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A REVISION OF THE TERTIARY VOLUTIDAE (MOLLUSCA: GASTROPODA) OF SOUTH-EASTERN AUSTRALIA

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Abstract

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The Volutidae of Australia consists of 18 genera or subgenera of which five are known only as fossils and three only in the living fauna. (Twenty other genus group taxa have been synonymised.) The fossil genera can be grouped according to their affinity as:

Cosmopolitan: *Lyria* (Late Oligocene-Recent), *Athleta* (Late Paleocene) and *Scaphella (Aurinia)* (Late Eocene).

Endemic (the dominant element): *Livonia* (Late Oligocene–Recent), *Ericusa* (Late Oligocene–Recent), *Nannamoria* (Late Oligocene–Recent) and *Amoria* (Middle Miocene–Recent).

Neozelandic: *Alcithoe (Alcithoe)* (Late Miocene, Late Pliocene), *Alcithoe (Waihaoia)* (Late Eocene–Middle Miocene).

Indo-Pacific or Tethyan: *Cymbiola* (Late Oligocene–Recent), *Mitreola* (Late Eocene) and *Leptoscapha* (Middle Miocene, Recent).

The living volutes of the Southern Australian region are almost entirely derived from the Southern Australian Tertiary volute fauna.

Twenty-two new species group taxa are proposed:

Lyria acuticostulata (E–M Mioc.), *L. mitraeformis crassicosta* (E Pleist.), *Mitreola salaputium* (L Eoc.), *Scaphella (Aurinia) johannae* (L Eoc.), *Notovoluta variculifera* (L Eoc.), *N. capitonica* (L Eoc.), *N. verconis medicata* (E Pleist.), *N. kreuslerae occulta* (E Pleist.), *N. linigera* (E Mioc.), *N. differta* (E Mioc.), *Nannamoria amplexa* (L Mioc.), *N. fasciculata* (E. Mioc.), *N. trionyma* (M Mioc.), *N. paraboloides* (L Mioc.–L Plioc.), *N. deplexa* (E Mioc.), *N. cinctuta* (L Plioc.), *Alcithoe (Waihaoia) pagadoides sororcula* (L Olig.), *A. (W.) neglectoides* (L Olig.), *Alcithoe (A.) orphanata* (L Plioc.), *Livonia mortoni connudata* (E Mioc.), *L. voluminosa* (M Mioc.), *Notopeplum primarugatum* (E Olig.)

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Introduction

Volutidae are carnivorous burrowing molluscs represented in all oceans of the world, but particularly in those of the Southern Hemisphere. The seas surrounding Australia probably have the greatest diversity of genera, and about one third of the described species. Volutes are generally thought of as tropical animals, but, in fact, the majority of species occurs in warm-temperate to temperate waters and some even in the cold waters of the Antarctic and in abyssal depths (Weaver and du Pont, 1970). Distribution with depth ranges from intertidal to abyssal, but most are confined to depths less than 200 metres. The oldest species of the family appear in the Late Cretaceous of North America, Europe, the Middle East and India and the family was well established throughout the world by the Eocene (Wenz, 1943).

In general, this study has shown that the Australian Tertiary Volutidae, by virtue of the distribution of the Tertiary rocks, is similar to that presently found in temperate to warm-temperate waters of the southern half of the Australian Continent and distributed between 0 and 250 metres. They range in size from the 9 mm *Leptoscapha crassilabrum* (Tate) to the 300 mm *Livonia hannafordi* (McCoy).

Owing to their beauty and diversity, the Australian living volutes attracted the attention of professional and particularly amateur conchologists for many years. Much has been written on the group but there has been no serious attempt to analyse the fauna as a whole and relate it to the fossil record. The most comprehensive account of Australian Recent volutes is that of Weaver and du Pont (1970) who monographed the Volutidae of the World. However, whilst their work will remain a classic study of the family, they could not, of necessity, treat the Australian members in detail, particularly with reference to status of genera, and they did not touch on the geological history of the family. Nevertheless, their work brings together the widely scattered literature, provides up-to-date information, excellent figures of the living species, and is of considerable assistance to workers on the family.

The fossils, on the other hand, received a minimum of attention. Apart from the original descriptions of species, there has been little further work, and no attempt at systematic revision or proper synthesis of the Tertiary and Recent faunas. The work reported here has involved a systematic study of the entire fossil fauna at both the generic and specific levels and an attempt has been made to elucidate the geological history of the group and to integrate fossil and living species. The palaeontologist, if the geological record is good, sometimes has an excellent opportunity to study the variations in morphology of a group, since he is dealing with organisms which range through time as well as in space; hence he may have a better appreciation of range of variation and relationships within a genus than the worker on living species.

There are several factors which hitherto tended to prevent a critical appraisal of the volute family as a whole. Firstly, excessive taxonomic splitting, particularly at the generic level, mainly by workers on living species, lead to the creation of monotypic genera, obscurred relationships and articially differentiated between living and fossil species by inflation of the living fauna. Secondly, many of the Tertiary species, such as those of *Notopeplum*, *Notovoluta* and *Ternivoluta*, belong to groups at present found in moderately deep water, beyond the reach of normal collecting and it is only in recent years with the development of trawling that species, such as *Nannamoria parabola*, *Ternivoluta studeri* and *Notopeplum translucidum* have become readily available for study and comparison with Tertiary species. Thirdly, previous workers on volutes have tended to be wholly involved either with fossils, or with living species and have not

made more than token comparisons between the two groups.

In this revision, the genera of Recent volutes receive considerable attention but the species are not dealt with in detail in view of the work of Weaver and du Pont (1970). The species of volutes of Southern Australia are assigned by the author to 18 genera or subgenera, of which five are known only as fossils. there are two further taxa, *Volutoconus* and *Melo*, known only from Northern Australia doubtfully recorded as fossils and another, *Lyrenaeta,* not known in the fossil record, which are mentioned only in passing. Twenty genus-group taxa have been sunk in synonomy with one or other of the 18 recognised genera. *Teramachia*, recently recorded from north-western Australia, is not regarded by the author as a member of the family. Though its familial relationship is uncertain, because the anatomy of the animal is unknown, the author suggests that it would be better placed in the Turbinellidae pending examination of the animal. Even so, the Australian volute fauna is the most diverse in the world and because of this diversity both at generic and specific levels, the Volutidae is potentially an exceedingly useful family for stratigraphical purposes in this country. Many species have short time ranges and are easily recognisable. Volutes are found in a wide range of depths and on a variety of substrates. In the Tertiary sequence of south-eastern Australia fossil volutes are, therefore, found in many different kinds of rocks throughout the stratigraphical column.

Previous work

The original authors of the many Australian fossil species of volutes described in the nineteenth and early twentieth century, McCoy (1866, 1874, 1876), Tenison Woods (1876), Johnston (1880, 1888), Tate (1888, 1889b) and Pritchard (1896, 1898, 1913), described their species, with the exception of those in *Lyria* under the old Linnaean name *Voluta,* despite the fact that several other generic names had already been used for some of the living species from Australia. Tate (1889) did use *Amoria* and *Volutoconus*, but only as sections rather than as subgenera. Harris (1897) distributed 19 of the described species known to him, in eight genera or subgenera, with a measure of success, by using the form of the protoconch as a guide, in the manner advocated by Dall (1890b). Tate (1898) stated that Harris's classification did not meet all the requirements and he offered the first overall classification of the entire group of fossils. He distributed 32 species in two genera, *Volutilithes* and *Voluta,* the latter having nine sections. *Lyria* was not mentioned. His proposal was a distinct advance and much of his grouping still stands, though with a few modifications owing to changes in nomenclature. Cossmann's classification (1899) made only minor alterations to that of Tate but did not include all species.

Finlay (1927, 1930) and Marwick (1926), when dealing with New Zealand fossil and living volutes, made occasional references to Australian fossil species. Cotton (1949) proposed a comprehensive classification of the Tertiary and Recent species; however, he accepted uncritically all genera and species described to that time. He listed 79 living and 48 fossil species in 22 genera. Later authors, Ludbrook (1958), McMichael (1959, 1960, 1961) and Wilson (1972) have dealt with or mentioned various species and genera, but have made no overall revision or review.

Composition and origins of the Australian volute fauna

The composition of any volute fauna in any region will depend, to some extent, on the mobility, or otherwise, of particular species. As adult volutes are benthic animals with little mobility, one must look to the larvae for possible means of dispersal. Little is known of the larval development of the various species, particularly those from deep water; however, of those species for which this information is available (Wilson, 1971) all have direct development and no planktonic or free-swimming larval stage. Therefore their means of dispersal is limited and leads to genetic isolation and hence considerable intra-specific variation, a feature which has already been mentioned by McMichael (1959), and Wilson (1971). This also leads to marked provincialism among volutes since trans-oceanic dispersal is greatly inhibited. Thus with few exceptions, genera are not widely distributed and at present are restricted to epi-continental areas or larger islands (Kay, 1967). In fact the volute fauna of the areas where species occur today was largely established by mid-Tertiary time and little has been added since. This generalisation is true only for the areas which have a reasonable fossil record and a living volute fauna.

These are as follows:

Japan: *Fulgoraria* and its allies range from Oligocene to Recent.

Central America: *Voluta* Miocene to Recent, *Scaphella* Miocene to Recent, *Mitreola* (= *Enaeta*) Miocene to Recent.

South America: *Adelomelon* Miocene to Recent, *Pachycymbiola* Miocene to Recent, *Miomelon*

Miocene to Recent.

New Zealand: *Wathoata* Eocene to Miocene, *Alethoe* Miocene to Recent.

Australia: *Ternivoluta* Eocene to Recent, *Notovoluta* Eocene to Recent, *Ericusa* Oligocene to Recent, *Livonia* Oligocene to Recent, *Notopeplum* Eocene to Recent, *Amoria* Miocene to Recent, *Nannamoria* Oligocene to Recent.

The only truly cosmopolitan genera are *Athleta*, *Lyria* and their allies which in the early Tertiary make up a large proportion of the volute fauna of the world. A possible inference from this is that the cosmopolitan genera had planktonic larval stages at least in the early Tertiary and that direct development which led to the marked provincialism evolved in the middle Tertiary.

The genera in the Australian fauna recognised by the author, their synonyms, time ranges and number of species or subspecies in Australia are summarised below. Further details will be found under the systematic descriptions of each of the taxa.

Athleta (Athleta). Late Paleocene (Numerous synonyms, Darragh, 1971). A single species is known similar to those present in the early Tertiary of Europe. The genus had virtually a cosmopolitan distribution in the Paleogene, became more restricted during the Neogene and at present is confined to the Indian and Atlantic Oceans off the coast of Southern Africa.

Athleta (Ternivoluta). Late Eocene–Recent (= *Austrovoluta*). Ten specific taxa, two of which are living. An endemic subgenus, derived from *Athleta (Athleta)* in the Eocene, is well represented throughout the Tertiary of South eastern Australia but is now confined to small areas in deep water off the central east coast of Australia (Darragh, 1971, 1979).

Lyria. Late Oligocene–Recent (= *Harpeola*). Twelve specific taxa, 3 of which are living. *Lyria* is probably derived from a member of the Athletinae in the Late Cretaceous. It was established by the Paleocene and in the Eocene had virtually a cosmopolitan distribution. The present distribution is much more restricted, as it is now confined to the tropical and temperate West Pacific and Indian Oceans and the Western Atlantic. The Australian species appear to be most closely related to Eocene species of the Paris Basin and Oligocene–Miocene species of South-eastern Asia.

Lyrenaeta, a monotypic genus, is restricted to central and northern New South Wales. Specimens are rare. The genus is closely related to *Lyria* and the Southern African *Callipara*, but there are no obvious ancestors in the fossil record.

Leptoscapha. Middle Miocene, Recent. The single species known appears to be closely related to the type species from the Middle Eocene of the Paris Basin and another species from the Late Eocene of Java.

Mitreola. Late Eocene (= *Enaeta*). A single species of the genus is known from South-west Australia. The genus was established in Europe in the Paleocene and became extinct there in the Oligocene. It reached the American region in the Early Miocene and is now confined to the Central American region.

Scaphella (Aurinia). Late Eocene. The single species known is similar to those present in the early Tertiary of Europe. The subgenus ranges in Europe from Paleocene to Pliocene. In America, it appears in the Miocene and is now confined to the coasts of eastern central America.

Alethoe (Wathaona). Late Eocene–Middle Miocene. Seven specific taxa known of which three make up a group of related taxa. The other four seem to be closely related to New Zealand species of the genus rather than to the other Australian species. The genus may have arrived in Australia from New Zealand in the Early to Middle Eocene, however the taxon is not known in New Zealand prior to the Middle Eocene.

Alethoe (Alethoe). Late Miocene, Late Pliocene (= *Leporemax*, *Carolluta*, *Gilvostia*), two species. The origin and relationships of each of these species are obscure, but they seem to be closely related to New Zealand species rather than to one another. There is no unbroken record of the taxon through the Southern Australian Tertiary and each species may represent a separate migration from New Zealand.

Ericusa. Late Oligocene–Recent (= *Mesericusa*.) Eleven specific taxa, four living of which two are known as fossils. This taxon and *Livonia* are closely related and presumably had a common origin in the Eocene or early Oligocene.

Livonia. Late Oligocene–Recent (= *Mamilla*, *Pterospira*, *Cottonia*), 12 specific taxa, five living of which one is known as a fossil.

Notopeplum. Late Eocene–Recent. Six specific taxa, two living, one of which is known as a fossil. An endemic Southern Australian genus whose origins are obscure, but it seems to be related to *Livonia* and *Ericusa*.

Cymbiola. Late Oligocene–Recent (= *Aulica*, *Aulicina*, *Cymbiolena*, *Cymbiolacca*). About 14 specific taxa are currently recognised in Australia but revision will probably cut this figure to about 10. Most species are found in Northern Australia. In the south, three species are known, of which two

are known only as fossils and the other occurs living in Western Australia and as a fossil in South-eastern Australia. There are numerous other taxa throughout the Indonesian and Philippine Islands. The genus ranges from Late Miocene to Recent in the former area.

Melo. Pliocene–Recent (Indonesia) (= *Melocorona*). This genus, known from the Neogene of Indonesia and doubtfully from the Middle Miocene of North Western Australia, is not represented in the fossil record of the Southern Australian Region. It is well established in the Northern Australian Region and has penetrated as far south as Victoria, presumably arriving in the Late Pliocene or the Pleistocene. This genus is closely related to *Cymbiola*.

Amoria. Middle Miocene–Recent (= *Amorena, Relegamoria, Cymbiolista, Zebramoria*). Four fossil taxa, two of which are still living. Several other species occur around the Australian coast, particularly in the north and extending into the southern islands of Indonesia. The known fossils are of species with southern affinities. The history of the genus is obscure, however as there is no fossil record in the Neogene of Indonesia, the genus may have its origin in the Australian Tertiary.

Nannamoria. Late Oligocene–Recent (= *Paramoria*). Seventeen specific taxa of which five are living. An endemic genus widely distributed in the southern Australian Region and common in the Tertiary of South-eastern Australia. The origin of the genus is not clear. On the basis of shell characters, a possible relationship with *Cymbiola* and *Notovoluta* is suggested.

Notovoluta. Late Eocene–Recent. Seventeen specific taxa, six living, of which one is known as a fossil. This is another endemic genus whose origin is obscure.

Volutoconus. No fossil record in the south but doubtfully recorded from the Middle Miocene of North-west Australia. Four specific taxa in Northern Australia. Judging from shell characters, the genus is related to *Cymbiola*, but the radula is unusual and allies it with the South American genera *Miomelon and Odontocymbiola*.

The fossil fauna

The fossil fauna is composed of four groups of genera defined by their origin or affinity. These are as follows:

1. Cosmopolitan Element represented by *Lyria, Athleta* sensus lato and *Scaphella (Aurinia)*.

2. Endemic Element which is dominant and represented by *Livonia, Ericusa, Notopeplum, Notovoluta, Nannamoria* and *Amoria*.

3. Neozelandic Element represented by *Alcithoe (Alcithoe)* and *A. (Waihaoia)*.

4. Indo-Pacific or Tethyan Element represented by *Cymbiola, Mitreola* and *Leptoscaphia*.

The representatives of the first group, whilst once widespread, particularly in the Paleogene, are now more restricted in their distribution. Those of the second group make up the major part of the Southern Australian living fauna, but *Amoria* is a prominent element of the Northern Australian Region. The third group is now confined to the waters surrounding New Zealand and is not now represented in the Australian fauna. Both the second and third groups, in part, belong to Fleming's (1962, 1963) Paleoaustral Element. The genera *Livonia, Ericusa, Notopeplum, Notovoluta (?)* and *Alcithoe* are most probably related to the Southern American genera *Zidona, Adelomelon* and *Proscaphella*. Of the last group (4), only *Cymbiola* is still extant and is characteristic of the present Northern Australian fauna, but there are still some representatives of the genus in Southern Australia, particularly in the Overlap Zones between the Southern Australian Region (temperate) and the Northern Australian Region (tropical).

It can be argued that some of the genera cited above had their origin in the Southern Australian Region and subsequently colonised other areas, but the fossil record in the north is so poor in Volutidae that it is not possible to support or disprove this argument. *Cymbiola*, for instance, is known only from the Late Miocene and Pliocene in the Indonesian archipelago and from the Middle Miocene of North-west Australia, whereas, in Southern Australia, the first record is from the late Oligocene. Specimens are uncommon, however, and the evidence suggests that South-eastern Australia was a marginal area in the distribution of the genus.

For a general discussion of the composition of the fossil fauna see Darragh (1985).

The living fauna

The Volutidae of Australia can be conveniently divided into two groups, both of which fall neatly into the two biogeographic regions proposed by Wilson (1971) on the basis of general molluscan distribution, the Northern Australian or Tropical Region and the Southern Australian or Temperate Region. Between these two regions are two areas which Wilson calls the Western and Eastern overlap zones, extending respectively from Northwest Cape south to Cape Leeuwin and from Fraser Island south to Cape Howe. In these there is an overlap or transition between the two faunas.

Volute genera characteristic of the Southern Aus-

tralian Region are *Notovoluta, Livonia, Ericusa, Notopephum* and *Nannamoria,* all of which are well represented in the Tertiary of Southern Australia and are not known elsewhere. The Northern Australian Region is characterised by *Volutoconus* and *Melo* which are not known as fossils in the south (records of *Volutoconus* are not correct, see below), and by *Amoria* and *Cymbiola* which are poorly represented in the fossil record of the south. Both *Melo* and *Cymbiola* are represented in the Late Tertiary of the Indonesian Archipelago. The two overlap zones have representatives of both groups.

This study shows that the volutes of the Southern Australian Region are almost entirely derived from the Southern Australian Tertiary fauna, whereas those of the Northern Australian Region belong to the western Indo-Pacific fauna and seem to have their origins in the Tethyan fauna of Fleming (1967) and Ludbrook (1954), the volutes of which unfortunately are not well documented, particulary prior to the Pliocene.

Classification

The classification of the Volutidae currently accepted by most workers is essentially that of Pilsbry and Olsson (1954). These authors reviewed in some detail previous attempts to classify the genera of the family and then proposed their own classification. They divided the family into twelve subfamilies on the basis of radula, where known, and shell characters, particularly the nature of the protoconch. One subfamily included, the Volutomitrinae, is now regarded as a family in its own right (Ponder, 1972) and is excluded from discussion. Later, Clench and Turner (1964) examined the anatomy of many American species of volutes, slightly modified the classification, but confirmed the subdivisions at least for the groups they examined. Weaver and du Pont (1970) accepted the classification, but Turner, who contributed new anatomical data to their monograph, expressed doubts on the placement of some taxa, particularly in regard to some of the Australian genera, such as *Amoria* and *Ericusa.*

The writer, in association with B.J. Smith, has completely reassessed the subfamilies and the placement of genera on the basis of previously published anatomical data (listed in Weaver and du Pont, 1970) and on personal examination of the anatomy of specimens of over 30 nominal taxa of Australian volutes (see Appendix 2). The principal features used by Clench and Turner (1964) to characterise the subfamilies, namely, radula, siphon and anterior digestive system, have also been used in this study, together with the presence or absence of an operculum and the nature of the head lobe, to produce a new classification in which the generic arrangement differs considerably from that of Weaver and du Pont (1970).

The classification followed in this work is outlined below and lists the Australian genera recognised by the writer. Further details and diagnoses of the subfamilies can be found under the appropriate subfamily in the systematic section.

Athletinae: *Athleta (Athleta), Athleta (Ternivoluta).*

Volutinae (= Lyriinae, Volutilithinae, Calliotectinae): *Lyria, Leptoscapha, Mitreloa, Lyrenaeta.*

Scaphellinae: *Scaphella (Aurinia).*

Subfamily uncertain: *Notovoluta, Volutoconus.*

Amoriinae: *Amoria, Nannamoria.*

Zidoninae: *Alcithoe (Alcithoe), Alcithoe (Waihaoia), Ericusa, Livonia, Notopephum, Cymbiola, Melo.*

Stratigraphical record in South-eastern Australia

The fossil record of Volutidae in South-eastern Australia is rather fragmented owing to facies changes in Tertiary sediments and lack of appropriate outcrop. These aspects have been discussed in more detail by Darragh (1985) and are only outlined here.

The Paleocene and Early to Middle Eocene are represented by a series of shallow-water marine or non-marine sediments in which volutes are either absent or rare. The single undoubted volute species known, *Athleta (Athleta) wangerrip* Darragh, may be ancestral to the Late Eocene to Early Oligocene *Athleta (Ternivoluta) curvicostata* Darragh. The Late Eocene sediments are of open marine origin and though reasonably widespread, outcrop is limited.

Early Oligocene marine sediments are also limited in outcrop. The volute fauna of the Late Eocene and Early Oligocene is meagre and it is not until the Late Oligocene through to Middle Miocene that the volute fauna is rich. During this latter period moderately deep neritic sediments were deposited across Southern Australia and outcrop of these sediments, in general, is excellent.

The volute fauna of the Late Miocene through the Pliocene to the Pleistocene is rather poor, since sediments of this age are mostly of shallow-water origin and volutes, apart from *Amoria*, are rare. There are also numerous breaks in the sequence, particularly in the Late Pliocene, so that a continuous record of volutes is not possible.

Notwithstanding problems of limited outcrop and lack of sediments of appropriate facies, the members of the family are extremely useful

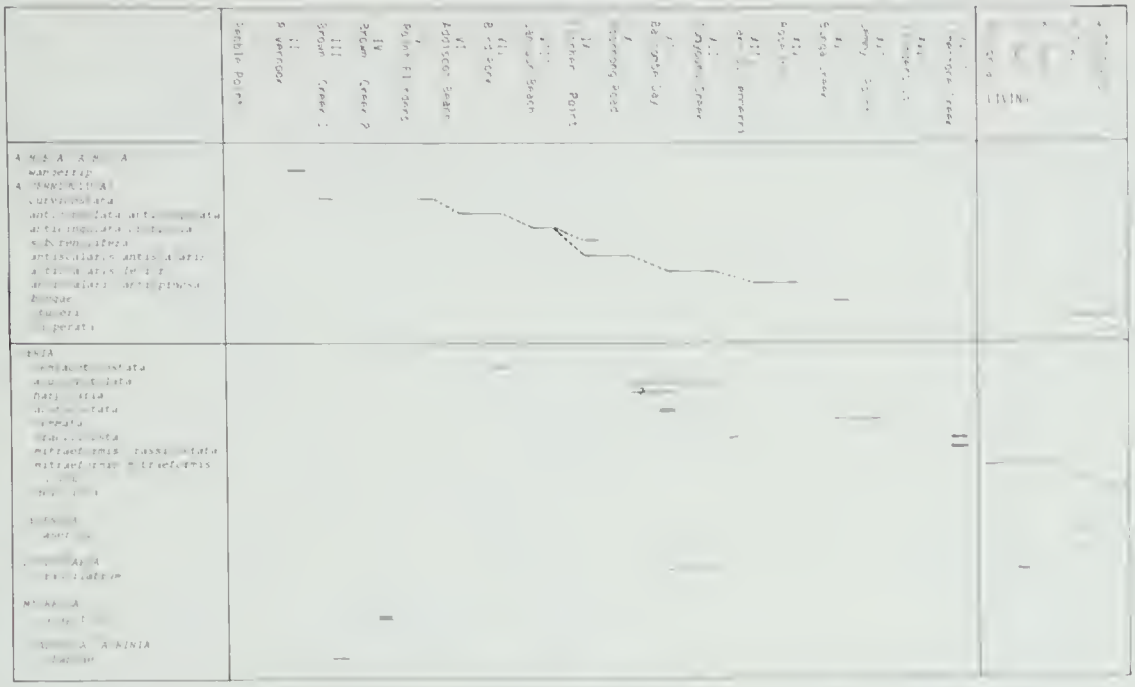

Table 1. Ranges of volute species in terms of molluscan assemblages. ■ denotes occurrence of taxon in strata of equivalent age in South Australia and Western Australia (continued on next page).

stratigraphically within the period for Late Eocene to Early Pliocene. (Table 1). Within certain genera it is possible to demonstrate lineages of species which are particularly useful for fine stratigraphical subdivision.

To establish a lineage of taxa it is necessary for the taxa to be similar in morphology and succeed one another closely in time. In theory, there should be a continuous record of morphological change with time. In practice, lineages are very difficult to establish and document beyond reasonable doubt, owing to the fickle nature of the fossil record, and only small sections of the continuum are preserved. Variables, such as geographical distribution of outcrops, nature of outcrops, richness of outcrops, facies of sediments preserved or outcropping, disconformities and lack of continuous sections, contribute to the problem and prevent lineages being recognised. In South-eastern Australia from the Late Eocene to Middle Miocene, but particularly from Late Oligocene to Middle Miocene, it is possible to control some of these variables and suggest possible lineages. In this part of the stratigraphical column there are sufficient localities to compose a composite section of reasonably uniform lithology which have yielded material to document five lineages. These occur within the genera *Nannamoria, Notopeplum, Notovoluta* and the subgenus *Ternivoluta.* It can be shown for each of the proposed lineages that certain morphologically similar taxa succeed one another within short intervals of time in a reasonably uniform succession of clastic sediments and in a geographically restricted area, the Otway Basin. In each case there are no other morphologically similar taxa in the sediments concerned and the simple and most reasonable explanation for the succession of these closely related taxa is to assume that the older taxa gave rise to the younger.

Terminology

Species descriptions are arranged within genera in approximate order of their appearance in the stratigraphical record. Measurements are given as follows: L, Total length of shell from tip of protoconch to end of anterior canal along the axis of the shell; HA, Height of aperture from suture to end of anterior canal, measured parallel to the axis of the shell; W, Width of shell measured perpendicular to the axis of the shell and between any axial sculpture.

Localities are abbreviated and listed under locality numbers, e. g., FI.82, Clifton Bank, a key to which can be found as Appendix 1. Grid references are given in brackets throughout.

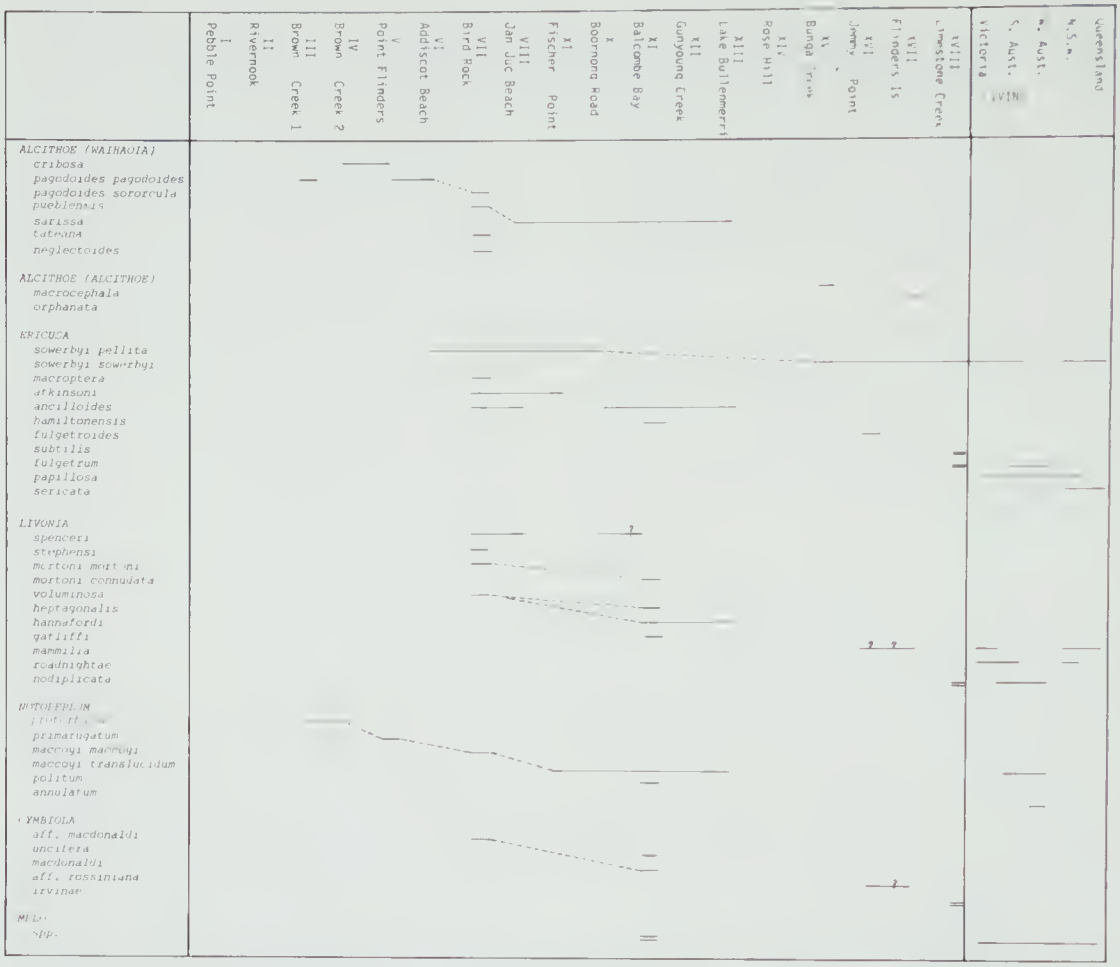

Table 1 (continued). Ranges of volute species in terms of molluscan assemblages. = denotes occurrence of taxon in strata of equivalent age in South Australia and Western Australia (continued on next page).

Systematic Palaeontology

Volutidae Rafinesque, 1815

Diagnosis. Shell: Shell ovate to fusiform, ranging in size from small (10 mm) to very large (500 mm), often coated with a smooth, highly polished glaze. Sculpture, if present, highly variable, consisting either of axial or radial elements and sometimes both. Protoconch generally smooth, usually calcareous, but chitineous and deciduous in some groups, sometimes multiwhorled and coiled with axis of shell, but generally of 1 to 3 whorls, the first of which may be deviated from axis of shell. Aperture elongate, usually about a third length of shell and produced into a short, but well defined anterior canal, having in most groups a siphonal notch and fasciole, which if present vary in degree of development. Outer lip of aperture generally simple and slightly thickened, but produced laterally into a pronounced wing in some groups. Plaits highly variable in number, sometimes absent, but generally 3 to 5 strong plaits are present, which may have numerous weaker plaits inserted between or posterior to them. Shell generally highly coloured with variable colour patterns.

Animal: Foot large and broad. Head wide and flattened, usually with a large central lobe, which in some groups is divided by a median cleft, and 2 lateral lobes on which are situated 2 flattened triangular tentacles. Eyes, if present, usually behind and at base of tentacles. Siphon large, overlying head, with 1 or generally 2 lateral lobes or appendages at base. Mantle in some groups large and capable of enveloping shell. Mantle, siphon, proboscis

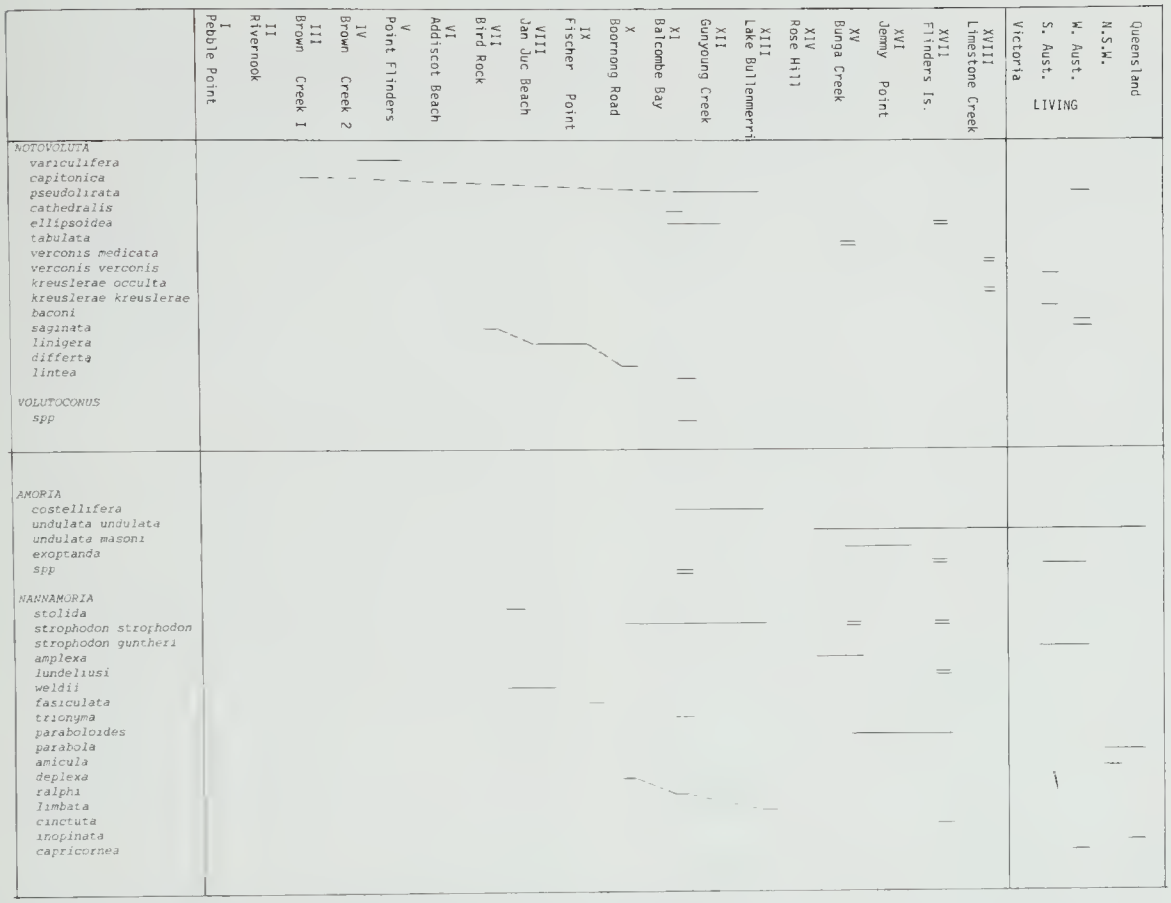

Table 1 (continued). Ranges of volute species in terms of molluscan assemblages. = denotes occurrence of taxon in strata of equivalent age in South Australia and Western Australia.

sheath and foot highly coloured, usually complementing colour of shell.

Proboscis present. Radula normally uniserial, with tricuspid, rarely unicuspid or multicuspid teeth; when present lateral teeth simple and weakly developed.

Males usually with a long penis folded back into mantle cavity. Vas deferens in some groups imbedded in body wall, in others an open pallial groove.

Athletinae Pilsbry and Olsson, 1954

Diagnosis. Foot broad, flat, entire. Head bilobed, divided by a prominent median cleft and laterally produced into 2 tentacles behind which are prominent eye stalks. Siphonal appendages absent or very weakly developed. No operculum. Tubular salivary gland separated from the racemose salivary gland. Radula triserial with a central row of small tricuspid teeth and small unicuspid laterals.

Remarks. The subfamily Athletinae is represented in Australia by *Athleta* s.s. and the subgenus *Ternivoluta,* the species of which have been discussed by Darragh (1971, 1979). Since this work was published, the only important addition to record for this subfamily is the finding of a specimen of *Athleta (Ternivoluta) curvicostata* Darragh at locality FL11 in the lower part of the Brown Creek Formation, which extends the range of this species and that of the genus into the Late Eocene.

Volutinae Rafinesque, 1815

(= Lyriinae Pilsbry and Olsson, 1954, Volutilithinae Pilsbry and Olsson, 1954, Calliotectinae Pilsbry and Olsson, 1954).

Diagnosis. With a horny operculum. Head bilobed with triangular lobes posterior to the eyes. Siphonal appendages unequal with the left longer and flatter, right appendage occasionally absent. Tubularly salivary gland of the anterior digestive system usually short and free from the racemose salivary gland. Radula uniserial, though rarely with vestigial laterals, rachidean tricuspid but occasionally mul-

ticuspid. Shell characters variable. Plaits absent or numerous with the anterior 2 the stronger.

Remarks. The subfamily Volutinae, as recognised herein, embraces certain genera not assigned to it by Pilsbry and Olsson (1954), as well as those genera which they placed in the Lyriinae, Volutilithinae and Calliotectinae. They are listed below. This present grouping is based on observations which show that the anatomical details of the living species e.g. *Lyria cordis, L. deliciosa, Neptuniopsis gilchristi, Calliotectum vernicosum* of these genera are all similar and unlike the majority of the other genera of the Volutidae, particularly in having an operculum and a bilobed head.

Those genera previously placed in the Lyriinae are difficult to separate from *Voluta* s.s. on shell characters (Gardner, 1935) and the only obvious difference is in the radula, which is multicuspid in *Voluta*, and was the basis for separating the other volutes from the Volutinae. However, *Voluta virescens* Lightfoot has its central and terminal cusps stronger than the others (Bayer, 1971, fig. 60B) and *Lyria cordis* Bayer is tricuspid with a series of small denticulations between the cusps, suggesting that the presence or absence of denticulations is of specific or perhaps generic significance, rather than of subfamily significance. A similar variation in radular pattern is found in the Scaphellinae (Clench and Turner, 1964; Bayer, 1971). Bayer has commented on the interspecific variation of the radula and points out that this may be related to the development of specialised feeding habits. Hoerle and Vokes (1978) also pointed out that *Falsilyria* Pilsbry and Olsson (1954) morphologically is intermediate between *Voluta* and *Lyria*. In view of this and the close similarity of the anatomy of *Lyria* and *Voluta* (Bayer, 1971) there are no grounds for maintaining them in separate subfamilies.

With respect to those genera placed in the Calliotectinae, it is obvious on the basis of anatomy and radula (Dall, 1980a; Woodward, 1900; Pace, 1902) that they are closely related to *Voluta* and *Lyria* and not to any other volutes. The obvious differences are in shell characters, which appear to be functional modifications for life in deepwater. In general most deep water volutes lack columella plaits or have few weakly developed plaits. The vestigial laterals of the radula are reminiscent of those found in *Lyria* and *Festilyria*.

The grouping outlined above brings together all the known operculate volutes with the exception of *Saotomea*. The anatomy of this genus is unknown, though its shell characters resemble *Fusivoluta*, and currently it is placed in the Fulgorariinae, however, subsequent study of the anatomy may show that it too would be better placed in the Volutinae.

The genera included in the subfamily Volutinae by the writer are as follows:

Voluta Linnaeus, 1758 (anatomy described Clench and Turner, 1964).

Pseudaulica Furon, 1948 (probably a synonym of *Voluta*).

Falsilyria Pilsbry and Olsson, 1954.

Chiraluta Olsson, 1931.

Woodsivoluta Pilsbry and Olsson, 1954 (probably a synonym of *Chiraluta*).

Peruluta Olsson, 1928.

Calliotectum Dall, 1890 (anatomy described Dall, 1890a.)

Neptuneopsis Sowerby, 1898 (anatomy described Pace, 1902; Woodward, 1900).

Fusivoluta Martens, 1902 (anatomy described Rehder, 1969; Kilburn, 1971).

Lyria Gray, 1847 (= *Harpeola* Dall, 1907, *Sannalyria* Pilsbry and Olsson, 1954, *Paralyria* Shuto, 1962).

Cordilyria Bayer, 1971, (anatomy described Fischer, 1867; Bayer, 1971; Cosal and Blocher, 1977).

Mitreola Swainson, 1833 (= *Enaeta* H. and A. Adams, 1853).

Lapparia Conrad, 1855.

Harpulina Dall, 1906.

Festilyria Pilsbry and Olsson, 1954 (possibly a synonym of *Harpulina*; anatomy described Turner in Weaver and du Pont, 1970).

Volutilithes Swainson, 1829.

Pseudolyria Martin, 1931.

Ctenilyria Woodring, 1964, (possibly a synonym of *Pseudolyria*).

Leptoscapha Fischer, 1883.

Lyreneta Iredale, 1937.

Callipara Gray, 1847.

Notoplejona Marwick, 1926, included by Pilsbry and Olsson (1954) in their Lyriinae, has been shown (Darragh, 1971) to be a synonym of *Athleta* (Athletinae).

Comments on the above list. Discussion of the synonyms of *Lyria* and *Mitreola* is given below following the descriptions of those genera .

The genus *Harpulina* Dall, 1906 (= *Harpula* H. and A. Adams, 1953 non Swainson, 1831) with *Voluta arausiaca* Lightfoot as type species, was grouped with *Alcithoe* by both Pilsbry and Olsson (1954) and Weaver and du Pont (1970). However, comparison of specimens of the type species with illustrations of *Lyria cloveriana* Weaver shows that

these two taxa cannot be separated on shell characters and can thus be regarded as congeneric.

The apertural features of *Harpulina* are similar to *Lyria* so that both belong in the same subfamily. Furthermore there is the possibility that *Harpulina* and *Festilyria* Pilsbry and Olsson, 1954 are related or even synonymous, as species of these two genera have much in common. The latter genus was placed in the Fulgorariinae by both Pilsbry and Olsson (1954) and Weaver and du Pont (1970), though the latter authors pointed out the resemblance of the shell characters to *Voluta* s.s. However, Kilburn (1971) placed two species, *Voluta ponsonbyi* Smith and *V. africana* Reeve, which were previously referred to *Festilyria*, in *Lyria* on the basis of the radula and shell morphology. Certainly the presence of an operculum, the nature of the radula and the apertural features all point to *Festilyria* as a close relative of *Lyria*, but the overall shell characters appear to be distinctive, particularly the wide nodulose shoulder which is not present in *Lyria* s.s. Therefore these species are retained in *Festilyria* and the genus placed in the Volutinae next to *Harpulina*.

Volutilithes Swainson, 1829, which was placed with *Lapparia* Conrad, 1855, in a separate subfamily Volutilithinae by Pilsbry and Olsson (1954), is also very close to *Festilyria* in shell characters. The type species of the genus *V. muricinus* (Lamarck) has shouldered whorls, strong ribs and apertural features identical to *Festilyria festiva* (Lamarck), the type species of *Festilyria*. In fact there are few shell characters to separate them and *Festilyria* and possibly *Harpulina* may well be synonyms of *Volutilithes*. *Lapparia* seems to be the Western Hemisphere analogue of *Volutilithes* and as the apertural features are similar to *Mitreola* it is placed in this subfamily. The close affinity of *Lapparia* and *Mitreola* has already been discussed by Stenzel and Turner (1940).

Callipara Gray, 1847 was placed in the Cymbiinae by Pilsbry and Olsson (1954), and they were followed by Weaver and du Pont (1970) who provisionally placed the genus in that subfamily on the basis of the appearance of the protoconch and columella plaits. However the shell characters of the type and only species in the genus *C. bullatiana* Weaver and du Pont are similar to those found in species of *Lyria*, as noted by Cossmann (1899) and to those of *Lyreneta laseroni* Iredale, so that until the radula and anatomy are known a place in the Volutinae seems more appropriate. Both *Callipara* and *Lyreneta* bear some resemblance to *Harpulina*.

The genera of the Volutinae were distributed throughout the area of Tethys and adjacent seas in Tertiary time, however those species surviving at present have a relict distribution mostly marginal to the Tethys area. The only genera of the subfamily present in the Tertiary of South-eastern Australia are *Lyria* and *Leptoscapha*. *Mitreola* occurs in the Late Eocene of South-western Australia. *Lyria*, *Leptoscapha* and *Lyreneta* are the only genera represented in the living fauna of the continent.

Lyria Gray, 1847

Lyria Gray, 1847:141.
Lyria (Lyria).—Adams and Adams 1853: 166.
Lyria.—Gray 1855a:16.
Lyria (Harpella) Gray, 1855a: 17 (non Schrank, 1802 (Lepidoptera)).
Lyria (Harpella).—Adams and Adams 1858: 618.
Lyria.—Stoliczka, 1867: 96.—Crosse, 1866: 111.—Tryon, 1882: 101.—Fischer, 1884: 610.—Cossmann, 1889: 197.—1899: 113.
Lyria (Lyria).—Dall, 1907: 350.
Lyria (Harpeola).—Dall, 1907: 350.
Lyria.—Marwick, 1926: 271.—Peyrot, 1928: 339.
Lyria (Lyria).—Theile, 1929: 348.
Lyria (Harpella).—Theile, 1929: 348.
Lyria.—Cotton and Godfrey, 1932: 51.—Gardner, 1935: 241.—1937: 403.
Lyria (Lyria).—Smith, 1942: 9.
Lyria (Harpeola).—Smith, 1942: 1.
Lyria (Lyria).—Wenz, 1943: 1330.
Lyria (Harpella).—Wenz, 1943: 1331.
Lyria (Sannalyria) Pilsbry and Olsson, 1954: 23 (type species (original designation): *Lyria pulchella* Sowerby).
Lyria (Lyria).— Korobkov, 1955: 313.
Lyria (Harpella).— Korobkov, 1955: 313.
Lyria.—MacPherson and Gabriel, 1962: 217.
Lyria (Paralyria) Shuto, 1962: 69.
Lyria (Lyria).— Weaver and du Pont 1970: 15.
Lyria (Harpeola).— Weaver and du Pont, 1970: 29.
?Lyria (Cordilyria) Bayer, 1971: 204.
Lyria (Lyria).— Hoerle and Vokes, 1978: 106, 107.
Lyria (Harpeola).—Hoerle and Vokes, 1978: 106, 113.

Type species. Original designation: *Voluta nucleus* Lamarck, 1811, Recent, Eastern Australia.

Description. Shell solid, small to medium size, ovately fusiform with sub-conical to gradate spire, occasionally with channeled sutures. Protoconch smooth, variable in size and shape, frequently with impressed sutures, of 1½–3 whorls, the first of which is sometimes deviated at right angles to axis of the shell. Spiral sculpture weakly developed, but usually present on the anterior quarter of the body whorl. Axial sculpture generally well developed and

consisting of strong close set costae, frequently nodulate at the posterior suture. Aperture narrow, elongate, slightly produced anteriorly and reflexed dorsally; outer lip thickened externally rarely denticulate internally; inner lip covered with a thin glaze, occasionally with a small posterior denticle. Columella with two strong anterior plaits and a weaker posterior plait and usually numerous, thin plicae posterior to these, which decrease in size posteriorly. Siphonal notch broad and shallow; fasciole well developed.

Stratigraphic range. Late Cretaceous–Recent.

Distribution. Europe (Paleocene–Miocene), Africa (Senonian (?), Recent), Asia (Senonian (?)–Recent), Australia (Late Oligocene–Recent), New Zealand (Early Miocene), North and Central America (Paleocene–Recent), South America (Late Eocene–Early Miocene).

Comments. Dall (1907) erected *Harpeola* for *Voluta anna* Lesson, separating it from *Lyria* by the presence of a channelled suture and a shallow posterior sinus. These features are variable even within a species and there is every gradation between species with shouldered whorls such as *Lyria queckett*i (Smith), to those with grooved sutures such as *L. nucleus*. As there is no clear cut distinction *Harpeola* is regarded as a synonym of *Lyria*. *Paralyria* was stated to be an intermediate between *Lyria* and *Harpella*, having the rounded whorls and slight shoulder of the former and the high spire of the latter.

Sannalyria was separated from *Lyria* by Pilsbry and Olsson (1954) because of its strongly lirate inner lip, however, species of *Lyria*, e.g. *L. lyraeformis* (Swainson) and *Lyria mitraeformis* (Lamarck), frequently show this feature and its occurrence even varies within a species, so that *Sannalyria* has been relegated to the synonymy of *Lyria*.

Bayer (1971) described *Cordilyria* with *Lyria (Cordilyria) cordis* Bayer as type, and separated it from *Lyria* s.s. on the presence of small denticles between the larger cusps of the radula, which feature is similar to the radula of *Voluta*. The overall shell features of the type species are similar to *Lyria acutiscostata* Pritchard and to some extent *L. deliciosa* (Montrouzier) of the Western Pacific, and it is closely related to *L. beaui* (Fischer and Bernardi) and *L. vegai* Clench and Turner of the Central West Atlantic, so it seems doubtful that this subgenus should be maintained (Emerson, 1985).

The distributional data, though incomplete, suggest that *Lyria* originated during the Late Cretaceous in what is now the south-eastern Asia area of Tethys. It was represented in this area by several species throughout the Tertiary and at the present time there are six or so species in the subtropical and warm temperate Indo-West Pacific area. The genus migrated west into Europe by Paleocene time, where it persisted until the Miocene (*Lyria magorum* Brocchi). It is found in North America in the Paleocene (*Lyria wilcoxiana* Aldrich) and South America in the Late Eocene (*L. sabulosa* Olsson) but became extinct there in the Early Miocene (*L. musicinoides* White). During the late Tertiary the distribution contracted to the Central American region where *Lyria* is represented by six species in the subtropical West Atlantic (Emerson, 1985). The genus migrated south from the Tethys area to the Australian region in the Late Oligocene during the mid Tertiary thermal maximum, and still is represented in the region by three species. In the Early Miocene the range of the genus was temporarily extended to New Zealand, where it was represented by a single species *Lyria zelandica* Finlay.

In the Tertiary rocks of Southern Australia there are seven taxa of which only one, *Lyria mitraeformis crassicostata* sub. sp. nov. is closely related to those still living in the area. Two species are known from the Middle Miocene of north-west Western Australia, one of which is closely related to *L. semiacuticosta* from the Early Miocene of south-eastern Australia. The Australian fossil species show strong affinity with species from the Paleogene of Europe and south-eastern Asia, and with Neogene and living species from the Western Indo-Pacific Region.

Lyria semiacuticostata Pritchard

Plate 1, figure 18
Plate 2, figures 6, 7
Figure 1

Lyria semiacuticostata Pritchard, 1896 : 91, pl. 2, fig. 8.

Description. Shell elongate-ovate with a narrow acute spire and channelled suture. Protoconch small, of 2½ smooth whorls coiled with axis of spire. Spiral sculpture absent. Axial sculpture of thin well-spaced costae present over whole spire, but becoming obsolete on body whorl. Costae tuberculate at posterior suture and decreasing in strength anteriorly on penultimate and body whorls. 20–28 costae present on penultimate whorl. Columella with 3 plaits, numerous posterior ridges and posterior denticle. Siphonal notch and siphonal fasciole well developed.

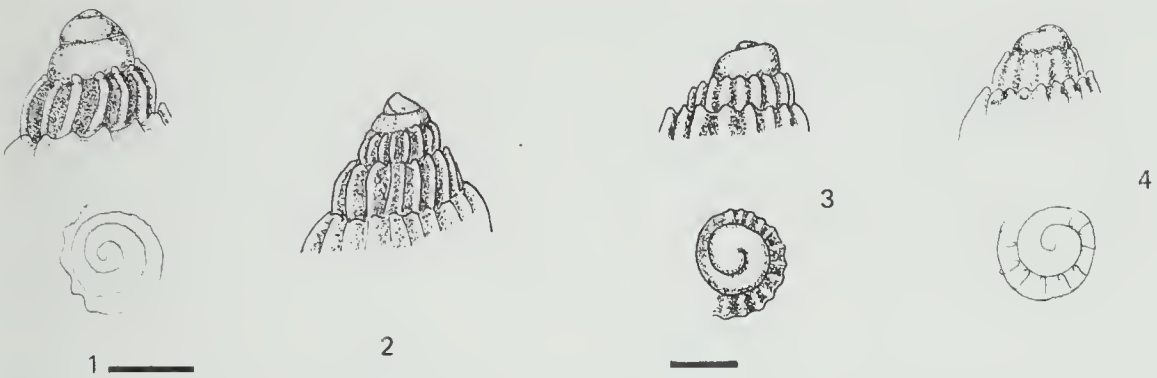

Figure 1. *Lyria semiacuticostata* Pritchard, P2734, hypotype, Lower Bed, Table Cape, Tas. (scale = 1 mm)
Figure 2. *Lyria acuticostulata* sp. nov., P31146, paratype, Fossil Beach.
Figure 3. *Lyria harpularia* Tate, P31877, hypotype, Clifton Bank.
Figure 4. *Lyria gemmata* Tate, P31876, hypotype, Spring Creek, Minhamite. (scale for figs 2–4 = 2 mm)

Dimensions. Holotype (P2653) L29, HA15, W14; Hypotype (P2733) L42, HA24, W19; Hypotype (P2734) L35, HA19, W16.

Location of types. National Museum of Victoria: Holotype P2653, Hypotype P2633, Hypotype P2734, E.D. Atkinson Collection.

Type locality. "Lower bed, Table Cape". FL28, Lower part of cliff between Fossil Bluff and Table Cape, N of Wynyard, Tasmania (Table Cape 930630). Freestone Cove Sandstone, Janjukian.

Stratigraphic range. Janjukian, Early Miocene.

Occurrence. Type locality; Upper Maude Limestone, Moorabool River near Lethbridge.

Material. Holotype and 4 topotypes.

Comments. The form of the costae of this species has some resemblance to that of *L. gemmata* Tate, but that species has a squatter spire, closer set costae and anterior spiral grooves. *Lyria carolinensis* Kellum, 1926 from the Early Miocene, Silverdale Beds of North Carolina, bears a superficial resemblance to both *L. semiacuticostata* and *L. gemma* (Hoerle and Vokes, 1978).

Three fragmentary silicified specimens from the Trealla Limestone (Middle Miocene "f" stage), east flank of the Cape Range, Geological Survey of Western Australia, locality 30055, (Onslow, 1:250,000 Ref. 185260) are close to typical specimens of *L. semiacuticostata* but the ribs are much thicker, being wider than the interspaces.

The specimen from the Upper Maude Limestone is poorly preserved but appears to belong to this species.

Lyria acuticostulata sp. nov.

Plate 1, figures 2–5
Figure 2

Lyria acuticostata Chapman, 1922: 15, pl. 3, fig. 23 (non Chapman, 1920).

Description. Shell ovate, with low or even squat spire, and tumid body whorl abruptly contracted to canal. Protoconch of 1 ½ whorls, the first of which deviated at right angles to axis of spire and granulated, flattened and irregular; second whorl smooth shining and convex. Spire whorls convex with impressed suture. Spiral sculpture of faint striae covering the whole shell but often absent. Axial sculpture of thin, erect, flexuous costae which extend from suture to suture on spire, and from suture to fasciole on body whorl, 19–29 costae present on last whorl. Interspaces between costae wide. Columella with 2 prominent anterior plaits, a weaker plait posterior to these and 3–4 weak posterior ridges. Canal twisted and reflexed dorsally, siphonal notch shallow, siphonal fasciole prominent.

Dimensions. Holotype (P31145) L18, HA11, W9; Paratype (P31146) L18, HA10, W9; Paratype (P31147) L19, HA12, W9; (P31148) L21, HA12, W9;

Location of types. National Museum of Victoria: Holotype P31145, Paratype P31146, Paratype P31147, presented J. Cunningham 17 Oct 1966. Hypotype (Chapman, 1922, pl. 15, fig. 23) P13249.

Type locality. FL78, Shore platform, Fossil Beach, Balcombe Bay, 3 km S of Mornington (Western Port 273658). Balcombe Clay, Balcombian, Middle Miocene.

Stratigraphic range. Batesfordian, Early Miocene-Bairnsdalian, Middle Miocene.

Occurrence. Type locality; FL38, Curlewis; FL40, Belmont Shaft; FL 48, Boornong Road Cutting; FL67, SE end of Gibson Beach; FL69, Red Hill, Shelford; FL77, Altona Coal Shaft; FL81, Overburden, Batesford Quarry; FL 82, Clifton Bank, Muddy Creek; FL100, Murgheboluc 4A; FL103, Lower and Middle beds, downstream Gunyoung Cr; FL104, Manyung Rocks.

Material. Types and 30 topotypes.

Comments. This species is distinguished from *L. acuticostata* by the presence of continuous thin erect costae, and by the convex spire whorls. The Torquay specimen figured by Chapman (1922, pl. 3, fig. 22, P13248) is unique, and differs somewhat from this species, though it is obviously ancestral. Of living species it most resembles the type of the genus, *L. nucleus*, but that species has wider and closer spaced costae and more tumid whorls. *L. harpularia* (Lamarck) Lutetian, Paris Basin has fewer and stronger ribs and a prominently thickened outer lip. *L. varicosa* Vredenburg, Oligocene, Burma, has broader ribs and appears closely related to the Torquay specimen.

Batesfordian and Bairnsdalian specimens generally are squatter and more tumid than Balcombian specimens, but still fall within the range of variation of the latter.

Lyria harpularia Tate

Plate 1, figures 7, 12, 17, 19, 20
Figure 3

Lyria harpularia Tate, 1888: 176, pl. 12, fig. 12 (figure only).—Tate, 1889: 118 (description).—Harris, 1897: 99, pl. 4, figs 9a, b.—Cotton, 1949: pl. 14.

Description. Shell ovate, rather tumid with low gradate spire. Protoconch of 1½ smooth whorls with impressed sutures, coiled with axis of shell and markedly differentiated from teleconch whorls. Sculpture of numerous thin, erect, flexuous costae, terminated posteriorly in blunt points and separated from posterior suture by narrow channel. Spiral sculpture of fine threads feebly developed on, or absent from, spire and usually present on anterior quarter of body whorl. Body whorl rather tumid and abruptly contracted anteriorly. Aperture elliptical. Columella with 2 strong anterior plaits, one weak plait posterior to these and with several other thin plaits or folds on posterior portion of columella. Siphonal notch deep; siphonal fasciole well developed.

Dimensions. Holotype (T395A) L33, HA19, W17; Hypotype (P31150) L40, HA24, W21; Hypotype (P31877) L30, HA17, W14; Hypotype (P31878) L35, HA20, W17.

Location of types. South Australian Museum: Holotype T395A, R. Tate Collection. National Museum of Victoria: Hypotypes P31150, F.S. Colliver Collection; P31877, G.B. Pritchard Collection; P31878, F.A. Cudmore Collection.

Type locality. Muddy Creek, i.e. FL82, Clifton Bank, Muddy Creek, 5 miles W of Hamilton (Coleraine WD825219). Muddy Creek Formation, Balcombian.

There is some doubt as to the correct type locality, as the preservation of the holotype, T395A, figured by Tate in 1888 and described in 1889, is typical of Schnapper Point (i.e. Balcombe Bay) and not Muddy Creek, which is the locality cited in the explanation of the figure. Schnapper Point is written on the tablet on which the type is glued, together with Muddy Creek and Gellibrand River, but there is no clear indication which specimen comes from Schnapper Point.

Stratigraphic range. Batesfordian (?), Balcombian, Middle Miocene.

Occurrence. FL38, Curlewis; FL69, Red Hill; FL70, Farrells; FL77, Altona Bay Coal Shaft; FL78, Fossil Beach; FL80, Moorabool River; FL81, Batesford Quarry; FL82 Type Locality.

Material. Holotype and 20 topotypes.

Comments. The record from FL38, Curlewis is based on a single specimen and may possibly have an inaccurate label, as the species is not represented in any other localities of similar age. Matrix from this specimen suggests it may come from FL69, Red Hill. This species has some resemblance to *L. anna* (Lesson) but the latter is more elongate with coarser and fewer costae and has a more prominent channel, in fact almost a shoulder, against the suture. *L. turgidula* (Deshayes) Lutetian, Paris Basin is of similar morphology but also has fewer and coarser costae.

Lyria acuticostata Chapman

Plate 2, figures 8, 13

Lyria acuticostata Chapman, 1920: 24.

Description. Shell elongate with flat whorls and thick axial costae. On body whorl costae are 2 mm thick and interspaces 1.5 mm wide.

Dimensions. The length of a complete shell would be about 35 mm.

Location of types. National Museum of Victoria: Syntypes P13164, P13165, F.A. Cudmore Collection. The latter should be chosen as lectotype if it is ever necessary to choose such.

Type locality. Ooldea well, Ooldea Station, Transcontinental Railway, South Australia. Nullabor Limestone, Middle (?) Miocene.

Stratigraphic range. Middle (?) Miocene.

Occurrence. Type locality only.

Comments. The available material of this species consists of the two external moulds upon which Chapman founded the species. They are fragments of two individuals so comparison with other species is difficult. It is not related to the delicately costated *L. acuticostulata* sp. nov. of the Victorian Miocene, with which Chapman allied it, but more to the coarse ribbed southern Australian living species, *Lyria mitraeformis*, from which it differs by the flatter whorls and more elongate spire. It is very close to *Lyria mitraeformis crassicostata* subsp. nov. from the Roe Calcarenite, but has less swollen whorls and the suture is not as impressed.

Lyria sp.

Occurrence. Geological Survey of Western Australia locality 30055, E flank Cape Range (Onslow, 1:250,000 185260). Trealla Limestone, Middle Miocene "f" stage.

Remarks. Two poorly preserved specimens are available. The species is rather squat with swollen whorls, somewhat impressed sutures and prominent thick axial costae as wide as the interspaces and with fine, close set lirae covering the whole of the whorls. In overall shape it resembles *Lyria mitraeformis mitraeformis*, but has coarser ribs and is covered with fine lirae, a feature which sets it apart from most species known to the writer, however it does resemble a specimen from the Miocene of Java illustrated by Martin (1916, pl. 1, fig. 20) as *Lyria edwardsi* d'Archaic (= *Lyria jugosa* Sowerby). *Lyria jugosa* has a prominenty channeled suture, but some specimens do have whorls entirely covered in lirae.

Lyria gemmata Tate

Plate 1, figures 6, 13, 14
Figure 4

Lyria gemmata Tate, 1889b: 118, pl. 3, fig. 4.

Description. Shell ovate with subconical spire and slightly channelled suture. Protoconch of 1½ smooth whorls coiled with axis of shell. Spiral sculpture of fine, well spaced grooves on anterior half of body whorl. Axial sculpture of closely spaced, slightly flexuous costae, which terminate on posterior suture with a small tubercle and decrease in strength anteriorly on body whorl; 25–30 costae present on body whorl. Columella with 2 strong anterior plaits, a weaker posterior plait and several weak folds posterior to these. Outer lip of aperture thickened. Canal reflexed dorsally. Siphonal notch weak; siphonal fasciole well developed.

Dimensions. Holotype (T613) L19, HA–, W9; Hypotype FL132 (P31876) L25, HA15, W13.

Location of types. South Australian Museum: Holotype T613, R. Tate Collection. National Museum of Victoria: Hypotype P31876, coll. E.D. Gill and H.E. Wilkinson, 16 May 1962.

Type locality. Upper beds, Muddy Creek, i.e. FL139, McDonalds bank, Muddy Creek below Yulecart Hall (Coleraine 827219). Grange Burn Formation, Kalimnan, Early Pliocene.

Stratigraphic range. Cheltenhamian, Late Miocene-Kalimnan, Early Pliocene.

Occurrence. Type locality; FL132, Spring Creek, Minhamite.

Material. Holotype, 1 topotype P31149 and 2 specimens from Minhamite.

Comments. The resemblance of this species to *L. semiacuticostata* has already been mentioned and its resemblance to *L. gracilicostata* is dealt with under that species.

Lyria gracilicostata Ludbrook

Plate 28, figures 1–6

Lyria gracilicostata Ludbrook, 1978: 163, pl. 18, figs 15–18.

Description. Shell elongate-ovate with narrow subacute spire and impressed suture. Protoconch of 1½ smooth whorls, coiled with axis of shell. Spiral sculpture of several low broad lirae confined to anterior quarter of last whorl. Axial sculpture of strong close-set costae, 29–34 on body whorl, which are interrupted close to posterior suture so that they are nodulate against it. Columella with 2 prominent anterior plaits and numerous posterior ridges. Posterior denticle rarely present. Outer lip of aperture thickened internally and externally.

Dimensions. Holotype (GSWA F6951) L43, HA25, W19; Hypotype (P56031) L45, HA23, W20; Hypotype (P56032) L35, HA20, W15.

Location of types. Geological Survey of Western Australia: Holotype F6951, Paratype F6951, coll; D.C. Lowry. Western Australian Museum: Paratypes WAM 69.511, 66.621, 69.510, 69.561, 70.32, 70.33. Geological Survey of South Australia: M1270, M3251, National Museum of Victoria: Hypotypes P56031 P56032, coll. V. Ryland, G.W. and W.E. Kendrick, 5–13 Aug. 1978.

Type locality. Locality 4133-FL7, 21 km NE of Eyre (Burnabbie 443032), (32°05′08″S, 126°24′30″E).

Occurrence. Roe Calcarenite, various borrowpits along the Eyre Highway and foundation holes for Hampton Microwave Tower, Roe Plain, Western Australia.PL 3173, Point Ellen, South Australia.

Material. Holotype and 26 specimens.

Comments. This taxon is closely related to *L. gemmata,* but is more elongate and has a higher spire. It may fall within the range of variation of the latter if more material of that species was available. Certainly *L. gemmata* is ancestral to this taxon. *L. delessertiana* (Petit de Saussaye) of Madagascar seems to be the closest relative among living species of the genus. *Lyria ickei* Martin from the Late Miocene of Java also bears a close resemblance but it is much smaller with a very low spire.

Lyria mitraeformis crassicostata subsp. nov.

Plate 28, figures 7–12

Lyria mitraeformis.—Ludbrook, 1978: 164, pl. 18, figs 13, 14.

Description. Shell elongate, fusiform with high spire of somewhat rounded whorls and with small shoulder developed on body whorl. Protoconch of 1½ smooth whorls, first of which deviated at low angle from axis of shell. Spiral sculpture of low broad lirae, present on anterior quarter of body whorl. Axial sculpture of coarse well spaced costae, 14–17 on body whorl. Surface of outer lip of aperture thickened exteriorly. Columella with 3 well developed anterior plaits, several posterior ridges and posterior denticle.

Dimensions. Holotype (WAM 79.396a) L58, HA29, W23; Paratype (WAM 79.404b) L38, HA22, W17; Paratype (P56034) L39, HA19, W17.

Location of types. Western Australian Museum: Holotype WAM 79.396a, coll. V.A. Ryland, G.W. and W.E. Kendrick, 5–13 Aug 1978; Paratype WAM 79.404b, coll. V.A. Ryland, G.W. and W.E. Kendrick, 22–28 Sep 1976. National Museum of Victoria: Paratype P56034, coll. T.A. Darragh, 7 Sep 1973.

Type locality. Quarry on access road to Hampton Microwave Repeater Tower. 1.5 km N of Tower, Roe Plain, Western Australia (Eucla, 1:250,000 563047). Roe Calcarenite.

Stratigraphic range. Roe Calcarenite.

Occurrence. Roe Calcarenite, various borrow pits along Eyre Highway and foundation holes for Hampton Microwave Tower, Roe Plain, Western Australia.

Material. Types, 21 topotypes and 19 other specimens.

Comments. This taxon is ancestral to the living *L. mitraeformis* and differs from typical specimens of *L. mitraeformis* by its higher spire, more prominent shoulder and fewer and more widely spaced axial costae. The affinity with *L. acuticostata* has been mentioned above, and it is probably derived from it. In morphology it is intermediate between *L. acuticostata* and *L. mitraeformis mitraeformis.*

Lyria mitraeformis mitraeformis (Lamarck)

Plate 2, figure 1

Voluta mitraeformis Lamarck, 1811: 73.—1822: 347.
Voluta multicostata Broderip, 1827: 82, pl. 3, fig. 2.
Voluta mitraeformis.—Kiener, 1839: 36, pl. 41, fig. 2.—Kuster, 1840: 178, pl.38, fig. 2.
Voluta mitriformis (sic).—G.B. Sowerby II, 1845: 216, pl. 52, figs 81, 82; pl. 55, fig. 109.
Voluta mitraeformis.—Reeve, 1849: No. 7, pl. 3, fig. 7a, b.
Lyria mitraeformis.—Tryon, 1882: 103, pl. 31, fig. 143.
Voluta (Lyria) grangeri G.B. Sowerby III, 1900: 440, pl. 11, fig. 2.
Lyria multicostata.—Cotton and Godfrey, 1932: 51, pl.2, fig. 12.
Lyria kimberi Cotton, 1932: 538, figs 1–3.
Lyria multicostata.—Smith, 1942: 11, fig. 17.
Lyria kimberi.—Cotton, 1957: fig. 1.
Lyria mitraeformis.—Cotton, 1957: fig. 2.—MacPherson and Gabriel, 1962: 217, fig. 258.
Lyria (Lyria) grangeri.—Weaver and du Pont, 1968: 36, pl.3, figs 1–6.
Lyria (Lyria) kimberi.—Weaver and du Pont, 1970: 21, pl. 4 K, L.
Lyria (Lyria) mitraeformis.—Weaver and du Pont, 1970: 22, pl. 5C–E; pl. 6A, B.
Lyria mitraeformis.—Wilson and Gillett, 1971: 126, pl. 83, figs 7, 7a, b.

Description. Shell fusiform, of medium to large size, with rounded costate whorls and impressed sutures. Protoconch of 1½ smooth whorls, first of which deviated about 45° to axis of shell. Teleconch whorls convex, impressed at suture and bearing strong axial costae as thick as interspaces; costae number 17 to 20 on body whorl. Spiral sculpture of low broad, somewhat irregularly spaced costae on anterior quarter of body whorl only. Surface of outer lip of aperture thickened exteriorly. Columella with 2–3 strong anterior plaits and numerous posterior ridges.

Dimensions. SAM (D10185), L30, HA17, W14.

Location of types. Muséum d'Histoire Naturelle, Geneva: syntype 1103.38.2. South Australian Museum. Holotype of *Lyria kimberi* Cotton D10185.

Type locality. "Côtes de Java (Laichenau), et celles de la Nouvelle-Hollande (Péron)." It is probable that the syntype figured by Kiener was collected by Péron in Bass Strait or South Australia.

Stratigraphic range. Pleistocene–Recent.

Occurrence. Fossil: Western Australia: Adrians Nursery Bore cnr Thomas and Semple Rds, Jandacot at 126–129 ft, Frank Paulicks Bore, W side of Semple Rd, Jandacot at 130 ft. Living: Cape Leeuwin, South-west Western Aus-

tralia-Gippsland, Victoria; Northern Tasmania.

Comments. The writer agrees with previous authors who have placed *L. multicostata* and *L. grangeri* in the synonymy of *L. mitraeformis* and also places *L. kimberi* therein. The type specimen of the latter is merely a rather squat specimen from Port Lincoln but all grades between this and typical specimens of *L. mitraeformis* can be found in the same area. The colour differences cited by Weaver and du Pont probably have arisen because the holotype was collected as a dead shell.

Lyria nucleus (Lamarck)

Voluta nucleus Lamarck, 1811: 73.
Lyria (Lyria) nucleus. – Weaver and du Pont, 1970: 23, pl. 5 F–H.

Comments. This species occurs off northern New South Wales, Norfolk Island and Kermadec Islands, New Zealand. Weaver and du Pont (1970) listed five synonyms of this species and have provided a good description and figures.

Lyria deliciosa (Montrouzier)

Voluta deliciosa Montrouzier, 1859: 375.
Lyria deliciosa howensis Iredale, 1937: 129.
Lyria (Lyria) deliciosa howensis. – Weaver and du Pont, 1970: 18, pl. 4E.

Comments. This species occurs from central Queensland to northern New South Wales, Lord Howe Island and New Caledonia. Some authors have considered that the Australian populations should be subspecifically separated from the New Caledonian population as indicated above.

Lyreneta Iredale, 1937

Lyreneta Iredale, 1937: 128.
Lyria (Lyreneta). – Weaver and du Pont, 1970: 28.

Type species. Original designation: *Lyreneta laseroni* Iredale, 1937 (= *Voluta (Callipara) brazieri* Cox, 1873 non Brazier, 1870); Wooli Wooli, northern New South Wales.

Comments. This genus is monotypic and the type species is rare. As yet it has not been found as a fossil. The type species ranges from central to northern New South Wales. The early teleoconch whorls bear a typical *Lyria* type sculpture but these are almost enveloped in the body whorl which bears no sculpture. The plaits on the columella are typical of species of *Lyria*. The overall appearance bears a close resemblance to that of *Callipara bullatiana* Weaver and du Pont from South Africa.

Leptoscapha Fischer, 1883

Voluta (Leptoscapha) Fischer, 1883: 608.
Voluta (Leptoscapha). – Cossmann, 1899: 191.
Leptoscapha. – Cossmann, 1889: 120. – Wenz, 1943: 1340.

Type species. Original designation: *Voluta variculosa* Lamarck, 1803; Eocene, Grignon, France.

Description. Shell small, ovately fusiform. Protoconch of 1–1½ smooth shining whorls, first of which deviated to axis of shell. Spiral sculpture of numerous close set threads. Axial sculpture absent except for trace of apertural varices. Aperture lenticular, elongate, produced anteriorly to form short canal which is reflexed dorsally. Outer lip thickened externally and on some species internally, constricting anterior canal, and also occasionally with posterior denticle on inner surface. Inner lip covered with thick glaze of callus. Columella with 3 strong anterior plaits, of which anterior is weakest, and 1 or 2 other weak posterior plaits. Siphonal notch shallow; siphonal fasciole well developed.

Stratigraphic range. Middle Eocene–Middle Miocene, Recent.

Distribution. Europe (Middle–Late Eocene), South-east Asia (Late Eocene), South-eastern Australia (Middle Miocene, Recent).

Comments. This genus is characterised by its small size, being amongst the smallest of the volutes, by its fusiform shape and absence of axial sculpture, except for the trace of apertural varices, a feature which is most uncommon in the family. The genus to which it seems to be most closely related is *Mitreola.*

In addition to the type species the following species seem to belong in the genus: *Voluta mitreola* Lamarck, Lutetian, Paris Basin; *V. intusdentata* Cossmann, Bartonian, Paris Basin; *V. pusilla* Martin, Late Eocene, Java; *V. crassilabrum* Tate, Middle Miocene, Recent, Australia. Specimens of all these species are rare and as a consequence little is known of the stratigraphical history or distribution of the genus.

Leptoscapha crassilabrum (Tate)

Plate 1, figures 1, 8, 9
Plate 27, figures 2, 3, 5–10

Voluta crassilabrum Tate, 1889b: 128, pl. 3, figs 2a–c.
Ericusa crassilabrum. – Cotton, 1949: pl. 15.

Description. Shell thick, small, ovate. Protoconch

of 1½ smooth, shining rounded whorls, first of which slightly deviated from axis of shell. Teleconch whorls convex. Body whorl convex and rather abruptly contracted anteriorly. Spiral sculpture of thin close set wavy threads over whole of whorls. Axial sculpture weak and irregular, consisting of trace of previous apertural varices. Aperture elongate ovate, narrow and produced anteriorly into short dorsally reflexed canal. Outer lip thickened externally and internally, occasionally bearing small posterior denticle. Inner lip covered with thick callus. Columella usually with 3 anterior plaits and 1 or 2 weaker posterior plaits. Siphonal notch absent; siphonal fasciole prominent.

Dimensions. Holotype (T622A) L9, HA–, W4, Hypotype (P32207) L15, HA10, W7; (F53231) L8, HA4.5, W3.5; (F53232) L11, HA6, W4.5; (F53233) L12, HA6, W5; (F53234) L8.5, HA4.5, W4.

Location of types. South Australian Museum: Holotype T622A. National Museum of Victoria: Hypotype P32207, F.A. Cudmore Colln. Hypotypes F53231-4, coll. M.P. Marrow, 28 Dec 1983.

Type locality. Lower beds, Muddy Creek, i.e. FL82, Clifton Bank, Muddy Creek, 8 km W of Hamilton (Coleraine WD825219). Muddy Creek Formation, Balcombian.

Stratigraphic range. Balcombian-Bairnsdalian, Middle Miocene, Recent.

Occurrence. Type locality; FL103, Gunyoung Creek; FL104, Manyung Rock; Shell sand, Gleesons Landing, Daly Head, Yorke Peninsula, South Australia.

Material. Holotype, 1 topotype and 5 other fossil specimens and 11 recent specimens.

Comments. Tate (1898:387) has pointed out the close similarity between this species and *L. variculosa*. The sculpture, aperture and plaits are exactly the same as this species, however *L. variculosa* is more elongate and the protoconch is deviated almost at right angles to the axis of the shell. In shape *L. crassilabrum* is closely similar to *L. mitreola and L. pusilla*.

The recent specimens were collected from shell sand and some are, therefore, somewhat rolled and abraded, but the sculpture, size and shape match the fossil specimens closely. Three of the specimens are sufficiently well preserved to show a colour pattern of white tentlike triangular markings on an orange base, somewhat similar to that of *Amoria praetexta* (Reeve) and *Notovoluta verconis* (Tate).

The occurrence of this species in the living fauna has a parallel with that of *Notopeplum transhucidum* Verco, which is found in Early and Middle Miocene strata and living and with *Notovoluta pseudolirata* (Tate) which is found in Middle Miocene strata and living.

The distribution of the known species suggests that the genus may have been widespread through the Tethys area in the Eocene and migrated into the Southern Australian region in the Miocene, when a number of other Tethyan genera also made their appearance there (Darragh, 1985).

Mitreola Swainson, 1833

Mitreola Swainson, 1833: pl 128.
Lyria (Enaeta) Adams and Adams, 1853: 167. (Type species, subsequent designation, Cossmann, 1899): *Voluta harpa* Barnes, 1824 = *V. barnesii* Gray, 1825).
Strigatella (Mitreola). – Adams and Adams, 1853: 174.
Lyria (Enaeta). – Adams and Adams, 1858: 618.
Voluta (Enaeta). Chenu, 1859: 190.
Mitra (Mitreola). – Chenu, 1859: 194.
Lyria (Enaeta). – Tryon, 1882: 104.
Enaeta. – Fischer, 1884: 610.
Mitra (Mitreola). – Fischer, 1884: 612.
Enaeta. – Cossmann, 1899: 105.
Mitreola. – Cossmann, 1899: 159.
Enaeta. – Dall, 1907: 351.
Lyria (Enaeta). – Thiele, 1929: 348.
Enaeta. – Smith, 1942: 12.
Strigatella (Mitreola). – Wenz, 1943: 1330
Lyria (Enaeta). – Wenz, 1943: 1331. – Korobkov, 1955: 314.
Mitreola. – Korobkov, 1955: 320.
Lyria (Enaeta). – Keen, 1958: 432.
Lyria (Enaeta). – Weaver and du Pont, 1970: 25.
Mitreola. – Cernohorsky, 1970: 62.
Lyria (Enaeta). – Keen, 1971: 619.
Lyria (Enaeta). – Cate, 1972: 47.
Enaeta. – Abbott, 1974: 245.
Lyria (Enaeta). – Hoerle and Vokes, 1978: 106, 114.

Type species. Subsequent designation. (Herrmannsen, 1847): *Mitra monodonta* Lamarck, 1803; Eocene, Grignon, France.

Description. Shell of small size, solid, ovately-fusiform, frequently with shouldered whorls. Protoconch of 1–1½ smooth whorls, first of which is very slightly deviated from axis of shell. Axial sculpture of coarse to fine ribs, sometimes absent from body whorl. Spiral sculpture weak or absent. Aperture lenticular, elongate, slightly notched posteriorly and produced anteriorly to form short canal, which is frequently reflexed dorsally. Outer lip thickened externally and bearing internally a denticle situated slightly to posterior of midpoint; occasionally with serrations on anterior half. Inner lip covered with thick glaze of callus. Columella with 3 or 4 strong anterior plaits and often with weak posterior plaits. Siphonal notch and siphonal fasciole present, variably developed.

Stratigraphic range. Paleocene–Recent.

Distribution. Europe (Paleocene–Oligocene). South-eastern North America, Central America, Northern South America (Early Miocene–Recent), South-west Australia (Late Eocene).

Comments. Shells of this genus are amongst the smallest in the family. Both Cernohorsky (1970) and Cate (1972) have demonstrated the similarity between *Mitreola* and *Enaeta* and the latter author cites the following differences between them: presence of labral nodule on the outer lip of *Enaeta*, lack of prominent parietal wall in *Enaeta*, the more slender shell of *Mitreola*, the more prominent and more mamillate nucleus in *Mitreola* and differences in colour pattern between some species of the genera. A comparison between specimens of *Enaeta cumingi* (Broderib) and *Mitreola raricostata* (Lamarck) shows that they are alike and that most of the alleged differences are not consistent. The labral nodule is present in most, if not all, species of *Mitreola* as already indicated by Cernhorsky (1970) and the other differences cited are characters which frequently vary greatly within particular species of Volutidae and are not regarded as being of generic significance. The writer regards *Enaeta* as a junior synonym of *Mitreola*.

Mitreola was established in Europe in the Palcocene, where it remained through to the Oligocene. It apparently migrated west and appeared in the Central American region in the Early Miocene and has remained in this area to the present. Living species are confined to the subtropical Central American region. The genus is also known from a single species in the Late Eocene of South-western Australia and represents an example of the Tethyan Indo-Pacific element in the Australian Eocene (Darragh, 1985).

Mitreola salaputium sp. nov.

Plate 1, figures 10,-11, 15, 16

Description. Shell very small, ovately fusiform. Protoconch of 1 ½ smooth whorls, first of which very slightly deviated from axis of shell. Teleconch whorls slightly depressed at posterior suture then slightly convex. Body whorl convex and abruptly contracted anteriorly. Axial sculpture of thick, low costae, as wide as interspaces, present on first teleconch whorl and subsequent spire whorls, but absent from body whorl. Spiral sculpture absent. Aperture narrow, elongate-ovate, notched posteriorly and slightly produced anteriorly into short canal. Outer lip of aperture thickened externally into prominent varix and internally bearing a small denticle slightly posterior to midpoint. Inner lip covered with thick callus. Columella with 4 prominent plaits and posterior denticle. Siphonal notch weak, siphonal fasciole weakly developed.

Dimensions. Holotype (WAM 79.386) L11, HA5, W4.5; Paratype (P50007) L10.5, HA5, W4.

Location of types. Western Australian Museum: Holotype WAM 79.386. National Museum o Victoria: Paratype P50007 coll. T.A. Darragh and G.W. Kendrick, 30 Aug 1973.

Type locality. Gravel scrape, Thompsons Rd, 1.9 km N of Mount Franklin Road, 24 km N of Walpole, Western Australia (Deep River, 1:50,000 743487). Pallinup Formation, Late Eocene.

Stratigraphic range. Late Eocene.

Material. Types and 7 topotypes.

Comments. This species is the smallest of the Australian volutes. In overall size, shape and sculpture, it most closely resembles the living *Mitreola reevei* (Dall) from Honduras. It differs from that species by the presence of four well developed plaits rather than the many weak plaits of the former, by its weak rather than strong siphonal notch and by the very weak posterior sutural depression which is quite prominent in *M. reevei*. It differs from *Leptoscapha crassilabrum*, its closest Australian relative, by the presence of well developed axial costae.

Scaphellinae H. and A. Adams, 1858

(= Haliinae Thiele, 1929; Auriniinae Smith, 1942)

Diagnosis. Head broad, flat, bilobed with tentacles merely extensions of the lobes. Siphon with single left appendage. Operculum absent. Tubular salivary gland of anterior digestive system short and free from racemose salivary gland. Gland of Leiblein large and convoluted, surrounding and bound to oesophagus. Radula uniserial, with Y-shaped usually tricuspid rachidian, central cusp of which concave and well developed and lateral cusps reduced to denticles or occasionally absent. Protoconch of about 2 whorls somewhat irregular with callused summit, sometimes with exsert tip (calcarella).

Remarks. The above diagnosis is based on an anatomical description by Clench and Turner (1964). As recognised here the subfamily excludes *Amoria* and related taxa for reasons which are stated under Amoriinae. *Notopeplum* and *Notovoluta* which were included in the subfamily by Weaver and du Pont (1970) have also been excluded on the basis of their anatomy which is discussed under the respective genera.

The cleft head of species of the Scaphellinae is reminiscent of species in Athletinae and Volutinae. The early appearance of the Scaphellinae in the stratigraphic record reflects this relationship since all three subfamilies are known from the earliest Tertiary. The earliest undoubted representatives of the Scaphellinae appear in the Paleocene of Europe and North America. There is a single species of *Scaphella (Aurinia)* known from the Late Eocene of Victoria, the only record of the subfamily in the Australian Tertiary.

The genera included in the subfamily are as follows:

Scaphella Swainson, 1832.
S. (Clenchina) Pilsbry and Olsson, 1953.
S. (Aurinia) H. and A. Adams, 1853.
Ampulla Roding, 1798 (= *Halia* Risso, 1826).
Volutifusus Conrad, 1863.
Atraktus Gardner, 1937.
Caricella Conrad, 1855.
Montia Glibert, 1973.
M. (Houzeauia) Glibert, 1973.
?Sycospira Palmer, 1953.

Scaphella Swainson, 1832

Scaphella (Aurinia) H. and A. Adams, 1853.

Fulgurariа (Aurinia) H. and A. Adams, 1853: 166.
Voluta (Aurinia). – Crosse, 1871: 309. – Fischer, 1883: 608.
Scaphella (Aurinia). – Dall, 1889: 150. – Dall, 1890: 80.
Aurinia. – Koenan, 1890: 522. – Cossmann, 1899: 128.
Scaphella (Aurinia). – Thiele, 1929: 350.
Aurinia. – Smith, 1942: 63 (in part).
Scaphella (Aurinia). – Wenz, 1943: 1352.
Rehderia Clench, 1946: 45 (Type species (original designation): *Aurinia schmitti* Bartsch).
Scaphella (Aurinia). – Clench, 1946: 51.
Aurinia. – Gardner, 1948: 261.
Aurinopsis Clench, 1953: 378 (Type species (original designation: *Scaphella kieneri* Clench).
Aurinia. – Pilsbry and Olsson, 1953: 5.
Scaphella (Aurinia). – Weaver and du Pont, 1970: 144.

Type species. Monotypy: *Voluta dubia* Broderip, 1827; Recent, south-eastern United States of America.

Description. Shell thin, elongate, fusiform. Protoconch of 1½–2 smooth whorls somewhat truncate, first somewhat irregular and often with prominent pointed calcarella. Whorls occasionally with weak shoulder. Sculpture absent, or if present weakly developed and consisting of weak axial costae on spire whorls and fine spiral threads. Columella margin straight or weakly sigmoidal and bearing 2 or 3 weak plaits which may be absent on adult specimens. Siphonal notch and fasciole absent.

Stratigraphic range. Paleocene–Recent.

Distribution. Europe (Paleocene–Pliocene); North America (Miocene–Recent); South-eastern Australia (Victoria) (Late Eocene).

Comments. This subgenus is distinguished from *Scaphella* s. s. by the absence of any trace of siphonal fasciole, by the reduced number or even absence of plaits and by the tricuspid rather unicuspid radula. The taxon first makes its appearance in the Danian of Denmark and various species occur scattered through the stratigraphic column in England, Germany, Holland, Belgium and France. In the Paleogene the taxon is confined to Northern Europe and does not occur in the south until the Miocene. It became extinct in Europe in the Late Pliocene. In the Middle Miocene it first appears in the South-eastern United states and various species occur there and in Central America through the late Tertiary to the present. There is a single species in the Late Eocene of Victoria, Australia, closely related to Eocene and Oligocene species of Europe and represents another example of the Tethyan Indo-Pacific element in the australian Eocene.

Scaphella (Aurinia) johannae sp. nov.

Plate, 2, figures 9–12
Figure 5

Description. Shell fusiform with gently tapering spire. Protoconch conical, of 1½ smooth, flattened and slightly irregular whorls with impressed sutures and coiled with axis of shell. Teleoconch whorls smooth and regularly convex. Body whorl rather abruptly contracted anteriorly and produced into short canal. Columella with 1 strong anterior plait and 3 or 4 feeble posterior plaits. Siphonal notch and fasciole absent.

Dimensions. Holotype (P41757) L47, HA27, W18; Paratype, immature (P41758) L34, HA21, W13.

Location of types. National Museum of Victoria: Holotype P41757 coll. T.A. Darragh 24 Feb 1971; Paratype P41758 coll. T.A. Darragh 18 Oct 1971.

Type locality. FL11, 9.6 m dark clay beneath greensand, washout nearest Browns Creek, Johanna (Glenaire 080057). Browns Creek Clay, Aldingan, Late Eocene.

Stratigraphic range. Aldingan, Late Eocene.

Occurrence. Type locality only.

Material. Types and 3 topotypes.

Comments. In shape this taxon resembles *Scaphella*

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Figure 5. *Scaphella (Aurinia) johannae* sp. nov., P41757, holotype, Browns Creek. (scale = 2 mm)

(Aurinia) crenistriata (von Koenan) from the Paleocene of Copenhagen and *S. (A) bolli* (Koch) from the Middle Miocene of Germany and Belgium but those species have numerous spiral threads present over the whole of the spire whorls. *Scaphella (A.) weatherellii* (Sowerby) from the Early Eocene of England is more elongate and the whorls are depressed at the posterior suture. *Scaphella (A.) siemsseni* (Boll) from the Middle and Late Oligocene of the North Sea basin is very close in general appearance, but is more elongate with a narrower more elongate spire.

Subfamily uncertain

Notovoluta Cotton, 1946

Notovoluta Cotton, 1946: 15.—Weaver and du Pont, 1970: 167.—Wilson, 1972: 347.

Type species. Original designation: *Voluta kreuslerae* Angas, 1865; Recent, South Australia.

Description. Shell moderately thick fusiform, elongate to elongate-ovate. Spire subconical or gradate with prominantly shouldered whorls. Protoconch of 2 or 3 smooth usually dome-shaped whorls with central nucleus and coiled with axis of shell. Spiral sculpture if present of fine threads. Axial sculpture of plicae or strong costae but often reduced to tubercles or even absent. Thin axial plicae usually present on first and 2nd teleoconch whorls. Aperture elongately eliptical; anterior portion of outer lip slightly reflexed dorsally; columella usually with 4 strong plaits and rarely 1 or 2 weaker plaits. Canal slightly reflexed dorsally; siphonal notch shallow and wide; siphonal fasciole moderately developed.

Stratigraphic range. Late Eocene-Recent.

Distribution. Southern Australia. Victoria (Late Eocene-Middle Miocene); South australia (Middle Miocene-Late Pliocene, Recent); Western Australia, south coast (Early Pleistocene-Recent), midwest coast (Recent).

Comments. The dome shaped protoconch and fine plicae on the first and second spire whorls are the most characteristic features of the genus. Cotton erected the genus to include the type species, *N. occidua* Cotton, *Voluta rossiteri* Brazier, and *V. verconis* Tate. Subsequently (Cotton, 1947) he placed *Voluta thatcheri* McCoy and *V. perplicata* Hedley and ten fossil species in the genus. Weaver and du Pont (1970) removed the latter two living species to the genus *Cymbiolacca* and were followed by Wilson (1972). Examination of the anatomy of *V. thatcheri* and *V. perplicata* by the writer confirms this action. Of the fossil species listed by Cotton, only *V. cathedralis* Tate, *V. tabulata* Tate, *V. lintea* Tate and *V. sexuaplicata* Chapman (= *V. ellipsoidea* Tate) have features in common with the living species and are retained by the writer in the genus. the others are placed in *Alcithoe*.

The fossil species of the genus fall into two groups, one characterised by the type species *Voluta kreuslerae*, to which also belong all the other living species, and the other characterised by *V. saginata* Finlay. The latter group has fusiform shells and lacks the prominent shoulders typical of the first group, but the protoconchs and apertural features are similar and larger specimens often have poorly developed shoulders. It is possible that this latter group is related to the group of *Nannamoria ralphi* Finlay, but because of the presence of axial riblets on the first and second spire whorl, the group is retained in *Notovoluta*.

The systematic position of the genus itself is in doubt since the information available on the anatomy of *N. verconis* and *N. kreuslerae* precludes its placement in any of the existing subfamilies. Weaver and du Pont (1970), the only authors to consider its systematic position, placed it in the Scaphellinae near *Amoria*, without any explanation for their action. The anatomy, so far as it is known (Darragh, 1983), has no close affinity with *Amoria*, as the gland of Leiblein is tightly bound to the oesophagus and cannot be easily separated as in *Amoria* and most other volutes. Also, though the radula is typically uniserial and tricuspid unlike that of *Amoria*, the cusps are somewhat fanglike and therefore quite unlike the radulae of most other Australian volutes. On the other hand, the anterior digestive system is similar to that found in most other Australian volutes including *Amoria*. Until more information on *Notovoluta* is available it does not seem appropriate either to erect a new subfamily for the reception of the genus, or to attempt to place it in an existing subfamily.

The earliest known species of *Notovoluta* occur in the Late Eocene of South-eastern Australia and

there are 9 other taxa distributed through the middle and late Tertiary including one species still living. There are no obvious ancestors of *Notovoluta* known, nor are there any close relatives and its origin is obscure at present.

Group One

Notovoluta varicellifera sp. nov.

Plate 3, figures 7, 9, 13, 14

Description. Shell narrowly fusiform with gently convex whorls, capped by dome shaped protoconch of 3 whorls. First teleconch whorl flat and sculptured with thin, somewhat irregular, weak, axial plicae. Remainder of teleoconch whorls regularly convex from suture to suture, spiral sculpture of numerous close set threadlets which are present over whole surface of shell. Outer lip of aperture thickened externally and internally so as to form almost a varix. Columella with 4 plaits, anterior of which is weakest. Rarely an extra, weak, posterior plait present. Siphonal notch and fasciole absent.

Dimensions. Holotype (P48599) L33, HA17, W11; Paratype (P48600) L37, HA20, W12.

Location of types. National Museum of Victoria: Holotype P48599, coll. T.A. Darragh, 25 Feb 1971; Paratype P48600, coll. T.A. Darragh, 20 Nov 1970.

Type locality. FL14, BC III, dark gritty clay in washout 2, forked gully nearest mouth of Johanna River, Johanna (Glenaire 079059). Browns Creek Clay, Aldingan.

Stratigraphic range. Aldingan (Late Eocene-Early Oligocene).

Occurrence. FL13, Washout nearest Browns Creek; FL14, type locality; FL19, Point Flinders.

Material. Types and 6 other specimens.

Comments. This species is probably ancestral to *N. ellipsoidea*, though no intermediates between the two are known from the Late Oligocene to the Early Miocene. It differs from *N. ellipsoidea* by its narrower and smaller shell, in the presence of axial sculpture, in its more prominent sculpture on all the whorls and it lacks a siphonal notch and fasciole. It also bears some resemblance in size and shape to *N. cathedralis*, but lacks the prominent shoulder and shoulder nodules of that species.

Notovoluta capitonica sp. nov.

Plate 3, figures 8, 11, 12, 15
Plate 27, figures 1, 4

Description. Shell elongate with gradate spire. Protoconch turbinate, almost pupiform, of 2½–3 smooth whorls with impressed sutures. First teleconch whorl flat and bearing thin axial costae and fine spiral threads. Subsequent 2 or 3 spire whorls shouldered and bearing axial costae which are weak or absent on posterior whorl slope but well developed from shoulder to anterior suture. Remainder of teleconch whorls not prominently shouldered nor axially costate, but are merely covered with fine spiral threads. Columella with 4 strong plaits. Siphonal notch not preserved, siphonal fasciole well developed.

Dimensions. Holotype, aperture broken, (P126803) L74(est), HA–, W25; Paratype (P32209) L35, HA17, W12; Paratype, broken, (P32210) L43, HA–, W–.

Location of types. National Museum of Victoria: Holotype P126803, Coll. T.A. Darragh 9 May 1979; Paratype P32209, coll. T.A. Darragh 20 Nov 1970, Paratype P32210, coll. T.A. Darragh, and H.E. Wilkinson, 6 Dec 1968.

Type locality. FL11, BC1, 9.6 m dark clay with *Turritella* below greensand in washout 1 nearest mouth of Browns Creek, Johanna (Glen Aire 080057). Browns Creek Clay, Aldingan, late Eocene.

Stratigraphic range. Aldingan, late Eocene.

Occurrence. Type locality; FL10, Lower beds, Aldinga Bay.

Material. Types and 2 topotypes, 3 specimens from Aldinga Bay SAM P6567.

Comments. The axial costae on the juvenile spire whorls and the spiral threads over the whole spire distinguish this species from others in the genus. It is probably ancestral to *N. cathedralis* and *N. pseudolirata* however, as yet there is no record in the Oligocene of any similar species of *Notovoluta*.

Notovoluta pseudolirata (Tate)

Plate 4, figures 2, 4
Plate 5, figures 2, 10–12
Figure 9

Voluta pseudolirata Tate, 1888: 176, pl. 13, fig. 6 (figure).–Tate, 1889b : 131 (description).

Voluta (Aulica) pseudolirata.–Harris, 1897: 104.

Notovoluta pseudolirata.–Cotton, 1949: pl. 14.–Wilson, 1972: 349, pl. 32, figs 4–7.

Description. Shell elongate, fusiform, with shouldered whorls. Protoconch domeshaped of 2½ whorls. First and second teleoconch whorls gently convex, remainder of whorls prominently shouldered. Spiral sculpture absent. Axial costae somewhat variable in development and strength. Usually first and second spire whorls sculptured with thin costae and later whorls bear 9–15 costae which become nodulate on shoulder. Rarely, shell is

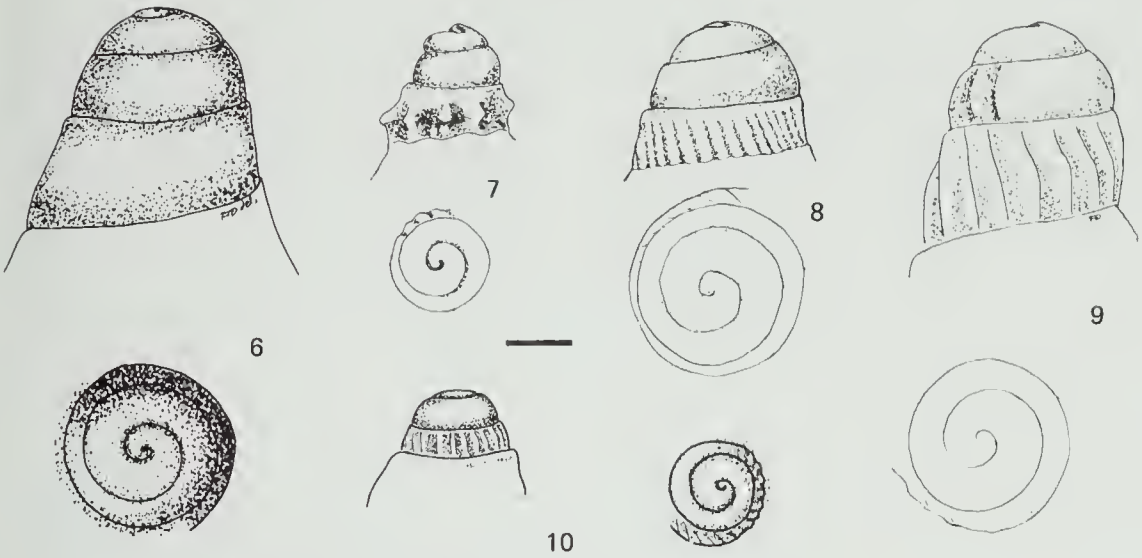

Figure 6. *Notovoluta kreuslerae kreuslerae* (Angas), Gabriel collection 1561, SA.
Figure 7. *Notovoluta tabulata* (Tate), SAM P5740a, hypotype Minderie, SA.
Figure 8. *Notovoluta kreuslerae occulta* sp. nov., WAM 69.389a, holotype, Quarry, 1.5 km N of Hampton Tower, WA.
Figure 9. *Notovoluta pseudolirata* (Tate) P32211, hypotype, Clifton Bank.
Figure 10. *Notovoluta linigera* sp. nov., P32218, paratype, SE side of Fishers Point. (scale = 2 mm)

smooth apart from a few incipient costulae. Siphonal notch deep, siphonal fasciole prominent. Colour cream with pattern of triangular spots and broad orange, spiral bands.

Dimensions. Holotype (T608C) L57, HA30, W19; T608D, L62, HA32, W19; Hypotype (P32211) L67, HA35, W22.

Location of types. South Australian Museum: Holotype T608C, R. Tate Collection. National Museum of Victoria: P32211, T.S. Hall in F.A. Cudmore Collection.

Type locality. Lower bed, Muddy Creek, i.e., FL82, Clifton Bank, Muddy Creek near Hamilton (Coleraine WD820224). Muddy Creek Formation, Balcombian, Middle Miocene.

Stratigraphic range. Balcombian, Middle Miocene–Recent.

Occurrence. Fossil: FL69, Red Bluff; FL70, Farells; FL71, SW of Glenleigh; FL72, Orphanage Hill, Fyansford; FL78, Fossil Beach, FL81, Overburden Batesford Quarry; FL82, Type locality; FL87, NW shore Lake Bullenmerri; FL88, NW end of Gibson Beach; FL103 Downstream section, Gunyoung Creek; FL104, Manyung Rocks.

Recent: In addition to the localities listed by Wilson 1972 the species has been dredged from the following: WAM 483-72, NW of Bunbury (33°S, 114°37'E), 212-226 m, HMAS "Diamantina", DM 1/72, Stn 6, 18 Mar 1972.

WAM 484-72, NNW of Cape Hamelin (34°10'S, 114°03'E), 148 m HMAS "Diamantina" DM 1/72, 16 Mar 1972.

Material. Holotype and 17 topotypes.

Comments. Traces of colour pattern in the form of triangular spots and spiral bands are present on fossils from Muddy Creek and Fossil Beach in positions similar to those of the living species. The development of the axial sculpture is variable but the living species fall within the range of variation of topotypes. It differs from *N. kreuslerae,* the other large species in the genus, by its more elongate spire.

Notovoluta cathedralis (Tate)

Plate 2, figures 14, 15
Plate 4, figures 3, 5

Voluta cathedralis Tate, 1888 : 176, pl. 13, fig. 10 (figure).—Tate, 1889b: 131. (description).
Scaphella (Eopsephia) cathedralis.—Harris, 1897: 117.
Notovoluta cathedralis.—Cotton, 1949: pl.15.

Description. Shell elongate with high tapering spire capped by small low dome-shaped protoconch. Protoconch of 2 smooth whorls and half a whorl sculptured with close-set axial ribs. First 2 teleoconch whorls almost flat, sculptured with fine close set spiral threads which continue and are present on posterior third of body whorl. Penultimate and body whorls bearing elongate nodules (8–10 on body whorl) which tend to become obsolete towards aperture. Siphonal notch wide and

deep, siphonal fasciole present.

Dimensions. Holotype (T596B) L47, HA25, W15; Hypotype (P32213) L42, HA21, W14.

Location of types. South Australian Museum: Holotype T596B, R. Tate Collection. National Museum of Victoria: Hypotype P32213, T.S. Hall in E.A. Cudmore Collection.

Type locality. Lower beds, Muddy Creek, i.e., FL82, Clifton Bank, Muddy Creek, Hamilton (Coleraine WD820224). Muddy Creek Formation, Balcombian, Middle Miocene.

Stratigraphic range. Balcombian, Middle Miocene.

Occurrence. FL74, SE Trunk Sewer at Junction Road; FL75, SE Trunk Sewer between Braeside and Centre Dandenong Rd; FL82, Type locality; Fl84, Cadell Marl.

Material. Holotype and 30 topotypes.

Comments. This species is distinguished by the elongate nodules and the presence of spiral threads on the posterior slope of the whorls. The species is relatively common at the type locality and rare elsewhere. It bears a somewhat similar relationship to *N. verconis* as *N. pseudolirata* does to *N. kreuslerae*, however *N. verconis* has a prominent shoulder which is absent in *N. cathedralis*.

Notovoluta ellipsoidea (Tate)

Plate 2, figure 3
Plate 3, figure 2
Plate 5, figures 4, 5

Voluta ellipsoidea Tate, 1888: 176, pl. 13, fig. 4 (figure). — Tate, 1889b: 127 (description).
Voluta (Aulica) ellipsoidea — Harris, 1897: 105.
Voluta (Aulica) sexuaplicata Chapman, 1922: 15, pl. 3, fig. 24.
Fricusa ellipsoidea — Cotton, 1949: pl. 15.
Fricusa (Fricusa) ellipsoidea — Eadbrook, 1958: 76.

Description. Shell narrowly fusiform with gently convex whorls capped by prominent subcylindrical or rarely domeshaped protoconch of $2^1/_2$–$3^1/_2$ smooth whorls. First teleoconch whorl flat to concave, remainder of whorls gently convex and occasionally slightly depressed against posterior suture of whorl. Axial sculpture absent. Spiral sculpture of numerous close-set threadlets which are present over whole of whorls but are stronger and more obvious on first and second teleoconch whorls and decrease in strength on subsequent whorls. Aperture notched posteriorly at suture. Columella with 4 strong plaits. Siphonal notch shallow and wide; siphonal fasciole prominent.

Dimensions. Holotype (T601C), L53, HA28, W18; Hypotype (T601A), L68, HA40, W24; P13250, L71, HA38, W23.

Location of types. South Australian Museum. Holotype T601C, Hypotype T601A,. Tate Collection. National Museum of Victoria: Holotype of *V. (A.) sexuaplicata* P13250, Pres. G. P. Tait, 22 Jul 1907.

Type locality. Lower beds, Muddy Creek, i.e., FL82, Clifton bank, Muddy Creek, Hamilton (Coleraine WD820224). Muddy Creek Formation, Balcombian, Middle Miocene.

Stratigraphic range. Balcombian, Middle Miocene–Yatalan, Late Pliocene.

Occurrence. FL82, type locality; Gellibrand Marl (Harris dahan): Cliff 5 km NW of Point Ronald, Princetown. Dry Creek Sands (Late Pliocene): Abattoirs Bore (fide Eadbrook, 1958).

Material. Types and 8 topotypes.

Comments. The absence of any axial sculpture and the overall fine spiral threads distinguish this species from others in the genus. The holotype of *Voluta (Aulica) sexuaplicata* is worn, particularly on the posterior portion of the spire. There are however faint spiral threads present and the protoconch is typically that found in *N. ellipsoidea*. This specimen is merely a narrow individual of *N. ellipsoidea* which has an extra two weak columella plaits.

Notovoluta tabulata (Tate)

Plate 4, figures 1, 6, 8, 10
Figure 7

Voluta tabulata Tate, 1888: 176, pl. 13, fig. 3 (figure). — Tate, 1889b: 132 (description).

Description. Shell fusiform with rather short gradate spire of prominently shouldered whorls. Protoconch somewhat dome-shaped, of $2^1/_2$ swollen whorls, latter half whorl bearing axial plicae which on anterior half of teleoconch whorls develop into more prominent costae. Spiral sculpture absent. Body whorl with 9–10 rather sinuous costae which are subspinose on shoulder, are absent from posterior whorl slope and fade out at middle of anterior whorl slope. Anterior half of body whorl abruptly contracted to the anterior canal.

Dimensions. Holotype (T611A), L36, HA22, W16; T611B, L38, HA , W17; Hypotype (SAM P5740a), L38, HA20, W16; Hypotype (SAM P5740b), L37, HA19, W14.

Location of types. South Australian Museum: Holotype T611A, R. Tate Collection; Hypotypes P5740a–b, "old collection".

Type locality. "Well sinking, Murray Desert" (Tareena, NSW). Bookpurnong beds, late Miocene. Tate (1899:102) stated that the species described from the "Murray Desert"

in previous papers came from a deep well at Tareena, NSW.

Stratigraphic range. Cheltenhamian, Late Miocene.

Occurrence. Bookpurnong Beds (Cheltenhamian): type locality; Well sinking at Mindarie, South Australia.

Material. Holotype, 1 topotype and 2 other specimens.

Comments. The species is distinguished by the low spire and subspinose costae. This, the nominate subspecies, is ancestral to *N. tabulata* subsp. from the Dry Creek Sands. Of the other species of *Notovoluta* it seems to come closest to *N. verconis* (Tate) but differs in the points mentioned above.

Notovoluta tabulata subsp. nov.

Description. Shell fusiform with gradate spire of prominently shouldered whorls. Protoconch dome-shaped as in *N. kreuslerae.* Spiral sculpture absent. Shoulder of whorls bearing prominent subspinose projections, of which there are about 8 on body whorl. These projections are posterior portions of axial costae which are frequently poorly developed. Body whorl abruptly contracted anteriorly and having prominent siphonal fasciole.

Occurrence. Dry Creek Sands, various bores, Adelaide Plains, SA.

Comments. This subspecies is currently under study by Dr H.H. Ludbrook, but is included in order that the list of species might be complete. *Notovoluta tabulata tabulata*, which is probably ancestral to this subspecies, is more elongate, has more persistant axial sculpture and the whorls of the protoconch are swollen. In view of the variation in morphology of the Dry Creek Sands specimens and because of the paucity of specimens of *N. tabulata tabulata* this taxon is regarded as a subspecies of the latter.

Notovoluta verconis medicata subsp.nov.

Plate 29, figures 1–6

Notovoluta verconis.—Ludbrook, 1978: 166, pl. 18, fig. 19.

Description. Shell elongate, fusiform with high spire and weakly shouldered whorls. Protoconch, dome-shaped of 2 smooth whorls and third whorl sculptured with close-set weak axial riblets. Teleoconch weakly shouldered and sculptured with axial costae which are often weakly developed overall and sometimes becomes obsolete on body whorl. Spiral sculpture of very fine close-set threads confined to shoulder of whorls. Columella with 4 strong plaits, weak posterior plait and often 1 or more weak plaits inserted between the others.

Dimensions. Holotype (WAM 79.2595), L29, HA17, W11; Paratype (P59665), L30, HA15, W12; Paratype (WAM 76.2399), L32, HA18, W12.

Location of types. Western Australian Museum: Holotype WAM 79.2595, coll. V.A. Ryland, G.W. and W.E. Kendrick, 5–13 Aug 1978; Paratype WAM 76.2399, coll. P.J. Bridge and K. Williamson, Apr 1973. National Museum of Victoria: Paratype P59665 coll. T.A. Darragh 24 Apr 1969.

Type locality. Quarry 1.5 km N of Hampton Microwave Repeater Tower, Roe Plain Western Australia. (Eucla, 1:250,000 365465). Roe Calcarenite.

Stratigraphic range. Roe Calcarenite.

Occurrence. Type locality; Foundation holes for Hampton Microwave Repeater Tower; Nurina Cave, Roe Plain, Western Australia.

Material. Types, 11 topotypes and 3 other specimens.

Comments. This taxon is close to *N. verconis verconis* (Tate) but may be distinguished by its more weakly developed shoulders and therefore less gradate spire. The body whorl is not as swollen and the axial costae tend to be much weaker and more numerous (13–18 on penultimate whorl as against 11–13) and are often virtually absent from the body whorl. As these differences seem to be somewhat gradational the taxon is regarded as a subspecies of *N. verconis. Notovoluta occidua* Cotton is much narrower, has virtually no shoulder and the axial costae are much more strongly developed.

Notovoluta kreuslerae occulta subsp. nov.

Plate 29, figures 11–14
Figure 8

Notovoluta kreuslerae subtilis Ludbrook, 1978 : 166 (in part).

Description. Shell elongate, fusiform, with rather flattened whorls. Protoconch dome-shaped of 2½–3 smooth whorls. First teleoconch whorl almost flat, sculptured with close-set axial costae on first half of whorl. Remainder of spire whorls and body whorl usually smooth except for growth striae, but rarely with weakly developed axial plicae. Spire whorls and body whorl on some specimens with weakly developed shoulder. Columella with 4 strong plaits. Siphonal notch, wide and deep; siphonal fasciole present.

Dimensions. Holotype (WAM 79.389a). L72, HA40, W25; Paratype (WAM 76.2476), L72, HA40, W29; Paratype (P53038), L60, HA33, W22; P53037, L64, HA37, W24.

Location of types. Western Australian Museum: Holotype WAM 79.389a, coll. V.A. Ryland, G.W. and W.E.

Kendrick, 5–13 Aug 1978. WAM 76.2476 coll. E. and N. Zeffert, Jan 1976. National Museum of Victoria: P53038 coll. T.A. Darragh, 21 Apr 1969.

Type locality. Quarry on access road to Hampton Microwave Repeater Tower, 1.5 km N of Tower, Roe Plain, Western Australia (Eucla, 1:250,000 365464). Roe Calcarenite, Early Pleistocene.

Stratigraphic range. Early Pleistocene.

Occurrence. Type locality and various borrow pits in the Roe Calcarenite along Eyre Highway, Roe Plain, Western Australia.

Material. Types, 5 topotypes and 13 other specimens.

Comments. This subspecies differs from *Notovoluta kreuslerae kreuslerae* by its more slender shape, by the lack of a well defined shoulder and lack of prominent axial sculpture. However as Ludbrook has indicated, there is some degree of variability in morphology and, indeed, of overlap between the Pleistocene and living forms, therefore the writer agrees with Ludbrook and maintains subspecific rank for the Pleistocene taxon.

The holotype of *Notovoluta kreuslerae subtilis* is an *Ericusa* which leaves the subspecies of *Notovoluta* without a name. The paratypes WAM 69.606 are specimens of this subspecies of *Notovoluta*. The two taxa which have been confused are somewhat similar in overall morphology but may be separated by the protoconchs, that of *N. kreuslerae occulta* is coiled in the axis of the shell, that of *Ericusa subtilis* is deviated. *Ericusa subtilis* also has no axial sculpture.

Notovoluta kreuslerae kreuslerae (Angas)

Plate 5, figures 1, 7
Figure 6

Voluta (Alcithoe) kreuslerae Angas, 1865: 55, pl. 2, fig. 3.

Voluta kreuslerae. – G.B. Sowerby III, 1887: 299, pl. 515, fig. 150.

Voluta rossiteri Brazier, 1898: 779.

Notovoluta kreuslerae. – Weaver and du Pont, 1970: 168, pl. 72J, 72K.

Notovoluta rossiteri. – Weaver and du Pont, 1970: 168, pl. 72F, 72G.

Notovoluta kreuslerae. – Wilson, 1972: pl. 32, fig. 13.

Comments. Weaver and du Pont (1970) have provided a good description and figures of this species. However, in their citation of Portland, Victoria, as type locality, they have overlooked the fact that Angas cited Glenelg, South Australia as the origin of his specimen. Wilson (1972:348) has pointed out that the holotype of *Voluta rossiteri* Brazier is merely a large specimen of *N. kreuslerae* and the writer agrees with this. This holotype is a beach worn specimen from Lakes Entrance, Victoria, and no other specimen has yet been found in Victorian waters, despite extensive dredging particularly off Gippsland.

The species is confined to South Australia and ranges from Cape Donnington to Encounter Bay.

Notovoluta verconis verconis (Tate)

Plate 2, figure 5
Plate 4, figure 7
Plate 5, figure 3

Voluta verconis Tate, 1892: 125, pl. 1, fig. 5.

Notovoluta verconis. – Weaver and du Pont, 1970: 169, pl. 72H, 72I; Fig. 37.. – Wilson, 1972: pl. 32, figs 10–12.

Comments. Weaver and du Pont (1970) have provided a good description and illustration of this species. It ranges from Nuyts Archipelago to Encounter Bay, South Australia.

Notovoluta occidua Cotton

Plate 2, figure 4

Notovoluta occidua Cotton, 1946: 16.

Notovoluta occidua. – Wilson, 1972: 348, pl. 32, figs 8, 9

Comments. This species was synonymised with *N. verconis* by Weaver and du Pont (1970), however, Wilson (1972) pointed out certain differences between the two taxa and accepted *N. occidua* as a good species. Unfortunately, there are as yet only a few worn specimens available from two restricted areas off Hopeton and off Eucla, W.A. and it is not possible to fully assess whether this is the case or not.

Notovoluta baconi Wilson

Plate 5, figures 6, 13

Notovoluta baconi Wilson, 1972:352, pl. 32, figs 1–3.

Comments. This species was founded on two specimens and no additional material is available. Wilson has provided a detailed description and comparison. It closely resembles *N. pseudolirata* from which it differs principally by the presence of more numerous axial costae on the penultimate and body whorls.

Notovoluta gardneri Darragh

Plate 27, figures 11, 14

Notovoluta gardneri Darragh, 1983: 84, Figs 1, 3, 6, 8.

Comments. This species is distinguished from the other known living species by the absence of axial sculpture. In shape it most closely resembles the

Early Miocene *N. differta* sp. nov., but that species has numerous close-set threads covering the whole spire.

Group Two

Notovoluta saginata (Finlay)

Plate 2, figure 2
Plate 5, figure 8

Voluta lirata Johnston, 1880: 37 non Brocchi, 1814.
Voluta allporti.—Johnston, 1888: pl. 30, fig. 10, non Johnston, 1880.
Voluta maccoyi.—Pritchard, 1896: 95 (partim) non Tenison Woods, 1877.
Voluta lirata.—Pritchard, 1913: 197, pl. 20, figs 7, 8.
Notopeplum saginatum Finlay, 1930: 45.—Ludbrook, 1967: 67, pl. 3, figs 5, 7 (Holotype of *V. lirata*).

Description. Shell fusiform with elongate conical spire. Protoconch somewhat dome-shaped of 2 smooth whorls the second of which is swollen and half a whorl which has a few weak widely spaced riblets and 2 spiral threads. Spire whorls generally flat, rarely a little depressed posteriorly, sculptured with numerous slightly sinuous axial riblets which become obsolescent on body whorl. Body whorl a little ventricose, contracting rapidly to anterior canal. Columella with 4 strong plaits. Siphonal notch shallow, siphonal fasciole prominent.

Dimensions. Holotype (AIM TM1072), L51, HA32, W23; Hypotype (MUGD 1795), L32, HA18, W16 (Pritchard 1913, pl. 20, figs 7, 8); TM Z185, L47, HA28, W21 (Johnston, 1880: 37; 1888, pl. 30, fig. 10).

Location of types. Auckland Institute and Museum: Holotype TM 1072 H. Finlay Collection. Melbourne University Geology Department: Hypotype 1795, G.B. Pritchard Collection. Tasmanian Museum: Holotype of *Voluta lirata*, Z185, R.M. Johnston Collection.

Type locality. "Table Cape", Fossil Bluff, Wynyard, Tasmania (Table Cape 930630).

Stratigraphic range. Janjukian, Early Miocene.

Occurrence. FL28, Lower bed, Fossil Bluff; FL29, upper bed, Fossil Bluff.

Material. Numerous specimens from FL28; 6 specimens from FL29.

Comments. This species and the following three are closely related and are probably part of the same lineage. *N. saginata* is characterised by its ventricose appearance, by the elongate conical spire which is almost half the length of the shell and by the axial riblets present on the spire whorls. The specimen figured by Johnston (1888) as *Voluta allporti* is probably the holotype of *Voluta lirata*. For comment on *V. allporti* see *Ericusa pellita*.

Notovoluta linigera sp. nov.

Plate 3, figures 3, 4, 6, 10
Figure 10

Description. Shell ovate, rather squat, almost biconic. Protoconch of 1½–2 whorls, last whorl of which is axially plicate. Spire whorls depressed posteriorly, convex against anterior suture. Body whorl depressed posteriorly then gently convex and tapering anteriorly to canal. Axial sculpture of thin, close but somewhat irregularly spaced riblets. Spiral sculpture of thin close-set threads which are well developed and cover spire whorls but tend to decrease in strength anteriorly on body whorl and may be entirely obsolete on body whorl of large specimens.

Dimensions. Holotype (P32216), L33, HA19, W14; Paratype (P32218), L32, HA16, W13.

Location of types. National Museum of Victoria: Holotype P32216 coll. T.A. Darragh and T. Hughes 30 Nov 1972. Paratype P32218 coll. T.A. Darragh and H.E. Wilkinson 4 Dec 1968.

Type locality. FL35, Cliff section 10 m above Lake Craven, Aire River, SE of Fischers Point Horden Vale (Princetown 155040). Lower mollusc horizon, Fishing Point Marl. Longfordian.

Stratigraphic range. Longfordian, Early Miocene.

Occurrence. FL32, SE end of Jan Juc Beach; FL34, S bank of Lake Costin; FL35, Type locality.

Material. Types and 8 topotypes, several other specimens.

Comments. This is a more slender shell than *N saginata* and has more prominent spiral threads and axial sculpture. *N. lintea* has similar spiral threads but the axial sculpture consists of widely spaced, elongate nodules rather than closely spaced fine riblets. The spiral sculpture on specimens from the Puebla Clay is not as strongly developed as on those from Horden Vale.

Notovoluta differta sp. nov.

Plate 4, figures 11–14

Description. Shell ovate with rapidly tapering spire. Protoconch dome-shaped, of 2 smooth whorls, and half a whorl with poorly developed axial plicae. First and second teleoconch whorls flat, subsequent whorls depressed posteriorly and convex anteriorly. Axial sculpture absent. Spiral sculpture of numerous close-set threads covering whole of spire whorls and posterior third of body whorl. Aperture as in *N. saginata*. Siphonal notch shallow; siphonal fasciole present. Colour pattern of thin, widely spaced, sinuous, axial bands.

Dimensions. Holotype (P32221), L 51, HA33, W20; Paratype (P32222), L 49, HA32, W20.

Location of types. National Museum of Victoria: Holotype P32221, coll. T.A. Darragh and H.E. Wilkinson, Paratype P32222, G.B. Pritchard Collection.

Type locality. LL43, cutting on Lavers Hill–Cobden Rd, 0.8 miles S of Kennedys Creek turnoff (Princetown 969253). Gellibrand Marl, Batesfordian.

Stratigraphic range. Batesfordian, Early Miocene.

Occurrence. LL38, Curlewis; LL42, Amphitheatre; LL43, Type locality; LL48, Boornong Rd cutting.

Material. Holotype, 5 topotypes and 11 other specimens.

Comments. The shell of this species is not so tumid as in *N. sagmata* and there is an incipient shoulder developed which is not present in the latter. *N. lunigera* has prominent axial sculpture and *N. lintea* has elongate nodules which are not present in the species under consideration.

Notovoluta lintea (Tate)

Plate 3, figures 1, 5
Plate 4, figure 9

Voluta lintea Tate, 1889b: 129, pl. 3, figs 1a, b.
Notovoluta lintea — Cotton, 1949: pl. 15.

Description. Shell elongate ovate with slender spire. Protoconch dome-shaped of 2½ whorls the last half whorl of which axially plicate. First teleconch whorl flat, penultimate and final whorls depressed in front of posterior suture. Suture grooved. Spiral sculpture of numerous close-set threads which tend to decrease in strength on body whorl. Axial sculpture of widely spaced, low, elongate nodules present on the penultimate and final whorls and situate in front of posterior depression of whorls. Columella with 4 strong plaits. Siphonal notch shallow; siphonal fasciole weak.

Dimensions. Holotype (T600), L 27, HA15, W11; Hypotype (P32219), L 27, HA17, W10, P32220, L 32, HA18, W11.

Location of types. South Australian Museum. Holotype T600, R. Tate Collection. National Museum of Victoria. Hypotype P32219, F.A. Cudmore Collection.

Type locality. "Calciferous sandstones of the River Murray Cliffs near Morgan". The locality is on the left bank of the River Murray at a gully 4.8 km S of Morgan–Cadell Rd, SA (Renmark, 1:250000 268789). Cadell Marl lens, Morgan Limestone, Balcombian.

Stratigraphic range. Balcombian, Middle Miocene.

Occurrence. Type locality only.

Material. Holotype and 2 topotypes.

Comments. The widely spaced, low, elongate nodules and slender shape distinguish this species from the others in the group.

Volutoconus Crosse, 1871

Voluta (Volutoconus) Crosse, 1871: 306.

Type species. Monotypy: *Voluta conformis* Cox 1871; Recent, Western Australia.

Distribution. Northern Australia (North-west Western Australia–Northern New South Wales).

Comments. There are four living species in the genus. All previous fossil records attributed to this genus are based on species of *Nannamoria* and are discussed under that genus.

Volutoconus sp.

Remarks. This record is based on a single silicified juvenile specimen from the Mid Miocene Trealla Limestone at Geological Survey of Western Australia locality 30055, E flank of Cape Range near Exmouth, Western Australia. The specimen consists of four protoconch whorls and one teleoconch whorl. The protoconch bears well-defined axial costae much narrower than the interspaces. Teleoconch whorl has numerous close set costae and there are four strong plaits on the columella. The specimen bears a close resemblance to *Volutoconus hargreavesi* which occurs in off-shore waters from Houtman Abrolhos to the Dampier Archipelago, North-west Western Australia.

Amoriinae subfam. nov

Diagnosis. Head broad, flat, entire with short flat tentacles. Siphonal appendages short, flat and equal. Operculum absent. Tubular salivary glands of anterior digestive system very short and free from racemose salivary gland. Radula uniserial, usually Y-shaped and consisting of single cusp or sometimes trieuspid. Protoconch multispiral with whorls coiled in axis of shell. Shell covered with hard brilliant glaze. Aperture usually with 4 strong plaits and occasionally with 1 or more weaker secondary plaits.

Remarks. The subfamily has been erected for the reception of *Amoria* and *Nannamoria*, genera which have been placed in the Scaphellinae by previous authors, on the basis of a rather superficial resemblance of the radulae of *Scaphella* and *Amoria*. The animal of *Scaphella*, described by Clench and Turner (1964), however differs principally from *Amoria* by having a cleft head similar to that present in the Volutinae and Athletinae, a single left siphonal appendage and a gland of

Leiblein which is bound to the oesophagus and cannot be separated as in *Amoria*.. These features are of sufficient magnitude to warrant subfamily separation of *Amoria* and *Scaphella*.

The anatomy of *Scaphella* has certain "primitive" features, e.g. the cleft head, resembling those of the Volutinae and Athletinae, a situation reflected by the geological record of this group, since *Scaphella* is known from the Late Cretaceous and Paleocene of Europe and hence qualifies as one of the earliest volutes. Members of the Amoriinae, however, are known only from the latest Oligocene or Early Miocene and the anatomical features of the group are closer to those found in the Zidoninae.

The principal difference between the Amoriinae and Zidoninae is the presence of a short tubular salivary gland free from the racemose salivary gland in the former, in contrast to a very long tubular salivary gland loosely associated with the racemose gland in the latter.

The oldest known members of the family appear in the latest Oligocene or Early Miocene and the family is known only from the Australian region. In view of the similarity of the anatomy and shell characters to members of the Zidoninae, particularly *Cymbiola,* it is suggested that the Amoriinae is derived from the former in the early Tertiary.

Amoria Gray, 1855

Amoria Gray, 1855b: 64.

Voluta (Amoria).—Tryon, 1882: 92.—Fischer, 1883: 608.—Harris, 1897: 108.

Amoria—Cossmann, 1899: 119.

Scaphella.—Hedley, 1915: 721 (non Swainson, 1832).

Amoria (Amorena) Iredale, 1929: 180 (Type species (original designation): *Voluta undulata* Lamarck).

Amoria (Zebramoria) Iredale, 1929: 180 (Type species (original designation): *Voluta zebra* Leach).

Cymbiola (Cymbiolista) Iredale, 1929: 181. (Type species (original designation): *Voluta marmorata* Swainson).

Relegamoria Iredale, 1936: 314 (Type species (original designation): *Regelamoria moleri* Iredale, 1936).

Amorena.—Cotton and Godfrey, 1932: 47.

Amoria.—Smith, 1942: 50.

Amoria (Amoria).—Wenz, 1943: 1339.

Amoria (Zebramoria).—Wenz, 1943: 1339.

Amoria (Amorena).—Wenz, 1943: 1339.

Adelomelon (Cymbiolista)—Wenz, 1943: 1349.

Cymbiolista.—McMichael, 1960: 11.

Amorena.—Macpherson and Gabriel, 1962: 222.

Zebramoria.—Macpherson and Gabriel, 1962: 223.

Amoria.—McMichael, 1964: 265.

Zebramoria.—McMichael, 1964: 271.

Amoria (Amoria).—Weaver and du Pont, 1970: 147, 148.

Amoria (Amorena).—Weaver and du Pont, 1970: 159.

Amoria (Relegamoria).—Weaver and du Pont, 1970: 162.

Amoria (Zebramoria).—Weaver and du Pont, 1970: 163.

Cymbiolista.—Weaver and du Pont, 1970: 171.

Amoria.—Wilson, 1972: 340.

Type species. Subsequent designation by Harris (1897): *Voluta turneri* Griffith and Pidgeon, 1834; Recent, Northern Australia.

Description. Shell fusiform or elongate-ovate with subconical or rarely gradate spire; spire whorls usually flat though sometimes weakly shouldered, body whorl shouldered. Protoconch multispiral, conical, coiled with axis of shell, of 3½–4½ smooth, flat or convex whorls, which may or may not have narrow shoulder. Surface of shell shining, generally smooth but occasionally with weakly developed axial costae or nodules. Aperture narrow, somewhat elliptical, slightly notched posteriorly; columella with 4 strong plaits and occasionally with extra 1 or 2 weaker plaits. Siphonal notch deep; siphonal fasciole usually prominent.

Stratigraphic range. Middle Miocene–Recent.

Distribution. Australian waters generally and south-eastern Indonesia. 0–500 metres. Victoria and South Australia. (Middle Miocene–Recent), Western Australia (Middle Miocene, Pleistocene–Recent).

Comments. In the above synonymy, references which merely cite names have been omitted, and only those which include descriptions or discussions of generic taxa are included.

Wenz (1943) and Ludbrook (1953) both synonymised without comment *Relegamoria* with *Amoria* and have been followed by McMichael (1964) who stated that the radula of the former was typical of *Amoria* and the apical characters could not be distinguished from other species of *Amoria.* However, Weaver and du Pont (1970) have resurrected *Relegamoria* stating that the ridgelike callus on the inner side of the outer lip, the pointed protoconch and the presence of a fifth columella plait are differential characters of sufficient importance to warrant subgeneric status for the taxon. The author agrees with Wenz, Ludbrook and McMichael that *Relegamoria* should be placed in synonymy with *Amoria,* since these features are variable from species to species and individual to individual, but would go further and on similar grounds also include *Amorena, Cymbiolista* and *Zebramoria.*

Amorena was erected with the bare statement that the form, apex and columella plaits differed from *Amoria,* and it is only recently that any

author has attempted to describe how these features differ. Weaver and du Pont (1970) stated that "*Amorena* differs from *Amoria* s.s. in having a smaller, irregularly coiled protoconch and stronger less oblique columella plaits, often with secondary plaits in between the normal ones". They included in the taxon *Amorena exoptanta* Reeve, *A. benthalis* McMichael (= *undulata*), *A. undulata* Lamarck and *A. sclateri* Cox (= *undulata*). The protoconchs of all these taxa are similar, but vary somewhat in size, all are coiled with the axis of the shell, are conical and consist of four or so whorls and fall within the range of variation of the protoconchs found in species assigned to *Amoria*. The so-called irregular coiling presumably refers to that fact that in *A. undulata* the whorls of the protoconch are convex, whereas the spire whorls are flat, so that the top of the spire has a knoblike appearance. The strength of development of the plaits is subject to individual variation, as is the number present. Generally there are four plaits present in *A. undulata* and only rarely are others found, so this cannot be of generic significance. In elongate specimens of *A. undulata* the plaits are as oblique as in *A. grayi* or any other elongate *Amoria*, so that the alleged differences are not of any significance and *Amorena* cannot be maintained.

Cymbiolista Iredale, 1929 was erected as a subgenus of *Cymbiola* without diagnosis, and later was raised to the rank of genus without comment by Iredale (1931). The type and only species, *Cymbiolista hunteri* Iredale (= *marmorata* Swainson), was placed in *Amoria* by Smith (1942) following Tryon (1882). McMichael (1960) described the radula of *C. hunteri* as of the *Amoria* type, placing the genus *Cymbiolista* with *Amoria* in the subfamily Scaphellinae, and commented that the shell did not resemble *Amoria* in any way. The author disagrees with the latter statement. The conical multispiral protoconch, aperture, plaits, siphonal notch and fasciole, colour pattern (for what it is worth) and overall appearance are typical of species of *Amoria*. The only difference is that the shoulder is sharply nodulate on the edge, a feature which the author regards as of specific rather than generic significance.

Iredale (1929) erected *Zebramoria* on the grounds that it differed from *Amoria* in the same details as his subgenus *Amorena*. Subsequent authors, e.g. Weaver and du Pont (1970) have noted only the difference in the protoconch, "with the exception of the protoconch whorls and early teleoconch whorls the shell morphological characteristics of *Zebramoria* confirm to those of *Amoria*". The protoconch is multispiral of 2½–3 smooth whorls, coiled in the axis of the shell. The protoconch is a miniature version of that found in *A. undulata*, except that it is not as squat and the whorls are more swollen, giving a pupiform appearance to the protoconch. These differences are not considered to be sufficient grounds for the separation of *Zebramoria* from *Amoria* and accordingly it has been synonymised with the latter.

An examination of the animal has shown that the external morphology, the radula and the anterior digestive system of the type species of *Relegamoria*, *Cymbiolista*, *Amorena* and *Zebramoria* are identical to those found in the various species of *Amoria*, which confirms the above observations based on shell morphology.

The oldest representatives of the genus *Amoria*, *A. costellifera* (Tate) and *Amoria* sp. occur respectively in the Middle Miocene of south-eastern Australia and North-west Australia and there are no obvious ancestors in the Australian Tertiary. A second species, *A. undulata* (Lamarck) which is still living in the area, makes its appearance in the Late Miocene, however, there is no direct connection between these two species. In the past *Amoria* has tended to be regarded as a tropical genus, because many species have been described from Northern Australia, however the significance of the genus in that area has been overemphasised, since most of these taxa are merely colour varieties and the number of good species is quite small. There are no known representatives of the genus in the Tertiary rocks of Java, Timor or New Guinea which may indicate that *Amoria* is a new immigrant into that area.

The relationships of the genus are not clear and the poor stratigraphic record throws no light on the problem. On the basis of general shell morphology and the anatomy, some relationship with *Cymbiola* and possibly *Notovoluta* is suggested.

Amoria costellifera (Tate)

Plate 6, figures 4, 8, 10–12
Figure 11

Voluta lirata Tate, 1889b: 130, pl. 2, fig. 4 (non Johnston, 1880).
Voluta costellifera Tate, 1889b: 131, pl. 2, fig. 8.
Voluta (Aulica) lirata.—Harris, 1897: 103, pl. 4, fig. 12.
Nannamoria absidata Cotton, 1949: 192, pl.14.
Nannamoria costellifera.—Cotton, 1949: pl. 14.

Description. Shell fusiform with gradate to subconical spire. Protoconch smooth, conical of 3½ whorls with grooved suture. Whorls usually depressed posteriorly then concave and generally

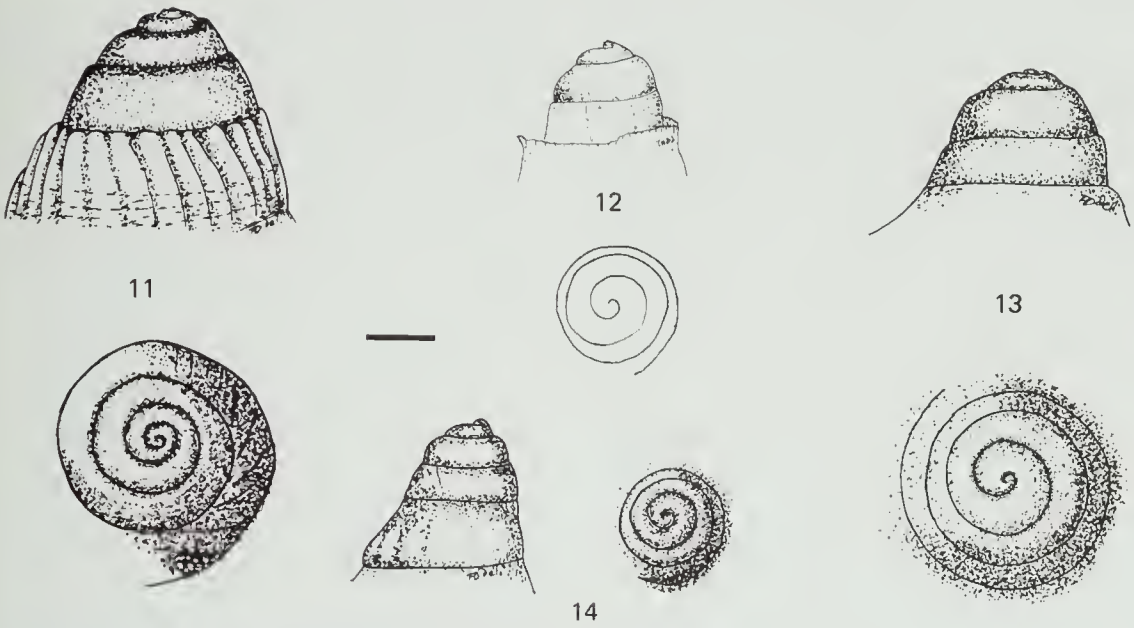

Figure 11. *Amoria costellifera* (Tate), P61286, hypotype, Clifton Bank.
Figure 12. *Nannamoria limbata* (Tate), P33087, hypotype, Manyung Rocks.
Figure 13. *Nannamoria strophodon guntheri* (Smith), St. Francis Is., SA.
Figure 14. *Nannamoria amicula* Iredale, F21294, off Broken Bay, NSW. (scale = 2 mm)

prominently shouldered. Axial sculpture of relatively broad low costae, variable in degree of development and number per whorl. First teleconch whorl usually seulptured with eoarse close-set costae. Spiral seulpture absent. Columella generally with 4 plaits; siphonal noteh broad; siphonal faseiole prominent. Colour pattern of thin elose set axial bands whieh zig-zag on slope of shoulder of whorl and bifureate on shoulder itself.

Dimensions. Holotype (T603), L61, HA44, W29; T597B, L63, HA42, W25 (Tate, 1889, p. 130, pl. 2, fig. 4); Hypotype (P34261), L74, HA51, W30.

Location of types. South Australian Museum. Holotype T603; Holotype of *Nannamoria absidata* Cotton T597B, R. Tate Collection. National Museum of Victoria: Hypotype, P34261, F.S. Colliver Collection; Hypotype P61286, G.B. Pritchard Collection.

Type locality. Lower beds, Muddy Creek, i.e., FL82, Clifton Bank, Muddy Creek near Hamilton (Coleraine WD820224). Muddy creek Formation, Balcombian, Middle Miocene.

Stratigraphic range. Balcombian-Bairnsdalian, Middle Miocene.

Occurrence. FL78, Fossil Beach; Griffins (=Retreat Farm), 0.2 km due N of FL80; FL82, Type locality; FL84, 4 miles below Morgan; FL87, Lake Bullenmerri; FL100, Murgheboluc 4A; FL103, downstream section, Gunyoung Creek; FL104, Manyung Rocks.

Material. Types and 20 topotypes.

Comments. Pritchard (1896, 1913) has already pointed out that Tate's speeimen figured as *Voluta lirata* Johnston and subsequently described as *Nannamoria absidata* Cotton, is the same speeies as that which bears the name *Voluta costellifera*. The Muddy Creek population of this species is rather variable in morphology. The ribs may be well or poorly devcloped, and numerous or few, the spire may be low or high and the whorls may or may not be depressed at the posterior suturc. Tate's type of *V. costellifera* is rather wide with a low spire, whereas his speeimen figured as *V. lirata* is morc representative of the population as a whole.

Of reeent speeies this taxon most elosely resembles *Amoria exoptanda* (Reeve) from South Australia. The protoeoneh of the latter is similar, thc spire whorls are depressed at the posterior suture and coneave at the anterior, the juvenile eolour pattern has some similarity and there is a suggestion of obsolete axial costae on thc spire.

Amoria undulata masoni (Tatc)

Plate 6, figures 5, 6, 9

Voluta masoni Tate, 1889b: 128, pl. 3, fig. 9.
Voluta (Amoria) masoni.—Harris, 1897: 110, pl. 4, fig. 14a, b.
Amoria masoni.—Cossmann, 1899: 120, pl. 5, fig. 10,

pl. 6, fig. 7.—Cotton, 1949: pl. 14

Description. Shell smooth, polished, ovate to subpyriform with squat conical spire and ventricose body whorl. Protoconch turbinate, of 3½ whorls, last usually slightly larger than succeeding teleoconch whorl. Spire whorls flat, body whorl flat or slightly concave between posterior suture and shoulder and abruptly contracted anteriorly. Colour pattern of thin, undulose, axial, chestnut bands with apricot coloured apertural glaze.

Dimensions. Lectotype (T385A), L59, HA–, W29; Hypotype (P34263), L69, HA50, W34.

Location of types. South Australian Museum: lectotype T385A (Tate's figured specimen); paralectotypes T385B-H, R. Tate collection. National Museum of Victoria: Hypotype P34263, F.S. Colliver Collection.

Type locality. Upper beds, Muddy Creek, i.e., FL139, Macdonalds bank, Muddy Creek, below Yulecart School (Coleraine WD827219). Grange Burn Formation, Kalimnan, Early Pliocene.

Stratigraphic range. Cheltenhamian, Late Miocene-Kalimnan, Early Pliocene.

Occurrence. FL132, Spring Creek, Minhamite; FL137, Forsythes Bank; FL139, Type locality.

Material. Types and 10 topotypes.

Comments. This subspecies differs from *A. undulata* s.s. by its squat conical spire and more ventricose bodywhorl. These differences are not regarded as being of sufficient magnitude to warrant specific distinction from *A. undulata*. Specimens from Spring Creek Minhamite often show signs of axial costae on the first teleoconch whorl not unlike those found in *A. zebra*.

Amoria undulata undulata (Lamarck)

Plate 6, figures 1–3, 7

Voluta undulata Lamarck, 1804: 157, pl. 12, fig. 1a, b.
Voluta sclateri Cox, 1869: 358, pl. 26, fig. 3.
Voluta kingi Cox, 1871: 76, pl. 4, fig. 2.
Voluta (Amoria) undulata.—Harris, 1897: 109.
Amoria (Amorena) undulata.—Ludbrook, 1953: 145, pl. 17, figs 3, 4 (holotype).
Amoria (Amorena) sclateri.—Ludbrook, 1953: 147, pl. 16, fig.7 (holotype).
Amoria (Amorena) undulata.—McMichael, 1964: 269.
Amoria (Amorena) benthalis McMichael, 1964: 271, pl. 28 lower figs.
Amoria (Amorena) benthalis.—Weaver and du Pont, 1970: 160, pl. 66H, 66I.
Amoria (Amorena) undulata.—Weaver and du Pont, 1970: 161, pl. 71A, 71B, 71C; Figs 33 d, e.

Description. Shell elongate ovate with conical spire. Protoconch of 3½ whorls. Spire whorls slightly concave. Body whorl depressed between posterior suture and shoulder and tapering gently from shoulder to anterior. Siphonal notch deep; siphonal fasciole not prominent.

Dimensions. Hypotype (P34267), L63, HA48, W32; Hypotype (P6593), L80, HA60, W38.

Location of types. Muséum d'Histoire Naturelle, Geneva: Holotype, Lamarck Collection No. 38, coll. F. Peron. National Museum of Victoria: Hypotype P34267, J. Dennant Collection; Hypotype P6593, coll. W. Kershaw.

Stratigraphic range. Late Miocene-Recent.

Occurrence. Fossil. Unnamed formation (Late Miocene), 55 m in bore on R. Hardy's property, Dalmore, FL111, Rose Hill; FL115, SE end of Lake Bunga; FL118, Ritchies Cutting; FL123 North Arm, below Ferndale Parade; FL129, Bentley Sewer; FL130, Beaumaris; FL148, E of Kalimna Jetty; FL149, Road cutting, Jemmys Point; FL151 Nyerimalang Estates Rd, Meringa Creek; FL158, Limestone Creek, Glenelg River. Flinders Is., Tas., Cameron Inlet Formation (Late Pliocene); Dam (58) on lot 47, Furneaux Estate Sect. B, 1.3 km due E of junction of No. 3 and No. 7 Rds (Flinders Is. 994657); spoil heap from North Patriarch dram on Block 6 Furneaux Estate A, 1.1 km from Link Rd (Flinders Is. 914741); Dam (64) on block 22 Furneaux Estate Sect. A, 4.3 km ENE of junction of No. 4 and No. 3 Rds (Flinders Is. 987733). Memana Formation (Early Pleistocene): Dam (5) on block 82, Furneaux Estate Sect. D, 2.6 km NNE of junction of No. 11 and No. 2A Rds (Flinders Is. 912814); Dam (6) on block 88, Furneaux Estate (Sect. D, 2.4 km ENE of junction of No. 11 and No. 2A Rds (Flinders Is. 915809). Roe Plain, WA, Roe Calcarenite (Early Pleistocene): 78 mile pit, N side Eyre Highway, 58.5 km E of Madura (Eucla, 1:250,000 369469); Pit 88 km W of Eucla Motel (Eucla, 1:250,000 406476); Pit 1.5 km N of Hampton Tower (Eucla, 1:250,000 365464).

Comments. This common species has been described in detail by both Ludbrook (1953) and Weaver and du Pont (1970), who have also provided extensive synonymies. However, *Voluta sclateri* Cox and its generally accepted synonym, *V. kingi* Cox, have been included in the author's synonymy, since the author regards these as mere colour variants of *A. undulata*. There are no differences in shell morphology which separate these taxa. *Amoria benthalis* McMichael is also included since it seems to be a dwarfed form of *A. undulata*, found in deep water at the extreme limit of the geographic range of *A. undulata*. Small specimens of the latter from Tasmania match specimens of *A. benthalis*. *Scaphella moslemica* Hedley is also based on a similar deep water form from 450 m off Sydney, as McMichael (1964) has indicated.

Fossil specimens from various localities also exhibit considerable size variation, but there is no systematic pattern, and all fossil populations fall

well within the range of variation of living specimens.

Some specimens from the Jemmys Point Formation, Cameron Inlet Formation, Memana Formation and Roe Calcarenite show colour pattern similar to that on living specimens.

Amoria exoptanda (Reeve)

Plate 29, figures 7, 10

Voluta exoptanda Reeve, 1849: pl. 10, species 22.
G.B. Sowerby II, 1864: 271, pl. 261, fig. 136.
Voluta (Aulica) exoptanda. – Tryon, 1882: 91, pl. 26, fig. 72.
Aulica exoptanda. – Smith, 1912: 36, pl. 14, fig. 100.
Amoria (Amorena) exoptanda. – Weaver and du Pont, 1970: 160, pl. 66 F–G, Fig. 35.
Amoria exoptanda. – Wilson and Gillett, 1971: 124, pl. 81, fig. 5.

Description. Shell large, solid, ovate, with conical spire capped by large conical protoconch. Protoconch of 4 smooth whorls with slight shoulder producing a grooved suture. Teleoconch whorls sometimes slightly depressed at suture. Body whorl massive with prominent shoulder. Siphonal notch wide, siphonal fasciole not prominent. Colour pattern of thin, chestnut, zig-zag lines, closely spaced, covering whole shell, but leaving pale triangular patches.

Dimensions. Hypotype (WAM 79.394a) 188, HA65, W41.

Location of types. British Museum (Natural History): Holotype 1952.3.21.3, W.R. Crotch collection. Western Australian Museum: Hypotype 79.394a, coll. V.A Ryland, G.W. and W.E. Kendrick 5–13 Aug 1978.

Type locality. Port Lincoln, South Australia.

Stratigraphic range. Pleistocene–Recent.

Occurrence. Fossil, Roe Plain, WA, Roe Calcarenite: Foundation holes for Hampton Microwave Repeater Tower (Eucla, 1:250,000 365462); Pit 1.5 km N of Hampton Tower (Eucla, 1:250,000 365464).
Living, Esperance, WA–Encounter Bay, SA.

Material. 4 fossil and 5 living specimens.

Comments. This species is distinguished by its massive shell and large conical protoconch. Living specimens are quite rare and, hitherto, it has not been recorded as a fossil. The hypotype bears traces of the colour pattern typical of living specimens.

Amoria sp.

Comments. A single, poorly preserved and fragmentary specimen is available from the Middle Miocene, Trealla Limestone at Geological Survey of Western Australia locality 30055 on the E flank of Cape Range, Grid Ref. Onslow (1:250,000) 185260.

The specimen is a typical smooth *Amoria* but the preservation prevents any detailed comparison with any described species of the genus. It is mentioned here as the occurrence represents the oldest record of the genus in North Western Australia, equivalent in age to the oldest record for the south east of the continent.

Nannamoria Iredale, 1929

Nannamoria Iredale, 1929: 181. – Cotton and Godfrey, 1932: 48.
Amoria (Nannamoria). – Wenz, 1943: 1339.
Nannamoria. – McMichael, 1960: 11.
Paramoria McMichael, 1960: 12 (Type species (original designation): *Voluta gunthari* Smith, 1886).
Nannamoria. – Weaver and du Pont, 1970: 170.
Paramoria. – Weaver and du Pont, 1970: 165.

Type species. Original designation: *Nannamoria amicula* Iredale, 1929. Recent, New South Wales.

Description. Shell solid, small to medium size, usually shouldered with subconical to gradate spire though spire often concealed by body whorl. Protoconch dome-shaped to pupiform, of $2\frac{1}{2}$–$3\frac{1}{2}$ smooth, convex whorls, coiled with axis of shell. Spiral sculpture poorly if at all developed. Axial sculpture generally well developed and consisting either of strong costae, usually spinose on shoulder, or of nodules which can be strongly or weakly developed. Aperture narrow, elongate, frequently slitlike. Outer lip slightly thickened. Columella with 4 strong plaits and often with 1 or more weaker plaits inserted between others. Siphonal notch usually scarcely developed; siphonal fasciole present but usually poorly developed.

Stratigraphic range. Late Oligocene–Recent.
Distribution. Southern Australia. Central Queensland–New South Wales (Recent); Victoria (Late Oligocene–Late Miocene); Tasmania (Early Miocene, Late Pliocene); South Australia (Middle Miocene–Recent); Western Australia, south Coast (Pleistocene, Recent), west coast (Recent). 40–250 metres.

Comments. The relationships of the genus are with *Amoria*. The shell characters suggest affinity with *Notovoluta* and *Amoria* on the one hand and *Cymbiola* on the other. The anterior digestive system and radula of *N. strophodon gunthari* (Smith) have been examined by the author and no significant differences from species of *Amoria* were found. However the author (Darragh, 1979) has also examined the animals of *N. amicula* Iredale, the type species of the genus, and *N. inopinata* and

notes that whilst the anterior digestive system of both is similar to *N. strophodon guntheri*, the radulae are the typical uniserial tricuspid radulae found in many other volutes, e.g. in species of *Cymbiola*, rather than the Y-shaped radula of *Amoria*. Unfortunately the radula of *N. parabola* Garrard, which is closely related to *N. amicula*, is not known and it is not possible to determine whether this difference in radula is significant. In the genus *Scaphella* the radula morphology is quite variable within the various species, and it seems that *Nannamoria* presents a similar case, as there are no other features of the anatomy of *N. strophodon guntheri* and *N. amicula* which seem to differ. McMichael (1960) separated *Paramoria* and *Nannamoria* on the grounds that the former had a wide rather than slitlike aperture which was not produced posteriorly as in the latter, and by having four rather than several columella plaits and a larger protoconch. He further stated that the two had a distant common ancestry in the Tertiary. A study of the fossils shows that the above shell features not only vary considerably from species to species, but also from individual to individual within a species. In addition, some species such as *N. weldii* (Tenison Woods) can be readily placed in either *Paramoria* or *Nannamoria* as defined, depending on the particular specimen examined. Thus the author prefers to regard the two taxa as synonyms until further anatomical work proves otherwise.

Nothwithstanding the foregoing, three informal species groupings can be recognised, consisting of species lineages and taxa closely related to species within lineages. They are the group of *N. strophodon*, *N. weldii* and *N. ralphi* respectively and each group has at least one living representative. The species are described below in these groups.

The oldest known species of the genus is *N. weldii* (Tenison Woods) from the late Oligocene of Victoria and there is no known ancestral form in Australia. On the basis of shell characters and anatomy the genus may be derived from the early ancestors of *Cymbiola*.

Group One

Nannamoria stolida (Johnston)

Plate 7, figures 12–15
Plate 9, figures 2, 3

Voluta stolida Johnston, 1880: 36. – Johnston, 1888: pl. 30, figs 4, 4a.

Voluta strophodon var. *stolida*. – Pritchard, 1896: 94. – Pritchard, 1913: 194.

Paramoria stolida. – Ludbrook, 1967: 68, pl. 3, figs 9, 10.

Description. Shell ventricose with short, blunt, gradate spire. Protoconch slightly shouldered, smooth, of about 2½–3 rather swollen whorls which merge imperceptibly with teleconch whorls. Shoulder of whorls prominent, concave and smooth. First teleoconch whorl smooth, second and third with prominent spinose axial costae. Body whorl with 11–13 spinose axial costae which fade out anteriorly about half-way down whorl. Siphonal notch broad and shallow; siphonal fasciole moderately developed. Colour pattern of thin numerous close set axial stripes.

Dimensions. Holotype (Z186), L 53, HA 36, W 29; Hypotype (P32910), L 53, HA 39, W 31; P2534, L 57, HA 44, W 32.

Location of types. Tasmanian Museum: Holotype Z186 R.M. Johnston Collection. National Museum of Victoria: Hypotype P32910, J. Dennant collection. Hypotype P2534, L.D. Atkinson Collection.

Type locality. "Table Cape". The preservation of the holotype indicates that it came from the lower bed, i.e., TL28, Lower bed in the cliff between Fossil Bluff and 1.5 km NW towards Table Cape, Wynyard, (Table Cape 930630). Freestone Cove Sandstone, Janjukian.

Stratigraphic range. Janjukian, Early Miocene.

Occurrence. Type locality only.

Material. Holotype and 7 topotypes.

Comments. This species is probably ancestral to *N. strophodon* (McCoy) and is distinguished from it by its more ventricose appearance. The great swollen protoconch and overall appearance are similar to species of *Cymbiola*, but it lacks the prominent fasciole and deep siphonal notch present in species of *Cymbiola*.

Nannamoria strophodon strophodon (McCoy)

Plate 8, figures 1, 4, 5, 6, 9, 11

Voluta strophodon McCoy, 1876: 25, pl. 37, figs 2, 3, 4, 4a–c. – Tate, 1889b: 134.

Voluta (Aulica) strophodon. – Harris, 1897: 101, pl. 4, figs 11a, b.

Vespertilio weldi. – Cossmann, 1899: 118, pl. 4, fig. 23, pl. 6, fig. 8.

Voluta strophodon var. *brevispira* Pritchard, 1913: 194 (non Doncieaux, 1908).

Voluta strophodon var. *longispira* Pritchard, 1913: 194.

Cymbiola strophodon. – Cotton, 1949: pl. 15.

Notovoluta tabulata. – Cotton, 1949: pl. 14 (non Tate, 1888).

Cymbiola (Cymbiola) tabulata. – Ludbrook, 1958: 74, pl. 6, fig. 2 (non Tate, 1888).

Description. Shell ovate to biconic with low, blunt, conical to gradate spire. Protoconch low, dome-shaped, of about 3 smooth whorls with impressed suture. Shoulder of teleconch whorls prominent and bearing 10–13 spinose tubercles on body whorl. Body whorl tapering gently to anterior. Columella with 4 plaits and often with well developed tubercle posterior to plaits. Siphonal notch shallow, siphonal fasciole present. Colour pattern of thin, close set, wavy, axial chestnut lines.

Dimensions. Holotype (P12154),L31, HA21, W16 (fig. 3 in McCoy, 1876, pl. 37); Paratype (P26388), L40, HA25, W19 (figs 4, 4b); Paratype (P26389), L40, HA26, W20 (figs 4a, c); Paratype (P12153), L32, HA25, W20 (fig. 2).

Location of types. National Museum of Victoria: Holotype P12154, coll. R. Daintree, Apr 1861; Paratype P26388, Paratype P26389, coll. R. Daintree, Aug 1861; Paratype P12153, Geological Survey of Victoria collection. McCoy's indication that fig. 3 was the average specimen and that the others figured were the conoidal and long-spired varieties is taken as designation of the holotype.

Type locality. FL38, Geological Survey of Victoria locality Ad 14, Section 24, block 1, Parish of Moolap, 2.4 km N of Curlewis railway crossing (Portarlington 823733). Fyansford Formation, Batesfordian.

Stratigraphic range. Batesfordian, Early Miocene–Yatalan, Late Pliocene.

Occurrence. FL38, Type locality; FL40, Belmont Shaft; FL47, Kennedys Creek; Fl48, Boornong Rd; FL67, 3.4 km NW of Point Ronald; FL69, Red Bluff, Shelford; FL71, SW of Glenleigh; FL72, Fyansford; FL74, Junction Rd. caisson shaft; FL77, Altona Bay Coal Shaft; FL78, Fossil Beach; FL82, Clifton Bank; FL84, 4 miles below Morgan; FL87, Lake Bullenmerri; FL88, NW end of Gibson Beach; FL89, VAL Quarry, Curdies; Fl 93, Rutledges Beach; FL97, Murgheboluc 2B; FL100, Murgheboluc 4A; FL103, downstream section Gunyoung Creek; FL104, Manyung Rocks; ? FL132, Spring Creek, Minhamite.

SA, Bookpurnong Beds, Cheltenhamian: Mindarie Well, S.A. Dry Creek Sands, Yatalan: Abattoires Bore; Observation Bore A, Virginia, Hd of Munno Para sec 3036, 63.7–66.1 m; H.K. Weymouths bore, 1935, Sec 2271, Hd of Yatala 94.5–99 m; Kooyonga bore no. 1, 1932, Hd of Adelaide, Sec. 2028, 119–146 m; F. Virgin bore, Mar 1958, Hd of Munno Para Sec. 3224 103–107 m; DeRuro bore, Waterloo Corner, Hd of Munno Para, Sec. 4259, 73.2–74.7 m; Jones bore, 1934, Bolivar, Hd of Port Adelaide, Sec. 3502, 106 m.

Material. Types, 2 topotypes and numerous other specimens.

Comments. This species exhibits considerable morphological variation from locality to locality, as is the case with many species of volute. Generally the Batesfordian and Bairnsdalian populations have lower spires than those of the Balcombian, but there is so much variation within these populations and others that Pritchard's names *brevispira* and *longispira* are not used subspecifically. Specimens from the Dry Creek Sands tend to have less gradate spires and larger and more sloping shoulders however, these features are not considered distinct enough to warrant subspecific separation of this population, particularly in view of the variation mentioned above. It seems probable that the living populations of *N. guntheri* (Smith) and *N. weaveri* (McMichael) also fall within the range of variation of *N. strophodon* but there is insufficient living material available at present to check this possibility. For the time being *N. weaveri* is regarded as a synonym of *N. guntheri* which is relegated to the status of a subspecies of *N. strophodon*. Of interest is the fact that the colour pattern of *N. strophodon* observed in Dry Creek Sands specimens and a single specimen from Muddy Creek is similar to that present in *N. guntheri*.

Nannamoria strophodon guntheri (E.A. Smith)

Plate 10, figure 4
Figure 13

Voluta guntheri E.A. Smith, 1886: 62. – G.B. Sowerby III, 1887: 302, pl. 17, figs 162, 163, holotype, Western Australia.

Voluta adcocki Tate, 1889a: 64, pl. 11, fig.

Paramoria guntheri. – McMichael, 1960: 11, pl. 1, fig. 5. – McMichael, 1961: pl. 5, lower figs.

Paramoria weaveri McMichael, 1961: 55, pl. 5, upper figs.

Paramoria guntheri guntheri. – Weaver and du Pont, 1970: 165, pl. 72A, B, C.

Paramoria guntheri weaveri. – Weaver and du Pont, 1970: 167, pl. 72D, E.

Comments. This species is the type of the genus *Paramoria* McMichael, 1960 and the reasons for placing the latter in the synonomy of *Nannamoria* have been discussed above. *Voluta adcocki* and *Paramoria weaveri* are regarded as being mere colour forms of the same species and accordingly are included in the above synonomy. Attention has been drawn above to the fact that the differences in morphology between *N. guntheri* and *N. strophodon* are slight, and for this reason the former has been relegated to the status of a subspecies of the latter.

The range of this taxon is from Houtman Abrolhos Islands, Western Australia to Encounter Bay, South Australia.

Nannamoria amplexa sp. nov.

Plate 7, figures 2, 3, 6
Plate 9, figures 9, 12
Plate 10, figure 12

Description. Shell biconical with low spire. Protoconch dome-shaped of 3½ smooth whorls, the last of which is partly hidden by first teleoconch whorl. Teleoconch whorls occasionally encroaching on previous whorls. Spire whorls convex at posterior suture and concave medially, usually axially costate and with row of spinose tubercles at anterior suture. Body whorl with prominent narrow shoulder, convex at suture and concave medially. Spiral sculpture absent. Axial sculpture on body whorl of 14–18 thin, poorly developed, irregularly spaced costae which extend from suture to fasciole and developed into spinose nodes on shoulder. Columella with 4 strong plaits. Siphonal notch shallow, siphonal fasciole weak and bordered posteriorly by thin, weak ridge.

Dimensions. Holotype (P33069), L 37, HA29, W19; Paratype (P33071), L 36, Ha27, W20; Paratype (P33072), L 31, HA23, W19.

Location of types. National Museum of Victoria, Holotype P33069, Paratype P33071, Paratype P33072, coll. Mrs Coralie Griffiths, 1972–1973

Type locality. FI 123, Below high tide level, North Arm below Ferndale Parade, Lakes Entrance (Bairnsdale 867075). Jemmys Point Formation, Cheltenhamian.

Stratigraphic range. Mitchellian Cheltenhamian, Late Miocene.

Occurrence. Upper quarry, Bellevue, left bank, Mitchell River; FI 116, Ditch near L.E.D. No. 1 Bore; FI 124, North Arm, north side, Hunter Gully.

Material. Types, 4 topotypes, and 3 other specimens.

Comments. This species is closely related to *N. strophodon*, but differs from the low spired specimens of that species by having weakly spinose nodules and weaker ribs which tend to cover the whole of the spire and body whorl. The fasciole is also bounded posteriorly by a weak ridge, which is a feature usually not well developed in *N. strophodon*.

Nannamoria lundelinsae Ludbrook

Plate 29, figures 8, 9
Plate 30, figures 5, 6

Nannamoria lundelinsae Ludbrook, 1978: 165, pl. 18, figs 20, 21.

Description. Shell elongate ovate with subconical spire. Protoconch subconical of 3 smooth whorls. Spire whorls with weakly developed shoulder, usually with axial sculpture but occasionally with low obsolete plicae. Body whorl gently tapering anteriorly from shoulder. Aperture narrow and elongate. Columella with 4 strong plaits. Siphonal notch deep; siphonal fasciole weakly developed. Colour pattern of thin, widely spaced, chestnut axial lines with 3 narrow spiral bands at suture, posterior and anterior third of body whorl.

Dimensions. Holotype (GSSA M2521) L 48, HA31, W18; Paratype (WAM 72.26) L 38, HA27, W16; Hypotype (WAM 76.2389a) L 43, HA28, W18.

Location of types. Geological Survey of South Australia: Holotype M2521, Paratypes M3253. Geological Survey of Western Australia: Paratypes F6942, 7084. Western Australian Museum: Paratypes WAM 62.49, 66.622, 72.26, Hypotype WAM 76.2389a.

Type locality. Locality 4434-FI 9, 64 km E of Madura (Eucla 575054), 31°53'42"S, 127°41'30"E. Roe Calcarenite, Early Pleistocene.

Stratigraphic range. Roe Calcarenite.

Occurrence. Roe Calcarenite, various borrow pits along Eyre Highway and foundation holes for Hampton Microwave Tower, Roe Plain, Western Australia.

Material. 22 specimens.

Comments. On first glance this species could be placed in *Amoria* but because of the occasional presence of axial sculpture and the similarity of colour pattern to *N. strophodon* and *N. guntheri* it has been placed in *Nannamoria*. This species demonstrates the close affinity between *Amoria* and *Nannamoria*.

Group Two

Nannamoria weldii (Tenison Woods)

Plate 7, figures 5, 7
Plate 10, figures 1, 2

Voluta weldii Tenison Woods, 1876: 24, fig. 2. – Johnston, 1888: pl. 30, figs 6, 6a, b, 7. – Tate, 1889b: 134. – Pritchard, 1896: 93.

Voluta (Aulica) weldi (sic). – Harris, 1897: 102.

Voluta weldii. – Pritchard, 1913: 193, pl. 20, fig. 1.

Voluta weldii var. *angustior* Pritchard, 1913: 194, pl. 20, figs 4, 5.

Cymbiola weldii. – Cotton, 1949: 189, pl. 14.

Paramoria weldi. – Ludbrook, 1967: 68, pl. 3, figs 1, 2.

Description. Shell ventricose, elongate-ovate, occasionally biconical with elongate subconical spire. Protoconch smooth, dome-shaped, of 3 whorls. Spire whorls sometimes with weakly developed shoulder, but often without and bearing row of weakly developed tubercles against anterior suture

which become stronger towards body whorl. Body whorl bearing 8–10 prominent elongate tubercles on posterior third of whorl and narrowing rapidly and regularly anteriorly. Canal slightly reflexed dorsally; siphonal notch weak, siphonal fasciole well developed.

Dimensions. Holotype (Z191), L39, HA23, W23 (Upper bed); Hypotype (MUGD 1792), L40, HA22, W21 (Upper bed, Pritchard, 1913, pl. 20, fig. 1); MUGD 1794, L28, HA17, W13 (Lower bed, Pritchard, 1913, pl. 20, figs 4, 5).

Location of types. Tasmanian Museum: Holotype Z191. Melbourne University Geology Department: Hypotype MUGD 1792, Holotype of var. *angustior* MUGD 1794, G.B. Pritchard Collection.

Type locality. "Table Cape". The preservation of the holotype and the matrix inside its aperture indicates that it came from the upper bed, FL29, Fossil Bluff Sandstone in cliff between Fossil Bluff and 1.5 km NW towards Table Cape, Wynyard, Tas (Table Cape 930630). Janjukian, Lake Miocene.

Stratigraphic range. Janjukian, Late Oligocene–Longfordian, Early Miocene.

Occurrence. FL24, *Chione* beds opposite Bird Rock; FL28, Lower bed, Table Cape; FL29, Type locality; FL32, SW end of Jan Juc Beach; FL33, Birregurra.

Material. Holotype and 30 topotypes.

Comments. The narrow spire, prominent elongate nodules and biconical appearance distinguish this species from others in the genus. Specimens from the type locality are all of the typical ventricose biconical form, whereas those from the underlying "lower bed" tend to be more variable in morphology, with a narrow form the "var. *angustata* Pritchard" the most common. As a whole the population of the "lower bed" has more depressed and slightly larger protoconchs.

Nannamoria fasciculata sp. nov.

Plate 7, figure 10
Plate 10, figures 9, 11

Description. Shell elongate with subgradate spire and grooved sutures. Protoconch as in *N. weldii*. First teleoconch whorl flat, subsequent whorls with oblique shoulder. Spiral sculpture absent. Axial sculpture of spire of numerous irregularly spaced thin costae, which on shoulder are produced into small sharp nodes. On penultimate and final whorls costae become shorter and regularly spaced and on last half whorl reduced to spinose nodules or spinose plicae.

Dimensions. Holotype (P32915), L42, HA26, W17; Paratype (P32916), L40, HA24, W16; P32914, L45, HA27, W17.

Location of types. National Museum of Victoria: Holotype P32915, Paratype P32916, coll. T.A. Darragh and H.E. Wilkinson, 4 Dec 1968 and 14 Dec 1967 resp.

Type locality. FL35, cliff section SE of Fischers Point about 10 m above Lake Craven, Hordern Vale (Princetown 155040). Fishing Point Marl (lower mollusc horizon), Longfordian.

Stratigraphic range. Longfordian, Early Miocene.

Occurrence. FL34, Lake Costin, FL35, Type locality; FL36, Red Hill, Hordern Vale.

Material. Types 11 topotypes and 7 other specimens.

Comments. The numerous irregularly spaced costae and the high subgradate spire distinguish this species from other in the genus. It has evolved from *N. weldii* as specimens of the latter from Birregurra, a locality on a slightly older horizon, tend to have a similar sculpture but lack the high subgradate spire.

Nannamoria trionyma sp. nov.

Plate 11, figures 1, 4, 6, 7

Voluta weldii var. *intermedia* Pritchard, 1913: 194, pl. 20, figs 2, 3 (non Lahille, 1895: 304).

Description. Shell ovately elongate with low subgradate spire. Protoconch flat but with papillary nucleus. First teleoconch whorl bearing numerous axial plicae, which on second whorl develop into pointed trihedral nodules, of which there are 8–13 on body whorl and which fade out towards aperture. Spiral sculpture absent. Siphonal notch shallow; siphonal fasciole weakly developed.

Dimensions. Holotype (P32920), L36, HA23, W16; Paratype (P32918), L34, HA21, W16.

Location of types. National Museum of Victoria: Holotype P32920, F.S. Colliver Collection, Paratype P32918, coll. T.A. Darragh, 22 Oct 1971. Geology Department, University of Melbourne: Holotype of *Voluta weldii* var. *intermedia* MUGD 1793 G.B. Pritchard collection.

Type locality. FL82. Clifton Bank, Muddy Creek, 7 km W of Hamilton (Coleraine WD825219). Muddy Creek Formation, Balcombian.

Stratigraphic range. Balcombian, Middle Miocene.

Occurrence. FL69, Red Hill, Shelford; FL77, Altona Bay Coal Shaft; FL78 Fossil Beach; FL82, Type locality; FL84, 4 miles below Morgan.

Material. Types and 18 topotypes.

Comments. As Pritchard's varietial name is preoccupied by *Voluta colocynthus intermedia* Lahille, 1895 the taxon has been redescribed. It is derived from *N. weldii* and differs from it by having more numerous tubercles which tend to be subspinose,

and by having a squatter spire. *N. weldii* tends to be biconical in appearance whereas *N. trionyma* tends to be ovate.

Nannamora paraboloides sp. nov.

Plate 9, figures 6, 7
Plate 10, figures 7, 8
Plate 11, figures 2, 3

Description. Shell ovate with low subconical spire. Protoconch pupiform of 2½–3 smooth convex whorls. Whorls slightly to prominently shouldered, concave posterior to shoulder. Anterior whorls almost overlapping shoulder so that anterior whorl slope of spire is much reduced or even absent. Sculpture of low nodes or axial plicae on shoulder which vary in strength and generally fade out towards aperture. Usually 10–12 nodes present on body whorl. Columella with 4 strong plaits. Siphonal notch deep; siphonal fasciole well marked. Canal slightly reflexed dorsally. Traces of colour pattern present consisting of triangular tent-like markings.

Dimensions. Holotype (P33077), L29, HA21, W14; Paratype (P33079), L28, HA20, W15; Paratype (P52308), L 42, HA30, W25.

Location of types. National Museum of Victoria: Holotype P33077, coll. T.A. Darragh and M. Waldman, 1967. Paratype P33079, coll. T.A. Darragh, D.M. Shanks and H.E. Wilkinson, 6 Feb 1969. Paratype P52308, coll. T.A. Darragh, 14 Feb 1978.

Type locality. FL132, bed of Spring Creek below "tuff" band, 0.8 km NE of Spring Creek Homestead, Minhamite (Hawkesdale 367129).

Stratigraphic range. Cheltenhamian, Late Miocene–Late Pliocene.

Occurrence. FL111, Rose Hill; FL132, Type locality; FL141, SW side, Bunga Creek, FL142, bed 6g, NE side Bunga Creek; FL151, Nyerimalang Estates Rd, Meringa Creek; Tas, Cameron Inlet Formation (Late Pliocene); PL1234, Dam an addition to Lot 37, Memana; PL1258, Dam on lot 47, Memana; PL1264, Dam on lot 22, Memana; PL1265, Dam on lot 22, Memana; PL 1268, Patriarch drain at Block 6, Memana. Jemmys Point Formation (Cheltenhamian): 175–185 ft Tanjil Point Addis No. 2 Bore.

Material. Types, 4 topotypes and numerous specimens from Flinders Is.

Comments. In general outline this species resembles *N. parabola* Garrard but the generally feeble sculpture and subconical spire distinguish it from that species.

Nannamoria amicula Iredale

Figure 14

Nannamoria amicula Iredale, 1929: 181, pl. 40, fig. 4. – Weaver and du Pont, 1970: 170, pl. 73A and B. – Wilson and Gillett, 1971: 132, Fig. 26 (holotype).

Comments. Weaver and du Pont (1970) have given good figures and descriptions of this and the following species. *N. amicula* ranges from southern to northern New South Wales.

Nannamoria parabola Garrard

Nannamoria parabola Garrard, 1960: 3, pl. 1, figs 1A, 1B.
Nannamoria parabola. – Weaver and du Pont, 1970: 171, pl. 73F, F.

Comments. The species is restricted to vicinity of Moreton Island, southern Queensland.

Group Three

Nannamoria deplexa sp. nov.

Plate 7, figures 1, 4
Plate 10, figures 5, 6
Plate 11, figures 5, 8

Description. Shell pyriform, ventricose with low blunt spire. Protoconch of 2½–3 whorls, somewhat flattened and with papillary nucleus; last whorl of protoconch and first teleoconch whorl enveloped by succeeding whorls. Spire whorls inflated. Body whorl inflated against suture and tapering rapidly to anterior. Spiral sculpture of microscopic close-set wavy grooves confined to spire and posterior quarter of body whorl. Aperture long and narrow. Columella covered with thin glaze and bearing 4 strong plaits and rarely 1 or 2 weaker plaits inserted between others. Siphonal notch and siphonal fasciole barely developed.

Dimensions. Holotype (P32922), L32, HA23, W15; Paratype (P32923), L 32, HA21, W17; Paratype (P32924), L27, HA20, W16.

Location of types. National Museum of Victoria: Holotype P32922, Paratype P32923, Paratype P32924, coll. T.A. Darragh and H.E. Wilkinson, 27 Dec 1969.

Type locality. FL48, Cutting on Boornong (= Steen) Rd, 2.1 km N of Cooriemungle Rd, Cooriemungle (Princetown 810337) Gellibrand Marl, Batesfordian.

Stratigraphic range. Batesfordian, Early Miocene.

Occurrence. FL39, Ad 12, Curlewis; FL40, Belmont Shaft; FL41 Amphitheatre; FL42, Yarrowee R, S of Amphitheatre; FL47, Kennedys Creek Cutting; FL48, Type locality; FL50, Fischers Point, FL51 Devils Den, Glenelg R; PL3163, Williams Rd, Cowleys Creek.

Material. Types and 22 topotypes.

Comments. This species is ancestral to *N. ralphi* (Finlay) and differs in having a more ventricose body whorl and a less prominent spire, the protoconch also is not pupiform but low and broad and there are rarely any visible nodulae on the body whorl as in *N. ralphi*.

Nannamoria ralphi (Finlay)

Plate 9, figures 1, 4, 5, 8
Plate 10, figure 3

Voluta (Volutoconus) conoidea Tate, 1888: 176, pl. 13, fig. 9 (non Renier, 1804).
Voluta conoidea. – Tate, 1889b: 125 (description).
Voluta (Volutoconus) conoidea. – Harris, 1897: 107, pl. 4, figs 13a, b.
Volutoconus conoideus. – Cossmann, 1899: 131, pl. 7, fig. 3.
Volutoconus ralphi Finlay, 1930: 44. – Cotton, 1949: pl. 15.

Description. Shell biconic with moderately short, blunt spire. Protoconch as in *N. limbata*. Spire whorls partly concealed by suceeding whorls. Body whorl bearing 5–7 low nodules at posterior third, but these frequently absent. Posterior whorl slope sculptured as in *N. limbata*. Aperture long and narrow. Siphonal notch and siphonal fasciole barely developed.

Dimensions. Holotype (T588A), L44, HA30, W21; Hypotype (P33074), L36, HA27, W16; Hypotype (P33076), L35, HA26, W16.

Location of types. South Australian Museum: Holotype T588A, R.Tate Collection. National Museum of Victoria: Hypotype P33074, Mrs M. Robertson Collection; Hypotype P33076, G.B. Pritchard Collection.

Type locality. Lower beds, Muddy Creek, i.e., FL82 Clifton Bank, Muddy Creek, near Hamilton (Coleraine WD820224). Muddy Creek Formation, Balcombian.

Stratigraphic range. Balcombian, Middle Micoene.

Occurrence. FL72, Fyansford; FL77, Altona Bay coal shaft; FL82, Type locality.

Material. Holotype and 17 topotypes.

Comments. This taxon is derived from *N. deplexa* sp. nov. and is ancestral to *N. limbata* (Tate). Compared with the latter it has fewer nodules, is not as variable in morphology and has no lamellar extensions covering the suture of the spire whorls. It has been compared with *N. deplexa* under the description of that taxon.

Traditionally, this taxon and *N. limbata* have been placed in the genus *Volutoconus*, however the species in that genus have deep narrow siphonal notches, prominent siphonal fascioles and multispiral, ribbed, planorbid protoconchs with an exert tip.

Nannamoria limbata (Tate)

Plate 7, figures 8, 9, 11
Plate 9, figures 10, 11
Figure 12

Voluta (Volutoconus) limbata Tate, 1888: 176, pl. 13, fig. 8 (figure).
Voluta limbata. – Tate, 1889b: 125 (description).
Volutoconus limbata. – Cotton, 1949: pl. 15.

Description. Shell usually subcylindrical with short and often concealed spire, occasionally elongate biconic with high conical spire. Protoconch pupiform of 2½–3 whorls, last of which axially costulate and usually covered by lamella extension of following teleoconch whorl. Sutures and spire generally concealed by lamella extension of final or penultimate whorl. Body whorl gently convex and bearing at posterior third row of 6–10 weak nodules which tend to fade in strength towards aperture. Posterior whorl slope sculptured with numerous, close-set spiral grooves. Aperture narrowly elongate. Columella covered with thick glaze and bearing 4 strong and rarely 1 or 2 other weaker plaits inserted between others. Siphonal notch barely developed; siphonal fasciole present but not prominent. Visible colour pattern of 4 thick, alternate light and dark spiral bands.

Dimensions. Holotype (T590A), L33, HA23, W16; Hypotype (P33086), L42, HA36, W18; Hypotype (P33088), L39, HA26, W17.

Location of types. South Australian Museum: Holotype T590A, R. Tate Collection. National Museum of Victoria: Hypotype P33086, Hypotype P33088, F.A. Cudmore Collection.

Type locality. "Schnapper Point". As no specimens of this species have been found at Fossil Beach 3.2 km S of Schnapper Point, Mornington, Tate's type must have been collected from exposures of Balcombe Clay in the vicinity of Gunyoung (Grices) Creek, 3.2 km NE of Schnapper Point. The preservation of the holotype including the presence of colour bands, is typically that found in specimens from Gunyoung Creek or Manyung Rocks. Accordingly, the latter locality is herein designated the type locality. Cliff section immediately south of Manyung Rocks and N of the jetty and sewer pipe, bed 10Ba (Western Port 309712). Upper Balcombe Clay, Bairnsdale.

Stratigraphic range. Bairnsdalian.

Occurrence. FL87, Lake Bullenmerri, FL88, NW end of Gibson Beach; FL89, Curdies; FL93, Rutledges Beach; FL96 Leigh River due north of Inverleigh; FL103,

Lower-Upper beds Grices Creek; FL104 type locality. Leigh R at Inverleigh bridge; Grange Burn 1.2 km above Hentys.

Material. Holotype and 13 topotypes.

Comments. This is an exceedingly variable species. Specimens from Lake Bullenmerri generally have high spires and prominent nodulose shoulders, but other members of this population are similar to those found at the type locality. The colour bands preserved in some specimens are similarly placed to those found in *N. parabola* Garrard and *N. inopinata* Darragh.

Nannamoria cinctuta sp. nov.

Plate 11, figures 9–12

Description. Shell obconical with low and rapidly tapering spire. Protoconch pupiform of 2½–3 smooth whorls. Spire whorls almost covered by succeeding whorls. Suture somewhat channelled. Body whorl convex and tapering gently anteriorly. Spiral sculpture absent. Axial sculpture of weak plicae on spire and low elongate nodules sometimes present on body whorl. Columella with 4 strong plaits.

Dimensions. Holotype (P33081), L48, HA34, W23; Paratype (P33082), L47, HA36, W24.

Location of types. National Museum of Victoria: Holotype P33081, Paratype P33082, coll. T.A. Darragh, D.M. Shanks and H.E. Wilkinson, 10 Feb 1969.

Type locality. Tas, PL 1264, Dam on Block 22 (Lees), Furneaux Sect. A, 4.4 km ENE of junction of No. 4 and No. 3 Roads, Memana (Flinders Is. 987733). Cameron Inlet Formation, Late Pliocene.

Stratigraphic range. Late Pliocene.

Occurrence. Type locality only.

Material. Types and 6 topotypes.

Comments. This species resembles *N. ralphi* but has flat rather than prominently convex spire whorls and a low rather insignificant spire. *N. limbata* has prominent spiral sculpture and the body whorl is not as ventricose.

Nannamoria capricornea (Wilson)

Plate 8, figures 2, 3, 10

Volutoconus capricorneus Wilson, 1972: 346, pl. 31, figs 9–12.

Comments. Wilson (1972) has given a good description and figure of this species and discussed its affinities in detail. He assigned it provisionally to *Volutoconus* because of its close resemblance to *Nannamoria limbata* and *N. ralphi*, which were at that time regarded as species of *Volutoconus*. The writer regards these latter as species of *Nannamoria* and accordingly, after examination of the paratype, also places *V. capricorneus* in that genus. Of the two fossils mentioned above the living species most closely resembles *N. ralphi* but differs in having a wider and blunter spire and is ovate in outline rather than biconical as in *N. ralphi*. Neither the radula nor anatomy of this species is yet known, so it is not possible to confirm its relationship with the other living species of *Nannamoria*.

Nannamoria inopinata Darragh

Plate 27, figures 12, 13

Nannamoria inopinata Darragh, 1979: 133, figs 1–3, 5, 6, 12.

Description. Shell biconic to subcylindrical with short, blunt, almost domelike spire. Protoconch of 3 dome-like whorls, coiled in axis of spire. Spire whorls convex, partly concealed by overlapping of succeeding whorls and occasionally bearing small spinose nodules at anterior suture. Body whorl gently convex and tapering anteriorly, bearing at posterior quarter row of 8–10 blunt to subspinose nodules. Spiral and axial sculpture absent. Columella with 5 strong plaits and 3 or 4 other weaker plaits inserted between others. Siphonal notch and fasciole barely developed. Colour pattern of numerous thin, anastomosing, axial, chestnut lines, over whole shell, and on body whorl 2 dark reddish bands at posterior and anterior third of whorl.

Animal very similar to that of *N. amicula*. Foot broad, flat, entire; siphonal appendages short, paired and equal; tubular salivary gland of digestive system, short, paired and easily separated from racemose salivary gland. Radula uniserial, tricuspid with central tooth the larger.

Dimensions. Holotype (C108644a), L48, HA41, W20; Paratype (C108644b), L39, HA–, W17; Paratype (C109012), L40, HA34, W17.

Location of types. Australian Museum: Holotype C108644a, Paratype C108644b, coll. W.F. Ponder, I. Loch and P. Terrill, 14 Dec 1977; Paratype C109012, coll. P. Colman and F. Rowe, 17 Nov 1977.

Type locality. Capricorn Channel, 42 km NE of Lady Musgrave Is, Queensland (23°38.8′S, 152°45.5′E), 365 m, 1977 HMAS "Kimbla" Cruise Station 24, 14 Dec 1977.

Occurrence. 40 km E of Lady Musgrave Is, Qld (24°44′S, 152°49′E), 348–357 m, shelly grey ooze, 1977 HMAS "Kimbla" Cruise Station 2, 17 Nov 1977. 39 km E of Lady Musgrave Is, Qld (23°33.7′S, 152°37′E), 348–339 m, 1977 HMAS "Kimbla" Cruise Station 3, 17 Nov 1977. E of North West Is, Capricon Channel, QLD (23°19.5′S, 152°35.4′E), 320 m, globigerine mud, 1977 HMAS

"Kimbla" Cruise Station 23, 14 Dec 1977.

Material. Types, 2 adults and 4 juvenile specimens and 6 fragments.

Comments. This species most closely resembles the Middle Miocene *N. limbata* (Tate) from Victoria from which it differs by the dome-like, rather than pupiform protoconch, by the complete absence of spiral sculpture and the lack of lamella extension of the posterior part of the whorls, typical of the latter. From *N. ralphi* (Finlay) it differs by its more slender and elongate shape and relatively low spire. The dark spiral bands of the colour pattern are somewhat similar to those preserved on *N. limbata.* Neither *N. ralphi* nor N. limbata have the subspinose nodules as sharply developed as in *N. inopinata.* Of the living species of the genus, *N. parabola* Garrard from Southern Queensland and Northern New South Wales has a similar colour pattern, but is half the size with a gradate spire and prominent spinose shoulders. *N. capricornia* (Wilson) from Western Australia, has a more conical spire, is two-thirds the size, has no subspinose nodules and lacks any linear type colour pattern. This latter species also lacks spiral sculpture.

Zidoninae H. and A. Adams, 1853

(= Alcithoinae Pilsbry and Olsson, 1954)

Diagnosis. Head broad, flat, undivided with short flat tentacles. Siphon with 2 equal to subequal appendages. Operculum absent. Tubular salivary gland of anterior digestive system very long and easily separated from racemose salivary gland. Gland of Leiblein large, convoluted and easily separated from the oesophagus. Radula uniserial with tricuspid rachidian, central cusp of which usually the larger.

Remarks. The grouping of genera within the subfamily is based on studies of the taxa listed in Appendix 2. In addition to those South American and New Zealand genera included in the subfamily by Pilsbry and Olsson (1954), Clench and Turner (1964) and Weaver and du Pont (1970) there are added the Australian genera *Cymbiola* and *Melo,* previously included by those authors in the Cymbiinae, and *Ericusa and Livonia,* previously included in the Fulgorarinae. The anatomy and radulae of species of these genera have been examined and, since they agree in all respects with those described by Clench and Turner (1964) for the Zidoninae, these genera are included here. *Notopeplum,* overlooked by Pilsbry and Olsson (1954), was placed in the Scaphellinae by Weaver and du Pont (1970), presumably on the basis of shell characters as the soft parts were not known. Subsequently Wilson (1972) described the anatomy and radula which are similar to that of *Ericusa* and for that reason the genus is placed in the Zidoninae. Other non-Australian genera included in the subfamily here on the basis of radula and anatomy are *Guivillia* (Knudson, 1973) *Harpovoluta* (Eales, 1923) and *Miomelon* (Stuardo and Villorreal, 1974). The other genera, including those known only as fossils, are included on the basis of their affinity with genera having living species whose systematic position is known.

The number of New Zealand genera seems out of proportion when compared with those of other regions, but may well be reduced in the light of a modern revision.

The taxa included in the subfamily by the writer are as follows:

Zidona H. and A. Adams, 1853 (see Clench and Turner, 1964);

Adelomelon Dall 1906 (= *Janithoe* Pilsbry and Olsson, 1954);

A. (Weaveria) Clench and Turner, 1964;

A. (Pachycymbiola) Ihering, 1907;

Miomelon Dall, 1907 (see Stuardo and Villoreal, 1974);

Proscaphella Ihering, 1907;

Guivillea Watson, 1886 (see Knudson, 1973);

Harpovoluta Thiele, 1912 (Eales, 1923);

Alcithoe H. and A. Adams, 1853 (= *Leporemax* Iredale, 1937;

Palomelon finlay, 1926, *Caroluta* Iredale, 1937, *Gilvostia* Iredale, 1937) (see Ponder, 1970);

A. (Waihoaia) Marwick, 1926;

Pachymelon Marwick, 1926 (= *Palomelon* Finlay, 1926);

Iredalina Finlay, 1926;

Mauira Marwick, 1943;

Mauithoe Finlay, 1930;

Teremelon Marwick, 1926;

Metamelon Marwick, 1926;

Spinomelon Marwick, 1926;

Ericusa H. and A. Adams, 1858 (= *Mesericusa* Iredale, 1929);

Livonia Gray, 1855 (= *Mamillana* Crosse, 1871; *Pterospira* Harris, 1897; *Cottonia* Iredale, 1934);

Notopeplum Finlay, 1927 (see Wilson, 1972);

Sigaluta Rehder, 1967 (possibly a synonym of *Notopeplum);*

Melo Broderip in Sowerby, 1826 (= *Melocorona* Pilsbry and Olsson, 1954);

Cymbiola Swainson, 1831 (= *Aulica* Gray, 1847, *Aulicina* Roverato, 1899, *Cymbiolacca* Iredale, 1929, *Cymbiolena* Iredale, 1929).

The distribution of representatives of this sub-

family through the Tertiary and in present seas is principally Southern Hemisphere, in fact circum-Antarctic with two main northern extensions through South America and through Australia, New Zealand, Indonesia and the Philippines. The present distribution closely mirrors that of the Subfamily in the Tertiary. The origin of most genera is not clear as the American genera appear in the Miocene without earlier Tertiary ancestors, however, they seem to have close affinity with the New Zealand and Australian genera some of which appear in the Eocene.

In the Australian Tertiary the subfamily is represented by *Alcithoe, Ericusa, Livonia, Notopeplum and Cymbiola* of which the last four and *Melo* occur in the living fauna. *Melo* is known from the Pliocene of Indonesia, doubtfully from the Middle Miocene of north-western Australia, but not from the Tertiary of south-eastern Australia.

Alcithoe H. and A. Adams

Alcithoe (Waihaoia) Marwick

Waihaoia Marwick, 1926: 270, 274.

Type species. Original designation: *Waihaoia allani* Marwick, 1926. Eocene, McCullough's Bridge, New Zealand.

Description. Shell of small to medium size, fusiform, very elongate, somewhat contracted anteriorly and with high spire. Protoconch of 1½–2 smooth whorls, generally coiled with axis of shell, occasionally with small spike or calcarella on initial whorl. Prominent shoulder on body whorl and often on spire whorls. Axial sculpture of coarse ribs usually well developed and frequently with nodules at shoulder of whorl. Spiral sculpture of small threads but frequently absent. Aperture narrow, elongate with slightly reflexed outer lip. Columella with 4 and sometimes 5 strong plaits. Siphonal notch very shallow and siphonal fasciole not well developed or absent.

Stratigraphic range. Middle Eocene–Late Miocene.

Distribution. New Zealand, North and South Islands (Middle Eocene–Late Miocene).

Australia. Victoria, (Late Eocene–Middle Miocene); South Australia (Late Eocene, Middle Miocene); Tasmania (Early Miocene).

Comments. The very elongate appearance and the well developed costae are the characteristic features of this taxon. It is differentiated from *Alcithoe* s.s. by the presence of a shallow siphonal notch, and by the fasciole, which is not marked off posteriorly by a thin ridge, but is either a raised cord, or is sometimes absent. According to Finlay (1930) only *Spinomelon* and *Metamelon* have a strongly spiked protoconch, however, well preserved topotypes of *Waihaoia allani* the type species of *Waihaoia* do show this feature (see Figure 16), thus it has little or no significance as a generic feature. Both *A. (W.) sarissa* (Tate) (Early–Middle Miocene, Australia) and *A. (W). rugosa* Marwick (Late Miocene, New Zealand) have reasonably well developed siphonal fascioles which seems to indicate that this feature developed in species towards the end of the range of the genus.

Waihaoia has a rather similar range in time in both Australia and New Zealand. It appears a little earlier (Middle Eocene) in New Zealand but there are no suitably fossiliferous Middle Eocene sediments known in Australia. It is absent from the Australian Late Miocene but does survive into the Late Miocene in New Zealand. There are no known Australian offshoots or descendants from the genus, whereas Marwick (1926) has indicated possible offshoots in the New Zealand Tertiary.

In the Tertiary of south-eastern Australia there are six species in the subgenus, of these three *A. (W.) tateana* (Johnston), *A. (W.) pueblensis* (Pritchard) and *A. (W.) sarissa* (Tate) form a group of closely related species and the others are perhaps more closely related to New Zealand species rather than to any other Australian species.

Cotton (1949) placed the above three species and *Voluta cribrosa* Tate in the genus *Notovoluta*, but they do not possess the regularly coiled, dome-shaped, multispiral protoconch characteristic of species of that genus.

Alcithoe (Waihaoia) cribrosa (Tate)

Plate 13, figures 1–4

Voluta cribrosa Tate, 1889b: 129, pl. 3, fig. 8.

Description. Shell fusiform with moderately high spire. Protoconch with impressed suture, of 2 smooth whorls, first of which swollen with erect initial portion, and second flattened, passing somewhat abruptly into sculptured teleoconch whorls. Teleoconch whorls slightly depressed at posterior suture and slightly convex anteriorly. Body whorl with weak shoulder. Spiral sculpture of thin, close-set threads, present over whole of spire and body whorls. Axial sculpture of low, but sharp, well spaced costae, extending from suture to suture on spire, but obsolete on shoulder of body whorl and becoming weaker and finally absent towards aperture. Columella with 4 plaits, of which anterior is weakest. Siphonal notch broad and shallow; siphonal fasciole not developed.

Dimensions. Lectotype, specimen crushed (T605A), L34, HA–, W–; Hypotype, specimen crushed, (P34824), L51, HA29, W17 est.; Hypotype, (FL14) (P34825), L57, HA30, W20.

Location of types. South Australian Museum: Lectotype T605A (Tate's figured specimen selected herein); paralectotypes T605B–D, R. Tate Collection. National Museum of Victoria; Hypotype P34824, coll. T.A. Darragh, 30 Oct. 1971; Hypotype P34825, coll. T. Hughes, 29 Nov 1972.

Type locality. "*Turritella* clays" Blanche Point, Aldinga Bay (Noarlunga 689963). Blanche Point Marl, Aldingan. Late Eocene.

Stratigraphic range. Aldingan, Late Eocene.

Occurrence. FL10, Type locality; FL14, BC 111 washout nearest Johanna River; FL19, Point Flinders.

Material. Types and 4 topotypes.

Comments. There are no close relatives of this species in the Australian Tertiary, but it bears some resemblance to the New Zealand Bortonian *Waihaoia striata* Laws, from which it differs by having stronger sculpture and being less elongate.

Alcithoe (Waihaoia) pagodoides pagodoides (Tate)

Plate 12, figures 1, 4, 7, 10, 13
Figure 17

Voluta pagodoides Tate, 1888: 176, pl. 13, fig. 7 (figure).
Voluta pagodoides. – Tate, 1889b: 132 (description).
Scaphella (Eopsephia) pagodoides. – Harris, 1897: 117.
?Notovoluta pagodoides. – Cotton, 1949: pl. 14
Notovoluta pagodoides. – Ludbrook, 1969: Fig. 96-3. – Ludbrook, 1973: pl. 25, figs 34, 35.

Description. Shell elongate, fusiform with slender turreted spire bearing median row of tubercles. Protoconch of 2 smooth convex whorls with impressed suture and coiled with axis of shell. First teleoconch whorl bearing thin longitudinal ribs which develop into median row of sharp tubercles on subsequent whorls. Body whorl bearing 9–10 tubercles on posterior third of whorl. Spiral sculpture of fine threads present on first 2 or 3 teleoconch whorls. Columella with 4 strong plaits and occasionally weaker posterior fifth plait. Canal reflexed dorsally. Siphonal notch shallow; siphonal fasciole a weak cord.

Dimensions. Holotype (T610B), L50, HA27, W17; Hypotype (P34821), L40, HA23, W17; Hypotype, FL11 (P34822), L52, HA27, W16.

Location of types. South Australian Museum: Holotype T610B, R. Tate Collection. National Museum of Victoria: Hypotype P34821, F.S. Colliver Collection, Hypotype P34822, coll. K. Bell and T.A. Darragh, 25 Feb 1970.

Type locality. The holotype is labelled "fig. 7 Kent Town bore" but the explanation of the original figure states the locality as Aldinga. The matrix within the aperture is typical Blanche Point Marl from Blanche Point, Aldinga Bay, rather than the dark clayey greensand of the bore.

Stratigraphic range. Aldingan, Late Eocene–Early Janjukian, late Oligocene.

Occurrence. South Australia. Blanche Point Marl: FL10, Type locality; Adelaide bore, Kent Town Waterworks; 25 m, bore 240 (G. Heading), Sect. 261. Hd of Yatala, Klemzig; Ardrossan. Buccleuch Group: 15 m coal bore, Moorlands.

Victoria. FL11, BC1, washout nearest Brown Creek; FL19, Point Flinders; FL22, Addiscot Beach.

Material. Type and 8 topotypes.

Comments. This taxon is characterised by the general absence or poor development of spiral sculpture and the presence of shoulder tubercles. There is some variability in the degree of elongation of the spire and development of the shoulder tubercles. Victorian specimens tend to be more elongate and have more prominent tubercles than specimens from South Australia, though there is sufficient overlap in morphology between the two groups to maintain them in the same subspecies. Of the New Zealand species of the genus it bears the closest resemblance to *A. (W.) suteri* Marwick and *A. (W.) thomsoni* Marwick but lacks the prominent axial costae characteristic of these species.

Alcithoe (Waihaoia) pagodoides sororcula
subsp. nov.

Plate 12, figures 2, 3, 6, 8

Description. Shell small elongate, fusiform with slender turreted spire bearing median row of sharp tubercles. Protoconch as in *A. (W.) pagodoides pagodoides*. Body whorl bearing 8–11 small sharp tubercles. Spiral sculpture consisting of close-set threadlets present over whole surface of spire and body whorls. Columella with 4 strong plaits and occasional weaker plait inserted between others. Siphonal notch very shallow; siphonal fasciole scarcely developed.

Dimensions. Holotype (P37630), L38, HA19, W12; Paratype (P37631), L33, HA18, W12.

Location of types. National museum of Victoria. Holotype P37630, Paratype P37631, J. Dennant Collection.

Type locality. FL24, Bird Rock Cliffs, Torquay (Torquay 642518). Jan Juc Formation, Janjukian.

Stratigraphic range. Janjukian, Late Oligocene.

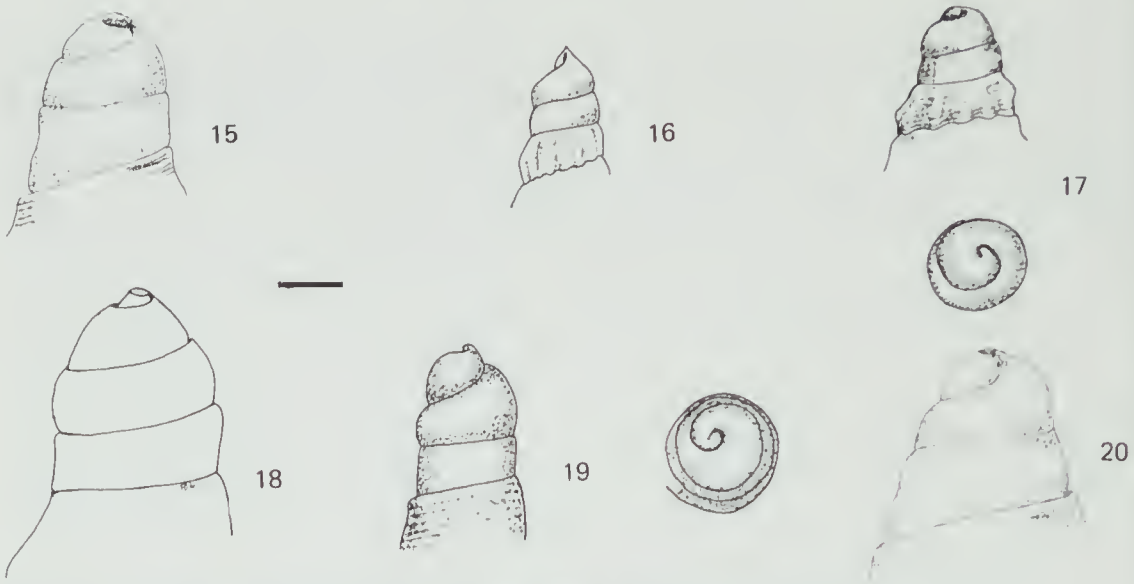

Figure 15. *Alcithoe (Waihaoia) pueblensis* (Pritchard), MUGD 1806, holotype, Bird Rock Cliffs.
Figure 16. *Alcithoe (Waihaoia) allani* (Marwick), GS 9508, McCulloughs Bridge, New Zealand.
Figure 17. *Alcithoe (Waihaoia) pagodoides pagodoides* (Tate), P34821, hypotype, Blanche Point, SA.
Figure 18. *Alcithoe (Alcithoe) macrocephala* (Finlay), SAM P5755, hypotype, "Murray Plains".
Figure 19. *Alcithoe (Waihaoia) sarissa* (Tate), P38301, hypotype, Clifton Bank, Muddy Creek.
Figure 20. *Alcithoe (Alcithoe) orphanata* sp. nov., P37635, holotype, Flinders Is., Tas. (scale = 2 mm)

Occurrence. FL24, Type locality; FL26, Barwon River S of Birregurra.

Material. Types and 30 topotypes.

Comments. This subspecies has been separated from *A. (W.) pagodoides pagodoides* (Tate) on the basis of its spiral sculpture, which consists of fine close set threads covering the entire surface of the shell. In *A. (W.) pagodoides pagodoides* the spiral sculpture, if at all present, is merely confined to the first one or two teleoconch whorls. It is generally much larger in size.

Alcithoe (Waihaoia) neglectoides sp. nov.

Plate 12, figures 5, 9, 11, 12

Description. Shell elongately fusiform with narrow turriculate spire. Protoconch of 1½–2 convex whorls somewhat flattened on top. Spire whorls flat to gently convex. Spiral sculpture of numerous close-set threads covering whole of spire whorls and body whorl. Axial sculpture of sharp tubercles which are occasionally present on penultimate whorl but usually only on body whorl. Body whorl with 9–12 tubercles on posterior third of whorl. Columella with 4 strong plaits, weak posterior fifth plait and rarely other weaker plaits present. Canal reflected dorsally. Siphonal notch shallow; siphonal fasciole a weakly developed cord. Colour pattern of thin widely spaced zigzag lines.

Dimensions. Holotype (P37628), L45, HA29, W16; Paratype (P37627), L37, HA22, W13.

Location of types. National Museum of Victoria. Holotype P37628, F.A. Cudmore collection; Paratype P37627, F.S. Colliver collection.

Type locality. FL24, Cliff section below Bird Rock cap, Bird Rock Cliffs, Torquay (Torquay 642518). Jan Juc Formation, Janjukian.

Stratigraphic range. Janjukian, Late Oligocene.

Occurrence. Type locality only.

Material. Types and 14 topotypes.

Comments. This species has been confused with *A. (W.) pagodoides*, however it differs in having a gently tapering spire of relatively flat whorls and lacks nodules on the spire whorls. It bears a strong resemblance to the New Zealand Early Miocene species, *Alcithoe neglecta* Marwick, but is generally more elongate and has fewer tubercles on the body whorl. The siphonal notch and fasciole are not as well developed as in typical *Alcithoe* and for this reason the species is retained in the subgenus *Waihaoia* pending a revision of the New Zealand volute genera.

Alcithoe (Waihaoia) pueblensis (Pritchard)

Plate 14, figures 1–3, 8–10
Figure 15

Voluta pueblensis Pritchard, 1898: 109, pl. 8, fig. 7.

Description. Shell fusiform, elongate with acute spire and weakly shouldered body whorl. Protoconch somewhat conical of 2½ smooth rather flattened whorls and coiled with axis of shell. Initial teleoconch whorls flat but becoming shouldered with development of thin axial costae. On body whorl there are 9–12 costae which extend anteriorly from shoulder to about midpoint of whorl and then become obsolete. Spiral sculpture of threads confined to spire whorls and posterior third of body whorl. Columella with 4 strong plaits; siphonal notch broad and shallow; siphonal fasciole poorly developed.

Dimensions. Holotype (MUGD 1806), L 57, HA32, W19; Hypotype (P34842), L53, HA29, W17; Hypotype (P12773), L75, HA43, W24.

Location of types. Melbourne University Geology Department: Holotype MUGD 1806, purchased G.B. Pritchard, 11 Oct 1939. National Museum of Victoria. Hypotype P34842 F.A. Cudmore Collection. Hypotype P12773, coll. J.F. Bailey.

Type locality. "Lower horizon . . . Spring Creek, south of Geelong", i.e. FL24, cliff section below Bird Rock cap, Bird Rock cliffs, Torquay (Torquay 642518). Jan Juc Formation, Janjukian.

Stratigraphic range. Janjukian, Late Oligocene.

Occurrence. Type locality only.

Material. Type and 14 topotypes.

Comments. As stated by Pritchard (1913: 195) there is a close relationship between this taxon and *A. (W.) tateana* (Johnston) but the latter has bolder costae, a larger and more prominently shouldered body whorl and the spiral sculpture is much finer. *A. (W.) sarissa* (Tate), its successor in younger strata, is more slender, has more prominent spiral sculpture and has axial costae which fade out on the spire whorls as they approach the anterior suture.

Alcithoe (Waihoaia) sarissa (Tate)

Plate 13, figure 5
Plate 14, figures 5, 11
Figure 19

Voluta sarissa Tate, 1889b: 129, pl. 2, figs 1a, b.
Scaphella (Eopsephia) sarissa. – Harris, 1897: 116, pl. 4, figs 16a, b.
Notovoluta sarissa. – Cotton, 1949: pl. 14.

Description. Shell slenderly fusiform, elongate, with prominent acuminate spire. Protoconch coiled with axis of shell, of 1½–2 smooth whorls, initial portion of which frequently exsert. First and second teleoconch whorls flat to gently convex, subsequent whorls more convex but depressed against posterior suture. Axial sculpture of prominent costae of which there are 8–10 on the body whorl; costae on spire extend back from anterior suture to posterior depression and on body whorl are present on posterior third. Fine spiral lirae present over whole spire and posterior half of body whorl. Columella generally with 4 strong plaits of which anterior is weaker and often with weak fifth posterior plait on mature specimens. Canal dorsally reflexed; siphonal notch very broad and shallow; siphonal fasciole a prominent broad low cord.

Dimensions. Lectotype (T578A), L 78, HA37, W22; Hypotype (P38303), L80, HA40, W21; Hypotype (P38301), L46, HA20, W12.

Location of types. South Australian Museum: Lectotype T578A, Paralectotypes T578B-G (Muddy Creek). (Tate's figured specimen chosen as lectotype). National Museum of Victoria: Hypotype P38303, F.S. Colliver collection; Hypotype P38301, G.B. Pritchard collection.

Type locality. Lower beds, Muddy Creek, i.e., FL82, Clifton Bank, Muddy Creek, W of Hamilton (Coleraine WD820224). Muddy Creek Formation, Balcombian, Middle Miocene.

Stratigraphic range. Longfordian, Early Miocene Bairnsdalian, Middle Miocene.

Occurrence. FL32, SW end, Jan Juc Beach; FL34, S side, Lake Costin; FL35, SE of Fishers Point; FL38, Curlewis; FL41, Amphitheatre; FL77, Altona Bay Coal Shaft; FL78, Fossil Beach; FL82, Type locality; FL84, Four miles below Morgan; FL87, Lake Bullenmerri; FL98, Native Hut Creek S of Highway, FL100, Murgheboluc 4A; FL102, Warrambine Creek; FL103, Downstream section, Grices Creek; FL104, Manyung Rocks. Gellibrand River horizon not known. South eastern Trunk Sewer between Braeside and Dingley (Fyansford Formation, Balcombian).

Material. Types and numerous topotypes.

Comments. This species is distinguished by its narrow elongate appearance. It is derived from *A. (W.) pueblensis* (Pritchard) from which it differs by being proportionately more elongate with a narrow spire, and by having a prominent siphonal fasciole and slightly coarser spiral lirae. It is placed in *Waihaoia* because of its close affinity to *pueblensis* despite the fact that it has a rather prominent siphonal fasciole, a feature generally weakly developed or absent from species in that subgenus.

Alcithoe (Waihaoia) tateana (Johnston)

Plate 14, figures 4, 6, 7, 12

Voluta tateana Johnston, 1880: 37.—Johnstone, 1888: pl. 30, fig. 3, 3a.—Tate, 1889b: 132, pl. 2, fig. 5.—Pritchard, 1913: 195.

Notovoluta tateana.—Cotton, 1949: pl. 14.—Ludbrook, 1967: 68, pl. 4, figs 1, 2.

Description. Shell fusiform, elongate with high tapering spire and prominently shouldered body whorl. Protoconch of about 2 whorls, somewhat similar to *A. (W.) sarissa*. Spire whorls with bold axial costae on anterior half of whorl and fine close-set spiral threads on posterior half. Body whorl bearing 9–12 costae which extend from shoulder to midline of body whorl and then obsolete. Spiral threads present on shoulder of body whorl. Columella with 4 plaits of which anterior is weaker. Siphonal notch broad; siphonal fasciole poorly developed.

Dimensions. Holotype (Z187), L75, HA40, W26; Hypotype (T388B), L70, HA35, W25; Hypotype (P2587), L59, HA32, W20.

Location of types. Tasmanian Museum: Holotype Z127 R.M. Johnston Collection. South Australian Museum: Hypotype T388B, R. Tate Collection. National Museum of Victoria: Hypotype P2587, E.D. Atkinson Collection.

Type locality. "Table Cape". The preservation of the holotype indicates that it comes from the lower bed, i.e., FL28, lower bed in cliff between Fossil Bluff and 1.5 km towards Table Cape, Wynyard, Tas (Table Cape 930630). Freestone Cove Sandstone, Janjukian.

Stratigraphic range. Janjukian, Early Miocene.

Occurrence. FL28, Type locality; FL29, Upper bed, Table Cape.

Material. Types and 20 topotypes.

Comments. Specimens of this species are usually rolled and the delicate spiral sculpture is lost. The tapering spire and massive body whorl distinguish this species from its close relatives *A. (W.) pueblensis* and *A. (W.) sarissa*. The features which distinguish *A. (W.) tateana* from *A. (W.) pueblensis* are discussed in more detail under the description of the latter.

Alcithoe (Alcithoe) H. and A. Adams, 1853

Scaphella (Alcithoe) H. and A. Adams, 1853: 164.

Scapha (Alcithoe).— H. and A. Adams, 1858: 617.

Voluta (Alcithoe).—Crosse, 1871: 293.—Tryon, 1882: 94.—Fischer, 1883: 607.

Fulguraria (Alcithoe).—Cossmann, 1899: 132.—Suter, 1913: 444.

Alcithoe.—Marwick, 1926: 260, 270.

Waihaoia (Palomelon) Finlay, 1926: 432 (Type species (original designation): *Cymbiola lutea* Watson).

Alcithoe (Alcithoe).—Theile, 1929: 348.

Alcithoe (Leporemax) Iredale, 1937: 105 (Type species (original designation): *Voluta fusus* Quoy and Gaimard).

Alcithoe (Carolluta) Iredale, 1937: 105 (Type species (original designation): *Fulguraria hedleyi* Murdoch and Suter).

Gilvostia Iredale, 1937: 105 (Type species (original designation): *Gilvostia ostenfeldi* Iredale.

Alcithoe.— Smith, 1942: 24.

Alcithoe (Alcithoe).—Wenz, 1943: 1342.

Alcithoe (Carolluta).—Wenz, 1943: 1345.

Alcithoe (Gilvostia).—Wenz, 1943: 1345.

Alcithoe (Leporemax).—Wenz, 1943: 1345.

Alcithoe (Alcithoe).—Weaver and du Pont, 1970: 109.

Alcithoe (Leporemax).—Weaver and du Pont, 1970: 113.

Alcithoe.—Dell, 1978: 167–175.

Type species. Subsequent designation (Cossmann, 1899): *Voluta pacifica* Perry, 1810 (= arabica Gmelin, 1791) ICZN Opinion 479, Recent, New Zealand.

Description. Shell medium to large, generally thick, elongate, fusiform, somewhat abruptly contracted anteriorly. Protoconch of 2 to 3 smooth whorls, first slightly irregular and deviated from axis of shell. Spiral sculpture usually absent; axial sculpture usually present in form of costae and often developed into prominent elongate nodules on body whorl, rarely absent. Aperture wide and elongate. Outer lip of aperture thickened and reflexed, often almost winglike posteriorly. Columella bearing 4 strong plaits and often 5 with occasionally the addition of 1 or 2 weaker plaits. Siphonal notch deep; siphonal notch well developed or well marked.

Stratigraphic range. Early Miocene–Recent.

Distribution. Australia, Victoria and South Australia (Late Miocene); Flinders Is. (Pliocene); New Zealand (Early Miocene–Recent). 0–700 m.

Comments. It is not the author's intention to revise the generic status of New Zealand volutes, however, the above synonymy of *Alcithoe* has been compiled since there are representatives of the group in the Australian Tertiary. *Leporemax* Iredale, 1937 was separated from *Alcithoe* on the grounds that it differed in its small size, apertural features, sculpture and plaits. However, Iredale did not state in what manner it differed and other authors, such as Weaver and du Pont (1970), who have accepted *Leporemax* as a subgenus of *Alcithoe*, have cited only its small size and relatively larger, more obtuse protoconch as the features of difference. In the writer's opinion these vary so much within individuals that they are not worthy

of generic significance and as no significant differences can be found between the two taxa *Leporemax* has been relegated to the synonymy of *Alcithoe*.

Carolluta Iredale, 1937 was separated from *Leporemax* on the basis of the type species differing by being of smaller size, narrower and having an elongate spire and narrow aperture. These features are not regarded as being of generic significance.

The type species of *Gilvostia* Iredale, 1937, *G. ostenfeldi* Iredale, is a synonym of *Alcithoe swainsoni* Marwick (Weaver and du Pont, 1970) and accordingly *Gilvostia* has also been placed in the above synonymy. Dell (1978) has discussed the synonymy of *Palomelon* Finlay, 1926 with *Alcithoe*.

At present there are only two species of Australian volute referred by the author to *Alcithoe* s.s., these are *A. macrocephala* Finlay and *A. orphanata* sp. nov. from the Late Miocene and Pliocene respectively. These appear to be isolated immigrants from New Zealand, as there is no close relationship between the two and there are no other species which could link them in a lineage. It seems that the south-eastern Australian area was very much on the fringe of the distribution of *Alcithoe* in the late Tertiary, since the paucity of species present contrasts remarkably with the radiation exhibited by the genus in the New Zealand Tertiary.

A detailed anatomical description of the type species has been given by Ponder (1970).

Alcithoe (Alcithoe) macrocephala (Finlay)

Plate 13, figures 6–8
Figure 18

Voluta capitata Tate, 1889b: 127, pl. 2, figs 3a, b (non Perry, 1811).

Scaphella macrocephala Finlay, 1927: 513.

Description. Shell fusiform with rapidly tapering spire. Protoconch pointed, subconical of 2½–3 smooth rather flattened whorls, coiled with axis of shell and with impressed sutures. First teleoconch whorl with few weak spiral threads, remainder of whorls smooth. Teleoconch whorls markedly depressed at posterior suture and prominently convex at anterior suture. Body whorl tumid, contracted abruptly to siphonal fasciole. Aperture wide, notched posteriorly. Columella with 4 plaits, anterior of which weakest. Siphonal notch broad and deep; siphonal fasciole prominent and bounded posteriorly by a ridge.

Dimensions. Holotype (T389), L62, HA–, W25; Hypotype (SAM P5755), L46, HA27, W18.

Location of types. South Australian Museum: Holotype T389, R. Tate collection; Hypotype P5755, Kimber Collection.

Type locality. "Well sinking, Murray Desert" (Tareena, NSW, fide Tate 1899: 102). Bookpurnong Beds, Cheltenhamian, Late Miocene.

Stratigraphic range. Cheltenhamian, Late Miocene.

Occurrence. Type locality; FL132, Minhamite.

Material. Holotype and hypotype.

Comments. Tate (1889b) compared this species with "*V. pacifica* (= *Alcithoe arabica*) and other members of the section *Alcithoe*; but it has not the outer lip proper to them; from *V. pacifica*, which it resembles most in shape, it differs by its smooth flattish whorls". Cotton (1949) referred this species to *Amoria* but it does not have the regular, conical, multispiral protoconch of that genus. The protoconch is similar to that of *A. swainsoni* figured by Marwick (1926: 261, fig. 1c).

Alcithoe (Alcithoe) orphanata sp. nov.

Plate 13, figures 9–12
Figure 20

Description. Shell fusiform, of moderate size with elongate conical spire. Protoconch of 1½ smooth, somewhat irregularly shaped whorls, first of which is slightly deviated from axis of shell, suture impressed. Spire whorls slightly depressed at suture and slightly convex at anterior suture. Spiral sculpture absent. Axial sculpture of almost obsolete costae present on second and third teleoconch whorl. Body whorl smooth, very slightly concave against posterior suture then regularly convex and tapering anteriorly. Aperture narrow, notched posteriorly. Inner lip thickly callused. Columella with 5 well developed plaits, anterior and posterior of which weaker. Siphonal notch broad and deep; siphonal fasciole prominent.

Dimensions. Holotype (P37635), L105, HA63, W39; Paratype (P37636), L117, HA72, W42.

Location of types. National Museum of Victoria: Holotype P37635, Paratype P37636, coll. T.A. Darragh, D.M. Shanks and H.E. Wilkinson, 10 Feb 1969.

Type locality. Flinders Is., Tas., PL1264, Dam on Block 22 (Lees), Furneaux Estate Sect. A, 11 km ENE of junction of No. 4 and No. 3 Rds (Flinders Is. 987733). Camerot Inlet Formation, Pliocene.

Stratigraphic range. Pliocene.

Occurrence. Type locality; PL1268, North Patriarch Drain, Block 6, 1.1 km E of Link Rd, Memana (Flinders Is., 914741).

Material. Types, 1 topotype and 5 other specimens.

Comments. The overall smoothness of the whorls is the most conspicuous characteristic of this species. In shape it closely resembles the New Zealand Nukumaruan and Castlecliffian species *A. (A.) transformis* Marwick but lacks the tubercles present on the bodywhorl of that species. *A. nukumaruensis* (Marshall and Murdoch) also lacks sculpture but is more elongate and the spire is not conical. The protoconch and apertural features are typical of the *Alcithoe swainsoni* group and it seems probable that *A. orphanata* is derived from a Pliocene member of this group such as *A. irregularis* Marwick as there are no other Australian representatives known.

Ericusa H. and A. Adams, 1858

Zidona (Ericusa) H. and A. Adams, 1858: 619.
Ericusa.— Hedley, 1915: 724.
Alcithoe (Ericusa).—Thiele, 1929: 348.
Mesericusa Iredale, 1929: 181 (Type species (original designation): *M. sowerbyi perspecta* Iredale, 1929).
Ericusa.—Cotton and Godfrey, 1932: 49.
Ericusa (Ericusa).—Wenz, 1943: 1346.
Ericusa (Mesericusa).—Wenz, 1943: 1347.
Ericusa.—Macpherson and Gabriel, 1962: 217.
Ericusa (Ericusa).—Weaver and du Pont, 1970: 50.
Ericusa (Mesericusa).—Weaver and du Pont, 1970: 53.

Type species. Subsequent designation (Cotton and Godfrey, 1932): *Voluta fulgetrum* G.B. Sowerby I, 1825. Recent, Southern Australia.

Description. Shell solid, elongate, fusiform, medium to large size, with elongate spire; whorls rarely with shoulder. Protoconch somewhat globose, medium to large, of 1½–2½ smooth whorls, first deviated at 45° to axis of shell and frequently with initial portion exsert. Spiral sculpture generally weakly developed. Axial sculpture usually absent, but occasionally of large costae or tubercles. Aperture large, lenticular. Outer lip slightly thickened, occasionally produced laterally into winglike expansion.

Columella very arcuate with 3 well developed plaits and often with 1 or more weaker plaits. Siphonal notch very wide; siphonal fasciole absent.

Radula uniserial with tricuspid teeth, the central cusps of which are larger and longer than lateral cusps.

Stratigraphic range. Late Eocene (?)-Recent.

Distribution. Southern Queensland (Moreton Bay) (Recent); New South Wales (Recent); Victoria (Late Eocene (?)-Recent); Northern Tasmania (Early Miocene, Pliocene, Recent); South Australia (Middle Miocene, Pliocene, Recent); Western Australia (South Coast) (Early Pleistocene-Recent). 0–250 m.

Comments. Iredale (1929) erected *Mesericusa* on the basis of the strength and thickness of the plaits of *Ericusa kenyoniana* (Brazier) (= *papillosa* Swainson) compared with *Voluta sowerbyi* Kiener, and on the elongate shape of the latter compared with the former. Weaver and du Pont (1970) maintained *Mesericusa* as a subgenus of *Ericusa* on the basis of the former having a smaller protoconch and a higher spire. However, McPherson and Gabriel (1962) have pointed out that such differences are not of generic significance and synonomised *Mesericusa* with *Ericusa*. The writer fully supports this action and points out that the differences cited are subject to considerable variation from individual to individual within a species.

Though the first named species of *Ericusa* occur in the Late Oligocene of Victoria, there are fragmentary specimens of a species in the Late Eocene Browns Creek Clay, possibly related to *E. atkinsoni* Pritchard. *E. sowerbyi*, represented by the subspecies *pellita*, first appears in the Late Oligocene and ranges through to Recent. The other fossil species, with the exception of *E. atkinsoni*, are closely related to living species. On the basis of anatomy, radula and shell morphology *Ericusa* is most closely related to *Livonia* and some of the early species of that genus such as *L. spenceri* (Pritchard) and *L. stephensi* (Pritchard) are somewhat similar in morphology to *E. atkinsoni*. A common ancestry is therefore suggested.

Of the other genera in the subfamily *Ericusa* has considerable affinity with *Alcithoe* and to a lesser extent with the South American genera *Adelomelon* and *Proscaphella*.

Ericusa sowerbyi pellita (Johnston)

Plate 15, figures 7, 8
Plate 16, figures 4, 5
Plate 17, figures 4, 5
Plate 18, figures 4, 5
Figure 21

Voluta pellita Johnston, 1880: 36.
? Voluta allporti Johnston, 1880: 35.
Voluta pellita.—Johnston, 1888: pl. 30, fig. 2.—Pritchard, 1896: 97.
Voluta halli Pritchard, 1896: 101, pl. 2, figs 1–3.
Voluta pellita.—Pritchard, 1913: 198.
Voluta halli.—Pritchard, 1913: 198.
Ericusa (Mesericusa) pellita.—Ludbrook, 1967: 67, pl. 4, figs 9, 10 (holotype).

Description. Shell narrowly fusiform with regularly convex whorls. Protoconch of 2 smooth whorls

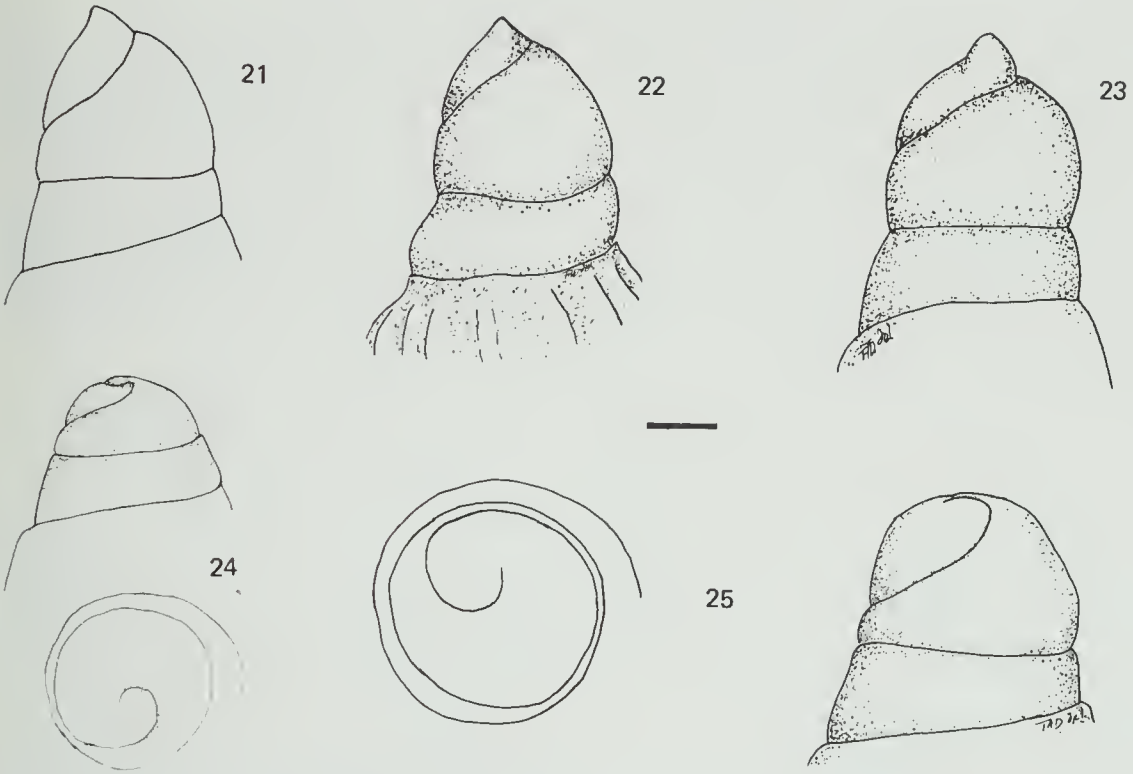

Figure 21. *Ericusa sowerbyi pellita* (Johnston), P41709, hypotype, lower bed, Table Cape, Tas.
Figure 22. *Ericusa atkinsoni* (Pritchard), P41724, hypotype, lower bed, Table Cape, Tas.
Figure 23. *Ericusa macroptera* (McCoy), P61287, hypotype, Bird Rock cliffs, Torquay.
Figure 24. *Ericusa subtilis* (Ludbrook), WAM 69.515, holotype, Hampton Microwave Repeater Tower, WA.
Figure 25. *Ericusa ancilloides* (Tate), P61288, hypotype, Balcombe Bay. (scale = 2 mm)

with initial portion exsert. First and second teleoconch whorls flatly convex and sculptured with numerous close-set spiral threads. Remainder of spire whorls and body whorl gently convex and smooth except for growth striae. Columella with 3 or very rarely 4 plaits.

Dimensions. Holotype (Z156), L116, HA68, W42; hypotype (P41709) (Crushed laterally), L175, HA115, W–; Hypotype (P41710), (FL129), L144, HA73, W47; MUGD 1789 (Crushed laterally), L163, HA85, W–; P41707, L163, HA97, W64; P41708, L120, HA71, W51.

Location of types. Tasmanian Museum: Holotype Z156, R.M. Johnston Collection. Melbourne University Geology Department: Holotype of *Voluta halli* Pritchard, 1896, MUGD 1789, Purchased G.B. Pritchard, 11 Oct 1939. National Museum of Victoria: Hypotype P41709, P41710, F.A. Cudmore Collection.

Type locality. "Table Cape". Preservation of the holotype indicates FL28, lower bed in cliff between Fossil Bluff and 1.5 km NW towards Table Cape, Wynyard, Tas. (Table Cape 930630). Freestone Cove Sandstone, Janjukian.

Stratigraphic range. Janjukian (Late Oligocene)–? Batesfordian (Middle Miocene).

Occurrence. FL22, Addiscott Beach; FL24, Bird Rock cliffs, FL28, type locality; FL29, upper bed, Table Cape; FL32, Jan Juc Beach; FL34, S of Lake Costin; FL38, Curlewis; FL43, 1.3 km S of Kennedys Creek; FL48, Boornong Road, Cooriemungle.

Material. Holotype and 15 topotypes.

Comments. Johnston (1880) stated that his new species *Voluta allporti* was the largest volute from Table Cape and his description could well apply to *V. pellita*, the next species described on the page. However, the former species has never been figured, no previous authors have used the name and the type specimen is lost, so it seems proper, in terms of Article 24(a) and Recommendation 24A of the Code of Zoological Nomenclature, to continue to use *V. pellita* and place *V. allporti* in the synonomy of this species, though the latter has page priority.

Large specimens from Torquay, the type local-

ity of *V. halli*, are rare and the few that are available show some variation from the type specimen of *V. halli* in that the whorls are inflated as in *V. pellita*. In the upper bed, Table Cape specimens are uniformly slender with flatter whorls than specimens from the bed below. It is felt that this is a phenotypic variation reflecting the differing bottom conditions at the time of deposition, so that *V. pellita* is regarded as having a fair degree of variation in morphology within which fall the Torquay specimens. Until further well preserved material is available from Torquay it seems best to consider *V. halli* as a synonym of *V. pellita*.

The upper limit of the stratigraphic range of the taxon is not known with certainty, since there are a number of broken specimens or juveniles known from higher in the column which may well be this taxon, or perhaps specimens of *Ericusa sowerbyi* s.s.

E. sowerbyi pellita differs from *E. sowerbyi sowerbyi* in having a narrower and more elongate spire and by having stronger spiral threads on the early teleoconch whorls, however, these differences are slight and can only justify subspecific separation.

Cotton (1949) listed the taxon as *Ericusa pellita* and *Mesericusa halli*.

Ericusa sowerbyi sowerbyi (Kiener)

Plate 16, figures 1–3, 7
Plate 17, figure 3
Plate 18, figure 8

Voluta fusiformis Swainson, 1822: 11 (non Brocchi, 1814).

Voluta sowerbyi Kiener, 1839: 47, pl. 50, fig. 2.

Voluta fusiformis.—Swainson and Hanley, 1841: 37.—G.B. Sowerby I, 1845: 208, pl. 54, fig. 100.—Reeve, 1849: pl. 3, fig. 6.—Tryon, 1882: 95, pl. 28, fig. 103.

Mesericusa sowerbyi perspecta Iredale, 1929: 181, pl. 41, fig. 9.

Alcithoe fusiformis.—Smith, 1942: 32, pl. 20, fig. 137

Ericusa sowerbyi porcellana Jackson, 1954: 37.

Mesericusa sowerbyi.—McMichael, 1960: 5, fig. 1B (radula).

Mesericusa stokesi Cotton, 1961: (1).

Ericusa (Mesericusa) sowerbyi.—Weaver and du Pont, 1970: 53, pl. 20 E–H.

Ericusa (Mesericusa) stokesi.—Weaver and du Pont, 1970: 54, pl. 20 A–B.

Description. Shell elongate, fusiform with flatly convex whorls. Protoconch of 1½ smooth whorls deviated at about 45° to axis of shell. Spiral and axial sculpture absent. Bodywhorl regularly convex and tapering gradually to anterior, occasionally somewhat depressed at posterior suture. Columella with 3 strong plaits and occasionally with 1 or more secondary plaits. Siphonal notch very wide; siphonal fasciole absent.

Dimensions. Hypotype (P41731), L111, HA65, W46; Hypotype (P41732), L134, HA79, W59; SAM D14625, L135, W58.

Location of types. Syntypes: Not known with certainty (Muséum National d'Histoire Naturelle, Paris, and Muséum d'Histoire Naturelle, Geneva). National Museum of Victoria: Hypotype P41731, coll. P. Roberts Jul 1975; Hypotype P41732, coll. T.A. Darragh, D.M. Shanks and H.E. Wilkinson, 10 Feb 1969. South Australian Museum: Holotype of *Mesericusa stokesi* D14625, presented A.J. Stokes.

Type locality. "les mers de l'Inde". The syntypes were probably collected by one of the French expeditions in Victoria or Tasmania.

Stratigraphic range. Cheltenhamian (Late Miocene)–Recent.

Occurrence. Living. Cape Morton, Queensland Beachport, South Australia, Northern Tasmania. 40–250 m. Fossil FL114, bed b, NE side, Bunga Creek; FL115, Lake Bunga tramway crossing; FL119, Ritchies Cutting, Scrivenors Road; FL148, Jemmys Point; FL151, right bank, Meringa Creek; FL156, Glenelg River at Roscoes; FL158, Limestone Creek. Tasmania: Cameron Inlet Formation (Pliocene): PL1258, Dam on lot 47, Memana (Flinders Is. 994657); PL1264 Dam on lot 22, Memana (Flinders Is. 987733); PL1268 North Patriarch drain, block 6, Memana (Flinders Is. 914741).

Comments. *Voluta fusiformis* Swainson, 1822 is preoccupied by Brocchi, 1814 and the next available name for this taxon is *Voluta sowerbyi* Kiener, 1839. The latter is not a replacement name for the former and was described by Kiener without reference to Swainson's name, therefore the types are not those of *Voluta fusiformis* as implied by Weaver and du Pont (1970: 53) but the specimens upon which Kiener based his species.

Of all the Australian species this is perhaps the most featureless and therefore very difficult to characterise. The entry into the stratigraphic record of this taxon is not known with precision owing to the lack of well preserved adult specimens in the Middle Miocene. This taxon is descended from *Ericusa sowerbyi pellita* (Johnston) and further comments are under that taxon.

Cotton (1961) separated *E. stokesi* from *E. sowerbyi* on the basis of it having a bulbous protoconch, a less elongate shell and the fact that it was unicoloured. The size of protoconch and the colour vary from individual to individual and cannot be regarded as of specific value. With regard to shape the holotype and a series of specimens from Port McDonald and Apollo Bay in the col-

lection of F. Rossack have been compared with a series of specimens from southern New South Wales and it is apparent that the holotype of *E. stokesi* is merely a ventricose specimen of *E. sowerbyi* and there is overlap in morphology between the South Australian and New South Wales specimens. Similarly, *E. sowerbyi perspecta* (Iredale) and *E. sowerbyi porcellana* Jackson fall within the range of variation of specimens from South Australia and Bass Strait.

Ericusa macroptera (McCoy)

Plate 15, figures 1, 2
Plate 17, figures 1, 2
Plate 18, figure 3
Figure 23

Voluta macroptera McCoy, 1866: 375.—McCoy, 1874: 29, pl. 7, figs 1-4.—Tate, 1889b: 124.
Pterospira macroptera.—Cotton, 1949, pl. 15.

Description. Shell fusiform with ventricose body whorl and winglike outer lip. Protoconch of about 2 smooth whorls, first of which is larger and has projecting initial portion. Teleoconch whorls depressed posteriorly and convex anteriorly. Spiral sculpture of numerous fine threads on spire whorls but becoming obsolete on penultimate whorl. Axial sculpture of a few weak plicae on first and second teleoconch whorls. Body whorl depressed at posterior suture, ventricose medially and abruptly contracted anteriorly. Outer lip of aperture extended laterally into prominent triangular winglike expansion. Inner lip projecting well beyond outer lip. Columella with 4 plaits. Siphonal notch wide and triangular in shape. Siphonal fasciole absent.

Dimensions. Lectotype (P12379), L125, HA–, W62 (McCoy, 1874, pl. 7, fig. 2); Paralectotype (P12378), L141, HA105, W64 (pl. 7, fig. 1); Paralectotype (P12380), L129, HA78, W55 (pl. 7, fig. 3); Paralectotype (P12381), L41, HA–, W17 (pl. 7, fig. 4); Hypotype (P48588), L134, HA87, W52.

Location of types. National Museum of Victoria: Lectotype P122379, paralectotypes P12378, P12380, P12381, coll. Richard Daintree, G.S.V. Jul and Aug 1861. The best preserved specimen is chosen as lectotype. Hypotype P48588, J. Dennant Collection; Hypotype P61287, F.S. Colliver Collection.

Type locality. Geological Survey of Victoria locality Ad22, Bird Rock Cliffs. This locality is a set of strata from about 5.2 to 11.3 m below the cap of Bird Rock (Torquay 642518). Jan Juc Formation, Janjukian.

Stratigraphic range. Janjukian, Late Oligocene.

Occurrence. Type locality only.

Material. Types and 16 topotypes.

Comments. In overall whorl shape this species resembles *Ericusa fulgetrum* but has a more slender spire and winglike outer lip of the aperture. Pritchard (1913: 199, pl. 20, fig. 6) recorded this species from Table Cape, Tasmania, but the specimen figured is a juvenile of *E. atkinsoni*.

Ericusa atkinsoni (Pritchard)

Plate 19, figures 3, 5
Plate 20, figures 1, 3
Figure 22

Voluta atkinsoni Pritchard, 1896: 100, pl. 3, fig. 1.
Voluta macroptera.—Pritchard, 1913: 199, pl. 20, fig. 6 (non McCoy, 1866).

Description. Shell fusiform with slender rapidly tapering spire of flat to convex whorls and tumid angulate bodywhorl which attenuates abruptly to canal. Protoconch of 2 smooth whorls, somewhat conical in shape with central initial portion projecting posteriorly as in *E. macroptera*. Spire whorls flat to convex and sculptured with low, wide, axial costae and numerous spiral threads. Spiral threads absent from body whorl. Body whorl angulate with well developed shoulder which bears 11–13 prominent oblique tubercles. Columella with 3 strong plaits. Outer lip of aperture slightly reverted laterally and produced posteriorly. Siphonal fasciole not present.

Dimensions. Holotype (P2985), L132, HA85, W66, Hypotype (P41723), L140, HA92, W61.

Location of types. National Museum of Victoria: Holotype P2985, E.D. Atkinson Collection; Hypotype P41723, F.A. Cudmore collection.

Type locality. Table Cape. The preservation of the holotype indicates FL28, lower bed in the cliff between Fossil Bluff and Table Cape, Wynyard, Tas. (Table Cape 930630). Freestone Cove Sandstone, Janjukian.

Stratigraphic range. Janjukian–Longfordian, Early Miocene

Occurrence. FL28, Type locality; FL32, Jan Juc beach; FL33, Birregurra; FL34, S side of Lake Costin; FL35, SE of Fischers Point; from 19 m in a shaft at Wurdi Boluc, Jan Juc Formation; 73 m, Mundys Well, Canegrass Station, via Kooringa, South Australia.

Material. Holotype and 3 topotypes.

Comments. This species has a similar protoconch to *Ericusa macroptera* and the spire whorls are sculptured in a fashion similar to those specimens of *E. macroptera* which have axial costae and spiral lirae, however, the sculpture is much more strongly developed than in the latter and the aperture also

lacks the well developed winglike extension of *E. macroptera*. Whilst the two are closely related and *E. atkinsoni* succeeds *E. macroptera* it is not clear that the latter is in fact ancestral to the former.

Few fragmentary specimens of a large (170 mm) *Ericusa*, very similar in shape and sculpture to this species have been found in the lower part of the Late Eocene Browns Creek Clay.

Specimens from the Fishers Point area seem to be smaller and have more slender and more elongate spires than topotypes, but there are insufficient well preserved topotypes to determine if there are significant differences between the two populations.

Ericusa ancilloides (Tate)

Plate 15, figures 3–5
Figure 25

Voluta ancilloides Tate, 1889b: 126, pl. 3, fig. 7.
Scaphella ancilloides.—Harris, 1897: 112.
Alcithoe ancilloides.—Cossmann, 1899: 133, Fig. 21, pl. 7, fig. 6.
Ericusa ancilloides.—Cotton, 1949: pl. 14
Ericusa (Ericusa) ancilloides.—Ludbrook, 1958: 77, pl. 4, fig. 2 (lectotype).

Description. Shell small, fusiform, ventricose with blunt almost conical spire. Protoconch large, of 1½–2 smooth whorls, first of which deviated at slight angle to axis of shell. Teleoconch whorls gently convex, sculptured with growth striae and fine spiral lirae which fade out towards body whorl. Body whorl flattened near margin of aperture, otherwise ventricose at midline and tapering anteriorly. Inner lip extending well beyond outer lip. Columella gently convex and bearing 3 plaits. Siphonal notch wide and deep. Siphonal fasciole absent.

Dimensions. Lectotype (T396D), L 76, HA43, W28; Hypotype (P41730), L 70, HA44, W29.

Location of types. South Australian Museum: Lectotype T396D, Paralectotypes T396A, C, T393, R. Tate Collection. National Museum of Victoria: Hypotype P41730 coll. David Burn, 12 Jun 1971; Hypotype P61288 coll. F.A. Cudmore. (Tate's figured specimen is chosen as lectotype).

Type locality. "Schnapper Point", i.e., FL78, shore platform at Fossil Beach, 3 km S of Mornington (Western Port 273658). Fyansford Formation Balcombian, Janjukian (Early Miocene)–Bairnsdalian (Middle Miocene).

Occurrence. FL28, lower bed, Table Cape; FL33, Birregurra; FL38, Curlewis; FL43, 1.3 km S of Kennedys Creek; FL48, Boornong Road, Cooriemungle; FL68, SE end of Gibson Beach; FL69, Red Bluff; FL70 Farrells; FL72, Orphanage Hill, Fyansford; FL77, Altona Bay Coal Shaft; FL78, Type locality; FL82, Clifton Bank, FL84, 4 miles below Morgan; FL87, Lake Bullenmerri; FL100, Mungheboluc 4A; FL103, Gunyoung Creek.

Material. Types and 9 topotypes.

Comments. Specimens from Muddy Creek occasionally have rather poorly developed irregular axial costae present on the first and second teleoconch whorls. Comparisons with *Ericua hamiltonensis* (Pritchard) have been made under that species. Of living volutes it most closely resembles *E. sericata* Thornley but is more ventricose in the body whorl and the spire whorls are convex rather than flat as in that species. It may be ancestral to that species.

Ericusa hamiltonensis (Pritchard)

Plate 15, figures 6, 9
Plate 18, figures 2, 7

Voluta hamiltonensis Pritchard, 1898: 107, pl. 8, fig. 5.

Description. Shell fusiform with rather flat spire whorls capped by large, smooth, globose protoconch. Protoconch of 1½–2 whorls, the first of which is deviated 45° to axis of shell. Sutures impressed. Spiral sculpture consisting of 4 or so faint threads confined to first teleoconch whorl. Columella with 3 plaits. Siphonal notch wide and deep; no siphonal fasciole. Colour pattern of thin, widely spaced, zigzag, axial bands.

Dimensions. Holotype (MUGD 1832) L 115, HA59, W41; Hypotype (P12566) L 101, HA56, W38.

Location of types. Melbourne University Geology Department: Holotype MUGD 1832, purchased G.B. Pritchard, 11 Oct 1939. National Museum of Victoria: Hypotype P12566, purchased R.H. Annear, 23 Jan 1912.

Type locality. "Eocene (i.e. lower) beds, Muddy Creek", i.e. FL82, Clifton Bank, Muddy Creek, 7 km W of Hamilton (Coleraine WD818225). Muddy Creek Formation, Balcombian.

Stratigraphic range. Balcombian, Middle Miocene.

Occurrence. FL71, SW of Glenleigh; FL78, Fossil Beach; FL82, Type locality; Gellibrand River (precise horizon not known).

Material. Holotype and 5 topotypes.

Comments. This taxon differs from *Ericusa ancilloides* (Tate) in having a larger protoconch and hence the spire is not as tapering as in that species, the whorls are flatter and the body whorl is more abruptly contracted anteriorly. Cotton (1949) listed this species under *Cymbiola* but the deviated protoconch, the three plaits, the siphonal notch and absence of fasciole are all typical of *Ericusa*.

Ericusa fulgetroides (Pritchard)

Plate 16, figures 6, 8
Plate 18, figures 1, 6

Voluta fulgetroides Pritchard, 1898: 105, pl. 7, fig. 4.
Ericusa fulgetroides.—Cotton, 1949: 186.

Description. Shell ovately fusiform with somewhat convex whorls and impressed sutures. Protoconch large of 2½ smooth whorls, first of which deviated at 45° to axis of shell. First and second teleoconch whorls gently convex and bearing numerous, close-set, spiral threads which tend to become obsolete towards body whorl. Body whorl smooth except for growth striae, broadly convex and tapering gently to anterior canal. Columella with 3 plaits. Siphonal notch as in *E. sowerbyi*.

Dimensions. Holotype (MUGD1804), L121, HA80, W62; Hypotype (P7843), L118, HA76, W57; P41736, L130, HA60, W82.

Location of types. Melbourne University Geology Department: Holotype MUGD 1804, purchased G.B. Pritchard, 11 Oct 1939. National Museum of Victoria: Hypotype P7843, presented R. Hughan, Dec 1905.

Type locality. "Miocene beds of Muddy Creek, and of Grange Burn, Western Victoria; also from the Miocene deposits of Beaumaris". The preservation of the holotype and the matrix within the shell indicates that it comes from grey silt at base of section at FL137, Forsyths bank, left bank of Grange Burn (Coleraine WD 832237). Grange Burn Formation, Kalimnan.

Stratigraphic range. Kalimnan, Early Pliocene.

Occurrence. FL137, Type locality; FL139, McDonalds Bank.

Material. Holotype and 6 specimens.

Comments. Compared with *Ericusa fulgetrum* (Sowerby) the spire of *E. fulgetroides* is not as high and the whorls are evenly convex; with *E. papillosa* (Swainson) the shell is more ventricose, the whorls evenly not flatly convex and not depressed at the suture. *E. sowerbyi* (Kiener) is the most closely related living species but the spire of *E. fulgetroides* is squatter with fine spiral threads, and the whorls more convex and the sutures somewhat impressed.

A greater series of specimens from Hamilton and also more material of fossil *E. sowerbyi* from Gippsland may show that there is morphological overlap and hence that *E. fulgetroides* is merely a population of the former.

Ericusa subtilis (Ludbrook)

Plate 30, figures 1–4
Figure 24

Notovoluta kreuslerae subtilis Ludbrook, 1978: 166, pl. 19, figs 4, 5.

Description. Shell small, narrowly fusiform with elongate subconical spire. Protoconch of 1½ smooth whorls, first of which slightly deviated from axis of shell. Teleoconch whorls virtually flat and sculptured merely with growth striae. Body whorl tapering gently to anterior. Columella almost straight and bearing 3 or 4 strong plaits. Siphonal notch wide and deep; siphonal fasciole absent.

Dimensions. Holotype (WAM 69.515), L67, HA38, W24; Hypotype (WAM 79.391), L71, HA41, W25.

Location of types. Western Australian Museum: Holotype WAM 69.515, coll. T.A. Darragh, M. Archer and G.W. Kendrick, 5 Mar 1969, Hypotype WAM 79.391, coll. V.A. Ryland, G.W. and W.E. Kenrick, 5–13 Aug 1978.

Type locality. PL3172, Foundation holes for Hampton Microwave Repeater Tower, 53 km E of Madura, Roe Plain, WA (Eucla 365462). Roe Calcarenite.

Stratigraphic range. Roe Calcarenite.

Occurrence. Type locality; Pit 1.5 km N of Hampton Tower, Roe Plain, WA.

Material. Types, 5 topotypes and 6 other specimens.

Comments. As noted under *Notovoluta kreuslerae occulta*, the holotype of *N. kreuslerae subtilis* is an *Ericusa* having the typical deviated protoconch of that genus. This species is the smallest and narrowest of all described species of *Ericusa*. Both *E. ancilloides* and *E. sericata* which bear the closest resemblance to it, are considerably larger and more ventricose and the spire whorls of *E. ancilloides* are convex rather than flat.

Ericusa fulgetrum (G.B. Sowerby I)

Plate 30, figure 7

Voluta fulgetrum G.B. Sowerby I, 1825: 28, pls 4, 5.
Ericusa orca Cotton, 1952: 53, pl. 4, figs 4–6.
Ericusa (Ericusa) fulgetra (sic).—Weaver and du Pont, 1970: 50, pl. 19 A–D, Fig. 9.
Ericusa (Ericusa) orca.—Weaver and du Pont, 1970: 51, pl. 19, E–F, (Holotype).
Ericusa fulgetrum orca.—Lubrook, 1978: 167, pl. 19, figs 2, 3.

Description. Shell large, elongate, ovately fusiform with high almost gradate spire. Protoconch large, papillary, of 2 smooth whorls, first slightly deviated to axis of shell. Teleoconch whorls depressed posteriorly and abruptly contracted anteriorly. Columella with 3 strong plaits. Siphonal notch very broad, siphonal fasciole absent.

Dimensions. Hypotype (WAM 79.410) L 124, HA78, W52; Hypotype (WAM 71.337) L 102, HA58, W38 (Ludbrook, 1978, pl. 19. figs 2, 3).

Location of types. British Museum (Natural History): Holotype 1837.12.1.37. ex Tankerville collection. South Australian Museum: Holotype of *E. orca* Cotton, 1952, D13816. Western Australian Museum: Hypotype WAM 71.337, coll. A.J. Carlisle, 1968; Hypotype WAM 79.410, coll. V.A. Ryland, G.W. and W.L. Kendrick, 29 Sep 1976.

Type locality. Not stated.

Stratigraphic range. Roe Calcarenite-Recent.

Occurrence. Living: South-east Western Australia to eastern South Australia. Fossil: Roe Plain, WA, Roe Calcarenite: Pit on Eyre Highway, 6.3 km E of Hampton Tower Road; Pit on Eyre Highway near Mundrabilla; Foundation Holes for Hampton Microwave Repeater Tower; Pit 1.5 km N of Hampton Tower.

Material. 4 fossil specimens.

Comments. Weaver and du Pont (1970) have provided good figures and a detailed synonomy of this taxon. *Ericusa orca* is merely an ecomorph from the western end of the range and is synonomised with *E. fulgetrum*.

Ericusa papillosa (Swainson)

Voluta (Scaphella) papillosa Swainson, 1822: 10.
Ericusa (Ericusa) papillosa. – Weaver and du Pont, 1970: 51, pl. 19G–I

Comments. This species has not yet been recorded as a fossil. Weaver and du Pont (1970) have provided good figures, a description and detailed synonomy of this and the following species. The species ranges from Eucla, Western Australia to Central New South Wales and Tasmania.

Ericusa sericata Thornley

Ericusa sericata Thornley, 1951. 53, Fig. 6.
Ericusa (Ericusa) sericata. – Weaver and du Pont, 1970: 52, pl. 20C, D.

Comments. This species has not yet been recorded as a fossil though *E. ancilloides* (Tate) is probably ancestral to it. The species ranges from Central New South Wales to Southern Queensland.

Livonia Gray, 1855

Scapha (Livonia) Gray, 1855a: 8.
Voluta (Mamillana) Crosse, 1871: 308 (Type species (monotypy): *Voluta mammilla* G.B. Sowerby I, 1844).
Voluta (Mamillana). – Tryon, 1882: 101. – Fischer, 1883: 607.
Voluta (Pterospira) Harris, 1897: 100. (Type species (original designation): *Voluta hannafordi* McCoy, 1866)
Voluta (Mamillana). – Tate, 1898: 386, 387.
Mamillana. – Cossmann, 1899: 107.
Pterospira. – Cossmann, 1899: 134
Voluta (Mamillana). – Dantzenberg, 1901: 10.
Mamillana. – Cossmann, 1901: 253.
Livonia. – Hedley, 1915: 723.
Pterospira. – Cotton and Godfrey, 1932: 48
Cottonia Iredale, 1934: 57 (Type species (original designation): *Scaphella dannevigi* Verco, 1912 = *Voluta nodiplicata* Cox, 1910).
Mamillana. – Smith, 1942: 49.
Pterospira. – Wenz, 1943: 1333.
Cymbium (Mamillana). – Wenz, 1943: 1338.
Alethoe (Cottonia). – Wenz, 1943: 1344.
Mamillana. – Macpherson and Gabriel, 1962: 216.
Pterospira. – Macpherson and Gabriel, 1962: 220.
Livonia. – Weaver and du Pont, 1970: 47.
Cottonia. – Weaver and du Pont, 1970: 124.

Type species. Subsequent designation by Hedley, 1915: *Voluta mamilla* G.B. Sowerby I, 1844. Recent, south-eastern Australia.

Description. Shell usually large and thick, ovate to ovate fusiform, with prominent shoulder and gradate spire. Protoconch with first whorl large for size of the shell, smooth, globose and deviated at 45 –90° to axis of shell; second whorl usually smaller and merging with teleoconch whorls. Spiral sculpture of threads or lirae usually present on shoulder of spire whorls and obsolete or absent on body whorl. Axial sculpture, if present, of strong ribs, tuberculate at shoulder.

Outer lip of aperture reflected laterally and usually extended laterally and posteriorly into prominent winglike expansion. Inner lip covered with thin glaze. Columella arcuate, usually with 3 strong plaits, though rarely with 2 or 4. Siphonal notch shallow and wide. Siphonal fasciole absent.

Radula uniserial with tricuspid teeth, central cusp larger and longer than lateral cusps.

Stratigraphic range. Late Oligocene–Recent.

Distribution. Southern Australia, New South Wales (Recent); Victoria (Late Oligocene–Recent); Northern Tasmania (Early Miocene, Pliocene, Recent); South Australia (Middle Miocene; Recent); Western Australia (Recent). 20–470 m.

Comments. The species in this genus have the heaviest nodulation of any known volute. Weaver and du Pont (1970) in designating a type species of the genus, have overlooked Hedley's (1915) prior designation. Their copy (Fig. 8a) of Gatliff and Gabriel's (1909) photograph of the radula of *L. mammilla* is incorrect.

Pterospira Harris, 1897, erected on the basis of the winglike outer lip and large globose protoconch, was synonymised with *Mamillana* by Tate (1898)

who pointed out that the latter had a similar protoconch and an incipient winged lip. Hedley (1915) designated *Voluta mammilla* as type species of *Livonia,* a genus which had been overlooked by earlier authors, and therefore *Mamillana* became a junior objective synonym of *Livonia.*

Cottonia was erected by Iredale in 1934 and that author included *Voluta alticostata* Tate and *V. heptagonalis* Tate as possible members of the genus. There was no comparison with other taxa except *Alcithoe.* The protoconch of the type species, illustrated by Wilson and Gillet (1971: 124, Fig. 24) and other features such as the absence of a siphonal fasciole, the presence of three plaits on the columella and the incipient winged lip are all features typical of *Livonia,* hence the writer has synonomised *Cottonia* with that genus. The anatomy of the type species of *Livonia, Pterospira* and *Cottonia* was examined and seems identical in all three.

The earliest known species of *Livonia* makes its appearance in the Late Oligocene of Victoria and there are several species in the Early Miocene of Victoria and Tasmania. Because of the close affinity of these species to Early Miocene species of *Ericusa* a common origin is suggested, and this supposition is born out by a study of the anatomy of species of both genera.

Livonia spenceri (Pritchard)

Plate 23, figure 2
Plate 24, figure 5

Voluta spenceri Pritchard, 1896: 98, pl. 4, figs 1, 2.

Description. Shell broadly fusiform with gradate spire and angular body whorl. Protoconch of 2 whorls, first deviated at about 45° to axis of shell. Spire whorls angulate and bearing close set spiral threads and sharp tubercles on shoulder. Body whorl ventricose, with prominent shoulder, almost keeled and abruptly contracted anteriorly giving quadrate appearance. Shoulder bearing 10 or so prominent blunt tubercles which may extend anteriorly in form of broad low costae. Columella with 3 plaits, outer lip slightly reflected laterally. Fasciole absent.

Dimensions. Holotype (P2990) L97, HA-, W54 (Protoconch and portion of canal missing); Paratype (MUGD 1813) unknown (Curlewis).

Location of types. National Museum of Victoria: Holotype P2990, E.D. Atkinson Collection. Melbourne University Geology Department: Paratype MUGD 1813, Purchased G.B. Pritchard, 11 Oct 1939.

Type locality. "Table Cape". The preservation of the specimen indicates the lower bed, i.e., FL28, lower bed in cliff between Fossil Bluff and Table Cape, N of Wynyard, Tas. (Table Cape 930630). Freestone Cove Sandstone, Janjukian.

Stratigraphic range. Janjukian (Early Miocene)–? Balcombian (Middle Miocene).

Occurrence. FL28, Type locality; FL32, SW end of Jan Juc Beach; FL38, Curlewis; FL48, Boornong Rd, Cooriemungle; ? FL78, Fossil beach; PL3163, Williams Rd cutting, Cowleys Creek.

Material. Holotype and 1 crushed specimen from FL32.

Comments. The Fossil Beach specimen is narrow, more elongate and has many more tubercles on the shoulder. Because of the rarity of the species it has not been possible to determine whether these differences are significant. The protoconch of this species is somewhat like that of species of *Ericusa* and in this it is similar to *L. stephensi.* The form of the aperture is also like that of *L. stephensi,* however the spire whorls of *L. spenceri* are angulate and bear nodules rather than costae as in the former.

Livonia stephensi (Johnston)

Plate 23, figures 1, 3–6
Plate 30, figures 8, 9
Figure 26

Voluta stephensi Johnston, 1880: 35. – Johnston, 1888: pl. 30, fig. 1. – Tate, 1888: 122. – Pritchard, 1896: 94.
Voluta wynyardensis Pritchard, 1913: 200, pl. 21, figs 1, 2.
Alcithoe (Cottonia) stephensi. – Ludbrook, 1967: 67, pl. 3, figs 3, 4.

Description. Shell fusiform with narrow gradate spire and prominently shouldered body whorl somewhat abruptly contracted to anterior canal. Protoconch moderately large, of 2 smooth whorls, first deviated at about 30° to the axis of spire. First teleoconch whorl convex, remainder of whorls concave posterior to shoulder. Axial sculpture of coarse costae which increase in strength towards aperture but become obsolete on shoulder and nodulate at shoulder. Body whorl with 12–14 short, sinuous tuberculate costae. Spire covered with numerous fine lirae which become obsolete on body whorl. Columella with 3 plaits and rarely fourth feeble plait anterior to others. Outer lip slightly reflected laterally. Siphonal notch wide, siphonal fasciole not present.

Dimensions. Holotype (Z183), L106, HA59, W49; A.J.M. (TM839), Holotype of *Voluta wynyardensis* Pritchard, L78, HA45, W36; Hypotype (P41366), L110, HA65, W52; Hypotype (P41367), L91, HA51, W41.

Location of types. Tasmanian Museum: Holotype Z183, R.M. Johnston Collection. National Museum of Victoria:

Figure 26. *Livonia stephensi* (Johnston). P61290, hypotype, lower bed, Table Cape, Tas.
Figure 27. *Livonia gatliffi* (Pritchard). MUGD 1805, holotype, Clifton Bank, Muddy Creek.
Figure 28. *Livonia mortoni mortoni* (Tate, 1889). P61289, hypotype, lower bed, Table Cape, Tas. (scale = 2 mm).

Hypotypes P41366, P41367, coll. I. A. Darragh, 30 Nov. 1969. Hypotype P61291, E. D. Atkinson Collection, Auckland Institute and Museum, New Zealand. Holotype of *Volutilithes wynyardensis* Pritchard, 1913, TM839, H. A. Finlay Collection ex R. N. Atkinson.

Type locality. "Table Cape". The matrix indicates the lower bed, i.e. FL28, lower bed in cliff between Fossil Bluff and 1.5 km NW towards Table Cape, Wynyard, Tasmania (Table Cape 930630). Freestone Cove Sandstone, Janjukian.

Stratigraphic range. Janjukian (Late Oligocene–Longfordian (Early Miocene).

Occurrence. FL24, Ledge Bird Rock cliffs. Type locality.

Material. Holotype, lectotype of *L. wynyardensis*, 5 complete and 4 fragmentary topotypes.

Comments. This species lacks the prominently expanded outer lip which is found in most other species of the genus, and the protoconch is more like that found in species of *Ericusa*, however the overall appearance of the shell is more like that of species of *Livonia* and for this reason it is placed in the latter genus.

The type specimen is poorly preserved. One side has been exposed to weathering and the sculpture is almost obliterated, whilst the other side shows signs of the shell having been rolled prior to burial and the fine spiral sculpture is not present. The weathered side was figured by Johnstone and this, coupled with the poor quality of illustration, no doubt led Pritchard (1913) to misidentify the species. He mistook *L. voluminosa* sp. nov. for *L. stephensi* and proceeded to describe as new *Volutilithes wynyardensis* which is based on an immature specimen of *L. stephensi* in which the axial costae of the last whorl are not so well developed as is usual in mature specimens.

Livonia mortoni mortoni (Tate)

Plate 22, figures 1–4
Figure 28

Livonia mortoni Tate, 1889b: 124, pl. 9, fig. 1.
Pterospira mortoni – Ladd in Kanakoff, 1967: 67, pl. 3, figs 6–8.

Description. Shell small, delicate, fusiform, generally smooth and with prominently winged aperture. Protoconch of 1½ small, smooth whorls, deviated at about 45° to axis of shell. First teleoconch whorl gently convex, penultimate and body whorls prominently shouldered. No obvious spiral sculpture. Axial sculpture of incipient nodules occasionally present on shoulder. Columella gently arched with 2 (rarely 3) well developed plaits and rarely third weaker posterior plait; siphonal notch broad, siphonal fasciole absent.

Dimensions. Lectotype (Z208), L61, HA–, W32. Hypotype (P25710), L73, HA55, W36.

Location of types. Tasmanian Museum, Lectotype (herein designated, Z208), R.M. Johnston Collection. National Museum of Victoria, Hypotype P25711, E.D. Atkinson Collection, Hypotype P61288, F.A. Cudmore Collection.

Type locality. "Table Cape". The preservation of the lectotype indicates that it comes from the lower bed, i.e. FL28, lower bed in cliff between Fossil Bluff and Table Cape, NW of Wynyard, Tasmania (Table Cape 930630). Freestone Cove Sandstone, Janjukian.

Stratigraphic range. Janjukian, Early Miocene.

Occurrence. FL28, Type locality. FL29, upper bed, Table Cape.

Material. Lectotype and 7 topotypes.

Comments. The small size, general smoothness of the shell and the angular whorls distinguish this spe-

cies. The closest relative is *L. mortoni connudata* subsp. nov. whose affinity is discussed under that species. The lectotype has been broken since it was illustrated by Tate (1889b: pl. 9, fig. 1) and portion of the body whorl and columella lost.

Livonia mortoni connudata subsp. nov.

Plate 22, figures 6, 7

Voluta mortoni Tate, 1889b: 124, pl. 9, fig. 2.
Pterospira mortoni.—Cossmann, 1899: 134, pl. 6, fig. 4.—Cotton, 1949: pl. 15.

Description. Shell thin, ovate, of medium size, with regularly convex whorls. Protoconch large, globose, of about 1½ smooth whorls, first deviated at right angles to the axis of shell. Spire whorls convex with traces of incipient spiral threads. Body whorl usually regularly convex, tapering gently to canal and occasionally depressed at posterior suture. No axial sculpture. Columella prominently arched and bearing 3 well developed but thin plaits. Outer lip of aperture everted slightly and expanded posteriorly to form small wing. Siphonal notch shallow and wide; siphonal fasciole absent.

Dimensions. Holotype (P41558), L87, HA62, W43 (Wing broken).

Location of types. National Museum of Victoria: Holotype P41558, G. Sweet Collection. South Australian Museum: Paratype T384, R. Tate Collection (Tate 1889b: pl. 9, fig. 2.)

Type locality. FL82, Clifton Bank, Muddy Creek, 7 km W of Hamilton (Coleraine WD 818225). Muddy Creek Formation, Balcombian.

Stratigraphic range. Balcombian, Middle Miocene.

Occurrence. FL82, Type locality; SE Trunk sewer near Braeside.

Material. Types and 6 specimens.

Comments. This is the Middle Miocene descendant of *L. mortoni mortoni* (Tate) from which it differs in having three well developed plaits, a strongly arched columella, regularly convex rather than shouldered whorls and there is no trace of axial nodules. In overall appearance it resembles in miniature, *L. mammilla*.

Livonia voluminosa sp. nov.

Plate 19, figures 1, 2, 4, 6

Voluta alticostata.—Pritchard, 1896: 103 (non Tate, 1889).
Voluta stephensi.—Pritchard, 1913: 195, pl. 21, figs 3, 4 (non Johnston, 1880).

Description. Shell large, thick, broadly fusiform with gradate spire and ventricose body whorl. Protoconch as in *L. hannafordi*. First teleoconch whorl convex, subsequent whorls angular with prominent flat shoulder. Spiral sculpture of fine lirae on spire whorls, fading out on penultimate and body whorls. Axial sculpture of thick costae present on anterior whorl slope of all teleoconch whorls but first. Body whorl angulate prominently shouldered, abruptly contracted anteriorly and bearing 9–12 prominent short costae tuberculate on shoulder of whorl. Columella with 3 strong plaits. Outer lip of aperture extended posteriorly and laterally into winglike expansion.

Dimensions. Holotype (P41368), L141, HA97, W75 (First whorl of protoconch missing); Paratype (P2986), L184, HA111, W86 (First whorl of protoconch missing); Paratype (MUGD1796), L162, HA90, W81 (First whorl of protoconch missing); P41370, L151, HA–, W75.

Location of types. National Museum of Victoria: Holotype P41368 coll. T.A. Darragh 15 Oct 1971. Paratype P2986, E.D. Atkinson Collection. Melbourne University Geology Department: Paratype MUGD 1796, Purchased G.P. Pritchard.

Type locality. FL28, Lower bed in cliff between Freestone Cove and Table Cape, N of Wynyard, Tas. (Table Cape 930630). Freestone Cove Sandstone, Janjukian.

Stratigraphic range. Janjukian, Early Miocene.

Occurrence. FL28, Type locality; FL29, Upper bed, Table Cape.

Material. Types and 9 other reasonably complete specimens.

Comments. This species resembles *L. heptagonalis* but has an abruptly contracted body whorl and a greater number of less prominent tubercles on the body whorl. It differs from *L. stephensi* from the same locality, and with which it has been confused, by having a globose protoconch similar to *L. hannafordi*, by having an expanded outer lip, more prominent axial costae, more angulate whorls and generally by its larger shape and crass features. It is probably ancestral to both *L. hannafordi* and *L. heptagonalis*.

Livonia sp. cf. **L. nodiplicata** (Cox)

This record is based on an incomplete external mould (WAM 78.3950) from the Early Miocene Abrakurrie Limestone in Spider Sink (N 41), Madura district, Western Australia (Madura 528087). The specimen is similar in size to the largest specimens of *L. nodiplicata*, but it has a much weaker shoulder which fades out on the penultimate whorl, the shoulder nodules are weaker and fade out on the whorl before the penultimate whorl.

Livonia heptagonalis (Tate)

Plate 21, figures 2, 5
Plate 24, figures 1, 2

Voluta heptagonalis Tate, 1889b: 121, pl. 4, figs 1, 7.
Cottonia heptagonalis.—Cotton, 1949: pl. 14.

Description. Shell solid, large, narrowly fusiform with broad, high, gradate spire and gently tapering body whorl. Protoconch as in *L. hannafordi*. Whorls prominently shouldered and on spire bearing numerous spiral threads which become obsolete on body whorl. Axial costae thick, prominent, extending from shoulder to anterior suture of spire whorls; somewhat tuberculate on shoulder. Costae on last whorl short, much enlarged and produced out and away from aperture; 8–10 costae on body whorl. Columella coated with thick callus and bearing 3 plaits; outer lip slightly everted and flanged posteriorly.

Dimensions. Lectotype (T397A), L 137, HA88, W64 (Tate, 1889: pl. 4 fig. 7), Paralectotype (T397C), L 141, HA , W19, (pl. 4, fig. 1); Hypotype (P13895), L 163, HA99, W78.

Location of types. South Australian Museum: Lectotype T397A, Paralectotype 397C, R. Tate Collection. National Museum of Victoria: Hypotype P13895, F.A. Cudmore Collection. The adult specimen figured by Tate is designated lectotype.

Type locality. River Murray cliffs near Morgan, i.e., FL84, left bank of the River Murray at a gully 4.8 km S of Morgan-Cadell Rd, SA (Morgan 790280). Cadell Marl lens, Morgan Limestone, Balcombian.

Stratigraphic range. Balcombian, Middle Miocene.

Occurrence. Type locality only.

Material. Types and 5 topotypes.

Comments. The grotesque tubercles and gentle anterior tapering of the body whorl distinguish this species from *L. hannafordi* and *L. voluminosa* sp. nov.

Livonia hannafordi (McCoy)

Plate 20, figures 5, 6
Plate 21, figures 4, 6
Plate 22, figure 5

Voluta hannafordi McCoy, 1866: 376.—McCoy, 1874: 23, pl. 6, fig. 1.—McCoy, 1876: 25, pl. 36, fig. 1.—Tate, 1889b: 121.

Voluta alticostata Tate, 1889b: 122, pl. 5, fig. 7.

Voluta (Pterospira) hannafordi. Harris, 1897: 100, pl. 4, figs 10a, b.

Pterospira hannafordi.—Cossmann, 1899: 134; pl. 6, fig. 6.

Voluta valdecostata Dennant and Kitson, 1903: 100, nom. nov. for *V. alticostata* Tate.

Pterospira hannafordi.—Cotton, 1949: pl. 14.

Cottonia alticostata.—Cotton, 1949: pl. 14.

Pterospira hannafordi.—Wilson and Gillett, 1971: Fig. 25.

Description. Shell broadly fusiform with gradate spire. Protoconch of 2 smooth whorls, first globose and deviated at 45° to axis of shell. Whorls strongly convex, frequently with prominent shoulder particularly on body whorl. Body whorl abruptly contracted to anterior canal. Spiral sculpture confined to posterior half of spire whorls and shoulder area of body whorl and consisting of 6–10 lirae with intercalated fine threads. Axial sculpture variable, occasionally poorly developed or absent but usually present on anterior whorl slope of spire and consisting of broad costae which are nodulate on shoulder. Body whorl usually with 10–12 large tubercles at shoulder. Columella with 3 or occasionally 4 or 5 plaits. Siphonal notch broad; siphonal fasciole poorly developed.

Dimensions. Lectotype (P12155), L 150, HA100, W77; 1392, L 89, HA58, W50; Hypotype (P12972), L 300, HA180, W140.

Location of types. National Museum of Victoria: Lectotype P12155 (McCoy's figured specimen chosen herein), Paralectotype P6646, presented S. Hannaford, 1 Apr 1857, Hypotype P12972. South Australian Museum: Holotype of *Voluta alticostata* Tate T392 R. Tate Collection.

Type locality. "Clays near the foot of Mount Eliza", i.e. FL103, downstream section at the mouth of Gunyoung Creek, Mount Eliza (Western Port 309712). Fyansford Formation, Bairnsdalian.

Stratigraphic range. Balcombian Bairnsdalian, Middle Miocene.

Occurrence. FL68, SE end of Gibson Beach; FL69, Red Bluff, Shelford; FL70 Farrells; FL71, SW of Glenleigh; FL72, Orphanage Hill, Fyansford; FL74, SE Trunk Sewer; FL78, Fossil beach; FL81, Overburden, Batesford Quarry; FL82, Clifton Bank, Muddy Creek; FL87, Lake Bullenmerri; FL98, Native Hut Creek, S of highway; FL99, Junction Barwon R. and Native Hut Creek; FL103, Type locality; FL104, Manyung Rocks.

Material. Types, 13 reasonably complete individuals, many fragmentary specimens.

Comments. This is an exceedingly variable species. Specimens from the Fyansford Formation frequently lack any costae or they may be feebly developed, whereas specimens from the Muddy Creek Formation vary, some having no costae or feeble costae, and others have sharp well developed costae. The latter specimens have received the name *Voluta alticostata* Tate, however as there is every

gradation between the two extremes the entire suite of specimens is regarded as a single population.

This species is probably ancestral to *L roadnightae* (McCoy) and possibly also to *L. nodiplicata* (Cox). The largest known specimen of the species (P12972 from Muddy Creek) rivals in size specimens of the latter.

Livonia gatliffi (Pritchard)

Plate 20, figures 2, 4
Plate 21, figures 1, 3
Figure 27

Voluta gatliffi Pritchard, 1898: 108, pl. 8, fig. 6.

Description. Shell small, ovately fusiform with gradate spire. Whorls prominently shouldered and bearing well developed but narrow, sinuous axial costae on anterior whorl slope. Costae somewhat tuberculate on shoulder. Costae number 15–21 on body whorl and extend from shoulder to trace of fasciole. Numerous thin spiral threads present on shoulder of spire whorls which become obsolete and disappear on body whorl. Outer lip slightly everted. Siphonal notch wide; siphonal fasciole present.

Dimensions. Holotype (MUGD 1805), L71, HA37, W31; Hypotype (P41472), L71, HA43, W35 (Protoconch missing).

Location of types. Melbourne University Geology Department: Holotype MUGD 1805 purchased G.B. Pritchard. National Museum of Victoria: Hypotype P41472, J. Dennant Collection.

Type locality. "Eocene beds of Muddy Creek", i.e. FL82, Clifton Bank, Muddy Creek, 7 km W of Hamilton (Coleraine WD818225). Muddy Creek Formation, Balcombian.

Stratigraphic range. Balcombian, Middle Miocene.

Occurrence. Type locality only.

Comments. The seulpture and whorl shape of this species are very similar to those of specimens of *L hannafordi* which were described as *Voluta alticostata*, but the mature shell is considerably smaller and the ribs narrower and more closely spaced. This species and *L. mortoni* are the smallest species in the genus.

Livonia mammilla (G.B. Sowerby I)

Voluta mammilla G.B. Sowerby 1, 1844: 149.
Voluta mammilla (sic). – G.B. Sowerby 1, 1845: 207, pl. 50, figs 57, 58.
Livonia mammilla. – Weaver and du Pont, 1970: 48, pl. 17 A–C.

Comments. Weaver and du Pont (1970) have provided good figures and descriptions with synonymy of this species. Specimens of this species, or a closely related taxon, occur in the Early Pliocene strata at Jemmys Point, Kalimna and in the Pliocene Cameron Inlet Formation on Flinders Is. The fossils tend to have a more erect spire and better developed shoulders than in living specimens, but there are only three broken specimens available and it is not possible to determine if these differences are of significance.

The species ranges from western Victoria to southern Queensland and Tasmania.

Livonia roadnightae (McCoy)

Voluta roadnightae McCoy, 1881: 88, pl. 7, figs 1, 2.
Livonia roadnightae. – Weaver and du Pont, 1970: 49, pl. 18A–B, Fig. 8b.

Comments. Weaver and du Pont (1970) have provided a synonomy, good figures and a description of this species. It appears to be descended from *L. hannafordi* (McCoy), but there are no known specimens in the fossil record.

The species ranges from southern coast of Western Australia to central new South Wales and northern Tasmania.

Livonia nodiplicata (Cox)

Voluta nodiplicata Cox, 1910: 146, pl. 3.
Scaphella dannevigi Vereo, 1912: 225, pl. 13, figs 1, 2.
Cottonia nodiplicata. – Weaver and du Pont, 1970: 124, pl. 54 A–B, Fig. 26. – Wilson and Gillett, 1971: 124, pl. 81, fig. 1, Fig. 24.

Comments. Weaver and du Pont (1970) provided a synonomy, good figures and a description of this species; whereas Wilson and Gillett (1971) illustrated, for the first time, the typical *Livonia* type protoconeh, whieh is usually broken off when specimens are eollected. This taxon is most elosely related to *L. hannafordi* McCoy. A specimen from the Roe Calcarenite in a pit 1.5 km N of Hampton Tower (WAM 79.402) consisting of the protoconeh and half a teleoconch whorl is almost identical to the figure in Wilson and Gillett (1971). Two other specimens from this locality are larger in size and lack the protoconchs. They are similar to living specimens, but the shoulder is not as well developed and the shoulder nodules are not as sharp.

The species ranges from Rottnest Island to Eucla, Western Australia.

Livonia joerinkensi (Poppe)

Cottonia joerinkensi Poppe, 1987: 99, pl. 1, figs 1, 2, 4, 5, 6; pl. 2, figs 7, 8; pl. 3, figs 10, 13.

Comments. This taxon bears a very close resemblence to *Livonia hannafordi*, however, it is more

elongate and lacks the prominent shoulder and wing-like expansion of the outer lip of the latter.

It is recorded from 470 m, 120 km off Mermaid, in the direction of Scott Reef, Western Australia.

Notopeplum Finlay, 1927

Notopeplum Finlay, 1927: 514.—Finlay, 1930: 45.—Cotton and Godfrey, 1932:4.—Wenz, 1943: 1340.—Weaver and du Pont, 1970: 169.—Wilson, 1972: 353.

Type species. Original designation: *Scaphella victoriensis* Cossmann, 1899 = *Voluta polita* Tate, 1887, Miocene, Victoria.

Description. Shell small, thin, ovate-elongate to subfusiform, generally smooth, and covered with brilliant glaze. Adult whorls smooth except for growth striae, juvenile whorls occasionally with axial riblets. Initial portion of protoconch deciduous and sealed off from remainder of protoconch by irregular layer of callus, herein called embryonic scar, which forms blunt tip of spire. Remainder of protoconch not sharply differentiated from spire whorls. Aperture lenticular, about one-half to one-third height of shell. Outer lip of aperture frequently thickened and slightly reflexed dorsally. Inner lip produced anteriorly beyond outer lip. Columella usually with 3 strong plaits and weaker fourth posterior plait, rarely 3 or 5. Anterior plait formed by thickening of anterior portion of columella. Siphonal notch wide and shallow but well defined; siphonal fasciole present but not prominent.

Stratigraphic range. Late Eocene–Recent.

Distribution. Southern Australia. Victoria (Late Eocene–Middle Miocene); South Australia (Late Eocene, Middle Miocene, Recent); Western Australia, south coast (Recent), south-west coast (Recent). 12–200 m.

Comments. The high gloss, smooth shell, nature of protoconch and *Ericusa* like apertural features are the most characteristic features of the genus. Its systematic position has been in doubt ever since the genus was described. Wilson (1972) having described the animal and radula of *N. annulatum* pointed out that the separated salivary glands were similar to the Volutinae and particularly the Scaphellinae however other features were dissimilar. The tricuspid radula resembles that of *Ericusa* as does the external anatomy of the animal, in contra-distinction to that of *Scaphella*. The anterior digestive system has no obvious major distinction from that of *Ericusa*, therefore a place in the Volutidae near *Ericusa* seems reasonable until further information comes to hand. The genus which first makes its appearance in the Late Eocene is endemic to southern Australia and has no obvious ancestry.

Notopeplum protorhysum (Late Eocene), *N. primarugatum* (Early Oligocene) *N. maccoyi maccoyi* (Early Miocene) and *N. maccoyi translucidum* (Early Miocene–Recent) are probably all part of a single evolutionary lineage. The only other described species of the genus are the type species *N. politum* (Middle Miocene) and *N. annulatum* (Recent).

Notopeplum saginatum Finlay originally included in the genus by Finlay (1930) is not closely related to any of the above species and is better placed in *Notovoluta*.

Notopeplum protorhysum (Tate)

Plate 25, figures 7, 10–11
Figure 31

Voluta protorhysa Tate, 1889b: 126, pl. 2, figs 6a, b.
Notopeplum protorhysum.—Finlay, 1927: 514.—Cotton, 1949: 191, pl. 15.—Ludbrook, 1973: pl. 25, fig. 36.

Description. Shell elongate ovate with somewhat tumid shouldered whorls. Embryonic scar small, flattened, edge ridged and slightly overlapping first teleoconch whorl. Spire whorls slightly depressed posteriorly. First teleoconch whorl sculptured with numerous, prominent, thin, transverse ribs strongest on shoulder of second teleoconch whorl and fade out completely at end of third or fourth whorl. Remainder of whorls sculptured merely with growth striae.

Dimensions. Lectotype (T589A), L40, HA20, W14; Hypotype (P31155), L29, HA18, W13 (Blanche Point FL10); Hypotype (P31156), L35, HA–, W– (Blanche Point FL10, distorted); P31157, L24, HA13, W10 (FL11).

Location of types. South Australian Museum: Lectotype T589A, Paralectotypes 1589B-D juveniles, R. Tate collection. National Museum of Victoria: Hypotype P31155, coll. T.A. Darragh, Mar 1966. Hypotype P31156, coll. T.A. Darragh, 25 Apr 1969.

Stratigraphic range. Aldingan (Late Eocene).

Occurrence. South Australia, Blanche Point Marl (Aldingan): Type locality; 80 ft, bore 240 (G Heading), Sect. 261, Hd of Yatala, Klemzig; FL10, Lower beds, Blanche Point. Victoria: FL11, BC1, Washout nearest Browns Creek; FL13, BC III, Washout nearest Johanna R.

Material. Types and 10 specimens from Blanche Point, 18 specimens from Browns Creek.

Comments. The shell shape of this species is somewhat variable. The type specimens are rather more elongate than those from Klemzig and Blanche

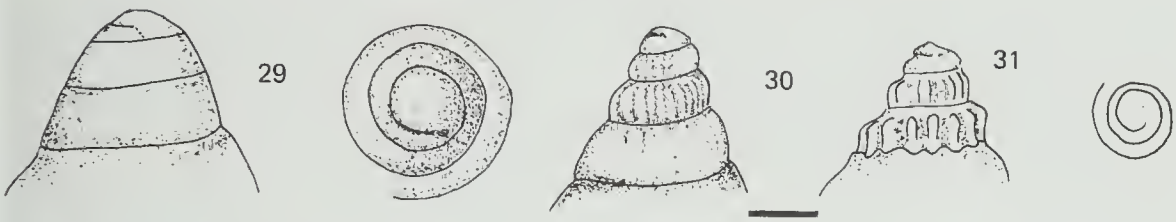

Figure 29. *Notopeplum politum* (Tate), P31164, hypotype, Clifton Bank, Muddy Creek.
Figure 30. *Notopeplum primarugatum* sp. nov., P61291, paratype, Aw 1, Point Flinders.
Figure 31. *Notopeplum protorhysum* (Tate), P31156, hypotype, Blanche Point, SA. (scale = 2 mm)

Point. The Browns Creek specimens have a more prominent shoulder on the early whorls, are less elongate than the types but more elongate than those from Blanche Point. The well developed ribs distinguish this species from others in the genus. A crushed specimen from Browns Creek is 70 mm in length.

Notopeplum primarugatum sp. nov.

Plate 25, figures 1–4, 6
Figure 30

Description. Shell relatively solid, elongately ovate with regularly convex whorls. Embryonic scar small, convex, edge slightly ridged against first teleoconch whorl which is uniformly convex and smooth. Second whorl sculptured with numerous thin, crowded axial riblets which continue onto third whorl where they gradually fade out. Penultimate and final whorls sculptured with growth striae only.

Dimensions. Holotype (P31158), L25, HA13, W9; Paratype (P31159), L26, HA15, W10; Paratype (P33160), L32, HA16, W14.

Location of types. National Museum of Victoria. Holotype P31158, coll. T.A. Darragh, 10 Mar 1977; Paratypes P31159, P31160, P61291, F.A. Cudmore Collection.

Type locality. FL19, Geological Survey locality AW1, W side of Point Flinders near Cape Otway, (Aire 367097). Lower Glen Aire Clay, Upper (?) Aldingan, Early Oligocene.

Stratigraphic range. Upper (?) Aldingan, Early Oligocene.

Occurrence. Type locality only.

Material. Types and 19 topotypes.

Comments. This species is derived from *N. protorhysum* and differs from it in having less prominent but more numerous and closely spaced ribs on the early spire whorls, by not having shouldered whorls and by its more ventricose appearance. The presence of ribs distinguishes it from younger species to which it probably gives rise.

Notopeplum mccoyi mccoyi (Tenison Woods)

Plate 26, figures 1, 6, 11, 12

Voluta m'coyi Tenison Woods, 1877: 95.
Voluta agnewi.—Johnston, 1888: pl. 30, fig. 9 (non Johnston, 1880).
Voluta maccoyii.—Pritchard, 1913: 196 (partim).

Description. Shell elongate ovate with rapidly tapering spire. Whorls gently convex, rarely slightly depressed posteriorly, and sculptured merely with growth striae. Embryonic scar small, irregularly convex, not ridged or overlapping first spire whorl. First teleoconch whorl somewhat tumid and slightly larger than second so that tip of spire has knobbed appearance.

Dimensions. Holotype L30, HA18, W11; Hypotype (P31161), L33, HA18, W13, Hypotype (P31162), L28, HA17, W12.

Location of types. Holotype missing. National Museum of Victoria: Hypotype P31161 Purch. R.N. Atkinson, 8 May 1911. Hypotype P31162 F.A. Cudmore Collection.

Type locality. Table Cape. Herein designated, FL28, lower bed, cliff between Fossil Bluff and Table Cape, N of Wynyard, Tasmania (Table Cape 930630). Freestone Cove Sandstone, Janjukian.

Stratigraphic range. Janjukian, Early Miocene.

Occurrence. FL28, Type locality; FL29 Upper bed, Table Cape.

Material. 7 topotypes.

Comments. The holotype was not listed by Ludbrook (1967) and enquiry at the Tasmanian Museum has failed to produce the specimen, so it is presumed to be lost. There is no need for a neotype to be selected as Tenison Wood's description and dimensions can only apply to the one taxon. The species name has been applied by both Tate (1889) and Pritchard (1896, 1913) to a closely related taxon, from Victoria, which Finlay subsequently described as *Notopeplum balcombensis* and which the author believes to be synonomous with

N. translucidum, and which also should be regarded merely as a subspecies of *N. mccoyi*.

The specimen figured as *Voluta agnewi* by Johnston (1888) is a typical *N. mccoyi*. Johnston's original description states that *V. agnewi* has 9 or 10 ribs which are raised near the centre into blunt tubercles and, therefore, it cannot be a *Notopeplum*.

Notopeplum mccoyi translucidum (Verco)

Plate 26, figures 2–5, 7–9, 13

Voluta maccoyi. – Tate, 1898b: 126, pl. 2, fig. 2 (non Tenison Woods, 1877).

Voluta translucida Verco, 1896: 217, pl. 6, figs 4, 4 a.

Voluta maccoyi. – Pritchard, 1896: 95.

Scaphella maccoyi. – Harris, 1897: 111.

Notopeplum balcombensis. – Finlay, 1930: 46.

Notopeplum translucidum. – Cotton and Godfrey, 1932: 47, pl. 2, fig. 10.

Notopeplum balcombensis. – Cotton, 1949: pl. 15.

Notopeplum translucidum. – Weaver and du Pont, 1970: 170, pl. 73 C, D. – Wilson, 1972: 354, pl. 33, figs 5, 6.

Description. Shell elongately ovate, with usually slightly pointed spire and tumid whorls. Embryonic scar small, usually somewhat obliquely flattened so tip of spire may appear pointed. Whorls convex, but generally depressed somewhat at posterior suture, so that whorls are almost shouldered. Colour white with pale chestnut zigzag axial lines.

Dimensions. Holotype (D13614), L40, HA25, W17; Hypotype (D15013), L35, HA21, W16 (W of Eucla); TM1071, L41, HA26, W17 (Holotype of *N. balcombensis* Finlay); Hypotype (P31163), L44, HA26, W18.

Location of types. South Australian Museum: Holotype D13614, Hypotype D15013, Sir Joseph Verco Collection. Hypotype T382B R. Tate Collection. Auckland Institute and Museum: Holotype of *N. balcombensis* TM 1071, H. Finlay Collection. Museum of Victoria: Hypotype P31163, coll. Sir Robert Blackwood, Jun 1957.

Type locality. Off Newland Head, outside Backstairs Passage, 20 fm, SA.

Stratigraphic range. Longfordian (Early Miocene)–Recent.

Occurrence. Fossil. Slip, edge of Lake Craven, 100 m W of FL36; FL38, Curlewis; FL41, Amphitheatre; FL43, 0.8 miles S of Kennedys Creek; FL46, 0.4 miles S of Kennedys Creek; FL47, Princetown-Simpson Road cutting nearest Melrose Rd; FL48, Boornong Rd cutting; FL60, Lot 393, Tomahawk Creek; FL70, Farrells; FL78, Fossil Beach; FL82, Clifton Bank, Muddy Creek; FL84, 4 miles below Morgan; FL87, NW shore, Lake Bullenmerri; FL100, Murgheboluc 4A; FL103, beds a-f downstream section, Ginyoung Creek; FL104, Manyung Rocks; PL3163, Williams Rd, Cowleys Creek.

Living. Type locality; 6-10 fm, Yatala Shoal, SA; 22 fm, Backstairs Passage, SA; 100 fm, 90 miles W of Eucla, WA.

Material. Holotype and 3 Recent specimens, numerous fossil specimens.

Comments. This is the most common representative of the genus and has the longest stratigraphic range and the widest geographic distribution. It differs from *N. mccoyi* s.s. by its more ventricose whorls and by the presence of a depression close to the posterior suture. These differences are slight but appear to be consistent within the material available so that subspecific separation from *mccoyi* seems justifiable. Shell shape is somewhat variable though, ranging from the relatively squat specimens of Fossil Beach (*N. balcombensis* Finlay) to the relatively elongate specimens of Clifton bank. Living specimens are intermediate between these two, but there is overlap between populations from all localities. The shoulder though usually present, varies in degree of development from complete absence to prominent within the one population. Fossil specimens frequently attain a length of 50 mm or more.

Notopeplum politum (Tate)

Plate 25, figures 8, 9, 12
Figure 29

Voluta polita Tate, 1889b: 127, pl. 2, fig. 7.

Scaphella polita. – Harris, 1897: 112, pl. 4, figs 15a, b (protoconch).

Scaphella polita. – Harris, 1897: 112, pl. 4, figs 15a, b (protoconch).

Scaphella victoriensis Cossmann, 1899: 127, nom. nov. for *Voluta polita* Tate non Conrad (invalid name change).

Notopeplum victoriensis. – Finlay, 1927: 513.

Notopeplum politum. – Wilson, 1972: 357, fig. C (protoconch of holotype).

Description. Shell ovate with tumid whorls and blunt spire. Suture somewhat impressed. Whorls regularly convex sculptured merely with growth striae. Embryonic scar large and convex forming low dome on point of spire.

Dimensions. Lectotype (T602A), L28, HA18, W13; Hypotype (P31164), L30, HA20, W14; P31165, L30, HA19, W14.

Location of types. South Australian Museum: Lectotype T602A, Paralectotypes T602B-F, R. Tate Collection. National Museum of Victoria: Hypotype P31164, J. Jutson Collection.

Type locality. Lower beds at Muddy Creek, i.e., FL82, Clifton Bank, Muddy Creek, Hamilton (Coleraine 820224). Muddy Creek Formation, Balcombian, Middle Miocene.

Stratigraphic range. Balcombian (Middle Miocene).

Occurrence. Type locality only.

Material. Types and 17 topotypes.

Comments. The specimes is not common but is distinguished from other species in the genus by its ventricose whorls, impressed sutures and blunt spire. Cossmann's name change is invalid as the supposed senior homonym is *Caricella polita* Conrad, 1854, originally described as a *Caricella* and still placed in that genus.

Notopeplum annulatum Wilson

Plate 25, figure 5
Plate 26, figure 10

Notopeplum annulatum Wilson, 1972: 354, pl. 33, figs 1-4; Figs A, B, D, F-H.

Description. Shell elongate with high spire and slightly convex, almost flat whorls. Colour cream to apricot with poorly developed pale spiral bands with orange blotches.

Dimensions. Holotype (WAM 132-64), L54, HA29, W19.

Location of types. Western Australian Museum: Holotype WAM 132-64, Paratype WAM 134-64 coll. HMAS "Diamentina", 12 Oct 1963; Paratype WAM 472-71 coll. HMAS "Diamentina", 28 Aug 1963.

Type locality. CSIRO Station 225 (32°00'S, 115°, 16'E), W of Rottnest Is., Western Australia, 141-146m.

Occurrence. Type locality; CSIRO Station 144 (32°00'S, 115°08'E), W of Rottnest Is, 141 m; NW of Rottnest Is, 156 m, Western Australia.

Material. Holotype.

Comments. Wilson (1972) has described this species in great detail. It differs from all others in the genus by its elongate appearance and almost flat whorls.

Cymbiola Swainson, 1831

Cymbiola Swainson, 1831: 83.
Aulica Gray, 1847: 141 (Type species (original designation): *Voluta aulica* G.B. Sowerby I.)
Scapha Gray, 1847: 141 (Type species (original designation): *Voluta vespertilio* Linneus) (non Molchulsky, 1845, Coleoptera).
Vespertilio Morch, 1852: 123 (Type species (original designation) *Voluta vespertilio* Linneus) (non Linneus 1758, Mammalia).
Melo (Ausoba) H. and A. Adams, 1853: 160 (Type species: (monotypy) *Voluta cymbiola* Gmelin).
Aulica.—H. and A. adams, 1853: 160.
Voluta (Vespertilio).—Tryon 1882: 86.
Voluta (Aulica).—Tryon, 1882: 87.
Voluta (Vespertilio).—Fischer, 1883: 607.
Voluta (Aulica).—Fischer, 1883: 607.
Voluta (Cymbiola).—Fischer, 1883: 607.
Voluta (Aulica).— Harris, 1897: 101.
Vespertilio.—Cossmann, 1899: 117.
Vespertilio (Aulica).—Cossmann, 1899: 106.
Voluta (Aulicina) Roverato, 1899: 103, nom. nov. pro *Vespertilio*.
Voluta (Eteroaulica) Roverato, 1899: 103, footnote, nom. nov. pro *Aulica* Gray, Invalid replacement.
Cymbiola.—Hedley, 1915: 723.
Aulica (Aulica).—Thiele, 1929: 348.
Aulica (Ausoba).—Thiele, 1929: 348.
Aulica (Aulicina).—Thiele, 1929: 349.
Cymbiolena Iredale, 1929: 181 (Type species (original designation): *Voluta magnifica* Gebauer).
Cymbiola (Cymbiolacca) Iredale, 1929: 181 (Type species (original designation): *Cymbiola complexa* Iredale).
Aulica.—Smith, 1942: 34.
Cymbiola (Cymbiola).—Wenz, 1943: 1335.
Cymbiola (Aulicina).—Wenz, 1943: 1335.
Cymbiola (Aulica).—Wenz, 1943: 1335.
Adelomelon (Cymbiolena).—Wenz, 1943: 1349.
Volutocorona Pilsbry and Olsson, 1954: 25 (Type species (original designation): *Voluta imperialis* Lamarck).
Cymbiola.—McMichael, 1959a: 375.
Aulica (Aulica).—McMichael, 1959a: 375.
Aulica (Aulicina).—McMichael, 1959a: 375.
Pseudocymbiola McMichael, 1961: 54 (Type species (original designation): *P. provocationis* McMichael).
Cymbiola (Cymbiola).—Weaver and du Pont, 1970: 76.
Cymbiola (Aulica).—Weaver and du Pont, 1970: 76.
Cymbiola (Aulicina).—Weaver and du Pont, 1970: 84.
Cymbiola (Cymbiolena).—Weaver and du Pont, 1970: 90.
Cymbiolacca.—Weaver and du Pont, 1970: 92.

Type species. (Tautonomy): *Voluta cymbiola* Gmelin, 1791. Recent, Moluccas.

Description. Shell small to large, solid, squat to ovate with gradate to subconical spire. Protoconch multispiral of 3 to 4 whorls, coiled with axis of shell. Protoconch whorls either smooth, or with weak to strong axial costae, frequently shouldered. Spiral sculpture absent. Axial sculpture generally developed, but occasionally reduced or absent; usually in form of spinose or blunt nodules on shoulder of whorls, sometimes in the form of thin axial costae developed over whole whorl, costae terminating posteriorly in spines on shoulder of whorl. Columella with 4 to 5 strong plaits, occasionally with 1 or more weaker posterior plaits, or with secondary plaits inserted between others. Siphonal notch narrow and deep. Siphonal fasciole prominent, usually bounded posteriorly by thin low ridge.

Radula uniserial with tricuspid teeth, central cusp longest.

Stratigraphic range. Late Oligocene-Recent.

Distribution. South China Sea–Philippines (Recent); Indonesia (Late Miocene–Recent); New Guinea–Solomon Is., Northern Australia (Recent); Southern Australia; Victoria (Late Oligocene–Early Pliocene), Flinders Is., (Pliocene); South Australia (Middle Miocene, Pliocene), Western Australia (Middle Miocene, Early Pleistocene–Recent).

Comments. Of the names in the above synonomy *Scapha* and *Vespertilio* are secondary homonyms as indicated, *Ausoba* is a junior objective synonym of *Cymbiola* and *Eteroaulica* is an invalid replacement name for *Aulica*. The other taxa are synonomised as the writer considers the grounds of separation from *Cymbiola*, cited by the various authors, are not of sufficient worth to warrant separation either at the generic or subgeneric level.

Cymbiola and *Aulica* were distinguished by McMichael (1959a) on the basis of the former having a low spire, and the position of the spines which are high up on the whorls of the former; and by Weaver and du Pont (1970) on the basis of the small low protoconch, low spire and presence of six columella plaits in *Cymbiola*. All these features may vary even from individual to individual, for example, in *C. aulica* (G.B. Sowerby I) and *C. flavicans* (Gmelin), and are certainly gradational between species. Compare for example the gradation in the series *C. cymbiola* (Gmelin), C. flavicans, C. aulica, C. chrysostoma (Swainson) and *C. imperialis* (Lightfoot) as illustrated in Weaver and du Pont (1970).

Aulicina has been distinguished from *Cymbiola* on the basis of its ribbed or nodulose protoconch however, whilst some species are strongly ribbed, others have large to small tubercles and there are others, such as *C. deshayesi* (Reeve) and *C. norrisii* (Gray), in which the ribs or tubercles are considerably reduced or even absent. *Cymbiola rossiniana* (Bernardi), previously placed in *Aulica*, does in fact show obsolete ribs on some specimens. The Pliocene *C.* cf. *rossiniana* also has obsolete ribs and specimens of *C.* cf. *irvinae* from the Roe Calcarenite of Western Australia show obsolete to weak ribs or tubercles. Specimens of *C. complexa* (Iredale) from the Cape Morton area either have strong ribs on the protoconch or the protoconch is completely smooth. Therefore, the presence or absence of ribs or tubercles on the protoconch does not seem to be a consistant feature and therefore *Aulicina* is regarded as a synonym of *Cymbiola*.

Cymbiolacca was erected as a subgenus of *Cymbiola* on the grounds that it differed from the latter in not having the planate protoconch of *Cymbiola*. McMichael (1959a) raised the taxon to genus on the grounds that the protoconch was conical and ribbed, rather than planate and smooth as in *Aulica*, and that the shells were small and light with small knobs and spines. Weaver and du Pont (1970) stated that *Cymbiolacca* was close to *Aulicina* but had a smaller conical protoconch and often more numerous plaits. The species placed in *Cymbiolacca* are merely smaller versions of such species as *C. vespertilio* (Linnaeus), *C. deshayesi* and *C. aulica*. The size of protoconch is not considered to be of generic significance and is comparable to that of *C. flavicans*. The presence and absence of protoconch ribs on specimens of *C. complexa* has been noted above. The number of plaits present is usually four, though *C. perplicata* (Hedley) and *C. thatcheri* (McCoy) have additional smaller posterior plaits. *Cymbiolena* was erected on the basis of its large size, delicate plaits and regularly wound, small protoconch. Weaver and du Pont (1970) accepted the taxon as a subgenus of *Cymbiola*, the only obvious difference between the type species and species of *Cymbiola*, apart from that of size, appears to be the absence of spines on the shoulder of the former, and as this feature is variable within other species of the group, such as *C. nivosa* (Lamarck). *Cymbiolena* has been synonomised with *Cymbiola*.

Weaver and du Pont (1970) have already placed *Pseudocymbiola provacationis* McMichael in synonomy with *C. complexa* and the writer supports this action. These authors also have synomised *Volutocorona* on the grounds that the cited criteria for separation are of little importance for generic and subgeneric separation. The writer also agrees with this action.

The anatomy of many of the species allocated to the above taxa (see Appendix 2) has been examined and seems identical, providing no evidence to support the separation of any of the taxa.

Wenz (1943) listed the stratigraphic range and distribution of *Cymbiola (Aulicina)* as Late Cretaceous to Recent, Europe, North Africa, West Africa, India, Sunda Is. and Australia. These records are based, in part, on the occurrence of species of Vasidae, such as *Eovasum frequens* (Meyer-Eymer) and *E. haimei* (d'Archaic), which have a superficial resemblance to Volutidae and, in particular, to species of *Cymbiola*. These vasids are common in the Late Cretaceous and Early Tertiary of Africa and India. The writer is not aware of any undoubted records of the genus beyond that cited above under stratigraphic range and distribution.

In the Tertiary of south-eastern Australia *Cymbiola* appeared first in the Late Oligocene along with a number of Indo-Pacific (Tethyan) immigrants during the mid-Tertiary rise in sea tem-

perature, and became extinct in the late Pliocene as the seas cooled. It appears that even in the Tertiary south-eastern Australia was a marginal area in the distribution of *Cymbiola* as specimens are not common.

Cymbiola uncifera (Tate)

Plate 24, figures 4, 7

Voluta uncifera Tate, 1888: 176, pl. 12, fig. 10 (figure only).
Voluta uncifera.—Tate, 1889b: 124 (description).

Dimensions. Lectotype (T394B), L37, HA–, W22; Paralectotype (T394A), L33, HA22, W20.

Location of types. South Australian Museum: Lectotype T394B, Parlectotype T394A, R. Tate collection. Tate's figured specimen is selected as lectotype.

Type locality. River Murray Cliffs near Morgan, i.e., FL84, left bank of River Murray at gully 4.8 km S of Morgan-Cadell Rd SA (Morgan 790280). Cadell Marl lens, Morgan Limestone, Balcombian, Middle Miocene.

Stratigraphic range. Balcombian, Middle Miocene.

Occurrence. Type locality only.

Material. Types and 2 topotypes, all juveniles.

Comments. This species was based on two juvenile specimens and another two juveniles are present in the Cudmore Collection, National Museum of Victoria. The obvious point of difference between these and specimens of *C. macdonaldi* (Tate) is the presence of a single costa in the former rather than paired costae which appear to be characteristic of the latter. The points of difference mentioned by Tate, viz. a more convex and feebly ridged protoconch, a more attenuated body whorl and the presence of nine spines on the shoulder in *C. uncifera*, are subject to such variation in *C. macdonaldi* that they have little value in specific differentiation of juvenile shells. Until more material is available a valid comparison between the two cannot be made.

Cymbiola macdonaldi (Tate)

Plate 24, figures 3, 6

Voluta macdonaldi Tate, 1888: 176, pl. 12, fig. 11 (figure only).—Tate, 1889b: 123, pl. 3, fig. 5.
Voluta (Aulica) macdonaldi.—Harris, 1897: 106.
Cymbiola macdonaldi.—Cotton, 1949: pl. 14.

Description. Shell oblong-ovate with gradate spire. Protoconch of 3 to 4 whorls which are shouldered, spirally lirate, prominantly axially costate and merge with teleoconch whorls. First and second teleoconch whorls bearing from 12 to 20 sinuous costae which become less prominent and finally absent on third teleoconch whorl. Costae paired and each pair merge at shoulder and capped by prominent spinose scale. Body whorl ventricose without costae and having prominent shoulder bearing about 16 large spinose nodules. Columella with 4 strong plaits. Siphonal notch deep; siphonal fasciole prominent and bounded posteriorly by sharp ridge. Colour pattern of numerous triangular patches similar to those present in *Cymbiola rossiniana*.

Dimensions. Holotype (T381D), L30, HA20, W20; Hypotype (T381A), L119, HA76, W66.

Location of types. South Australian Museum: Holotype T381D. Hypotype T381A, R. Tate collection.

Type locality. "Schnapper Point", i.e., FL78, shore platform at Fossil Beach, 3 km S of Mornington (Western Port 273658). Fyansford Formation, Balcombian.

Stratigraphic range. Batesfordian (?) (Early Miocene)–Balcombian (Middle Miocene).

Occurrence. ?FL50, Top of Fischers Point; FL71, SW of Glenleigh; FL78, Type locality; FL82, Clifton Bank; Gellibrand River, horizon not known.

Material. Types and 5 topotypes.

Comments. The paired costae terminating in the shoulder spines are the most characteristic features of this species. The single juvenile specimen from Fischers Point has this feature and hence is tentatively included in the species. This is not a common species and adult specimens are rare. Its relationship with younger species is not clear though it may well give rise to *Cymbiola* cf. *rossiniana*. There are juvenile specimens and one mature (?) specimen of a species of *Cymbiola* in the Jan Juc Formation which may be ancestral to *C. macdonaldi*, however the material is not sufficient for formal description. As far as the writer is aware this constitutes the oldest undoubted record of the genus.

Cymbiola sp. cf. **C. rossiniana** Bernardi

Cymbiola (Aulicina) irvinae.—Ludbrook, 1973: pl. 28, fig. 107.

Comments. There are fragmentary specimens of a species from the Grange Burn Formation (Kalimnan, Early Pliocene) which compare closely with specimens of the living species *Cymbiola rossiniana* Bernardi, 1859 from New Caledonia. A juvenile specimen from the Cameron Inlet (Pliocene) of Flinders Is. may also be the same species and represents the youngest record of the genus in the stratigraphic column of south-eastern Australia. Similar specimens occur in the Late Pliocene Dry

Creek Sands of South Australia, recorded by Ludbrook (1973) as *C. irvinae* (E. A. Smith), a closely related living species from Western Australia. Ludbrook (1973, 1974) recorded *C. irvinae* from the Roe Calcarenite of Western Australia. Specimens from this locality are larger than typical *irvinae* from Rottnest Is. and are somewhat intermediate in morphology between the latter and the specimens from the Grange Burn Formation. The available material from the Pliocene is poor, but suggests that the Pliocene taxon is ancestral both to *C. rossiniana*, now confined to New Caledonia on the east of the Australian continent and also, in view of the Roe Calcarenite material, to *C. irvinae* now confined to the west coast of Australia. Cooling of temperatures toward the end of the Tertiary may have led to extinction of *Cymbiola* on the south coast of Australia and the contraction of the ranges of species.

Cymbiola irvinae (Smith)

Voluta irvinae Smith, 1889: 97, pl. 5 Rottnest Is., W.A.
Cymbiola (Aulicina) irvinae – Weaver and du Pont, 1970: 45, pl. 35A–C. – Ludbrook, 1974: 164, pl. 16, figs. 22–23.

Comment. The above authors provide good descriptions and figures of this species. This species occurs in the Early Pleistocene Roe Calcarenite of the Roe Plain, Western Australia, however, as noted above, specimens from there are larger than topotypes of the species and have higher, more gradate spires. In some specimens, the shoulder is not angular, but rounded and lacks any spinose sculpture. Such variation is also seen in the living populations of the species. Wilson (1971) pointed out that there is some degree of overlap in morphology between *C. irvinae* and *C. nivosa* (Lamarck).

Cymbiola sp. cf. **C. nivosa** (Lamarck)

Comments. This record is based on a poorly preserved fragmentary specimen from the Middle Miocene Treatia Limestone on the E flank of Cape Range at Geological Survey of Western Australia locality 30055. It is a small *Cymbiola* akin to *C. nivosa* Lamarck, 1804 but the preservation prevents detailed comparison. It is mentioned here as the specimen is the earliest record for the north and western half of the continent.

Melo Broderip in Sowerby, 1826

(= *Melocorona* Pilsbry and Olsson, 1954)

?Melo sp.

Comments. Three fragmentary juvenile specimens from the Middle Miocene Treatia Limestone at Geological Survey of Western Australia locality 30055, E flank of Cape Range are available. They seem to belong to a species of *Melo* in which case they constitute the only Australian fossil record, but until more mature specimens are available the record should be treated as doubtful as there is a slight possibility that they are juvenile specimens of an undescribed *Cymbiola*.

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Appendix 1. Collecting localities

The localities FL1 etc used throughout this paper are equivalent to PL3001 etc in the Museum of Victoria, Department of Invertebrate Palaeontology, locality data file.

For each locality listed here, exact locality, grid reference, formation, epoch and local stage are given. Yard grid references are given in brackets.

PL 3001, 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 903097, Pebble Point Formation, Middle Paleocene, Wangerripian (Yard grid ref. Princetown 083222).

PL 3002, N side of Dilwyn Cove, S side of Pebble Point, G.S.V. loc. Aw6, 5 km SE of Princetown, Victoria, Princetown 900103, Pebble Point Formation, Middle Paleocene, Wangerripian (Yard grid ref. Princetown 081229).

PL 3003, Cove between Buckley Point and Point Pember, 4.5 km SE of Princetown, Victoria, Princetown 894109, Pebble Point Formation, Middle Paleocene, Wangerripian (Yard grid ref. Princetown 076234).

PL 3004, Shelly band about 10 m above beach, NW side of Buckley Point, 4 km SE of Princetown, Victoria, Princetown 891113, Pebble Point Formation, Middle Paleocene, Wangerripian (Yard grid ref. Princetown 074235).

PL 3005, W end of large slip at Killara Bluff at top section, allot. 4, sect. A, Parish of Killara, Victoria, Dartmoor WD313291, Bahgallah Formation, Middle Paleocene, Wangerripian.

PL 3006, Ironstone about 100 m above river, right bank of Glenelg River on Hazell Bank, Bahgallah, Victoria, Dartmoor WD324296, Bahgallah Formation, Middle Paleocene, Wangerripian.

PL 3007, Middle of Rivernook Beach, SE side of where track comes down, 0.4 km SW of Rivernook, Victoria, Princetown 888119, Dilwyn Formation, Rivernook Member, Late Paleocene, Wangerripian (Yard grid ref. Princetown 066247).

PL 3008, Rivernook Beach, half-way between PL 3009 and Rivernook bed, Victoria, Princetown 887120, Dilwyn Formation, Late Paleocene, Wangerripian (Yard grid ref. 0652548. Younger than Rivernook Member).

PL 3009, 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, Dilwyn Formation, *Trochocyathus* band, Late Paleocene, Wangerripian (Yard grid ref. Princetown 063250).

PL 3010, Lower 6.5 m of cliff on S side of Blanche Point, Port Willunga, South Australia, Noarlunga 689963, Blanche Point Marl, Late Eocene, Aldingan (Yard grid ref. Echunga 475452).

PL 3011, BC1, 9.6 m dark clay with *Turritella* below green sand in Washout 1 nearest mouth of Browns Creek, Johanna, Victoria, Princetown 080057, Browns Creek Clay, Late Eocene, Aldingan (Yard grid ref. Aire 277177).

PL 3012, BC11, greensand in washout 1 nearest mouth of Browns Creek, Johanna, Victoria, Princetown 080057, Browns Creek Clay, Late Eocene, Aldingan (Yard grid ref. Aire 277177).

PL 3013, BC 111, dark gritty clay 16 m above greensand in Washout 1 nearest mouth of Browns Creek, Johanna, Victoria, Princetown 080057, Browns Creek Clay, Late Eocene, Aldingan (Yard grid ref. Aire 277177).

PL 3014, BC111, dark gritty clay, in washout 2, forked gully nearest mouth of Johanna River, Johanna, Victoria, Princetown 079059, Browns Creek Clay, Late Eocene, Aldingan (Yard grid ref. Aire 276179).

PL 3015, Marl with bivales, above dark gritty clay in W (right) fork of washout 2, forked gully nearest mouth of Johanna River, Johanna, Victoria, Princetown 079059, Browns Creek Clay, Late Eocene, Aldingan (Yard grid ref. Aire 276179).

PL 3016, G.S.V. loc. Aw5, 220 mm bed with smooth pectinids, lowest fossiliferous outcrop at W end of Castle Cove, Glenaire, Victoria, Princetown 105044, Browns Creek Clay, Late Eocene, Aldingan (Yard grid ref. Aire 306163).

PL 3017, Cutting on Great Ocean Road about 0.4 km NW of Hamilton Creek bridge, Hordern Vale, Victoria, Princetown 168065, Browns Creek Clay, Late Eocene, Aldingan (Yard grid ref. Aire 372187).

PL 3018, Bed of Hamilton Creek, about 0.6 km upstream from the Great Ocean Road, Hordern Vale, Victoria, Otway 172069, Browns Creek Clay, Late Eocene, Aldingan (Yard grid ref. Otway 626192).

PL 3019, G.S.V. loc. Aw1, slips immediately N of Point Flinders, near Cape Otway, Victoria, Princetown 162983, Glenaire Clay, Early Oligocene (Yard grid ref. Aire 367097).

PL 3020, G.S.V. loc. Aw4, Middle Beach, Aire Coast, clays beneath limestone, Victoria, Princetown 121030, Glenaire Clay, Early Oligocene (Yard grid ref. Aire 323147).

PL 3021, Left bank Duck Creek opposite junction with Deep Creek, clay beneath limestone, Hordern Vale, Victoria, Princetown 168034, Glenaire Clay, Late Eocene (Yard grid ref. Aire 374152).

PL 3022, Cliff section Addiscot Beach, beds Bl09-107, SW of small gully, clay overlying Demons Bluff Formation, Victoria, Torquay BT619490, Jan Juc Formation, Late Oligocene, Janjukian (Yard grid ref. Anglesea 354675. Lower Jan Juc Formation).

PL 3023, Addiscot Beach, Bed Bl00, clay immediately beneath the Point Addis Limestone, SW side of Bell Headland, Victoria, Torquay BT620491, Jan Juc Formation, Late Oligocene, Janjukian (Yard grid ref. Anglesea 356676).

PL 3024, Cliff section opposite Bird Rock, below Bird Rock cap, Torquay, Victoria, Torquay 642518, Jan Juc Formation, Late Oligocene, Janjukian (Yard grid ref. Anglesea 356676).

PL 3025, Lower part of cliff, Fishermans Steps, 1.5 km SW of Bird Rock, Torquay, Victoria, Inverleigh 632506, Jan Juc Formation, Late Oligocene, Janjukian (Yard grid ref. Anglesea 372697).

PL 3026, Left bank of Barwon River, 5.5 km S of Birregurra, Victoria, Colac 413473, Gellibrand Marl, Late Oligocene, Janjukian (Yard grid ref. Colac 863645).

PL 3027, South side of small gully about 300 m E of left bank of Moorabool River, about 20 m above river, allotment 13e Parish of Darriwill, Victoria, Bacchus Marsh 509931, Lower Maude Limestone, Late Oligocene, Janjukian (Yard grid ref. Meredith 237158).

PL 3028, Lower bed in cliff between Fossil Bluff and 1.5 km NW towards Table Cape, Wynyard, Tasmania, Table Cape 930630, Freestone Cove Sandstone, Early Miocene, early Longfordian (Yard grid ref. Table Cape 750530).

PL 3029, Upper bed in cliff between Fossil Bluff and 1.5 km NW towards Table Cape, Wynyard, Tasmania, Table Cape 930630, Fossil Bluff Sandstone, Early Miocene, early Longfordian (Yard grid ref. Table Cape 750530).

PL 3030, N slope, Cape Grim, 5.5 km NW of Woolnorth Homestead, Tasmania, Welcome 045939, Cape Grim Beds, Early Miocene, Longfordian.

PL 3031, Marl pit on Misery Knob about 0.8 km SW of Doctors Rocks and 0.4 km NW of Burnie sheet fossil locality, Wynyard, Tasmania, Hellyer 972585, Fossil Bluff Sandstone, Early Miocene, early Longfordian (Yard grid ref. Burnie 796480).

PL 3032, Cliff 30–40 m NE of Bird Rock at SW end of Jan Juc Beach, Torquay, Victoria, Inverleigh BT 642519, Puebla Formation, Early Miocene, Longfordian (Yard grid ref. Anglesea 379706).

PL 3033, Cliff on left bank of Barwon River below golf course, Birregurra, Victoria, Colac 435522, Gellibrand Marl, Early Miocene, Longfordian (Yard grid ref. Colac 885701).

PL 3034, Surface material from slips on S bank of Lake Costin, 0.5 km W of Hordern Vale–Red Hill Road, Hordern Vale, Victoria, Princetown 156043, Fishing Point Marl, lower mollusc horizon, Early Miocene, Longfordian (Yard grid ref. Aire 363163).

PL 3035, Cliff section SE of Fischers Point about 10 m above Lake Craven, Hordern Vale, Victoria, Princetown 155040, Fishing Point Marl, lower mollusc horizon, Early Miocene, Longfordian (Yard grid ref. Aire 358159)

PL 3036, Cliff 30 m above Lake Craven, 0.4 km NW of Red Hill, Hordern Vale, Victoria, Princetown 156030, Fishing Point Marl, lower mollusc horizon, Early Miocene, Longfordian (Yard grid ref. Aire 359149).

PL 3037, Cutting on fence on N side of camping reserve, Hordern Vale, 0.4 km SW of Red Hill, Victoria, Princetown 156025, Fishing Point Marl, lower mollusc horizon, Early Miocene, Longfordian (Yard grid ref. Aire 358143).

PL 3038, G.S.V. loc. Ad14, shore platform 2.4 km N of Curlewis railway crossing, section 24, block 1, Parish of Moolap, Victoria, Portarlington 823733, Fyansford Formation, Early Miocene, Batesfordian (Yard grid ref. Portarlington 578937. Marked on Quarter sheet 23 SW).

PL 3039, G.S.V. loc. Ad12, shore platform, NE corner section 23, block 1, Parish of Moolap, Victoria, Geelong 807732, Fyansford Formation, Early Miocene, Batesfordian (Yard grid ref. Geelong 561936. Marked on Quarter sheet 23 SW).

PL 3040, Belmont shaft at 18 m at "New Geelong" between Colac Road and Germantown Road, close to the latter, Victoria, Fyansford Formation, Early Miocene, Batesfordian (Shaft sunk about 1891, probably in Allot. 9, Parish of Barrarbool).

PL 3041, G.S.V. loc. Fe20, bed 7, 20 m above flood plain, Amphitheatre, S of Bull Island, left bank of Yarrowee River, Victoria, Ballarat 615928, Fyansford Formation, Early Miocene, Batesfordian (Yard grid ref. Rokewood 058156).

PL 3042, Left bank of Yarrowee River (= Leigh) about 30 m above river, above prominent limestone bands, S of small gully, Victoria, Ballarat 605922, Fyansford Formation, Early Miocene, Batesfordian (Yard grid ref. Rokewood 050148).

PL 3043, Cutting on Lavers Hill–Cobden Road, 1.3 km S of Kennedys Creek, Victoria, Princetown 969253, Gellibrand Marl, Early Miocene, Batesfordian (Yard grid ref. Princetown 155390).

PL 3044, Chapple's locality, landslips on Latrobe Creek 1.2 km NW of Princetown, Victoria, Gellibrand Marl, Early Miocene, Batesfordian.

PL 3045, Cutting on Great Ocean Road, 0.8 km N of Princetown, Victoria, Princetown 877159, Gellibrand Marl, Early Miocene, Batesfordian (Yard grid ref. Princetown 053286).

PL 3046, Cutting on Lavers Hill–Cobden Road, 0.6 km S of Kennedys Creek, Victoria, Princetown 968256, Gellibrand Marl, Early Miocene, Batesfordian (Yard grid ref. Princetown 156395).

PL 3047, Cutting on Princetown–Simpson Road, 4.5 km N of Great Ocean Road, Victoria, Princetown 856211, Gellibrand Marl, Early Miocene, Batesfordian (Yard grid ref. Princetown 032348).

PL 3048, Cutting on Boornong (= Steens) Road, 2.1 km N of Cooriemungle Road, Cooriemungle, Victoria, Princetown 810337, Gellibrand Marl, Early Miocene, Batesfordian (Yard grid ref. Princetown 982485).

PL 3049, Cutting on SE side of Great Ocean Road, about 50 m NE of Serpentine (= Latrobe) Creek, Princetown, Victoria, Princetown 872149, Gellibrand Marl, Early Miocene, Batesfordian (Yard grid ref. Princetown 049278).

PL 3050, Top of section, close to Fischers Point, 25 m above Lake Craven, Hordern Vale, Victoria, Fishing Point Marl, Fishing Point Marl, upper mollusc horizon, Early Miocene, Batesfordian (Yard grid ref. Aire 352163).

PL 3051, Left bank of Glenelg River just above water level at S end of Devils Den, Myaring, Victoria, Dartmoor WD207188, Port Campbell Limestone, Myaring Member, Early Miocene, Longfordian.

PL 3052, G.S.V. loc. W/TM1, left bank of Moorabool River, 2.8 km S of Maude in small slip amphitheatre about 30 m above river, allot. 12a and 13e Parish of Darriwil, Victoria, Bacchus Marsh 510925, Upper Maude Limestone, Early Miocene, Longfordian (Yard grid ref. Meredith 238151. Quarter sheet 19 SW).

PL 3053, G.S.V. loc. W/TM2, left bank of Moorabool River, 3 km S of Maude, Victoria, Bacchus Marsh 511922, Upper Maude Limestone, Early Miocene, Longfordian (Yard grid ref. Meredith 239147. Marked on Quarter sheet 19 SW).

PL 3054, G.S.V. loc. F31, at water level in left bank of Mitchell River, Skinners, SW corner of allotment 29A1, Parish of Wuk Wuk., Victoria, Stratford 433167, Wuk Wuk Marl, Early Miocene, Batesfordian (Yard grid ref.

Stratford 439382. Marked on Wuk Wuk geological parish plan. Base of Wuk Wuk Marl).

PL 3055, Cliff and shore platform on south side of Golf Course, Flinders, Victoria, Western Port 268387, Flinders Limestone, Early Miocene, Batesfordian (Yard grid ref. Western Port 061553).

PL 3056, Cutting on Princetown–Simpson Road, 4 km N of Ocean Road, Victoria, Princetown 857210, Gellibrand Marl, Middle Miocene, Balcombian (Yard grid ref. Princetown 033346).

PL 3057, Block 256 (S.M.Roberts) 6.5 km S of Simpson on Princetown Road, 2nd gully E of road approx., Victoria, Princetown 900334, Gellibrand Marl, Middle Miocene, Balcombian (Yard grid ref. Princetown 082480).

PL 3058, Bend in Waarre Road, opposite old house, 1.2 km NE of Eastern Creek Road, Waarre, Victoria, Princetown 779270, Gellibrand Marl, Middle Miocene, Balcombian (Yard grid ref. Princetown 948412).

PL 3059, Cutting on Great Ocean Road, 1.9 km NE of Princetown, Victoria, Princetown 884165, Gellibrand Marl, Middle Miocene, Balcombian (Yard grid ref. Princetown 063297).

PL 3060, Dam on Lot 393 (A. Smith) in 2nd gully NE of house, tributary of Tomahawk Creek, Victoria, Princetown 968303, Gellibrand Marl, Middle Miocene, Balcombian (Yard grid ref. Princetown 157454).

PL 3061, Slips in small gully on N side of Eastern Creek and 0.75 km E of Port Campbell Road, Victoria, Princetown 761278, Gellibrand Marl, Middle Miocene, Balcombian (Yard grid ref. Princetown 928419).

PL 3062, Cutting on Cooriemungle Road, just S of Guys Road, 1.4 km NE of Gallum Road, Victoria, Princetown 861325, Gellibrand Marl, Middle Miocene, Balcombian (Yard grid ref. Princetown 919425).

PL 3063, Cutting at junction of Ford Road and Latrobe Road, N of Princetown, Victoria, Princetown 888203, Gellibrand Marl, Middle Miocene, Balcombian (Yard grid ref. Princetown 066335).

PL 3064, Cutting on Port Campbell–Timboon Road, 0.7–1.5 km N of Eastern Creek Road, Victoria, Princetown 752283, Gellibrand Marl, Middle Miocene, Balcombian (Yard grid ref. Princetown 919425).

PL 3065, Cutting on Eastern Creek Road, 0.5 km E of Port Campbell Road, Victoria, Princetown 758273, Gellibrand Marl, Middle Miocene, Balcombian? (Yard grid ref. Princetown 924416).

PL 3066, Cutting on Port Campbell–Timboon road, 0.75 km S of Eastern Creek Road, Victoria, Princetown 749268, Gellibrand Marl, Middle Miocene, Balcombian (Yard grid ref. Princetown 916408).

PL 3067, Low cliff immediately SE of rocks at SE end of Gibson Beach, 3.4 km NW of Point Ronald, Princetown, Victoria, Princetown 848162, Gellibrand Marl, Middle Miocene, Balcombian (Yard grid ref. Princetown 027292).

PL 3068, Low cliff at SE end of Gibson Beach, 3.9 km NW of Point Ronald, Victoria, Princetown 846165, Gellibrand Marl, Middle Miocene, Balcombian (Yard grid ref. Princetown 025295).

PL 3069, Cutting on Shelford–Inverleigh road, Red Bluff, 4.8 km N of Hamilton Highway, Victoria, Colac 616847, Fyansford Formation, Middle Miocene, Balcombian (Yard grid ref. Beeac 064066).

PL 3070, Cliff on left bank of Yarrowee (= Leigh) River at "Farrells", Allotment 44, Parish of Carrah, Victoria, Inverleigh 337823, Fyansford Formation, Middle Miocene, Balcombian (Yard grid ref. Geelong 090042).

PL 3071, 0–5 m in cliff on left bank of Native Hut Creek, 1 km SW of Glenleigh, Victoria, Inverleigh 454816, Fyansford Formation, Middle Miocene, Balcombian (Yard grid ref. Geelong 173034).

PL 3072, Approx. G.S.V. loc. Ad28, Orphanage Hill, Fyansford, Victoria, Geelong 648748, Fyansford Formation, Middle Miocene, Balcombian (Yard grid ref. Geelong 386956. Quarter sheet 24 SE (not marked)).

PL 3073, 12–15 m in a caisson shaft of SE Trunk Sewer on S side of Centre Dandenong Road, about 200 m E of Boundary Road, Dingley, Victoria, Newport Formation, Middle Miocene, Balcombian (Yard grid ref. Ringwood 148173).

PL 3074, 18–20 m in caisson shaft of SE Trunk Sewer, NE corner of Boundary Road and Junction Road, Dingley, Victoria, Newport Formation, Middle Miocene, Balcombian.

PL 3075, Spoil from SE Trunk Sewer between Brayside Shaft and shaft on S side of Centre Dandenong Road about 200 m E of Boundary Road, Dingley, Victoria, Newport Formation, Middle Miocene, Balcombian

PL 3076, Bed of Earimil (= Dennant) Creek about 50 m downstream from older volcanics, Victoria, Western Port 316724, Balcombe Clay, Middle Miocene, Balcombian (Yard grid ref. Cranbourne 120918).

PL 3077, Altona Bay Coal Shaft No.2 (1908), Victoria, Newport Formation, Middle Miocene, Balcombian.

PL 3078, Shore platform at Fossil Beach, 3 km S of Mornington, Victoria, Western Port 273658, Balcombe Clay, Middle Miocene, Balcombian (Yard grid ref. Cranbourne 072845).

PL 3079, Upstream section, Gunyoung (= Grices) Creek, Mt Eliza, Victoria, Western Port 311710, Balcombe Clay, Middle Miocene, Balcombian (Yard grid ref. Cranbourne 111910. Section 8A of Gostin (1966) *Proceedings of the Royal Society of Victoria* 79: 467).

PL 3080, 0–2 m above water on right bank of Moorabool River, NNW of Dryden Farm, Victoria, Geelong 637778, Fyansford Formation, Middle Miocene, Balcombian (Yard grid ref. Geelong 375990).

PL 3081, Clay overburden just above limestone, Australian Cement Quarry, right bank of Moorabool River, Batesford, Victoria, Geelong 625785 approx., Fyansford Formation, Middle Miocene, Balcombian (Yard grid ref. Geelong 360000 approx).

PL 3082, Clifton Bank, Muddy Creek, 7 km W of Hamilton, Victoria, Coleraine WD 818225, Muddy Creek Formation, Middle Miocene, Balcombian.

PL 3083, Top of Muddy Creek Formation on right bank of Muddy Creek about 100 m downstream from McDonalds Bank, Victoria, Coleraine WD 825219, Muddy Creek Formation, Middle Miocene, Balcombian.

PL 3084, Small gully 4.8 km S of Morgan Ferry–Cadell road on left bank of Murray River opposite Brenda Park Homestead, South Australia, Morgan 790280, Morgan

Limestone, Cadell Marl Lens, Middle Miocene, Balcombian (Renmark 1:250,000 sheet grid ref. 268789).

PL 3085, E and SE side of Lake Keilambete, Terang, Victoria, Mortlake 650688, Gellibrand Marl, Middle Miocene, Bairnsdalian (Yard grid ref. Mortlake 810868).

PL 3086, E bank of Lake Gnotuk, Camperdown, Victoria, Gellibrand Marl, Middle Miocene, Bairnsdalian.

PL 3087, NW shore of Lake Bullen Merri, Camperdown, Victoria, Corangamite 830653, Gellibrand Marl, Middle Miocene, Bairnsdalian.

PL 3088, NW end of Gibson Beach, 4.5 km NW of Point Ronald, Princetown, Victoria, Princetown 843168, Gellibrand Marl, Middle Miocene, Bairnsdalian (Yard grid ref. Princetown 022298).

PL 3089, Clay beneath limestone, cutting on track up to Victorian Agriculture Lime limestone quarry, Curdie, Victoria, Mortlake 709430, Gellibrand Marl, Middle Miocene, Bairnsdalian (Yard grid ref. Panmure 871589).

PL 3090, Cutting on Timboon–Scotts Creek Road, 2.4 km NE of Timboon, Victoria, Mortlake 740400, Gellibrand Marl, Middle Miocene, Bairnsdalian (Yard grid ref. Panmure 905554).

PL 3091, Large cutting opposite shops in Timboon, Victoria, Mortlake 727384, Gellibrand Marl, Middle Miocene, Bairnsdalian (Yard grid ref. Panmure 891536).

PL 3092, Cutting on Timboon–Port Campbell Road about 100 m S of Timboon shopping centre, Victoria, Mortlake 728382, Gellibrand Marl, Middle Miocene, Bairnsdalian (Yard grid ref. Panmure 893534).

PL 3093, G.S.V. loc. Awl0, 0–10 ft above HWL, Rutledges Beach, E side of the mouth of Rutledge Creek, Victoria, Princetown 783209, Port Campbell Limestone, Rutledge Creek Member, Middle Miocene, Bairnsdalian (Yard grid ref. Princetown 955345).

PL 3094, Notch at the Amphitheatre, mouth of Ingle Creek, Victoria, Princetown 779211, Port Campbell Limestone, Rutledge Creek Member, Middle Miocene, Bairnsdalian (Yard grid ref. Princetown 947346).

PL 3095, G.S.V. loc. Adl5, Western Beach, Corio Bay, Geelong, Victoria, Inverleigh 682754, Fyansford Formation, Middle Miocene, Bairnsdalian (Yard grid ref. Geelong 426960. Locality indicated on Quarter sheet 24 SE by Note 4).

PL 3096, 1–3 m above river in cliff, left bank of Yarrowee (= Leigh) River, due N of Inverleigh, Victoria, Inverleigh 420792, Fyansford Formation, Middle Miocene, Bairnsdalian (Yard grid ref. Geelong 138007).

PL 3097, 0–2 m above water, cliff on left bank of Barwon River, Section 2h, Parish of Murgheboluc, Victoria, Inverleigh 475776, Fyansford Formation, Middle Miocene, Bairnsdalian (Yard grid ref. Geelong 197988).

PL 3098, Right bank of Native Hut Creek, 100 m S of Hamilton Highway, Victoria, Inverleigh 459794, Fyansford Formation, Middle Miocene, Bairnsdalian (Yard grid ref. Geelong 181009).

PL 3099, 0–3 m in the cliff on the left bank of Barwon River about 500 m downstream from junction with Bruces Creek, Section 4a, Parish of Murgheboluc, Victoria, Inverleigh 462788, Fyansford Formation, Middle Miocene, Bairnsdalian (Yard grid ref. Geelong 184003).

PL 3100, 0–3 m in the cliff on the left bank of Barwon River about 500 m downstream from junction with Bruces Creek, Section 4a, Parish of Murgheboluc, Victoria, Inverleigh 503770, Fyansford Formation, Middle Miocene, Bairnsdalian (Yard grid ref. Geelong 229983).

PL 3101, Cliff, Moorpanyal Park, North Shore, Corio Bay, Geelong, Victoria, Geelong 696796, Fyansford Formation, Middle Miocene, Bairnsdalian (Yard grid ref. Geelong 007441).

PL 3102, Bed of Warrambine Creek, immediately downstream from Winchelsea–Inverleigh Road bridge, Victoria, Geelong 375769, Fyansford Formation, Middle Miocene, Bairnsdalian (Yard grid ref. Geelong 090982).

PL 3103, Downstream section at mouth of Gunyoung (= Grices) Creek, Mt Eliza., Victoria, Western Port 309712, Balcombe Clay, Middle Miocene, Bairnsdalian (Yard grid ref. Cranbourne 111910. Section 8B, beds a–f of Gostin (1966) *Proceedings of the Royal Society of Victoria* 79: 467).

PL 3104, Cliff section S of Manyung Rocks and N of sewer pipe and jetty, Mt Eliza, Victoria, Western Port 305705, Balcombe Clay, Middle Miocene, Bairnsdalian (Yard grid ref. Cranbourne 106903. Bed 10B(a) of Gostin (1966) *Proceedings of the Royal Society of Victoria* 79: 459–512).

PL 3105, Quarry in Allotment 15, Section A, Parish of Moormuing, 400 m W of Pleasant Creek, Hillside, East Gippsland, Victoria, Bairnsdale 455136, Gippsland Limestone, Bairnsdale Limestone Member, Middle Miocene, Bairnsdalian (Yard grid ref. Bairnsdale 463347).

PL 3106, Left bank, Nowa Nowa Arm of Lake Tyers, Victoria, Orbost 997177, Gippsland Limestone, Bairnsdale Limestone Member, Middle Miocene, Bairnsdalian (Yard grid ref. Hartland 055386).

PL 3107, McCraes Quarry, left bank of Toorloo Creek, Victoria, Orbost 913163, Gippsland Limestone, Bairnsdale Limestone Member, Middle Miocene, Bairnsdalian (Yard grid ref. Hartland 964372).

PL 3108, Cliff just beneath Bairnsdale Limestone, left bank Mitchell River, G.S.V. loc. F5O, 5l, SW corner of Allotment 15, Parish of Wy Yung (Driers), Victoria, Bairnsdale 501145, Wuk Wuk Marl, Middle Miocene, Bairnsdalian (Marked on Bairnsdale 1:63,36O Geological Sheet, grid ref. 513358, Top of Wuk Wuk Marl).

PL 3109, Right bank of Toorloo Arm of Lake Tyers, 0.5 km S of bridge, Victoria, Orbost 932141, Tambo River Formation?, Late Miocene, Mitchellian (Yard grid ref. Hartland 985347).

PL 3110, Large cutting on left bank of Tambo River, 200 m S of Princes Highway, Swan Reach, Victoria, Bairnsdale 759132, Tambo River Formation, Late Miocene, Mitchellian (Yard grid ref. Bairnsdale 795340).

PL 3111, Right bank of Mitchell River, Moondara Farm, about 50 m N of first gully SW of house (Rose Hill), Victoria, Bairnsdale 500132, Tambo River Formation, Rose Hill Marl Member, Late Miocene, Mitchellian (Yard grid ref. Bairnsdale 512344).

PL 3112, G.S.V. loc. F7l, right bank of Mitchell River, immediately SW of small gully on "Carinya", Victoria, Bairnsdale 503126, Tambo River Formation, Rose Hill Marl Member, Late Miocene, Mitchellian (Marked on Bairnsdale 1:63,36O Geologieal Sheet, grid ref. 514337).

PL 3113, Right bank of Nowa Nowa Arm of Lake Tyers, Victoria, Orbost 991153, Jemmys Point Formation, Late Miocene–Early Pliocene, Cheltenhamian? (Yard grid ref. Hartland 961302).

PL 3114, Cutting on Princes Highway, beds 6a,b, lowest shell bed and nearest bridge, NE side of Bunga Creek, Victoria, Orbost 911100, Jemmys Point Formation, Late Miocene–Early Pliocene, Cheltenhamian (Yard grid ref. Harland 961302).

PL 3115, Left bank of SE end of Lake Bunga near old trambridge (Lake Bunga Crossing), Victoria, Orbost 918085, Jemmys Point Formation, Late Miocene–Early Pliocene, Cheltenhamian (Yard grid ref. Hartland 967285).

PL 3116, Outcrop in road ditch, 20 m W of Lakes Entrance Development No.1 oil bore, right bank of Bunga Creek, Victoria, Orbost 912096, Jemmys Point Formation, Late Miocene–Early Pliocene, Cheltenhamian (Yard grid ref. Hartland 964298).

PL 3117, Cutting, Princes Highway, NE side of Bunga Creek, second lowest shell bed nearest bridge (bed b), Victoria, Orbost 911100, Jemmys Point Formation, Late Miocene–Early Pliocene, Cheltenhamian (Yard grid ref. Hartland 961302).

PL 3118, G.S.V. loc. F2, floor and sides of tramway cutting N of Scrivenors Road, Mississippi Creek, Victoria, Bairnsdale 836116, Jemmys Point Formation, Late Miocene–Early Pliocene, Cheltenhamian (Marked on Bairnsdale 1:63,360 Geological Sheet, grid ref. 878322. Same as PL532).

PL 3119, G.S.V. loc. F1, Ritchies Cutting, Scrivenors Road, W side of Mississippi Creek, Victoria, Bairnsdale 835114, Jemmys Point Formation, Late Miocene–Early Pliocene, Cheltenhamian (Marked on Bairnsdale 1:63,360 Geological Sheet, grid ref. 878329).

PL 3120, Cutting N side of John Street, Lakes Entrance, E of small gully, SE corner of allotment 30A, Section A, Parish of Colquhoun, Victoria, Bairnsdale 869075, Jemmys Point Formation, Late Miocene–Early Pliocene, Cheltenhamian (Yard grid ref. Bairnsdale 915275).

PL 3121, Shells in soil, 0–4 m above high water mark, right bank of North Arm at end of Hunters Road, Kalimna, Victoria, Bairnsdale 869075, Jemmys Point Formation, Late Miocene–Early Pliocene, Cheltenhamian (Yard grid ref. Bairnsdale 903288).

PL 3122, Bluff on W side North Arm, Kalimna, S of Hunters Gully, Victoria, Bairnsdale 865074, Jemmys Point Formation, Late Miocene–Early Pliocene, Cheltenhamian (Yard grid ref. Bairnsdale 909275).

PL 3123, Just below high tide level, E side of North Arm, on point below Ferndale Parade, Lakes Entrance, Victoria, Bairnsdale 867075, Jemmys Point Formation, Late Miocene–Early Pliocene, Cheltenhamian (Yard grid ref. Bairnsdale 913276).

PL 3124, Bluff on W side of North Arm, N side of Hunters Gully, Lakes Entrance, 0–1 m above high water mark, Victoria, Bairnsdale 864077, Jemmys Point Formation, Late Miocene–Early Pliocene, Cheltenhamian (Yard grid ref. Bairnsdale 909278).

PL 3125, Outcrop in road, 15.2 above water, E bank North Arm opposite end of Hunters Road, Lakes Entrance, Victoria, Bairnsdale 861087, Jemmys Point Formation, Late Miocene–Early Pliocene, Cheltenhamian (Yard grid ref. Bairnsdale 906289).

PL 3126, About 3 m above water on left bank of North Arm, below Nautilus Way, Lakes Entrance, Victoria, Bairnsdale 867080, Jemmys Point Formation, Late Miocene–Early Pliocene, Cheltenhamian (Yard grid ref. Bairnsdale 911282).

PL 3127, Shells loose in soil in tramway cutting, Mississippi Creek near terminus, Victoria, Jemmys Point Formation, Late Miocene–Early Pliocene, Cheltenhamian.

PL 3128, Cutting at bridge on farm track, right bank of first main northern tributary of Bunga Creek, SE corner, allotment 145, Parish of Colquhoun, Victoria, Orbost 897111, Jemmys Point Formation, Late Miocene–Early Pliocene, Cheltenhamian (Yard grid ref. Hartland 945318).

PL 3129, Sands exposed in sewer tunnel, 12.2 m below Wright Street, Bentleigh, between Centre Road and Beech Street, Victoria, Black Rock Sandstone, Late Miocene–Early Pliocene, Cheltenhamian.

PL 3130, Shelly clay at base of cliff at high tide mark opposite Dogtooth Beacon between Deauville Street and Hutchinson Avenue, Beaumaris, Victoria, Black Rock Sandstone, Late Miocene–Early Pliocene, Cheltenhamian.

PL 3131, Left bank Moorabool River, track on hillside about 300 m N of Moorabool Viaduct, Victoria, Geelong 616827, Moorabool Viaduct Sands, Late Miocene–Early Pliocene, Cheltenhamian (Yard grid ref. Geelong 354045).

PL 3132, Bed of Spring Creek below tuff band, 800 m NE of Spring Creek Homestead, Minhamite, Victoria, Warrnambool 248925, Late Miocene–Early Pliocene, Cheltenhamian (Yard grid ref. Hawkesdale 367129).

PL 3133, Left bank of River Murray at Wookool Bend about 3 m above water level, Loxton, South Australia, Renmark VG563869, Bookpurnong Beds, Late Miocene–Early Pliocene, Cheltenhamian.

PL 3134, Cutting behind Loxton Pumping Station, North Loxton, South Australia, Renmark VG623912, Loxton Sands, Pliocene, Kalimnan?

PL 3135, Cutting on Kingston–Loxton Road at Yatco Lagoon, 137 mile post, 10.0 km SE of Kingston, South Australia, Loxton Sands, Pliocene, Kalimnan? (Yard grid ref. Renmark 1:250,000 337763).

PL 3136, Cutting on Kingston–Loxton Road at Yatco Lagoon, 11.8 km SE of Kingston, South Australia, Loxton Sands, Pliocene, Kalimnan? (Yard grid ref. Renmark 1:250,000 336762).

PL 3137, Forsyths Bank, left bank of Grange Burn about 1 m above water level, Victoria, Coleraine WD832237, Grange Burn Formation, Early Pliocene, Kalimnan (See map by Spencer-Jones, in Wopfner and Douglas (eds). 1971. *The Otway Basin of southeastern Australia.* Special Bulletin Geol. Surveys S. Aust. Vict., figs 12–1, p. 243).

PL 3138, Bed of Grange Burn at the E end of "Porphry Gorge" by the "rock stack", Victoria, Coleraine WD837235, Grange Burn Formation, Early Pliocene, Kalimnan.

PL 3139, Bed of Muddy Creek at McDonalds Bank, Yulecart, Victoria, Coleraine WD826219, Grange Burn Formation, Early Pliocene, Kalimnan (See map by

Spencer-Jones, in Wopfner and Douglas (eds). 1971. *The Otway Basin of southeastern Australia.* Special Bulletin Geol. Surveys S. Aust. Vict., figs 12-1, p. 243).

PL 3140, Cutting on Princes Highway, bed 6d, NE side of Bunga Creek, Victoria, Orbost 912102, Jemmys Point Formation, Early Pliocene, Kalimnan (Yard grid ref. Hartland 962303).

PL 3141, Cutting on Princes Highway, SW side of Bunga Creek, bed 5c, upper Jemmys Point shell bed, Victoria, Orbost 907097, Jemmys Point Formation, Early Pliocene, Kalimnan (Yard grid ref. Hartland 956300).

PL 3142, Cutting on Princes Highway, NE side of Bunga Creek, bed 6g, uppermost shell bed, Victoria, Orbost 912103, Jemmys Point Formation, Early Pliocene, Kalimnan (Yard grid ref. Hartland 963304).

PL 3143, Cliff on left bank of Nowa Nowa Arm of Lake Tyers, Victoria, Orbost 997132, Jemmys Point Formation, Early Pliocene, Kalimnan (Yard grid ref. Hartland 056337).

PL 3144, Cliff section of S side of Lake Tyers Aboriginal Station, Victoria, Orbost 958111, Jemmys Point Formation, Early Pliocene, Kalimnan (Yard grid ref. Hartland 012315).

PL 3145, Cliff on W bank of Lake Tyers, about 7 m above water, NE corner of allotment 6, section F, Parish of Colquhoun, Victoria, Orbost 948109, Jemmys Point Formation, Early Pliocene, Kalimnan (Yard grid ref. Hartland 002313).

PL 3146, 3 m above water on E bank of Nowa Nowa Arm of Lake Tyers, 1 km NE of Tyers House, Victoria, Orbost 989121, Jemmys Point Formation, Early Pliocene, Kalimnan (Yard grid ref. Hartland 047324).

PL 3147, G.S.V. loc. F7, shell bed in cliff behind Nyerimalang Jetty, about 3 m above high tide, Victoria, Bairnsdale 816072, Jemmys Point Formation, Early Pliocene, Kalimnan (Yard grid ref. Hartland 857274. Marked on Colquhoun geological parish plan).

PL 3148, 0·4 m above high water mark in cliff E of Kalimna Jetty, Kalimna, Victoria, Bairnsdale 840070, Jemmys Point Formation, Early Pliocene, Kalimnan (Yard grid ref. Bairnsdale 883271. Lower shell bed in Jemmys Point Formation).

PL 3149, Shell band exposed in cutting on Princes Highway, Jemmys Point, Victoria, Bairnsdale 850068, Jemmys Point Formation, Early Pliocene, Kalimnan (Yard grid ref. Bairnsdale 895262).

PL 3150, Shell band about 7 m above high water mark in cliff on E side of Hopkins Bight, Nungurner, Victoria, Bairnsdale 789069, Jemmys Point Formation, Early Pliocene, Kalimnan (Yard grid ref. Bairnsdale 826270).

PL 3151, Large cutting on Nyerimalang Estates Road, on right bank of Meringa Creek about 200 m S of Kalimna–Nungurner Road, Victoria, Bairnsdale 82507, Jemmys Point Formation, Early Pliocene, Kalimnan (Yard grid ref. Bairnsdale 866279. Same as PL 531).

PL 3152, Ditch on E side of Kalimna–Nungurner Road about 100 m N of Bridge over Meringa Creek, Victoria, Bairnsdale 825082, Jemmys Point Formation, Early Pliocene, Kalimnan (Yard grid ref. Bairnsdale 8662883).

PL 3153, Bed of Minnie Creek, allotment 27, Parish of Myaring, Victoria, Dartmoor WD218178, Whalers Bluff Formation, Late Pliocene–Pleistocene, Werrikooian.

PL 3154, Base of large quarry, right bank of Glenelg River, about 10 m above river, allotment 3, Parish of Wilkin, Victoria, Whalers Bluff Formation, Late Pliocene–Pleistocene, Werrikooian.

PL 3155, *Pecten* bed in grey sand, quarry on E side of McKinnon Road, about 1 km N of Myaring Bridge road., Victoria, Dartmoor WD220208, Whalers Bluff Formation, Crawford Member, Late Pliocene–Pleistocene, Werrikooian.

PL 3156, Loose shells in Glenelg River derived from slips at Roscoes Cliff, Victoria, Dartmoor WD225235, Whalers Bluff Formation, Late Pliocene–Pleistocene, Werrikooian.

PL 3157, Shells in sand about 7 m below *Pecten* bed at SW end of Roscoes Cliff on left bank of Glenelg River, Victoria, Dartmoor WD219223, Whalers Bluff Formation, Late Pliocene–Pleistocene, Werrikooian.

PL 3158, Loose shells at ford, left bank of Limestone Creek about 3 m above water level, 100 m upstream from Glenelg River, Victoria, Dartmoor WD203184, Whalers Bluff Formation, Late Pliocene–Pleistocene, Werrikooian.

PL 3159, Top of cliff at small gully, 4.8 km S of Morgan Ferry–Cadell road on left bank of Murray River, South Australia, Morgan 790280, Norwest Bend Formation, Pliocene (Renmark 1:250,000 sheet grid ref. 268789).

PL 3160, Quarry at top of cliff, right bank of Murray River, E side of approach to Cadell Ferry, South Australia, Morgan 858344, Norwest Bend Formation, Pliocene (Renmark 1:250,000 sheet grid ref. 275796).

PL 3161, Pit on S side of Runymede Road, about 3 km E of Runymede Station, Sandford., Victoria, Gellibrand Marl, Sandford Limestone Member, Early Miocene, Longfordian.

PL 3162, Cutting on corner of Melrose (= Seaview Range) Road and Cooriemungle Road, about 2 km W of Cooriemungle., Victoria, Princetown XC788311, Gellibrand Marl, Middle Miocene, Balcombian.

PL 3163, Cutting on Williams Road, 0.6 km E of Boornong Road junction, Cowleys Creek, Victoria, Coorangamite XC815374, Gellibrand Marl, Early Miocene, Batesfordian.

PL 3164, Western slope of Meanarra Hill, 5 km E of Kalbarri, Western Australia, Gantheaume KQ250330, Toolonga Calcilutite, Late Cretaceous, Santonian.

PL 3165, Large Main Road Department quarry, 16 km S of Madura Roadhouse, Roe Plain, Western Australia, Burnabbie 1:250,000 sheet grid ref. 315643, Roe Calcarenite, Late Pliocene.

PL 3166, Test pits on E side of access road to Hampton Microwave Repeater Tower, 2.5 km N of Hampton, Roe Plain, Western Australia, Eucla 1:250,000 sheet grid ref. 365465, Roe Calcarenite, Late Pliocene.

PL 3167, Pit 1.6 km N of Hampton Microwave Repeater Tower, Roe Plain, Western Australia, Eucla 1:250,000 sheet grid ref. 365464, Roe Calcarenite, Late Pliocene.

PL 3168, At type locality of Merlinleigh Sandstone and from W side of small mesa immediately to the SE on W side of fence, about 1.5 km SE of Merlinleigh Station,

Western Australia, Mt Sandiman LU175087, Merlinleigh Sandstone, Late Eocene (Type locality of Formation).
PL 3169, Small knoll about 1 km SE of the type locality of Merlinleigh Station and immediately E of NS boundary fence, Mount Sandiman Station, 2.8 km SE of Merlinleigh homestead site, Western Australia, Mt Sandiman LU183076, Merlinleigh Sandstone, Late Eocene.
PL 3170, In third gully S of track NW from Merlinleigh Station homestead, where track crosses escarpment, 2 km NNE of homestead site, Western Australia, Mt Sandiman LU165110, Merlinleigh Sandstone, Late Eocene.
PL 3171, Gravel scrape beside Thomson Highway, 23.5 km N of Highway 1, N of Walpole, Western Australia, Deep River 1:50,000 sheet grid ref. 743487, Pallinup Siltstone, Late Eocene (Silicified fossils weathered out in situ from Pallinup Siltstone).
PL 3172, Spoil from 10 m foundation holes for Hampton Microwave Repeater Tower, 53 km E of Madura and 6.3 km S of Eyre Highway, Roe Plain, Western Australia, Eucla 1:250,000 sheet CK365462, Roe Calcarenite, Late Pliocene (Yard grid ref. Eucla 563045).

Appendix 2

Species whose general anatomy has been examined by the author

Volutinae

Lyria mitraeformis, Fusivoluta clarkei

Family uncertain

Notovoluta verconis, N. gardneri, N. kreusleri, Volutoconus bednalli, V. grossi helenae

Amoriinae

Amoria grayi, A. undulata, A. macandrewi, A. damoni, A. exoptanda, A. molleri, A. canaliculata, A. zebra, A. "volva", A. hunteri, A. ellioti, Nannamoria inopinata, N. guntheri, N. amicula.

Zidoninae

Ericusa sowerbyi, E. papillosa, E. serricata, E. fulgetrum, Livonia mamilla, L. roadnightae, L. nodiplicata, Melo amphora, Alcithoe arabica, Cymbiola magnifica, C. sophia, C. pulchra, C. thatcheri, C. vespertilio, C. nivosa, C. aulica.

Plate 1

Figure 1. *Leptoscapha crassilabrum* (Tate), T622A, holotype, Muddy Creek, ×3.2.

Figures 2, 4. *Lyria acuticostulata* sp. nov., P31145, holotype, Fossil Beach, ×1.9.

Figures 3, 5. *Lyria acuticostulata* sp. nov., P31147, paratype, Fossil Beach, ×1.9.

Figure 6. *Lyria gemmata* Tate, T613, holotype, McDonalds Bank, ×1.2.

Figure 7. *Lyria harpularia* Tate, T395 A, holotype, Muddy Creek, ×1.4.

Figures 8, 9. *Leptoscapha crassilabrum* (Tate), P32207, hypotype Gunyoung Creek, ×2.9.

Figures 10, 11. *Mitreola salaputium* sp. nov., WAM 79.386, holotype, Mount Franklin Rd, W.A., ×3.8.

Figures 12, 20. *Lyria harpularia* Tate, P31878, hypotype, Muddy Creek, ×1.4.

Figures 13, 14. *Lyria gemmata* Tate, P31876, hypotype, Spring Creek, ×1.9.

Figures 15, 16. *Mitreola salaputium* sp. nov., P50007, paratype, Mount Franklin Rd, WA. ×3.8.

Figures 17, 19. *Lyria harpularia* Tate, P31150, hypotype, Muddy Creek, ×1.4.

Figure 18,. *Lyria semiacuticostata* Pritchard, P2733, hypotype, Table Cape, Tasm., ×1.4.

Plate 2

Figure 1. *Lyria mitraeformis* (Lamarck), SAM D10185, holotype of *Lyria kimberi* Cotton, Port Lincoln, SA ×1.9.

Figure 2. *Notovoluta saginata* (Finlay), Z185, holotype of *Voluta lirata* Johnston, Table Cape, Tasm, ×1.

Figure 3. *Notovoluta ellipsoidea* (Tate), T601A, hypotype, Muddy Creek, ×1.

Figure 4. *Notovoluta occidua* Cotton, D14500, holotype, Hopetoun, W.A., ×1.4.

Figure 5. *Notovoluta verconis* (Tate), WAM 776-69, hypotype, Yankalilla Bay, SA, ×1.9.

Figures 6, 7. *Lyria semiacuticostata* Pritchard, P2653, holotype, Table Cape, Tasm, ×2.0.

Figure 8. *Lyria acuticosta* Chapman, P13165, syntype, Ooldea Well, SA, ×1.4.

Figures 9, 10. *Scaphella (Aurinia) johannae* sp. nov., P41757, holotype, Browns Creek, ×1.2.

Figures 11, 12. *Scaphella (Aurinia) johannae* sp. nov. P41758, paratype, Browns Creek, ×1.9.

Figure 13. *Lyria acuticostata* Chapman, P13164, syntype, Ooldea Well, SA, ×1.3.

Figures 14, 15. *Notovoluta cathedralis* (Tate), P32213, hypotype, Clifton Bank, ×1.4.

Plate 3

Figures 1, 5. *Notovoluta lintea* (Tate), P32219, hypotype, S of Morgan, SA, ×1.9.

Figure 2. *Notovoluta ellipsoidea* (Tate), T601C, holotype, Muddy Creek, ×1.

Figures 3, 4. *Notovoluta linigera* sp. nov., P32218, paratype, SE of Fischer Point, ×1.4.

Figures 6, 10. *Notovoluta linigera* sp. nov. P32216, holotype; SE of Fischer Point ×1.9.

Figures 7, 9. *Notovoluta variculifera* sp. nov., P48599, holotype, Browns Creek, ×1.9.

Figures 8, 15. *Notovoluta capitonica* sp. nov., P32209, paratype, Browns Creek, ×1.9.

Figures 11, 12. *Notovoluta capitonica* sp. nov., P32210, paratype, Browns Creek, ×1.7.

Figures 13, 14. *Notovoluta variculifera* sp. nov., P48600, paratype, Browns Creek, ×1.9.

Plate 4

Figure 1 . *Notovoluta tabulata* (Tate), T611A, holotype, Tarcena, NSW, ×1.4.

Figures 2, 4. *Notovoluta pseudolirata* (Tate), P32211, hypotype, Clifton Bank, ×1.1.

Figures 3, 5. *Notovoluta cathedralis* (Tate), T596B, holotype, Muddy Creek, ×1.5, ×1.

Figures 6, 10. *Notovoluta tabulata* (Tate), SAM P5740b, hypotype, Mindarie, SA, ×1.9.

Figure 7. *Notovoluta verconis* (Tate), D442, holotype, St Vincents Gulf, SA, ×1.5.

Figure 8. *Notovoluta tabulata* (Tate), SAM P5740a, hypotype, Mindarie SA, ×1.6.

Figure 9. *Notovoluta lintea* (Tate), T600, holotype, S of Morgan, SA, ×1.2.

Figures 11, 14. *Notovoluta differta* sp. nov., P32221, holotype, Kennedys Creek, ×1.4.

Figures 12, 13. *Notovoluta differta* sp. nov., P32222, paratype, Curlewis, ×1.4.

Plate 5

Figures 1, 7. *Notovoluta kreuslerae kreuslerae* (Angus), D8322, holotype of *Voluta rossiteri* Brazier, 1890, Lakes Entrance, ×0.7.

Figure 2. *Notovoluta pseudolirata* (Tate), T608C, holotype, Muddy Creek, ×1.1.

Figure 3. *Notovoluta verconis* (Tate), WAM 776-69, Yankalilla Bay, SA, ×1.5.

Figures 4, 5. *Notovoluta ellipsoidea* (Tate), P13250, holotype of *Voluta (Aulica) sexuaplicata* Chapman, 1922, Clifton Bank, ×1.

Figures 6, 13. *Notovoluta baconi* Wilson, WAM 1565-70, holotype, W of Wedge Is., WA, ×1.2.

Figure 8. *Notovoluta saginata* (Finlay), TM 1072, holotype, Table Cape, ×1.1.

Figure 9. *Notovoluta occidua* Cotton, D14500, holotype, Hopetoun, WA, ×1.5.

Figures 10, 11. *Notovoluta pseudolirata* (Tate), WAM 131-64, hypotype, W of Rottnest Is., WA, ×1.6.

Figure 12. *Notovoluta pseudolirata* (Tate), WAM 470-71, hypotype, NW of Rottnest Isl. WA, ×1.5.

Plate 6

Figures 1, 2. *Amoria undulata undulata* (Lamarck), P6593, hypotype, Jemmys Point, ×0.7.

Figures 3, 7. *Amoria undulata undulata* (Lamarck), P34267, hypotype, Rose Hill, ×1.

Figure 4. *Amoria costellifera* (Tate), T603, holotype, Muddy Creek, ×1.

Figures 5, 9. *Amoria undulata masoni* (Tate), P34263, hypotype, McDonalds Bank, ×0.8 (Fig. 5 specimen uncoated).

Figure 6. *Amoria undulata masoni* (Tate), T385A, lectotype, Muddy Creek, ×1.

Figure 8. *Amoria costellifera* (Tate), T597B, holotype of *Nannamoria absidata* Cotton, 1949, Muddy Creek, ×1.

Figures 10–12. *Amoria costellifera* (Tate), P34261, hypotype, Clifton Bank, ×1. (Fig. 12, specimen uncoated).

Plate 7

Figures 1, 4. *Nannamoria deplexa* sp. nov., P32922, holotype, Bornong Rd, ×1.8.

Figures 2, 3. *Nannamoria amplexa* sp. nov., P33072, paratype, Ferndale Parade, ×1.4.

Figures 5, 7. *Nannamoria weldii* (Tenison Woods), Z191, holotype, Table Cape, ×1.4.

Figure 6. *Nannamoria amplexa* sp. nov., P33071, paratype, Ferndale Parade, ×1.4.

Figure 8. *Nannamoria limbata* (Tate), T590A, holotype, Mornington, ×1.4.

Figures 9, 11. *Nannamoria limbata* (Tate) P33088, hypotype, Gunyoung Creek, ×1.4.

Figure 10. *Nannamoria fasciculata* sp. nov., P32916, paratype, SE of Fischers Point, ×1.4.

Figures 12, 13. *Nannamoria stolida* (Johnston), P32910, hypotype, Table Cape, ×1.

Figures 14, 15. *Nannamoria stolida* (Johnston), Z186, holotype, Table Cape, ×1.

Plate 8

Figures 1, 4. *Nannamoria strophodon strophodon* (McCoy), P12153, paratype, Lake Bullenmerri?, ×1.6.

Figures 2, 3. *Nannamoria capricornea* (Wilson), WAM 774-71, paratype, W of Point Cloates, WA, ×1.9.

Figures 5, 8. *Nannamoria strophodon strophodon* (McCoy), P12154, holotype, Curlewis, ×2.1.

Figures 6, 7. *Nannamoria strophodon strophodon* (McCoy), P26388, paratype, Fyansford, ×1.7.

Figures 9, 11. *Nannamoria strophodon strophodon* (McCoy), P26389, paratype, Fyansford, ×1.8.

Figure 10. *Nannamoria capricornea* (Wilson), WAM 146-64, holotype, W of Point Cloates, WA, ×1.8.

Plate 9

Figures 1, 5. *Nannamoria ralphi* (Finlay), P33074, hypotype, Clifton Bank, ×1.4.

Figures 2, 3. *Nannamoria stolida* (Johnston), P2534, hypotype, Table Cape, ×1.

Figures 4, 8. *Nannamoria ralphi* (Finlay), P33076, hypotype, Clifton Bank, ×1.4.

Figures 6, 7. *Nannamoria paraboloides* sp. nov., P52308, paratype, Meringa Creek, ×1.4.

Figures 9, 12. *Nannamoria amplexa* sp. nov., P33069, holotype, Ferndale Parade, ×1.9.

Figures 10, 11. *Nannamoria limbata* (Tate), P33086, hypotype, Manyung Rocks, ×1.4.

Plate 10

Figures 1, 2. *Nannamoria weldii* (Tenison Woods), MUGD 1794, holotype of *Voluta weldii* var.. *angustior* Pritchard, 1913, Table Cape, ×1.9.

Figure 3. *Nannamoria ralphi* (Finlay), T588A, holotype, Muddy Creek, ×1.2.

Figure 4. *Nannamoria strophodon guntheri* (Smith), D13517, holotype of *Voluta adcocki* Tate, 1889, St Vincents Gulf, SA, ×1.

Figures 5, 6. *Nannamoria deplexa* sp. nov., P32924, paratype, Bornong Rd, ×1.9.

Figure 7. *Nannamoria paraboloides* sp. nov., P33077, holotype Spring Creek, ×1.8.

Figure 8. *Nannamoria paraboloides* sp. nov., P33079, paratype, Lot 47, Furneaux Estate, Tas. ×1.9.

Figures 9, 10. *Nannamoria fasciculata* sp. nov., P32915, holotype, SE of Fischer Point, ×1.4.

Figure 11. *Nannamoria fasciculata* sp. nov., P32916,

paratype, SE of Fischer Point, ×1.4.

Figure 12. *Nannamoria amplexa* sp. nov., P33071, paratype, Ferndale Parade, ×1.4.

Plate 11

Figures 1, 4. *Nannamoria trionyma* sp. nov., P32920, holotype, Clifton Bank, ×1.7.

Figure 2. *Nannamoria paraboloides* sp. nov., P33077, holotype, Spring Creek, ×1.8.

Figure 3. *Nannamoria paraboloides* sp. nov., P33079, paratype, Lot 47, Furneaux Estate, Tasm., ×1.9.

Figures 5, 8. *Nannamoria deplexa* sp. nov., P32923, paratype, Bornong Rd, ×1.8.

Figures 6, 7. *Nannamoria trionyma* sp. nov., P32918, paratype, Clifton Bank, ×1.7.

Figures 9, 12. *Nannamoria cinctuta* sp. nov., P33081, holotype, Block 22, Furneaux Estate, Tasm., ×1.2.

Figures 10, 11. *Nannamoria cinctuta* sp. nov., P33082, paratype, Block 22, Furneaux Estate, Tas., ×1.2.

Plate 12

Figures 1, 4. *Alcithoe (Waihaoia) pagodoides pagodoides* (Tate), P34821, hypotype, Blanche Point, SA, ×1.4.

Figures 2, 3. *Alcithoe (Waihaoia) pagodoides sororcula* subsp. nov., P37630, holotype, Bird Rock, ×1.7.

Figures 5, 9. *Alcithoe (Waihaoia) neglectoides* sp. nov., P37627, paratype, Bird Rock, ×1.4.

Figures 6, 8. *Alcithoe (Waihaoia) pagodoides sororcula* subsp. nov., P37631, paratype, Bird Rock, ×1.8.

Figure 7. *Alcithoe (Waihaoia) pagodoides pagodoides)* (Tate), T610B, holotype, Blanche Point, SA, ×1.4

Figures 10, 13. *Alcithoe (Waihaoia) pagodoides pagodoides* (Tate), P34822, hypotype, Browns Creek, ×1.4.

Figures 11, 12. *Alcithoe (Waihaoia) neglectoides* sp. nov., P37628, holotype, Bird Rock, ×1.4.

Plate 13

Figure 1. *Alcithoe (Waihaoia) cribrosa* (Tate), P34825, hypotype, Browns Creek, ×1.4.

Figures 2, 3. *Alcithoe (Waihaoia) cribrosa* (Tate), P34824, hypotype, Blanche Point, SA, ×1.4.

Figure 4. *Alithoe (Waihaoia) cribrosa* (Tate), T605A, lectotype, Blanche Point, SA, ×1.5.

Figure 5. *Alcithoe (Waihaoia) sarissa* (Tate), P38303, hypotype, Clifton Bank, ×1.

Figures 6, 8. *Alcithoe (Alcithoe) macrocephala* (Finlay), SAM P5755, hypotype, Murray Plains, SA, ×1.4.

Figure 7. *Alcithoe (Alcithoe) macrocephala* (Finlay), T389, holotype, Tareena, NSW, ×1.

Figures 9, 12. *Alcithoe (Alcithoe) orphanata* sp. nov., P37636, paratype, Block 22, Furneaux Estate, Tas., ×0.7.

Figures 10, 11. *Alcithoe (Alcithoe) orphanata* sp. nov., P37635, holotype, Block 22, Furneaux Estate, Tas., ×0.7.

Plate 14

Figures 1, 8. *Alcithoe (Waihaoia) pueblensis* (Pritchard), MUGD 1806, holotype, Bird Rock, ×1.5.

Figures 2, 3. *Alcithoe (Waihaoia) pueblensis* (Pritchard), P12773, hypotype, Bird Rock, ×1.

Figures 4, 12. *Alcithoe (Waihaoia) tateana* (Johnston), P2587, hypotype, Table Cape, Tas., ×1.2.

Figure 5. *Alcithoe (Waihaoia) sarissa* (Tate), P38303, hypotype,, Clifton Bank, ×1.

Figures 6, 7. *Alcithoe (Waihaoia) tateana* (Johnston), Z187, holotype, Table Cape, Tas., ×1.

Figures 9, 10. *Alcithoe (Waihaoia) pueblensis* (Pritchard), P34842, hypotype, Bird Rock, ×1.4.

Figure 11. *Alcithoe (Waihaoia) sarissa* (Tate), T578A, lectotype, Muddy Creek, ×1.

Plate 15

Figures 1, 2. *Ericusa macroptera* (McCoy), P48588, hypotype, Spring Creek, Torquay, ×0.6.

Figures 3, 5. *Ericusa ancilloides* (Tate), P41730, hypotype, Red Bluff, Shelford, ×1.

Figure 4. *Ericusa ancilloides* (Tate), T396D, lectotype, Mornington, ×1.

Figures 6, 9. *Ericusa hamiltonensis* (Pritchard), P12566, hypotype, Muddy Creek, ×0.7.

Figures 7, 8. *Ericusa sowerbyi pellita* (Johnston), P41709, hypotype, lower bed, Table Cape, Tas., ×0.5.

Plate 16

Figures 1, 3. *Ericusa sowerbyi sowerbyi* (Kiener), P41732, hypotype, Block 22, Furneaux Estate, Flinders Is., Tas., ×0.6.

Figures 2, 7. *Ericusa sowerbyi sowerbyi* (Kiener), P41731, hypotype, Meringa Creek, ×0.7.

Figures 4, 5. *Ericusa sowerbyi pellita* (Johnston), P41710, hypotype, upper bed, Table Cape, Tas., ×0.5.

Figures 6, 8. *Ericusa fulgetroides* (Pritchard), P7843, hypotype, McDonalds, Muddy Creek, ×0.7.

Plate 17

Figures 1, 2. *Ericusa macroptera* (McCoy), P12379, lectotype, Bird Rock Cliffs, ×0.7.

Figure 3. *Ericusa sowerbyi sowerbyi* (Kiener), SAM D14625, holotype of *Mesericusa stokesi* Cotton, Beachport, SA, ×0.7.

Figures 4, 5. *Ericusa sowerbyi pellita* (Johnston), MUGD 1789, holotype of *Voluta halli* Pritchard, Spring Creek, ×0.7.

Plate 18

Figures 1,6. *Ericusa fulgetroides* (Pritchard), MUGD 1804, holotype, Grange Burn, ×0.7.

Figures 2,7. *Ericusa hamiltonensis* (Pritchard), MUGD 1832, holotype, lower beds, Muddy Creek, ×0.7.

Figure 3. *Ericusa macroptera* (McCoy), P12378, paralectotype, Bird Rock Cliffs, ×0.7.

Figures 4, 5. *Ericusa sowerbyi pellita* (Johnston), Z156, holotype, Table Cape, Tas., ×0.7.

Figure 8. *Ericusa sowerbyi sowerbyi* (Kiener), SAM D14625, holotype of *Mesericusa stokesi* Cotton, ×0.7.

Plate 19

Figures 1, 2. *Livonia voluminosa* sp. nov., P41368, holotype, lower bed, Table Cape, Tas., ×0.6.

Figures 3, 5. *Ericusa atkinsoni* (Pritchard), P41723, hypotype, lower bed, Table Cape, Tas., ×0.6.

Figures 4, 6. *Livonia voluminosa* sp. nov., P2986, para-

type, lower bed, Table Cape, Tas., ×0.5.

Plate 20

Figures 1, 3. *Ericusa atkinsoni* (Pritchard), P2985, holotype, Table Cape, Tas., ×0.7.

Figures 2, 4. *Livonia gatliffi* (Pritchard), MUGD 1805, lower beds, Muddy Creek, ×1.

Figures 5, 6. *Livonia hannafordi* (McCoy), P12155, lectotype, foot of Mt Eliza, ×0.7.

Plate 21

Figures 1, 3. *Livonia gatliffi* (Pritchard), P41472, hypotype, Muddy Creek, ×1.

Figures 2, 5. *Livonia heptagonalis* (Tate), P13895, hypotype, S of Morgan, SA, ×0.5.

Figures 4, 6. *Livonia hannafordi* (McCoy), P12972, hypotype, Muddy Creek, ×0.31.

Plate 22

Figures 1, 2. *Livonia mortoni mortoni* (Tate), P2571, hypotype, lower bed, Table Cape, Tas., ×1.

Figures 3, 4. *Livonia mortoni mortoni* (Tate), Z208, holotype, lower bed, Table Cape, Tas., ×1.4.

Figure 5. *Livonia hannafordi* (McCoy), T392, holotype of *Voluta alticostata* Tate, Muddy Creek, ×1.

Figures 6, 7. *Livonia mortoni connudata* sp. nov., P41558, holotype, Muddy Creek, ×1.

Plate 23

Figures 1, 3. *Livonia stephensi* (Johnston), P41366, hypotype, Table Cape, Tas., ×0.7.

Figure 2. *Livonia spenceri* (Pritchard), P2990, holotype, Table Cape, Tas., ×1.1.

Figure 5. *Livonia stephensi* (Johnston), P41367, hypotype, lower bed, Table Cape, Tas., ×0.9.

Figures 4, 6. *Livonia stephensi* (Johnston), Z183, holotype, Table Cape, Tas., ×1.

Plate 24

Figure 1. *Livonia heptagonalis* (Tate), T397A, lectotype, S of Morgan, SA, ×1.

Figure 2. *Livonia heptagonalis* (Tate), T397C, paralectotype, S of Morgan, SA, ×1.

Figure 3. *Cymbiola macdonaldi* (Tate), T381A, hypotype, Muddy Creek, ×1.

Figure 4. *Cymbiola uncifera* (Tate), T394B, lectotype, S of Morgan, SA, ×1.4.

Figure 5. *Livonia spenceri* (Pritchard), P2990, holotype, Table Cape, Tasm., ×1.1.

Figure 6. *Cymbiola macdonaldi* (Tate), T381D, holotype, Mornington, ×1.3.

Figure 7. *Cymbiola uncifera* (Tate), T394A, paralectotype, S of Morgan, SA, ×1.4.

Plate 25

Figures 1, 2. *Notopeplum primarugatum* sp. nov., P31159, paratype, Point Flinders, ×1.9.

Figures 3, 4. *Notopeplum primarugatum* sp. nov., P31158, holotype, Point Flinders, ×2.

Figure 5. *Notopeplum annulatum* Wilson, WAM 132-64, holotype, W of Rottnest I, WA, ×1.6.

Figure 6. *Notopeplum primarugatum* sp. nov., P31160, paratype, Point Flinders, ×1.9.

Figure 7. *Notopeplum protorhysum* (Tate), T589A, lectotype, Kent Town Bore, SA, ×1.4.

Figure 8. *Notopeplum politum* (Tate), T602A, lectotype, Muddy Creek, ×1.2.

Figure 9, 12. *Notopeplum politum* (Tate), P31164, hypotype, Clifton Bank, Muddy Creek, ×1.9.

Figures 10, 11. *Notoeplum protorhysum* (Tate), P31155, hypotype, Blanche Point, SA, ×1.9.

Plate 26

Figures 1, 6. *Notopeplum mccoyi mccoyi* (Tenison Woods), P31162, hypotype, Table Cape, Tas., ×1.9.

Figures 2, 3. *Notopeplum mccoyi translucidum* (Verco), D15013, hypotype, W of Eucla, WA, ×1.4.

Figures 4, 5. *Notopeplum mccoyi translucidum* (Verco), P31163, hypotype, Clifton Bank, Muddy Creek, ×1.1.

Figures 7, 8. *Notopeplum mccoyi translucidum* (Verco), TM 1071, holotype of *Notopeplum balcombensis* Finlay, Balcombe Bay, ×1.4.

Figures 9, 13. *Notopeplum mccoyi translucidum* (Verco), D13614 holotype, off Newland Head, SA, ×1.4.

Figure 10. *Notopeplum annulatum* Wilson, WAM 132-64, holotype, W of Rottnest Is., WA, ×1.6.

Figures 11, 12. *Notopeplum mccoyi mccoyi* (Tenison Woods), P31161, hypotype, Table Cape, Tas., ×1.9.

Plate 27

Figures 1, 4. *Notovoluta capitonica* sp. nov., P126803, holotype, Brown Creek, ×1.

Figures 2, 3. *Leptoscapha crassilabrum* (Tate), F53231, Gleesons Landing, SA, ×3.8.

Figures 5, 9. *Leptoscapha crassilabrum* (Tate), F53232, Gleesons Landing, SA, ×3.8.

Figures 6, 8. *Leptoscapha crassilabrum* (Tate), F53234, Gleesons Landing, SA, ×2.9.

Figures 7, 10. *Leptoscapha crassilabrum* (Tate), F53233, Gleesons Landing, SA ×2.9.

Figures 11, 14. *Notovoluta gardneri* Darragh, Mo11579, E. of Lady Musgrave Island, Qld, ×1.

Figures 12, 13. *Nannamoria inopinata* Darragh, C108644a, holotype, 42 km NE of Lady Musgrave Island, Qld, ×1.2.

Plate 28

Figures 1, 2. *Lyria gracilicostata* Ludbrook, P56032, hypotype, 1.5km N. of Hampton Tower, WA, ×1.4.

Figures 3, 4. *Lyria gracilicostata* Ludbrook, P56031, hypotype, 1.5 km N. of Hampton Tower, WA, ×1.

Figures 5, 6. *Lyria gracilicostata* Ludbrook, GSWA F 6951, holotype, 21 km NE of Eyre, WA, ×1.1.

Figures 7, 8. *Lyria mitraeformis crassicostata* subsp. nov., WAM 79.404 b, paratype, 1.5 km N. of Hampton Tower, WA, ×1.2.

Figures 9, 10. *Lyria mitraeformis crassicostata* subsp. nov., WAM 79.396a, holotype, 1.5 km N. of Hampton Tower, WA, ×1.

Figures 11, 12. *Lyria mitraeformis crassicostata* subsp. nov., P56034, paratype, 1.5 km N of Hampton Tower, WA, ×1.2.

Plate 29

Figures 1, 2. *Notovoluta verconis medicata* subsp. nov., WAM 76.2399, paratype, Quarry N of Hampton Tower, WA, ×1.4.

Figures 3, 4. *Notovoluta verconis medicata* subsp. nov., P59665, paratype, Hampton Tower, WA, ×1.4.

Figures 5, 6. *Notovoluta verconis medicata* subsp. nov., WAM 79.2595, holotype, 1.5 km N of Hampton Tower, WA, ×1.4.

Figures 7, 10. *Amoria exoptanda* (Reeve), WAM 79.394a, hypotype, 1.5 km N of Hampton Tower, WA, ×0.7.

Figures 8, 9. *Nannamoria lundeliusae* Ludbrook, WAM 76.2389a, hypotype, Access road to Hampton Tower, WA, ×1.2.

Figures 11, 12. *Notovoluta kreuslerae occulta* subsp. nov., WAM 76.2476, paratype, Hampton Tower, WA, ×1.

Figures 13, 14. *Notovoluta kreuslerae occulta* subsp. nov., WAM 79.389a, holotype, 1.5 km N of Hampton Tower, WA, ×1.

Plate 30

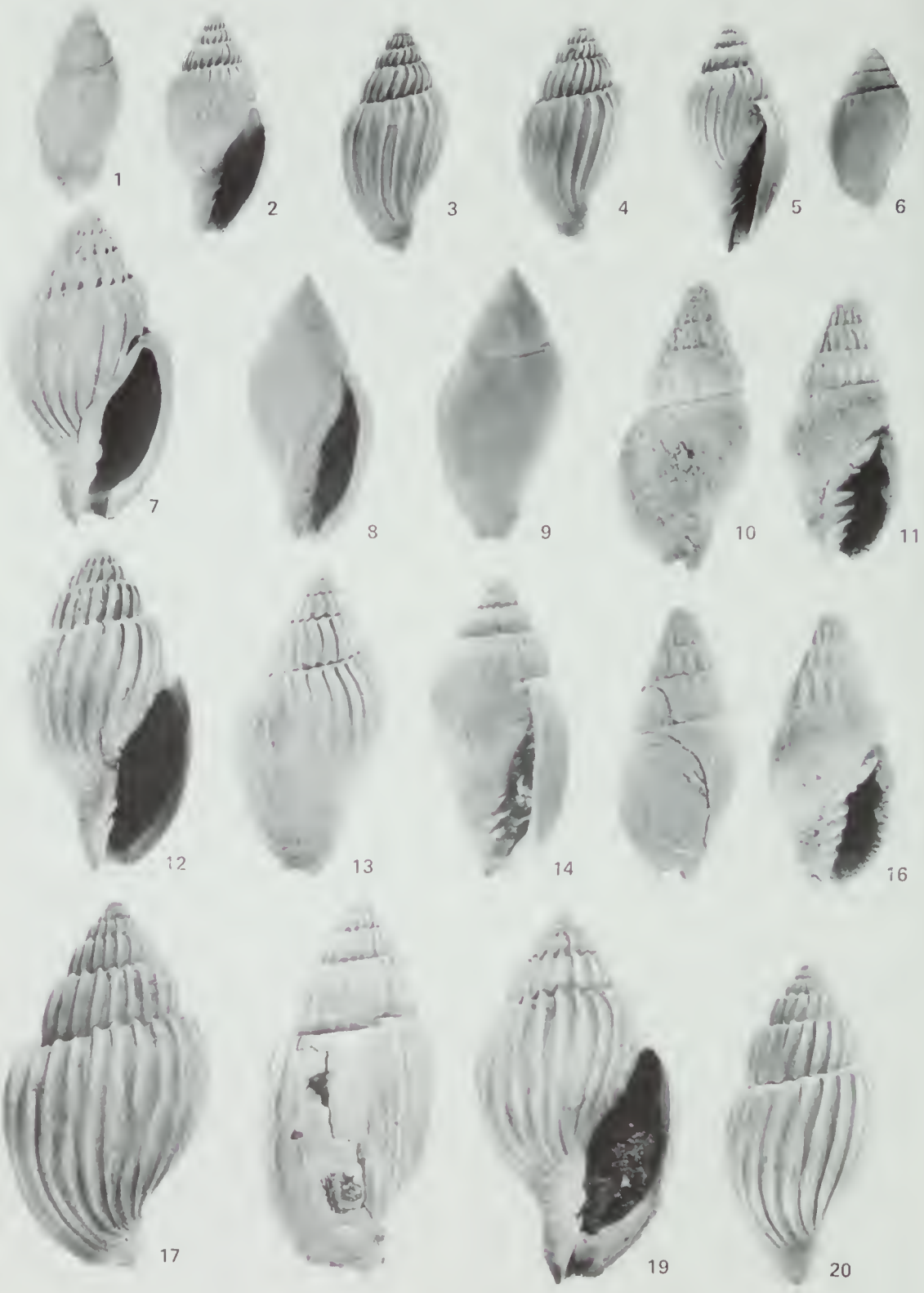
Figures 1, 2. *Ericusa subtilis* (Ludbrook), WAM 79.391, hypotype, 1.5 km N of Hampton Tower, WA, ×1.

Figures 3, 4. *Ericusa subtilis* (Ludbrook), WAM 69.515, holotype, Hampton Tower, WA, ×1.

Figures 5, 6. *Nannamoria lundeliusae* Ludbrook, WAM 72.26, paratype Quarry N of Hampton Tower, WA, ×1.3.

Figure 7. *Ericusa fulgetrum* (G.B. Sowerby I), WAM 79.410, hypotype, Pit, Eyre Highway, 6.3 km E of Hampton Tower Road, WA ×0.7.

Figures 8, 9. *Livonia stephensi* (Johnston), A.1.M. TM 839, ×1.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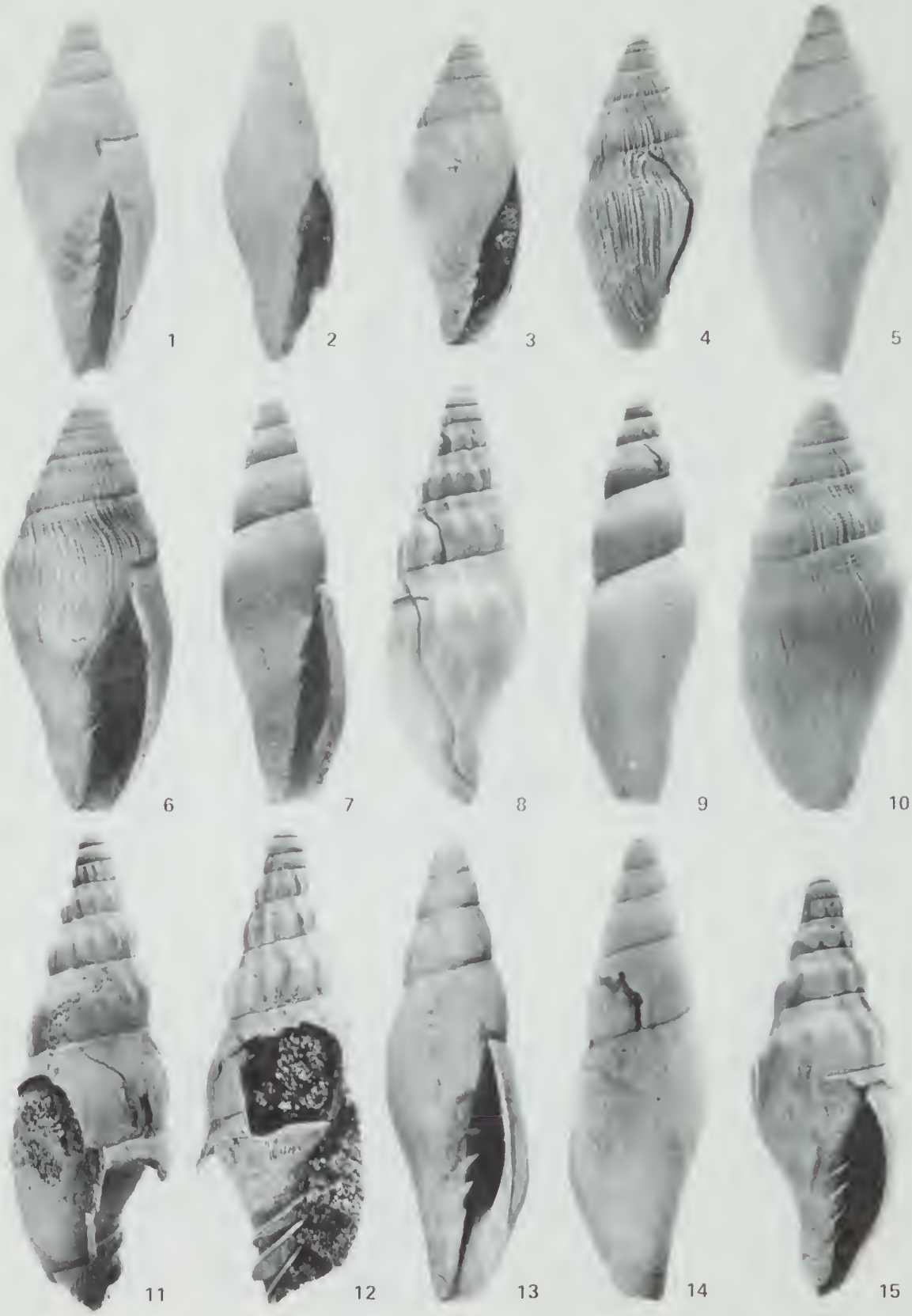
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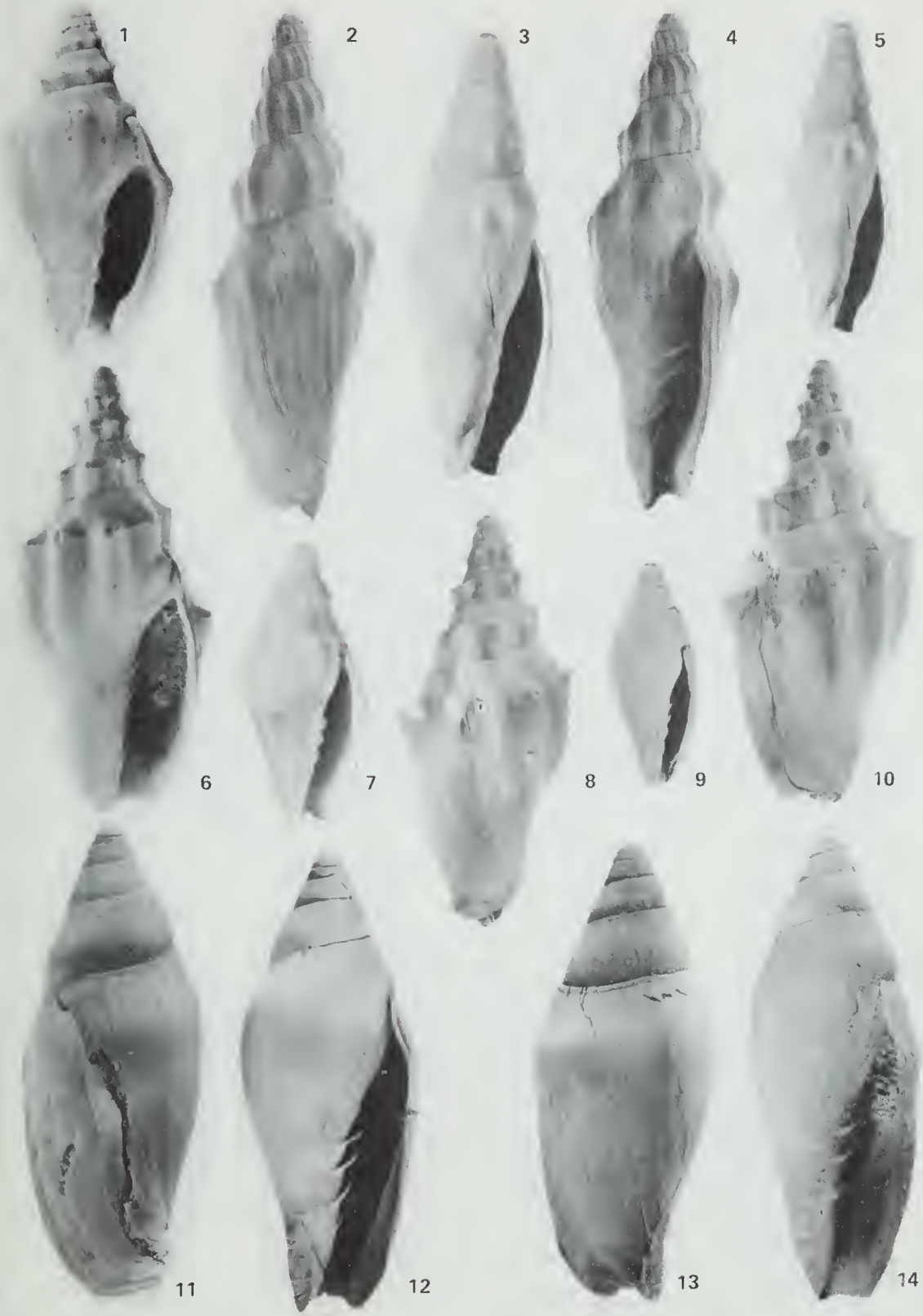
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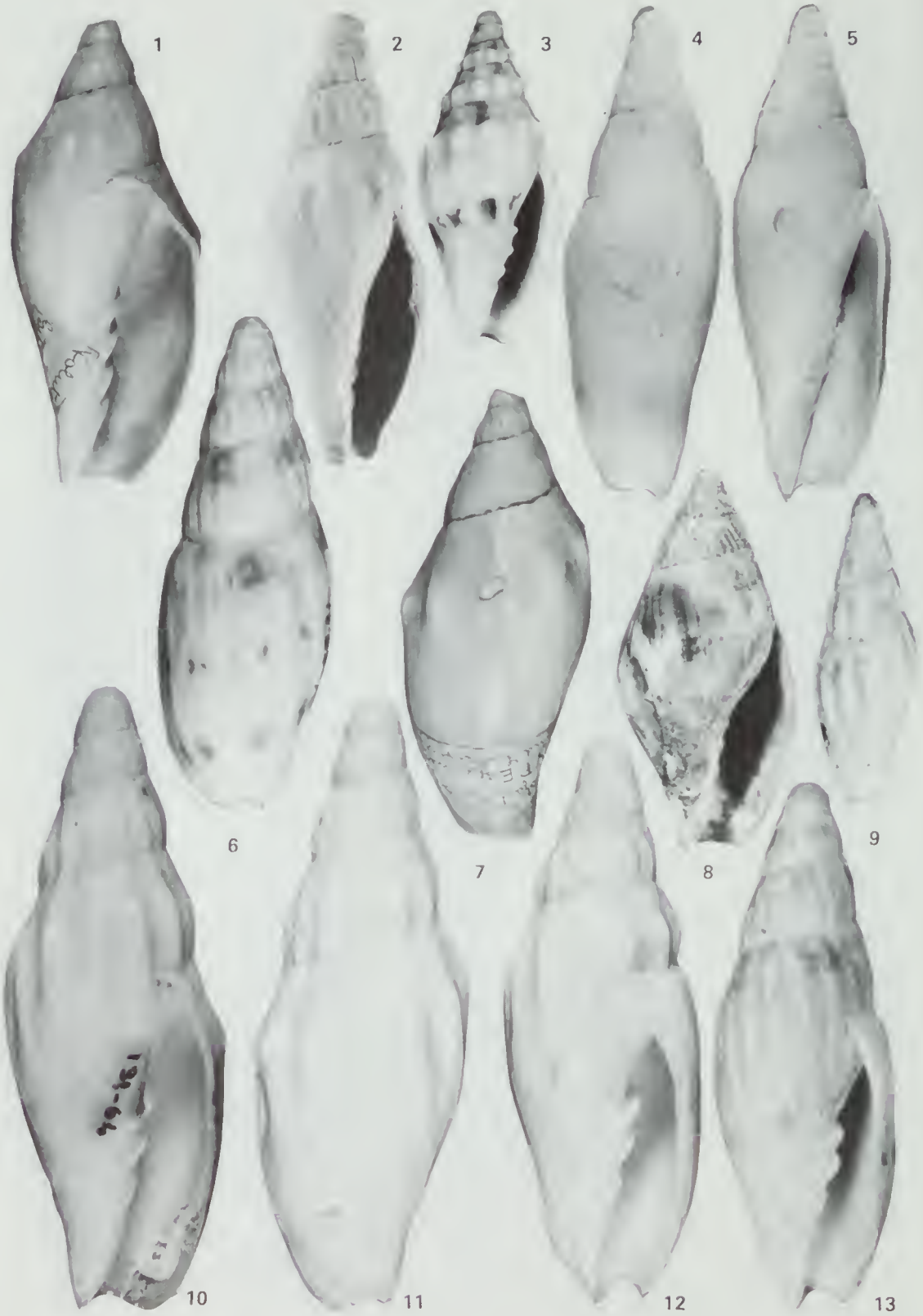
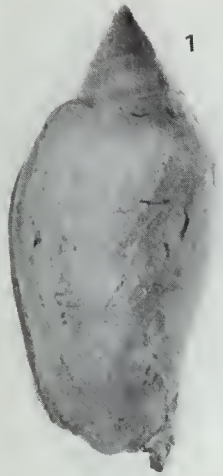
PLATE 5

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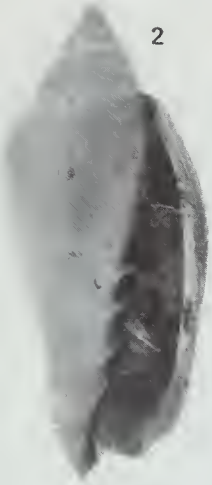
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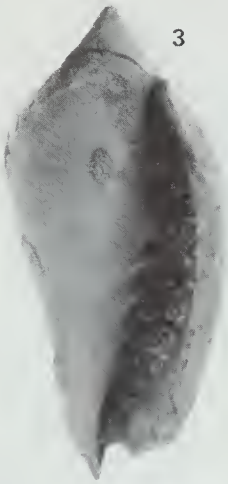
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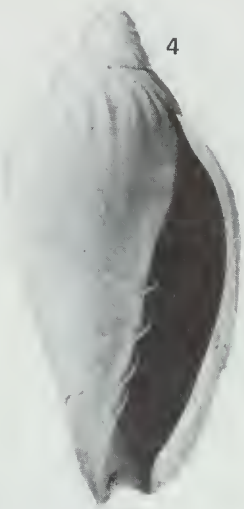
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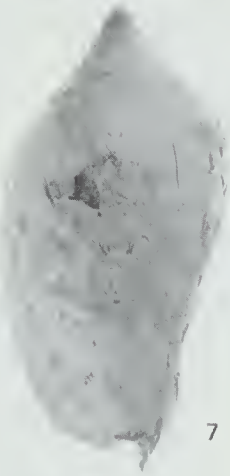
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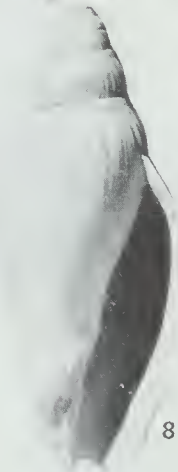
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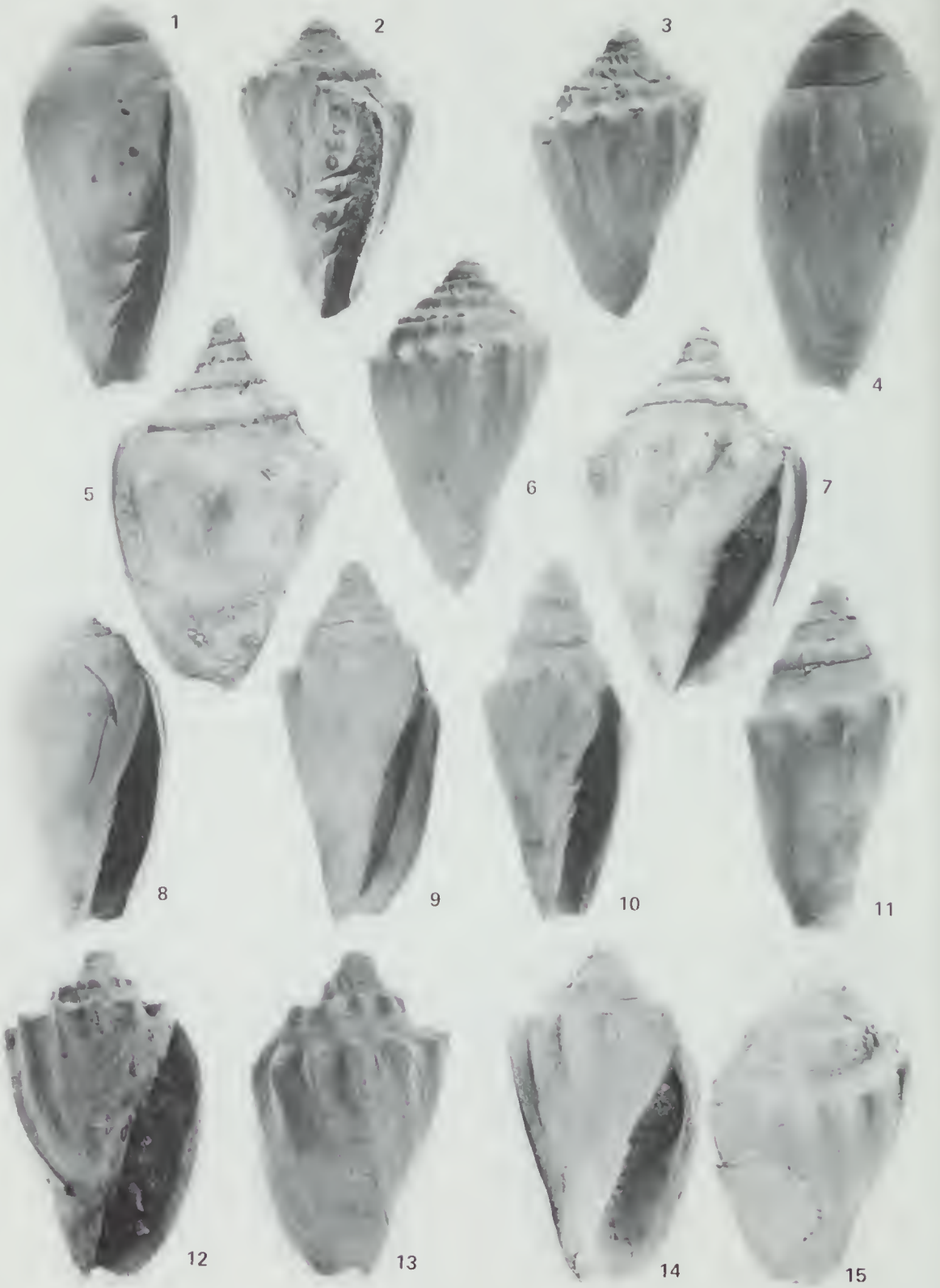
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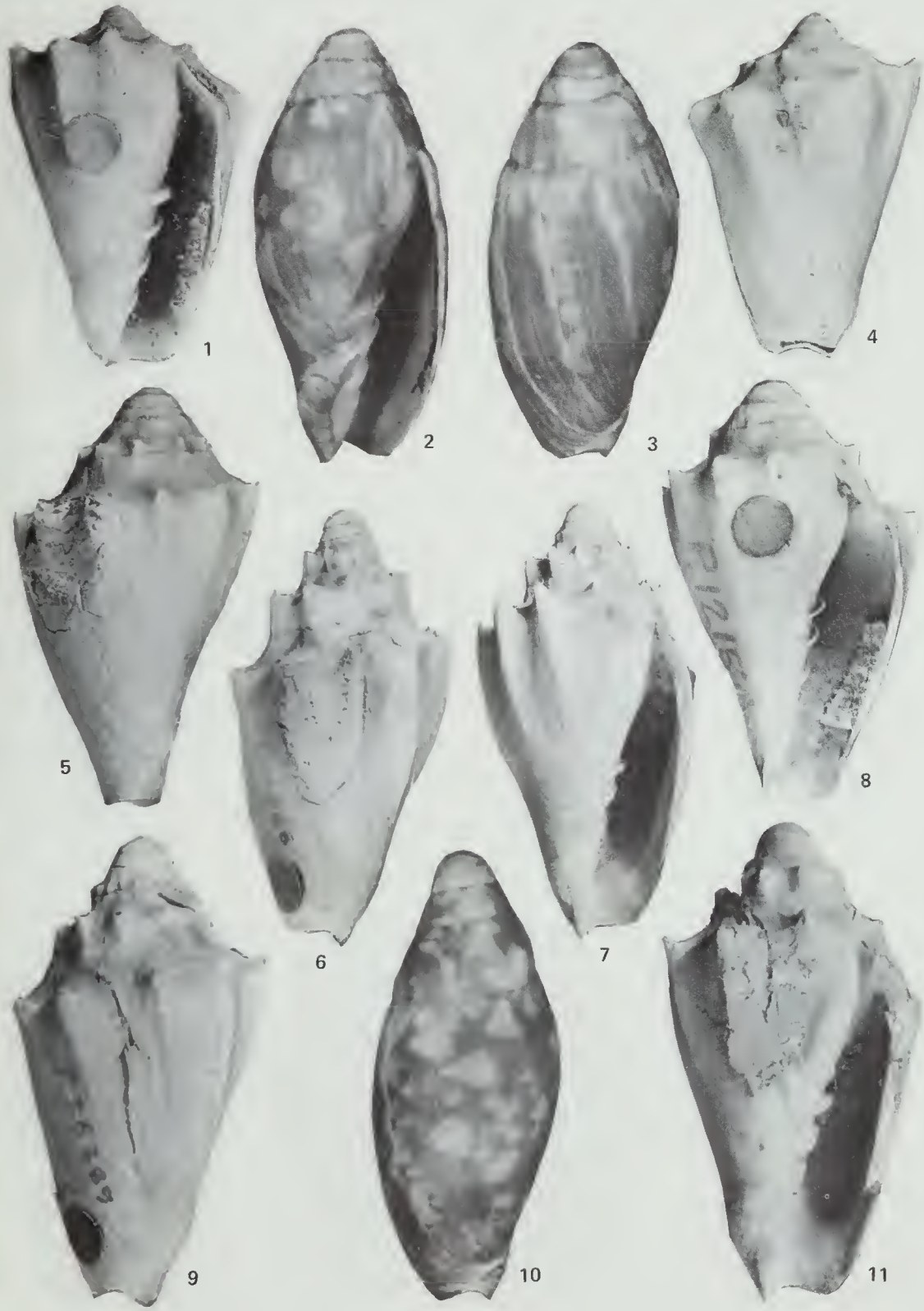
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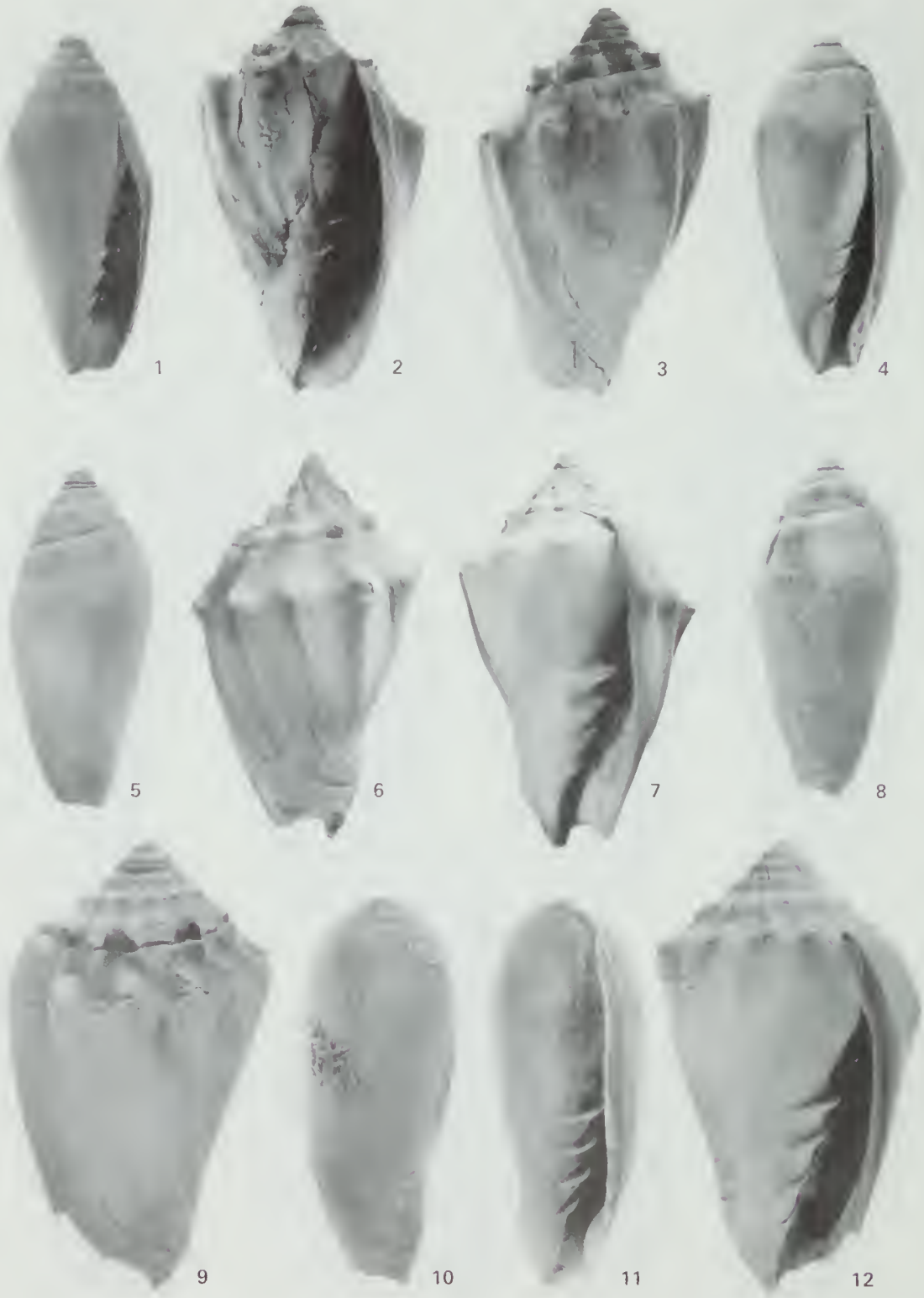
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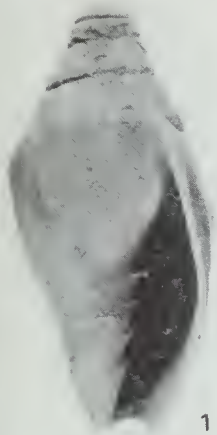
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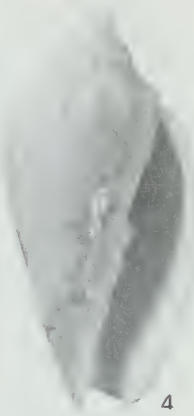
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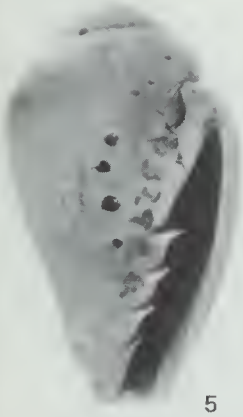
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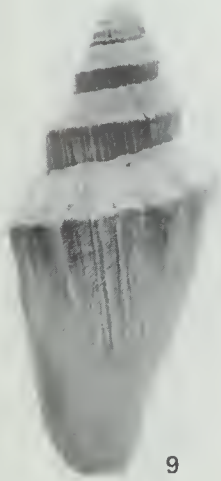
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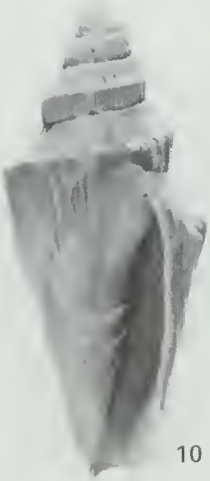
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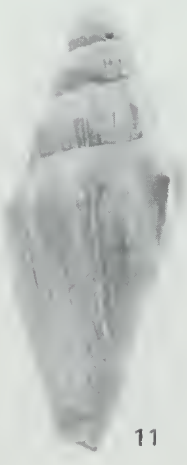
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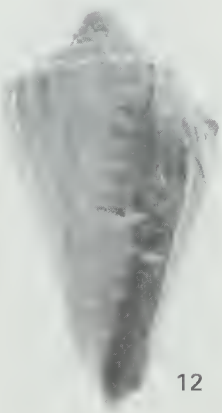
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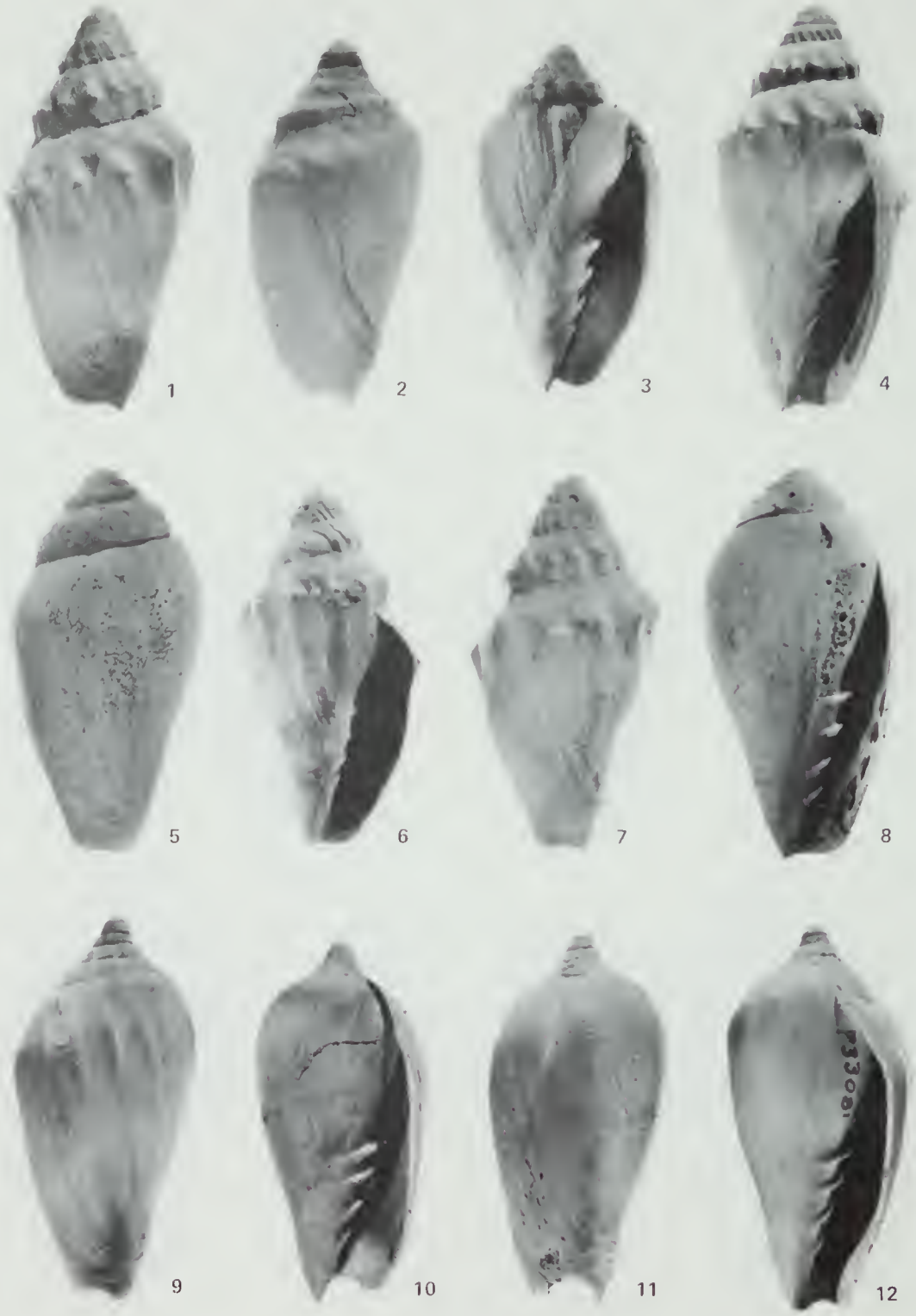
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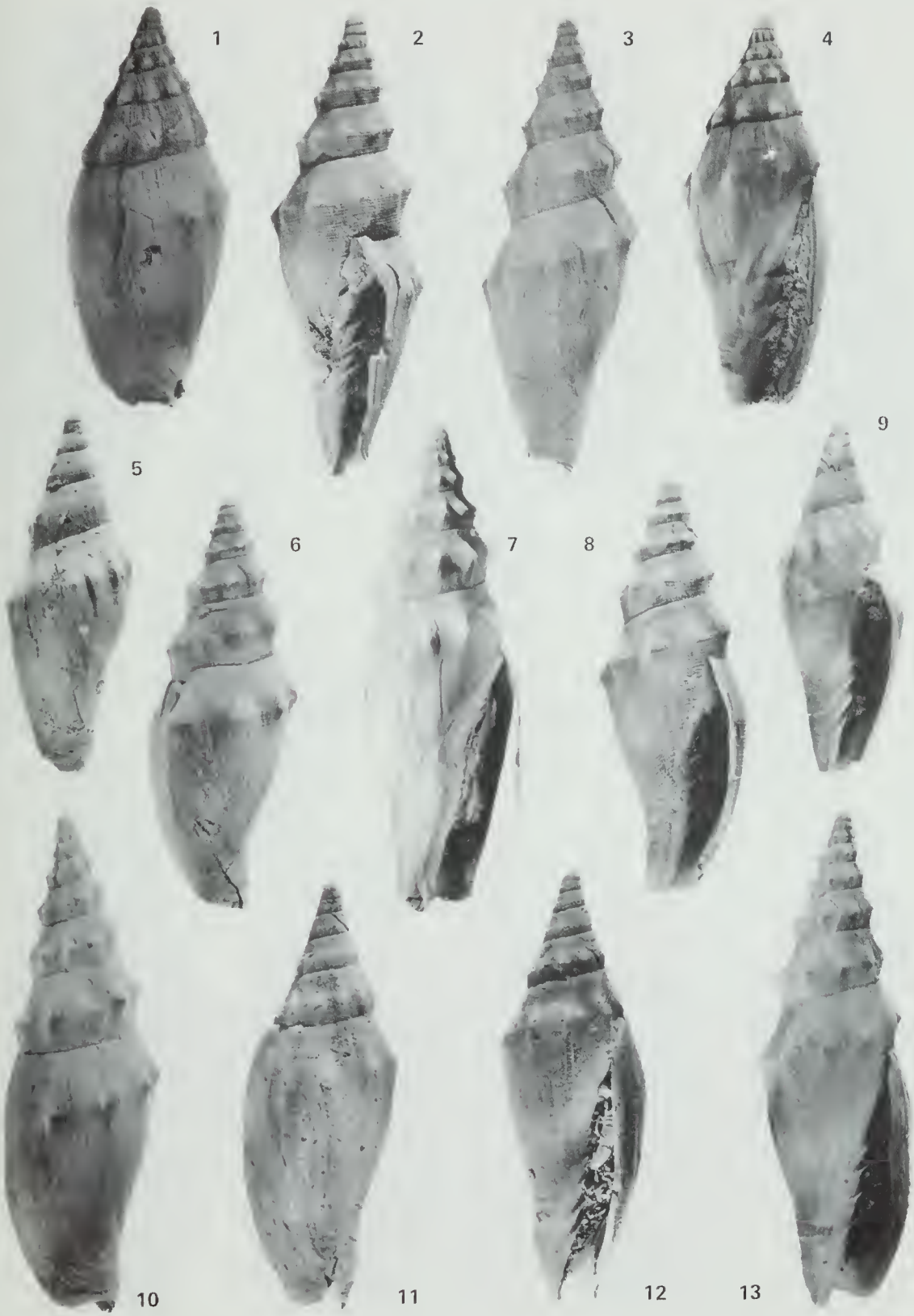
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PLATE 13


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PLATE 19

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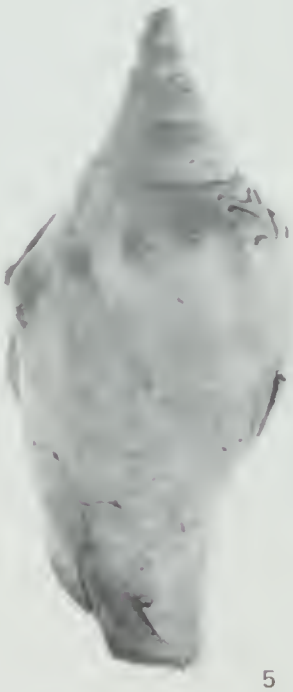

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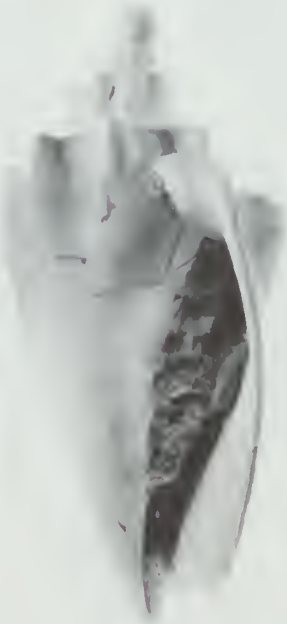

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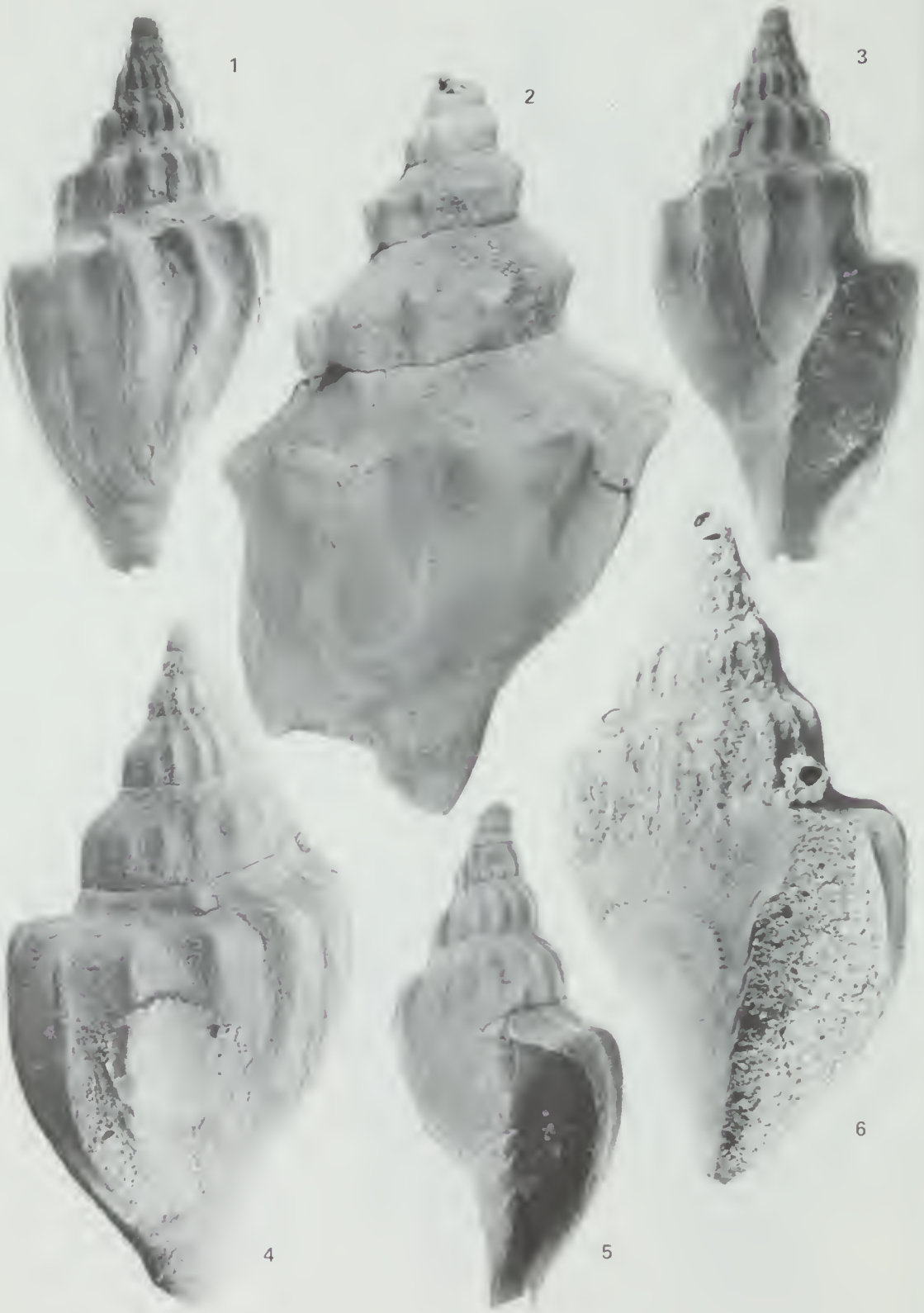
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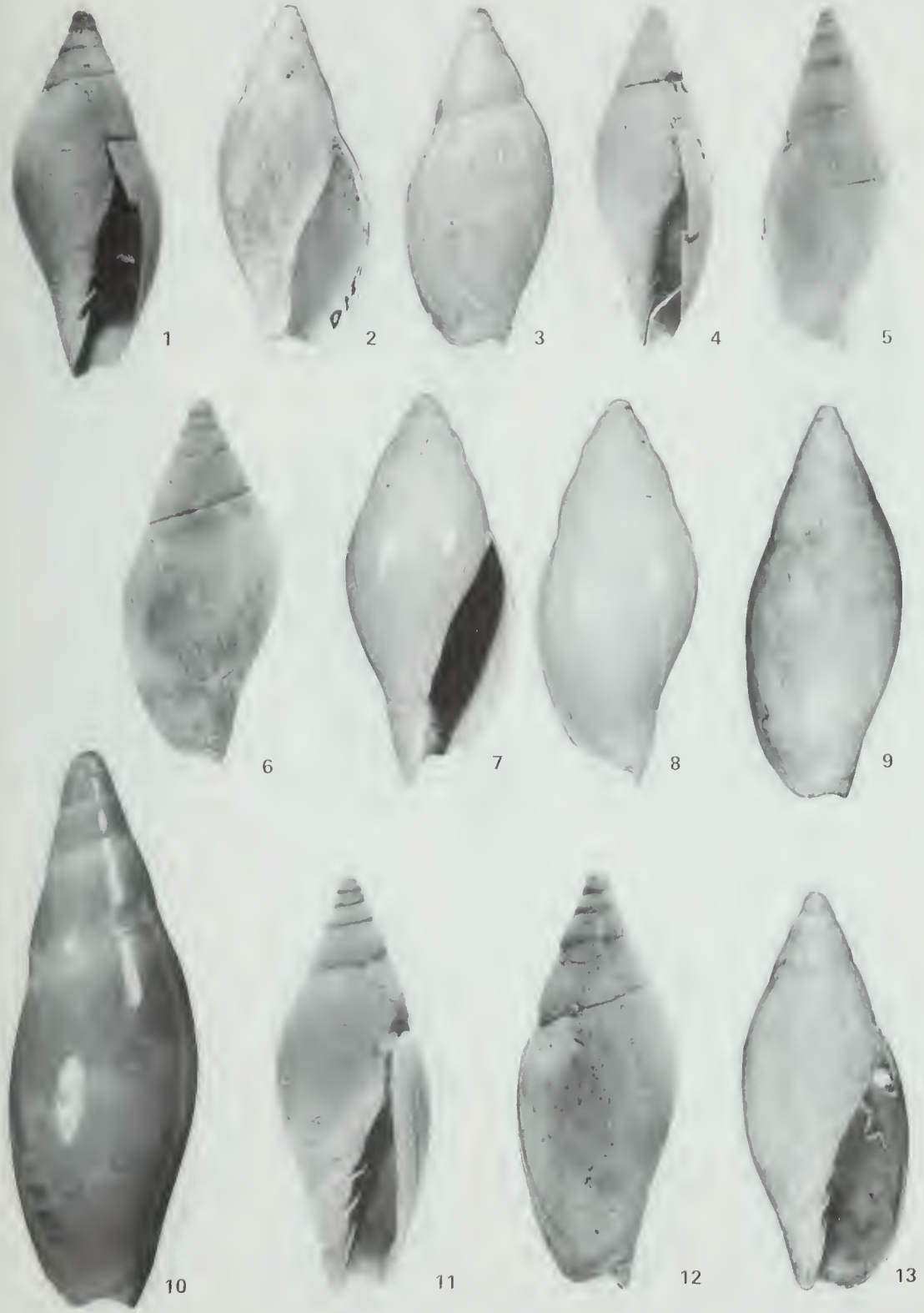
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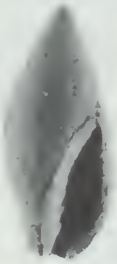
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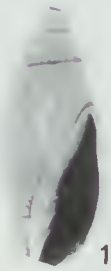
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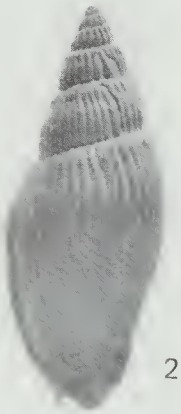
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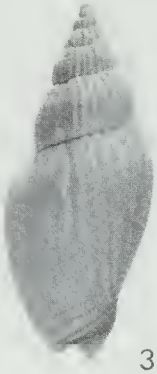
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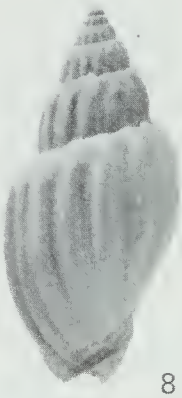
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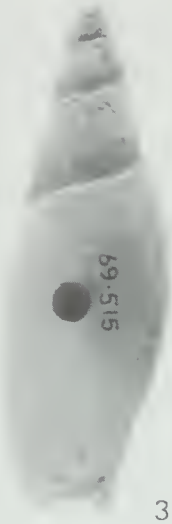

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