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# GASTROPODA, SCAPHOPODA, CEPHALOPODA AND NEW BIVALVIA OF THE PALEOCENE PEBBLE POINT FORMATION, VICTORIA, AUSTRALIA

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The molluscan fauna of the Paleocene Pebble Point Formation, Otway Basin, Victoria, Australia, contains forty-six gastropods of which 21 are formally described; three scaphopods, of which two are new; two cephalopods; and thirty-seven bivalves, of which six are newly described. New species are *Rimula crepiduloides*, *Puncturella* (*Altrix*) *caminata*, *Calliotropis microglyptophorus*, *Bathymophila bystromphalata*, *Conominolia parvistrigulata*, *Cirsochilus pilulatus*, *Colposigma uniangulata*, *Euspira saxosulensis*, *Austrofusus?* *crassiaulatus*, *Levifusus quadrifunifer*, *Columbarium rugatoides*, *Mitra?* *rhytidata*, *Proximitra trirugulata*, *Zemacies procerior*, *Marshallaria tumefacta*, *Cosmasyrinx* (*Tholotoma*) *levicristata*, *Acteon petricolus*, *Tornatellaea quindecimlirata*, *Gilbertina meridiana*, *Priscaphander bullariformis*, *Spiratella advenulata*, *Compressidens laticornuata*, *Gadila laguncula*, *Austronucula?* *arenaria*, *Comitileda brachyrhynchoides*, *Electroma glessaria*, *Limea* (*Notolimea*) *multicostulifera*, *Jagolucina psephenata*, *Bornia flabellaris*, *Cuspidaria obbata*. *Superstes glomerabilis* is described from the Early Eocene Dilwyn Formation. The fauna has no close affinity with any other, consisting in the main of cosmopolitan genera. Endemic genera are *Botelloides* and *Eotrigonia*. Genera with a Southern Hemisphere affinity are the bivalves, *Lahillia*, *Neilo* (*Australoneilo*), and gastropods, *Colposigma*, *Marshallaria* and *Zemacies*.

**Keywords:** Gastropoda, Scaphopoda, Cephalopoda, Bivalvia, Late Paleocene, Otway Basin, Victoria, Australia, palaeoecology, biogeography, taxonomy, new taxa.

PALEOCENE MOLLUSCA occur in the Pebble Point Formation of the Otway Basin, Victoria, Australia (Baker 1943, 1950). The major portion of the bivalve fauna and the general features of the formation were described by Darragh (1994). The remainder of the molluscan fauna is described here and also some new bivalve species. The previous paper recorded 32 bivalve taxa. Here five extra taxa are recorded making a total of 37 bivalves. There are 46 gastropods, three scaphopods and two cephalopods. Of the gastropods, three are represented by such poor material that meaningful comparisons are not possible. Twenty-one gastropods are formally described and the others recorded in open nomenclature because there is insufficient material to permit formal naming.

One scaphopod, *Fissidentalium gracilicostatium*, was described by Singleton (1943), the other two are new. The two cephalopods, *Aturoidea distans* and *Eutrephoceras victorianum*, were described by Teichert (1943, 1947).

The material described here was collected from the Pebble Point Formation outcrops along the coast southeast of Princetown, Victoria. A few specimens are included from inland localities near Hamilton (Spencer-Jones 1971) and Casterton (Kenley 1951, 1971).

## PEBBLE POINT FORMATION MOLLUSCAN FAUNA

For convenience a complete checklist of the molluscs is given here.

- Gastropoda
  - Fissurellidae
    - Emarginula* sp.
    - Rimula crepiduloides* sp. nov.
    - Puncturella* (*Altrix*) *caminata* sp. nov.
  - Cocculinidae
    - Cocculina?* sp.
  - Trochidae
    - Calliotropis microglyptophorus* sp. nov.
    - Bathymophila bystromphalata* sp. nov.
    - Conominolia parvistrigulata* sp. nov.
    - Botelloides* sp.
  - Turbinidae
    - Guildfordia* (*Opella*)? sp.
    - Turbinidae gen. et spec. indet.
    - Cirsochilus pilulatus* sp. nov.
    - Pareuchelus* sp.
  - Turritellidae
    - Colposigma uniangulata* sp. nov.
    - Turritellidae gen. et spec. indet.

- Naticidae  
   *Euspira saxosulensis* sp. nov.  
   Naticid sp. a  
   Naticid sp. b  
 Ranellidae  
   *Sassia* sp.  
 Epitoniidae  
   *Opalia (Pliciscala?)* sp.  
   Epitoniidae gen. et sp. indet.  
 Buccinidae  
   *Austrofuscus crassiaulatus* sp. nov.  
   *Pseudofax* cf. *ordinarius* (Marshall)  
   *Levifusus quadrifunifer* sp. nov.  
 Fasciolaridae  
   *Fusinus* sp.  
 Turbinellidae  
   *Columbarium rugatoides* sp. nov.  
   *Microfulgur?* sp.  
 Mitridae  
   *Mitra?* *rhytidata* sp. nov.  
 Volutomitridae  
   *Proximitra trirugulata* sp. nov.  
 Olividae  
   *Pseudoliva (Buccinorbis)* sp.  
 Turridae  
   *Zemacies procerior* sp. nov.  
   *Cosmasyrinx (Tholotoma) levicristata* sp. nov.  
   *Marshallaria tumefacta* sp. nov.  
   *Marshallaria* sp. a  
   *Marshallaria* sp. b  
 Acteonidae  
   *Acteon petricolus* sp. nov.  
   *Acteon* sp. b  
   *Tenuiactaeon* sp.  
   *Tornatiellaea quindecimlirata* sp. nov.  
 Ringiculidae  
   *Gilbertina meridiana* sp. nov.  
 Cylichnidae  
   *Cylichnania* sp.  
   *Priscaphander bullariformis* sp. nov.  
 Mathildidae  
   *Tuba* sp.  
 Pyramidellidae  
   *Odostomia* sp.  
 Amathinidae  
   *Raulinia* sp.  
 Limicinidae  
   *Spiratella advenulata* sp. nov.  
 Incertae sedis  
   gastropod with canal  
 Scaphopoda  
 Dentaliidae  
   *Dentalium (Fissidentalium) gracilicostatum*  
   Singleton  
   *Compressidens laticornuata* sp. nov.
- Gadilidae  
   *Gadila laguncula* sp. nov.  
 Cephalopoda  
 Nautilidae  
   *Eutrephoceras victorianum* (Teichert)  
 Hercoglossidae  
   *Aturoidea distans* Teichert  
 Bivalvia  
 Nucleidae  
   *Lamellinucula pyrenoides* Darragh  
   *Nucula*  
   *Austronucula? arenaria* sp. nov.  
 Nuculanidae  
   *Comitileda brachyrhynchoides* sp. nov.  
   *Ledina paucigradata* Singleton  
   *Neilo (Australoneilo) cultrata* Darragh  
 Cucullaeidae  
   *Cucullaea psepheia* Singleton  
 Limopsidae  
   *Limopsis rupestris* Darragh  
 Glycymeridae  
   *Glycymeris* sp.  
 Pinnidae  
   *Pinna* sp.  
 Pteriidae  
   *Electroma glessaria* sp. nov.  
 Propeamussiidae  
   *Parvamussium* sp.  
 Pectinidae  
   *Delectopecten* sp.  
 Anomiidae  
   *Anomia* sp.  
 Limidae  
   *Limea (Notolimea) multicostulifera* sp. nov.  
 Gryphaeidae  
   *Pycnodonte (Phygraea)* sp.  
 Trigoniidae  
   *Eotrigonia paleocenica* Darragh  
 Lucinidae  
   *Jagolucina psephenata* sp. nov.  
   Lucinid A  
   Lucinid B  
   *Myrtea faseolata* Darragh  
 Thyasiridae  
   *Thyasira* sp.  
 Ungulinidae  
   *Felaniella (Zemysia)* sp.  
 Erycinidae  
   *Bornia flabellaris* sp. nov.  
 Cyamiidae  
   *Cyamiocardium silicula* Darragh  
 Astartidae  
   *Astarte (A.) notialis* Darragh  
 Carditidae  
   *Venericardia (Rotundicardia) petraea* Darragh  
   *Carditellopsis bellissima* Darragh

Lahilliidae  
*Lahillia australica* Singleton  
 Tellinidae  
*Bertinella lapidaria* Darragh  
 Corbiculidae  
*Corbicula?*  
 Veneridae  
*Dosinia (Dosinobia) saxatilis* Darragh  
*Callistina (Tikia)? scopulensis* Darragh  
 Corbulidae  
*Caryocorbula* sp.  
 Hiatellidae  
*Panopea* sp.  
 Cuspidariidae  
*Cuspidaria obbata* sp. nov.  
 Verticordiidae  
*Verticordia* sp.

### PALAEOECOLOGY

#### Trophic composition

The reservations about the validity of a trophic analysis of the bivalve fauna expressed by Darragh (1994) apply equally well here and are not repeated. Broad general groupings of the gastropods, scaphopods and cephalopods according to feeding type are as follow:

**Grazers.** *Emarginula* sp., *Rimula crepiduloides* sp. nov., *Puncturella (Altrix) caminata* sp. nov., *Calliotropis microglyptophorus* sp. nov., *Bathymophila bystromphalata* sp. nov., *Conominolia parvistrigulata* sp. nov., *Botelloides* sp., *Guildfordia (Opella)?* sp., Turbinid, *Cirsochilus pilulatus* sp. nov., *Pareuchelus* sp.

**Deposit, suspension feeders.** *Colposigma uni-angulata* sp. nov., *Turritellid*, *Spiratella advenulata* sp. nov.

**Carnivores.** *Euspira saxosulensis* sp. nov., Naticid sp. a, Naticid sp. b, *Sassia* sp., *Austrofusus crassiatulatus* sp. nov., *Pseudofax cf ordinarius* (Marshall), *Levifusus quadrifunifer* sp. nov., *Fusinus* sp., *Columbarium rugatoides* sp. nov., *Microfulgur?* sp., *Mitra? rhytidata* sp. nov., *Proximitra trirugulata* sp. nov., *Pseudoliva (Buccinorbis)* sp., *Zemacies procerior* sp. nov., *Cosmasyrinx (Tholotoma) levicristata* sp. nov., *Marshallaria tumefacta* sp. nov., *Marshallaria* sp. a, *Marshallaria* sp. b, *Acteon petricolus* sp. nov., *Acteon* sp. b, *Tenuiacteon* sp., *Tornatellaea quindecimlirata* sp. nov., *Gilbertina meridiana* sp. nov., *Cylichnania* sp., *Priscaphander bullariformis* sp. nov.

**Symbiotic carnivores.** *Opalia (Pliciscala?)* sp., Epitoniid.

**Parasites.** *Odostomia* sp., *Raulinia* sp., *Tuba* sp.

**Pelagic predatory carnivores.** *Eutrephoceras victorianum* (Teichert), *Aturoidea distans* Teichert.

On comparing the above groupings with the table of numbers of specimens studied, it will be seen that the three species of gastropods forming 45% of the specimens collected fall into two groups. Two of these species, *Cirsochilus pilulatus* and *Conominolia parvistrigulata* which form 33% of the specimens collected, are assumed to be grazers and the other, *Colposigma uniangulata*, a presumed deposit feeder or suspension feeder, comprises 12%. Carnivores make up the largest group of species, as distinct from specimens, as might be expected. Of these, opisthobranchs comprise 23% of all specimens collected. Naticids are the only carnivores which have left a trace of their activities. It is assumed that they are responsible for the holes drilled in the bivalves (Darragh 1994).

Unlike the bivalves, it has not been possible to find relevant gastropods in communities in Recent seas, except that *Turritella* is a characteristic member of some of the Recent Northern Hemisphere cool shallow water communities (Thorson 1957).

A taxonomic structure analysis of the fauna was undertaken using the criteria set out in Maxwell (1992) and the results compared with the standard profiles established by Hickman (1984) using percentages of major mollusc groups for palaeobathymetric interpretation. This technique is based on the assumption that the proportions for shelf, bathyal and abyssal depths have remained constant through time.

Table comparing percentages of major molluscan groups in modern faunas with those from the Pebble Point Formation (PPt)

	Shelf	Bathyal	Abyssal	PPt	PPt*
<b>Gastropoda</b>					
Archaeogastropoda	8	20	21	26	26
Mesogastropoda	34	23	21	17	20
Neogastropoda	41	52	41	30	30
Opisthobranchia	18	6	18	25	22
<i>Incertae sedis</i>				2	2
*pyramidellids included with Mesogastropoda					
<b>Bivalves</b>					
Protobranchs	6	28	40	16	
Pteromorphs	19	21	20	27	
Heterodonts	70	22	15	49	
Septibranchs	5	28	20	8	

The profile of the Pebble Point gastropod fauna does not resemble any of the Hickman profiles. In particular, the percentage of opisthobranchs is very high, even when the pyramidellids are included with the mesogastropods which was probably the case in Hickman's analysis. The Pebble Point gastropod profile comes closest to the Abyssal profile, which is at variance with the other evidence. The bivalve profile is closest to that of the shelf, which is in accordance with other evidence. Assuming that the Hickman profiles hold good for the southern hemisphere and for faunas of the earliest Tertiary, the discrepancy in the gastropod profile may possibly be explained by the extremely shallow nature of the Pebble Point Formation. Also the fauna is relatively small, about 83 species, with many species represented by only one specimen, so that the finding of even one specimen each of additional species has a considerable effect on the percentages.

#### ENVIRONMENT AND DEPOSITION

The Gastropoda and Cephalopoda add a little to what has been stated previously, viz. that the Pebble Point Formation was deposited in a shallow-water, open ocean environment (McGowran 1965; Darragh 1994). The presence of the pelagic gastropod *Spiratella* in reasonable numbers as well as two species of cephalopods suggest that the Pebble Point Formation was deposited in an open ocean environment. One worm and poorly preserved turbinid gastropod may have been living on a hard bottom and transported some distance before burial. There are no other undoubted hard bottom dwellers present. As with the bivalves, many of the gastropods show considerable abrasion, suggesting transport before burial. Other specimens are well preserved or delicate, such as *Spiratella*, which seems to indicate that they were buried without being transported in sediment to any significant extent.

#### BIOGEOGRAPHY

In the previous paper on the bivalves (Darragh 1994), I expressed caution concerning biogeographic analysis because of the uncertainties of the generic placement of some of the taxa, both in the Pebble Point fauna and in Paleocene faunas around the world. The same remarks apply equally, if not more so, to the gastropods.

Table showing numbers of specimens used in this study.

<b>Gastropods</b>	
<i>Cirsoschilus pilulatus</i> sp. nov.	266
<i>Colposigma uniangulata</i> sp. nov.	140
<i>Conominolia parvistrigulata</i> sp. nov.	112
<i>Gilbertina meridiana</i> sp. nov.	94
<i>Priscaphander bullariformis</i> sp. nov.	85
<i>Austrofuscus crassiaulatus</i> sp. nov.	60
<i>Tornatellaea quindecimlirata</i> sp. nov.	59
<i>Spiratella advenulata</i> sp. nov.	36
<i>Marshallaria tumefacta</i> sp. nov.	33
<i>Euspira saxosulensis</i> sp. nov.	32
<i>Calliotropis microglyptophorus</i> sp. nov.	24
<i>Bathymophila ? bystromphalata</i> sp. nov.	23
Naticid sp. a	22
<i>Rimula crepiduloides</i> sp. nov.	21
<i>Proximitra trirugulata</i> sp. nov.	20
<i>Mitra ? rhytidata</i> sp. nov.	16
<i>Cosmasyrinx (Tholotoma) levicristata</i> sp. nov.	13
<i>Fusinus</i> sp.	11
<i>Cylichnania</i>	11
<i>Odostomia</i>	10
<i>Puncturella (Altrix) caminata</i> sp. nov.	9
<i>Acteon petricolus</i> sp. nov.	6
<i>Levifusus quadrifunifer</i> sp. nov.	6
<i>Zemacies procerior</i> sp. nov.	6
<i>Columbarium rugatoides</i> sp. nov.	4
<i>Botelloides</i>	4
<i>Acteon</i> sp. b	3
gastropod sp.	3
Epitoniid	2
<i>Pseudofax</i> cf. <i>ordinarius</i>	2
<i>Pseudoliva (Buccinorbis)</i> sp.	2
<i>Marshallaria</i> sp. b	2
<i>Opalia (Pliciscala?)</i> sp.	2
<i>Marshallaria</i> sp. a	2
<i>Microfulgur ?</i>	1
<i>Pareuchelus</i>	1
<i>Guildfordia (Opella) ?</i>	1
Naticid sp. b	1
<i>Sassia</i> sp.	1
<i>Tuba</i> sp.	1
Turritellid	1
Turbinid	1
<i>Tenuiactaeon</i> sp.	1
<i>Cocculina ?</i> sp.	1
<i>Emarginula</i>	1
<i>Raulinia</i>	1
Total	1153
<b>Scaphopoda</b>	
<i>Dentalium (Fissidentalium) gracilicostatum</i>	64
<i>Compressidens laticornuata</i> sp. nov.	61
<i>Gadila laguncula</i> sp. nov.	10
Total	135
<b>Cephalopoda</b>	
<i>Eutrephoceras victorianum</i>	9
<i>Aturoidea distans</i>	15
Total	24

Four Paleocene faunal groupings were outlined by Darragh (1994).

1. Early Paleocene Boreal fauna.
2. Temperate to warm temperate fauna of Southern Europe and America.
3. Tropical Tethyan fauna.
4. Southern Hemisphere fauna.

Group four is not a homogeneous grouping when compared with the other three.

The new records of bivalves reported here include *Nucula*, *Glycymeris*, *Delectopecten*, *Bornia* (previously recorded as *Borniola*?) and *Corbicula*? which are all cosmopolitan genera in cool to warm temperate faunas. One subgenus, *Limea* (*Notolimea*), is known living off the east coast of Australia and from the Tertiary of Australia, New Zealand and Europe. The bivalves, therefore, are overwhelming cosmopolitan in aspect, though with little affinity to group 3.

The three scaphopod genera, *Fissidentalium*, *Compressidens* and *Gadila*, are all cosmopolitan in distribution, though in the case of *Compressidens*, the genus has not previously been recorded earlier than Miocene.

The two cephalopod genera, *Eutrephoceras* and *Aturoidea*, are cosmopolitan in the Paleocene.

Of the 46 gastropods, only 13 seem to be related to taxa found in the New Zealand Paleocene: *Conominolia*, *Guildfordia* (*Opella*?), *Colposigma*, *Euspira*, *Pseudofax*, *Microfulgur*?, *Zemacies*, *Marshallaria*, *Cosmasyrinx* (*Tholotoma*), *Acteon*, *Tornatellaea*, *Cylichnania*, *Priscaphander* and *Tuba* (Marshall 1917; Finlay & Marwick 1937). Of these *Conominolia*, *Euspira*, *Pseudofax*, *Acteon*, *Tornatellaea* and *Tuba* are considered to be cosmopolitan genera and *Guildfordia* (*Opella*) (known from the New Zealand Miocene) and *Microfulgur* are recorded from the Pebble Point Formation with considerable doubt. These occurrences do not suggest a particularly strong relationship with New Zealand Paleocene faunas (Marshall 1917; Finlay & Marwick 1937; Beu & Maxwell 1990).

The genera in common with the Antarctic Late Eocene are *Colposigma*, *Pseudofax*, *Zemacies*, *Acteon*, *Tornatellaea* and *Tuba* (Stilwell & Zinsmeister 1992), of which the latter three and *Pseudofax* are cosmopolitan in distribution.

*Puncturella* (*Altrix*), *Levifusus* and *Tenuiactaeon* were previously known only from southeastern North America. *Rimula* and *Pareuchelus* are representatives of the European elements of Group two.

The only undoubted Australian endemic genus recorded is *Botelloides*.

The Pebble Point Formation gastropods are thus dominated by cosmopolitan genera and show no particular faunal affinity with any other Paleocene fauna, a feature also shown by the bivalve fauna. Unlike the bivalve fauna, which had two 'southern hemisphere' endemics present, *Lahillia* and *Neilo* (*Australoneilo*), there are no such elements present in the gastropod fauna, unless *Colposigma*, *Marshallaria* and *Zemacies* be considered such. The typical Austral elements, the struthiolariids, are entirely lacking and do not make an appearance in the Australian fauna until the Early Miocene (Darragh 1991). A truly Australian endemic presence is also very weak. This element is only represented by the taxa, *Eotrigonia* and *Botelloides*. As with the bivalves, the gastropods indicate that an endemic Australian fauna was not established in shallow water in the Paleocene. Such a fauna was established by the Late Eocene, at which time New Zealand and Tethyan/Indo-Pacific immigrants were also present, all forming the basis of the modern Southern Australian molluscan fauna.

The conclusions about the molluscan fauna existing in the seaway opening up between Australia and Antarctica (Frakes et. al. 1987; Veevers et. al. 1991) based on the study of the bivalves are thus reinforced by the evidence of the gastropods. Cosmopolitan taxa with presumed pelagic larvae established themselves first as shown by the Pebble Point Formation fauna and by early Eocene time an endemic element had evolved in the fauna and immigrants from the New Zealand and Tethyan regions became established (Darragh 1985).

#### RELATIONSHIPS WITH OLDER AUSTRALIAN FAUNAS

The next oldest fauna known in Australia is that found in the Maastrichtian Miria Formation of Western Australia (Darragh & Kendrick 1994). None of the gastropods of this formation are related to those in the Pebble Point Formation, with the possible exception of the taxon recorded as *Fusinus* ?.

#### RELATIONSHIPS WITH YOUNGER FAUNAS

Though species of *Fissidentalium*, *Emarginula*, *Botelloides*, *Sassia*, *Columbarium*, *Cylichnania*, *Odotomia*, *Acteon* and *Spiratella* occur in the Late Eocene fauna of the Otway Basin, none of the Eocene species seem to be closely related

to the Paleocene. *Marshallaria* occurs in the Early Oligocene and *Conominolia*, *Zemacies*, *Tenuiactaeon* and *Raulinia* occur in the Late Oligocene. *Fusinus* (Eocene taxa are very small and probably not related), *Proximitra* and *Gadila* are known from the Miocene.

Pebble Point genera not found above the Paleocene in Australia include *Rimula*, *Puncturella*, *Guildfordia* (*Opella*)?, *Euspira*, *Colposigma*, *Pseudofax* (unless it proves to be a synonym of *Cominella*), *Levifusus*?, *Microfulgur*?, *Pseudoliva* (*Buccinorbis*), *Cosmasyrinx* (*Tholotoma*), *Tornatellaea*, *Gilbertina*, *Priscaphander* and *Tuba*. *Pseudoliva* (*B.*) may be ancestral to the Australian endemic genus *Zemira* (Early Oligocene–Recent).

Genera previously known only from the Australian Recent fauna are *Compressidens* and *Calliotropis*.

#### LOCALITIES

The details of the localities from which material was collected are as follows. The numbers are from the Museum of Victoria fossil locality register and are used throughout to save repetition. The locality details given in Darragh (1994) contained erroneous grid references for localities PL3003, PL3004, PL3176 and PL3177 which are corrected here.

##### *Pebble Point Formation*

PL3001 SE side of Dilwyn Cove, N side of Bell Point, 6 km SE of Princetown, from boulders on beach derived from 0.5 m grey (weathered) sandstone about 15 m above beach, Victoria, Princetown 903100.

PL3002 N side of Dilwyn Cove, S side of Pebble Point, G.S.V. loc. Aw6, 5 km SE of Princetown, Victoria, Princetown 900103.

PL3003 Cove between Buckley Point and Point Pember, 4.5 km SE of Princetown, Victoria, Princetown 896106.

PL3004 Shelly band about 10 m above beach, NW side of Buckley Point, 4 km SE of Princetown, Victoria, Princetown 894110.

PL3005 W end of large slip at Killara Bluff at top section, allot. 4, sect. A, Parish of Killara, Victoria, Dartmoor WD313291.

PL3006 Ironstone about 100 m above river, right bank of Glenelg River on Hazell Bank, Bahgallah, Victoria, Dartmoor WD324296.

PL3176 Cutting on Morgiana Road, about 5 km south of Wannon, left bank Grange Burn, Coleraine WD760267.

PL3177 South flowing gully running into right bank of Grange Burn, about 0.5 km south of Clayton's Road, 3.5 km southeast of Wannon, Coleraine WD729253.

##### *Dilwyn Formation, Rivernook Member*

PL3007 Middle of Rivernook Beach, SE side of where track comes down, 0.4 km SW of Rivernook Victoria, Princetown 888119.

##### *Dilwyn Formation, Trochocyathus band*

PL3009 G.S.V. loc. Aw7, Rivernook Beach, black silt beneath outcrop of indurated siltstone, 1.5 km SE of Point Ronald, 0.4 km due W of Rivernook, Victoria, Princetown 885123.

Most of the material described here was collected from fallen boulders at PL3001 and PL3003.

#### SYSTEMATIC DESCRIPTIONS

All specimens are housed in the Invertebrate Palaeontology Collection, Museum of Victoria, register prefix P, except for some specimens housed in the Western Australian Museum, register prefix WAM.

Abbreviations used in citing dimensions are L (length), H (height), HA (height of aperture), W (width).

##### Class Gastropoda

##### Family FISSURELLIDAE

##### *Emarginula* Lamarck, 1801

*Type species. E. conica* Lamarck, 1801 (= *fissura* Linnaeus, 1758) Recent, Europe.

##### *Emarginula* sp.

##### Fig. 1N

*Description.* Shell small for genus (2×1.8 mm), cap shaped, high, narrow, apex above posterior margin. Sculptured with coarse, widely spaced radial ribs, eight on half of shell, and nine strong, well spaced colabral costae, giving shell a coarsely fenestrate appearance. Selenizone bounded on each side by narrow ribs and filled with thin widely spaced septa.

##### *Dimensions*

Figured specimen P302610 L 2.0 W 1.8 (est.)

*Figured material.* Figured specimen P302610, collected T. A. Darragh, 18 January 1996.

*Occurrence.* PL3003 (1 specimen).

*Remarks.* The single specimen is a worn fragment, consisting of about half the shell. It is somewhat similar to *Emarginula grata* Makarenko, 1976, Paleocene, Ukraine, in its coarse sculpture, but does not have the quadrate outline of that species and the radial ribs are all of equal strength unlike *E. grata*. It is also similar to *E. beclardi* Cossmann, Paleocene, Belgium but has fewer colabral costae.

*Emarginula* occurs in the Danian and Paleocene of Europe (Ravn 1939; Glibert 1973; Makarenko 1976), the Paleocene of Pitt Island, New Zealand (Campbell et al. 1993) and has a cosmopolitan distribution from Eocene to Recent. In Australia the genus was previously known from Late Eocene through to Recent. The Eocene species have much finer sculpture than this Paleocene taxon.

#### *Rimula* Defrance, 1827

*Type species.* *Rimula blainvilli* Defrance, 1827, Eocene, France.

#### *Rimula? crepiduloides* sp. nov.

Figs 1K, M, 11B–C, E–F

*Description.* Shell small (1.7×2.6 mm), thin, cap shaped, smooth. Apex close to posterior margin. Slit closed anteriorly and with long hole on anterior 2/3 of shell. Small septum present. On largest specimen apex coiled round twice with shelf visible inside coiling.

#### *Dimensions*

Holotype P302613	H 1.3	L 2.6	W 1.5
Paratype P302612	1.2	2.0	
Paratype P302007	1.8 approx.		1.7 approx.

*Type material.* Holotype P302613 and Paratype P302612, collected T. A. Darragh, 18 January 1996; Paratype P302007, collected T. A. Darragh, 24 November 1992; Paratype P302008, collected T. A. Darragh, 13 December 1994.

*Type locality.* PL3003.

*Occurrence and material.* PL3003 (21 specimens).

*Remarks.* Of the 21 specimens only five are possibly adult specimens, the others are almost certainly juveniles. A large fragment showing portion of the slit band with hole indicates that most of the reasonably complete specimens are about half the size of the fragment if it were complete.

This species is similar in size and shape to *Rimula praeintorta* Rutot in Cossmann, 1913,

Paleocene of Mons, but *R. praeintorta* has fine spiral lirae covering the whole whorl. *R. crepiduloides* seems to be related to species of *Rimula* from the Eocene of the Paris Basin, but these do not show the shelf on published illustrations, possibly because it is very small and very close to the coiled apex and hence out of sight. *R. crepiduloides* looks similar to *R. nincki* Cossmann, Cuisian, Paris Basin, in shape and lack of sculpture, but the latter is said not to have a shelf. The largest of the Pebble Point specimens has the shelf hidden back in the coiled apex and is only visible because the side of the shell is broken.

#### *Puncturella* (Altrix) Palmer, 1942

*Type species.* *Fissurella altior* Meyer & Aldrich, 1886, Middle Eocene, United States of America.

#### *Puncturella* (Altrix) *caminata* sp. nov.

Fig. 1P–Q, Y

*Description.* Shell small, conical, high, ovate in outline, wider anteriorly. Apical perforation key-hole shaped. Sculptured with strong radiating ribs, slightly narrower than interspaces (28–31); thinner ribs between most primary ribs (17–26). Ribs bearing low tubercles where crossed by strong concentric growth lines. Internal septum present against anterior side of apical perforation.

#### *Dimensions*

Holotype P302006	L 1.5	W 1.1	H 0.8
Paratype P302614	1.9	1.3	1.2
Paratype WAM 94.404	1.9	1.3	1.2

*Type material.* Holotype P302006, collected T. A. Darragh, 13 December 1994. Paratype P302614, collected T. A. Darragh, 18 January 1996. Paratype WAM 94.404, collected G. W. Kendrick, 13 November 1984.

*Type locality.* PL3003.

*Occurrence and material.* PL3003 (6 complete specimens and three fragments).

*Remarks.* This species looks very like *Puncturella* (Altrix) *altior* (Meyer & Aldrich), Middle Eocene, southeastern USA, but is not so heavily sculptured. There does not seem to be any taxa quite like this in the Paleocene of Europe or New Zealand or the Eocene of Antarctica, having such a tall conical shape.

#### Family COCCULINIDAE

#### *Cocculina* Dall, 1882

*Type species.* *C. rathbuni* Dall, 1882, Recent, north-western Atlantic.



*Cocculina?* sp.

Fig. 1L, O

*Description.* Shell of average size for genus (2×1.5), high, cap-like, narrowly elongate-oval, with subparallel sides. Apex of shell situated slightly posterior of mid point. Protoconch broken, trace preserved on posterior.

*Dimensions*

Figured specimen P302609 H 2.0 W 1.5 L 2 (est.)

*Figured material.* Figured specimen P302609, collected T. A. Darragh, 18 January 1996.

*Occurrence and material.* PL3003 (1 specimen).

*Remarks.* The internal surface of the shell is not visible and preservation of the specimen is not good enough to be absolutely certain of the generic assignment. In addition many of the characters used to distinguish genera in this family are based on anatomical features not available in fossil material. This species bears some resemblance to *Cocculina cervae* Fleming, 1948, Recent, New Zealand and *C. pristina* Marshall, 1985, Miocene, New Zealand (Marshall 1985), but the Pebble Point specimen lacks any trace of radial sculpture. Members of the family have a cosmopolitan distribution, mostly in deep water, but *C. cervae* is found in depths ranging from 18 to 891 m. Living species feed on decayed wood. Fossil species have been recorded from the Miocene of Europe, West Indies and New Zealand. It is possible that some of the cap-shaped species recorded from the Palaeogene of Europe as *Acmaea* may belong in *Cocculina*.

## Family TROCHIDAE

*Calliotropis* Seguenza, 1903

*Type species.* *Trochus otto* Philippi, 1844, Pleistocene, Italy.

*Calliotropis microglyptophorus* sp. nov.

Fig. 2C, Q-T

*Description.* Shell conical, small (9–12 mm), nacreous of five to seven flat whorls with deeply impressed sutures. Protoconch of one whorl, smooth, somewhat globose, coiled at slight deviation to axis of shell.

First teleoconch whorl convex, bearing widely spaced costae, keel developing on second teleoconch whorl. Spire whorls with three prominent and widely spaced lirae; anterior lira most prominent and forming pronounced keel. Last whorl with three prominent lirae and anterior to keel another five widely spaced strong lirae.

Axial sculpture of regularly and widely spaced costae extending from posterior suture to keel, sharply nodulate where crossed by spiral lirae; costae not present anterior to keel on last whorl, 18–22 on last whorl. Microsculpture of dense, wavy, procline lamellae.

Aperture subcircular, internal lip smooth. No umbilicus.

*Dimensions*

Holotype P301884	H 9.5	W 6.2	HA 3.0
Paratype P301885	9.0	6.4	3.0
Paratype P301886	12.0	9.0	—

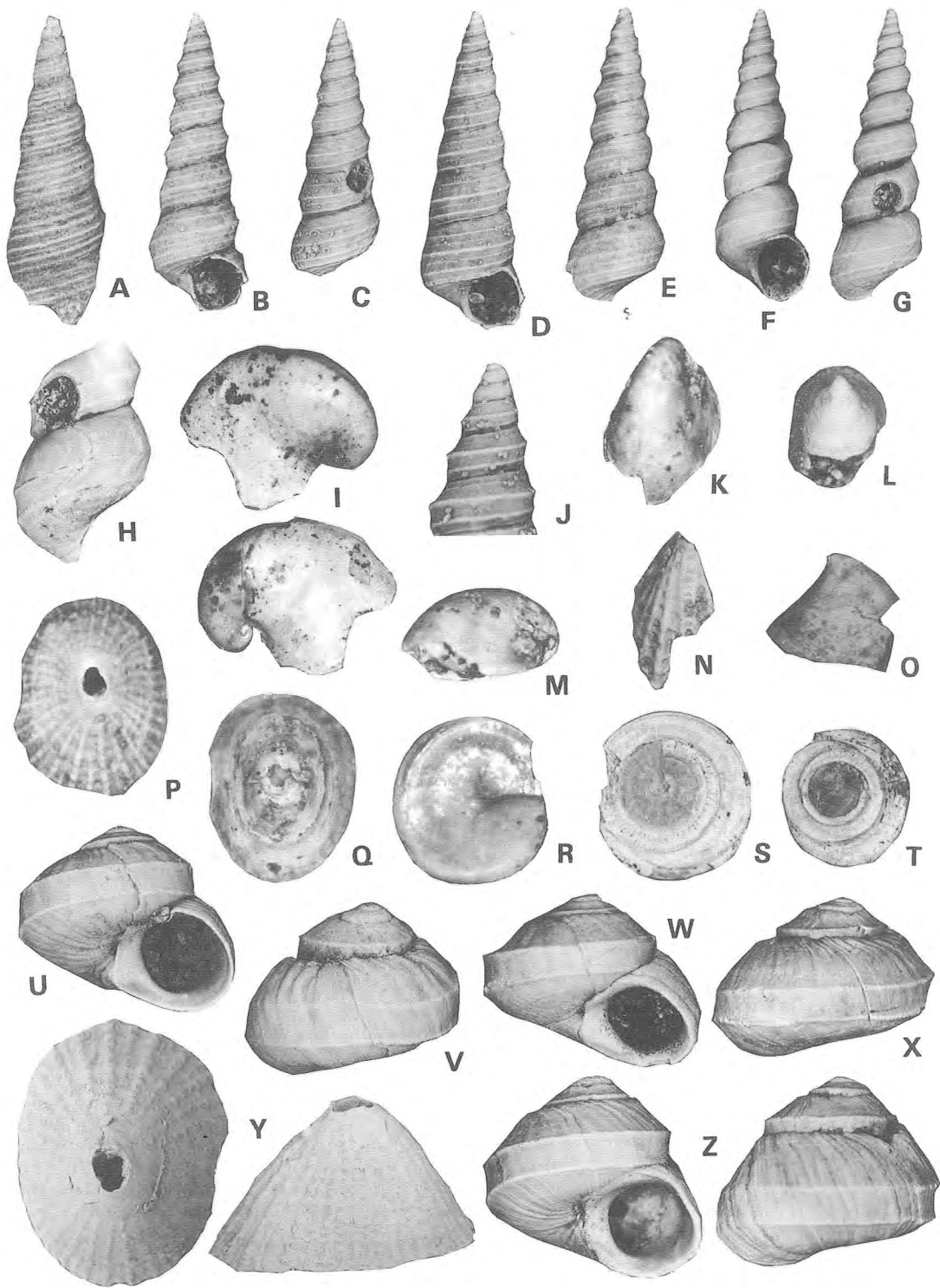
*Type material.* Holotype P301884, collected T. A. Darragh, 17 February 1981; Paratype P301885, collected T. A. Darragh, 8 May 1979; Paratype P301886, collected T. A. Darragh, 13 November 1984. Paratype WAM 94.409, collected G. W. Kendrick, 13 November 1984.

*Type locality.* PL3003.

*Occurrence and material.* PL3001 (7 specimens), PL3003 (14 specimens), PL3004 (1 specimen), Pebble Point area unlocalised (2 specimens).

*Remarks.* I follow Marshall (1979) in his concept of the genus, which includes species that range from having a wide umbilicus to those with no umbilicus.

*Fig. 1.* A, Turritellid, NMV P301904, figured specimen, PL3001, ×4.9. B–H, J, *Colposigma uniangulata* sp. nov. B–C, J, NMV P301902, paratype, PL3003, B, ×5.1, C, ×4.0, D, ×12.5. D–E, NMV P301901, holotype, PL3003, ×3.9. F–H, P301903, paratype, PL3003, F–G, ×4.1, H, ×6.8. I, K, M, *Rimula crepiduloides* sp. nov. I, NMV P302007, paratype, PL3003, ×15.0. K, M, NMV P302008, paratype, PL3003, ×20. L, O, *Cocculina?* sp., NMV P302609, figured specimen, PL3003, ×11.8. P–Q, Y, *Puncturella (Altrix) caminata* sp. nov., NMV P302006, holotype, PL3003, P–Q, ×20. Y, ×27. R–X, Z, *Cirsochilus pilulatus* sp. nov. R–S, possible operculum, NMV P301899, figured specimen, PL3003, ×13.2. T, possible operculum, NMV P301899, figured specimen, PL3003, ×14. U–V, NMV P301896, holotype, PL3003, ×6.6. W–X, NMV P301897, paratype, PL3003, ×6.6. Z, NMV P301898, paratype, PL3003, ×6.2.



The recent species of the genus have a cosmopolitan distribution in deep water, but the fossil record is very fragmentary. Species occur in the Paleocene of Denmark (*Calliotropis oedumi* (Ravn)), Early Oligocene of Germany, (*C. bundensis* (v Koenen)) and Pleistocene of Italy, (*C. otto* (Philippi)). In New Zealand, species have been found ranging in age from Late Eocene to Recent. *Calliotropis microglyptophorus* is somewhat similar *C. bundensis* (von Koenen), but that species has weak axial ribbing on the base and is much smaller. It also bears some resemblance to *C. acherontis* Marshall, Recent, Kermadec Islands and east coast of New South Wales and Queensland, but is much larger, not so narrow and has a more prominent midwhorl keel.

In Australia the genus is not known from younger Tertiary rocks, but several species have been recorded from deep water off the east coast of Australia by Jansen (1994).

### *Bathymophila* Dall, 1881

*Type species. Margarita euspira* Dall, 1881, Recent, Caribbean.

### *Bathymophila? bystromphalata* sp. nov.

Fig. 2A–B, F–H

*Description.* Shell small to medium size (7×7–1×1 mm), nacreous, conical, spire subgradate with very narrow horizontal ramp against posterior suture. Protoconch planorbid of two smooth whorls coiled with axis of shell. Whorl shoulder bearing closely spaced nodules.

Spiral sculpture of few thick lirae; two or three on spire whorls against anterior suture, on some specimens two weaker lirae between these and shoulder. Lirae on some specimens beaded. On some specimens weak lirae on ramp. Last whorl with up to five lirae clustered at whorl periphery. Base smooth. Umbilicus encircled by two lirae bearing close set nodules. No axial sculpture.

Aperture subcircular, outer lip prosocline. Inner lip with thin callus extending over and plugging umbilicus. Umbilical plug on many specimens damaged or missing.

#### *Dimensions*

Holotype P301887	H 8.8	W 9.8	HA 4.2
Paratype P301888	6.9	7.7	4.1
Paratype P301889	9.5	8.8	4.2

*Type material.* Holotype P301887, collected T. A. Darragh, 24 November 1992; Paratype P301888, collected T. A. Darragh, 28 February 1970; Paratype P301889, collected T. A. Darragh, 17 February 1981.

*Type locality.* PL3003.

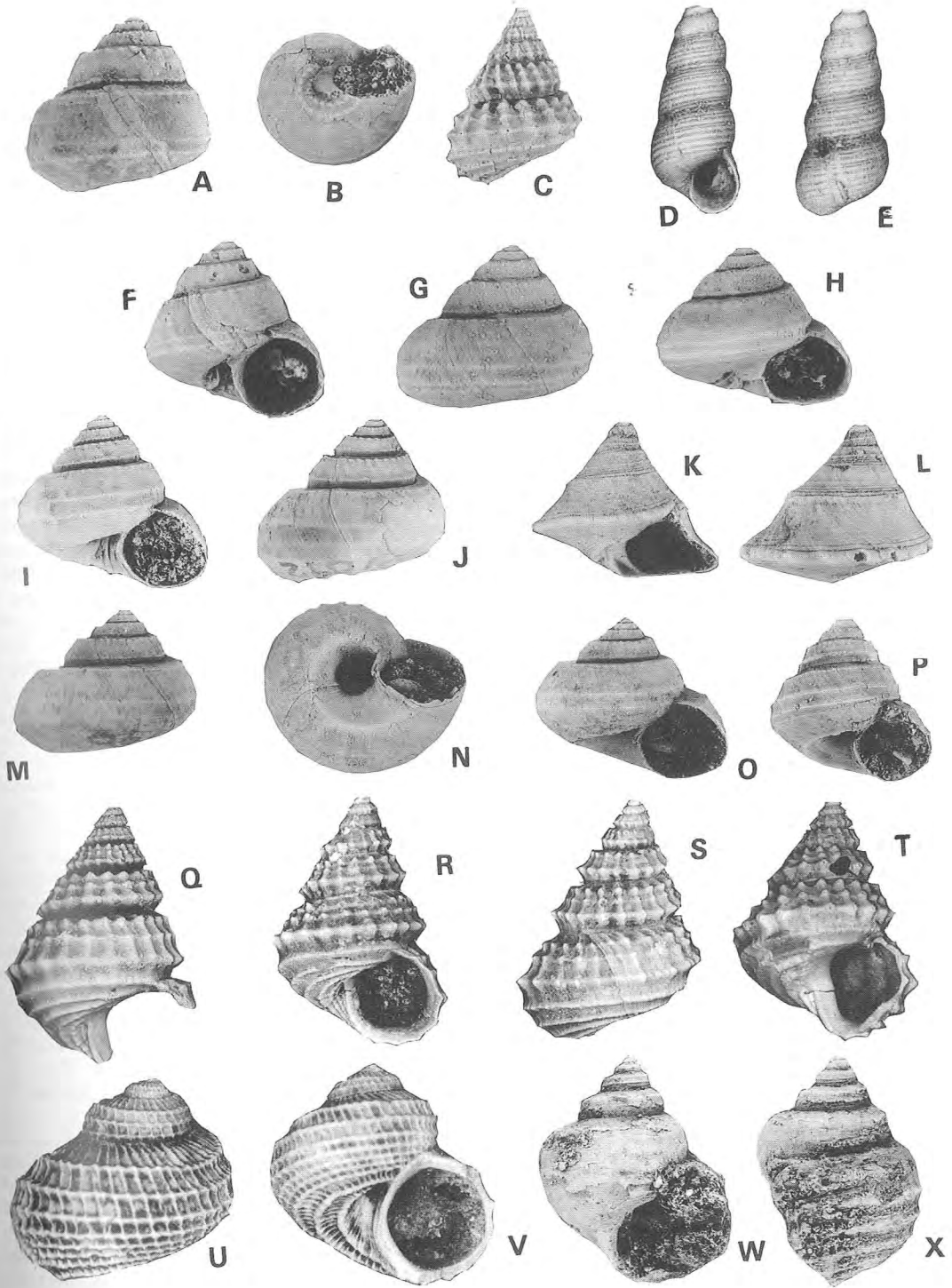
*Occurrence and material.* PL3001 (5 specimens), PL3003 (17 specimens), PL3001 (1 specimen).

*Remarks.* Most specimens are decorticated to some extent and have the umbilical plug missing. There is nothing like this taxon in the New Zealand Paleocene or Antarctic Eocene. I have placed this species provisionally in *Bathymophila* because it has considerable resemblance to *Bathymophila bairdi* (Dall, 1889), Recent, Florida.

*Bathymophila? bystromphalata* sp. nov. can be confused with *Conominolia parvistrigulata* sp. nov. because it has a somewhat similar shape, but the whorl shoulder of *B. bystromphalata* is strongly beaded up to the aperture, the umbilicus is plugged, and there are no numerous fine spirals, only three or four fine cords at the maximum convexity on the last whorl, the strongest of which is on the spire whorls close to the anterior suture. *Conominolia parvistrigulata* has a more gradate spire.

Bruce Marshall (in litt.) draw my attention to this species' similarity to species of *Lamellitrochus* Quinn, 1991. The shape is somewhat similar, but species of *Lamellitrochus* do not seem to have a plugged umbilicus and all species have lamellate axial riblets on the early teleoconch whorls which are lacking in *B. bystromphalata*. He also pointed out that *Trochus marginulatus* Philippi, 1844, Pleistocene, Sicily, is very similar in shape and sculpture. This latter species has an umbilicus

Fig. 2. A–B, F–H, *Bathymophila? bystromphalata* sp. nov. A, F, NMV P301889, paratype, PL3003, ×2.7. B, NMV P301888, paratype, PL3001, ×3.1. G–H, NMV P301887, holotype, PL3003, ×2.8. C, Q–T, *Calliotropis microglyptophorus* sp. nov. C, T, NMV P301885, paratype, PL3003, C, ×2.8, T, ×3.9. Q, NMV P301886, paratype, PL3003, ×3.3. R–S, NMV P301884, holotype, PL3003, R, ×3.9, S, ×3.8. D–E, *Botelloides* sp. NMV P301893, figured specimen, PL3003, ×6.6. I–J, M–P, *Conominolia parvistrigulata* sp. nov. I–J, NMV P301892, paratype, PL3003, ×2.2. M–O, NMV P301890, holotype, PL3003, M, ×2.2, N, ×2.4, O, ×2.3. P, NMV P301891, paratype, PL3001, ×2.4. K–L, *Guildfordia (Opella)?* sp., NMV P301894, figured specimen, PL3003, ×2.1. U–V, *Paraeuchelus?* sp., NMV P301900, figured specimen, PL3003, ×10.3. W–X, Turbinid indet., NMV P301895, figured specimen, PL3003, ×2.2.



×2.7.  
*otropis*  
 1886.  
 es sp.  
 I-J.  
 ×2.3.  
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which is almost but not completely filled with callus.

*B. bystromphalata* bears some resemblance to *Calliomphalus firketi* (Briart & Cornet), Paleocene, Mons but that species has more numerous lirae and the umbilicus is not plugged.

### *Conominolia* Finlay, 1926

*Atira* Stewart, 1927: 315.

*Garramites* Stephenson, 1941: 262.

*Type species.* *Heliacus conica* Marshall, 1917, Paleocene, New Zealand.

### *Conominolia parvistrigulata* sp. nov.

Fig. 2I–J, M–P

*Description.* Shell of average size for genus (7×7.5–13×11 mm), subconical, nacreous. Protoconch planorbid, smooth, coiled with axis of shell, about 1½ whorls. Teleoconch of five to six whorls. Spire whorls biangulate, flat between angulations, with prominent narrow flat horizontal sutural ramp. Edge of ramp beaded, whorl sloping steeply to second angulation slightly anterior of mid whorl. Whorl slope flat, sutures impressed, third angulation barely visible above anterior suture on some specimens. Last whorl with third angulation at anterior 2/3; whorl rounded and abruptly contracting to base.

Sculpture of fine spiral threads present over whole of spire whorls and last whorl including umbilicus; umbilicus smooth on some specimens. Beading on shoulder becoming weaker anteriorly. No axial sculpture.

Umbilicus wide, conical, bounded by prominent cord bearing coarse beading. Aperture broadly sub-lenticular, angulate on outer lip side, columella subcircular. Outer lip prosocline.

#### *Dimensions*

Holotype P301890	H 10.5	W 12.5	HA 5.5
Paratype P301891	11.4	10.1	5.8
Paratype P301892	12.0	13.0	6.5

*Type locality.* PL3003.

*Type material.* Holotype P301890, collected T. A. Darragh, 13 December 1994; Paratype P301891, collected T. A. Darragh, 16 February 1981; Paratype P301892, collected T. A. Darragh, 27 November 1972. Paratype WAM 94.405a, collected G. W. Kendrick, 13 November 1984.

*Occurrence and material.* PL3001 (33 specimens), PL3003 (69 specimens), PL3004 (7 specimens), Pebble Point area unlocalised (13 specimens).

*Remarks.* Shells of this species are easily decorticated and lose the thin outer shell surface which bears fine spiral threads, thus exposing the nacreous layer and so appearing smooth-surfaced. *Conominolia parvistrigulata* sp. nov. is very similar to the type species of the genus, *C. conica* (Marshall), but differs in having less rounded, flatter and more angular whorls, less developed spiral lirae (finer and more numerous), and beading only on the edge of the ramp. In shape *C. parvistrigulata* is more conical rather than turbiniform as in *C. conica*. *C. sulcatina* (Suter, 1917), late Oligocene, New Zealand, has fewer and much coarser spirals.

*Conominolia parvistrigulata* is very similar to *C. strigata* (Tenison Woods, 1879), late Oligocene–Middle Miocene, Victoria, but that species is about 2/3 the size of *C. parvistrigulata* for the same number of whorls. *C. parvistrigulata* has coarser beading on the whorl shoulder, and more spiral lirae which are well developed over the whole whorl, whereas on *C. strigata* the lirae are weaker on the base and may be obsolete. *C. strigata* also has much more rounded whorls than *C. parvistrigulata*, that is the angulations are not so well developed, and the aperture is D shaped rather than sublenticular as in *C. parvistrigulata*.

*Conominolia* ranges in age from Paleocene to Pliocene in New Zealand and in Australia it occurs in the Paleocene and at least from Late Oligocene to Middle Miocene. Species that seem to belong in *Conominolia* occur in the Paleocene (*Delphinula multilineata* Briart & Cornet, 1887) (Glibert 1973) and Eocene (*Turbo odontotus* Bayan, 1873) of Europe and the Late Cretaceous of the United States of America. Finlay & Marwick (1937) suggested that *Atira* Stewart, 1927, type species *Angaria ornatissima* Gabb, late Cretaceous, California, was a synonym of *Conominolia*. I agree with this suggestion. Sohl (1960a) placed several species from the late Cretaceous of the south-eastern United States in the genus *Calliomphalus* Cossmann, 1888 and synonymised *Garramites* Stephenson, 1941 with this genus. The type species, *Garramites nitidus* Stephenson (Stephenson 1941), is very similar to species of *Conominolia*, as are some of the species placed by Sohl in *Calliomphalus*. *Conominolia* is very similar to *Calliomphalus* but I retain the former as there are some differences. Compared with *Calliomphalus squamulosus* (Lamarck), type species of the genus, species of *Conominolia* are more angular in outline, have a gradate spire and the umbilicus is angular and bounded by a beaded cord. *Calliomphalus (Planolateralus) Sohl*, 1960 is somewhat intermediate between *Conominolia* and

*Calliomphalus* s.s., having a cone shaped spire and prominent axial sculpture like species of *Calliomphalus*. It is similar to *Conominolia* in having an angulate umbilicus bounded by a beaded cord. The two species placed by Sohl in *Calliomphalus* s.s. (*americanus* Wade and *nudus* Sohl) would be better placed in *Conominolia*.

#### **Botelloides** Strand, 1928

*Type species.* *Onoba bassiana* Hedley, 1911, Recent, southern Australia.

#### **Botelloides** sp.

Fig. 2D-E

*Description.* Shell of large size for genus (4.7 mm), elongate, pupiform, solid. Protoconch of about 1½ smooth planorbid whorls, coiled with axis of shell and merging imperceptibly with spire whorls. Teleoconch of 4½ regularly convex whorls. Spiral sculpture of eight coarse, close-set lirae, about 18 on last whorl. Axial sculpture of growth lines only.

Aperture subcircular, outer lip thin, thickened within. Columella covered with thick glaze.

#### *Dimensions*

Figured specimen P301893 H 4.7 W 2.0

*Figured material.* P301893, collected T. A. Darragh, 24 November 1992.

*Occurrence and material.* PL3003 (1 specimen and 4 fragments).

*Remarks.* Ponder (1985) has recorded the genus from late Eocene to Recent in Australia and this record extends the range to the Paleocene. Species are found living around the entire coast line of Australia in coarse substrates on the continental shelf or subtidally (Ponder 1985). The Pebble Point species has much more convex whorls than the younger species. Of the Australian species it is most similar to the late Eocene *Botelloides darraghi* Ponder, but it has much more convex whorls and stronger lirae. It has some resemblance to *Halistylus pupoideus* (Carpenter), Recent, California, a species of a related genus known from Pliocene to Recent (Hickman & McLean 1990).

### Family TURBINIDAE

#### **Guildfordia (Opella)** Finlay, 1926

*Type species.* *Astraea (Uvanilla) subfimbriata* Suter, 1917, Early Miocene, New Zealand.

#### **Guildfordia (Opella) ? sp.**

Fig. 2K-L

*Description.* Shell small (11 mm), coeloconoid, nacreous, wider than high. Protoconch of one smooth depressed whorl. Teleoconch of 5½ whorls, first 1½ whorls convex, next ½ whorl flatter, remainder of whorls concave.

Spiral sculpture of low broad lirae, somewhat irregularly distributed across whorl face and better developed closer to anterior suture. One strong thin lira beginning on second teleoconch whorl and extending for 2½ whorls, then fading on fifth whorl. Last whorl with prominent keel at edge of base bearing widely spaced low tubercles. Base with close-set low lirae extending from keel to centre of base.

Aperture trapezoidal, inner lip covered with thin glaze. Outer lip extended behind and in front of columella forming depression between it and columella.

#### *Dimensions*

Figured specimen P301894 H 11 W 3.4 HA 4

*Figured material.* Figured specimen P301894, collected T. A. Darragh, 24 November 1992.

*Occurrence and material.* PL3003 (1 specimen).

*Remarks.* This specimen is unlike any other known in Paleocene or Eocene strata. It has some resemblance to species placed in *Astralium*, *Pomaulax*, *Bellastrea* and *Uvanilla*, but lacks the granular ribs characteristic of most of these. The spire is also uniformly concave unlike many of those species in which each whorl is concave and the suture projects. It comes closest to *Guildfordia (Opella) subfimbriata* (Suter), type species of the genus, and *Guildfordia (Opella)* sp. (Beu & Maxwell, 1990) and so I have placed it provisionally here. It may possibly be ancestral to this taxon. There is nothing like it known from the later Tertiary of Australia.

#### Turbinidae, gen. et spec. indet.

Fig. 2W-X

*Description.* Shell small for the genus (14×16 mm), turbiniform with gradate spire. Protoconch of 2½ smooth whorls, first whorl depressed, other whorls convex. Teleoconch of four whorls with prominent shoulder, ramp flat to gently concave.

Spiral sculpture of six to seven weak lirae on ramp, one thick lira on shoulder and two prominent lirae anterior to it on spire whorls. Last whorl with

about 6 prominent lirae anterior to shoulder cord and two fine threads between each pair of cords. Aperture not preserved. No umbilicus.

*Dimensions*

Figured specimen P301895 H 16 W 14

*Figured material.* Figured specimen P301895, collected T. A. Darragh, 17 February 1981.

*Occurrence and material.* PL3003 (1 specimen).

*Remarks.* The single specimen is badly decorated on the anterior whorls and the aperture is broken away, so that generic assignment is not possible. In shape and sculpture it looks very like *Turbo radiosus* Lamarck, Eocene, Paris Basin. There is nothing like it recorded from the Paleocene of Europe or New Zealand.

Species of *Turbo* sensu lato are known from the Early Miocene and later in southeastern Australia, but all have less gradate spires, more rounded whorls and prominent beading on the spiral sculpture.

**Cirsochilus** Cossmann, 1888

*Type species.* *Delphinula striata* Lamarck, 1804, Eocene, Europe.

**Cirsochilus pilulatus** sp. nov.

Fig. 1R–X, Z

*Description.* Shell small, of average size for genus (5.5×4.9–6.2×4.5 mm), solid, turbinate, depressed, nacreous within. Protoconch of about one smooth whorl, not differentiated from teleoconch whorls. Whorls three to four, angulate; each teleoconch whorl almost enveloped by succeeding whorl. Spire whorls with prominent shoulder developed into keel. Last whorl with second anterior keel.

Base of shell on some specimens with three or four widely spaced spiral grooves. Axial sculpture merely of growth lines, somewhat irregularly developed; on some specimens growth lines form ridges against posterior suture.

Aperture circular. Outer lip oblique; inner lip with callus spreading over small umbonal chink.

Possible operculum, calcareous, subcircular, paucispiral, calcified pad smooth, centre of operculum missing (possibly corneous, multispiral).

*Dimensions*

Holotype P301896	H 4.2	W 5.0	HA 2.2
Paratype P301897	3.9	5.0	2.0
Paratype P301898	5.5	5.5	2.2

*Type material.* Holotype P301896, Paratype P301897, Paratype P301898, Figured opercula P301899, all collected T. A. Darragh, 13 December 1994. Paratype WAM 94.406, collected G. W. Kendrick, 13 November 1994.

*Type locality.* PL3003.

*Occurrence and material.* PL3001 (29 specimens), PL3003 (214 specimens), PL3004 (18 specimens), Pebble Point area unlocalised (5 specimens).

*Remarks.* *Cirsochilus pilulatus* sp. nov. is very similar to the type species, *Cirsochilus striatus*, but that species has numerous spiral lirae in addition to the keels, as well as a wider umbilicus. *C. pilulatus* has only an umbilical chink which is covered in most specimens. *Tipua* Marwick, type species *Submargarita tricincta* Marshall, Eocene, New Zealand, scarcely differs from *Cirsochilus* and the cited differences, lack of a border to the outer lip, a smaller umbilicus, and the spreading parietal callus, seem minor. *C. pilulatus* is similar in morphology to *Tipua tricincta* but lacks the spiral threads between the keels of that species.

The genus is widespread in the Eocene and Oligocene of Europe and the Eocene of the United States of America, but has not been recorded from the Eocene of Antarctica, nor from the Paleocene of New Zealand, northern Europe or the United States of America. It occurs in the Eocene (assuming *Tipua* is a synonym) and Miocene of New Zealand. It has *C. pilulatus* is very similar to *Solariella parva* Makarenko, Paleocene, Ukraine, but that species has a wider umbilicus.

**Pareuchelus** Boettger, 1907

*Type species.* *Euchelus (Pareuchelus) excellens* Boettger, 1907, Miocene, Hungary.

**Pareuchelus ? sp.**

Fig. 2U–V

*Description.* Shell small (3.4×3.3 mm), turbinate. Protoconch damaged, of one or two whorls, coiled in axis of shell. Teleoconch whorls three with narrow sutural ramp bounded by sharp shoulder.

Spiral sculpture of prominent sharp well spaced lirae, one at shoulder, one at anterior suture and one midway between these two. Nine lirae on last whorl, two closest to umbilicus stronger than others. Axial sculpture of narrow sharp costae, slightly narrower than lirae, extending from suture

to suture on spire and on last whorl from suture into umbilicus; slightly nodulate on crossing lirae.

Aperture subcircular, broken. Umbilicus prominent, deep.

*Dimensions*

Figured specimen P301900 H 3.3 W 3.4

*Figured material.* Figured specimen P301900, collected T. A. Darragh, 2 December 1985.

*Occurrence and material.* PL3003 (1 specimen).

*Remarks.* This species resembles *Pareuchelus lefevrei* Rutot in Cossmann, 1915, Paleocene, Mons, but it is squatter and the axial costae are not so strong. It is also very similar to *P. cancellatocostatus* (Sandberger), Rupelian, Germany, but it has a small umbilicus rather than the mere umbilical chink present in that species. The genus occurs in central Europe from Paleocene to Middle Miocene. It is not known from northern Europe.

## Family TURRITELLIDAE

### *Colposigma* Finlay & Marwick, 1937

*Type species.* *Colposigma mesalia* Finlay & Marwick, 1937, Paleocene, New Zealand.

The terminology used in the description of the following species is that of Marwick (1957).

### *Colposigma uniangulata* sp. nov.

Fig. 1B-H, J

*Description.* Shell of average size for genus (3.7×11.8–3.9×13.5 mm) with narrow prominently keeled spire whorls. Protoconch polygyrate of 3½ smooth, swollen, very convex whorls coiled with axis of shell. Teleoconch of nine to ten whorls. First teleoconch whorl with two spirals (B and C), B central and C anterior develop together, B stronger and develops rapidly into prominent keel. Second whorl with spiral A appearing against posterior suture and spiral D against anterior suture. Third whorl on some specimens with very weak lirae developing between A and B. Fourth whorl with fine spiral appearing between C and D. Base with three to four fine lirae anterior to D. Last whorl on most specimens regularly rounded and not keeled.

Apertural sinus deep, apex between posterior suture and mid whorl.

*Dimensions*

Holotype P301901	H 11.5	W 3.8
Paratype P301902	9.5	3.0
Paratype P301903	11.0	3.6

*Type material.* Holotype P301901, Paratype P301902, both collected T. A. Darragh, 24 November 1992; Paratype P301903, collected T. A. Darragh, 8 March 1977.

*Type locality.* PL3003.

*Occurrence and material.* PL3001 (42 specimens), PL3003 (91 specimens), PL3004 (8 specimens).

*Remarks.* Specimens are very common in the formation but it is difficult to collect unbroken specimens. Most specimens show signs of abrasion.

The genus was first described from New Zealand and ranges there from Paleocene to Eocene. It is not known from the Eocene in Australia. Marwick (1957) recognised that *Colposigma* occurred in Australia, based on material from the Pebble Point Formation. Compared with *Colposigma mesalia* Finlay & Marwick, *C. uniangulata* sp. nov. has more angulate whorls, because the central spiral (B) is more prominently developed giving the shell an angular appearance. *C. uniangulata* has five or more spirals not four as in *C. mesalia*. Neither *C. plebeia* Marwick, 1960 nor *C. imparicincta* Finlay & Marwick, 1937 are keeled and *C. uniangulata* bears no resemblance to them.

Turritellid gen. & spec. indet.

Fig. 1A

*Description.* Shell turriculate with incised sutures. Protoconch missing. Teleoconch whorls convex. Spiral sculpture of five lirae. Aperture broken, growth lines not visible.

*Dimensions*

Figured specimen P301904 H 9.5 W 3.5

*Figured material.* Figured specimen P301904, collected T. A. Darragh, 21 November 1970.

*Occurrence.* PL3001 (1 specimen).

*Remarks.* The single specimen is broken and worn, so it is not possible to trace the development of the spirals. Superficially the specimen has some resemblance to specimens of *Colposigma mesalia* and also to species of *Spirocolpus*, but the preservation is so poor that detailed comparison is not possible.

## Naticidae

### *Euspira* Agassiz, 1837

*Type species.* *Natica glaucinoides* Eocene, Europe.



*Euspira saxosulensis* sp. nov.

Fig. 3O–R, V

**Description.** Shell small, of average size for genus (11×11.2–17×17.5 mm) solid, smooth, globose. Spire somewhat squat and subgradate. Protoconch of one whorl, depressed, not separated from spire whorls. Teleoconch of four whorls, regularly convex. Last whorl very large.

Aperture ovate, outer lip rounded, moderately prosocline, inner lip with very little callus. Umbilicus open, no funicle or callus.

**Dimensions**

Holotype P301906	H 12.0	W 10.5	HA 9.5
Paratype P301907	12.1	11.5	7.5
Paratype P301908	17.0	16.0	14.0

**Type material.** Holotype P301906, collected T. A. Darragh, 2 December 1985; Paratype P301907, F. A. Cudmore Collection 1941–46; Paratype P301908, collected T. A. Darragh, 21 November 1970.

**Type locality.** PL3003.

**Occurrence and material.** PL3001 (10 specimens), PL3003 (15 specimens), PL3004 (6 specimens), Pebble Point area unlocalised (1 specimen).

**Remarks.** This and the next two species are probably responsible for the bore holes present in the bivalves from this formation (Darragh 1994). Specimens are reasonably common but in most cases very poorly preserved, owing to decortication of the shell.

This species is very similar to *Euspira fyfei* (Marwick, 1924), Paleocene, New Zealand, but *E. saxosulensis* is much smaller, does not have a sutural channel and the whorls are not quite so regularly convex and swollen. Somewhat similar species occur in the Paleocene of Copenhagen, Mons and United States of America. *E. saxosulensis* is similar in shape to *E. cantiana* Wrigley, 1949, Paleocene, England, but has less callus on the columella.

## Naticid sp. a

**Description.** Shell of average size (13×15–

20×22 mm), spire somewhat conical. Whorls slightly depressed at posterior suture. Aperture D shaped, internal lip of aperture straight, callus well developed. Umbilicus open, covered a little by callus. No funicle.

**Occurrence.** PL3001 (21 specimens), PL3004 (1 specimen).

**Remarks.** The available material is poorly preserved and consists mostly of small juvenile specimens. It is not possible to determine if more than one taxon is present. The specimens are readily separated from those of *Euspira saxosulensis* sp. nov. by the conical spire and presence of considerably more callus on the columella.

## Naticid sp. b

**Description.** Shell small (11.7×9.0 mm), solid, smooth, somewhat auriform. Spire scarcely projecting. Teleoconch of about 4 whorls. Aperture D shaped. Parietal callus confined to posterior portion of inner lip. Umbilicus wide, no funicle.

**Dimensions**

P301909	H 9	W 11.7
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**Occurrence and material.** PL3004 (1 specimen).

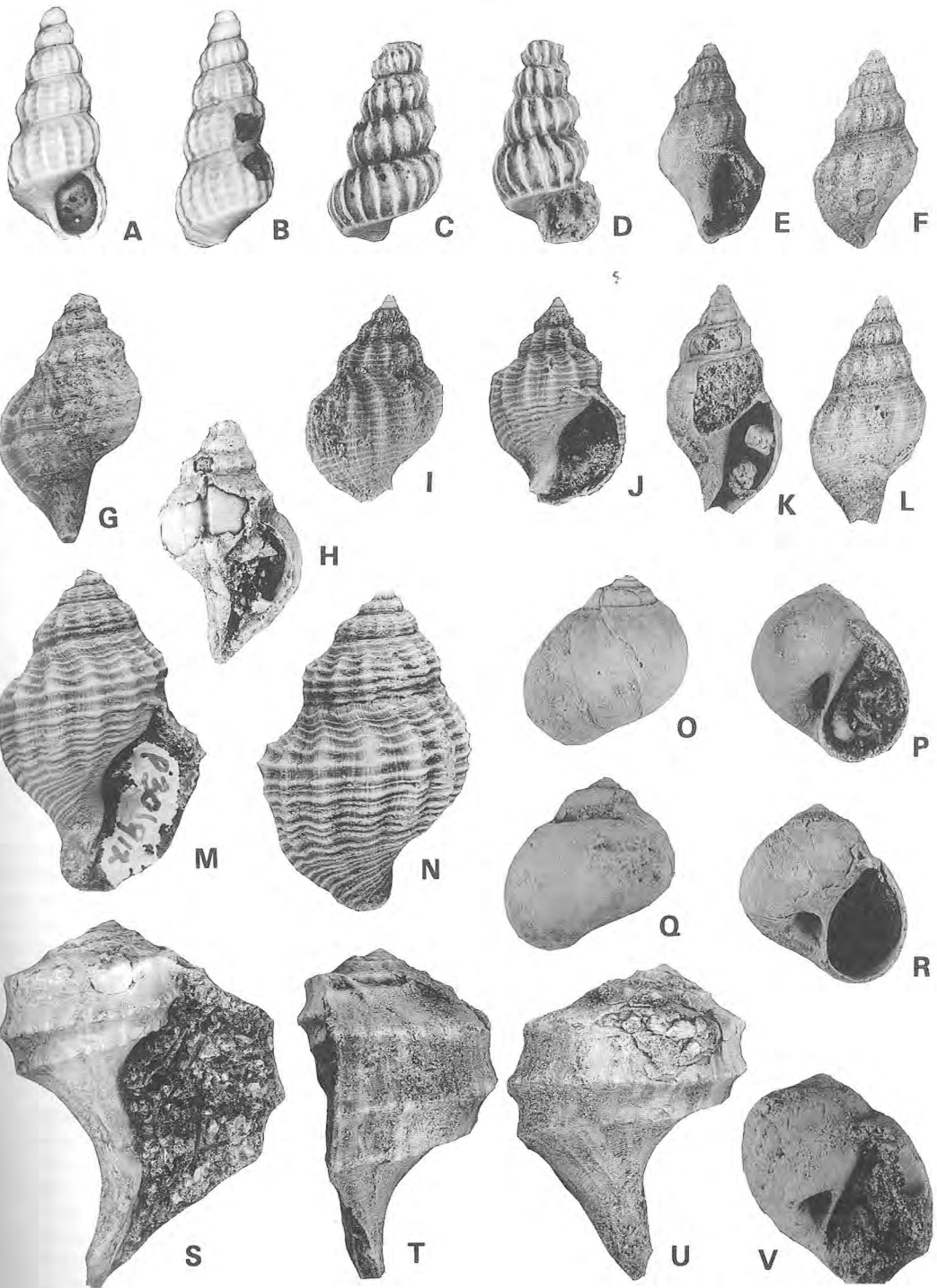
**Remarks.** The specimen is not well preserved, being slightly decorticated as are many specimens from this locality. It has a large naticid borehole on the ventral side of the last whorl. In shape this taxon resembles species of *Eunaticina* but species of that genus possess spiral sculpture which may not be preserved on this specimen.

## Family RANELLIDAE

*Sassia* Bellardi, 1872

**Type species.** *Triton apenninica* Sassi, 1872, Miocene–Pliocene, Italy.

Fig. 3. A–B, Epitoniid, NMV P301911, figured specimen, PL3003, ×10.8. C–D, *Opalia (Pliciscala)?* sp., NMV P301910, figured specimen, PL3004, ×3. E–F, K–L, *Pseudofax* cf. *ordinarius* (Marshall). E–F, NMV P98418, figured specimen, ×2.3. K–L, NMV P301914, figured specimen, PL3001, ×2.3. G–H, *Sassia* sp., NMV P301905, figured specimen, PL3001, ×1. I–J, M–N, *Austrofusus? crassiaulatus* sp. nov. I–J, NMV P301913, paratype, PL3001, ×2.4. M–N, NMV P301912, holotype, PL3001, ×2.2. O–R, V, *Euspira saxosulensis* sp. nov. O–P, NMV P301906, holotype, PL3003, ×2.2. Q–R, NMV P301907, paratype, Pebble Point, ×2.1. V, NMV P301908, paratype, PL3001, ×1.8. S–U, *Levifusus quadrifunifer* sp. nov., NMV P301915, PL3001, S, ×0.64, T–U, ×0.55.



)? sp.  
 NMV  
 ia sp.  
 NMV  
*Euspira*  
 Pebble  
 NMV

*Sassia* sp.

Fig. 3G-H

*Description.* Shell of average size for genus (20×37 mm), fusiform with carinate whorls. Protoconch not preserved. Teleoconch whorls with prominent shoulder with edge situated close to anterior suture. Last whorl with second weaker angulation slightly anterior to shoulder, contracted abruptly anteriorly and produced into short twisted canal. Varices long, narrow, at each  $\frac{2}{3}$  of whorl, only two visible, one at aperture and second near beginning of last whorl.

Spiral sculpture of narrow widely spaced fine lirae over whole whorl and two thicker cords, one on shoulder edge and second anterior to it forming a slight keel on last whorl. Axial sculpture of low costae, virtually obsolete on shoulder ramp, but developed into prominent tubercles where they cross spiral cords, not present on last whorl anterior to shoulder.

Aperture oval, outer lip thickened into varix, produced anteriorly into short, left deflected siphonal canal. Inner lip with callus and numerous ridges on columella.

*Dimensions*

Figured specimen P301905 W 20 H 37 est.

*Figured material.* Figured specimen P301905, collected T. A. Darragh, 28 November 1972.

*Occurrence and material.* PL3001 (1 incomplete specimen).

*Remarks.* *Sassia* has a cosmopolitan distribution. In Europe it is known from Paleocene to Pliocene. In New Zealand it is known from Eocene to Recent. European species of *Sassia* have rounded whorls, whereas the Pebble Point species has angular whorls. In this respect it resembles *Monocirsus carinulatus* Cossmann, Lutetian, Paris Basin, but that species has only one varix and the Pebble Point species has a second anterior keel on the last whorl lacking on *M. carinulatum*. Species of *Sassia* are common in southeastern Australia ranging from Eocene to Recent. In size and shape *Sassia* sp. resembles *Sassia (Austrotriton) annectens* (Tate) from the Middle Miocene of Victoria. It may be ancestral to *Sassia oligostira* (Tate) from the Late Eocene of Victoria and South Australia. It differs from this species by being larger and having a well developed keel on the shoulder and the cord anterior to the shoulder is much stronger than the equivalent lira on *S. oligostira*.

*Sassia* sp. has been recorded from the Late Paleocene of Pitt Island, New Zealand (Beu &

Maxwell 1990), but that species does not have the prominent shoulder of the Pebble Point taxon and has relatively well developed axial sculpture.

## Family EPITONIIDAE

*Opalia (Pliciscala)* Boury, 1887

*Type species.* *Scalaria gouldi* Deshayes, 1861, Eocene, Paris Basin.

*Opalia (Pliciscala)* ? sp.

Fig. 3C-D

*Description.* Shell of moderate size for genus (5×10+ mm), elongate. Protoconch and early spire whorls missing. Whorls strongly convex, sutures impressed. Basal disc well developed on last whorl.

Axial sculpture of prominent narrow, well raised, slightly sinuous costae, extending from suture to suture on spire whorls and on last whorl terminating at prominent spiral cord bounding basal disc; 17 costae on last whorl. Spiral sculpture of very weak threads.

Aperture circular; outer lip continuous truncated at base, produced anteriorly against columella.

*Dimensions*

Figured specimen P301910 H 10+ (broken) W 5

*Figured material.* Figured specimen P301910, collected T. A. Darragh, 20 October 1971.

*Occurrence and material.* PL3003 (1 whorl fragment), PL3004 (1 specimen).

*Remarks.* There is nothing like this taxon in the New Zealand Paleocene or Late Eocene of Antarctica. Somewhat similar species have been recorded from the Paleocene of Belgium and Ukraine (*Acrilla tournoueri* (Briart & Cornet) and *Opalia wateleti* (Briart & Cornet)) (Makarenko 1976); from the Paleocene of Greenland (*Opalia* sp.) (Kollmann & Peel 1983); and from the Early to Late Oligocene of Germany *Opalia (Pliciscala) exigua* (von Koenen) and *O. (P.) pusilla* (Philippi) (von Koenen 1891; Janssen 1978).

*Opalia (Pliciscala)?* sp. is somewhat similar to *Opalia (O.?) fistulosa* Sohl (1964), Late Cretaceous, southeastern United States of America, but the Pebble Point species has much more rounded whorls and impressed sutures. It is similar to *Opalia australis*, type species of the genus, but the whorls are more convex, hence the sutures are more impressed and there are more axial costae.

Epitoniidae, gen. et spec. indet.

Fig. 3A–B

*Description.* Shell small (1.5×4.5 mm), narrowly conical. Protoconch of 1½ smooth, swollen whorls. Teleoconch of four to five convex whorls, slightly concave at posterior suture. Sutures slightly impressed.

Spiral sculpture of four to five lirae, narrower than interspaces, not present on posterior depressed area. Axial sculpture of strong costae, weakly developed on posterior depressed area, 17 to 20 on last whorl.

Basal disc bounded by sharp lira, visible on spire whorls against anterior suture. Basal disc bearing three or four very weak lirae. Aperture subcircular, peristome discontinuous.

*Dimensions*

Figured specimen P30191	H 3.2	W 1.3
Measured specimen P302640	4.5	1.5

*Figured material.* Figured specimen P301911, collected T. A. Darragh, 24 November 1992.

*Occurrence and material.* PL3003 (2 specimens).

*Remarks.* These two specimens may possibly be juveniles of *Opalia (Pliciscala)?* sp., however, the most complete specimen of the latter lacks the juvenile whorls making comparison difficult. The posterior part of this specimen of *Opalia (Pliciscala)?* sp. does not closely resemble the largest of these two small specimens, having fewer and more prominent sharp costae which extend from suture to suture, unlike these specimens which have a relatively smooth concave area against the posterior suture.

There is nothing like this recorded from the Paleocene of New Zealand or the late Eocene of Antarctica.

Family BUCCINIDAE

*Austrofusus* Kobelt, 1879

*Type species.* *Drupa glans* Roeding, 1798, Recent, New Zealand.

*Austrofusus? crassiaulatus* sp. nov.

Fig. 3I–J, M–N

*Description.* Shell bucciniform of small size (14–22 mm). Protoconch conical of 3½ smooth, slightly swollen whorls, coiled with axis of shell. Teleoconch of five strongly convex whorls; sutures indented. Spire about half height of shell. Last

whorl slightly concave against posterior suture; contracting abruptly anteriorly and produced into short canal.

Axial sculpture of strong, rounded wide costae, slightly narrower than interspaces, 13 on last whorl; secondary axial sculpture of thin almost lamellate threads over whole shell. Axial sculpture fading rapidly over base of last whorl. Spiral sculpture of well developed lirae much narrower than interspaces present over whole whorl; slightly tuberculate on crossing axial costae; some interspaces with a weaker spiral thread present.

Aperture ovate, produced anteriorly into short strongly twisted anterior canal; interior of outer lip thickened, bearing about eight short lirae. Siphonal notch deep; siphonal fasciole prominent.

*Dimensions*

Holotype P301912	H 21	W 13	HA 10
Paratype P301913	13	8	6

*Type material.* Holotype P301912, collected T. A. Darragh, 28 February 1970; Paratype P301913, collected T. A. Darragh, 16 February 1981.

*Type locality.* PL3001.

*Occurrence and material.* PL3001 (50 specimens), PL3003 (9 specimens), PL3004 (1 specimen).

*Remarks.* The genus is known from Middle Eocene to Recent in New Zealand and *Austrofusus* sensu lato from the Late Paleocene of Pitt Island, New Zealand. Many of the New Zealand species have two weak keels. *Austrofusus? crassiaulatus* sp. nov. has only a slight suggestion of a keel at the edge of the shoulder. Of New Zealand taxa, it is most similar to *Austrofusus affiliatus* Finlay, Early Miocene which has one keel more prominent than on *Austrofusus? crassiaulatus*. *A. valedictus* King, Middle–Late Miocene, is somewhat similar but *Austrofusus? crassiaulatus* is much squatter. In its squat shape it has some resemblance to *A. pliocenensis* (Powell), Pliocene. It also has some resemblance to *Pseudofax weddellensis* Stilwell & Zinsmeister, Late Eocene, Antarctica.

*Pseudofax* Finlay & Marwick, 1937

*Type species.* *Phos ordinarius* Marshall, 1917, Paleocene, New Zealand.

*Pseudofax cf. ordinarius* (Marshall, 1917)

Fig. 3E–F, K–L

*Description.* Shell small, of average size for genus (7.5×14.5), elongate–ovate. Protoconch damaged,

of about  $2\frac{1}{2}$  smooth convex whorls, coiled in axis of shell. Teleoconch of five whorls. Spire whorls convex, with slightly less convex sutural ramp and weak shoulder. Last whorl contracting abruptly anteriorly and produced into short canal.

Axial sculpture of coarse costae about as wide as interspaces, present from shoulder to anterior suture on spire; on last whorl costae extend to about mid whorl; about 16 on last whorl. Spiral sculpture of strong cords of variable strength, slightly narrower than interspaces, slightly nodulate on crossing axial costae, about 8–12 on spire whorls, slightly more crowded on sutural ramp.

Aperture ovate. Canal short, slightly twisted and notched.

#### Dimensions

Figured specimen P301914 H 14.5 W 7.5 HA 6.5  
Figured specimen P98418 12.5+ 6.5 shell broken

*Figured material.* Figured specimen P301914, collected T. A. Darragh, 24 November 1992; Figured specimen P98418, collected T. A. Darragh, 16 October 1971.

*Occurrence and material.* PL3001 (2 specimens).

*Remarks.* Both specimens are slightly damaged. This taxon is very similar to *Pseudofax ordinarius* (Marshall), but the Pebble Point species has coarser axial costae and finer spiral sculpture. *Pseudofax* is recorded from the Paleocene of New Zealand, the Paleocene of Patagonia and Late Eocene of Antarctica. Somewhat similar taxa occur in the early Tertiary of California under the name of *Molophorus* and in the Paleocene to Oligocene of Europe as *Cominella* eg. *C. deserta* Solander, *C. acies* Walchlet and *C. ovata* Deshayes (Stewart 1927) and *C. bicorona* Meleville and *Buccinum gossardi* Nyst. *Pseudofax ordinarius* is very similar to *C. bicorona* Meleville, Paleocene, Paris Basin. *Pseudofax* may be a synonym of *Molophorus*, but if it is accepted as being sufficiently distinct from the Californian genus or from *Cominella*, the European taxa cited above should be placed in *Pseudofax* because they are so close in morphology to the New Zealand species. Whatever the case, the Southern Hemisphere species belong to a genus with a wide-spread distribution.

#### *Levifusus* Conrad, 1865

*Type species.* *Fusus trabeatus* Conrad, 1833, Early Eocene, USA.

#### *Levifusus? quadrifunifer* sp. nov.

Fig. 3S–U

*Description.* Shell large (65×84 mm), pyriform of about five whorls with low spire and prominent shoulder on last whorl. Protoconch not well preserved, of one? whorl slightly deviated from axis of shell. Spire whorls enveloped by each succeeding whorl, only flat sutural ramp of spire whorls visible. Last whorl abruptly contracted anterior to anterior spiral cord.

Sculpture on spire whorls of two prominent cords on sutural ramp at posterior and anterior sutures. Last whorl very large with four prominent cords bearing low coarse, somewhat irregular nodules. Posterior cord close to suture, separated from it by four to five fine lirae; second cord at whorl shoulder, 19–20 fine lirae between it and first cord; third cord at mid-whorl, 19–20 fine lirae between it and second cord; fourth cord situated at anterior  $\frac{2}{3}$  of whorl. Distance between third and fourth cords smaller than that between second and third cords and with 15 fine lirae present. Interspaces between cords concave. Fine lirae covering entire shell from fourth cord onto anterior canal. Interspaces between fine lirae twice width of lirae.

Aperture wide, polygonal in outline; columella strongly concave; aperture extending anteriorly into a large prominent left twisted canal. Siphonal fasciole well developed.

#### Dimensions

Holotype P301915 H 84 W 65 HA 50

*Type material.* Holotype P301915, collected T. A. Darragh, 16 February 1981.

*Type locality.* PL3001.

*Occurrence and material.* PL3001 (5 specimens), PL3004 (1 specimen).

*Remarks.* This taxon belongs with those genera formerly placed in Galeodidae. I follow Ponder & Warén (1988) who reduced this family to a synonym of the subfamily Melongeninae in Buccinidae.

*Levifusus* is known from the Paleocene and Eocene of the southeastern United States of America. *L. quadrifunifer* is similar to *L. dallianus* Harris, Paleocene of Alabama, but differs in having four prominent spiral cords not two. There do not seem to be any taxa in Europe, New Zealand or Antarctica that are similar to this species. The genus has been recorded from the Paleocene of East and West Africa (Adegoke 1977; Gliozzi &

Malatesta 1985), but the species recorded bear little resemblance to the type species of the genus.

#### Family FASCIOLARIIDAE

##### *Fusinus* Rafinesque, 1815

*Type species.* *Murex colus* Linnaeus, 1758, Recent, Indo-Pacific.

##### *Fusinus* sp.

Fig. 4T-U

*Description.* Shell elongate, fusiform with rounded whorls and long canal. Early spire whorls missing. Whorls regularly convex, slightly depressed at posterior suture.

Spiral sculpture of sharp ridge-like, regularly spaced, weakly denticulate lirae, much narrower than interspaces, seven on penultimate whorl, 11 on last whorl, slightly weaker and more crowded near posterior suture. Canal with seven lirae becoming weaker and fading anteriorly. Transverse sculpture of sinuous growth lines, forming low denticulations on crossing lirae.

Aperture obscured, oval, produced anteriorly into long straight canal.

##### *Dimensions*

Figured specimen P301916 H 57 W 20  
HA 20 specimen broken

*Figured material.* Figured specimen P301916, collected T. A. Darragh 16 February 1981.

*Occurrence and material.* PL3001 (10 specimens), PL3004 (1 specimen) all fragmentary.

*Remarks.* The most complete fragment consists of the canal, last whorl and about half the penultimate whorl. The other fragments consist of portions of the last whorl and one fragment consisting of the canal only measuring 69 mm in length. There is also a fragment of a spire which is probably the juvenile section of the spire whorls of this species. The youngest two whorls of this specimen have a prominent keel which rapidly decreases in strength abapically so that the whorl profile becomes regularly convex. Weak axial plicae are present, slightly nodulate where they cross the keel. The spiral sculpture consists of about nine regularly and widely spaced, weakly denticulate lirae. The growth lines are similar to the large canaliculate specimen. Until more complete specimens are found, it is not possible to be certain that this spire fragment belongs to the same taxon as the fragments of the last whorls.

This species belongs to a group of narrow aciculate fusiform gastropods present in the early Tertiary. In Australia the previously earliest representative of the group was *Fusinus sculptilis* (Tate), Late Eocene of Victoria and South Australia. There is also a species similar to the Pebble Point species in the Early Miocene of Tasmania and Tasmania in which the spire whorls bear prominent axial costae which become weaker anteriorly and eventually disappear except for slight denticulations on the spiral lirae. It also has a very weak, slightly dentate keel on the earliest spire whorls. These species are probably ancestral to the late Tertiary to Recent, *Fusinus novaehollandiae*.

The Pebble Point species is somewhat similar to *Fusinus dissimilis* (Deshayes, 1865), Late Eocene, Paris Basin, but the former has more rounded whorls and more regular and equal lirae than *F. dissimilis*. *F. aciculatus* Lamarck, Eocene, Paris Basin does not have keeled juvenile whorls.

#### Family TURBINELLIDAE

##### *Columbarium* Martens, 1881

*Type species.* *Pleurotoma (Columbarium) spinicincta* Martens, 1881, Recent, Queensland.

##### *Columbarium rugatoides* sp. nov.

Fig. 4L-M

*Description.* Shell of average size for genus, fusiform with gradate spire of about six prominently shouldered whorls. Protoconch large, of 1½ smooth whorls; first whorl globular, deviated at right angles to axis of shell. Spire whorls with posterior whorl slope smooth, flat to slightly concave. Shoulder forming prominent keel bearing triangular spikes. Anterior whorl slope with one lira at about mid point, and one stronger cord with prominent scales or triangular spikes against anterior suture of all spire whorls, becoming stronger adaperturally. Last whorl with prominent spinose cord at anterior 2/3, anterior to this a slightly less well developed anterior carina and another lira between anterior carina and canal.

Aperture subquadrate, continuous, notched posteriorly; columella covered with curved plate; outer lip slightly produced and toothed where intersected by anterior carina. Canal straight, bearing well developed thin, widely spaced spinose lirae.

*Dimensions*

Holotype P301917 H 35 broken W 15.5 HA 7.5

*Type material.* Holotype P301917, collected T. A. Darragh, 19 November 1970.

*Type locality.* PL3004.

*Occurrence and material.* PL3001 (2 specimens), PL3003 (1 specimen), PL3004 (1 specimen).

*Remarks.* In its sculpture *Columbarium rugatoides* sp. nov. resembles *C. spinicinctum* and in shape it is somewhat similar to *C. rugatum* (Aldrich, 1886), Early Eocene, Alabama. *C. rugatoides* sp. nov. is probably ancestral to *C. calcaratum* Darragh, 1969, Late Eocene–Early Oligocene, Victoria, but it is more elongate and not as spinose, the whorls are more quadrate in outline and it has less spiral cords on the anterior part of the body whorl. In sculpture *C. rugatoides* is somewhat similar to *C. vulneratum* (Finlay & Marwick), Paleocene, New Zealand, but the whorls are more quadrate in outline.

*Columbarium* has a cosmopolitan distribution in the Paleocene, occurring in Europe, Ukraine (Makarenko 1976), United States of America and New Zealand (Darragh 1969, 1987).

**Microfulgur** Finlay & Marwick, 1937

*Type species.* *Latirus (Mazzalina) longirostris* Marshall, 1917, Paleocene, New Zealand.

**Microfulgur** ? sp.

Fig. 4J–K

*Description.* Shell small, biconical, fusiform. Protoconch missing. Teleoconch whorls 4+. Spire whorls with prominent flat sutural ramp making up  $\frac{2}{3}$  of exposed spire whorl. Ramp with prominent lirae. Last whorl very convex anterior to ramp and then contracting rapidly to anterior canal.

Spiral sculpture of well developed lirae, much narrower than interspaces, five lirae on ramp of last whorl, three stronger lirae on remainder of last whorl, of which shoulder lira and two anterior to it are strongest.

Aperture oval. Columella with anterior fold or twist. Canal broken.

*Dimensions*

Figured specimen P301918 H 10 canal broken W 7.5

*Figured material.* Figured specimen P301918, collected T. A. Darragh & K. Bell, 21 November 1970.

*Occurrence and material.* PL3001 (1 specimen).

*Remarks.* The single specimen is broken and partly decorticated, so a precise description is not possible.

This species is placed in *Microfulgur* with some hesitation. Compared with *M. longirostris* (Marshall), the Pebble Point species is wider with a sharp shoulder and fewer spiral lirae. *Microfulgur* is known with certainty only from the Paleocene of New Zealand. The Pebble Point taxon bears some resemblance to *Strepsidura luciani* (Briart & Cornet, 1870) as figured by Makarenko (1976) from the Paleocene of Ukraine, but does not have the twisted canal of that taxon.

## Family MITRIDAE

**Mitra** Lamarck, 1798

*Type species.* *Voluta mitra* Linnaeus, 1758, Recent, Indo-Pacific.

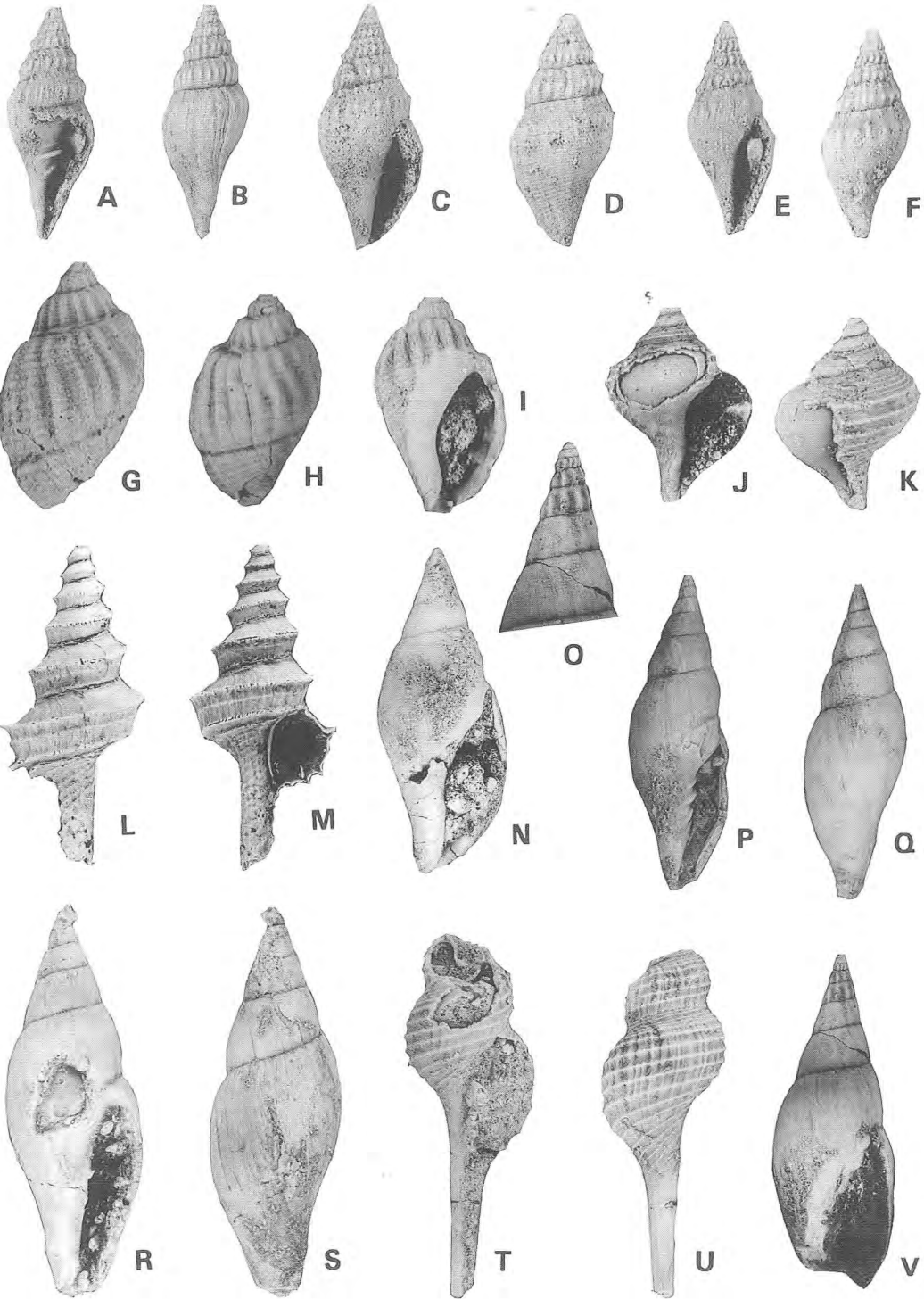
**Mitra?** *rhytidata* sp. nov.

Fig. 4N–S, V

*Description.* Shell of medium size for genus (16×47–20×49 mm), elongate fusiform with subconical spire and gently tapering last whorl. Protoconch of about  $3\frac{1}{4}$  smooth regularly convex whorls, first whorl deviated about 30° from axis of shell, sutures impressed. Spire whorls flat to slightly convex.

Spiral sculpture of close threads covering whole of whorl, becoming indistinct on last whorl. Axial sculpture of well developed sharp plicae, extending from suture to suture, beginning on first

Fig. 4. A–F, *Proximitra trirugulata* sp. nov., NMV P301923, holotype, PL3001, A, ×2.5, B, ×2.3. C–D, NMV P301924, paratype, PL3001, ×3.0. E–F, NMV P11829, paratype, PL3001, ×3.0. G–I, *Pseudoliva (Buccinorbis)* sp. G, NMV P301925, figured specimen, PL3001, ×1.3. H–I, NMV P301926, figured specimen, PL3001, ×1.3. J–K, *Microfulgur?* sp., NMV P301918, figured specimen, PL3001, ×2.9. L–M, *Columbarium rugatoides* sp. nov., NMV P301917, holotype, PL3004, ×1.4. N–S, V, *Mitra?* *rhytidata* sp. nov., NMV P301919, paratype, PL3001, ×1.0. O–V, NMV P301922, paratype, PL3001, O, ×1.5, V, ×1.0. P–Q, NMV P301921, holotype, PL3001, ×1.0. R–S, NMV P301920, paratype, PL3001, ×1.0. T–U, *Fusinus* sp., NMV P301916, figured specimen, PL3001, ×0.9





teleoconch whorl and present on second to third whorl then fading rapidly, 11–12 on first whorl, 10 on second whorl, about 9 on third whorl on some specimens.

Aperture narrowly elongate; outer lip slightly thickened, produced anteriorly into short canal; siphonal notch well developed; siphonal fasciole moderately developed; columella covered with thin callus, bearing two strong central plaits flanked by two slightly weaker plaits.

*Dimensions*

Holotype P301921	H 47	W 16	HA 24
Paratype P301919	49	20	28
Paratype P301920	60	21	29
Paratype P301922	49	19	specimen broken

*Type material.* Holotype P301921, collected T. A. Darragh, 21 November 1970; Paratype P301919, collected T. A. Darragh & D. J. Holloway, 24 November 1992; Paratype P301920, collected A. G. Beu, 16 October 1971; Paratype P301922, collected T. A. Darragh, 14 December 1994.

*Type locality.* PL3001.

*Occurrence and material.* PL3001 (9 reasonably complete and 12 fragmentary specimens), PL3003 (5 fragmentary specimens).

*Remarks.* This species is unusual for a mitrid in having two strong central plaits and a weaker posterior and anterior plait and in having plicae on the juvenile teleoconch whorls. The plicate spire may suggest a costate ancestor such as *Mesorhytis*. Large species of *Mitra* are rare in the Paleocene and none seem to be related to this taxon. *M.?* *rhytidata* sp. nov. looks a little like *Mitra elongata* Lamarck, Eocene, Paris Basin in shape but that species lacks axial or spiral sculpture. There is nothing quite like it in the Eocene or later Tertiary of Australia. *M.?* *rhytidata* is more tumid and the spire not nearly so elongate as *Eumitra alokiza* Tenison Woods and *E. uniplica* Tate, Miocene, Victoria.

Family VOLUTOMITRIDAE

*Proximitra* Finlay, 1926

*Type species.* *Vexillum (Costellaria) rutidolomum* Suter, 1917, Early Miocene, New Zealand.

*Proximitra trirugulata* sp. nov.

Fig. 4A–F

*Description.* Shell of medium size for genus, fusiform with slightly shouldered whorls. Proto-

conch of two smooth whorls, the first swollen and deviated at about 45° to spire axis. Teleoconch whorls five, with weak shoulder developing on first whorl; shoulder slightly convex at suture, then concave. Shoulder angulation on spire slightly anterior of mid whorl. Last whorl tapering gently anteriorly.

Axial sculpture of coarse costae, very weak on sutural ramp, extending to anterior suture on spire, becoming obsolete or confined to shoulder angulation on last whorl, 20 costae on penultimate whorl. Spiral sculpture of flat, well developed lirae about as wide as interspaces present over whole whorl. Aperture long, narrow, produced into very short canal. Columella with two strong anterior plaits and one weaker posterior plait. No siphonal fasciole.

*Dimensions*

Holotype P301923	H 15	W 5.5	HA 7
Paratype P118292	10.5	4.5	5
Paratype P301924	12	5.2	6

*Type material.* Holotype P301923, collected T. A. Darragh, 21 November 1970; Paratype P118292, collected T. A. Darragh, 16 February 1981; Paratype P301924, collected T. A. Darragh & K. Bell, 28 February 1970.

*Type locality.* PL3001.

*Occurrence and material.* PL3001 (18 specimens), PL3003 (2 specimens).

*Remarks.* The genus occurs in New Zealand from Middle Eocene to Early Pliocene, in France in the Eocene, in the United States of America in the Miocene, and in Australia from Early to Mid Miocene (Cernohorsky 1970). If the generic assignment is correct, the range of the genus is now extended back to the Paleocene. The specimens figured by Kollmann and Peel (1983, fig. 226) as *Cordieria* from the Paleocene of Greenland are very similar to *Proximitra trirugulata* sp. nov. but are more elongate. *P. trirugulata* has some resemblance New Zealand species, particularly to *P. parki* (Allan 1926), Late Eocene, New Zealand (Maxwell 1992), but differs by being more slender and having more prominent axial sculpture and fine spiral lirae over the whole shell. It bears little resemblance to the Australian Miocene species.

Family OLIVIDAE

*Pseudoliva (Buccinorbis)* Conrad, 1867

*Type species.* *Monoceras vetusta* Conrad, 1833, Eocene, United States of America.

**Pseudoliva (Buccinorbis) sp.**

Fig. 4G-I

*Description.* Shell solid, of average size for genus (16×28 mm), roundly fusiform, slightly ventricose with subconical spire about  $\frac{1}{3}$  height of shell. Protoconch not preserved. Spire whorls four. Whorls gently convex, suture impressed to slightly channelled.

Axial sculpture of prominent coarse, slightly sigmoidal costae, slightly narrower than interspaces, about 17 per whorl. Spiral sculpture of well developed lirae about as thick as interspaces, eight to nine on penultimate whorl. Last whorl regularly convex, tapering slightly anteriorly, with prominent spiral groove at anterior third, covered with well developed lirae, 16-17 lirae posterior to groove and about nine anterior to groove.

Aperture regularly lenticular with very short, wide anterior canal. Inner lip with prominent callus. Siphonal fasciole moderately developed.

*Dimensions*

Figured specimen P301925	H 28	W 16	HA 17
Figured specimen P301926	24	15	15

*Figured material.* Figured specimen P301925, collected T. A. Darragh & D. J. Holloway, 24 November 1992; Figured specimen P301926, collected K. Bell & T. A. Darragh, 23 November 1970.

*Occurrence and material.* PL3001 (2 specimens).

*Remarks.* This species belongs to a group of axially sculptured species present in the Late Cretaceous to Paleocene of France, Belgium, Germany, Copenhagen, Ukraine, Greenland, India and United States of America for which the generic taxa *Pseudoliva* and *Buccinorbis* have been variously used (Adegoke 1977). Species of *Buccinorbis* differ from those of *Pseudoliva* by the presence of strong axial and spiral sculpture and the genus is used for such sculptured European, Indian and American species.

The Pebble Point species is very similar to *B. curvicostata* (Briart & Cornet, 1870), Paleocene, Belgium, but is not so squat. *B. koeneni* Ravn, 1939, Paleocene, Copenhagen, is a small species not so globose as that from Pebble Point and with less prominent axials. There are no records of the genus from the Paleocene of New Zealand or the Late Eocene of Antarctica. The genus does not occur above the Paleocene in Australia. It may, however, be ancestral to the Australian endemic genus, *Zemira*, which ranges in age from Early Oligocene to Recent. The earliest occurrence of *Zemira* is an undescribed species from the Early

Oligocene of Point Flinders, Victoria (Ponder & Darragh 1975) which has an umbilicus like many species of *Buccinorbis* but lacks the prominent axial sculpture of the latter genus.

## Family TURRIDAE

**Zemacies** Finlay, 1926

*Type species.* *Zemacies elatior* Finlay, 1926, Miocene, New Zealand.

**Zemacies procerior** sp. nov.

Fig. 5O-P, U

*Description.* Shell of average size for genus (31 mm), elongate, fusiform, spire about  $\frac{2}{3}$  height of shell. Protoconch conical, of four smooth whorls, coiled with axis of shell. Teleoconch of about 7 whorls with concave ramp and blunt shoulder. Last whorl tapering gently to long anterior canal.

Axial sculpture of low broad opisthocline costae on shoulder (about 16 present) and extending to anterior suture on first four teleoconch whorls, on subsequent whorls becoming weaker and obsolete on last two whorls. Spiral sculpture of fine weak closely spaced lirae over whole whorl.

Aperture long and narrow; outer lip with deep notch on ramp. Columella long, straight and covered with thin glaze of callus.

*Dimensions*

Figured specimen P98421	H 31	W 9	HA 13.5
Figured specimen P98419	11.2	4.5	5

*Figured material.* Figured specimen P98421, collected K. N. Bell & T. A. Darragh, 28 February 1970; Figured specimen P98419, collected T. A. Darragh, 16 October 1971.

*Occurrence and material.* PL3001 (6 specimens).

*Remarks.* There are three other specimens which may belong to this taxon, but are too weathered for precise determination. Of the other six only one is a mature specimen. *Zemacies* in New Zealand ranges from Paleocene to Early Pliocene. In Australia it is known only from the Late Oligocene (*Z. inexpectata* Powell, 1944). *Apiotoma*, which ranges from Late Eocene to Mid Miocene, is somewhat similar in shape and sculpture to *Zemacies* but has a paucispiral protoconch. However, Bouchet (1990) has pointed out that such differences in turrid protoconchs do not have generic significance, so that *Zemacies* may well be a synonym of *Apiotoma*.

This taxon is very similar to *Zemacies immatura* Finlay & Marwick, 1937, Paleocene, New Zealand, but *Z. procerior* is relatively more elongate and without the infra-sutural cord present on *Z. immatura*. *Z. procerior* is very similar to the type species of the genus *Z. elatior*, but has more prominent axial costae present on about half the spire whorls and lacks the subsutural cord present in *Z. elatior*.

Stilwell & Zinsmeister (1992) record *Zemacies* from the Late Eocene of Antarctica but the specimens lack protoconchs and look more like *Apiotoma*.

### **Cosmasyrinx (Tholitoma)**

Finlay & Marwick, 1937

*Type species.* *Tholitoma dolorosa* Finlay & Marwick, 1937, Paleocene, New Zealand.

I follow Maxwell (1992) who reduced *Tholitoma* to a subgenus of *Cosmasyrinx* Marwick, 1931.

### **Cosmasyrinx (Tholitoma) levicristata** sp. nov.

Fig. 5R, V–W, Z

*Description.* Shell of medium size for genus (9–11.5 mm), elongate, pagodiform, with sharply angulate whorls. Protoconch of 4½ convex whorls coiled in axis of shell; first 3½ whorls smooth, next whorl bearing fine curved opisthocline axial ribs, concave adaperturally. Teleoconch whorls three with prominent flat to convex ramp and well developed shoulder slightly anterior to mid whorl on spire whorls.

Axial sculpture of obscure opisthocline elongate tubercles restricted to shoulder flange. Spiral sculpture of fine closely spaced threads present over whole shell with one coarser thread bearing prosocline nodules close to posterior suture.

Aperture triangular, outer lip with deep sinus on ramp. Columella long and straight.

### *Dimension*

Holotype P301930	L 8.8	W 4.4	HA 4.4
Paratype P98415	10	5	5

*Type material.* Holotype P301930, collected T. A. Darragh, 24 November 1992; Paratype P98415, collected T. A. Darragh, 16 October 1971.

*Type locality.* PL3001.

*Occurrence and material.* PL3001 (8 specimens), PL3003 (5 specimens).

*Remarks.* *Cosmasyrinx (Tholitoma) levicristata* sp. nov. differs from *C. (T.) dolorosa* by its less prominent sculpture and more prominent keel. It has some resemblance to species of the genus *Cochlespira* but it is relatively smoother, has a weakly tuberculate shoulder rather than the serrate shoulder of many species in the genus, and the ramp is flat to convex rather than flat to concave as in most species of *Cochlespira*.

The subgenus is known from the Paleocene and Eocene of New Zealand. A somewhat similar species, *Cosmasyrinx brychosinus* Stilwell & Zinsmeister, occurs in the Late Eocene of Antarctica.

### **Marshallaria** Finlay & Marwick, 1937

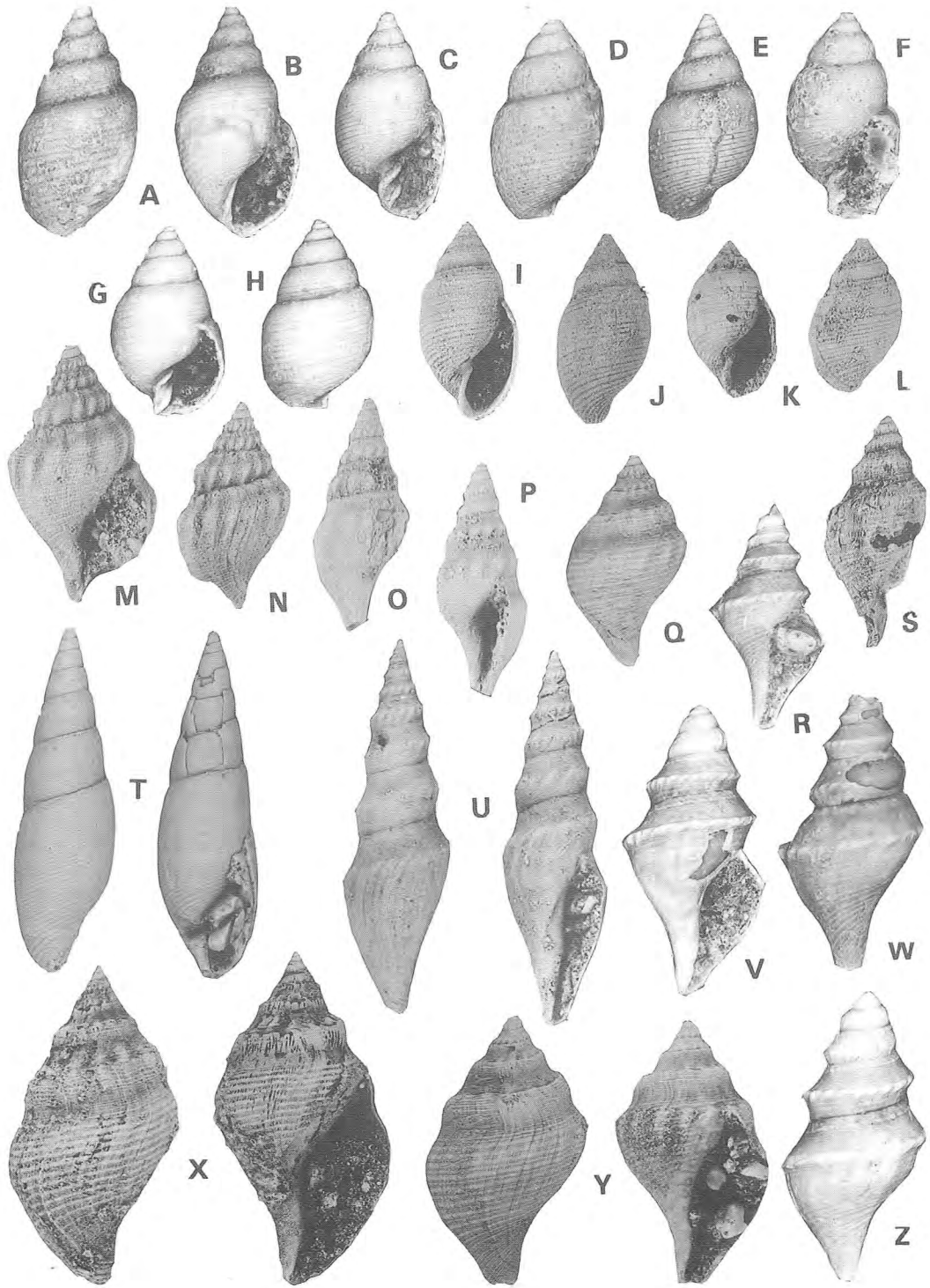
*Type species.* *Verconella spiralis* Allan, 1926, Late Eocene, New Zealand.

### **Marshallaria tumefacta** sp. nov.

Fig. 5Q, X–Y

*Description.* Shell of average size for genus (height 22–30+ mm), biconic, squat, tumid at mid whorl and tapering rapidly anteriorly. Protoconch of about 2½ smooth rounded whorls. Teleoconch of four to five whorls; spire about ⅓ shell height. First teleoconch whorl regularly convex bearing fine spiral threads on first half whorl; last half whorl with axial costae extending from suture

Fig. 5. A–B, *Acteon* sp. b, NMV P301966, figured specimen, PL3001, ×5.0. C–H, *Tornatellaea quindecimlirata* sp. nov. C, E, NMV P301967, holotype, PL3004, ×3.8. D, F, NMV P301968, paratype, PL3001, ×4.1. G–H, NMV P118290, paratype, PL3001, ×4.1. I–L, *Acteon petricolus* sp. nov. I–J, NMV P301931, holotype, PL3003, ×3.0. K–L, NMV P301932, paratype, PL3003, ×2.9. M–N, *Marshallaria* sp. a, NMV P301964, figured specimen, PL3001, M, ×3.0, N, ×2.3. O–P, U, *Zemacies procerior* sp. nov. O–P, NMV P98419, figured specimen, PL3001, ×3.1. U, NMV P98421, figured specimen, PL3001, ×1.8. Q, X–Y, *Marshallaria tumefacta* sp. nov. Q, NMV P301929, paratype, PL3001, ×1.8. X, NMV P301928, paratype, PL3003, ×1.8. Y, NMV P301927, holotype, PL3001, ×1.8. R, V–W, Z, *Cosmasyrinx (Tholitoma) levicristata* sp. nov. R, W, NMV P98415, paratype, PL3001, R, ×4.1, W, ×3.2. V, Z, NMV P301930, holotype, PL3001, ×4.9. S, *Marshallaria* sp. b, NMV P301965, figured specimen, PL3003, ×2.4. T, *Tenuiacteon* sp., NMV P302273, figured specimen, PL3001, ×3.0



to suture. Remainder of teleoconch whorls with prominent shoulder and ramp. Ramp convex against posterior suture forming well developed subsutural fold and deeply concave anterior to this. Spire whorls anterior to shoulder completely enveloped by each succeeding whorl.

Axial sculpture apart from first teleoconch whorl consisting of tubercles on shoulder, exposed on second and third teleoconch whorl, partly covered by succeeding whorls and becoming obsolete on last whorl. Spiral sculpture of strong cords, finer on ramp and coarser on last whorl anterior to shoulder, with fine threads in interspaces.

Aperture long, narrow, produced anteriorly into short canal; sinus arcuate, very broad, shallow, apex in middle of ramp; columella covered with thin callus; siphonal notch weak; no siphonal fasciole.

*Dimensions*

Holotype P301927	H 22	W 13	HA 15
Paratype P301928	26.5	14	16
Paratype P301929	17.5	9.5	11

*Type material.* Holotype P301927, collected T. A. Darragh, 21 November 1970; Paratype P301928, collected T. A. Darragh, 13 November 1984; Paratype P301929, collected T. A. Darragh, 14 December 1994.

*Type locality.* PL3001.

*Occurrence and material.* PL3001 (26 specimens), PL3003 (2 specimens), PL3004 (4 specimens), PL3005 (1 specimen).

*Remarks.* The genus is known only from New Zealand and southeastern Australia. In New Zealand it ranges in age from Early Paleocene to Late Miocene. In Australia *Marshallaria* has been recorded previously only from the Early Oligocene. *M. tumefacta* is not particularly close to any of the described species. It bears some similarity to *M. multincincta* Marshall, Paleocene, New Zealand, but is far more tumid and the spire whorls are enveloped by the succeeding whorls. It is somewhat similar to the species figured as *Turricula* by Kollmann & Peel (1983) from the Paleocene of Greenland and it is also similar to *Austrotoma ventricosa* Stilwell & Zinsmeister, 1992, Late Eocene, Antarctica, but *M. tumefacta* is more tumid and the shoulder tubercles are more prominent.

***Marshallaria* sp. a**

Fig. 5M–N

*Description.* Shell of average size for genus (13 mm), broadly fusiform, with somewhat gradate

spire less than half height of shell. Protoconch of three to four regularly convex whorls coiled in axis of shell, first two to three whorls smooth, last whorl with about seven broad lirae, wider than interspaces. Teleoconch of four whorls with prominent rounded shoulder; sutural ramp concave, bounded against posterior suture by one broad cord. Last whorl abruptly contracted anteriorly to form short canal.

Spiral sculpture continuing from protoconch, covering whole of last whorl, 37+ on last whorl, somewhat granulated where crossed by coarse growth lines. Axial sculpture of coarse costae, beginning as narrow plicae on first teleoconch whorl and rapidly increasing in strength, 15 on last whorl, strongest at shoulder and stronger on subsutural cord, extending to anterior suture on spire whorls, fading rapidly anteriorly on last whorl.

Aperture subtriangular; outer lip with shallow broad sinus on ramp; inner lip with thin callus. Canal short, narrow, without notch; siphonal fasciole very weak.

*Dimensions*

Figured specimen P301964 H 13 W 7 HA 6.5

*Figured material.* Figured specimen P301964, collected T. A. Darragh, 24 November 1992.

*Occurrence and material.* PL3001 (1 specimen), PL3009 (1 specimen).

*Remarks.* The specimen from PL3009, Dilwyn Formation, of Early Eocene age is a juvenile but seems to be the same species as that from the Pebble Point Formation. The Pebble Point taxon is somewhat similar to *Marshallaria decipiens* Maxwell, 1992, Eocene, New Zealand but is more tumid and the spiral sculpture is much finer than that species. The Pebble Point species has more prominent sculpture than *M. multincincta* (Marshall, 1917), Paleocene, New Zealand. *M. otwayensis* Long, 1981, Early Oligocene, Victoria, has much weaker sculpture and a more twisted columella.

***Marshallaria* sp. b**

Fig. 5S

*Description.* Shell of medium size for genus (6 × 14.5 mm), fusiform with gradate spire; spire about one third height of shell. Protoconch damaged or missing, of 3½ convex whorls, first two (?) smooth, last whorl with seven prominent lirae. Teleoconch of three whorls with prominent shoulder; sutural ramp sloping, flat. Last whorl tapering abruptly to form moderately long canal.

Spiral sculpture of prominent, closely spaced granulated cords; 11 on spire whorls, 28+ on last whorl. Axial sculpture of growth lines only.

Aperture damaged; outer lip with shallow broad sinus.

*Dimensions*

Figured specimen P301965 W 6 H 14.5 HA 8.5

*Figured material.* Figured specimen P301965, collected T. A. Darragh, 13 November 1984.

*Occurrence and material.* PL3001 (1 specimen), PL3003 (1 specimen).

*Remarks.* This species is distinguished from *Marshallaria* sp. a by the absence of axial sculpture. It is also much more slender. The protoconch is almost identical in morphology, so far as can be judged on the available material. It is somewhat similar to *M. multincta* (Marshall, 1917), Paleocene, New Zealand, but it has a flat rather than concave sutural ramp and lacks any axial sculpture.

Family ACTEONIDAE

*Acteon* Montfort, 1810

*Type species.* *Voluta tornatilis* Linnaeus, 1767, Recent, Europe.

*Acteon petricolus* sp. nov.

Fig. 5I-L

*Description.* Shell small (5×9.5 mm), subfusiform to ovate; spire about one third height of shell. Protoconch of one smooth whorl; first half whorl swollen, deviated at 45° to axis of shell. Teleoconch whorls 3½. Spire whorls regularly convex; sutures impressed.

Sculpture of wide spiral grooves, slightly narrower than interspaces; grooves interrupted at regular intervals by thin axial septa, so that groove consists of a series of rectangles; six grooves on spire whorls; last whorl covered with about 22 grooves.

Aperture lenticular; outer lip regularly and gently convex, slightly produced anteriorly. Columella covered with thin glaze, bearing one prominent fold where joined by outer lip, deep rounded channel posterior to fold.

*Dimension*

Holotype P301931	H 9.5	W 5	HA 5
Paratype P301932	8	4	4

*Type material.* Holotype P301931, Paratype P301932, collected T. A. Darragh, 18 November 1984.

*Type locality.* PL3003.

*Occurrence and material.* PL3003 (6 specimens).

*Remarks.* Species of *Acteon* are very widely distributed in the Paleocene. *A. petricolus* sp. nov. has some resemblance to *A. semispiralis* Marshall, 1917, Paleocene, New Zealand, but is more elongate and the spire whorls are more regularly rounded and the suture is impressed. Species of *Acteon* are known in the Tertiary of southern Australia from Eocene to Recent. *A. petricolus* has very little resemblance to the Eocene species. It is much larger, not so tumid and has flatter and more cylindrical whorls than *A. evanescens* Cossmann, 1897 from the late Eocene of southern Australia. *A. petricolus* is very similar to *Acteon scrobiculatus* Tenison Woods, 1877, Late Oligocene-Early Miocene, but has finer sculpture and a slight suggestion of a shoulder which is lacking in *A. scrobiculatus*. The spire is also not so tapering and the last whorl is more cylindrical than in *A. scrobiculatus*.

*Acteon* sp. b

Fig. 5A-B

*Description.* Shell small (5×9.5 mm), elongate-ovate with gradate spire. Protoconch heterostrophic of 2½ smooth whorls, first two whorls deviated at 137° to axis of shell, partly immersed. Whorls with prominent rounded shoulder, flat anterior to shoulder, sutures impressed, slightly channelled.

Sculpture of widely spaced grooves with transverse bars, more crowded on shoulder, 10-11 on spire whorls, about 22-27 on last whorl.

Aperture about half height of shell, narrowly elliptical. Columella covered with weak callus bearing one weak fold.

*Dimension*

Figured specimen P301966	H 7	W 3.5	HA 3.5
Measured specimen P302641	9.5	5	5.5

*Figured material.* Figured specimen P301966, collected T. A. Darragh, 28 February 1970.

*Occurrence and material.* PL3001 (3 specimens), PL3003 (4 specimens).

*Remarks.* *Acteon* sp. b is closest to *A. semispiralis* Marshall, 1917, Paleocene, New Zealand, but it has spiral grooves present over the entire whorl, the whorls are not so convex and the spire is gradate. Compared to the Pebble Point species, *A. semispiralis* has a gradate spire and the columella has only a very weak fold. The Pebble Point species has some resemblance to the Paris

Basin Eocene species *A. subinflatus* d'Orbigny, 1850 and *A. turgidus* (Deshayes, 1862) but has a more gradate spire and the whorls are not so convex as these. The prominent gradate spire of this species separates it from all other Australian Tertiary species.

#### **Tenuiactaeon Aldrich 1921**

*Type species.* *Tenuiactaeon pertenuis* Aldrich 1921, Eocene, United States of America.

#### **Tenuiactaeon sp.**

##### **Fig. 5T**

*Description.* Shell lanceolate, of six rather flat whorls; whorls somewhat imbricated, sutures impressed. Protoconch deviated at right angles to axis of shell (heterostrophic). Sculpture of widely spaced fine grooves, covering whole whorl, becoming wider and more irregularly spaced on anterior portion of last whorl.

Aperture elongate, lenticular. Columella with one wide fold, interior of aperture obscured with matrix.

##### *Dimensions*

Figured specimen P302273 L 17.1 HA 6.5 W 4.9

*Figured material.* Figured specimen P302273, collected T. A. Darragh, 17 January 1996.

*Occurrence and material.* PL3001 (one specimen).

*Remarks.* The aperture of the single specimen is filled with hard matrix and attempts to clear it damaged the columella, so it is not possible to determine the strength of the fold on the columella. This species has some similarity to species of *Nonacteonina* Stephenson, 1941, late Cretaceous, United States of America. Hitherto *Tenuiactaeon* has not been recorded from outside the United States of America.

This species is very similar to *T. olivellaeformis* (Tate), Late Oligocene–Middle Miocene, Victoria, but is somewhat larger (largest Muddy Creek Formation specimen of *T. olivellaeformis* is 14 mm in length) and also differs in having coarser grooves which are regularly spaced over the whole of the whorls. These tend to be irregularly spaced in *T. olivellaeformis*.

#### **Tornatellaea Conrad, 1860**

*Type species.* *Tornatellaea bella* Conrad, 1860, Eocene, United States of America.

#### **Tornatellaea quindecimilirata sp. nov.**

##### **Fig. 5C–H**

*Description.* Shell small, of average size for genus (5×7.7 mm), elongate, subcylindrical, with gradate spire. Protoconch of one smooth whorl, tip immersed, slightly deviated from axis of shell. Teleoconch of four whorls, convex only at shoulder. Sutures impressed.

Sculpture of well spaced punctate grooves, absent near the shoulder on some specimens, 15 on last whorl, slightly crowded anteriorly.

Aperture lenticular. Columella with two, thin high plaits.

##### *Dimensions*

Holotype P301967	H 8	W 4.5	HA 3.6
Paratype P118290	7	4	3
Paratype P301968	7.5	5	3.5

*Type material.* Holotype P301967, collected T. A. Darragh, 13 December 1994; Paratype P118290, collected T. A. Darragh, 16 February 1981; Paratype P301968, collected T. A. Darragh, 21 November 1970.

*Type locality.* PL3004.

*Occurrence and material.* PL3001 (15 specimens), PL3003 (39 specimens), PL3004 (5 specimens).

*Remarks.* *Tornatellaea quindecimilirata* sp. nov. is somewhat similar to *T. morbosa* Finlay & Marwick, 1937, Paleocene, New Zealand, but is much more tumid. It has a much more sharply defined shoulder when compared with *T. saucia* Finlay & Marwick, 1937, Paleocene, New Zealand. *Tornatellaea* has a cosmopolitan distribution in the Paleocene. The genus has hitherto not been recorded from Australia. In New Zealand the genus is also known only from the Paleocene.

#### **Family RINGICULIDAE**

#### **Gilbertina Morlet, 1888**

*Type species.* *Gilbertina inopinata* Morlet, 1888, Paleocene, France.

#### **Gilbertina meridiana sp. nov.**

##### **Fig. 6A–F, H–I**

*Description.* Shell small, of average size for genus (4×4 mm), solid, subglobular of 3½ whorls, spire barely projecting. Protoconch of 1½ smooth whorls coiled at slight angle to axis of shell

and sunken below spire whorls. Spire of 2–2½ rounded whorls. Last whorl large, uniformly inflated, almost covering penultimate whorl.

Sculpture of widely spaced spiral, punctate grooves more crowded towards posterior suture; nine spirals on spire whorls, 16–19 on last whorl.

Aperture pyriform; outer lip thickened into varix, interior of outer lip bearing one small ill defined denticle on some specimens. Siphonal notch shallow, broad, situated to right of midline of aperture. Columella covered with thick callus, bearing two blade-like plaits; thick vertical ridge of callus present posterior to plaits on dorsal part of columella.

*Dimension*

Holotype P301969	H 5.2	W 4.7	HA 3.1
Paratype P301970	4.0	3.8	2.7
Paratype P301971	4.2	3.8	2.2
Paratype P301972	4.7	4.3	2.8

*Type material.* Holotype P301969, Paratype P301970, collected T. A. Darragh, 24 November 1992; Paratype P301971, collected T. A. Darragh, 13 November 1984; Paratype P301972, collected T. A. Darragh, 23 November 1992. Paratype WAM 94.410, collected G. W. Kendrick, 13 November 1984.

*Type locality.* PL3003.

*Occurrence.* PL3001 (6 specimens), PL3003 (79 specimens), PL3004 (9 specimens).

*Remarks.* Three specimens have gastropod boreholes on the dorsal side of the last whorl. Species of the genus are found in Paleocene strata of Greenland, Denmark, Poland, France, Austria, Texas, Alabama and California, but it has not been recorded before in the Southern Hemisphere. *Gilbertina meridiana* sp. nov. is most similar to *G. ultima* (von Koenen, 1885), Paleocene, Copenhagen, but differs by the presence of a strong ridge of callus on the edge of the columella.

In the overlying Rivemook Member of the Dilwyn Formation there is another superficially similar species. It is much larger, has four plaits on the columella, and complex denticles on the inner side of the outer lip. It seems to belong to *Superstes* Finlay & Marwick, known from Paleocene to Eocene of New Zealand, and is described and figured for comparison with the Pebble Point Formation taxon.

**Superstes** Finlay & Marwick, 1937

*Type species.* *Superstes phoenix* Finlay & Marwick, 1937, Late Eocene, New Zealand.

**Superstes glomerabilis** sp. nov.

Fig. 6J–O

*Description.* Shell of average size for genus (7×5.5–8.5×7 mm), subglobular, of three to four whorls, spire scarcely projecting. Protoconch of two smooth whorls, first whorl sunken and slightly deviated from shell axis. First teleoconch whorl sculptured with punctate grooves, later whorls on some specimens smooth, others sculptured with punctate grooves present over whole whorl or confined to anterior quarter of last whorl.

Aperture pyriform with prominent shallow anterior notch. Outer lip slightly prosocline, considerably thickened, bearing fine denticulations on inner side and one prominent denticle at anterior 2/3; on some specimens a second denticle at about mid point of outer lip.

Columella covered with thick callus, strongly curved, with prominent thin vertical ridge between posterior of central plaits and posterior end of aperture. Four plaits; two strong, central, blade-like plaits; a third strong plait posterior to these set well into aperture behind vertical ridge and one weaker anterior, almost vertical plait set well back into aperture.

*Dimensions*

Holotype P302623	H 8.1	HA 5.1	W 7.0
Paratype P302624	6.9	4.4	5.4
Paratype P302627	7.2	4.5	6.5

*Type material.* Holotype P302623, Paratype 302624, collected T. A. Darragh, 21 February 1971; Paratype P302627, collected K. Bell & T. A. Darragh, 28 February 1970.

*Type locality.* PL3007.

*Occurrence.* PL3007 (13 specimens), PL3009 (1 specimen).

*Remarks.* This species closely resembles *Superstes phoenix* Finlay & Marwick, Late Eocene, New Zealand, but differs in having one prominent vertical ridge on the parietal area not two, and in having two strong central plaits flanked by two small plaits set well back in the aperture rather than three plaits as in *S. phoenix*. *S. glomerabilis* sp. nov. also has a relatively poorly developed anterior notch in the lip. Other species of *Superstes* lack parietal ridges.

The genus ranges from Early Paleocene to Late Eocene in New Zealand and hitherto has not been recorded outside New Zealand.



## Family CYLICHNIDAE

*Cylichnania* Marwick, 1931

*Type species.* *Cylichnania bartrumi* Marwick, 1931, Early Miocene, New Zealand.

*Cylichnania* sp.

Fig. 6T–V

*Description.* Shell small, narrow, cylindrical. Apex with deep umbilicus. Sculpture of weak, well spaced spiral grooves over whole shell. Columella with thick narrow callus and bearing one strong fold at base. Tiny umbilical chink present, considerably encroached upon by callus.

*Dimensions*

Figured specimen P301973	H 10	W 4
Figured specimen P301974	11	4.5

*Figured material.* Figured specimen P301973, collected T. A. Darragh, 17 February 1991; Figured specimen P301974, collected T. A. Darragh, 21 November 1970.

*Occurrence and material.* PL3001 (2 specimens), PL3003 (9 specimens).

*Remarks.* All specimens either have the sculpture almost worn away or are slightly decorticated. The genus is regarded as being confined to New Zealand but there are species in the Paris Basin recorded under *Acrostemma* Cossmann or *Cylichnina* which may belong in the genus, e.g. *Bulla ambigena* Deshayes, 1862. Somewhat similar species occur in the Eocene of the southeastern United States of America recorded as *Cylichnina*, e.g. *C. galba* (Conrad, 1833). Species of *Cylichnina* are not as cylindrical as are those of *Cylichnania*.

In Australia species of the genus are known from Late Eocene through to Middle Miocene. In New Zealand the genus ranges from Paleocene to Late Miocene. The Pebble Point species is similar in shape to *C. impar* Finlay & Marwick, 1937, Paleocene, New Zealand, but the fold on the

columella seems much more prominent than on *C. impar*. It also has a much more prominent columella fold than the Australian Late Eocene *C. angustata* (Tate & Cossmann, 1897).

*Priscaphander* Finlay & Marwick, 1937

*Type species.* *Haminea cingulata* Marshall, 1917, Paleocene, New Zealand.

*Priscaphander bullariformis* sp. nov.

Fig. 6Q, X–Z

*Description.* Shell large, of average size for genus, oval, slightly tumid, involute, tapering at anterior and posterior ends, apex non-umbilicate, covered by parietal callus. Sculpture of widely spaced, narrow spiral grooves. Axial sculpture of growth lines only.

Aperture large, narrow posteriorly, very wide anteriorly; outer lip convex, apical end protruding above apex; inner lip covered with callus from apex to anterior end, callus edge sharply bounded. One short weak fold present on columella on some specimens.

*Dimensions*

Holotype P301975	H 17	W 10
Paratype P301976	16	9.5
Paratype P301977	20	12

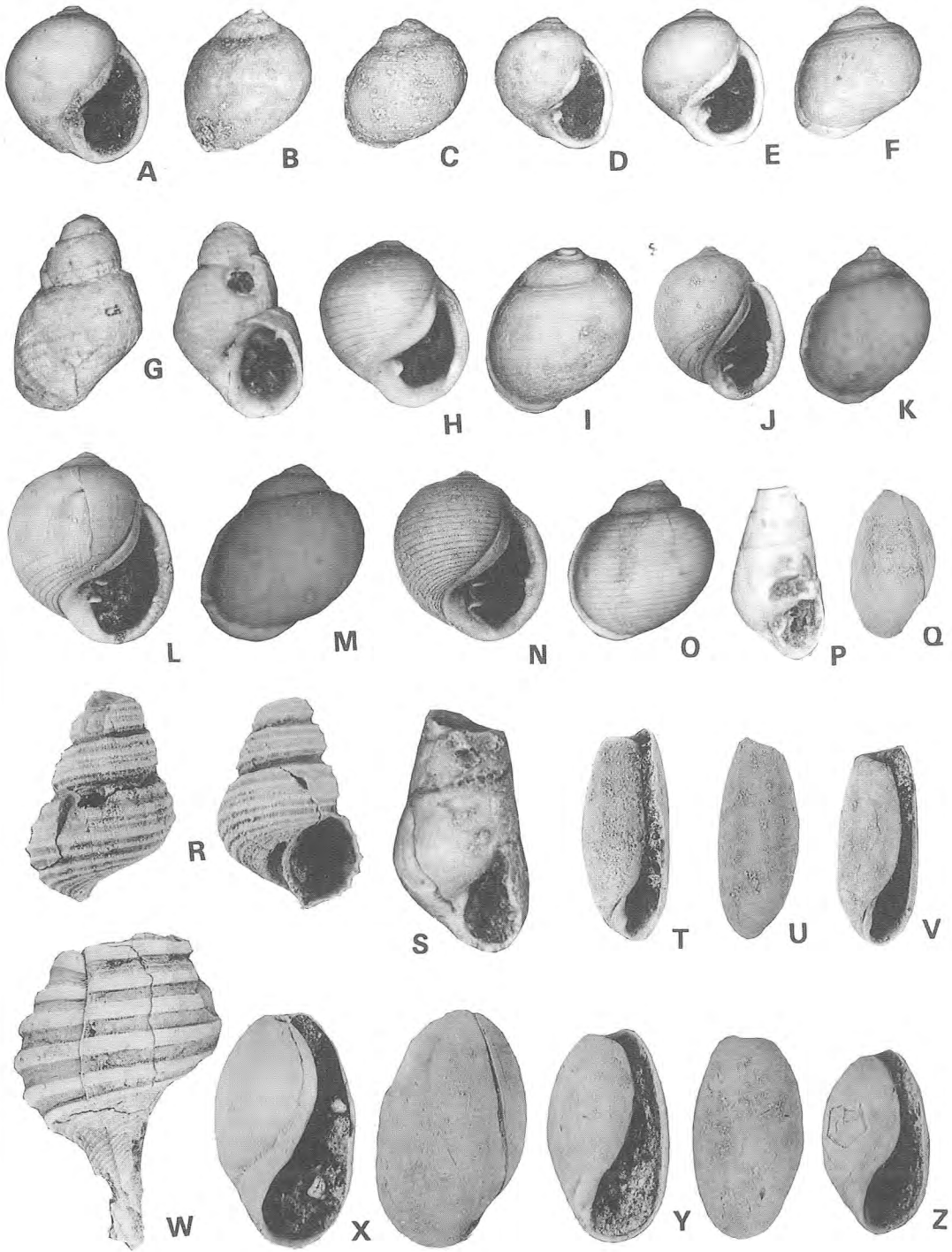
*Type material.* Holotype P301975, collected T. A. Darragh, 22 February 1971; Paratype P301976, collected T. A. Darragh, 13 November 1984; Paratype P301977, collected 27 November 1972.

*Type locality.* PL3001.

*Occurrence and material.* PL3001 (25 specimens), PL3003 (59 specimens), Pebble Point area unlocalised (1 specimen).

*Remarks.* *Priscaphander bullariformis* sp. nov. is very similar to *P. cingulata* (Marshall, 1917), but

Fig. 6. A–F, H–I, *Gilbertina meridiana* sp. nov. A–B, NMV P301972, paratype, PL3004,  $\times 5.0$ . C–D, NMV P301971, paratype, PL3003,  $\times 4.8$ . E–F, NMV P301970, paratype, PL3001,  $\times 5.25$ . H–I, NMV P301969, holotype, PL3003,  $\times 5.0$ . G, *Raulinia?* sp. NMV P301982, figured specimen, PL3003,  $\times 14.3$ . J–O, *Superstes glomerabilis* sp. nov. J–K, NMV P302624, paratype, PL3007,  $\times 3.4$ . L–M, NMV P302623, holotype, PL3007, L,  $\times 3.6$ , M,  $\times 3.3$ . N–O, NMV P302627, paratype, PL3009, N,  $\times 3.5$ , O,  $\times 3.3$ . P, S, *Odostomia* sp. P, NMV P301980, figured specimen, PL3001,  $\times 8.9$ . S, NMV P301979, figured specimen, PL3003,  $\times 16$ . Q, X–Z, *Priscaphander bullariformis* sp. nov. Q, Z, NMV P301976, paratype, PL3003, Q,  $\times 1.4$ , Z,  $\times 1.8$ . X, NMV P301977, paratype, PL3003,  $\times 1.8$ . Y, NMV P301975, holotype, PL3001,  $\times 1.8$ . R, *Tuba* sp. NMV P301978, figured specimen, PL3003,  $\times 2.8$ . T–V, *Cylichnania* sp. T–U, NMV P301974, figured specimen, PL3001,  $\times 2.9$ . V, NMV P301973, figured specimen, PL3003,  $\times 3$ . W, gen. et sp. indet., NMV P301981, figured specimen, PL3004,  $\times 1.5$ .



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it has much weaker spiral grooves and tapers more rapidly at the anterior and posterior ends, so that it is not so cylindrical. *P. bullariformis* is not so cylindrical and does not have such strong sculpture as *P. sanjosensis* Griffen & Hünicken from the Paleocene of Patagonia.

There seem to be no species of the genus in the Northern Hemisphere, unless the species figured as *Cylichna* sp. 1 by Kollmann and Peel (1983) from Greenland belongs. The genus has not been recorded from the Late Eocene of Antarctica. Somewhat similar shaped and sculptured species occur in the Late Cretaceous of North America which are placed in the genus *Ellipsoscapha*, Stephenson, 1941 but these have a perforate rather than an imperforate apex as in *Priscaphander*.

### Family MATHILDIDAE

#### *Tuba* Lea, 1833

*Type species.* *T. alternata* Lea, Dec. 1833 (= *Littorina antiquata* Conrad, Sept. 1833), Eocene, United States of America.

*Tuba* Lea, 1833 was placed on the ICZN Official List (Opinion 436).

#### *Tuba* sp.

##### Fig. 6R

*Description.* Shell of average size for genus, conical, with strongly convex whorls. Protoconch and early spire whorls missing. Sutures impressed. Spiral sculpture of four prominent cords on spire whorls and 10 cords on last whorl, somewhat weaker and more crowded on base. Axial sculpture of thin closely spaced lamellae.

Aperture subcircular, extended anteriorly into prominent siphonal notch; siphonal fasciole broad, well developed, bounding narrow umbilicus.

##### *Dimensions*

Figured specimen P301978 H 14 est. W 6.5

*Figured material.* Figured specimen P301978, collected T. A. Darragh, 28 November 1972.

*Occurrence and material.* PL3003 (1 specimen).

*Remarks.* This species is similar to *Kaitangata hendersoni* Finlay & Marwick, 1937, Paleocene, New Zealand in sculpture and apertural detail but *K. hendersoni* lacks an umbilicus. *Tuba* sp. has a prominent siphonal fasciole, the whorls are much more convex, it is narrower and has two fewer cords on the spire whorls. Maxwell (1992)

synonymised *Kaitangata* Finlay & Marwick 1937, *Tuba* Lea 1833 and *Tubena* Marwick 1943 with *Gegania* Jeffreys 1884. Though preoccupied, *Tuba* was placed on the Official List and so is an available name for this group. *Tuba* has a cosmopolitan distribution in the Early Tertiary. In New Zealand *Tuba* ranges from Paleocene to Early Miocene. Stilwell & Zinsmeister (1992) have recorded both *Tubena* and *Kaitangata* from the Late Eocene of Antarctica. The Pebble Point taxon is quite unlike the Antarctic forms in having very coarse lirae. *Tuba* has not been recorded from Australia before.

*Tuba* sp. is very similar to *G. antiquata* Conrad 1833, Eocene, Alabama, but is more slender in outline.

There are three small fragmentary specimens which may be juveniles of this species, though the proportions do not seem to match well. These specimens have strong well spaced lirae with fine axial lamellae in the interspaces. Two have protoconchs which are deviated at 120° to the axis of the shell and are partially covered by the first teleoconch whorl.

### Family PYRAMIDELLIDAE

#### *Odostomia* Fleming, 1817

*Type species.* *Turbo plicatus* Montagu, 1803, Recent, Europe.

#### *Odostomia* sp.

##### Figs 6P, S, 11D, N

*Description.* Shell of four to five whorls. Protoconch heterostrophic, partly immersed. Spire whorls flat with impressed suture. Last whorl flat posteriorly and contracting abruptly to base. Whorls smooth. Aperture broken. Columella with one very strong plait set well into aperture.

##### *Dimensions*

Figured specimen P301979	H 2.1	W 1.6
Figured specimen P301980	2.8	1.2
Figured specimen P302490	2.3	1.2
Figured specimen P302491	2.8	1.3

*Figured material.* Figured specimen P301979, collected T. A. Darragh, 24 November 1992; Figured specimen P301980, collected T. A. Darragh, 22 February 1971 (lost during photography); Figured specimens P302490–P302491, collected T. A. Darragh, 18 January 1996.

*Occurrence and material.* PL3001 (2 specimens), PL3003 (7 specimens), PL3004 (1 specimen).

**Remarks.** All specimens except three are fragments of the last whorl plus one or two other whorls. The genus has a cosmopolitan distribution. Similar looking taxa occur in the Paleocene of Mons, the Paleocene and Eocene of the Paris Basin, and the Paleocene of Greenland, Austria and West Africa. In New Zealand, the genus is known from Paleocene to Recent. In Australia species were hitherto known from Late Eocene to Recent.

#### Family AMATHINIDAE

##### *Raulinia* Mayer-Eymar, 1864

*Type species.* *Tornatella alligata* Deshayes, 1832, Oligocene, France.

##### *Raulinia?* sp.

##### Fig. 6G

**Description.** Shell thick, of small size for genus (1.4×2.1 mm), ovate. Protoconch poorly preserved, of one whorl, slightly deviated from axis of shell, slightly sunken. Teleoconch whorls 3½, sutures strongly impressed, very slightly convex.

Sculpture of widely spaced spiral punctate grooves, six on spire whorls, about 12 on last whorl.

Aperture oval; columella covered with thick callus plate; low broad plait set well into aperture. Small umbilical chink almost covered by callus.

##### *Dimensions*

Figured specimen P301982 H 2.1 W 1.4

*Figured material.* Figured specimen P301982, collected T. A. Darragh, 24 November 1992.

*Occurrence and material.* PL3003 (1 specimen).

**Remarks.** The single specimen is possibly a juvenile. The columella plait is set so far into the aperture that is only visible from a very oblique view of the aperture. Somewhat similar species to this occur in the Eocene and Oligocene of Europe and are placed in *Raulinia*. Other genera used for somewhat similar species are *Actaeopyramis* and *Leucotina*. It closely resembles juvenile specimens of *Raulinia eothinos* (Tate, 1894), Late Oligocene, Victoria, but these do not have the deeply impressed suture of the Pebble Point taxon.

#### Family SPIRATELLIDAE

##### *Spiratella* Blainville, 1817

*Limacina* Bosc, 1817.

*Type species.* *Clio helicina* Phipps, 1774, Recent, Polar seas.

Curry (1982) has shown that though Blainville's and Bosc's names were both published in December 1817, the volume containing Blainville's name was lodged in the Bibliotheque National in Paris before that containing Bosc's name. Thus *Spiratella* has priority over *Limacina*.

##### *Spiratella advenulata* sp. nov.

##### Fig. 7A-F

**Description.** Shell of average size for genus, sinistral, subglobose, somewhat planorbid, slightly wider than high; spire projecting slightly above last whorl. Whorls three to four with deeply impressed sutures. Outline of whorl more convex posteriorly. Aperture damaged, oval or reniform, produced anteriorly into lip. Umbilicus very narrow. Growth line near aperture sinuous.

##### *Dimensions*

Holotype P302009	max. W 1.6	H 0.9
Paratype P302010	1.0	0.8
Paratype P302617	1.6	
Paratype P302618	1.2	
Paratype P302619	1.5	
Paratype P302620	1.6	

*Type material.* Holotype P302009, collected T. A. Darragh, 24 November 1992; Paratype P302010, collected T. A. Darragh, 13 December 1994; Paratypes P302617–P302620, collected T. A. Darragh, 18 January 1996.

*Occurrence and material.* PL3001 (1 specimen), PL3003 (35 specimens).

**Remarks.** All 35 specimens are damaged. Pteropods are very rare in the Paleocene, most having been recorded from the Eocene onwards. This record may be the oldest for the genus. The only other Paleocene record of the genus is *Spiratella mercinensis* (Watelet and Lefèvre, 1885) (Curry 1965), which ranges from Latest Paleocene to Early Eocene in northwestern Europe (London Clay pteropod zone 6, latest Thanetian and Ypresian) (Janssen & King 1988). *S. advenulata* sp. nov. bears some resemblance to this taxon but is more globose, has a smaller umbilicus, narrower whorls, and the spire projects slightly. The aperture is damaged so this feature cannot be compared in detail, but it does seem to have an anterior projection somewhat similar to that in *S. mercinensis*.

*S. advenulata* bears some resemblance to *S. pygmaea* (Lamarck), Middle Eocene, Europe, but the spire does not project so much.

Species of *Spiratella* are recorded from Late Eocene to Middle Miocene of Australia and living in all surrounding seas. *S. advenulata* is much more globose than any of species described from the later Tertiary.

Family indeterminate

Genus and species indet.

Fig. 6W

*Description.* Known only from last whorl. Convex with six broad flat-topped cords, slightly narrower than interspaces. Aperture oval, produced anteriorly into short, very slightly twisted canal. Canal and base of last whorl bearing fine spiral threads much narrower than interspaces.

*Dimensions*

Figured specimen P301981 H31 W 21 fragment

*Figured material.* Figured specimen P301981, collected T. A. Darragh, 17 February 1981.

*Occurrence and material.* PL3001 (2 fragments of last whorl), PL3004 (1 specimen).

*Remarks.* The fragmentary nature of the material in hand makes comparison with other taxa almost impossible. The available material seems to bear

no resemblance to any other taxon recorded from Australia or New Zealand. What little remains of the last whorl looks a little like *Napulus fragilis* Sohl, 1964, Late Cretaceous, southeastern United States of America, but there is no trace of the axial sculpture present on species of *Napulus*.

Class Scaphopoda

Family DENTALIIDAE

**Fissidentalium** Fischer, 1885

*Type species.* *Dentalium ergasticum* Fischer, 1882, Recent, Europe.

**Fissidentalium gracilicostatum** Singleton, 1943

Fig. 8D-E, G-H, J-K

*Fissidentalium gracilicostatum* Singleton, 1943: 275, pl. 12, fig. 6a, 6b, pl. 13, fig. 9a, 9b.

*Description.* Shell of average size for genus (50 mm), solid, gently tapering, curved, compressed dorso-ventrally; posterior section of shell more compressed than anterior, elliptical in cross section, becoming less so anteriorly; shell wall very thick.

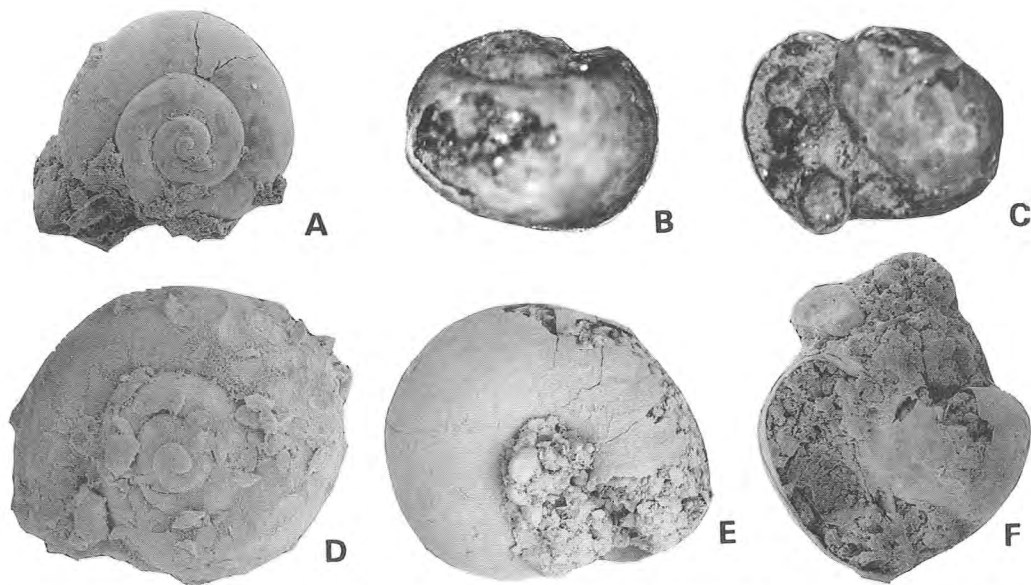


Fig. 7. A-F, *Spiratella advenulata* sp. nov., all PL3003. A, NMV P302618, paratype,  $\times 30$ . B-C, NMV P302009, holotype,  $\times 22$ . D, NMV P302619, paratype,  $\times 30$ . E, NMV P302617, paratype,  $\times 25$ . F, NMV P302620, paratype,  $\times 25$

Sculpture at extreme posterior of very fine close annular ribs, present for about 1 mm, next 0.5 mm cancellate with development of longitudinal ribs; remainder of shell with sculpture of fine close longitudinal ribs, sharply defined on posterior portion of shell, becoming wider and weaker anteriorly. On posterior part of shell two or three fine threads between strongly defined ribs, developing into wider ribs anteriorly; 30–35 primary ribs building up to 55–70 near aperture. On many specimens ribs fade out completely towards aperture.

No trace of apical slit.

#### Dimensions

Holotype P127989	L 21	Anterior W 5.5×5.1
		Posterior W 3.7×3.4
Figured specimen P301875	49	7.0×6.8
		2.1×1.7
Figured specimen P301876	31.7	7.6×4.5
		2.2×1.8
Figured specimen P301877	34	6.0×5.9
		1.7×1.0

*Type material.* Holotype P127989 (MUGD 1871), collected G. Baker, 22 January 1942; Figured specimens P301875, collected T. A. Darragh, 24 November 1992; P301876, collected T. A. Darragh & K. Bell, 28 February 1970; P301877, collected T. A. Darragh, 19 November 1970.

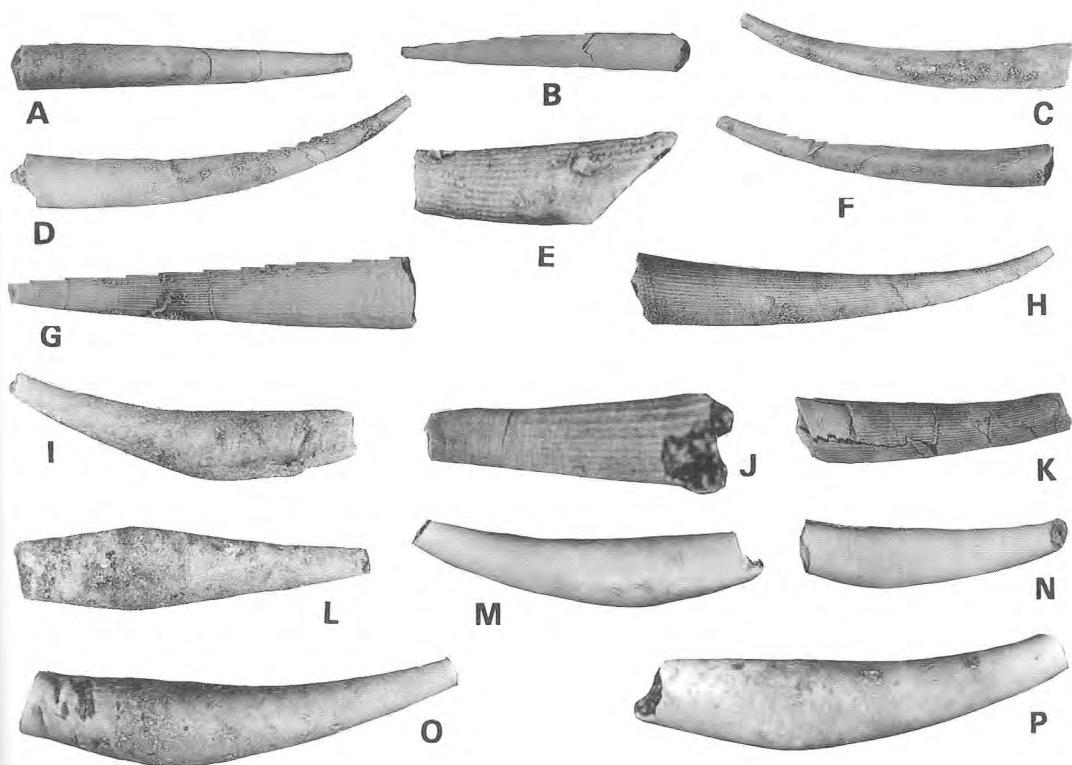


Fig. 8. A–C, F, *Compressidens laticornuta* sp. nov. A, F, NMV P301880, holotype, PL3003,  $\times 1.3$ . B, NMV P301879, paratype, PL3003,  $\times 1.3$ . C, NMV P301878, paratype, PL3003,  $\times 1.3$ . D–E, G–H, J–K, *Fissidentalium gracilicostatum* Singleton. D, NMV P301875, figured specimen, PL3003,  $\times 1.1$ . E, NMV P302631, figured specimen, apical portion showing annular ribs, PL3003,  $\times 18.2$ . G, NMV P301876, figured specimen, PL3001,  $\times 1.7$ . H, NMV P301877, figured specimen, PL3004. J, NMV P302632, figured specimen, apical portion showing annular ribs, PL3003,  $\times 29$ . K, NMV P127989, holotype, PL3004,  $\times 1.7$ . I, L–P, *Gadila laguncula* sp. nov. I, L, O, NMV P301881, holotype, I, L,  $\times 6.4$ , O,  $\times 8.1$ . M, P, NMV P301883, paratype, PL3001, M,  $\times 6.6$ , P,  $\times 8.3$ . N, NMV P301882, paratype,  $\times 5.4$ .

1970; P302631–P302632, collected T. A. Darragh, 13 December 1994.

*Type locality.* Coastal cliffs 2.5 miles south-east of Princetown, Victoria, second point north-west of Pebble Point (=PL3004).

*Occurrence and material.* PL3001 (10 specimens), PL3003 (39 specimens), PL3004 (15 specimens).

*Remarks.* *Fissidentalium gracilicostatum* seems to belong to that group of species of *Fissidentalium* that do not have an apical slit (Pilsbry & Sharp 1897; Emerson 1962). The species is more common in the formation than the above figures would suggest, because specimens are usually broken and difficult to collect. The genus is not known from the Paleocene of New Zealand nor from the late Eocene of Antarctica. Somewhat similar taxa are known from the Paleocene of southeastern USA, Copenhagen, Ukraine and the Anglo-Paris Basin, but *F. gracilicostatum* is much larger and heavier than any of these and has more ribs. *F. gracilicostatum* differs from *F. mawsoni* Ludbrook, Late Eocene to Middle Miocene, southeastern Australia, in being much more curved, in having an oval rather than circular cross section, having no fissure at the apex, and finer and more numerous ribs (50–70 as against 50). The difference between primary and secondary ribs in *F. gracilicostatum* is not very pronounced, whereas it is very pronounced in *F. mawsoni*.

### **Compressidens Pilsbry & Sharp, 1897**

*Type species.* *Dentalium pressum* Pilsbry & Sharp, 1897, Recent, Caribbean.

### **Compressidens laticornuata sp. nov.**

Fig. 8A–C, F

*Description.* Shell of average size for genus (25–35 mm), gently tapering, curved, compressed dorso-ventrally so as to form slight suggestion of lateral keels, lenticular in cross section; interior oval in cross section.

Sculpture of fine growth lines only. Posterior section with fine annular ribs. No slit.

#### *Dimensions*

Holotype P301880	L 34.6 W 4.8×4.4 width at ap. 1.9×1.7
Paratype P301878	L 33 W 5.0×4.5 width at aperture
Paratype P301879	L 29 W 3.8×3.6 width at aperture

*Type material.* Holotype P301880, collected T. A. Darragh, 13 December 1994; Paratypes P301878–P301879, collected T. A. Darragh, 13 December 1984. Paratype WAM 94.403a, collected G. W. Kendrick, 13 November 1984.

*Type locality.* PL3003.

*Occurrence and material.* PL3001 (4 specimens), PL3003 (53 specimens), PL3004 (4 specimens), PL3007 (3 specimens) (Rivernook Member).

*Remarks.* On 12 small specimens, probably belonging to this species, the posterior section has fine rings. All other specimens are bigger than these and do not have this section preserved. Most of the specimens collected are fragments of larger specimens because they are usually cracked across the shell.

This seems to be one of three species which range from the Pebble Point Formation into the overlying Early Eocene Dilwyn Formation.

There are no taxa previously recorded from the Paleocene quite like this one. All other similar looking taxa have a circular cross section and have been placed in *Laevidentalium*. The earliest record of *Compressidens* according to Emerson (1962) is Miocene, so that the Pebble Point occurrence, if the generic assignment is correct, constitutes the earliest known. The genus is not known in the fossil record in Australia but a living species, *Compressidens platyceras* Sharp & Pilsbry, is recorded from off the coast of New South Wales. The Pebble Point taxon is about three times larger than this species and more compressed.

### Family GADILIDAE

### **Gadila Gray, 1847**

*Type species.* *Dentalium gadus* Montagu, 1803, Recent, Europe.

### **Gadila laguncula sp. nov.**

Fig. 8I, L–P

*Description.* Shell small, of average size for genus (7 mm), solid, curved, smooth, shining, tapering towards anterior and posterior, posterior taper less than anterior, swollen at anterior  $\frac{2}{3}$ . Oval in cross section. Growth striae barely visible.

#### *Dimensions*

Holotype P301881	L 7.2 W 1.5 swelling at 4.6 mm from posterior
Paratype P301882	L 6.5
Paratype P301883	L 7.0 W 1.5 swelling at 5.0 mm from posterior

*Type material.* Holotype P301881, collected T. A. Darragh, 13 November 1984; Paratype P301882, collected T. A. Darragh, 17 February 1981; Paratype P301883, collected T. A. Darragh & K. Bell, 21 November 1970.

*Type locality.* PL3001.

*Occurrence and material.* PL3001 (1 specimen), PL3003 (9 specimens).

*Remarks.* The genus has a cosmopolitan distribution (Emerson 1962). The broken specimen of *Gadila* sp. recorded from Wangaloa by Finlay & Marwick (1937) may have the swelling much closer to the anterior end than the *G. laguncula* sp. nov. *G. antarctotubula* Stilwell & Zinsmeister, late Eocene, Antarctica is more curved and more slender. *G. turgida* Meyer, Paleocene, south-eastern USA is somewhat similar in shape but *G. laguncula* is not so curved. The genus is not known from the Paleocene of the Paris Basin nor of Ukraine.

*Gadila* is known from the Eocene, Miocene and Pliocene of southeastern Australia. *G. laguncula* is closest to the Miocene *G. mucronata* (Tate), but the swelling is closer to the mid point of the shell than in *G. laguncula*. The Eocene species, known from one specimen, has the swelling at the mid point of the shell. There are several living species of the genus recorded from southern Australia.

## Class Cephalopoda

### Family NAUTILIDAE

#### *Eutrephoceras* Hyatt, 1894

*Type species.* *Nautilus dekayi* Morton, 1834, Late Cretaceous, United States of America.

#### *Eutrephoceras victorianum* (Teichert, 1943)

Fig. 9A–C, E, I

*Nautilus victorianus* Teichert, 1943: 262, pl. 11, figs 5–7. *Eutrephoceras victorianum*.—Teichert, 1947: 43, figs 5–6.

*Description.* Conch small for genus (maximum diameter 125), subdiscoidal, involute with small umbilicus closed by callus. Whorl outline regularly rounded ventrally, slightly flattened laterally, regularly and deeply impressed dorsally.

Siphuncle situated slightly ventral of septum centre.

Growth lines sinuous, produced aperturally on flanks, wide ventral sinus.

Sutures with low broad umbilical saddle, very broad shallow lobe laterally and shallow ventral lobe.

#### *Dimensions*

Holotype P127999	D 47	W 32
Figured specimen P301871	95	45
Figured specimen P301872	67	40

*Type material.* Holotype P127999, collected G. Baker, January 1942; Figured specimen P301871, collected D. J. Holloway, 14 December 1994; Figured specimen P301872, collected G. Baker, 21 February 1956.

*Type locality.* 'In grit band 30–40 feet above Jurassic–Tertiary unconformity. Second point north-west of Pebble Point, south-east of Princetown' (=PL3004).

*Occurrence and material.* PL3001 (4 specimens), PL3003 (2 specimens plus 2 fragments), PL3004 (1 specimen).

*Remarks.* *Eutrephoceras* ranges in age from Jurassic to Middle Miocene and has a cosmopolitan distribution. *E. victorianum* is rather laterally compressed when compared with the subglobular shape of most of the species in the genus. In shape it most resembles *E. bryani* (Gabb, 1877), Early Eocene, United States of America and *E. allani* Fleming, 1945, Early Eocene, Chatham Islands. On the basis of the two specimens of *E. allani* figured (Fleming, 1945; Stilwell & Grebneff, 1996), it seems to be very similar to *E. victorianum*.

*Eutrephoceras* is also known from the Early to Middle Miocene of Victoria and South Australia. *E. victorianum* is narrower and higher than *E. geelongensis* (Foord) and *E. altifrons* (Chapman) and has slightly more sinuous sutures than these Neogene species.

#### *Aturoidea* Vredenburg, 1925

*Type species.* *Nautilus parkinsoni* Edwards, 1849, Eocene, England.

#### *Aturoidea distans* Teichert, 1943

Figs 9D, F–H, 10A–C

*Aturoidea distans* Teichert, 1943: 260, pl. 11, figs 1–4, fig. 1.—Teichert 1947: 40, figs 1–4.

*Description.* Conch very large (300+ mm diameter), subdiscoidal, moderately broad, involute, umbilicus closed.

Whorl outline regularly rounded ventrally, somewhat flattened laterally, sides diverging then rapidly contracting to umbilicus.



Suture with broad almost flat ventral saddle; lateral lobe narrow, elongate, asymmetrically attenuating; lateral saddle broad, strongly and regularly curved; umbilical lobe narrow, strongly curved; umbilical saddle narrow, strongly curved; dorsal lobe deep, narrow with parallel sides.

Siphuncle with orthochoanitic septal necks, situated close to dorsum; septal necks curved, long, one third to half length of camerae; connecting rings cylindrical, considerably overlapping septal necks and invaginating into preceding septal foramina.

Growth lines sinuous, strongly convex laterally then swinging backward to form deep hyponomic sinus.

#### Dimensions

Holotype P123012	D 110	W 50 (as preserved)
Figured specimen P301860	127	73
Figured specimen P128060	299	146

*Type material.* Holotype P123012 (formerly MUGD 1860), Paratype 123013 (MUGD 1861), Paratype P123014 (MUGD 1862), all collected G. Baker, January 1942; Figured specimen P128061 (MUGD 1932) (Teichert 1947, figs 3–4), collected O. P. Singleton, 1943; P128060 (MUGD 1931) (Teichert 1947, figs 1–2); Figured specimen P301860, collected T. A. Darragh, 2 December 1985; P301865, collected T. A. Darragh, 8 March 1977.

*Type locality.* 'Grit band, 30–40 feet above unconformity between Jurassic (i.e. Lower Cretaceous) and Tertiary. Second point north-west of Pebble Point, south-east of Princetown, Victoria', i.e. PL3004.

*Occurrence and material.* PL3001 (1 specimen), PL3003 (5 specimens), PL3004 (1 specimen), Pebble Point area (8 specimens), Killara Bluff (1 specimen).

*Remarks.* *Aturoidea* ranges in age from Late Cretaceous to Middle Eocene, but most species seem to have been recorded from rocks now known to be of Paleocene age. The genus has a cosmopolitan distribution having been found in England, Spain, Bulgaria, Libya, Angola, Pakistan, India, New Zealand, California, New Jersey and Australia. However, most species are represented by only one or two specimens, except in Western Australia and Victoria where species are represented by up to a 16 specimens.

Teichert's original illustration of the suture of *A. distans* is not correct. The lateral lobes

are not narrow and pointed, but asymmetrically attenuated just as in the type species *Aturoidea parkinsoni* (Edwards). According to Miller (1947), *A. parkinsoni*, *A. spathi*, *A. pilsbryi* and *A. paucifax* are all similar and not very different in age. *A. distans* can also be added to this list, as well as *A. brunnschweileri* Glenister, Miller & Furnish, from the Middle Eocene of Western Australia. Glenister et al. (1956) distinguished their species from *A. distans* by the differences in the shape of the suture of *A. distans* as described by Teichert. In fact the sutures of both species are very similar if not identical.

A small specimen of what seems to be this species occurs in the Early Eocene Rivernook Member of the Dilwyn Formation which overlies the Pebble Point Formation.

*Aturoidea* is not found above the Early Eocene in Eastern Australia.

#### Bivalvia

#### Family NUCULIDAE

#### *Nucula* Lamarck 1799

*Type species.* *Arca nucleus* Linnaeus, 1758, Recent, Europe.

#### *Nucula* sp.

#### Fig. 12B-C

#### Dimensions

Figured specimen P302630 W 2.1 H 2.2

*Figured material.* Figured specimen P302630, collected T. A. Darragh, 24 November 1992.

*Remarks.* The collection of additional material has permitted the confirmation of a second nuculid in the fauna. There are six specimens in hand, most of which are broken, ranging in size from 3×2.4 mm to an estimated 6×5.5 mm. This species belongs in *Nucula* s.s. The surface of the valve is almost smooth and covered with numerous closely spaced, very faint radial lines. Some specimens have coarse growth lines. The internal margin of the valve is denticulate. It bears considerable resemblance to European species of

Fig. 9. A–C, E, I, *Eutrephoceras victorianum* Teichert. A–B, NMV P127999, holotype, PL3004, A, ×1.0, B, ×1.4. C, NMV P301871, figured specimen, PL3001, ×0.6. E, I, NMV P301872, figured specimen, PL3003, E (first chamber removed), ×0.7, I (first chamber in place), ×0.9. D, F–H, *Aturoidea distans* Teichert. D, G, NMV P301860, figured specimen, PL3003, D, ×0.6, G, ×0.6. F, NMV P123012, holotype, PL3004, ×0.7. H, NMV P301865, figured specimen, PL3003, ×0.5.

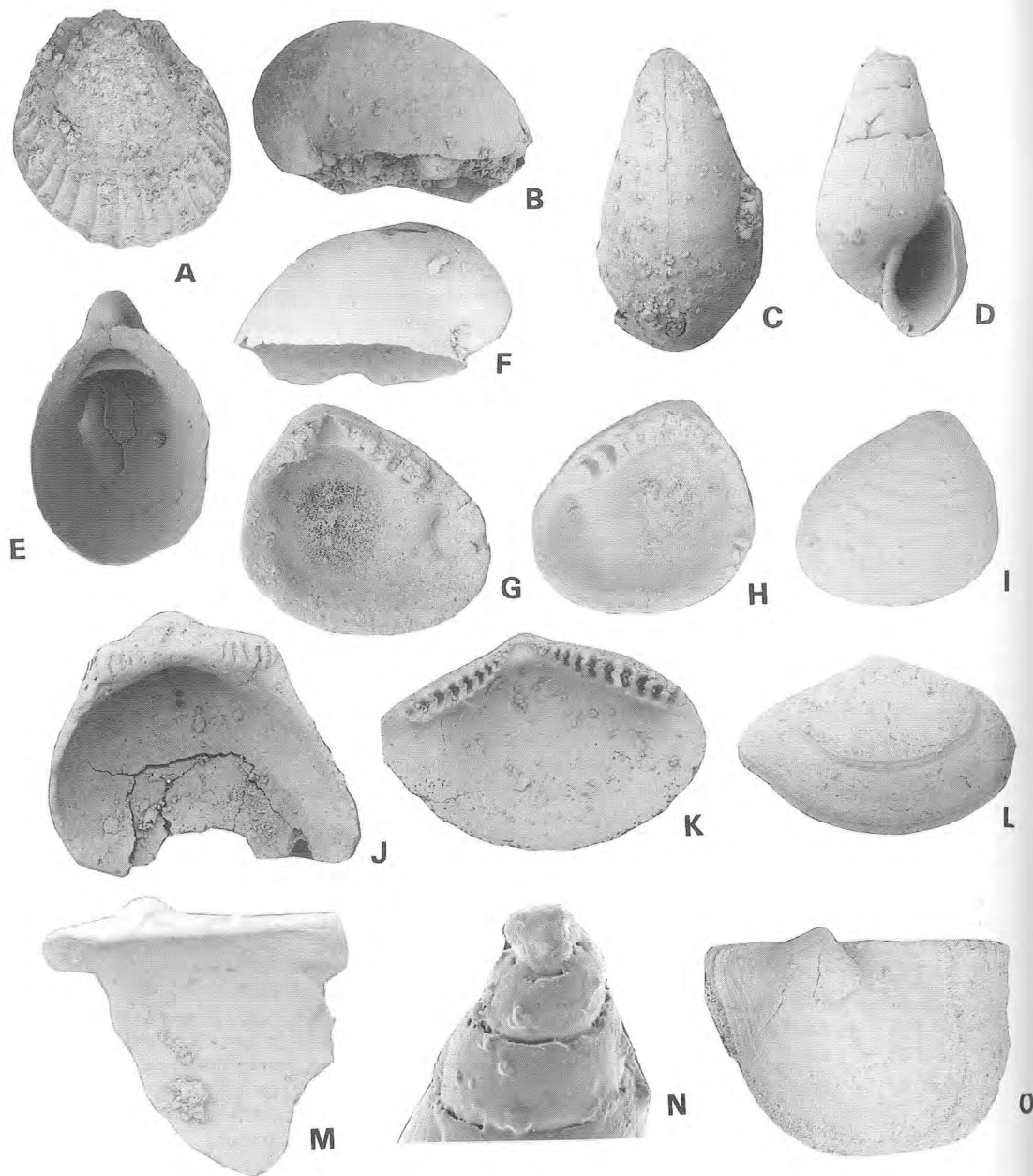


Fig. 11. A, J, *Limea (Notolimea) multicosulifera* sp. nov. A, NMV P302277, holotype, PL3003,  $\times 17$ . J, NMV P302278, paratype, PL3003,  $\times 25$ . B-C, E-F, *Rimula? crepiduloides* sp. nov. B, P302612, paratype, PL3003,  $\times 20$ . C, NMV P302613, holotype, PL3003,  $\times 17$ . E-F, specimen lost in scanning, PL3003,  $\times 30$ . D, N, *Odostomia* sp. D, P302490, figured specimen, PL3003,  $\times 17$ . N, NMV P302491, figured specimen, PL3003,  $\times 47$ . G-I, *Austronucula? arenaria* sp. nov. G, NMV P302283, paratype, PL3003,  $\times 39$ . H, NMV P302284, paratype, PL3003,  $\times 39$ . I, P302282, holotype, PL3003,  $\times 35$ . K-L, *Comitileda brachyrhynchoides* sp. nov. K, NMV P302326, paratype, PL3003,  $\times 17$ . L, NMV P302325, holotype, PL3003,  $\times 12.5$ . M, O, *Electroma glessaria* sp. nov. M, P302281, paratype, PL3003,  $\times 15$ . O, NMV P302280, holotype, PL3003,  $\times 25$ .

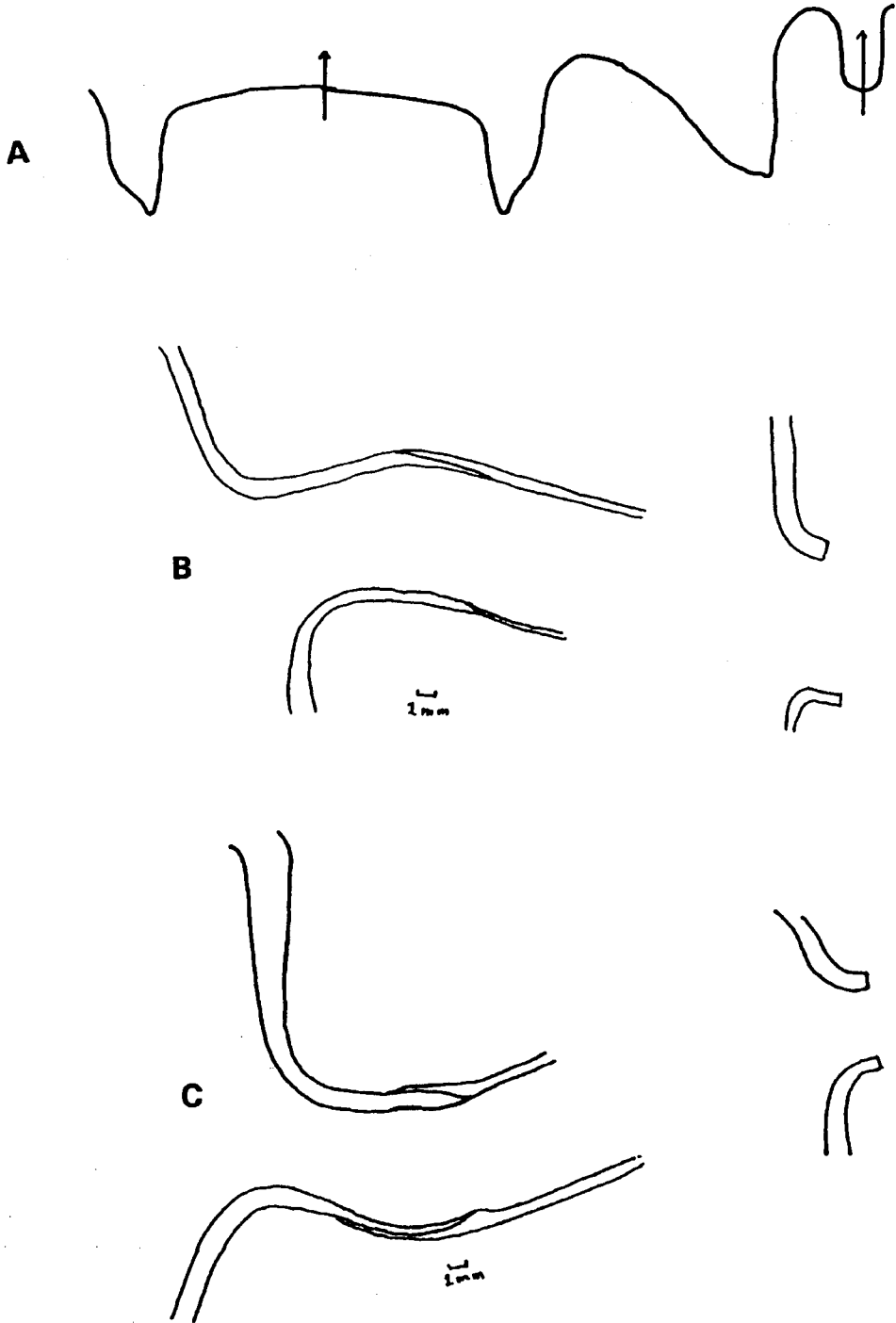


Fig. 10. A-C, *Aturoidea distans* Teichert. A, sketch of suture based on P301864. B-C, sketch of both sides of longitudinal section cut through siphuncle of P301863 showing attachment of septal ring to septal neck.

*Nucula* from the Paleocene and Eocene, such as *N. montensis* Cossmann (Paleocene, Belgium) and *N. fragilis* Deshayes (Paleocene–Eocene, Europe). This species is bigger and more triangular than *Lamellinucula pyrenoides* Darragh, Pebble Point Formation, and lacks the sharp, raised commarginal ribs.

Two specimens have gastropod boreholes.

#### **Austronucula** Powell, 1939

*Type species.* *Austronucula schenki* Powell, 1939, Recent, New Zealand.

#### **Austronucula?** *arenaria* sp. nov.

Fig. 11G–I

*Description.* Shell minute (0.9×0.8–1.3×1.1 mm), very solid, porcellanous, trigonal. Umbones orthogyral. Anterior dorsal margin straight; anterior margin short, rounded, merging imperceptibly with dorsal and ventral margins; posterior dorsal margin straight, longer than anterior dorsal margin; posterior margin short, rounded, merging imperceptibly with dorsal and ventral margins; ventral margin gently curved. Hinge separated into two parts by deep triangular vertical ligament pit; pit apex directed dorsally and pit sunk well below hingeline. Anterior tooth row with five to six teeth, posterior row with three teeth. Muscle impressions subequal, slightly oval; posterior adductor impression very deep. Pallial line entire. Inner ventral margin smooth. Internal surface of valve shining. External surface of valves shining, smooth, except for traces of fine growth striae.

#### *Dimensions*

Holotype P302282	W 0.9	H 0.9 pair
Paratype P302283	0.9	0.9
Paratype P302284	0.8	0.8

*Type material.* Holotype P302282, Paratype P302283, Paratype P302284, collected T. A. Darragh, 13 December 1994.

*Type locality.* PL3003.

*Occurrence and material.* PL3003 (77 specimens).

*Remarks.* The combination of small size and absence of any radial elements in the shell structure, absence of marginal denticulations and external sculpture in *Austronucula?* *arenaria* sp. nov. is quite unlike the characters of any other Australian nuculid so far recorded. The species is placed in *Austronucula* with some hesitation. Previously *Austronucula* has been recorded only from New Zealand. *A.?* *arenaria*

is more triangular than either of the two New Zealand species and lacks the prominent prodissoconch of these species. It has more teeth than *A. schenki* Powell, in which respect it resembles *A. galathea* Dell.

The material can be grouped into two. One group consists of very well preserved smooth shining valves, amongst which articulated valves are not uncommon. The second group consists of larger valves which are invariably worn, pitted and coloured green. Glauconite is deposited in pits and sockets and attached to the internal and external surfaces of the valves in the second group. The calcite in some specimens of this group may have been replaced by glauconite.

#### Family NUCULANIDAE

#### **Comitileda** Iredale, 1924

*Type species.* *Leda miliacea* Hedley, 1902, Recent, New South Wales.

Until a proper revision of the small rostrate nuculanids is undertaken, I follow Maxwell (1992) in using this genus rather than *Ledina* to which Australian species have been previously assigned. The genus occurs in New Zealand from Middle Eocene to Recent and in Australia from Paleocene to Recent.

#### **Comitileda** *brachyrhynchoides* sp. nov.

Fig. 11K–L

*Comitileda* sp. cf. *C. brachyryncha* Maxwell, 1992.—Darragh, 1994: p. 77, fig. 1K–M.

*Description.* Shell small (2–3 mm), ovate, almost equilateral, somewhat tumid, slightly rostrate at posterior end. Umbo central, projecting slightly, very slightly opisthogyral. Anterior dorsal margin gently convex; anterior margin strongly convex, merging into convex ventral margin; ventral margin gently convex, concave where it merges with posterior margin; posterior dorsal margin straight; posterior margin short, strongly convex. Surface of valve smooth except for growth ridges. Hinge with ten posterior and eight anterior chevron-shaped teeth, apex directed towards umbo. Muscle scars subequal, barely visible; pallial line with shallow rounded sinus. Internal valve margin smooth.

#### *Dimensions*

Holotype P302325	L 3.3	H 2.1
Paratype P302326	2.75	1.7
Paratype P142862	2.2	1.4 pair

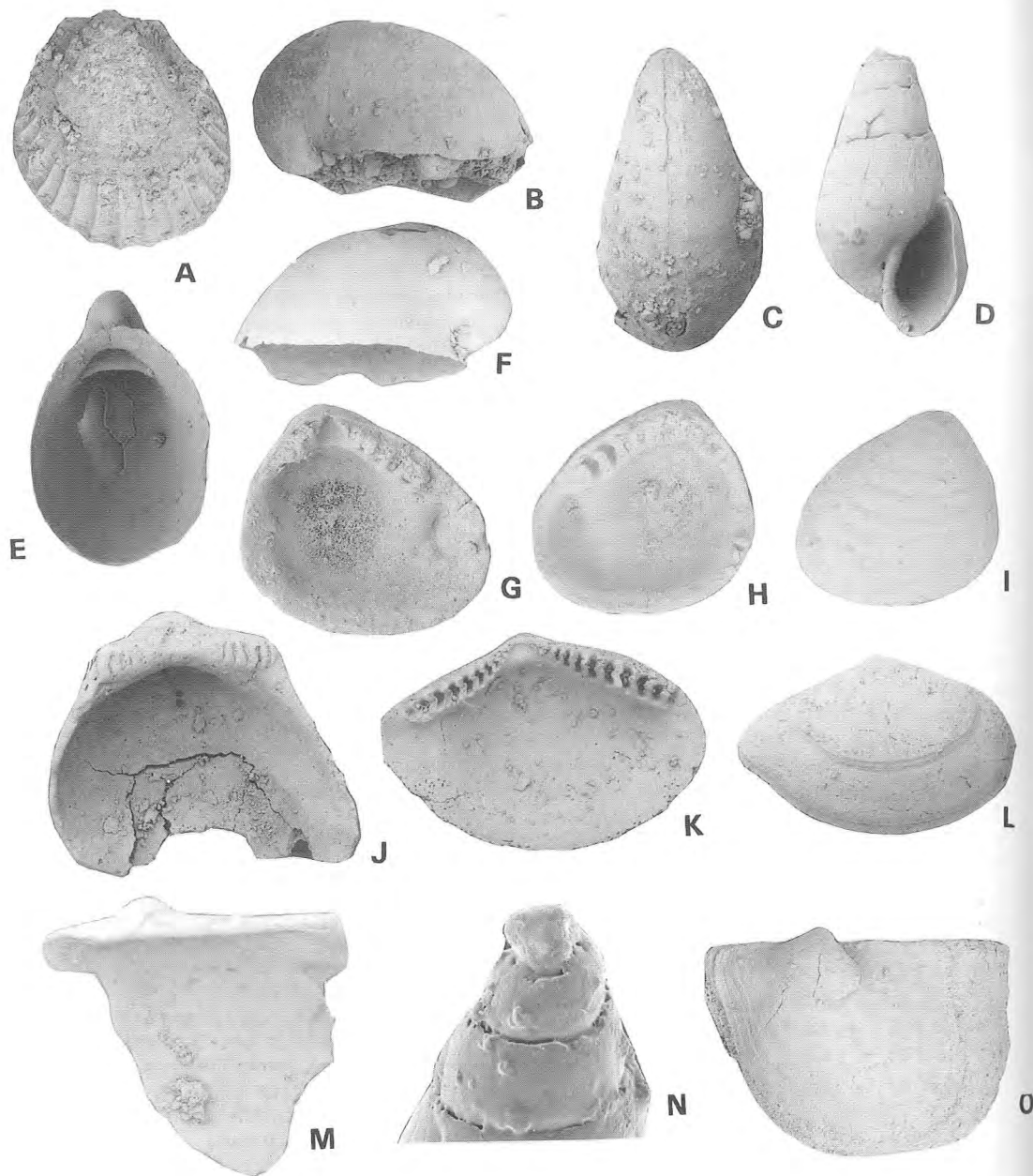


Fig. 11. A, J, *Limea (Notolimea) multicosulifera* sp. nov. A, NMV P302277, holotype, PL3003,  $\times 17$ . J, NMV P302278, paratype, PL3003,  $\times 25$ . B-C, E-F, *Rimula? crepiduloides* sp. nov. B, P302612, paratype, PL3003,  $\times 20$ . C, NMV P302613, holotype, PL3003,  $\times 17$ . E-F, specimen lost in scanning, PL3003,  $\times 30$ . D, N, *Odostomia* sp. D, P302490, figured specimen, PL3003,  $\times 17$ . N, NMV P302491, figured specimen, PL3003,  $\times 47$ . G-I, *Austronucula? arenaria* sp. nov. G, NMV P302283, paratype, PL3003,  $\times 39$ . H, NMV P302284, paratype, PL3003,  $\times 39$ . I, P302282, holotype, PL3003,  $\times 35$ . K-L, *Comitileda brachyrhynchoides* sp. nov. K, NMV P302326, paratype, PL3003,  $\times 17$ . L, NMV P302325, holotype, PL3003,  $\times 12.5$ . M, O, *Electroma glessaria* sp. nov. M, P302281, paratype, PL3003,  $\times 15$ . O, NMV P302280, holotype, PL3003,  $\times 25$ .

*Type material.* Holotype P302325, Paratype P302326, collected T. A. Darragh, 18 January 1996; Paratype P142862, collected T. A. Darragh, 24 November 1992.

*Occurrence and material.* PL3003 (26 specimens).

*Remarks.* Three specimens have countersunk gastropod drill holes. *Comitileda brachyrhynchoides* sp. nov. bears a very close resemblance to *C. brachyryncha* Maxwell, Eocene, New Zealand but differs by being slightly more elongate and having a more convex anterior margin. It is also very similar to *C. praelonga* Tate, Oligocene to Miocene, Australia. *C. praelonga* is more rostrate, more slender and more pointed at the posterior end, but the differences are slight. *C. brachyrhynchoides* is more tumid than *C. miliacea* (Hedley) but is not as elongate and the umbo is not so strongly opisthogyral. *Leda rhamphidia* Cossmann, Paleocene, Belgium is somewhat similar in shape to *C. miliacea*.

#### Family GLYCYMERIDAE

##### *Glycymeris* Da Costa 1778

*Type species.* *Arca glycymeris* Linnaeus, 1758, Recent, Europe.

##### *Glycymeris* sp.

Fig. 12I, P

*Description.* Shell of medium size for genus (48×51 mm), rounded, slightly higher than wide, umbo projecting. Sculpture, poorly preserved, seemingly of wide, low costae, separated by very narrow shallow grooves. Hinge arched, bearing about five teeth in each series.

##### *Dimensions*

Figured specimen P302275 W 48 H 51 T 23 approx.

*Figured material.* Figured specimen P302275, collected T. A. Darragh, 14 December 1994.

*Occurrence and material.* PL3001 (1 specimen and 1 fragment).

*Remarks.* The material in hand is poorly preserved and somewhat weathered. One specimen is a complete valve and the other specimen is a valve fragment. This species is about the same size as *Glycymeris concava* Marshall, 1917, Early Paleocene, New Zealand, type species of *Glycymerita* Finlay & Marwick, 1937, but it has a rounded rather than quadrate outline and the radial sculpture does not seem to be so well developed and so is not related.

Of Australian Tertiary taxa, it has some resemblance to *G. cainozoica* Tenison Woods, 1877, from the Late Oligocene to Middle Miocene of Victoria and Tasmania, but is more robust than that species.

*Glycymeris* has a cosmopolitan distribution from Late Cretaceous on. Somewhat similar looking species, but not so robust are known from the Paleocene of Belgium, Denmark and Ukraine. It is very similar to *G. erebratularis* (Lamarck, 1829) from the Thanetian of the Paris Basin.

#### Family PTERIIDAE

##### *Electroma* Stoliczka, 1871

*Type species.* *Avicula smaragdina* Reeve, 1857, Recent, Indonesia.

*Pterelectroma* Iredale 1939: 332.

##### *Electroma glessaria* sp. nov.

Fig. 11M, O

*Electroma* sp. Darragh, 1994: 84, fig. 3C–D, I.

*Description.* Shell small, thin, nacreous, oblique, inequivalve; left valve inflated, right valve relatively flat; anterior of valves with triangular wing separated from flank of valve by slight sinus. Umbo projecting slightly above hinge line, opisthogyral. Hinge long and straight with triangular posteriorly directed resilifer pit under umbo, slightly anterior of mid point of hinge. Hinge with long posterior lateral and one very short anterior lateral in left valve. Posterior adductor muscle impression large; anterior adductor impression very small, situated high under hinge, slightly anteriorly of umbo; other internal features of valve not preserved. Byssal notch very shallow. External surface of valve smooth.

##### *Dimensions*

Holotype P302280	L 1.8	W 1.4
Paratype P302281	3.0	3.1 broken
Paratype P142966	1.4	1.2
Paratype P142965	4.5+	2.5+

*Type material.* Holotype P302280, Paratype P302281, collected T. A. Darragh, 18 January 1996; Paratypes P142965–P142966, collected T. A. Darragh, 24 November 1992.

*Type locality.* PL3003.

*Occurrence and material.* PL3003 (32 valves and one pair).

*Remarks.* All specimens are small and are almost certainly juveniles. Only two valves are sufficiently complete and large enough for comparison with other taxa. *Electroma glessaria* sp. nov. seems similar to Palaeogene species assigned to *Electroma* Stoliczka, though *Pteria* Scopoli, 1777 has also been used for such species and may well be the correct taxon. The anterior of the valve is slightly more produced than in

juveniles of *Electroma georgiana* (Quoy & Gaimard), living, southern Australia, and the central part of the valve is much more convex (higher). In this respect it is somewhat similar to *E. zebra* (Reeve), Recent, Queensland.

In shape *E. glessaria* is similar to *E. stam-pinensis* (Deshayes), Early Oligocene, Europe, but it is not so oblique as other Eocene taxa assigned to *Electroma* by Glibert and Van der Poel (1965).

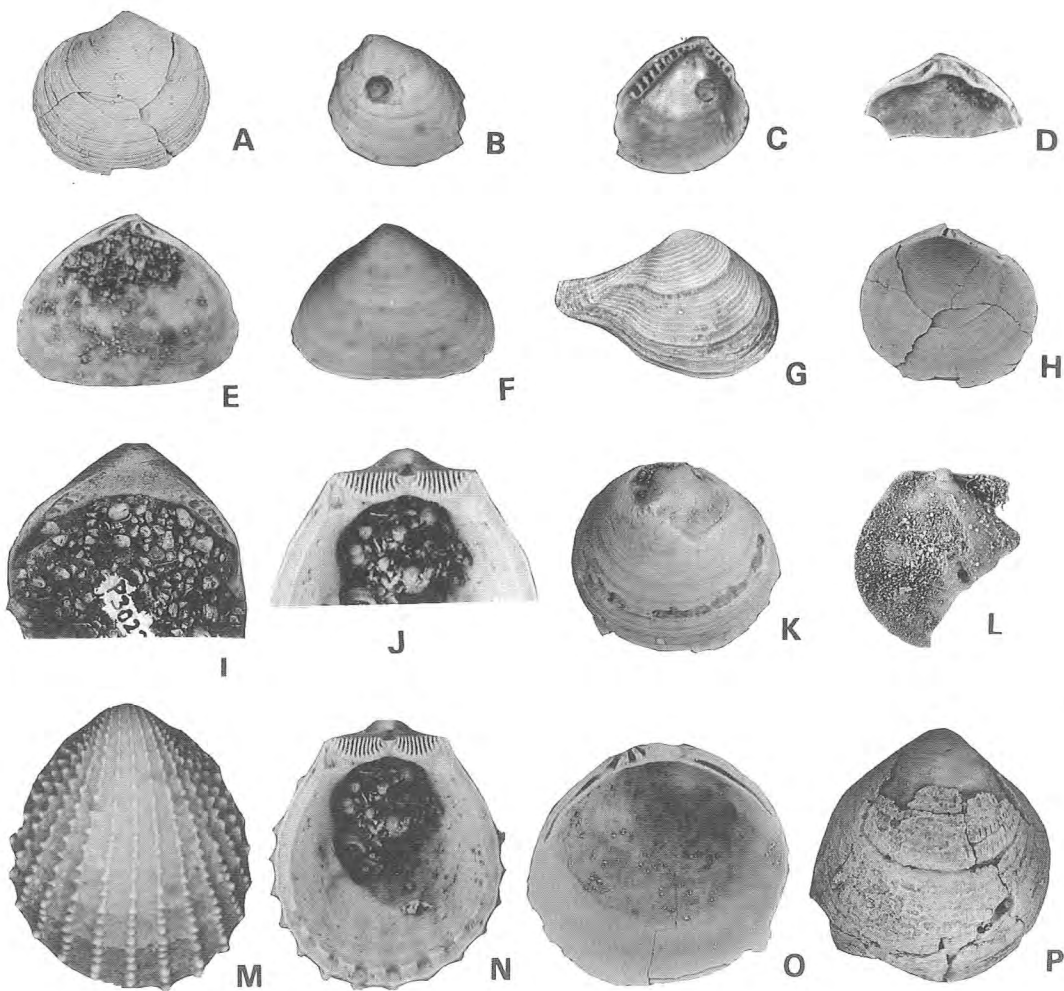


Fig. 12. A, H, *Jagolucina psephenata* sp. nov. NMV P301795, holotype, PL3003,  $\times 3.1$ . B-C, *Nucula* sp., NMV P302630, figured specimen, PL3003,  $\times 5.1$ . D-F, *Bornia flabellaris* sp. nov. D, NMV P302271, paratype, PL3003,  $\times 8.4$ . E-F, NMV P302270, holotype, PL3003, E,  $\times 8.2$ , F,  $\times 7.5$ . G, *Cuspidaria obbata* sp. nov. NMV P301644, holotype, PL3003,  $\times 2.5$ . I, P, *Glycymeris* sp. NMV P302275, figured specimen, PL3001,  $\times 0.7$ . J, M-N, *Limea (Notolimea) australis* (Smith), Australian Museum C26640, 1463 m, 35 miles east of Sydney, NSW,  $33^{\circ}51'S, 151^{\circ}58'-152^{\circ}0'E$ . K, O, *Corbicula?* sp. NMV P302276, figured specimen, PL3003, K,  $\times 2.3$ , O,  $\times 2.8$ . L, *Delectopecten* sp. NMV P302628, figured specimen, PL3003,  $\times 5.1$ .

It has a smaller anterior wing and is more rectangular in shape than *E. intacta* Finlay and Marwick, Wangaloan, New Zealand. *E. notiala* Stilwell and Zinsmeister, Late Eocene, Seymour Island, is much more oblique than the Pebble Point taxon. Despite the ambiguity in generic determination, i.e. whether *Pteria* or *Electroma*, it is clear that the Pebble Point taxon belongs to a group that was widespread in the early Palaeogene.

#### Family PECTINIDAE

##### **Delectopecten** Stewart, 1930

*Type species.* *Pecten (Pseudamussium) vancouverensis* Whiteaves, 1893, Recent, North eastern Pacific.

##### **Delectopecten** sp.

Fig. 12L

*Description.* Shell of average size for genus, thin, fragile, equivalve except for byssal notch, ovate, slightly produced posteriorly. Posterior ear of both valves small, not well defined. Sculpture of 'camptonectes' striae only.

##### *Dimensions*

Figured specimen P302628 L 4.5 est. H 4.6

*Figured material.* Figured specimen P302628, collected T. A. Darragh, 18 January 1996.

*Material.* PL3003 (4 specimens and fragments).

*Remarks.* *Delectopecten* has a very wide distribution. It is known living from the Indian Ocean, the north and eastern Pacific Ocean and from northern Australia, New Caledonia and New Zealand. It occurs from Eocene to Holocene in Western North America, in the Miocene of Europe and in the Oligocene and Miocene of Japan and eastern Russia.

This species will be described in more detail and illustrated with better material in a publication with A. G. Beu on Australian Tertiary Pectinidae.

#### Family LIMIDAE

##### **Limea (Notolimea)** Iredale, 1924

*Type species.* *Lima australis* Smith, 1891, Recent, New South Wales.

##### **Limea (Notolimea) multicostulifera** sp. nov.

Fig. 11A, J

Limid indet. Darragh, 1994: 85, fig. 3E.

*Description.* Shell small (2.2×2.6–2.9×3.6 mm), very slightly inequilateral, oval, slightly higher than wide; umbo somewhat inflated, orthogyral, projecting very slightly above hinge margin; auricles small, subequal. Approximately 24 to 30 radial ribs, thin and crowded on anterior and posterior flanks, broad and widely spaced on central flank. Ligamental area, centrally situated, triangular; eight to nine vertical teeth on each side of hinge, no teeth below ligament pit. Internal features of valves eroded. Internal valve margin denticulate.

##### *Dimensions*

Holotype P302277	L 2.9	H 3.6
Paratype P142881	2.4 est.	2.3+

*Type material.* Holotype P302277, Paratype P302278, collected T. A. Darragh, 18 January 1996; Paratype P142881, collected T. A. Darragh, 24 November 1992.

*Occurrence and material.* PL3001 (1 specimen); PL3003 (71 specimens); PL3004 (1 specimen).

*Remarks.* Most specimens are worn or decorticated and fragmentary, and consist of the umbonal or dorsal half of the valve suggesting that they may have travelled some distance before burial. One specimen shows traces of tubercles on the ribs. *Limea (Notolimea) multicostulifera* sp. nov. closely resembles the type species of *Notolimea*, *Limea australis*, but *L. (N.) multicostulifera* has 24 to 30 ribs compared with 17 to 18 in *N. australis* and it lacks the tubercles of that species except on one specimen. The hinge is identical to that of *N. australis*. The shell structure of *N. australis* consists of two parts; an internal white opaque layer and an external translucent layer. The fossil material seems to consist mostly of the internal opaque layer, the outer layer having been lost.

Species of *Notolimea* are known from the Eocene to Miocene of Europe. Of these *L. (N.) sacki* (Philippi), Early Oligocene, Germany, is similar in size and hinge morphology, but *L. (N.) multicostulifera* has thinner ribs, no secondary intercalated ribs and the ribs are not tuberculate as in *N. (L.) sacki*. Two other similar species, *N. (L.) eocenica* (de Laubrière) and *N. (L.) tenuisculptata* (Cossmann), occur in the Middle Eocene of the Paris Basin. *N. broccha* Marwick, 1931 occurs in the Middle Miocene of New Zealand.



In the Tertiary of southeastern Australia, there is only one species of *Notolimea* recorded so far. This is *Linea (Notolimea) alticosta* Tate which is similar in overall morphology to *L. (N.) multicostulifera* but has fewer ribs (14).

As the type species of this subgenus has never been adequately figured, figures of the exterior and interior are provided from a specimen dredged from 1463 m, 35 miles east of Sydney, NSW (Fig. 12J, M-N).

#### Family LUCINIDAE

##### *Jagolucina* Chavan, 1939

*Type species.* *Lucina concava* Defrance, 1823, Eocene, France.

##### *Jagolucina?* *psephenata* sp. nov.

Fig. 12A, H

*Jagolucina?* sp. Darragh, 1994: 87, fig. 4E, G.

*Description.* Shell subcircular, of average size (6–10 mm), moderately inflated; umbo pointed, prosogyral; anterior dorsal margin concave; anterior, ventral and posterior margins regularly convex, not differentiated from one another; posterior dorsal margin straight. Lunule short, prominent. Sculpture of fine, close set, com-marginal ribs.

Hinge: left valve with bifid anterior cardinal; thin posterior cardinal; two anterior laterals separated by short socket; possibly one posterior lateral.

Anterior muscle scar long, narrow, divergent from pallial line, extending from under anterior lateral tooth well into valve. Posterior scar lozenge-shaped, not clearly visible.

Internal margin of shell smooth.

##### *Dimension*

Holotype P301795	L 7.5	H 7.2
Paratype P142890	6.5	6
Measured specimen P142891	11.2	10.5

*Type material.* Holotype collected W. J. Parr, 11 January 1943; Paratype P142890, collected T. A. Darragh, 13 November 1984.

*Type locality.* Fourth point south-east of the mouth of the Gellibrand River (i.e. PL3003).

*Occurrence and material.* PL3001 (two left valves), PL3003 (10 left and three right valves).

*Remarks.* Additional material of this species found in the collections has permitted it to be

formally described. All specimens except the holotype are very worn and the generic position is very much open to doubt. Three of the left valves have gastropod boreholes. I have found no obviously related species in the Southern Hemisphere. *Jagolucina* occurs in the Paleocene and Eocene of Europe.

#### Family ERYCINIDAE

##### *Bornia* Philippi, 1836

*Type species.* *Bornia corbuloides* Philippi, 1836 (= *Cyclas sebetia* Costa, 1829), Recent.

##### *Bornia flabellaris* sp. nov.

Fig. 12D–F

*Borniola?* Darragh, 1994: 89, fig. 4N–O.

*Description.* Shell triangular, of average size for the genus; umbo pointed, slightly projecting, slightly prosogyral; valve strongly convex at flanks, central part of the disk flattened or slightly depressed; posterior dorsal margin straight, posterior and anterior margins short, strongly convex; ventral margin slightly concave.

Hinge: left valve with prominent long posterior tooth; central triangular resilifer flanked anteriorly by short curved tooth, separated by narrow socket from strong anterior tooth. Right valve with deep anterior socket, flanked posteriorly by strong, short, projecting, curved tooth; wide central triangular resilifer, flanked posteriorly by long strong lateral, lateral flanked posteriorly by long deep socket. Muscle scars subequal, situated high in valve. Pallial line entire. Sculpture of growth lines only.

##### *Dimensions*

Holotype P302270	L 3.6	H 2.8
Paratype P302271	3	3 fragment only
Paratype P142899	4.1	3.5

*Type material.* Holotype P302270, Paratype P302271, collected T. A. Darragh, 18 January 1996; Paratype P142899, collected T. A. Darragh, 13 November 1984.

*Type locality.* PL3003.

*Occurrence and material.* PL3003 (14 specimens).

*Remarks.* Since the first record of this taxon, more material has been collected which enables a more precise determination to be made. The hinge is very similar to the type species of the genus, *Bornia sebetia*, the teeth being virtually identical, however the resilifer pit is very short in the type

species and long in *B. flabellaris* sp. nov. Compared with *Bornia trigonalis* (Tate), Recent, southern Australia, *B. flabellaris* is more triangular in outline and the resilifer pit is larger. It also lacks the fine reticulate sculpture of *B. trigonalis*.

The genus is known from Eocene to Recent in Europe and United States of America and has a cosmopolitan distribution in Recent seas. There are probable unrecorded species of the genus in the Tertiary of southeastern Australia.

#### Family CORBICULIDAE

##### *Corbicula* Mergele von Mühlfeld, 1811

*Type species. Tellina fluminalis* Müller, 1774, Recent, Middle East.

##### *Corbicula* ? sp.

Fig. 12K, O

*Description.* Shell subcircular, somewhat globose, of small size for genus (11×12 mm). Umbonal region corroded. Sculpture of growth lines only.

*Hinge:* right valve with long anterior deep cross-grooved socket, very weak thin anterior cardinal, separated by wide socket from strong bifid cardinal; posterior cardinal weakly bifid separated from central cardinal by wide socket and flanked on posterior by narrow triangular socket; posterior socket long and cross-grooved.

RV 0 0 / \ 010 →

Internal margin of valve smooth. Muscle scars subequal; anterior slightly longer than width; posterior scar D-shaped, slightly larger than anterior scar. Pallial line possibly with a shallow sinus.

##### *Dimensions*

Figured specimen P302276 W 12 H 11 T 3

*Figured material.* Figured specimen P302276, collected T. A. Darragh, 18 January 1996.

*Material and occurrence.* PL3003 (1 specimen).

*Remarks.* This has some resemblance to small specimens of *Corbicula gravesi* (Deshayes, 1825), Early Eocene, Paris Basin, but is not so globose, has a rounded outline and the cardinal teeth are directed vertically not anteriorly as in *C. gravesi*.

*Corbicula* is known from the Paleocene and Eocene of Europe and the Paleocene and Eocene of the United States of America. Modern species

of the genus are found in brackish and fresh water, whereas Early Tertiary species are found in marine sediments as well as in sediments of fresh and brackish water origin. The single specimen from the Pebble Point Formation has a corroded umbonal region which suggests that it may have originated in a fresh or brackish water environment and been washed into the sea.

#### Family CUSPIDARIIDAE

##### *Cuspidaria* Nardo, 1840

*Type species. Tellina cuspidata* Olivi, 1792, Recent, Mediterranean.

##### *Cuspidaria obbata* sp. nov.

Fig. 12G

*Cuspidaria* sp. Darragh, 1994: 101, fig. 8A–C, E–F.

*Description.* Shell elongate ovate, rostrate, tumid, of average size for genus (11×7.7 mm); umbo opisthogyral, not projecting; anterior dorsal margin long convex; anterior margin short, strongly convex, continuous with dorsal margin; ventral margin convex then concave where it forms posterior rostrum; posterior dorsal margin concave extending to form posterior rostrum. Sculpture of thin, widely spaced, commarginal ribs present either on dorsal third of valve only or over whole of valve, other portion of valve sculptured with prominent growth ridges. Rostrum with three to five fine widely spaced radial threads, one of which bounds rostrum ventrally. Hinge with small resilifer under umbo, teeth if present in left valve not visible on available material. Right valve with long posterior lateral tooth. Posterior adductor scar subtriangular deeply sunken; anterior scar not visible.

##### *Dimensions*

Holotype P301644	L 11.7	H 7.7
Paratype P142946	10	6.5
Paratype P142948	9.5	7
Paratype P142951	8	5.5

*Type material.* Holotype P301644, collected T. A. Darragh, 13 December 1994; Paratypes P142946, P142948, P142950, collected T. A. Darragh, 23 November 1992.

*Type locality.* PL3003.

*Occurrence and material.* PL3001 (1 specimen), PL3003 (5 specimens), PL3004 (1 specimen).

*Remarks.* Additional material enables this species to be formally described. Three specimens are

left valves and are incomplete or worn. Two right valve are complete and unworn. This taxon is very close in morphology to *Cuspidaria subrostrata* Tate, Middle Miocene, Victoria. The sculpture is similar but the outline is subcircular rather than elliptical. In shape it resembles *Cuspidaria raincourtii* Cossmann, Eocene, Paris Basin, but that species has close-set, fine commarginal ribs covering the whole valve. The genus occurs rarely in the Paleocene of Europe and has been recorded from the Paleocene of Pitt Island, New Zealand (Campbell et al. 1993), but it is not recorded from the Early Tertiary of mainland New Zealand, Antarctica or from the Paleocene of the United States.

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