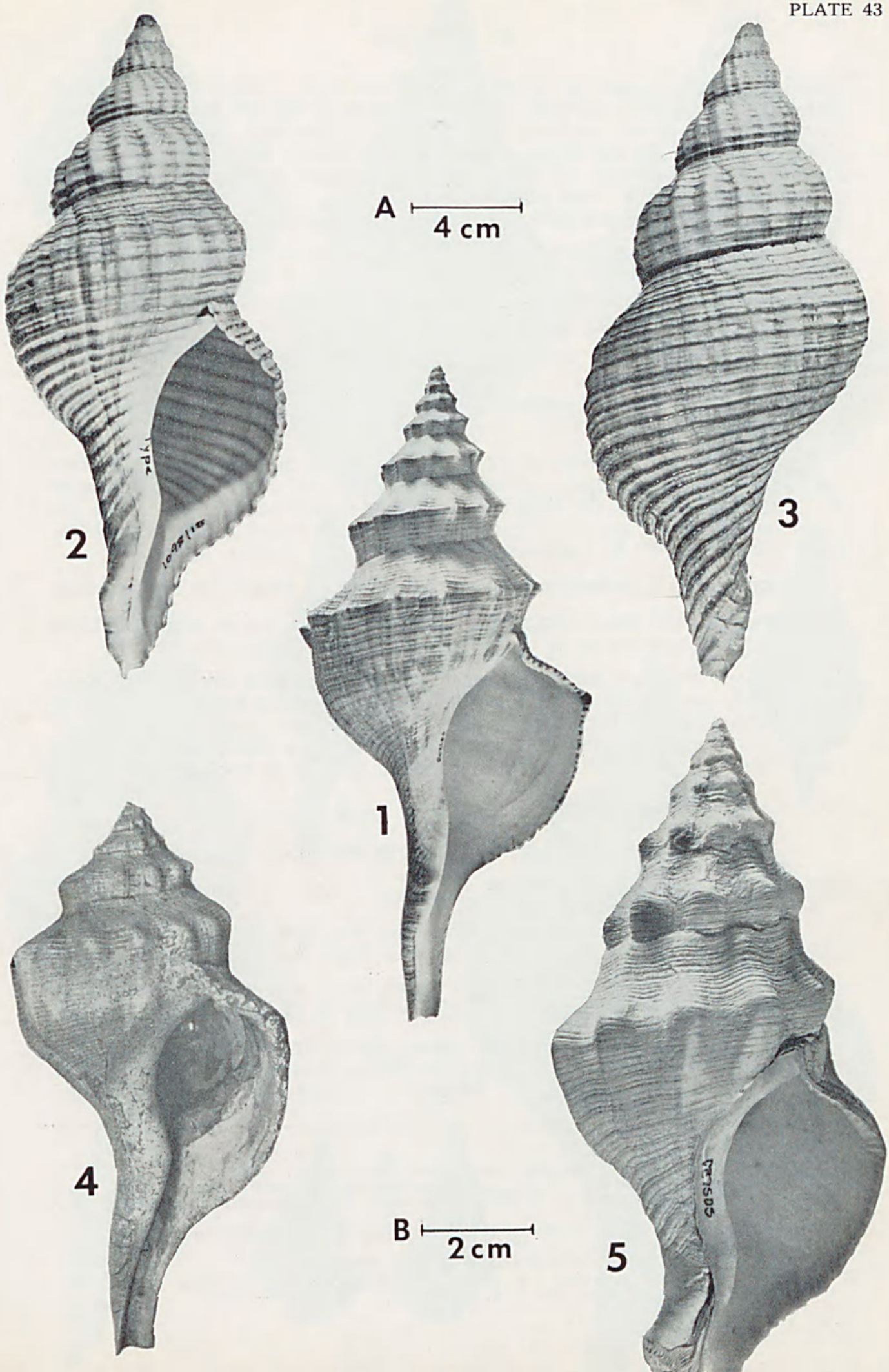
PLATE 43.

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.


A
4 cm
2
1
3
4
B
2 cm
5

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 $2\frac{1}{4}$ 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.

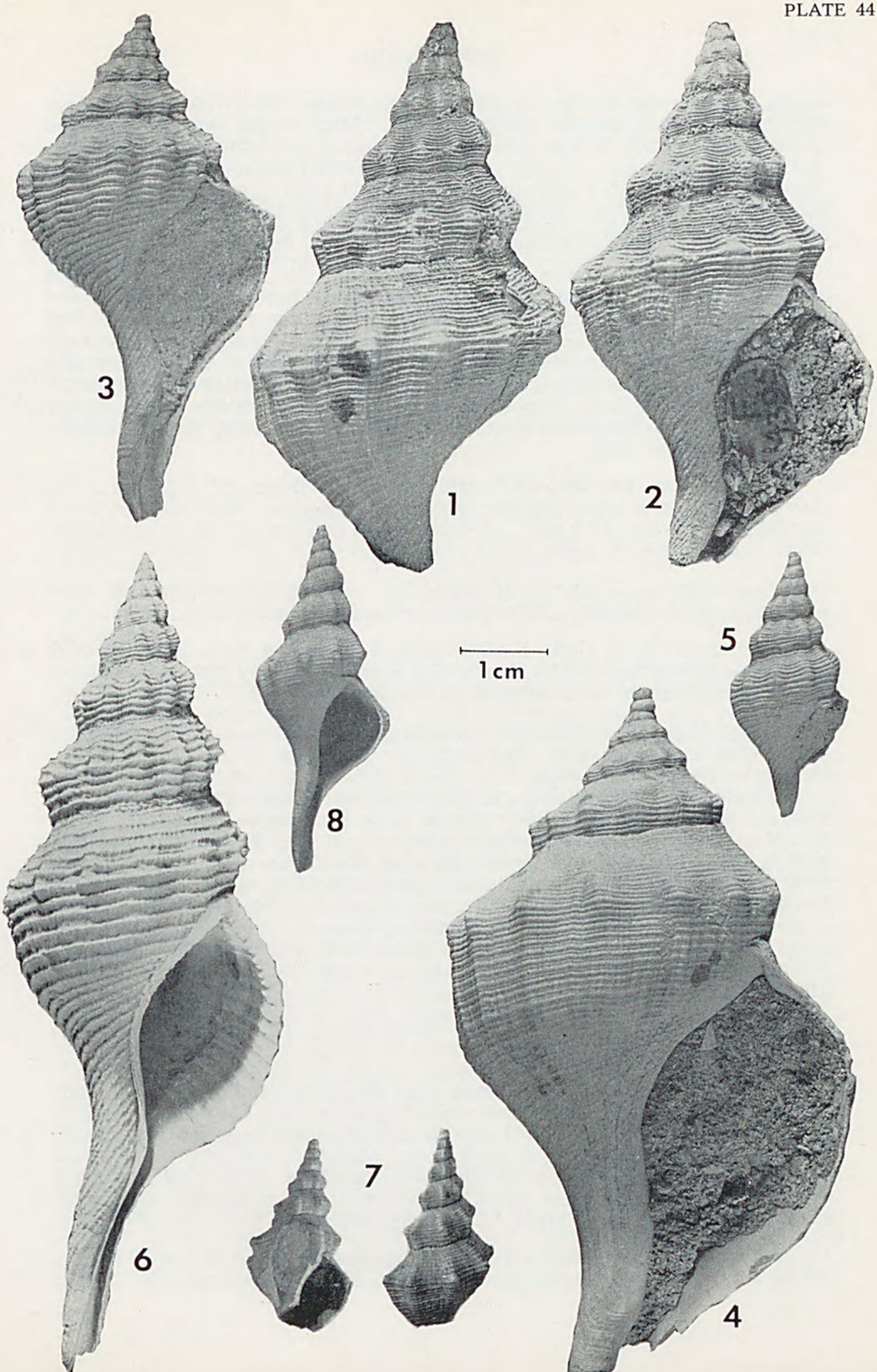
1, 2. *Penion roblini roblini* (T. Woods). Table Cape, Tasmania (F. 14395).

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
1 cm
5
8
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 $1\frac{1}{2}$-$1\frac{3}{4}$ smooth, convex whorls; terminated by a distinct varix; first $\frac{1}{2}$ 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 $8\frac{1}{2}$ 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 $\frac{1}{4}$ 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.

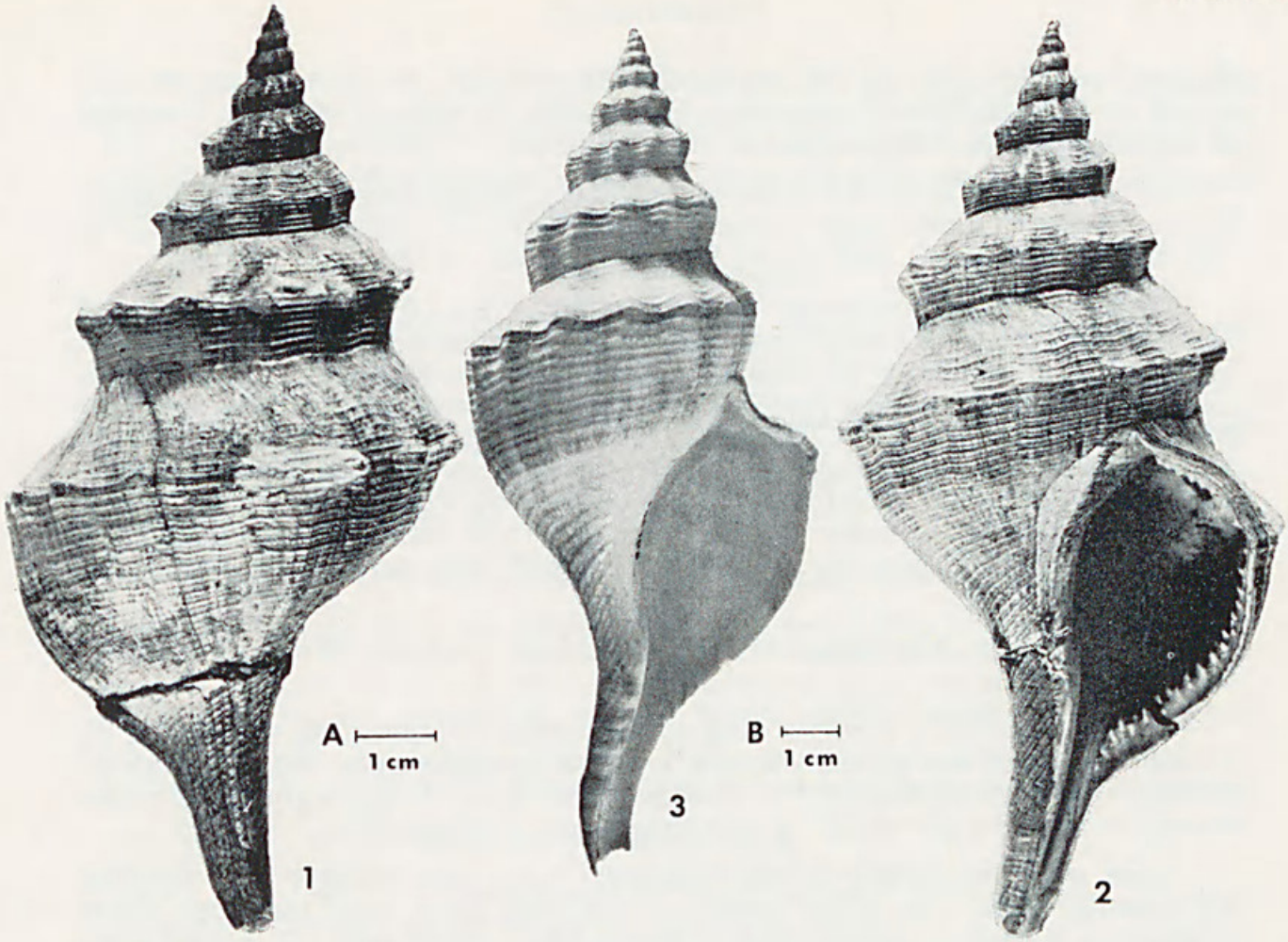


PLATE 45.

1, 2. *Penion roblini simulans* (Tate). "Lower beds, Muddy 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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