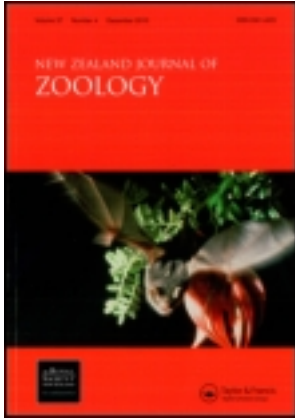


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### Taxonomic and nomenclatural notes on some New Zealand Cenozoic Mollusca, with descriptions of new taxa

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## Taxonomic and nomenclatural notes on some New Zealand Cenozoic Mollusca, with descriptions of new taxa

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The new names *Limopsis gisbornensis* and *Conilithes wollastoni* are proposed for *Limopsis retifera* Marwick, 1931 (not *L. retifera* Semper, 1861) and *Conus ornatus* Hutton, 1873 (not *C. ornatus* Michelotti, 1847) respectively. The taxon *Cardilona* Marwick, 1943 is considered to be a synonym of *Pecchiolia* Savi & Meneghini, 1850; and is transferred from the Cardiliidae to the Verticordiidae. *Longimacra* Finlay, 1928 (Mactridae) is synonymised with *Pseudoxyperas* Sacco, 1901, and *Claraxis* Iredale, 1936 (Architectonicidae) with *Granosolarium* Sacco, 1892. *Galeodea wylliei* Marwick, 1931 is transferred to *Galeocorys*, here considered to be a subgenus of *Galeodea*, and evidence is presented for retaining *Eudolium aoteanum* Beu, 1970 in *Eudolium* rather than transferring it to *Galeocorys*, as has been suggested by Cernohorsky. *Titanocardium* n. subgen. is erected for *Hedecardium cantuariense* (Laws, 1933) and related cardiids. The following new species are described - *Dimya westonensis*, *Hedecardium (Titanocardium) marwicki*, *Trachycardium (Regozara) delectabile*, *Oxyperas (Pseudoxyperas) xensis*, *Proxichione darraghi*, *P. otiakensis*, *Clavagella oamarutica Perotrochus masoni*, *Liotina turua*, *Cirsotrema gagei*, *Columbarium pataka*, *Ancillina kakano*, and *A. wellmani*.

### INTRODUCTION

This paper includes descriptions of new taxa of Cenozoic molluscs that might otherwise remain undescribed for some time, since they are members of faunas that are unlikely to be worked on in the near future or belong to groups with a relatively poor fossil record in New Zealand. Several species belong to genus-group taxa (*Clavagella*, *Regozara*, *Proxichione*, *Liotina*, and *Ancillina*) that have not previously been reported from New Zealand. In addition, new names are proposed for two preoccupied species; the affinities of *Cardilona* Marwick, 1943, *Longimacra* Finlay, 1928, *Galeodea wylliei* Marwick, 1931, *Eudolium aoteanum* Beu, 1970, and *Claraxis* Iredale, 1936 are discussed; and the classification of certain cardiids is commented on.

The material discussed is in the collections of the New Zealand Geological Survey, Lower Hutt. Type specimens have been given Type Mollusca Register (TM) numbers.

Class PELECYPODA  
Superfamily LIMOPSACEA  
Family LIMOPSIDAE

Genus *Limopsis* Sassi, 1827

1827 Giorn. Sci. Ligustico 1: 476.

TYPE SPECIES (by subsequent designation, Gray, 1847): *Arca aurita* Brocchi, 1814; Miocene-Recent, Mediterranean and eastern Atlantic.

*Limopsis gisbornensis* nom. nov.

1931 *Limopsis retifera* Marwick, Facont. Bull. N.Z. Geol. Surv. 13: 59, pl. 3 fig. 48, 49, 54. Not *Limopsis retifera* Semper, 1861 (synonymies given by Heering 1942, p. 33; Glibert & Poel 1965, p. 76).

HOLOTYPE. TM 4174.

TYPE LOCALITY. GS 1361\*, Tutamoe Conglomerate, Pangopango Stm, 2.4 km E of Reeve's homestead, Gisborne district (Lillburnian, Middle Miocene).

Superfamily PLICATULACEA  
Family DIMYIDAE

Genus *Dimya* Rouault, 1850

1850 Mem. Soc. geol. France (2nd ser.) 3(2): 470.

TYPE SPECIES (by original designation): *Dimya deshaysiana* Rouault, 1850; Eocene, France.

*Dimya westonensis* n.sp. (Fig. 1, 2)

Shell small, subquadrate, somewhat inequilateral, strongly inequivalve. Right valve highly inflated, with a small attachment area proximally in some specimens; left valve flat to concave. Dorsal margin of right valve short, almost straight; beak apparently very small; anterior end subvertical, almost straight; posterior end sloping backwards, slightly convex;

\*N.Z. Geological Survey macrofossil collection number

ventral margin convex. External concentric sculpture of irregular, flat-lying growth lamellae with fine interstitial threads; radial sculpture of irregular, rounded, low costae varying in width from shell to shell, not showing on shell interior but slightly crenulating the concentric lamellae. Right valve constricted internally by 2 divergent ridges on either side of hinge line, forming a narrow, discontinuous shelf. Resilifer oval, very small, deeply impressed, tucked in under middle of hinge, not visible from in front; cardinal area irregular, with fine vertical striae. A row of short but distinct radiating costellae around outer edge of internal shelf, in most specimens continuing below, some distance within ventral shell margin; costellae radiating not from umbo but from a point within shell; traces of similar rows of costellae within the main row in some specimens. Adductor muscle scars rather indistinct owing to recrystallisation and partial solution of aragonitic layer, but anterior scar apparently small, ovate, impressed, posterior scar much larger and more weakly impressed, apparently strongly bilobate. Interior of left valve not seen.

**DIMENSIONS OF HOLOTYPE (mm):** Length 10.5, height 10.5, inflation (r.v.) 4.1.

**HOLOTYPE.** TM 5456.

**TYPE LOCALITY.** GS 9539, upper part of dragline below Taylor's Quarry, Weston, North Otago.

**FORMATION.** Oamaru Diatomite (Runangan, Upper Eocene).

**LOCALITIES.** GS 9539 (holotype, 8 paratypes). GS 9543, near top of hillside below limestone escarpment, S end Jackson's Paddock, Weston (Runangan) (2 paratypes). Unnumbered collection in Geological Survey from "Maheno", probably from Maheno Marl (Runangan), a lateral equivalent of Oamaru Diatomite, or from immediately underlying Waiareka Tuffs (Runangan) (7 small paratypes).

**REMARKS.** *Dimya kauparaensis* Laws, 1944 (Otaian-Altonian, Lower Miocene, Pakaurangi), the only other fossil species so far described from New Zealand, is more irregular in form than *D. westonensis* and sculptured with closely spaced concentric lamellae but not radial costae. The extant species *D. maoria* Powell, 1937 (260 m, Three Kings Islands) has weakly malleate sculpture and a rather shallow right valve. *D. westonensis* is more similar to the Australian species *D. sigillata* Tate, 1886 (Upper Eocene, Victoria and South Australia) and *D. corrugata* Hedley, 1902 (Recent, New South Wales). However, *D. sigillata* is considerably smaller (6.5 × 7.5 mm - Tate 1886, p. 101) and has a much less inflated right valve and finer external radial sculpture; and *D. corrugata*, though more similar in size and sculpture, has a much shallower right valve. *Dimya corrugata* is the type species of *Dimyarina* Iredale, 1936 but it is not clear from Iredale's comments (1936, p. 269) how this taxon differs from *Dimya*. Cox & Hertlein

(in Moore 1969, p. N382) treat *Dimyarina* as a junior synonym of *Dimya*.

*Dimya* is recorded from at least as early as Bortonian (Middle Eocene) in New Zealand. A left valve from GS 11,155, Hampden Beach, North Otago, is similar in shape to *D. westonensis* but has only obscure concentric and malleate sculpture (so resembling *D. maoria*). Another species is represented by odd valves from GS 9957 (type locality of *Liotina turua* n.sp., and possibly older than Bortonian); this is similar to *D. kauparaensis* in shape and sculpture, and may be ancestral to it.

Superfamily CARDIACEA  
Family CARDIIDAE  
Subfamily PROTOCARDIINAE

Genus *Hedecardium* Marwick, 1944

1944 Trans. Roy. Soc. N.Z. 74(3): 260.

**TYPE SPECIES** (by original designation): *Cardium* (*Trachycardium*) *waitakiense* Suter, 1907; Oligocene, New Zealand.

Keen (in Moore 1969, p. N586) treats *Hedecardium* as a subgenus of *Vepricardium* Iredale, 1929 (type species *V. pulchricostatum* Iredale, 1929, Recent, Australia), but the two taxa differ in several significant features—some of them already noted briefly by Marwick (1944, p. 260)—as follows.

(1) *Vepricardium pulchricostatum* has nearly equilateral valves with the posterior end well rounded to weakly truncate; species of *Hedecardium* have more inequilateral valves with distinctly truncate posterior ends. In addition, the large species of *Hedecardium*—viz *H. greyi* (Hutton), *H. cantuariense* (Laws), and *H. marwicki* n.sp.—have pronounced posterior gapes, whereas *V. pulchricostatum* and the smaller species of *Hedecardium* like *H. waitakiense* and *H. olssoni* Marwick lack the gape entirely.

(2) Radial sculpture in *V. pulchricostatum* consists of prominent plicae (i.e., costae sculpturing the interior of the shell as well as the exterior) of roughly pentagonal cross section and bearing moderately large, closely spaced tubercles on the crests, particularly distally. There is no differentiation of radial sculpture into "main" and "posterior" costae (in the sense of Marwick 1944, p. 260).

Of the known species of *Hedecardium* only *H. subcordatum* (Suter) and *H. brunneri* (Hector) have true radial plicae; the others have costae with little or no internal expression. These costae are normally squarish to convex in cross section, but in some species certain costae may be of broadly triangular section. In *Hedecardium greyi* and *H. cantuariense* there is a tendency for the radial costae to develop narrow, longitudinal, medial grooves. Well preserved specimens of *H. waitakiense* and *H. olssoni* show very small tubercles on the anterior flanks of the

posterior costae, but apart from occasional medial grooves and growth lines the radial costae in *Hedecardium* are otherwise quite devoid of sculpture. Differentiation of costae into main and posterior types is marked in all species of *Hedecardium*; the posterior costae tend to be much narrower and more subdued than the main costae.

(3) The adductor muscle scars in *V. pulchricostatum* are larger but less strongly impressed than in specimens of *H. waitakiense* of comparable size, and the posterior portion of the pallial line is much closer to the shell margin.

(4) Hinge features are broadly similar in both *Vepricardium* and *Hedecardium*, but in all available specimens of *H. waitakiense*, *H. olssoni*, and *H. cantuariense* showing hinges the sockets to take the right anterior and posterior lateral teeth are much more strongly developed than in *V. pulchricostatum*.

These differences are pronounced enough to warrant separation of *Hedecardium* and *Vepricardium* at the generic level. If the two taxa are closely related, then they must have diverged in early Cenozoic times, since the oldest known species of *Hedecardium*—*H. collinsi* Marwick, from beds of probable late Dannevirke Series age (? mid-Eocene) in Otaio Gorge, South Canterbury—is already very similar to the type species, apart from its small size. Keen (*in Moore* 1969, p. N586) includes both *Vepricardium* and *Hedecardium* in subfamily Cardiinae, but the presence of tubercles on the anterior flanks of the posterior costae in *H. waitakiense* and other species of *Hedecardium* is at variance with Keen's diagnosis for the Cardiinae, viz "rib ornamentation along rib crests, as beading or furrowing, never arising from sides of ribs" (Keen, *in Moore* 1969, p. N583). In addition, none of the other taxa included by Keen in the Cardiinae has the radial sculpture differentiated into main and posterior costae that is so pronounced in *Hedecardium*.

The differentiation of the radial sculpture strongly suggests that *Hedecardium* belongs in subfamily Protocardiinae, and is probably derived from a species of *Nemocardium* (s.l.). In species of *Nemocardium* Meek, 1876 (s.s.) (type species *Cardium semiasperum* Deshayes, 1858; Eocene, France) the main radial sculpture is almost obsolete, but in subgenus *Pratulium* Iredale, 1924 (type species *C. thetidis* Hedley, 1902; Recent, southern Australia) it consists of numerous narrow costellae that are weaker, though only slightly narrower, than the posterior costellae. The posterior costellae in species of *Pratulium* bear small tubercles on their anterior flanks, whereas the main costellae are weakly sculptured by fine, concentric lamellae or irregular wrinkles. The oldest known species of *Hedecardium*, *H. collinsi*, is also the smallest (holotype 21 × 20 mm), and is comparable in size with some species of *Pratulium*.

The oldest New Zealand species of *Pratulium*, *Nemocardium modicum* Marwick, 1944 (Wangaloan, Paleocene, Boulder Hill), has about 45 main and about 16 posterior costellae; cf. *H. collinsi*, with about 45 main and 15 posterior costellae. Marwick (1960, p. 17) noted the similarity of *H. collinsi* to *Nemocardium* and *Pratulium*, and suggested that it might "be a connecting link between *Nemocardium* and *Hedecardium*". The relationship seems to be closer to *Pratulium* than to *Nemocardium* (s.s.), but Marwick's conclusion is otherwise borne out by the above observations.

Important events in the evolution of *Hedecardium* include the following.

(1) Derivation of *Hedecardium* from *Pratulium* or a related group by increase in strength of main radial costae and decrease in size of tubercles on posterior costae, probably in early Dannevirke Series (Paleocene-Lower Eocene).

(2) Gradual increase in shell size from *H. collinsi* (21 × 20 mm) to *H. waitakiense* (c.65 × 60 mm), from late Dannevirke Series (mid Eocene) to Duntroonian (mid Oligocene).

(3) Splitting off of a distinctive group of species characterised by large size (up to 150 mm long); a well defined lunule; broad, rounded radial costae; and, most important, presence of a pronounced posterior gape. A new subgenus, *Titanocardium*, is proposed below for this group, which includes *H. greyi*, *H. cantuariense*, and *H. marwicki* n.sp. The evolution of a posterior gape, a feature that is uncommon in the Cardiidae, indicates that members of this group occupied a very different ecological niche from *H. waitakiense* and related species. The extant cardiids without a posterior gape studied by Stanley (1970, p. 153–9) all burrow shallowly so that the shell is barely covered, but *Papyridea soleniformis* (Bruguière), which has a large posterior gape, has longer siphons and burrows to a much greater depth (Stanley 1970, p. 158). It is therefore inferred that *Titanocardium* burrowed more deeply than *Hedecardium* (s.s.), despite its large size and great inflation.

(4) Speciation within *Hedecardium* (s.s.), apparently producing two distinct lineages which are here not considered worthy of subgeneric separation. Of the three species recorded from the Duntroonian, *H. waitakiense* and *H. olssoni* are closely related and may be geographic subspecies, but *H. subcordatum* differs in having the shell distinctly plicate, and may be descended directly from *H. brunneri*.

*Hedecardium* (s.s.) is not known to have survived the Waitakian (late Oligocene), but *Titanocardium* (which is first recorded from the Duntroonian) lasted until at least the Waiauan or Tongaporutuan. The inferred burrowing capability of *Titanocardium* presumably allowed this subgenus to survive longer

than *Hedecardium* (s.s.), which would have been more susceptible to environmental changes, particularly in seafloor temperatures.

The named species of *Hedecardium* are as follows. *Hedecardium* (*Hedecardium*) *collinsi* Marwick, 1960; ?Late Dannevirke Series (? mid Eocene); Otaio Gorge, South Canterbury.

*H. (Hedecardium) brunneri* (Hector, 1886); Bortonian-Kaiatan (Middle-Upper Eocene); Westland, North Otago, South Canterbury.

*H. (Hedecardium) waitakiense* (Suter, 1907); Duntroonian (mid Oligocene); Waitaki Valley, South Canterbury.

*H. (Hedecardium) olssoni* Marwick, 1944; Duntroonian; Southland.

*H. (Hedecardium) subcordatum* Suter, 1919; Duntroonian; Castle Hill Basin, North Canterbury.

*H. (Titanocardium) greyi* (Hutton, 1873); Waitakian, ?Otaian (Lower Miocene); widespread.

*H. (Titanocardium) cantuariense* (Laws, 1933); Altonian (Lower Miocene); North Otago - South Canterbury.

*H. (Titanocardium) marwicki* n.sp.; Lillburnian - ?Tongaporutuan (Middle - ?Upper Miocene); Southland, Wairarapa.

#### *Titanocardium* n.subgen.

TYPE SPECIES: *Cardium (Trachycardium) cantuariense* Laws, 1933; Lower Miocene, New Zealand.

Shell as for *Hedecardium* (s.s.) but attaining a much greater size (up to at least 150 mm long) and having a large, well defined lunule and pronounced posterior gape. The main radial costae tend to be broader, lower, and more rounded medially than in the nominate subgenus; the posterior costae are similar in both groups.

Besides its type species, *Titanocardium* includes *Hedecardium marwicki* n.sp. and, as far as it is possible to tell, *Cardium greyi* Hutton, 1873. The type specimen of *C. greyi* is very poorly preserved, consisting largely of an internal mould with only a few scraps of badly worn or corroded shell remaining (Boreham 1965, p. 60, pl. 16 fig. 2). The mould is distinctly plicate distally, a feature not seen in *H. cantuariense*. but this may be a diagenetic effect by which the external sculpture is impressed on to the infilling matrix following partial solution of shell material. Powell & Bartrum (1929, p. 408) suggested that the large cardiid so common in the basal part of the Waitemata Group at Oneroa, Waiheke Island,

is conspecific with Hutton's species. This has been accepted by subsequent workers, although it is impossible to be certain until good topotypes of *C. greyi* are available. The type specimen of *C. greyi* does, however, have what appears to be a posterior gape, which makes its reference to *Titanocardium* very likely.

The earliest record of the subgenus is based on a fragmentary right valve from GS 9131, Chatton (Duntroonian, mid Oligocene), referred tentatively to *H. greyi*. Judging by growth lines on the posterior area, the posterior gape must have been narrower than on specimens of *Titanocardium* from Oneroa (about Waitakian, late Oligocene). The posterior gapes are similar in size in *H. cantuariense* and *H. marwicki*, and considerably stronger than in the Oneroa specimens, indicating that evolution of this feature was virtually complete by Lower Miocene times.

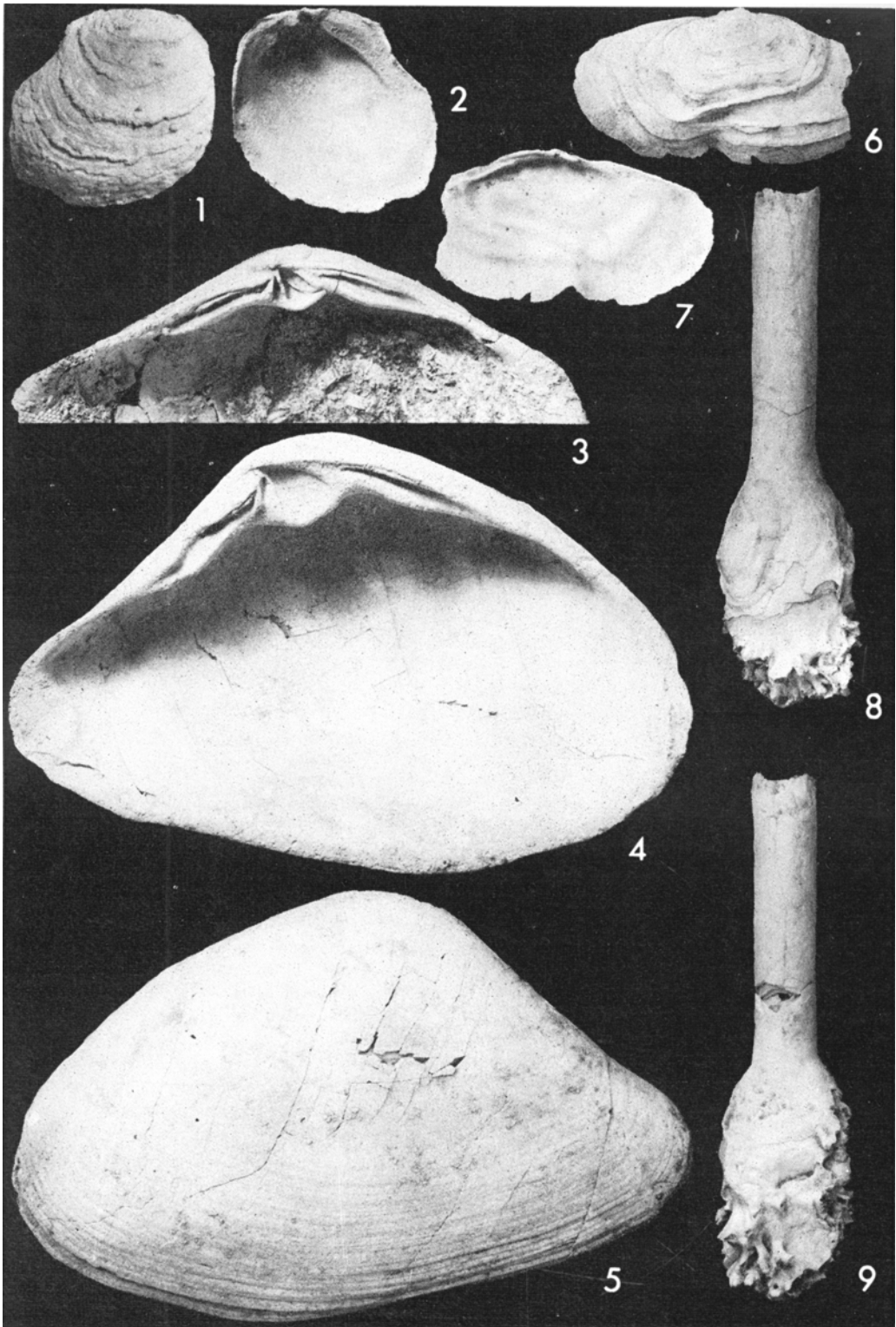
As the name suggests, *Titanocardium* includes some of the largest known cardiids. Of New Zealand species, only *Maoricardium spatiosum* (Hutton) rivals *H. (Titanocardium) marwicki*—the largest species of the subgenus—in overall dimensions. *M. spatiosum* has a considerably thicker shell than *H. marwicki*, indicating a smaller internal volume and therefore, presumably, a smaller animal. All known species of *Maoricardium* have completely closed valves, and have prominent external sculpture of strongly tuberculate radial costae, suggesting only shallow burrowing capability. The occurrence together of *Maoricardium* and *Titanocardium* at several localities suggests that these two unusually large cardiids occupied different ecological niches, and so were not in direct competition with each other.

#### *Hedecardium (Titanocardium) marwicki* n.sp. (Fig. 10-13)

1944 *Hedecardium greyi* (Hutton); Marwick, Trans. R. Soc. N.Z. 74(3): 263 (not Hutton, 1873).

Shell very large, moderately robust, strongly inflated, ovate. Umbones high, broad; beaks strongly incurved at anterior third to two-fifths. Dorsal margins rather short, subequal; anteodorsal margin slightly concave, descending moderately steeply; posterodorsal margin somewhat convex, more so in right valve than in left. Anterior margin moderately convex, merging smoothly with less convex ventral margin; posterior margin strongly truncate, lightly convex, sloping steeply, its junctions with posterodorsal and ventral margins

Fig. 1-9 (opposite page). 1, 2, *Dimya westonensis* n.sp., holotype (TM 5456),  $\times 3$  - GS 9539, Taylor's Quarry, Weston (Runangan, Upper Eocene). 3, *Oxyperas (Pseudoxyperas) leda* (Finlay, 1924), hypotype (TM 5464),  $\times 1$  - GS 239, Castle Hill Basin (Duntroonian, Oligocene). 4, 5, *O. (Pseudoxyperas) exensis* n.sp. (TM 5463),  $\times 1$  - GS 11,198, Tengawai R. (Waitakian, Oligocene). 6-9, *Clavagella oamarutica* n.sp.: 6, 7, paratype (TM 5467),  $\times 2$ ; 8, 9, holotype (TM 5458),  $\times 1$ , GS 9572, Target Gully, Oamaru (Altonian, Lower Miocene).



subangulate. Posterior areas narrow, slightly concave, distinguished from disc mainly by change in radial sculpture; posterior gape large. Lunule large, almost smooth, nearly flat on holotype, concave on figured paratype (Fig. 13); escutcheon narrow, concave on left valve of holotype, convex on right valve. (In the figured paratype the left valve escutcheon is slightly convex, the right valve escutcheon is damaged.) Main radial sculpture of 48 smooth costae, these strongly convex in section anteriorly but becoming more flattened medially and broadly triangular posteriorly. Intercostal spaces concave, equal to or slightly narrower than costae anteriorly, markedly narrowing (locally linear) medially, broadening again posteriorly. Posterior costae 13-15, low, convex, more subdued and less regular than main costae. Concentric sculpture of numerous, very fine intercostal striae over most of shell except for posterior areas, and rather subdued growth ridges at irregular intervals, particularly near ventral margin. Internal features only partly known - hinge apparently as in *H. cantuariense* but with left anterior cardinal tooth somewhat heavier. Nymph plates strong, rectangular, with deep, narrow ligamental grooves between them and shell margins. Marginal crenulations apparently as in *H. cantuariense*.

DIMENSIONS (mm):	Length	Height	Inflation (d.v.)
Holotype	114.5	107.5	90
Paratype (GS 1853)	142.5	126.5	105

HOLOTYPE. TM 5459; figured paratype, TM 5460.

TYPE LOCALITY. GS 11,188, Rockfall Beach, east side Park Bluff, Clifden Section, Waiau River, Southland, coll. A. G. Beu & P. A. Maxwell, Feb. 1969.

FORMATION. Gari Sand, Park Bluff Formation (type Lillburnian).

LOCALITIES. GS 11,188 (holotype). GS 2371, 60 chains at 110° from Trig. G, Mangaotero S.D., Dannevirke (Lillburnian), coll. A. M. Quennell, 1938 (paratype, a damaged left valve); GS 847, "East Wairarapa", coll. Mr Charlton of Christchurch, prob. late in 19th century, prob. from Mangapakeha Valley (large, double-valved paratype); GS 1853, End Hill Stream, Mangapakeha Valley, Masterton-Castlepoint road, Wairarapa, coll. M. Ongley & J. Marwick, 1933 (about Waiauan-Tongaporutuan from associated molluscs) (2 paratypes, 1 double-valved, 1 right valve).

STRATIGRAPHIC RANGE. Lillburnian - Waiauan or Tongaporutuan.

REMARKS. *Hedecardium* (*Titanocardium*) *marwicki* is apparently closely related to *H. cantuariense*, but differs in having a much broader lunule and rather different main radial sculpture. The anterior costae are similar in both species, but the other main costae, particularly the posterior ones, are much more flattened in *H. cantuariense* and tend to develop narrow,

longitudinal, medial grooves distally, a feature absent from *H. marwicki*, in which the posterior main costae are triangular in section.

Marwick (1944, p. 263) referred specimens of *H. marwicki* from Mangapakeha Valley to *H. greyi*, but they differ from *Oneroa* shells in having a broader lunule, weaker posterior costae, and stronger posterior gape. The longitudinal grooving of main radial costae is even more strongly developed in *H. greyi* than in *H. cantuariense*.

### Subfamily TRACHYCARDIINAE

#### Genus *Trachycardium* Mörch, 1853

1853 Cat. Conch. Yoldi 2: 34.

TYPE SPECIES (by subsequent designation, von Martens, 1870): *Cardium isocardia* Linnaeus, 1758; Recent, West Indies.

#### Subgenus *Regozara* Iredale, 1936

1936 Rec. Aust. Mus. 19(5): 275.

TYPE SPECIES (by original designation): *Regozara olivifer* Iredale, 1936; Recent, New South Wales (= *Cardium flavum* Linnaeus, 1758, auct.).

Interrelationships of the various genus-group taxa that have been proposed in the Trachycardiinae are far from clear. Iredale (1936, p. 275), whose taxonomic philosophy was unduly influenced by geographic considerations, proposed *Regozara* with the remark "this group of *Cardium*s is very characteristic, and has been called *Trachycardium*, but that name belongs to a superficially similar American group". Comparison of the type species of the two groups suggests that they are closely related, and that the differences barely justify separation at the subgeneric level. The following observations are relevant. (1) *Trachycardium isocardia* and *Regozara olivifer* are remarkably similar in shape and size, both species having similar obliquity and length-height ratios and growing to about 75 mm high.

(2) Radial costae in *T. isocardia* are squarish in section medially, with intercostal spaces slightly narrower, but become lower and more rounded anteriorly and very flattened, almost obsolete, on the posterior area. All costae bear small, triangular scales on their crests; the flanks of the costae are smooth except for irregular wrinkles. The medial costae in *R. olivifer* are heavy and triangular in section, and sculptured on the flanks with numerous fine, oblique ridges and on the crests with narrow, concentric lamellae that bear no relation to the flank ridges. The anterior costae are more rounded in section, lack the flank ridges almost entirely, but have stronger, concentric lamellae on their crests. The posterior costae are narrowly triangular, and bear lamellar scales that are as strongly developed as those in *T. isocardia*, though not triangular.

(3) Hinge features are similar in both species, except that the right anterior cardinal is fused to the top of the median cardinal in *T. isocardia*, but not in *R. olivifer*. The lunule is strongly pouting in *T. isocardia*, depressed in *R. olivifer*.

It is suggested that if *Regozara* is to be maintained as a distinct taxon, it should be used for those species of *Trachycardium* in which the anterior and medial costae lack scaly spines but which have the medial costae sculptured on the flanks with fine, oblique ridges. Whether or not this distinction is valid can be ascertained only by workers with access to large collections of cardiids, but it seems that on this basis *Regozara* includes many of the Indo-Pacific and Australian species and *Trachycardium* (s.s.) is confined to Central and South America.

Keen (in Moore 1969, p. N586-8) classes *Regozara*, *Vasticardium* Iredale, 1927, and *Ovicardium* Marwick, 1944 as subgenera of *Acrosterigma* Dall, 1900 (type species *Cardium dalli* Heilprin, 1887; Pliocene, Florida). *Acrosterigma dalli* is large (up to 140 mm high), greatly elongated dorsoventrally, and sculptured with very broad, almost flat-topped costae with narrow, incised interspaces. The medial and anterior costae are almost smooth except for occasional fine crenulations along their edges. There is nothing about the shell features to suggest particularly close relationship to *Regozara*.

Iredale (1927, p. 75-6) proposed *Vasticardium* for a group of large Pacific cardiids, naming *Cochlea nebulosa* Martyn, 1784 (which is non-binominal) as type species. According to Iredale, Martyn's species is the same as the large Philippine shell figured by Reeve (1844, pl. 9 fig. 46) as *Cardium elongatum* Brugière, 1792. According to Keen (1937, p. 22), however, the latter species is based on a Jamaican shell, and is probably a synonym of *Cardium magnum* Linnaeus, 1758; though Clench & Smith (1944; p. 7), without giving any reasons for their conclusion, decided that Brugière's species was probably of Indonesian origin. Regardless of the correct name for Martyn's species, there seems little doubt that it is closely related to *Acrosterigma dalli*, and that *Vasticardium* is a synonym of *Acrosterigma*. Dall in fact used *Acrosterigma*—as a section of *Cardium* (*Trachycardium*)—for "species of the group of *C. elongatum*" (Dall 1900, p. 1090); this was apparently overlooked by Iredale when he proposed *Vasticardium*.

*Ovicardium* was proposed as a subgenus of *Trachycardium* for *T. (Ovicardium) rossi* Marwick, 1944, a species now known to have a stratigraphic range of Kapitean to Waipiian. (A second species, *O. parki* Marwick, 1944, described from the basal Castlecliffian of Ototoka Stream, is now thought to be a badly worn, reworked specimen of *O. rossi* (Beu 1973, p. 318).) *Ovicardium rossi* is large (up to 95 mm long) and rather more rounded, more oblique, and less

elongate dorsoventrally than other trachycardiines. Sculpture consists of prominent, rather narrow radial costae that are squarish in section medially, becoming more convex anteriorly and posteriorly. The posterior costae bear small tubercles on their posterior flanks, the anterior costae moderately strong concentric wrinkles, but the remaining costae are smooth apart from weak concentric ridges distally. Relationship is probably with *Acrosterigma*, but shape and sculptural features suggest that *Ovicardium* may be retained as a distinct taxon. It probably represents a local, short-lived offshoot from a Pacific species of *Acrosterigma* that was unable to survive the late Cenozoic cooling in New Zealand.

Although Keen treated *Acrosterigma* as a genus in the classification adopted in the Treatise on Invertebrate Paleontology, she has since relegated it to subgeneric rank under *Trachycardium* (Keen 1971, p. 153). It is suggested that similar status be given to both *Regozara* and *Ovicardium* until the relationships of these groups to *Trachycardium* and *Acrosterigma* are better understood.

*Trachycardium (Regozara) delectabile* n.sp.  
(Fig. 16-18)

Shell rather small for subgenus, fragile, ovate, strongly inflated, somewhat oblique. Umbones high; beaks small, slightly forward of centre. Dorsal margins descending steeply; anterodorsal margin short, almost straight, its junction with anterior margin scarcely defined; posterodorsal margin long, weakly convex, strongly serrate on distal half, its junction with slightly convex posterior margin rounded. Anterior margin strongly convex, merging imperceptibly with less convex ventral margin, which in turn joins smoothly with posterior margin. Posterior area not strongly marked off from rest of shell, somewhat convex medially, otherwise slightly concave. Lunule small, rather flat, almost smooth; no escutcheon. Radial sculpture consisting of 57 costae (10 on posterior area), the anteriormost almost flat, becoming strongly convex or subtriangular medially; interspaces considerably narrower than costae, except distally. Posterior costae broad, almost flat, with linear interspaces, bordered on posterior margins by radial rows of small, oblique squamae. Other costae ornamented by numerous low, rounded, concentric ridges that in mid disc are generally strongest on posterior flanks of costae and often almost obsolete on crests. Interior of shell weakly plicate medially but not posteriorly. Anterior and ventral shell margins finely crenulate internally; posterior margin more coarsely crenulate. Adductor muscle scars ovate, flush or weakly impressed. Left hinge rather light, strongly arched; anterior lateral AII triangular, rather prominent, with a moderately deep groove above but no socket to take AI below, having instead



a narrow radial ridge at its base; anterior cardinal 2 small, narrowly triangular, with a weak groove in front; posterior cardinal 4b low, thin, lamellar, separated from 2 by a small triangular socket; posterior lateral PII small, with a weakly defined socket below. Nymph plate subrectangular, projecting slightly above posterodorsal margin; ligament groove deep and narrow. Right valve hinge shortened by anteroposterior crushing; anterior lateral AI very prominent, broadly triangular, with a deep, elongate socket between it and a thin AIII; anterior cardinal destroyed by crushing; posterior cardinal 3b small, tubercular; posterior lateral PI moderately strong, broadly triangular, with a short but deep socket above.

**DIMENSIONS OF HOLOTYPE (mm).** Length 43.5, height 49.0, inflation 16.3 (measurements taken from left valve; right valve somewhat crushed).

**HOLOTYPE.** TM 5462.

**TYPE LOCALITY.** GS 11,185, Slip Point, Clifden Section, Waiau River, Southland, coll. P. A. Maxwell, February 1972.

**FORMATION.** Slip Point Siltstone, Ngapari Formation, about 3 m below oyster bed (type Clifdenian, Middle Miocene).

**REMARKS.** *Trachycardium delectabile* is the first representative of subgenus *Regozara* to be recorded from New Zealand. It belongs to a group of closely related Pacific species that differ from typical *Regozara* in their smaller size, more lightly built shell, more rounded outline, and finer, more numerous radial costae, and so possibly represent a distinct subgenus. Recent species include *Cardium foveolatum* Sowerby, 1840 (= *C. cygnorum* Deshayes, 1855 according to Iredale & McMichael (1962, p. 21)) (southwestern Australia to New South Wales); *T. (Vasticardium) sorenseni* Powell, 1958 (Kermadec Islands); and a probable undescribed species from Norfolk Island (Powell 1958, p. 76) which is probably the same as that represented by small specimens in the collections of the National Museum, Wellington. *T. delectabile* differs from these species in having more numerous radial costae, coming closest to *T. sorenseni*, which has 54 costae, but differing from it in being ovate rather than subcircular.

Sea temperatures in New Zealand probably reached a peak in the Clifdenian (Beu & Maxwell 1968, p. 72), so the presence of a warm-water cardiid in Southland at this time is not surprising.

Superfamily MACTRACEA  
Family MACTRIDAE  
Subfamily MACTRINAE

Genus *Oxyperas* Mörch, 1853

1853 Cat. Conch. Yoldi 2: 4.

**TYPE SPECIES (by monotypy):** *Maetra triangularis* Lamarck, 1818 (not *M. triangularis* Montagu, 1803) = *M. lentiginosa* Gould, 1852; Recent, ?Indo-Pacific. The habitat of *M. lentiginosa* is uncertain (Reeve 1854; Lamy 1918, p. 324), but is probably within the Indo-Pacific region. A small specimen in the N.Z. Geological Survey World Mollusca Collection (WM 3678) is questionably from Ceylon.

Subgenus *Pseudoxyperas* Sacco, 1901

1901 Moll. Terr. terz. Piemonte Liguria 29: 26.

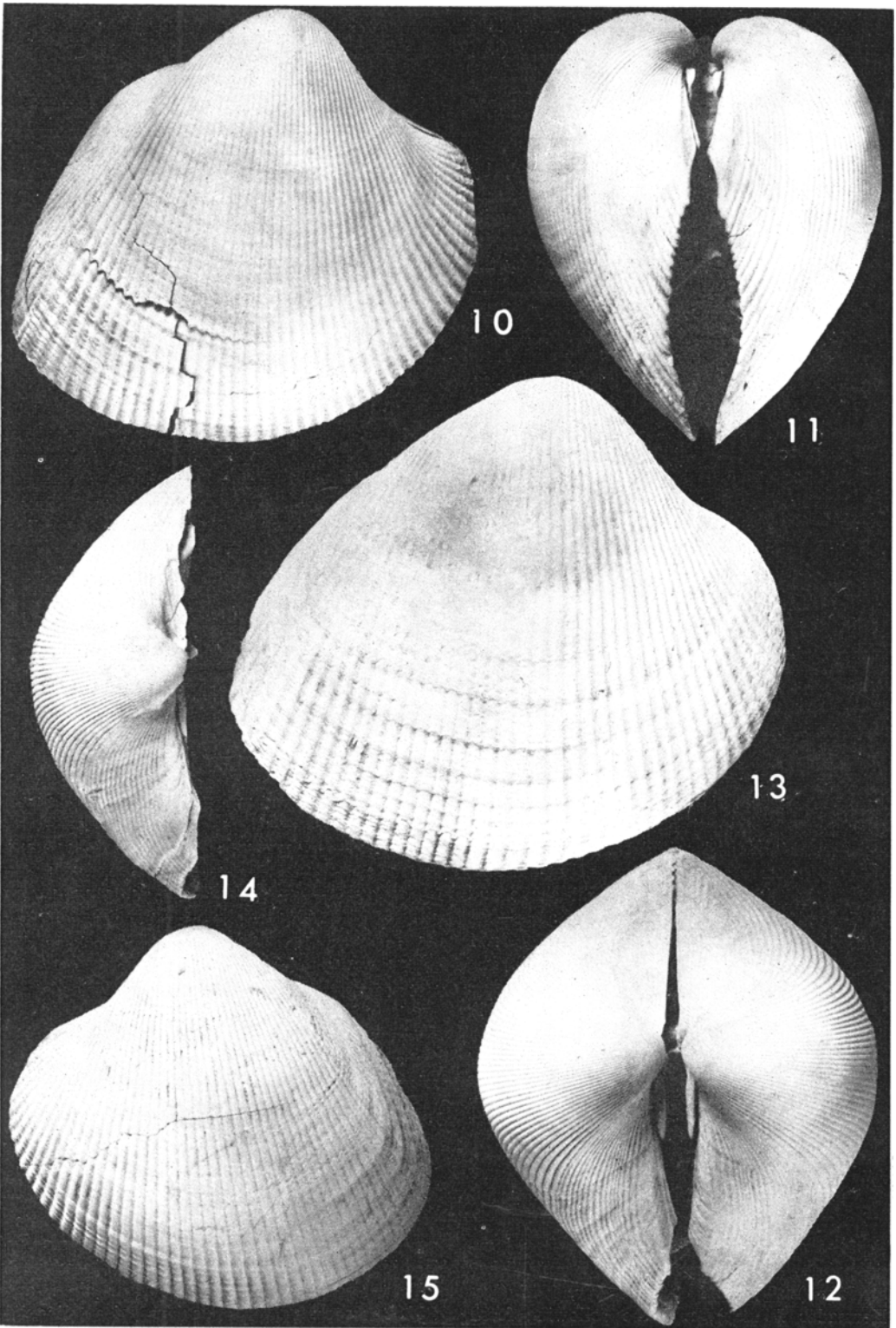
**TYPE SPECIES (by original designation):** *Maetra (Pseudoxyperas) proaspera* Sacco, 1901; Miocene, Europe.

**SYNONYM:** *Longimaetra* Finlay, 1928, Trans. N.Z. Inst. 59: 279–80 (type species (by original designation) *Maetra elongata* Quoy & Gaimard, 1833; Pleistocene–Recent, New Zealand).

The distinctive large maetrid originally described by Quoy & Gaimard as *Maetra elongata* has a somewhat involved taxonomic history, in that up to 1928 it had been variously referred to the genus-group taxa *Maetra*, *Spisula*, *Standella*, *Hemimaetra*, *Mulinia*, and *Mactrotoma* (see synonymies in Suter 1913, p. 965; Lamy 1917, p. 258). Finlay (1928, p. 279–80) concluded that *elongata* has sufficient distinctive features to warrant a new genus, and so proposed *Longimaetra*, citing the elongate shape, distinctive epidermal colour pattern (brown spots or blotches on a pale yellow background), deep pallial sinus, large adductor muscle scars, and elongated hinge as diagnostic characters. He did not assign any other species to the genus, and apart from pointing out that *elongata* has a spisuloid hinge (i.e., no ridge between the ligament and resilium), he made no mention of the relationship of *Longimaetra* to other maetrids. Like other writers before and since, he either overlooked or ignored the conclusion of both Sacco (1901, p. 27) and Lamy (1917, p. 258) that *elongata* is closely related to the Indo-Pacific species *Maetra aspersa* Sowerby, 1825.

*Maetra aspersa* is a rather uncommon species that has seldom been illustrated, but the figure—possibly of the holotype—given by Reeve (1854, pl. 14 fig. 65) shows a shell that is of similar shape, sculpture, and colour pattern to *elongata* though of somewhat smaller size. The excellent figures by Dautzenberg &

**Fig. 10–15 (opposite page).** 10–13, *Hedecardium (Titanocardium) marwicki* n.subgen., n.sp.: 10–12, holotype (TM 5459),  $\times 0.6$  – GS 11,118, Lima Sand, Clifden (Lillburnian, Middle Miocene); 13, paratype (TM 5460),  $\times 0.6$  – GS 1853, Mangapakeha Vly (Waiau?, Middle Miocene). 14, 15, *H. (Titanocardium) cantuariense* (Laws, 1933), type species of *Titanocardium* n.subgen., topotype (TM 5461),  $\times 0.6$  – GS 9700, Sutherlands, S. Canterbury (Altonian, Lower Miocene).



Fischer (1906, pl. 5 fig. 6–10) of a West African mastrid which they refer to *M. aspersa* show that the similarities extend to the internal features (i.e., narrow hinge, deep pallial sinus). The deep sinus, elongate shape, and distinctive colour pattern are uncommon features in the Mactridae, suggesting that *aspersa* and *elongata* are indeed closely related.

Sacco (1901, p. 27) referred *aspersa*—and, by implication, *elongata*—to *Pseudoxyperas*, a taxon that he distinguished from *Oxyperas* mainly by its less trigonal shape. The type species, *P. proaspersa*, is certainly similar to *aspersa* (as is indicated by the trivial name), and was in fact originally identified as *Mactra aspersa* (Mayer 1857, p. 180). Lamy (1917, p. 258), on the other hand, apparently unaware of Sacco's work, classed *elongata* as a variety of *Mactra aspersa* which he referred to subgenus *Mactrotoma*. (The type species of *Mactrotoma*, *M. fragilis* Gmelin, has a mactroid hinge (see Lamy 1917, p. 179), which makes it difficult to understand why Lamy should have referred *aspersa* and *elongata* there. However, the spiculoid nature of the hinge in *elongata* was first pointed out by Finlay (1928, p. 280), although this was apparently overlooked by Keen (in Moore 1969, p. N598), who classed *Longimactra* as a subgenus of *Mactra* and treated *Oxyperas* and *Pseudoxyperas* as subgenera of *Spisula* (Moore 1969, p. N603–4).)

Assuming that *elongata* is indeed closely related to *aspersa*, and that Sacco was correct in referring *aspersa* to *Pseudoxyperas*, there can be no justification for recognising *Longimactra* as a distinct taxon; accordingly, it is here treated as a junior synonym of *Pseudoxyperas*. *Pseudoxyperas* is in turn closely related to *Oxyperas*, and is here ranked as a subgenus of it. *Oxyperas lentiginosa* is a very rare species with colour pattern, hinge, and pallial sinus like those in *Pseudoxyperas aspersa* and *P. elongata*, but differing in its distinctly trigonal and equilateral shape and sharply defined anterior and posterior areas—see Reeve (1854), pl. 1 fig. 1; Lamy (1918), pl. 7 fig. 1 (reproduced in Moore (1969) as fig. E95, 6a). The only other species of *Oxyperas* s.s. described to date appears to be *O. coppingeri* (E. A. Smith, 1884) from Torres Strait; no fossil species are known, which may indicate that *Oxyperas* s.s. arose relatively recently from *Pseudoxyperas* (which has a sporadic fossil record back to mid Eocene times) or merely reflect the scarcity of marine Cenozoic rocks of suitable facies in the Indo-Pacific region. The very rarity and presumably restricted habitat of *Oxyperas* suggests an origin from an isolated peripheral population of a species of *Pseudoxyperas*.

Besides the species referred to above, *Pseudoxyperas* includes *Spisula (Oxyperas) bernardi* Pilsbry (Recent, Japan), *Spisula belliana* Oliver, 1915 (Recent, Kermadec Islands), and the following fossil

forms from New Zealand.

*Longimactra flemingi* Marwick, 1960; ?Late Dannevirke Series (?mid Eocene); Otaio Gorge, South Canterbury.

*Mactra leda* Finlay, 1924 (= *M. attenuata* Hutton, 1873, not Deshayes, 1854); Duntroonian (mid Oligocene); Castle Hill Basin, North Canterbury.

*Oxyperas (Pseudoxyperas) exensis* n.sp.; Waitakian (late Oligocene); Tengawai River, South Canterbury.

*Longimactra elongata komakoensis* Carter, 1972; Nukumaruan (Lower Pleistocene); Pohangina Valley and Wanganui.

*Oxyperas (Pseudoxyperas) exensis* n.sp. (Fig. 4, 5)

Shell rather large, moderately robust, ovate-trigonal. Umbones broad; beaks small, situated at about anterior three-eighths. Anterodorsal margin long, weakly concave, descending steeply, its junction with narrow, strongly convex anterior margin well rounded; posterodorsal margin gently convex, descending less steeply than anterodorsal margin, merging smoothly with the rather broad, well rounded posterior margin. Ventral margin broadly convex, somewhat flatter anteriorly than behind, merging gradually with anterior and posterior margins. Posterior area rather narrow, slightly convex, marked off from rest of shell by a weakly defined, rounded ridge. Lunule long, narrow, almost flat, weakly impressed; escutcheon long, slightly convex, scarcely defined. Sculpture consisting of weak concentric ridges and growth lines. Hinge heavy, strongly angled; right valve with anterior lateral tooth AI prominent, rather thick, with fine transverse striae dorsally and a long, narrow socket above; AIII short, thin, only weakly differentiated from shell margin; a thin, vertical cardinal tooth (apparently 3a) immediately behind AIII; 3b broken, apparently short, running along upper part of anterior edge of the large, posteriorly directed resilifer. Ligament attachment area weakly defined, not separated from resilifer. Posterior-lateral PI moderately strong, finely striate dorsally, with a deep, narrow socket above; PIII indistinct, barely defined by a shallow groove on dorsal margin. Left hinge with anterior lateral AII damaged but apparently moderately long, lamellar, striate dorsally, with a deep groove above; anterior cardinal 4a thin, triangular, descending steeply, separated from the short, bifid cardinal 2 by a narrow cleft; posterior lateral PII similar to PI, with a moderately deep groove above. Anterior adductor muscle scar ovate, impressed, confluent with pedal retractor scar, which is hidden beneath lower end of hinge; posterior adductor scar ovate, much larger than anterior adductor scar; pallial sinus large, deep, linguliform.

**DIMENSIONS OF HOLOTYPE** (mm). Length 102.2, height 66.1, inflation (1 valve) 19.5. (The damaged paratype, 68 mm high, was of similar overall size to the holotype.)

**HOLOTYPE.** TM 5463.

**TYPE LOCALITY.** GS 11,198, cross-bedded sands, right bank Tengawai River, South Canterbury, opposite mouth of Exe Creek, coll. P. A. Maxwell, 1969 (holotype and paratype).

**AGE.** Waitakian (late Oligocene).

**REMARKS.** *Oxyperas exensis* differs from *O. elongata* in its more strongly trigonal shape and in having a concave rather than weakly convex anterodorsal margin. The right lateral teeth AIII and PIII are much more weakly developed in the holotype of *O. exensis*, but this is possibly due to abrasion. An additional distinguishing feature is the weakness of the striae on the dorsal surface of the laterals AI, AII, PI, and PII in *O. elongata*; these were not mentioned by Suter (1913, p. 965-6) in his description of the species, and seem to have been overlooked by other workers also. *O. leda* has strongly striate laterals like *O. exensis*, but has an AIII and PIII as well developed as in *O. elongata* (see Fig. 5 - right hinge, topotype *O. leda*). *O. leda* is further differentiated from *O. exensis* by its more equilateral shape, a consequence of its greater anterior elongation, greater overall elongation, straighter anterodorsal margin, and lighter hinge. *O. flemingi* is based on small, probably subadult shells, but seems to have been of similar shape to *O. elongata*. The right hinge of *O. flemingi* is unknown, but was probably more like those of *O. leda* and *O. elongata* than that of *O. exensis*.

#### Superfamily VENERACEA

#### Family VENERIDAE

#### Subfamily VENERINAE

#### Genus *Proxichione* Iredale, 1929

1929 Australian Zoologist 5(4): 339.

**TYPE SPECIES** (by monotypy): *Proxichione materna* Iredale, 1929; Recent, New South Wales.

*Proxichione* is synonymised with *Periglypta* Jukes-Brown, 1914 (type species *Venus puerpera* Linnaeus, 1758; Recent, Pacific) in the most recent classification of the Veneridae (Keen, in Moore 1969, p. N672) but, as indicated by Darragh (1965, p. 165), *Proxichione* differs in having an angular rather than rounded pallial sinus and a simple instead of "prominently grooved" escutcheon. *Proxichione* is also similar to *Dosina* Gray, 1835 (type species *D. zelandica* Gray, 1835; Recent New Zealand), which was not discussed by Darragh, but the two taxa differ in several important features, as follows.

(1) All the species referred to *Proxichione* have at least moderately prominent surface radial sculpture of low, narrow costae that finely corrugate the concentric lamellae. In *Dosina* surface radial sculpture is either very feebly developed, as in the extant *D. crebra* (Hutton), or completely absent, although some worn specimens reveal the subsurface radial elements common to all venerines.

(2) One of the most characteristic features of *Proxichione*—though not mentioned by other workers—is the presence of a row of small, irregular, pallial muscle attachment pits well within and parallel to the ventral limb of the pallial line. In *Dosina* these pits are much weaker and run along the upper edge of the pallial line, although in large specimens of *D. firmocosta* (Marwick, 1927) (Altonian, Southland) the pits diverge slightly from the pallial line near the sinus. *Periglypta puerpera* has pits like those in *Dosina*.

(3) The pallial sinus in *D. zelandica* is much narrower and shorter than in species of *Proxichione*, but in some mid-Cenozoic species of *Dosina*—e.g., *D. utleyi* (Marwick, 1927) (Waitakian, North Otago) and *D. firmocosta*—it is considerably larger and approaches that found in *Proxichione*.

(4) The escutcheon is almost obsolete in both valves in *Dosina zelandica* and in some late Cenozoic species of *Dosina*, but strongly defined in the left valve and somewhat more weakly in the right valve in mid-Cenozoic species of *Dosina* and apparently in *Proxichione*. (Among Australian fossil species of *Proxichione*, at least *P. moondarae* Darragh, 1965 has the right escutcheon virtually obsolete.)

(5) Hinge features are essentially similar in both taxa, except that the left median cardinal 2b is considerably broader in species of *Proxichione* than in *Dosina*.

It is clear from the above that *Dosina* and *Proxichione* are distinct but closely related taxa, although *D. zelandica* itself is rather atypical. *Dosina* is recorded, albeit sporadically, from Duntroonian (mid Oligocene) to Recent in New Zealand; *Proxichione* ranges from Janjukian (about Duntroonian) to Recent in Australia (Darragh 1965), but is known in New Zealand only from the Duntroonian and Waitakian (late Oligocene) stages. Species of both groups occur together at Trig. Z, Otiake (Waitakian), the type locality of *Dosina utleyi* (Marwick) and *Proxichione otiakensis* n.sp.

#### *Proxichione darraghi* n.sp. (Fig. 19, 20)

Shell of moderate size for genus, robust, ovate, moderately inflated. Umbones broad, rather high; beaks at about anterior one-third. Anterodorsal margin short, feebly convex, with a small re-entrant at junction with the well rounded anterior margin; posterodorsal margin long, gently convex, its junction

with the subvertical, weakly convex posterior margin subangulate. Ventral margin broadly convex, merging gradually with anterior margin, its junction with posterior margin subrounded. Lunule moderately large, slightly pouting, bounded by a narrow groove; escutcheon on left valve large, slightly concave, marked off from the weakly defined posterior area by a sharp ridge; escutcheon on right valve somewhat narrower, its ventral ridge not as sharp as that in left valve. Concentric sculpture consisting of heavy, squarish-sectioned costae that tend to overhang slightly on dorsal side. Spacing rather irregular, but 3 or 4 costae in the interval 50–60 mm from beak in middle of shell. Costae smooth medially, becoming narrower and distinctly corrugated toward ends of shell, stopping abruptly at edge of escutcheon in left valve but persisting for a short distance on to right escutcheon. In both valves concentrics becoming much thinner and lower on lunule. Radial sculpture of numerous narrow, low costellae with interspaces of similar or greater width, strongest towards the ends, where they corrugate the concentrics, but rather subdued medially. About 12 costellae per cm at 50 mm from beak. Hinge heavy. Left valve with small, tubercular anterior lateral AII; anterior cardinal 2a narrowly triangular, subvertical; 2b heavy, subrectangular, unequally subdivided by narrow groove, the posterior portion larger; posterior cardinal 4b gently curved, subhorizontal, partly fused to nymph. Ligamental groove long, broad; nymph extending along most of its length. Right valve with small, pit-like socket to take AII; anterior cardinal 3a lamellar, subparallel to lunular margin; median cardinal 1 subvertical, narrowly triangular, divided by narrow groove into two parts, the anterior much larger; posterior cardinal 3b narrowly triangular, split by moderately deep groove, the anterior portion the smaller. Adductor muscle scars prominent, ovate; anterior scar strongly impressed along posterior margin; posterior scar much larger than but not as strongly impressed as anterior scar. Anterior pedal retractor muscle scar moderately large, ovate, deeply impressed, situated in underside of hinge plate close to, but separated from, anterior adductor scar. A row of small pits (probably pedal elevator muscle scars) running from pedal retractor along underside of hinge plate up into umbonal cavity. Pallial line well marked, with a row of small pits (presumably pallial muscle scars) running parallel to, and within, the ventral limb; pallial sinus moderately deep, broadly triangular. Anterodorsal, anterior, ventral, and posterior margins finely crenulate internally.

DIMENSIONS (mm):	Length	Height	Inflation
Holotype (r.v.)	68.5	58.0	22.2
Paratype (l.v.)	73.5	66.1	23.8

HOLOTYPE. TM 5465.

TYPE LOCALITY. GS 9805, shellbed in "greensand", right bank Waikaka Stream, Wendon Valley, Southland, coll. T. A. Darragh and P. A. Maxwell, February 1968 (holotype, paratype).

AGE. Duntroonian (mid Oligocene), on the basis of such associated molluscs as *Limopsis parma* Marwick, *Parvamussium paradoxum* (Maxwell), *Venericardia* (*Cyclocardia*) *christiei* Marwick, *V. (Megacardita) ponderosa* Suter, *Hedecardium* (*Hedecardium*) *olssoni* Marwick, *Solecortus chattonensis* Finlay, and *Conomolnia vixincisa* (Marwick).

REMARKS. *P. darraghi* and *P. otiakensis* are the first species of *Proxichione* to be described from New Zealand. Of the Australian species discussed by Darragh (1965), *Proxichione hormophora* (Tate, 1885) (Uppermost Janjukian to Batesfordian) is closest to *P. darraghi* in shape and sculpture, but has a lighter hinge, narrower right median cardinal, broader, more obviously bifid right posterior cardinal, and larger pallial sinus. In addition, both New Zealand species appear to have broader ligamental grooves than any of the Australian species, with the possible exception of *Proxichione subtilicostata* Darragh, 1965.

#### *Proxichione otiakensis* n.sp. (Fig. 21, 22)

Shell similar to that of *Proxichione darraghi* except in the following respects: hinge lighter; right escutcheon narrower and less well defined; lunule smaller and more strongly pouting; concentric costae lower, somewhat more closely spaced, with rounded rather than flattish crests; right anterior cardinal 3a subvertical instead of subparallel to lunular margin; median cardinal 1 narrower, more nearly horizontal; adductor muscle scars less strongly impressed; pallial muscle scars much less distinct.

DIMENSIONS OF HOLOTYPE (mm). Length 67.1, height 56.0, inflation (r.v.) 19.6.

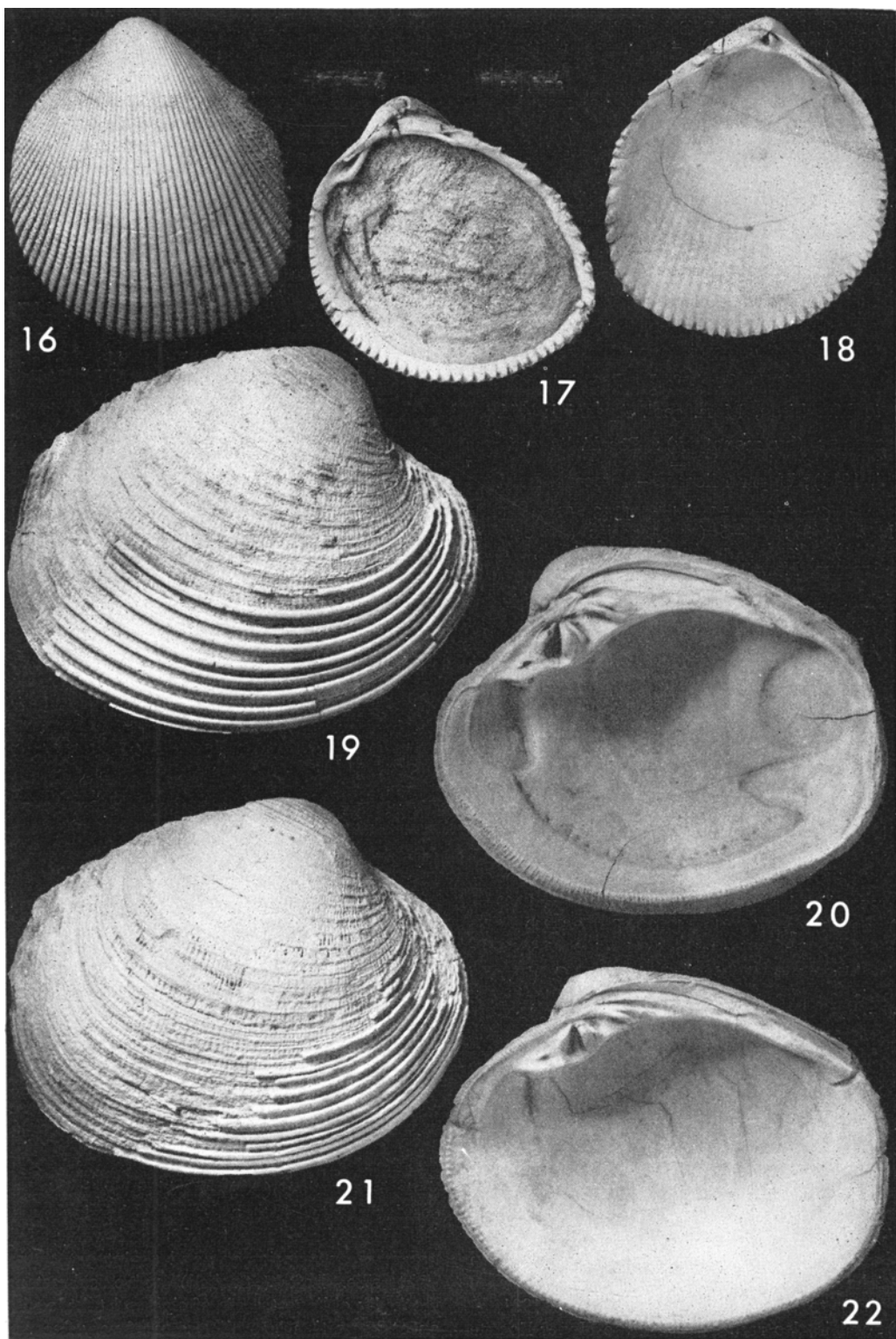
HOLOTYPE. TM 5466.

TYPE LOCALITY. GS 9516, Trig. Z, Otiake, Waitaki Valley, North Otago, coll. P. A. Maxwell, November 1962.

FORMATION. Otekaikē Limestone (Waitakian, late Oligocene).

LOCALITIES. GS 9516 (holotype). ?GS 3600, right

Fig. 16–22 (opposite page). 16–18, *Trachycardium (Regozara) delectabile* n.sp., holotype (TM 5642),  $\times 1$  – GS 11,185, Slip Point, Clifden (Clifdenian, Middle Miocene). 19, 20, *Proxichione darraghi* n.sp., holotype (TM 5465),  $\times 1$  – GS 9805, Wendon Vly, Southland (Duntroonian, Oligocene). 21, 22, *P. otiakensis* n.sp., holotype (TM 5466),  $\times 1$  – GS 9516, Trig Z, Otiake, Waitaki Vly (Waitakian, Oligocene).



bank Mataura R. near Brydone, Southland, recollection by A. G. Beu, W. M. Briggs, & P. A. Maxwell, March 1967 (Waitakian) – a large right valve measuring 75.5 × 62.1 × 21.0 mm, rather corroded but resembling the holotype in hinge, shape, and, as far as can be judged, sculptural features, may belong here.

REMARKS. *Proxichione otiakensis* is superficially similar to *Dosina uttleyi* (Marwick, 1927), also described from Trig. Z. Otiake, and may therefore have been overlooked by previous collectors. However, it is certainly far less common than *D. uttleyi*, which is one of the most abundant bivalves at Trig. Z.

Superfamily POROMYACEA  
Family VERTICORDIIDAE

Genus *Pecchiolia* Savi & Meneghini, 1850

1850 in Murchison, Mem. geol. Apennini: 456.

TYPE SPECIES (by monotypy): *Pecchiolia argentea* Savi & Meneghini 1850 (= *Chama* (?) *arietina* Brocchi, 1814); Upper Miocene – Pliocene, Italy.

SYNONYM: *Cardilona* Marwick, 1943, Trans. Roy. Soc. N.Z. 73(3): 185–6 (type species (by original designation) *Cardilona bensoni* Marwick, 1943; Upper Eocene, New Zealand).

Marwick proposed *Cardilona* for an unusual bivalve from tuffs at Bridge Point, North Otago, characterised by its highly inflated shell, coiled, strongly prosogyrous beaks, alate posterior end, impressed lunule, edentulous hinge, large chondrophore, and radial sculpture of low, rounded costae. He was uncertain of its affinities, but suggested that it belonged in the rather obscure family Cardiliidae, a classification accepted by Keen (in Moore 1969, p. N608). However, apart from the fact that that it possesses a well defined lunule, *Cardilona bensoni* is very similar to European species of the verticordiid genus *Pecchiolia* illustrated by Hoernes (1870, pl. 20 fig. 4a–d; reproduced as fig. F31, 2a–c in Moore 1969, p. N857) and Sacco (1901, pl. 29 fig. 23–31). The European species differ also in having the beaks considerably more tightly coiled than *C. bensoni* (which is on the way to uncoiling); this would effectively obscure any lunule generated in a similar way to that in *C. bensoni* (i.e., by that segment of the shell margin bearing the chondrophore). In my opinion the degree of coiling is significant only at the specific level in this group (some variation in this feature seems evident in the specimens figured by Sacco), and *Cardilona* is accordingly synonymised with *Pecchiolia*.

*Pecchiolia* has no known extant representatives, and all the Recent species previously referred there have been transferred to other genera (Soot-Ryen 1966). The genus ranges from at least Upper Eocene (Bartonian) to Pliocene in Europe (Sacco 1901, p. 131–2), and is also recorded from the Upper Eocene

of Wilmington, North Carolina (*P. dalliana* Harris, 1919, described as “exogyroid” in form and similar to the European Upper Eocene species *P. wemmelensis* Vincent, 1897). The presence of *Pecchiolia* in the Upper Eocene of New Zealand may be further evidence for the warm (probably subtropical) conditions believed to have prevailed at this time (e.g., Beu & Maxwell 1968).

*Pecchiolia bensoni* (Marwick, 1943) (Fig. 27–30)

1943 *Cardilona bensoni* Marwick; Trans. R. Soc. N.Z. 73(3): 185–6, pl. 25 fig. 4–6.

1966 *Cardilona bensoni*; Fleming, Bull. N.Z. Dep. scient. ind. Res. 173: 31, pl. 60 fig. 666–8.

1969 *Cardilona bensoni*; Keen, in Moore, Treat. Invert. Paleont. (N) Moll. 6: N608, fig. E100, 3a–b.

HOLOTYPE. TM 4716.

TYPE LOCALITY. GS 2141, calcareous tuffs, Bridge Point, near Kakanui, North Otago.

FORMATION. Waiareka Volcanics (Runangan, Upper Eocene, on foraminiferal evidence – Bridge Point is the type locality of *Bolivina pontis* Finlay, the first appearance of which marks the base of the Runangan stage).

REMARKS. *Pecchiolia bensoni* appears to be very rare at Bridge Point, only one specimen—a largely decorticated steinkern of a small left valve—having been collected in the course of my several visits to the locality. Marwick recorded it from GS 626, “Isis” bed, Campell’s Beach, Kakanui (Waitakian), but the specimen concerned is a steinkern that cannot be confidently regarded as congeneric, let alone conspecific, with *P. bensoni*.

Superfamily CLAVAGELLACEA  
Family CLAVAGELLIDAE

Genus *Clavagella* Lamarck, 1818

1818. Hist. nat. Animaux sans Vert. 5: 430.

TYPE SPECIES (by subsequent designation, Children, 1823): *Clavagella echinata* Lamarck, 1818; Middle-Upper Eocene, Paris Basin.

*Clavagella oamarutica* n.sp. (Fig. 6–9)

Shell of moderate size for genus (total length unknown, but possibly as much as 100 m). Siphonal tube rather irregular, ovate in cross section, without definite longitudinal keels; posterior end unknown. Anterior portion (sac) considerably inflated, more so dorsoventrally than laterally, bearing numerous irregularly branching tubules and wavy, frill-like processes on anterior end and (holotype) on part of right side. Left (attached) valve subrectangular, markedly oblique to axis of siphonal tube, sculptured on early portion by radial rows of very fine papillae

(largely absent from holotype because of decortication); remainder with fine growth lines and numerous fine, oblique wrinkles. A short tongue of shell extending from dorsal surface of sac over left umbo. Right (free) valve irregularly subrectangular; umbo very low; proximal sculpture of radial rows of papillae well developed; rest of valve with strong, irregular growth ridges and oblique wrinkles. Interior nacreous; adductor muscle scars very obscure; pallial sinus moderately long, narrowly triangular. Hinge edentulous; nymph short and narrow.

**DIMENSIONS OF HOLOTYPE** (mm). Length (incomplete) 80.5, maximum height (measured dorsoventrally) 21.5, maximum width 19.8.

**HOLOTYPE.** TM 5458.

**TYPE LOCALITY.** GS 9572, thin shellbed with abundant *Lima colorata colorata* Hutton and common *Nemocardium (Varicardium) patulum* (Hutton) in calcareous greensands about 10 m below Target Gully Shellbed, Target Gully, Oamaru, coll. P. A. Maxwell, May 1966.

**FORMATION.** Gee Greensand (early Altonian, Lower Miocene; "Hutchinsonian" of earlier workers).

**LOCALITIES.** GS 9572 (holotype, 3 paratypes, including an isolated right valve). GS 170, Awamoa Beach, near Oamaru (Altonian) (1 small, somewhat decorticated paratype). Poorly preserved clavagellids which are similar to, if not conspecific with, *C. oamarutica* occur at the following localities: GS 646, greensands, Mokau, North Taranaki (? Altonian); GS 11,185, Slip Point, Clifden, just below oyster bed (Clifdenian, Middle Miocene); GS 11,186, same locality but above oyster bed (Lillburnian, Middle Miocene); GS 10,343, Nissen No. 1 Shellbed, Clifden (Waiauan, Middle Miocene).

**REMARKS.** The holotype was found in a subhorizontal position with the left side facing upward; this orientation may be purely fortuitous, but the asymmetrical development of the tubules on the sac suggests that this was its position in life. However, one of the paratypes from GS 9572, consisting of most of the sac, is nestled in the umbonal cavity of a *Lima colorata* with the left side facing outwards and the siphonal tube subhorizontal, assuming that *Lima* lay with its commissure in a roughly horizontal plane.

Deshayes (1860, pl. 1 fig. 16) figures a specimen of *Clavagella cristata* Lamarck (Eocene, Paris Basin) nestled in the umbonal cavity of a crassatellid; in this instance, however, the left side of the sac is horizontal rather than vertical. A ventral view of the same specimen detached from the crassatellid (Deshayes 1860, pl. 1 fig. 17) clearly shows an asymmetrical development of the tubules rather like that in the holotype of *C. oamarutica*.

Since the posterior end of its siphonal tube is not known, *C. oamarutica* could conceivably belong in

subgenus *Stirpulina* Stoliczka, 1870, in which the tube is periodically expanded, rather than *Clavagella* (s.s.), which has a simple tube. However, the new species is similar to *Clavagella (Clavagella) majorina* B. J. Smith, 1971 from the Janjukian of Victoria and Tasmania, and there seems little doubt that the two species are consubgeneric. Judging from Smith's illustrations and description (1971, p. 139-41, pl. 10 fig. 6-8), *C. majorina* differs from *C. oamarutica* in having the sac much less expanded and tubules confined to the anterior end; the latter feature suggests that it habitually lay in a vertical rather than a horizontal position. B. J. Smith (1971, p. 141) noted that the European fossil species included in *Clavagella* (s.s.) by L. A. Smith (1962, p. 170) differ from *C. majorina* in their much smaller size, relatively large valves (compared with the size of the sac), and having tubules not restricted to the anterior end of the sac. Except in the last-named feature, *C. oamarutica* is more akin to *C. majorina* than to the European species.

Kilburn (1974) has described a living species of *Clavagella* s.s. from Natal (*C. mullerae*) that resembles *C. oamarutica* in having a distinctly expanded sac with tubules distributed in much the same fashion. The unique holotype was found in a rock crevice, and Kilburn suggests that this habitat may account for the distribution of tubules on the sac and for another unusual feature of this species, the way in which the siphonal tube is set at an angle to the sac. He points out the similarity of *C. mullerae* to the Paris Basin species, but remarks that close relationship is unlikely. *C. mullerae* (total length only 41 mm) is much smaller than *C. oamarutica*.

*C. oamarutica* is the first clavagellid to be described from New Zealand; the Recent species *Penicillus novaezelandiae* Brugière, 1789—referred to *Brechites (Foegia)* by B. J. Smith (1971, p. 152)—is almost certainly from Swan River, Western Australia (Smith 1971, p. 152), not New Zealand, as the specific epithet suggests. Suter (*in Park* 1918, p. 72; 1921, p. 89) recorded "*Clavagella* sp." from GS 966, Teschemakers Old Quarry, North Otago (Runangan, Upper Eocene), but the specimen so identified in the N.Z. Geological Survey collections is a crooked tube about 13 mm long and 4 mm in diameter, open at both ends and with a single narrow, longitudinal ridge and weak transverse ridges, that is doubtfully referable to the Mollusca, let alone the Clavagellidae.

Two fragmentary specimens from GS 9806, Shell Gully, Chatton, Southland (Duntroonian, mid Oligocene) may represent a second New Zealand species of *Clavagella*. This appears to have differed from *C. oamarutica* by its smaller size, smoother left valve, and less swollen sac, but better material is required before it can be confidently identified.



Class GASTROPODA  
 Superfamily PLEUROTOMARIACEA  
 Family PLEUROTOMARIIDAE

Genus *Perotrochus* Fischer, 1885

1885 Man. Conchyl.: 850.

TYPE SPECIES (by original designation): *Pleurotomaria quoyana* Fischer & Bernardi, 1856; Recent, Western Atlantic.

Three genus-group taxa are currently recognised as applicable to Cenozoic and Recent pleurotomariids, viz *Perotrochus*, *Mikadotrochus* Lindhol, 1927 (type species *Pleurotomaria beyrichii* Hilger, 1877), and *Entemnotrochus* Fischer, 1885 (type species *Pleurotomaria adansoniana* Crosse & Fischer, 1861). Species referred to the last genus are sharply distinguished by their exceptionally large size, deep umbilicus, and very deep labral slit, which extends back for about half the circumference of the last whorl. *Perotrochus* and *Mikadotrochus*, on the other hand, appear to be closely related taxa in which the shells are non-umbilicate and the labral slit is short—about one-quarter of the last whorl in *Perotrochus* and one-fifth or less in *Mikadotrochus*. Differences between these two taxa are so slight (see discussion in Bayer 1966, p. 744–5) that they are better classed as weakly differentiated subgenera than as full genera.

Two species of *Perotrochus* have previously been described from New Zealand: *P. allani* Marwick, 1928 (? Upper Arnold Series, Upper Eocene, Chatham Islands); and *P. marwicki* Fleming, 1970 (Altonian, Lower Miocene, Tarakohe). These have very short labral slits (about one-sixth of the last whorl in *allani*, about one-eighth in *marwicki*), and may therefore be referred to subgenus *Mikadotrochus*—if indeed this taxon should be recognised at all.

Bayer (1966, p. 744–5; 1967) recognised the following three groups within Recent *Perotrochus*.

A – characterised by comparatively small size (maximum diameter usually considerably less than 60 mm), solid shell, and selenizone “conspicuously below mid-whorl”. This group includes *P. quoyanus*, *P. amabilis* (Bayer, 1963), *P. gemma* Bayer, 1966, and *P. lucaya* Bayer, 1966, all Western Atlantic (largely Caribbean) species.

B – in which the shells are larger (maximum diameter 80–120 mm) and thinner than those in group A and the selenizone is “but slightly below” mid-whorl. Bayer (1966, p. 744) considers this group to be “at least subgenerically distinct” from group A. Species included are *P. africanus* (Tomlin, 1948) (South Africa), *P. midas* Bayer, 1966 (western Atlantic), *P. pyramus* Bayer, 1967 (western Atlantic),

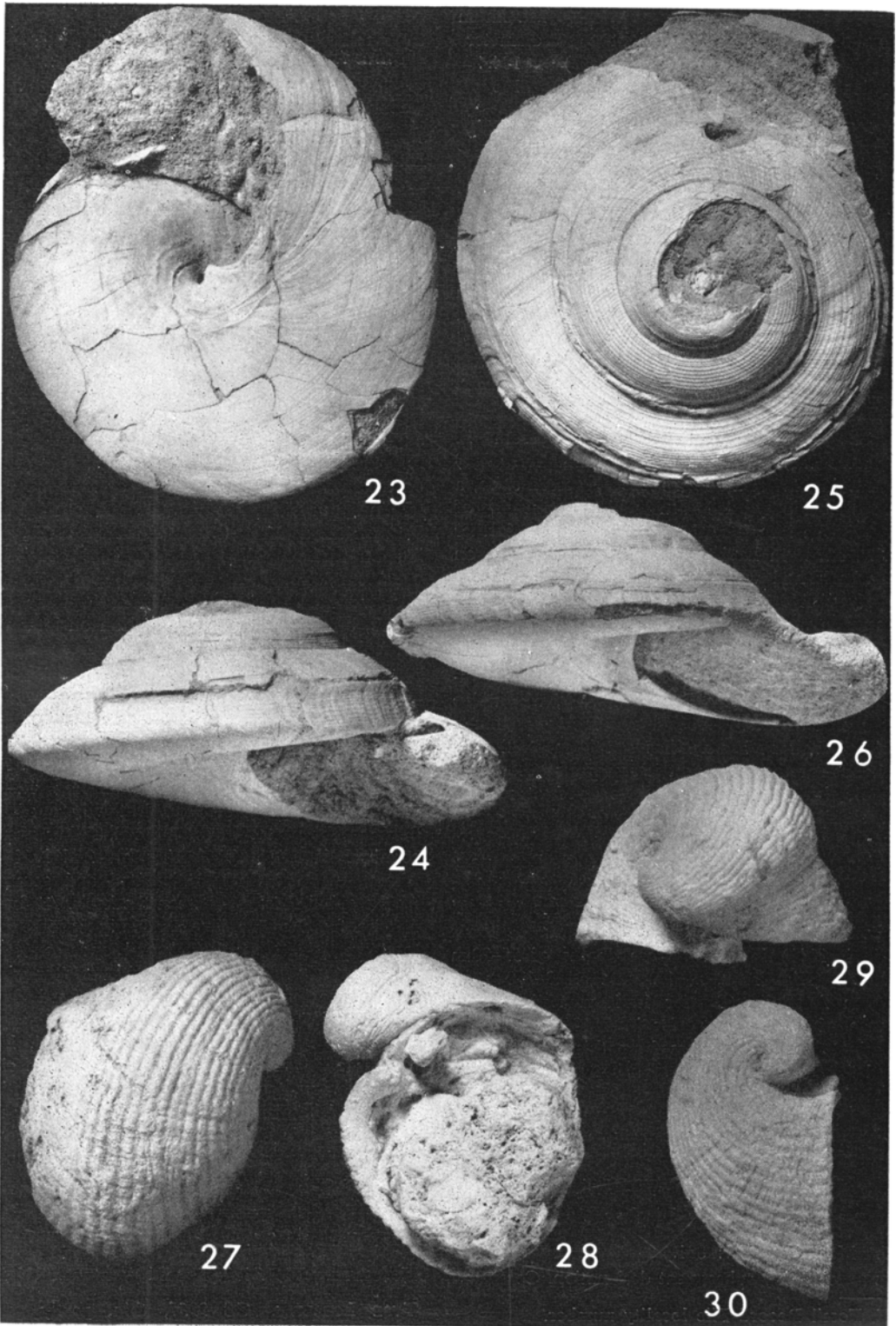
*P. teramachii* Kuroda, 1955 (Japan), and the Japanese species misidentified by Kira (1962, p. 1, pl 1 fig. 1) as *P. teramachii*. *P. masoni* n.sp. belongs to this widespread group.

C – comprising only *P. hirasei* (Pilsbry, 1903) (Japan), distinguished by its large, heavy shell with the selenizone placed as in group B. Most workers have referred this species to *Mikadotrochus*, but Bayer (1966, p. 783) notes that it has a deeper labral slit than either *M. beyrichii* or *M. salmiana* (Rolle, 1899), and therefore places it in *Perotrochus*.

*Perotrochus* (s.l.) *masoni* n.sp. (Fig. 23–6)

Shell large, fragile, broadly trochiform, considerably wider than high, nacreous within. Apical whorls missing in all specimens; 3 teleoconch whorls remaining on most complete shell (holotype). Spire whorls moderately convex, their sutures distinctly impressed; last whorl subangulate at periphery, contracted rapidly below. Base gently convex. Selenizone situated at or slightly below middle of spire whorls, considerably narrower on 1 paratype than on other 2 specimens, flush with whorl surface or slightly impressed. Spiral sculpture on spire consisting of rather subdued, narrow, rounded or flattish-topped cords, some of them subdivided by fine longitudinal grooves, usually with interspaces of similar width or less. Spirals much more widely spaced, narrower, more numerous on last whorl of holotype. Holotype with about 10 cords above selenizone, 7 or 8 below on penultimate whorl; paratypes seemingly with many more owing to presence of interstitial threads. Selenizone with 2 fine spiral grooves (1 paratype) or 2 narrow threads (other shells). Base of last whorl with numerous weak spiral threads which are almost obsolete adaxially. Axial sculpture on spire consisting of numerous fine collabral costellae or growth lines that are strongly prosocline and gently prosocyrct above selenizone, strongly opisthocyrct on selenizone, strongly prosocyrct below. Growth lines prosocline and weakly sinuous on base, much less numerous than on spire. Some fine beading of spiral cords at intersections with axial costellae, more marked on holotype. Aperture large, strongly prosocline, wider than high. Columella short, moderately callused, gently concave below, with a sharp sigmoid twist near the top, forming a narrow pseudumbilical depression that ascends helically some distance up into spire. Umbilical region depressed, covered by an arcuate band of callus, outer margin of which runs from base of columella around towards top of the thin outer lip. Labral slit apparently rather shallow,

Fig. 23–30 (opposite page). 23–26, *Perotrochus* (s.l.) *masoni* n.sp.: 23, 24, paratype (TM 5469),  $\times 0.75$ ; 25, 26, holotype (TM 5468),  $\times 0.75$  – S118/f613, Sisters Creek, Hakataramea Vly (Duntroonian, Oligocene). 27–30, *Pecchiolia bensoni* (Marwick, 1943), holotype (TM 4716),  $\times 1.5$  – GS 2141, Bridge Point, Kakanui (Runangan, Upper Eocene).



less than one-quarter circumference of last whorl.

DIMENSIONS (mm):	Height	Maximum diameter
Holotype	43 (incomplete)	104.4
Figured paratype	48.5 (incomplete)	106

HOLOTYPE. TM 5468; figured paratype, TM 5469.

TYPE LOCALITY. S118/f613\*, excavation for mysticete whale, hillside above right bank, North Branch, Sisters Creek, Hakataramea Valley, opposite "Riverside" homestead, coll. G. Mason, 1971 (holotype, 2 paratypes).

FORMATION. Otekaike Limestone. Foraminiferida and Ostracoda from S118/f613 indicate a Duntroonian (mid Oligocene) age (N. de B. Hornibrook, pers. comm.); the associated rich molluscan fauna has not yet been examined critically, but shows affinities with faunas of Duntroonian and Waitakian age from the Waitaki and Hakataramea Valleys.

REMARKS. *Perotrochus masoni* differs from *P. (Mikadotrochus) allani* and *P. (Mikadotrochus) marwicki* in having a much more depressed spire, a feature that is only partly attributable to crushing of the specimens after burial. *P. masoni* differs further from *P. allani* in having more numerous spirals on spire whorls and well developed collabral costellae (scarcely visible on *allani*), and from *P. marwicki* by its much weaker basal spirals.

Except for its apparently shallow labral slit, *P. masoni* is closely similar to the Recent species included in Bayer's group B (see above), which live at depths of about 350–700 m. The molluscan fauna associated with *P. masoni* has not been studied in detail, but for the most part it resembles other mid-Cenozoic faunas inferred to have lived at mid to outer shelf depths. The only exceptional feature is the abundance of specimens of a new species of the astraeine gastropod *Guildfordia* (A. G. Beu, pers. comm.), which is known to occur also, though less commonly, at Waitakian localities in the Waitaki Valley. The Recent Indo-Pacific species *G. triumphans* (Philippi, 1841) is known from depths of 55–90 m off Japan (Kira 1962, p. 19) and c.120–170 m off Northern Australia (Ponder 1971, p. 134), so the presence of a related species in S118/f613 is some indication that the molluscs from this locality lived at mid to outer shelf rather than bathyal depths.

Superfamily TROCHACEA  
Family TURBINIDAE  
Subfamily LIOTINAE

Genus *Liotina* Fischer, 1885

1885. Man. Conchyl.: 831.

TYPE SPECIES (by subsequent designation, Cossmann,

\*N.Z. Fossil Record File locality number.

1888): *Delphinula gervillei* DeFrance, 1818; Middle Eocene, France.

*Liotina turua* n.sp. (Fig. 35–8, 46–8)

ETYMOLOGY: from 'turua', a Maori word meaning 'beautiful'.

Shell of moderate size for genus, turbinate; apex flattened; spire about 0.4 total height in adults. Protoconch planorboid, of 1½ smooth whorls; nucleus rather small. Teleoconch of 3½ whorls; sutures strongly impressed; first 2 whorls or so with very depressed spire, adults with moderately elevated spire. Teleoconch whorls gently convex at first, then rapidly becoming keeled adapically to form a broad, almost horizontal sutural shelf, the keel gradually descending to a position near mid whorl, accompanied by a second keel of similar strength between it and upper suture. On last whorl 3 somewhat weaker keels appear, the topmost marking the peribasal angle, the lowest bordering the umbilicus. Spiral sculpture, apart from the cords which mark the keels on later whorls, consisting of 1 or 2 rounded cords within the umbilicus and much finer, rounded threads between the spiral keels and umbilical cords, appearing on 2nd whorl. Axial sculpture consisting of prominent, strongly raised collabral prosocline costae, narrow on early whorls, and bifurcating near adapical suture, broadly triangular in section on later whorls. On spire whorls costae reaching from suture to suture, on last whorl of subadult shells persisting across base and into umbilicus, gradually weakening adaxially, but on adults projecting laterally into umbilicus, giving it a serrate profile, but not extending far within. Costae slightly thickened at intersection with keels. Costae numbering 12–13 on penultimate whorl, 8–9 on last whorl of adults. Between the costae are numerous, rather prominent collabral lamellae (appearing on 2nd half of 1st whorl) that are finely reticulated and gemmulated by the spiral threads between the keels. At first these diverge from costae, but gradually become parallel to them. Umbilicus broad and open on subadult shells, much narrower and with steeper sides on adults, bearing a rather weakly defined funicular ridge adapically that suddenly twists near the aperture of adult shells to form a short, vertical, lamellar process adjacent to the inner lip. Aperture circular, prosoline, nacreous within; peristome continuous. Outer and basal lip heavily variciform, outer margin angled by spiral keels; inner lip narrower, with a strong, triangular denticle projecting into umbilicus at lower end.

DIMENSIONS OF HOLOTYPE (mm). Height 6.2, maximum diameter 7.1.

HOLOTYPE. TM 5470; figured paratype, TM 5471.

TYPE LOCALITY. GS 9957, thin, partly cemented

shellbed with abundant corals (especially *Dendrophyllia* sp.) and molluscs in glauconitic sands, bed of South Branch, Waihao River, about 100 m east of road near "Pentland Hills" homestead, coll. T. A. Darragh and P. A. Maxwell, February 1968.

LOCALITIES. 9957 (holotype, 9 paratypes). GS 11,650, shellbed in deep pool 100 m downstream from farm bridge, "Pentland Hills" (15 juvenile paratypes).

AGE. Bortonian (Middle Eocene) or somewhat older. Associated molluscs in GS 9957 include *Costacallista* aff. *hectori* (Finlay & Marwick), *Sigaretotrema fornicata* (Suter), and *Athleta* sp.; other forms present are undescribed, and have not been recorded away from the Pentland Hills area. Pre-Bortonian Eocene molluscs are too poorly known to give any clue as to the precise age of this fauna.

Foraminifera from GS 9957 and GS 11,650 were examined by N. de B. Hornibrook, who concluded (pers. comm.) that the assemblages are too small to tell whether they are Bortonian or somewhat older (i.e., Dannevirke Series, Lower-Middle Eocene).

REMARKS. This is the first species of this typically warm-water genus to be described from New Zealand. Cotton (1948, p. 31) proposed the taxon *Austroliota* (type species *Liotia botanica* Hedley, 1915; Recent, New South Wales) for superficially similar shells that differ from typical *Liotina* in having a more depressed spire and more open umbilicus, remarking that it appeared to be "a temperate relative of the warm-water *Liotina*". The new species is considered to be closer to *Liotina gervillei* (the type species) than to *Austroliota botanica*, and therefore marks yet another addition to the growing list of subtropical or tropical taxa recorded from the New Zealand mid Eocene.

Superfamily TONNACEA  
Family CASSIDAE

Genus *Galeodea* Link, 1807

1807 Besch. Nat. Samml. Univ. Rostock (3): 113.

TYPE SPECIES (by monotypy): *Buccinum echinophorum* Linnaeus, 1758; Recent, Mediterranean.

Subgenus *Galeocorys* Kuroda & Habe, 1957  
1957 Publ. Seto Mar. Biol. Lab. 6(1): 27.

TYPE SPECIES (by original designation): *Galeodea leucodoma* Dall, 1907; Recent, Japan.

Kuroda & Habe (1957, p. 27) referred *Galeocorys* to the Oocorythidae (considered by some authors to be a subfamily of the Tonnidae) on the basis of radular features in the type species. Fleming (1966b, p. 430) noted that the radula is closer to that of *Galeodea echinophora* than to species of *Oocorys* or *Eudolium*, and suggested that *Galeocorys* should be included in the Cassidae. Kilburn (1975, p. 584), however, states that the radula of *G. leucodoma* (see

Kuroda & Habe 1957, p. 28, fig. 1) "agrees substantially" with that of *Oocorys sulcata* Fischer, 1883, the type species of *Oocorys* Fischer, 1883 (see Bayer 1971, p. 146, fig. 20B,C), and suggests that *Galeocorys* should be regarded as a subgenus of *Oocorys*. The radulae of *Galeodea echinophora* (see Thiele 1931, p. 278, fig. 295b), *G. leucodoma*, and *O. sulcata* are in fact remarkably similar, suggesting that radular features are of little use for clarifying the relationships of *Galeocorys*. The opercular features of *G. leucodoma* are less equivocal, and support Fleming's contention that *Galeocorys* is a cassid related to *Galeodea*. In species of *Oocorys* the operculum is paucispiral with a raised, subterminal (i.e., anterior) nucleus (see Turner 1948, p. 167, fig. 8-12; Bayer 1971, p. 148, fig. 22B), whereas in *Galeodea* the nucleus is situated at about the anterior three-fifths, close to the outer margin (see Thiele 1931, p. 278, fig. 294). The operculum of *G. leucodoma* is described as having the "nucleus excentric, situated at the anterior three-fourths, near the outer margin" (Kuroda & Habe 1957, p. 27); i.e., basically similar to the operculum of *Galeodea* (and many other cassids). *Galeocorys* differs only slightly from *Galeodea* in shell features, the most important differences being the more restricted columellar callus shield and straighter siphonal canal of *Galeocorys*. Since it seems likely that *Galeocorys* was derived from a mid-Cenozoic species of *Galeodea* s.s. (see below), it is here treated as a subgenus of *Galeodea* rather than a distinct genus.

*Galeodea (Galeocorys) wylliei* Marwick, 1931  
(Fig. 31, 32)

1931 *Galeodea wylliei* Marwick, Paleont. Bull. N.Z. Geol. Surv. 13: 105, pl. 10 fig. 182.

1966 *Galeodea wylliei*; Fleming, Bull. N.Z. Dep. scient. ind. Res. 173: 55, pl. 100 fig. 1214.

Shell moderately large for genus, ovate; spire height about 0.3 × total height. Apical whorls missing. Remaining 2½ teleoconch whorls bluntly shouldered just above middle on spire; sutural ramp rather steep, flat. Last whorl large, strongly convex below shoulder, contracted to a short, nearly vertical neck. Spiral sculpture consisting of narrow cords of varying strength with some interstitial threads; about 10 cords on penultimate whorl, an additional 30 or so, also with interstitial threads, on base and neck of last whorl. Axial sculpture on penultimate whorl consisting of 2 rows of rather sharp tubercles; upper row stronger, positioned on shoulder, with 16 tubercles, the other just above the suture, with 19 tubercles. On last whorl 4 additional rows present on base, the lower 2 subdued and becoming obsolete near outer lip; top 4 rows with 16, 17, 13, and 13 definite tubercles (from top row downwards). Aperture rather large, pyriform. Columella almost straight

and vertical, slightly bent to left anteriorly at inception of short, open, apparently unnotched siphonal canal. Inner lip broadly callused, thinly in parietal region, where spiral cords show clearly through callus, more thickly over columella. Outer margin of callus sharply defined except near posterior end, not forming an expanded columellar shield as in *Galeodea* (s.s.). Outer lip moderately prosocline (about 20° to vertical), almost straight, quite strongly reflected and thickened externally by rounded varix, its inner face somewhat concave, its outer margin feebly crenulate along inner edge, otherwise smooth.

**DIMENSIONS OF HOLOTYPE (mm).** Height (incomplete) 57.2, maximum diameter 42.8.

**HOLOTYPE.** TM 5446.

**TYPE LOCALITY.** GS 11,177, soft blue sandstone, "coast 100 chains south of Whangara", near Gisborne, coll. B. K. Wyllie, probably in 1927.

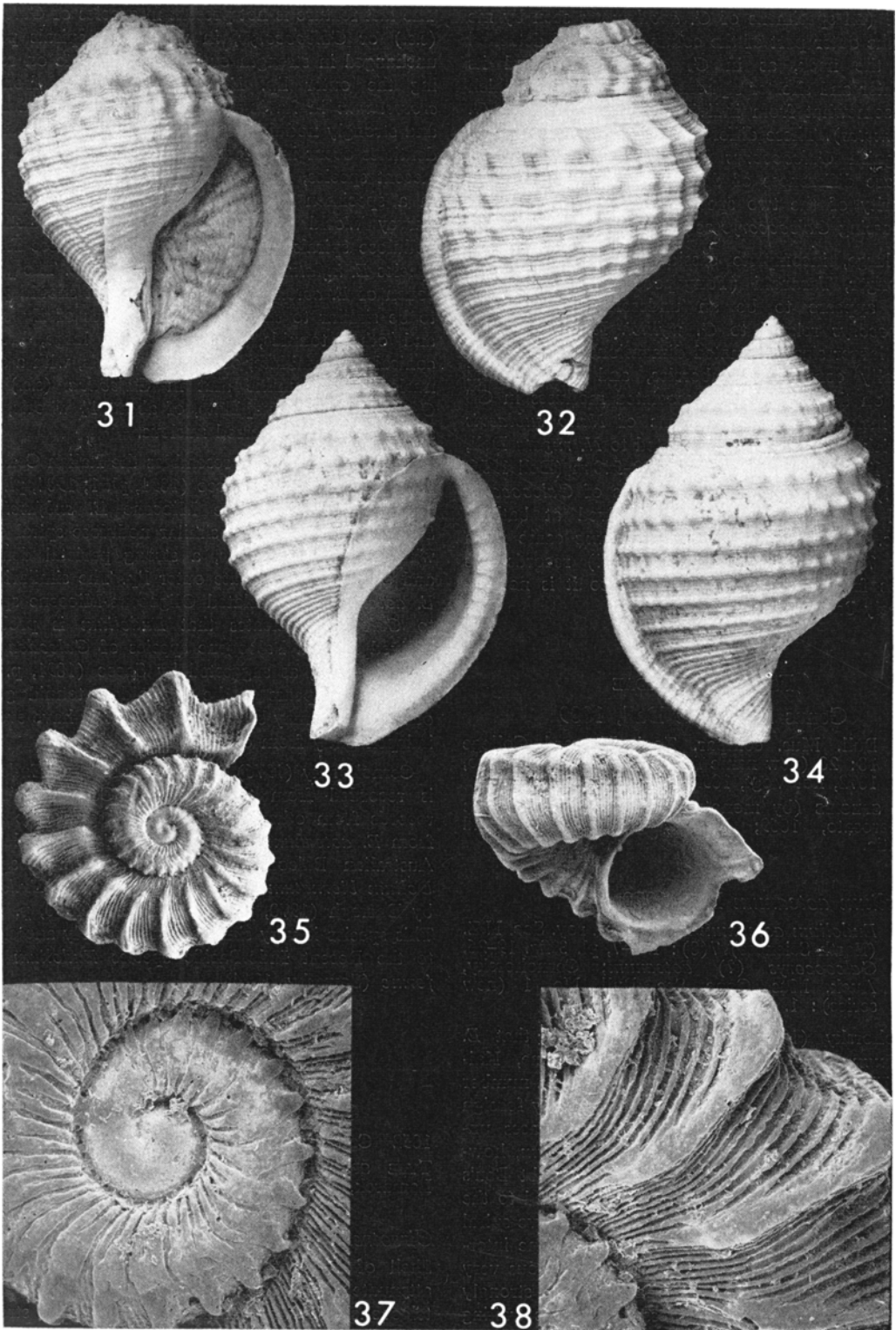
**AGE.** Marwick (1931, p. 13, 105) tentatively assigned this collection—which consists only of the holotype of *G. wylliei*—to the Wheao "Series", now thought to be of Altonian (Lower Miocene) age (Kingma, in Fleming 1959, p. 483). Fleming (1966a, p. 298) noted that the beds from which Wyllie collected are shown as "Awamoan" (i.e., Altonian) by Ridd (1964, fig. 8) and as undifferentiated Waipawan to Whaingaroan (late Paleocene – early Oligocene) by Kingma (1965). The former age seems more likely in view of the rarity of macrofossils in Paleogene beds in the Gisborne district, and is supported by microfossils obtained from matrix in the aperture of the holotype of *G. wylliei*. These are poorly preserved, but indicate a late Waitakian (or possibly late Altonian) to Lillburnian (Middle Miocene) age (A. R. Edwards, pers. comm.).

**REMARKS.** Dell (1953, p. 53) stated that *Galeodea wylliei* does "not appear to be on the direct line" from *G. apodemetes* Marwick, 1943 (Otaian-Altonian, Lower Miocene, North Otago – South Canterbury) to *G. trigancae* Dell, 1953 (Recent). However, its distinctiveness was not fully appreciated, probably because the aperture was largely filled with hard matrix (which may be why Marwick illustrated only the back view of the holotype). This matrix has now been partly removed and the apertural features more clearly exposed, so that the affinities of *G. wylliei* can be more readily assessed. The similarity of *G. wylliei* to *G. leucodoma* (Fig. 33, 34) is quite re-

markable as regards size, shape, and general sculptural features. *G. wylliei* has fewer and stronger tubercles than *G. leucodoma*, stronger spirals between the rows of tubercles, a more distinct twist near the lower end of the columella, somewhat more widely spreading columellar callus, and an outer lip that is almost smooth and distinctly excavated within rather than flange-like and lirate. (Acquisition of additional specimens of *G. wylliei* would probably show that the differences in outer lip features are not constant, since these fall within the intraspecific variation normal for cassids.) *G. wylliei* indeed resembles *G. leucodoma* much more closely than it does the other two New Zealand cassids previously referred to *Galeocorys*, *G. allani* Fleming, 1966 (Kapitean, Upper Miocene, Westland) and *Cassidaria sulcata* Hutton, 1873 (Kapitean-Waipipian, Upper Miocene-Pliocene, Westland and Wanganui) (see Fleming 1966b). The two last-named species, together with an undescribed species from Kai Iwi (Castlecliffian, Pleistocene) and the recently described *G. keyteri* (Kilburn, 1975) (Recent, southern Africa), differ from *G. wylliei* and *G. leucodoma* in having comparatively subdued axial sculpture—strongest in *G. allani*, weakest in *G. keyteri* and the Castlecliffian species—and more evenly developed spiral cords. (*G. keyteri* was described as a species of *Oocorys*, but the operculum, which is clearly shown in fig. 4 of Kilburn's paper, and is described as "ovate, nucleus about one-third of length from base of outer margin" (Kilburn 1975, p. 584), is of typical cassid form.) *Galeodea* (*Galeocorys*) *sulcata* and allied species appear to represent a distinct group that either split off from the *G. wylliei* – *leucodoma* stock or evolved independently from a Neogene species of *Galeodea* s.s.

*G. wylliei* is quite similar to the rather widespread Lower Miocene species *G. apodemetes*, and may have been derived from it or a related species in Paleogene or early Miocene times. The two species have similar sculpture, the only obvious difference being the presence of two additional rows of tubercles on the last whorl of *G. wylliei*, but these are weakly developed and probably reflect the larger size of *G. wylliei* (the largest specimen of *G. apodemetes* seen by me measures about 50 × 35 mm). The features of the outer lip described above for *G. wylliei* (i.e., excavated inner face and very weak crenulations on the outer edge) can be matched fairly closely in topotypes of *G. apodemetes*. Apart from size, the most important differences between the two species

**Fig. 31–38 (opposite page).** 31, 32, *Galeodea* (*Galeocorys*) *wylliei* Marwick, 1931, holotype (TM 5446), ×1 – GS 11,177, coast S of Whangara, Gisborne (Altonian?, Lower Miocene). 33, 34, *G. (Galeocorys) leucodoma* Dall, 1907, type species of *Galeocorys* Kuroda & Habe, 1957, hypotype (WM 8522), ×1 – Tosa, Shikohu, Japan (Recent). 35–38, *Liotina turua* n.sp., paratype (TM 5471) – GS 11,650, S. Branch, Waihao R. S. Canterbury (Bortonian?, Middle Eocene) (SEM photographs, 'Stereoscan Mk II, Physics and Engineering Lab., DSIR): 35, 36, apical and apertural views, ×25; 37, detail of protoconch and early teleoconch whorls, ×100; 38, detail of axial sculpture, last whorl, ×100.



are the limited extent of the columellar callus in *G. wylliei* (all specimens of *G. apodemetes* seen by me have the outer part of the columellar shield detached from the neck, as in *G. echinophora*) and its straighter and shorter siphonal canal (features which vary somewhat from individual to individual in *G. apodemetes*). These differences are in fact those that distinguish *Galeocorys* from *Galeodea*, and since they are differences of degree rather than kind the similarity of the two species is further justification for classing *Galeocorys* as a subgenus of *Galeodea*.

A large, incomplete cassid from GS 2091, Mt Messenger, Taranaki (Tongaporutuan, Upper Miocene) appears to be an undescribed species of *Galeocorys* related to *G. wylliei*. It differs in its much larger size (estimated dimensions 90 × 60 mm), vertically compressed tubercles, and heavy spiral cords on the last whorl. Associated molluscs in GS 2091 include several specimens of *Neilo sublaevis* Marwick, a species closely related to *N. rugata* Dell, which lives at depths of about 470–540 m (Dell 1956, p. 164), suggesting that this species of *Galeocorys*—and possibly *G. wylliei*—also lived at bathyal depths. The holotype of *G. leucodoma* came from about 720 m, but Kira (1962, p. 54) records this species from depths of 126–180 m, so it is not exclusively bathyal in habitat.

### Family TONNIDAE

#### Genus *Eudolium* Dall, 1889

1889 Bull. Mus. compar. Zool. Harvard College 18: 20 (new name for *Doliopsis* Monterosato, 1872, not Vogt, 1852 nor Conrad, 1865).

TYPE SPECIES (by monotypy): *Dolium crosseanum* Monterosato, 1869; Recent, Mediterranean and Atlantic.

#### *Eudolium aoteanum* Beu, 1970

1970 *Eudolium aoteanum* Beu, Trans. roy. Soc. N.Z. (Earth Sciences) 7(8): 126–7, pl. 3 fig. 19–26.

1976 *Galeocorys* (?) *aoteanum*; Cernohorsky, Auck. Mus. Conc. Sec. Bull. No. 1 (new series): 1.

Cernohorsky (1976, p. 1) has suggested that *E. aoteanum* (Otaian-Altonian, Lower Miocene, Kaipara Harbour) is a *Galeocorys*, and cites a number of features of this species that are supposedly foreign to *Eudolium*. None of the alleged differences unequivocally rules out assignment to *Eudolium*, however, and there is no good reason to doubt Beu's conclusion that *E. aoteanum* is closely related to the type species, *E. crosseanum*. Both species have spiral sculpture of moderately strong cords with fine interstitial threads that are cancellated by numerous very fine axial costellae, and have a reflected, strongly plicate outer lip that is buttressed along its trailing

edge by thickened extensions of the stronger spirals. The last feature is not present in species of *Galeodea* (s.s.) or *Galeocorys*, in which the spirals persist unchanged in strength or become obsolete on reaching the outer lip. *E. aoteanum* differs from *E. crosseanum* in having a prominent parietal denticle and strongly nodulose spiral cords, but weak parietal denticles occur in at least some specimens of another Recent species, *E. pyriforme* (Sowerby, 1914) (e.g., in a specimen from Japan in the N.Z. Geological Survey World Mollusca Collection), and distinctly nodulose spirals are present in the Japanese Recent species *E. inflatum* Kuroda & Habe, 1952. The protoconch of *E. aoteanum* is unknown, but should prove to be similar to that in Recent species of *Eudolium* and other tonnids, i.e., moderately large, broadly conical or mamillate, of about 4 whorls, with a small nucleus; and unlike that in *Galeodea* (s.s.) and *Galeocorys*, i.e., papillate, of about 1½ whorls, with a large, partly immersed nucleus.

*E. aoteanum* closely resembles the Italian Cenozoic species illustrated by Sacco (1891, pl. 1; 1904, pl. 22), particularly the Middle Miocene *E. subfasciatum* Sacco, 1891, which has similar nodulose spiral cords with interstitial threads, a strong parietal denticle, and a buttressed, plicate outer lip. The similarity of *E. aoteanum* and related Oligocene-Miocene species to *Galeodea* indicates that *Eudolium* is probably derived from a Paleogene species of *Galeodea* or a related cassid, as suggested by Sacco (1891, p. 17). *Eudolium* appears to be the oldest tonnid genus; other tonnids may be derived from it or have evolved independently from other cassids.

Cernohorsky (1976) states that although *Eudolium* is recorded from the European Cenozoic, "fossil records from other areas are wanting". Quite apart from *E. aoteanum*, however, *Eudolium* includes the Australian Balcombian (Middle Miocene) species *Dolium biornatum* Tate, 1894, referred to *Eudolium* by Darragh (1970, p. 158) and Beu (1970, p. 127). This species is very similar—and possibly ancestral—to the Recent Indo-Pacific species *Eudolium pyriforme* (Sowerby, 1914).

### Superfamily EPITONIACEA

#### Family EPITONIIDAE

#### Genus *Cirsotrema* Mörch, 1852

1852 Cat. Conch. Yoldi 1: 49.

TYPE SPECIES (by monotypy): *Scalaria varicosa* Lamarck, 1822; Recent, Indo-Pacific.

#### *Cirsotrema gagei* n.sp. (Fig. 44)

Shell of moderate size for genus, probably rather attenuate. Apical whorls missing from holotype, 5½ teleoconch whorls remaining. Spire whorls strongly

and evenly convex; last whorl with a well defined basal disc forming a strong, rounded, peribasal keel well below periphery. Base almost flat; fasciolar ridge, if present, hidden by aperture. Sutures obscured by fusion of axial costae with suprasutural cord and costae on preceding whorl. Axial sculpture consisting of slightly prosocline, blade-like costae reaching from suture to suture on spire and extending across base of last whorl to aperture, each comprising several (typically about 6) thin lamellae fused together. Heavy, rounded varices, narrowing posteriorly and composed of numerous fused lamellae, at irregular intervals; weak growth lines between costae. Penultimate whorl with 16 costae and varices. Apart from heavy suprasutural cord emerging on last whorl as peribasal keel, spiral sculpture consists of fine, weakly impressed grooves and occasional low, broad, subdued cords (about 5 on last whorl). Aperture oval; peristome complete, ringed by a heavy, rounded varix.

**DIMENSIONS OF HOLOTYPE** (mm). Height (incomplete) 48, maximum diameter 23.5.

**HOLOTYPE.** TM 5472.

**TYPE LOCALITY.** GS 3892, lower (tuffaceous) part of limestone overlying coarse, current-bedded tuffs, right bank Kakanui River near mouth, coll. M. Gage & J. Marwick, 1947.

**FORMATION.** McDonald Limestone (Whaingaroan, early Oligocene, by local stratigraphy).

**REMARKS.** The thinness of the axial costae, weakness of the intercostal spiral sculpture, and apparent absence of a fasciolar ridge distinguish *C. gagei* from other New Zealand species of *Cirsotrema*. The early Cenozoic *Cirsotrema* (*Tioria*) *youngi* Marwick, 1928 (Tioriori, Chatham Islands) also has lamellar axial costae and weak intercostal spiral sculpture, but differs in lacking definite varices and having strongly shouldered whorls, a scarcely thickened outer lip, and a narrow but well defined fasciole. Although *C. gagei* is rather different in appearance from 'typical' species like *C. lyrata* (Zittel, 1864) (which is present in a recollection of GS 3892), it is doubtful whether the differences are pronounced enough to warrant its assignment to another of the many genus-group taxa that have been proposed in this diverse family

**SYNONYM:** *Claraxis* Iredale, 1936, Rec. Australian Mus. 29(5): 327, 338 (type species (by original designation) *Claraxis illustris* Iredale, 1936; Recent, New South Wales and northern New Zealand).

Iredale introduced *Claraxis* without a diagnosis or any indication of how it differed from any of the other numerous genus-group taxa that have been proposed in the Architectonicidae. The only illustration of *C. illustris* given by Iredale (1936, pl. 24 fig. 16) is an apertural view of little help in identifying the species or determining its possible relationships. Wenz (1939, p. 668) was apparently very puzzled by *Claraxis*, for he classed it as a subgenus of *Mangonuia* Mestayer, 1930 (type species *M. bollonsi* Mestayer, 1930; Recent, northern New Zealand), a taxon to which it is related only at family level, Iredale & McMichael (1962, p. 68) and Powell (1971, p. 212), on the other hand, have retained *Claraxis* as a full genus of the Architectonicidae.

Powell (1971, p. 212, fig. 2-4) recorded *Claraxis* cf. *illustris* from two localities in northern New Zealand and gave excellent illustrations of a specimen from off Mayor Island. There are no obvious differences between this specimen and one in the N.Z. Geological Survey World Mollusca Collection (WM 8354) from 110 m off Port Jackson, New South Wales, i.e., a near-topotype. Comparison of the latter with a specimen of *Granosolarium millegranum* (WM 5747) from the Upper Miocene of Piedmont, Italy, failed to reveal any distinguishing features that could be regarded as being of supraspecific significance. Both species are biconvex or lenticular, with a narrow, peripheral keel and a wide, open umbilicus, and have very similar sculpture of closely spaced, finely gemmulate spiral cords and weak axial costellae. Both species have also a narrow, crenulate, infra-umbilical spiral cord ending near the middle of the inner lip. *Claraxis* is therefore regarded as a junior synonym of *Granosolarium*.

Two species of *Granosolarium* have been described from the New Zealand Cenozoic; *G. lawsi* Maxwell, 1969 (Waitakian, late Oligocene); and *G. marwicki* (Allan, 1926) (Bortonian, Middle Eocene) (Maxwell 1969, p. 182). A third species—very similar to *G. illustre* and possibly ancestral to it—is present in Altonian (Lower Miocene) beds at Parengarenga Harbour, Northland.

Superfamily ARCHITECTONACEA  
Family ARCHITECTONICIDAE

Genus *Granosolarium* Sacco, 1892

1892 Moll. terr. terz. Piemonte Liguria 12: 59.

**TYPE SPECIES** (by original designation): *Solarium millegranum* Lamarck, 1822 (= *Trochus canaliculatus* Brocchi, 1814, not Lamarck, 1804); Upper Miocene, Italy.

Superfamily MURICACEA  
Family COLUMBARIIDAE

Genus *Columbarium* Martens, 1881

1881 Conch. Mitt. 21 (1 & 2): 105.

**TYPE SPECIES** (by original designation): *Pleurotoma* (*Columbarium*) *spinicincta* Martens, 1881; Recent, Queensland.



*Columbarium* (s.l.) *pataka* n.sp. (Fig. 45)

ETYMOLOGY: from 'pataka', a Maori word for a storehouse raised off the ground on a pole (or poles).

Shell rather small for genus, fusiform; spire gradate, about 0.2 total height. Apical whorls worn; protoconch apparently missing. Remaining whorls (c.7) strongly shouldered, somewhat below middle at first, medially on penultimate whorl. Sutural ramp broad, slightly concave, its slides sloping inward. Last whorl biangulate, contracted quickly to a long, narrow, vertical neck. Spiral sculpture (not visible on earliest whorls) consisting of about 3 narrow, well spaced cords on sutural ramp and 3 slightly stronger ones between shoulder and lower suture, the strongest on the periphery. Anterior ramp spiral bifurcating as it begins to surmount each peripheral spine, the lower (and narrower) branch apparently stopping at the front edge of the spine, the other descending to bifurcate again at the beginning of the next spine. Last whorl with the anteriormost spiral cord emerging to form peribasal angle; 15 additional narrow, rounded cords on base and neck, the topmost—corresponding to the anterior carina of Darragh (1969, p. 71)—noticeably stronger than those immediately below but much weaker than the peribasal cord, those on lower part of neck subobsolete. Axial sculpture obscure on early whorls, on later whorls consisting of moderately heavy, rounded, slightly opisthocline costae that are produced into short triangular spines open in front on the shoulder. Costae reaching from suture to suture, weakening posteriorly on last 2 spire whorls and becoming obsolete below anterior keel on last whorl; 13 costae on penultimate whorl. Numerous fine growth lines over shell surface. Aperture pyriform, produced anteriorly to form a long, narrow almost straight siphonal canal. Inner lip thinly callused, impressed. Outer lip damaged. Most basal and neck spirals stopping abruptly at edge of inner lip, but anterior keel persisting virtually unchanged for a short distance within aperture, the 2 below showing very faintly through callus.

DIMENSIONS OF HOLOTYPE (mm). Height (slightly incomplete) 22.9, maximum diameter 11.5.

HOLOTYPE. TM 5473.

TYPE LOCALITY. GS 11,155, medium-grey siltstone, sea-cliffs south of mouth of Kakaho Creek, Hampden Beach, North Otago, coll. T. A. Darragh & P. A. Maxwell, February 1968. A very poorly preserved shell from Hampden in the N.Z. Geological Survey, collected by P. Marshall and identified by him as "*Fusinus* aff. *morgani*", is the only other specimen known to me.

FORMATION. Hampden Formation (Bortonian, Middle Eocene).

REMARKS. This is the species briefly noted by Darragh (1969, p. 119) as having a "shape somewhat like *Fulgurofusus brayi* but axially and spirally sculptured as in *Columbarium heberti*". *C. pataka* is, in fact, much closer to *C. heberti* (Maastrichtian-Montian, Europe) than to *C. vulneratum* (Finlay & Marwick, 1937) (Wangaloan, Paleocene, Boulder Hill), the only other fossil New Zealand species, or to the Australian Upper Eocene species *C. cochleatum* (Tate, 1888) and *C. calcaratatum* Darragh, 1969. Important features of *C. heberti* and *C. pataka* are summarised below.

(1) Both species have the inner lip impressed and thinly callused rather than projecting in front of the columella, as is normal in *Columbarium* (including *C. vulneratum*). The only other species with an impressed inner lip is *C. rugatum* (Aldrich, 1886) (Lower Eocene, Alabama).

(2) Both species have well developed axial costae, which are produced into scales on the periphery of *heberti* (Darragh 1969, p. 72-3) and into triangular spines on *pataka*. All other species of *Columbarium* lack definite axial sculpture apart from peripheral spines. The peripheral scales in *C. heberti* are similar in structure to the spines in *C. pataka* and other species of *Columbarium*, i.e., compressed and open towards the aperture (Darragh 1969, p. 73).

(3) Spiral sculpture is of similar prominence in both species, but whereas *pataka* has spiral cords on the sutural ramp as well as below the peripheral keel, *heberti* has a smooth ramp. The anterior keel is more strongly developed in the European species, and the spirals on the canal are scaly rather than smooth.

*C. pataka* is clearly rather divorced from other species of *Columbarium* (apart from *heberti*), and almost certainly belongs in some other genus-group taxon. It superficially resembles some species of *Coluzea* Finlay, 1927 (type species *Fusus spiralis* A. Adams, 1856; Pleistocene-Recent, New Zealand), but differs in having the peripheral spine open towards the aperture rather than closed. (The oldest known New Zealand species of *Coluzea* is *C. climacota* (Suter, 1917) (Bortonian-Kaiatan), tentatively recorded from Hampden by Marwick (1942, p. 278).) *C. pataka* possibly belongs to a group that gave rise to *Coluzea*, but too little is known of early Cenozoic columbariide to lend much support to this idea.

The most likely location for *C. pataka* is the taxon *Serratifusus* Darragh, 1969 (type species *Fusus craspedotus* Tate, 1888; Batesfordian-Balcombian, Victoria and South Australia). Species included in this group have peripheral spines like those in *Columbarium*, but have distinct axial costae on the last protoconch whorl and on early teleoconch whorls, lack an anterior carina, and have the inner

lip thinly callused rather than projecting (Darragh 1969, p. 89–90). *C. pataka* is possibly an early species of *Serratifusus* in which the axial costae persist on to the last whorl and the anterior keel is still distinguishable from the otherspirals. *Serratifusus* is probably better regarded as a subgenus of *Columbarium* than as a full genus.

Superfamily VOLUTACEA  
Family OLIVIDAE  
Subfamily ANCILLINAE

Genus *Ancillina* Bellardi, 1882

1882 Mem. Accad. Sci. Torino (2)34: 436.

TYPE SPECIES (by monotypy): *Ancillaria pusilla* Fuchs, 1877; Miocene, Europe.

*Ancillina kakano* n.sp. (Fig. 49)

ETYMOLOGY: from 'kakano', Maori for 'pip' or 'seed'.

Shell very small for subfamily, bullet-shaped. Spire cyrtocoenoid, 0.5–0.55 × total height, its apex narrow.

No sculpture apart from weak growth lines that are accentuated by weathering on some shells. Protoconch only weakly marked off from teleoconch, broadly conical, of about 4½ gently convex, smooth whorls with a tiny nucleus, covered by a very light glaze of callus that does not obscure sutures. Teleoconch of 3 whorls, those on spire flat-sided or weakly concave. Some shells with lower margin of spire callus band thickened to form a narrow spiral ridge. Last whorl contracted gradually, broadly truncate anteriorly. Spire whorls with a callus band that widens rapidly on first quarter-whorl of teleoconch, then runs parallel to sutures until it merges with parietal callus on last whorl. Anterior margin slightly below suture, posterior margin somewhat above middle of whorl, thereby leaving an uncallused zone on upper part of whorl. Aperture narrowly triangular, constricted posteriorly, with a short, shallow posterior groove; anterior notch broad and shallow. Columella subvertical, gently concave, bearing 2 or 3 shallow, oblique grooves on outer edge which do not extend within aperture. Inner lip moderately callused, par-

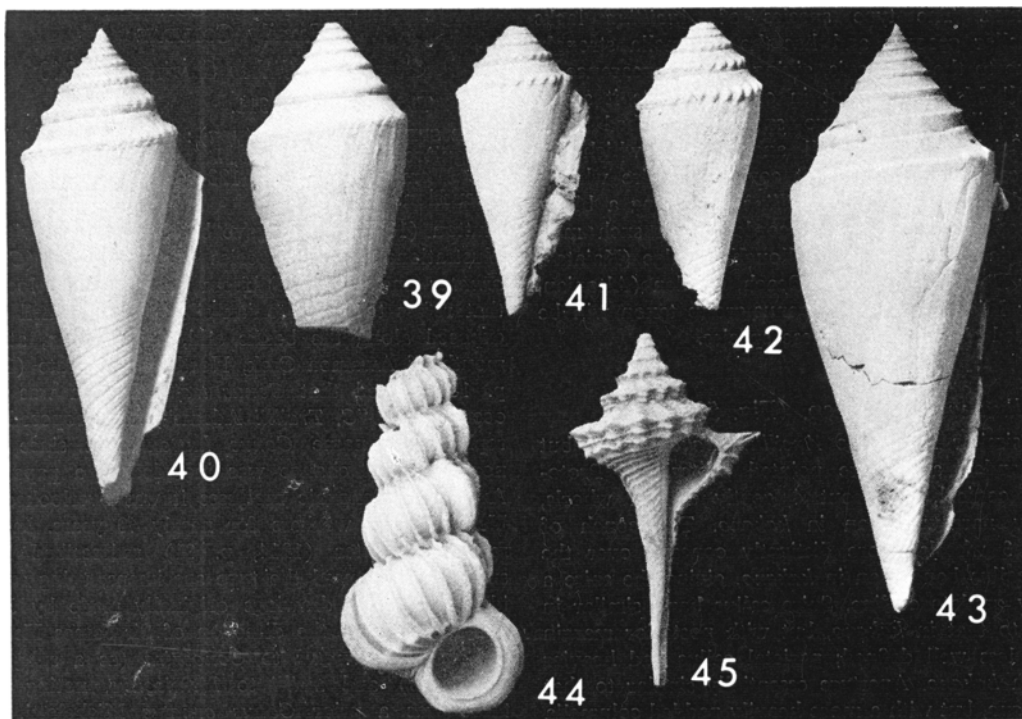


Fig. 39–45. 39, *Conus* (s.l.) *huttoni* Tate, 1890, holotype of *Conus trailli* Hutton, 1873 (not of A. Adams, 1855), (TM 5448), ×2 – “Awamoa”, N. Otago (Altonian, Lower Miocene). 40–43, *Conilithes wollestoni* n.n. for *Conus ornatus* Hutton, 1873 (not of Michelotti, 1847): 40, hypotype (TM 5476), ×2 – GS 9500, S. Oamaru; 41, 42, holotype (TM 5447), ×2 – “Awamoa”, N. Otago; 43, hypotype (TM 5477), ×2 (‘atypical’ form) – GS 9520, Awamoa Creek. All localities of Altonian (Lower Miocene) age. 44, *Cirsotrema gagei* n.sp., holotype (TM 5472), ×1 – GS 3892, Kakanui R., N. Otago (Whaingaroan, early Oligocene). 45, *Columbarium* (s.l.) *pataka* n.sp., holotype (TM 5473), ×2 – GS 11,155, Hampden Beach, N. Otago (Bortonian, Middle Eocene).

ticularly posteriorly, where in some shells a distinct pad borders the posterior groove. Outer lip thin, almost straight, slightly opisthocline. Anterior callus band rather narrow, bordered above by a fairly broad depressed band.

DIMENSIONS (mm):	Height	Maximum diameter
Holotype	6.5	2.2
Paratype	5.8	2.2

HOLOTYPE. TM 5474.

TYPE LOCALITY. GS 11,155, medium grey siltstone, low sea-cliffs immediately north of mouth of Kakaho Creek, Hampden Beach, North Otago, coll. P. A. Maxwell, 1970.

FORMATION. Hampden Formation (Bortonian, Middle Eocene).

LOCALITIES. GS 11,155 (holotype, 29 paratypes, mostly damaged anteriorly). GS 11,216, bluish-grey micaceous sandstone, mouth of gully entering South Branch, Waihao River, near "Waihao Downs" (Bortonian) (6 shells, smaller than Hampden shells and rather worn, but apparently conspecific).

REMARKS. The type species of *Ancillina* lacks columellar grooves and has the columella strongly oblique to the shell axis, giving it the appearance of a small *Melanopsis*, but in other respects it seems very similar to the two species described here. Superficially similar small ancillines in which the spire callus band does not cover the spire whorls, but which differ from *Ancillina* in having a blunt, callus-covered apex, are recorded from such mid-Cenozoic localities as McCullough's Bridge (Kaiatan, Upper Eocene) and Long Beach, Clifden (Altonian, Lower Miocene). A new genus-group taxon will be proposed elsewhere for these species.

#### *Ancillina wellmani* n.sp. (Fig. 50)

Shell similar in size to *Ancillina kakano* n.sp. but less slender, and more pointed posteriorly. Protoconch conical, of about 4 gently convex whorls, slightly narrower than in *kakano*. Teleoconch of about 3 whorls, more distinctly concave over the spire callus band than in *kakano*, giving the spire a weakly gradate outline. Spire callus band similar in width to that in *kakano*, but with posterior margin rather less well defined; parietal callus pad heavier than in *kakano*. Aperture essentially similar to that in *kakano*, but with a more heavily padded columella bearing stronger grooves.

DIMENSIONS (mm):	Height	Maximum diameter
Holotype	6.3	2.5
Paratype (GS 3159)	5.3	2.4

HOLOTYPE. TM 5475.

TYPE LOCALITY. GS 3159, blue-grey silty sandstone with limestone pebbles and common orbitoids, road cutting, Alexander Street, Greymouth, coll. M. Gage & H. W. Wellman, 1943.

FORMATION. Stillwater Mudstone, name proposed by Nathan (1974a, p. 32; 1974b, p. 436, 443) for the lower, fine-grained unit of the old "Blue Bottom" in the Greymouth district. The Alexander St locality has yielded a rich Clifdenian (Middle Miocene) micro- and macrofauna (Maxwell, in Nathan 1974a, p. 34-5; Hoskins, in Nathan 1974a, p. 37).

LOCALITIES. GS 3159 (holotype, 2 paratypes); GS 3160, Eason's Hill, Greymouth, coll. H. W. Wellman, 1943 (4 paratypes) (Clifdenian); GS 3271, mudstone above Cobden Limestone, Rocky Creek, Grey River, coll. H. J. Evans, 1944 (12 rather decorticated paratypes) (Clifdenian).

### Superfamily CONACEA Family CONIDAE

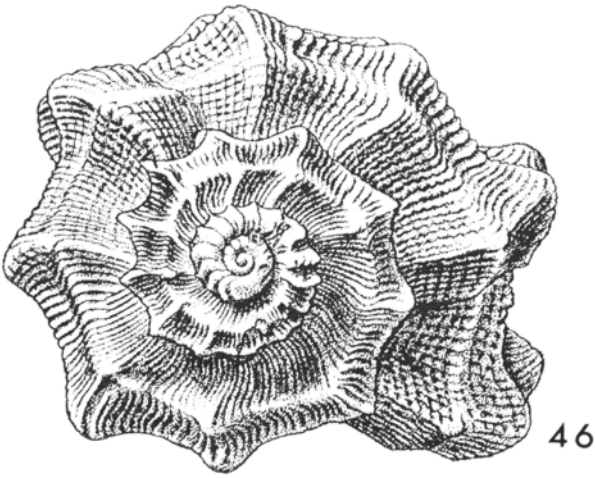
#### Genus *Conilithes* Swainson, 1840

1840 Treat. Malac.: 311.

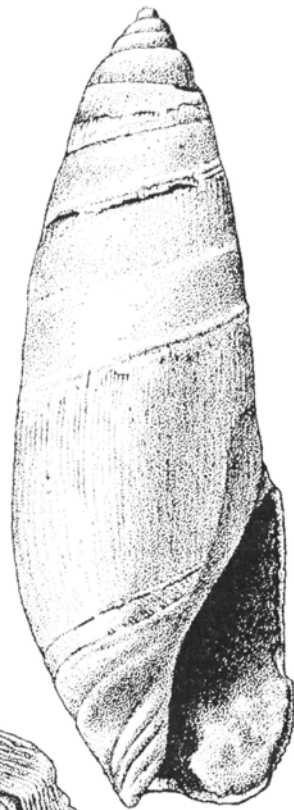
TYPE SPECIES (by monotypy): *Conus antediluvianus* Bruguière, 1792; Pliocene, Italy.  
See Fleming (1968, p. 123-4) for synonymy and discussion.

Hutton (1873, p. 10) gave brief diagnoses (without illustrations) of two species of fossil cones (*Conus ornatus* and *C. trailli*) from "Awamoa", a locality that refers to the Altonian siltstones and shell beds exposed along the banks and, on occasion, at the mouth of Awamoa Creek, North Otago. Tate (1890, p. 189) noted that *Conus trailli* Hutton was pre-occupied by "*C. Traillii* Adams", and proposed the replacement name *Conus huttoni*, but since this nomenclatural change was included in a paper on Australian Cenozoic molluscs it was overlooked by New Zealand workers for nearly 40 years. In the meantime, Suter (1914, p. 31) redescribed both species and figured the type specimens, using rather idealised pencil drawings originally made by John Buchanan under the direction of Sir James Hector. He referred *ornatus* to *Conospira* (as a subgenus of *Conus*) and *trailli* to *Hemiconus*, noting that there was a prior *Conus ornatus* Michelotti, but since he considered Michelotti's species to be a

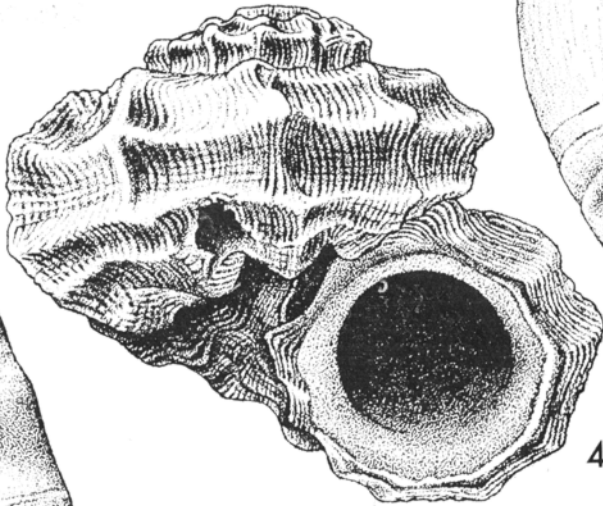
Fig. 46-50 (opposite page). 46-48, *Liotina turua* n.sp., holotype (TM 5470),  $\times 10$  - GS 9957, S. Branch, Waihao R. (Bortonian?, Middle Eocene). 49, *Ancillina kakano* n.sp., holotype (TM 5474),  $\times 16$  - GS 11,155, Hampden Beach, N. Otago (Bortonian, Middle Eocene). 50, *Ancillina wellmani* n.sp., holotype (TM 5475),  $\times 16$  - GS 3159, Alexander St, Greymouth (Clifdenian, Middle Miocene).



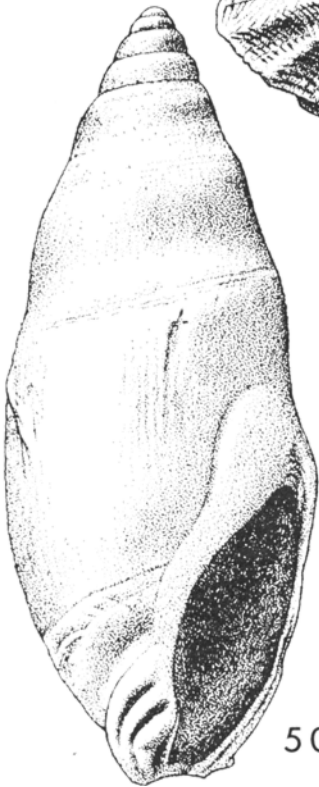
46



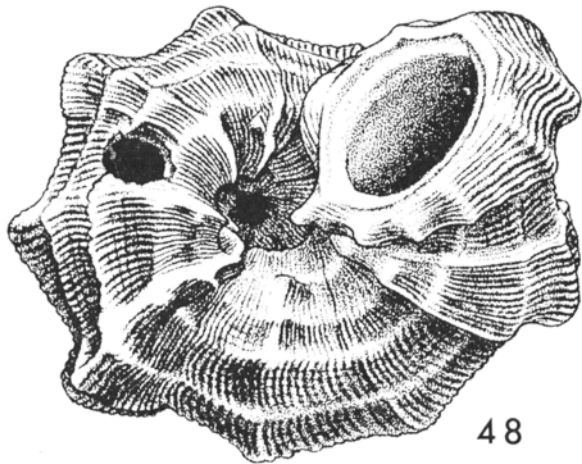
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48

*Hemiconus* he thought Hutton's name could stand. Somewhat later Suter had occasion to examine some cones collected by James Park from Pukeuri, North Otago (Altonian), and on the basis of the variation in strength of the peripheral nodules concluded that *C. ornatus* and *C. trailli* were synonyms (Suter 1917, p. 84). Suter decided to use the name *ornatus*, which has page priority, and—apparently overlooking his earlier statement about *Conus ornatus* Michelotti—referred Hutton's species to *Hemiconus*.

Finlay (1924a, p. 105) pointed out that since *Conus ornatus* Hutton is preoccupied by Michelotti's name, *C. trailli* should be used instead, assuming that the two Hutton names refer to the same species. Shortly afterwards Finlay (1924b, p. 498, footnote) discovered that *Conus trailli* Hutton was preoccupied by *C. trailli* A. Adams, 1855, and therefore introduced the new replacement name *Conospira* (misspelt *Cenospira*) *bimutata*. In yet another paper, Finlay (1927, p. 518–19) drew attention to Tate's much earlier replacement name for *Conus trailli* Hutton and transferred it to genus *Conospira*. Later workers have changed the generic name to *Conospirus* (Marwick 1931, p. 132) and *Conilithes* (Fleming 1966a, p. 70), but for some 45 years the specific epithet *huttoni* has been used, in one combination or the other, for the rather elegant cone that is so characteristic of Altonian faunas in North Otago and South Canterbury. My own work suggests that (a) *Conus ornatus* Hutton and *C. trailli* Hutton are distinct taxa; (b) *C. trailli* (= *C. huttoni*) is so far known only from the holotype; (c) since both *Conus huttoni* and *Conospira bimutata* were proposed as replacement names for *C. trailli*, the common 'Awamoan' cone is without a name.

*Conilithes wollastoni* nom. nov. (Fig. 40–3)

- 1873 *Conus ornatus* Hutton, Cat. Tert. Moll. Echin. N.Z.: 10 (not of Michelotti, 1847).  
 1914 *Conus (Conospira) ornatus*; Suter, Paleont. Bull. N.Z. Geol. Surv. 2: 31, pl. 2 fig. 14, pl. 17 fig. 7.  
 1917 *Hemiconus ornatus* (= *C. trailli*); Suter, Paleont. Bull. N.Z. Geol. Surv. 5: 84 (part; not *Conus trailli* Hutton, 1873).  
 1924 *Hemiconus trailli*; Finlay, Proc. Malac. Soc. London 16: 105 (part; not *Conus trailli* Hutton, 1873).  
 1957 *Conospirus huttoni* (Tate); Olson, in Gage, Bull. N.Z. Geol. Surv. (n.s.) 55: 126 (part; not *Conus huttoni* Tate, 1890 (= *C. trailli* Hutton, 1873, not of A. Adams, 1855)).

Shell of moderate size for genus, biconic; spire 0.25–0.3 × total height. Protoconch narrowly conical, of about 4 lightly convex, smooth whorls with obscure sutures; nucleus missing in all specimens seen. Teleoconch of up to 9 whorls, obtusely shouldered well below middle on spire; many specimens with shoulder just above lower suture. Sutural ramp flat

to gently concave, normally steeper in adults than in young shells; whorls sides sloping inward. Last whorl contracted gradually. Some shells almost straight from shoulder to anterior end, but most very gently convex over posterior two-thirds, straight and slightly oblique below, producing a weakly defined neck. Axial sculpture consisting of small, squarish, episthocline, peripheral nodules, usually extending a short distance below shoulder but scarcely encroaching on to sutural ramp; about 23–29 nodules on penultimate whorl. Interspaces usually similar in width to nodules. (See below for discussion of atypical specimens from Awamoa Creek, White Rock River, and Tengawai River.) Growth lines moderately prominent on sutural ramp, usually as narrow, sharp, slightly raised ridges, much weaker below shoulder. Spiral sculpture on spire whorls consisting of a few weak threads on sutural ramp and 2 or 4 much stronger, though still weak, threads on shoulder. Last whorl with about 11–14 well defined, narrow grooves confined to anterior half (or less), the anterior ones with narrow, convex interspaces, the others with broad, flat interspaces. Broad zone between topmost basal groove and shoulder occasionally showing 1 or 2 weakly defined grooves, otherwise smooth and polished. Aperture rather narrow, rectangular. Inner and outer lip almost parallel in apertural view. Inner lip typically with a callus pad at posterior end, bounded below by a short, horizontal groove. Outer lip thin, with a moderately deep, arcuate sinus on sutural ramp.

**DIMENSIONS OF HOLOTYPE** (mm). Height (lacking apex) 19.0, maximum diameter 8.2. The largest 'typical' specimen seen, from GS 9500, measures 39.1 × 14.5. Somewhat larger, though atypical, shells are present in GS 165; the largest measures 45.2 × 15.6.

**HOLOTYPE.** TM 5447; hypotypes TM 5476, 5477.

**TYPE LOCALITY.** "Awamoa" (Hutton 1873, p. 10). Early collections from Awamoa (5 km south of Oamaru) are from two distinct localities: (a) blue-grey siltstone with scattered macrofossils exposed at intervals along Awamoa Creek for about 800 m upstream from the mouth; (b) moderately cemented, richly fossiliferous sandstone either exposed on the beach near the mouth of the creek or represented by loose boulders. The former locality is still readily collectable, but the beach outcrops are nowadays almost continuously covered by sand. The preservation of the type of *Conus ornatus* and the lithology of the adhering matrix can be matched perfectly among shells collected from the beach outcrops and boulders, and there is little doubt that (b) is the type locality. The very large collection made by Alexander McKay in 1876 (GS 170)—which was "mainly from boulders between high- and low-water marks" (note in original N.Z. Geological Survey

register)—contains several hundred cones, most of which agree very closely with the holotype.

The origin of the fossils from "Awamoa" described or recorded by Hutton (1873) is uncertain, but it seems likely that they were presented to the Colonial Museum and N.Z. Geological Survey by Charles Traill. Park (1918, p. 87) states that Traill collected from Awamoa in 1869, although Traill does not state specifically where he collected the fossils he listed from the "Blue clay" (Traill 1870). That Hutton used the specific epithet *trailli* for species of *Hinnites*, *Crassatella*, *Conus*, and *Pleurotoma* from Awamoa is strong evidence that he was dealing with material collected by Traill.

**FORMATION.** Rifle Butts Siltstone (Altonian, Lower Miocene).

**LOCALITIES.** GS 170, Awamoa Beach and Creek — see note above (several hundred well preserved specimens, including juveniles). GS 9685, Pukeuri road cutting, North Otago (about 35 shells). GS 9500, excavation for a Council septic tank, South Oamaru c.2 km N of Awamoa Creek (22). GS 9700, Sutherlands, Tengawai River, South Canterbury (8). (All localities of Altonian age.)

Cones from several other Altonian localities in North Otago and South Canterbury differ from those listed above in having the peripheral nodules confined to the first four whorls or so of the teleoconch. In other respects they are very similar, and are here considered to be variants of *C. wollastoni*, although it is quite possible that they are distinct taxa. The strength of the peripheral nodules varies considerably in the Awamoa Beach, septic tank excavation, and Pukeuri samples, though among the large number of specimens examined none has the later whorls entirely devoid of them. (The variation in this feature in Pukeuri cones was noted by Suter (1917, p. 84) when he was seeking to demonstrate that *Conus ornatus* and *C. trailli* Hutton are conspecific — see below.) Shells from Ardgowan Shellbed and from GS 11,174 seem partially to bridge the gap between the two morphotypes, in that some have nodules persisting on to the 6th or 7th whorl; the available specimens are, however, rather worn.

Cones having the peripheral nodules absent from later whorls are known from the following Altonian localities: GS 9520, Awamoa Creek (3 specimens); ?GS 951, Target Gully Shellbed (2); GS 9521, Ardgowan Shellbed (5); GS 11,174, shellbed on hillside about 400 m NW of Ardgowan Shellbed (10); GS 5177, Tengawai River near Sutherlands (5); GS 165, White Rock River (7).

**REMARKS.** As noted above, the cone here named *Conilithes wollastoni* has long been thought to be conspecific with *Conus trailli* Hutton (= *C. huttoni* Tate), also described from "Awamoa". The holotype of *C. trailli* (Fig. 40) is a very incomplete shell

lacking much of the anterior end and having a large part of the front of the spire and upper part of the last whorl missing. The specimen originally measured about 25 × 10.5 mm, and so falls well within the size range of *C. wollastoni*. There are traces of weak peripheral nodules on the early spire whorls but not on later whorls, giving the shell a superficial resemblance to the smooth-shouldered cones here considered to be variants of *C. wollastoni* (see above). However, it differs from both forms of *wollastoni* in having distinct spiral grooves over the whole of the last whorl below the shoulder (assuming the grooves were present on the missing anterior portion also) (see Fig. 40). On this feature alone it falls well outside the observed limits of variation in *Conilithes wollastoni*, and is considered to represent a distinct taxon. Unfortunately, no other cones from North Otago or South Canterbury Altonian localities examined by me have comparable spiral sculpture, so our knowledge of *Conus huttoni* is extremely imperfect. The holotype of *huttoni* is perhaps merely an abnormal form of the species here named *Conilithes wollastoni*, but at present this is an untestable hypothesis, so it is expedient to recognise two distinct taxa.

The exact provenience of the holotype of *C. huttoni* is unknown. Matrix within the shell is soft, medium grey-brown siltstone, which suggests that it came from Awamoa Creek itself, but it is just as likely to have come from poorly fossiliferous siltstones interbedded with the shellbeds at Awamoa Beach (Park 1905, p. 511–12).

*Conilithes wollastoni* is probably related to the somewhat younger species *C. rivertonensis* Finlay, 1926 (? Clifdenian, Middle Miocene, Pourakino, Southland) and *C. oliveri* (Marwick, 1931) (Clifdenian, Middle Miocene, Muddy Creek, Gisborne district). Finlay (1926, p. 255) distinguished *C. rivertonensis* from *Conospira bimutata* Finlay (i.e., *Conilithes wollastoni*) by its "longer and more exsert spire and narrower shell". Judging by Finlay's illustration of the holotype (the only known specimen) the shoulder is situated much higher up on later spire whorls than in any specimen of *C. wollastoni*. *Conilithes oliveri* seems to be closer to *C. wollastoni*; Marwick (1931, p. 132) distinguished it "by the more slender form and steeply inclined shoulders", but these features vary widely in both species. A more reliable distinguishing feature is the protoconch, which is considerably larger and more narrowly conical in *oliveri* than in *wollastoni*.

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