THE FAMILY TURRIDAE IN THE INDO-PACIFIC

Part 1. The subfamily Turrinae

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The turrid gastropods comprise one of a group of five related families which form the superfamily Toxoglossa within the order Neogastropoda—1) Speightiidae, 2) Turridae, 3) Thatcheriidae, 4) Conidae, and 5) Terebridae. This monograph is the first of a series intended to cover the family Turridae. The turrids are the largest family group among the marine gastropods, and they occur from the intertidal zone to the abyssal depths and in all seas, including the Arctic and the Antarctic.

The term Toxoglossa refers to the extraordinary toxic property associated with a special type of radula which is found in many turrids, and reaches its climax of development in the Conidae. The radula of most toxoglossate gastropods is reduced to a single pair of slender marginals in each transverse row. In *Conus*, the teeth are barbed and lie loose in the radula sac from which they are ejected as individual harpoons.

Morphological Characters of the Turridae

The Shell of the Turridae – There is no characteristic turrid shape by which all members can be readily recognized, for many turrids simulate in shape such groups as the Buccinidae, Muricidae, Fasciolariidae, Columbellidae, Mitridae, Conidae, and even Terebridae. However, the one shell feature common to the members of the Turridae is a slit or shallow to deep sinus on the outer lip variously located between the suture and the periphery of the last whorl. In size, the adult turrid shell may vary from about 1 to 160 mm.

In the subfamily Turrinae, a well-developed sinus is situated either at the periphery or on a minor ridge immediately above it. Most Turrinae are fusiform with a tall spire and a long tapered anterior canal, although in some genera, such as *Xenuroturris*, the base of the shell is truncated. Typical Turrinae closely resemble *Fusinus* (family Fasciolariidae), the only apparent shell difference being in the presence of a turrid sinus on the outer lip. Characteristic labial profiles of the Turrinae are shown in plate 173, and of other subfamilies in plate 174.

The Protoconch of the Turridae – In most gastropod families the protoconch is fairly constant and characteristic, and is generally considered to be of importance in determining phylogenetic relationships. A radical difference in protoconch type usually suggests strong taxonomic dissimilarity. Some degree of difference in the size and number of the nuclear whorls exists within a species, depending upon the salinity variations in the environment; and there may be produced, again within the same species, either a short pelagic or a non-pelagic stage (in *Brachystomia*, Thorson, 1946, p. 206, and Rasmussen, 1951, pp. 210-221). Thorson (1950, p. 33) has shown that northern Arctic Naticidae have a nonpelagic development and hence a protoconch of large whorls, while Naticidae of temperate, warm seas have a short pelagic stage and a protoconch of small, more tightly-coiled whorls. However, Thorson placed all these species in the genus *Natica*, although, in fact, they belong to quite different genera having quite different opercula.

In turrids, there are species and genera which have almost identical adult shell characters, but which have quite dissimilar protoconchs. The significance of this phenomenon is not, as yet, completely understood, and in the present absence of

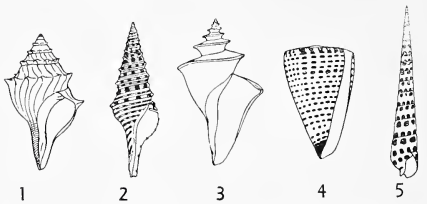

Plate 172. Five families of the superfamily Toxoglossa or Conacea. Fig. 1, Speightiidae (*Speightia*). Fig. 2, Turridae (*Turris*). Fig. 3, Thatcheriidae (*Thatcheria*). Fig. 4, Conidae (*Conus*). Fig. 5, Terebridae (*Terebra*).

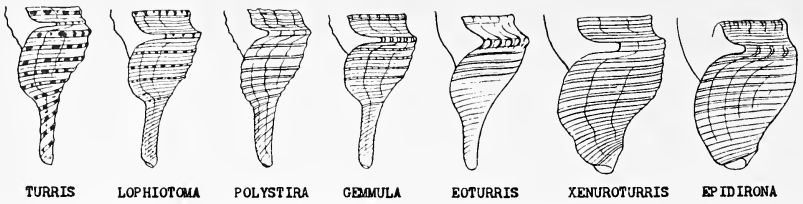

Plate 173. Labial profiles of genera in the subfamily Turrinae showing the characteristic shape and location of the sinus or labial slit.

life history and embryological facts, it is advocated that subgenera, or even genera, be recognized on the basis of the protoconch characters, even though the adult shells are almost identical. Examples of these "pairs" of higher taxa are the *Lophiotoma* and *Lophioturris* complex of species, and the *Tomopleura* and *Maoritomella* group.

In all likelihood, the size of the protoconch and its number of whorls are correlated with the length of the free-swimming stage of the veliger. A protoconch of few, rapidly-expanding whorls suggests a short free-swimming life, while one of several, slowly-expanding whorls or one with a sinusigerous-like outer lip suggests a long-living, and hence far-travelling, larval life.

The Dentition of the Turridae — The radula in the Turridae is of several very distinctive types ranging from the prototypic form, with central, lateral and marginal teeth, through a series characterized by the absence of laterals but with a compensating enlargement of the central tooth, to finally the toxoglossate state, in which only the marginals, one on each side, remain.

The prototypic radula is found in the subfamily Clavinae in genera such as *Clavus*, *Drillia* and *Spirotropis*. The second group, minus laterals, occurs in the Cochlespirinae (*Aforia* and *Leucosyrinx*) as well as in the Turrinae, and in *Ptychosyrinx* and *Turridrupa*. The third group, in which all but the marginals have disappeared, culminates in a radula form very close to that of the Conidae. The Mangeliinae, Daphnellinae and also some of the Clavinae have this toxoglossate style of dentition.

The radula form in the Turrinae and in some members of the Turriculinae is a modified toxoglossate type, having only marginals present, but these are "wishbone" in shape. They in turn show some relationship with the radula of the Clavatulinae in which the marginals are massive, often with one of the two extremities of the marginals existing as a separate plate. In addition there is an incipient or vestigial central tooth.

It was found that the prototypic style of radula was of common occurrence in many of the Clavinae, but on the other hand, quite a number of genera, *Phenatoma* for instance, with all the external shell characteristics of that subfamily, were found to possess only slender toxoglossate-like marginals.

Recently, Robinson (1960, Proc. Zool. Soc., **135**, p. 319) has demonstrated that the English species of *Mangelia* are comparable with the Conidae in that the radula is truly toxoglossate, complete with the neurotoxic apparatus as well as a long proboscis capable of sufficient extension to harpoon prey.

These animals have a greatly coiled poison gland which opens ventrally into the oesophagus immediately posterior to the opening of the buccal sac. The poison gland is a coiled tube, and the swollen end of this gland is a propulsive organ, termed the

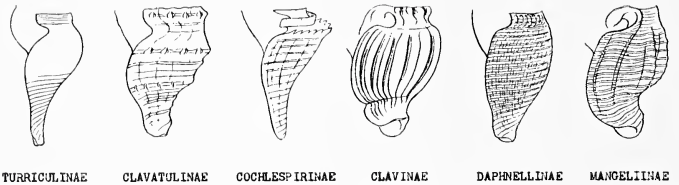

Plate 174. Labial profiles characteristic of other subfamilies in the Turridae. Turriculinae (*Turricula*); Clavatulinae (*Clavatula*); Cochlespirinae (*Ancistrosyrinx*); Clavinae (*Cymatosyrinx*); Daphnellinae (*Daphnella*); Mangeliinae (*Etrema*).

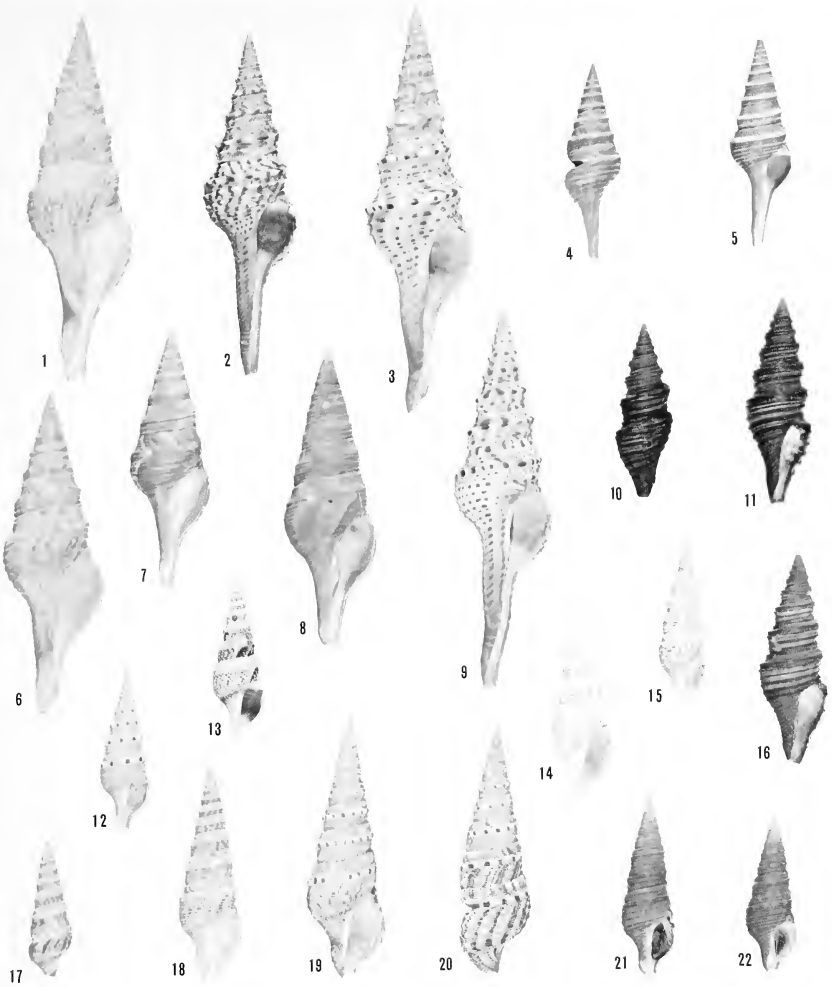

Plate 175

Figs. 1, 6 *Gemmula (Unedogemmula) unedo* (Kiener). Japan (see text p. 22-761).
2, 3 *Lophiotoma (Lophioturris) indica* (Röding). Cuyo Id., Philippines (p. 22-931).
4, 5 *Lophiotoma (Lophioturris) leucotropis* (Adams and Reeve) (p. 22-932).
7, 8 *Gemmula (Unedogemmula) deshayesii* (Doumet). Hongkong (7), Japan (8) (p. 22-762).
9 *Lophiotoma (Lophioturris) indica* (Röding). Philippines (p. 22-931).
10, 11 *Lophiotoma (Lophioturris) polytropa* (Helbling). Luzon Id., Philippines (p. 22-933).
12 *Xenuroturris cingulifera* (Lamarck). Zanzibar (p. 22-962).
13 *Xenuroturris millepunctata* (Sowerby). New Caledonia (p. 22-963).
14, 15 *Xenuroturris cerithiformis* (Tinker). Hawaiian Islands (p. 22-964).
16 *Lophiotoma (Lophioturris) indica* (Röding). Moluccas.
17, 18 *Xenuroturris millepunctata* (Sowerby). New Caledonia (p. 22-963).
19, 20 *Xenuroturris cingulifera* (Lamarck). Japan (p. 22-962).
21, 22 *Xenuroturris castanella* (Tinker). Hawaiian Islands (p. 22-964).
(all 2/3 natural size)

muscular bulb, which functions in the harpooning of prey by means of poison-charged, detached radular teeth.

The fully developed toxoglossate dentition does not seem to be correlated with definite shell characteristics; in fact, it appears to cut across any subfamily arrangement based upon shell features alone.

The subfamily groups in use in the Turrinae seem to form more or less natural groups that appear to have some geographical and chronological significance, yet the toxoglossate dentition is likely to develop in any one of them. It is probable, therefore, that a change from the prototypic to the toxoglossate state can take place independently in any one of the "subfamily" groups, and if so, no doubt as a direct response to a change to predaceous feeding.

If this is not the case, the inference is that the system of subfamilies at present in use is not morphologically sound, and merely indicates convenient groups of species based largely upon external resemblances. The following illustrations show some of the characteristic radula types in the Turridae:

The Operculum of the Turrids – The operculum is here considered to be of secondary importance as a taxonomic character, for after all, its shape is consequent to the shape of the aperture; opercular growth naturally takes the most convenient form to fill the apertural space. Opercular growth is achieved by means of a logarithmic spiral such as in *Turbo* or, as in the turrids, by the addition of concentric rings or the addition of excentric rings. For species with a long narrow aperture, the operculum is lanceolate or leaf-shaped. Excentric growth with an apical nucleus is the obvious mechanical method of growth in such types. The clavatulids, on the other hand, have a very different apertural shape, due to the lower median placing of the parietal angulation of the inner lip, and the adpressed suture which is clasped high over the preceding whorl. Thus by fan-wise excentric growth from a medio-lateral position the apertural space is best filled. A variation of the leaf-shaped operculum takes place where the aperture does not contract rapidly toward the anterior canal. The resultant squarish aperture is accommodated by an operculum in which the position of the nucleus may move over toward the outer lip in order to facilitate the mechanism of opercular growth.

Again in some abyssal genera such as *Steiraxis*, the operculum may become degenerate and remain

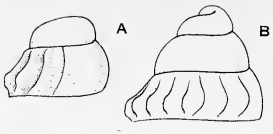

Plate 176 Example of paucispiral and polygyrate protoconchs in the Turridae. Fig. **a**, *Micantapex angustatus* Powell; fig. **b**, *Bathytoma bartrumi* Laws.

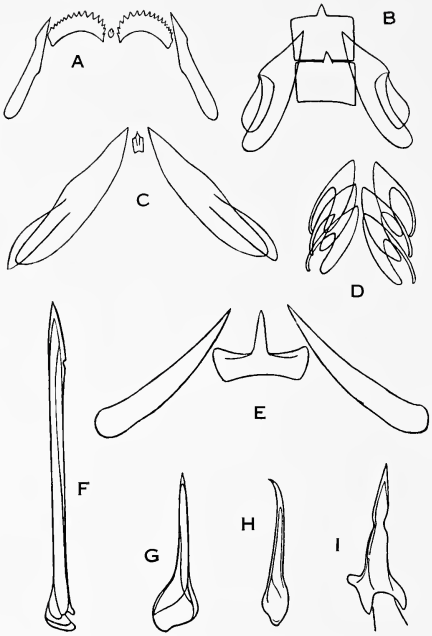

Plate 177. Radulae types in the Turridae. Fig. **a**, prototype with the central, lateral and marginal teeth present (formula: 1 + 1 + 1 + 1 + 1), *Drillia umbilicata* Gray from West Africa. Fig. **b**, *Ptychosyrinx bisinuatus* (Martens) from East Africa in which the central tooth is enlarged to compensate for the loss of the laterals (formula: 1 + 0 + 1 + 0 + 1). Fig. **c**, *Clionella sinuata* (Born) from South Africa with a small central and without laterals (formula: 1 + 0 + 1 + 0 + 1). Fig. **d**, *Turris babylonia* (Linnaeus) from the southwest Pacific with only "wish-bone"-shaped marginals (formula: 1 + 0 + 0 + 0 + 1). Fig. **e**, *Hormospira maculosa* (Sowerby) from West Mexico whose formula may be either 0 + 1 + 1 + 1 + 0 (marginals absent?) or 1 + 0 + 1 + 0 + 1 (laterals absent). Fig. **f**, *Phenatoma novaezelandiae* (Reeve) from New Zealand with only slender, barbed marginals (formula: 1 + 0 + 0 + 0 + 1). Fig. **g**, *Microdrillia optima* Thiele from off East Africa with only awl-shaped marginals (formula: 1 + 0 + 0 + 0 + 1). Fig. **h**, *Propebela turricula* (Montagu) from northern Europe (formula: 1 + 0 + 0 + 0 +1). Fig. **i**, *Daphnella cancellata* Hutton from New Zealand with marginals only (formula: 1 + 0 + 0 + 0 + 1) (all greatly enlarged, but not to scale).

permanently ovate, of small size and without subsequent growth accretions.

The operculum is found to be absent in the Mangeliinae, or at least in the few species that have been examined. On the other hand, the complex of Boreal species, such as *Oenopota*, "*Bela* auct." and "*Lora*," although closely resembling mangelids, possess an operculum.

The Daphnellinae are also supposed to lack an operculum, but one species, *Typhlodaphne purissima* (Strebel, 1908), from deep-water off South Georgia, has a vestigial operculum which is ovate, with an apical nucleus, and is very small in relation to the size of the aperture (Powell, 1951, Discovery Rep. 26, p. 196, fig. N.130).

Obviously, the operculum in the light of these considerations cannot be given a high taxonomic value.

Nomenclature of the Turrids—The Linnaean school did not distinguish turrids as a separate group but assigned them individually, according to appearance, to the genera *Murex*, *Buccinum* or *Strombus*. The earliest use of a group name for these shells seems to be the subfamily Pleurotominae of Swainson, 1840, in his "Treatise on Malacology" as one of four subfamilies of the Strombidae. However, H. and A. Adams, 1853, in "The Genera of Recent Mollusca" were the first to elevate the group to family rank, i.e., Turritidae; they admitted three subfamilies, the Turritinae, the Clavatulinae and the Defranciinae. Then for more than half a century the family name Pleurotomidae of Chenu, 1859, was in general use. With the recognition of Röding's Museum Boltenianum as nomenclaturally valid, *Pleurotoma* Lamarck, 1799, became a synonym of *Turris* Röding, 1798.

The acceptance of a family name based upon *Turris* Röding, 1798, to replace Pleurotomidae, based upon a synonym, is allowed under Article 40(a) of the 1961 edition of "The International Code of Zoological Nomenclature," and further, Article 40(b) rules that a name adopted by virtue of the provisions of section (a) takes the date of the rejected name.

The revised family name, however, has been rendered in two ways, i.e., Turritidae and Turridae. The first use of the former seems to have been by H. and A. Adams, 1853, in "The Genera of Recent Mollusca," but most modern authors since Hedley, 1922, have preferred the shorter rendering. The family name here adopted is TURRIDAE (= Pleurotominae = Turritidae = Pleurotomidae) Swainson, 1840.

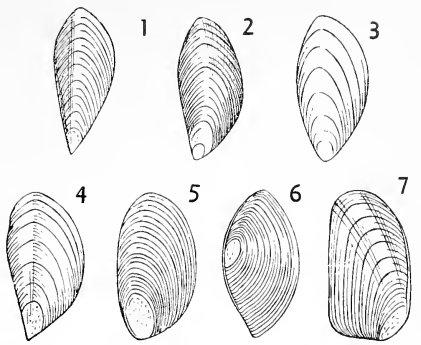

Plate 178. Opercula of Turridae. Fig. **1**, *Hormospira maculosa* (Sowerby), west Mexico. Fig. **2**, *Crassispira pluto* Pilsbry and Lowe, west Mexico. Fig. **3**, *Aoteadrillia otogoensis* Powell, 50 fms, off Otago Heads, New Zealand. Fig. **4**, *Xenuroturris cingulifera* (Lamarck), Queensland. Fig. **5**, *Tomopleura poulocnsis* (Jousseaume), Aden. Fig. **6**, *Pusionella nifat* (Bruguière), northwest Africa. Fig. **7**, *Aforia magnifica* (Strebel), Palmer Archipelago, Antarctic.

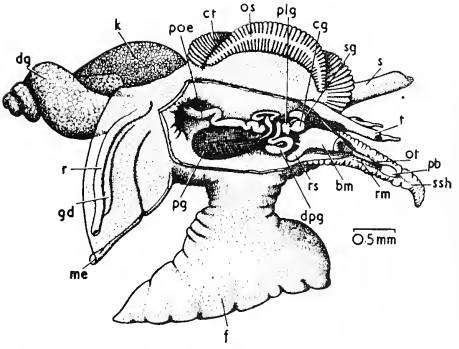

Plate 179. Gross anatomy of a turrid (*Mangelia powisiana* Dautzenberg). bm, buccal mass; cg, right cerebral ganglion; ct, ctenidium; dg, digestive gland; dpg, duct of poison gland; f, foot; gd, genital duct; k, kidney; me, mantle edge; os, osphradium; ot, oral tube; pb, proboscis; pg, muscular sac, the so-called poison gland; plg, right pleural ganglion; poe, posterior oesophagus; r, rectum; rm, retractor muscle of proboscis; rs, radular sac; s, siphon; sg, salivary gland; ssh, suspensory sheath; t, tentacle (from Fretter and Graham, 1962, *British Prosobranch Molluscs*, Ray Society, London, p. 167, fig. 104).

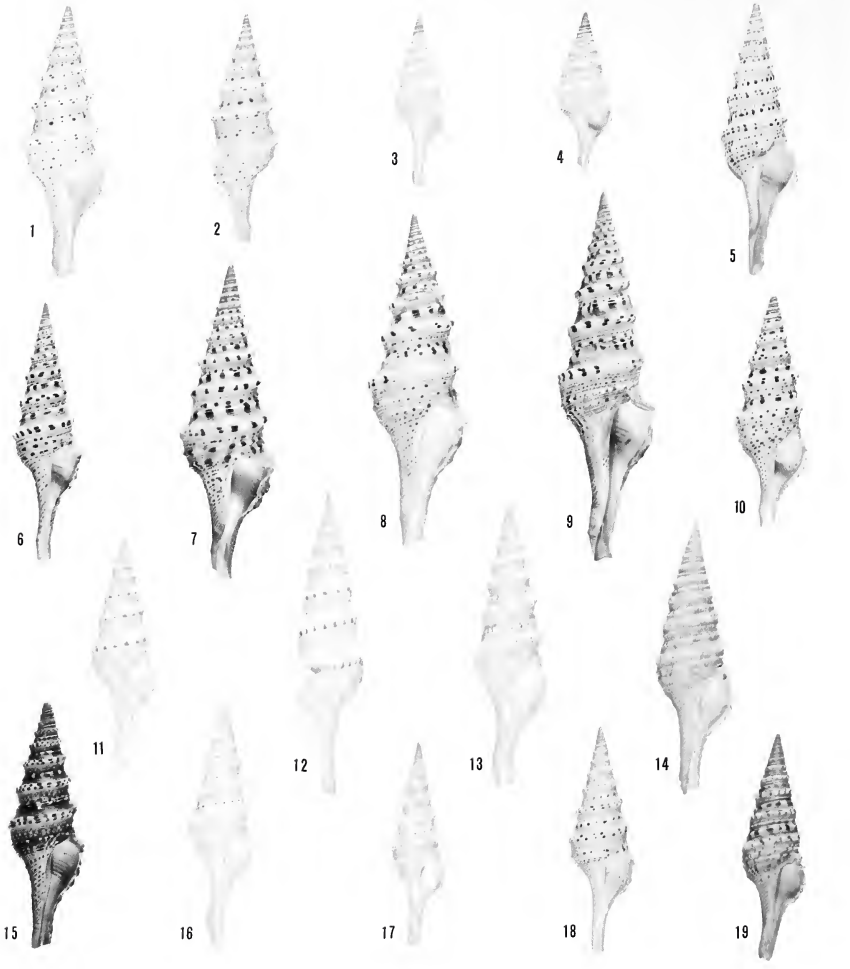

Plate 180 (see text p. 22-913)

All *Lophiotoma (Lophiotoma) acuta* (Perry) and its forms, except figs. 11, 12, which are *Lophiotoma albina* (Lamarck).

Figs. 1, 2 Bega Id., Viti Levu Id., Fiji.
3 Rani, west end of New Guinea.
4 Heron Id., Queensland, Australia.
5 Mindoro Id., Philippines.
6 *marmorata* form, west end New Guinea.
7, 8 Mozambique City, Portuguese East Africa.
9 Zanzibar Id., East Africa.
10 King's Reef, Queensland, Australia.
11, 12 *Lophiotoma albina* (Lamarck). Moluccas.
13 *L. acuta* form *microsticta*. Japan.
14 *L. acuta* form *jickelii*. Philippines.
15, 16 Zamboanga, Philippines and Palau Islands.
17 form *microsticta*. Ryukyu Islands.
18 Ryukyu Islands.
19 form *jickelii*. Red Sea.

(all natural size)

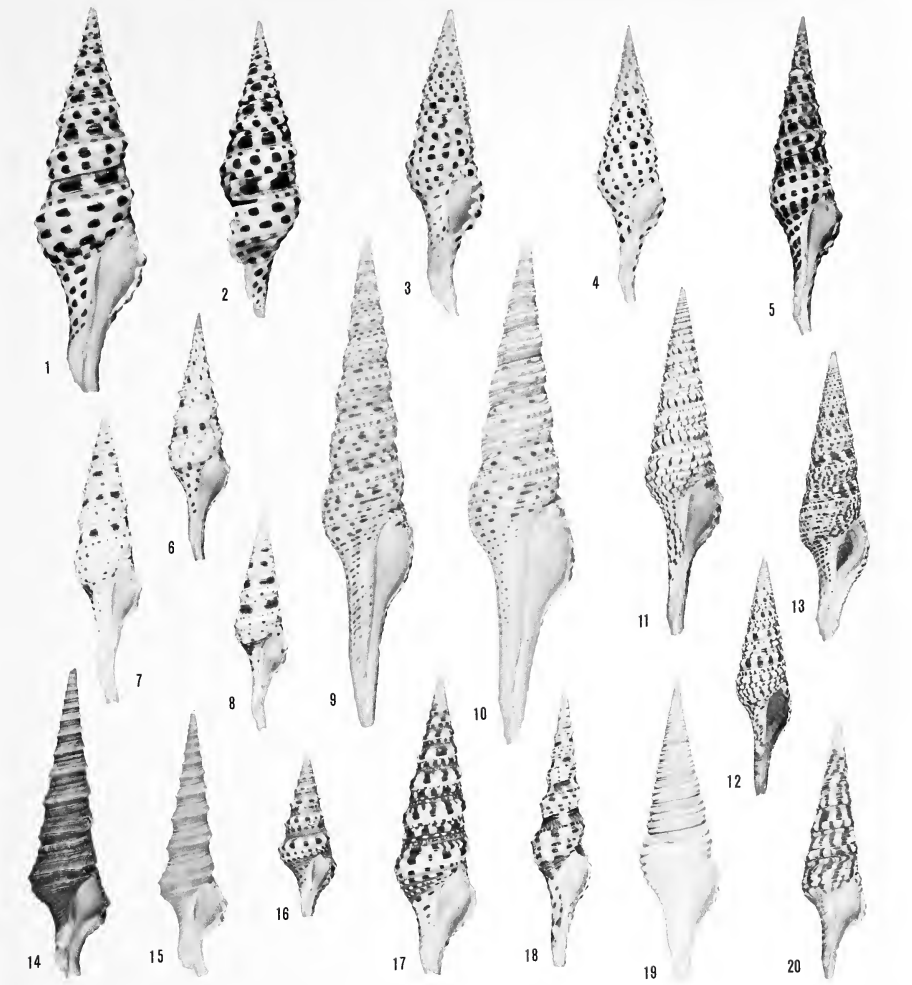

Plate 181 (see text p. 22-977)

Figs. 1, 2 *Turris babylonia* (Linnaeus). Southwest Pacific.
3, 4 *Turris babylonia* (Linnaeus). Philippines and west New Guinea.
5 *Turris babylonia* (Linnaeus). Narrow form; Philippines.
6 *Turris babylonia* (Linnaeus). Pale form; west New Guinea.
7, 8 *Turris garnonsii* (Reeve). Zanzibar.
9, 10 *Turris crispa* (Lamarck). Hongkong, 50 fms.
11, 12 *Turris crispa* (Lamarck). Luzon Id., Philippines (11); Noumea, New Caledonia (12).
13 *Turris crispa yeddoensis* (Jousseaume). Japan.
14, 15 *Turris cryptorrhaphe* (Sowerby). Bohol Id., Philippines.
16, 17 *Turris spectabilis* (Reeve), Philippines (16) and Moluccas (17).
18 *Turris garnonsii* (Reeve). Slender form; Lubang Id., Philippines.
19 *Turris annulata* (Reeve). Tosa, Japan.
20 *Turris undosa* (Lamarck). Mindoro Id., Philippines.

(all 2/3 natural size)

For subdivisions of the Turridae the reader is referred to the writer's 1942 paper (see bibliography), in which the following subfamilies were adopted and diagnosed: Turrinae Swainson, 1840 (emended); Turriculinae Powell, 1942; Cochlespirinae Powell, 1942; Clavatulinae H. & A. Adams, 1848; Conorbinae Powell, 1942; Clavinae Powell, 1942; Borsoniinae Bellardi, 1875; Mangeliinae Fischer, 1887 and Daphnellinae Hedley, 1922.

In the same paper two new families related to the Turridae were proposed: Speightiidae and Thatcheriidae. Charig (1963, Bull. Brit. Mus. (Nat. Hist.) Geol. 7(9), pp. 255-297) relegated the latter to subfamily rank within the Turridae but this question will be discussed at the appropriate place in a later number of "Indo-Pacific Mollusca."

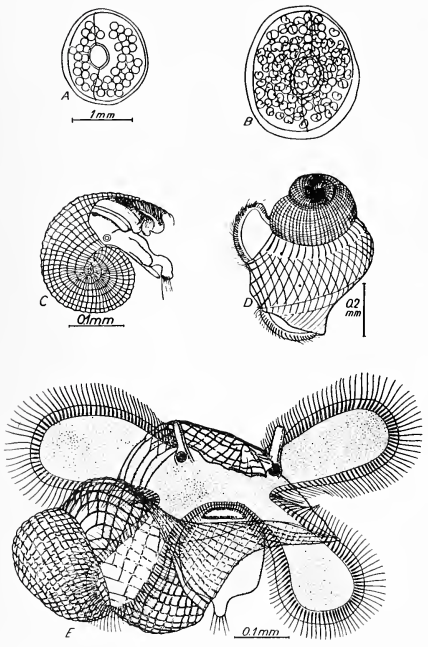

Plate 182. Development of a turrid (*Philbertia linearis* Montagu from Denmark). Fig. **a**, egg capsule with young embryos. Fig. **b**, embryos nearly ready to hatch. Fig. **c**, hatched larva. Fig. **d**, older larva. Fig. **e**, older larva swimming showing the ciliated velar lobes (from C. Thorson, 1946. Reproduction and Larval Development of Danish Marine Bottom Invertebrates, p. 237).

Doubtless when more is known concerning the soft parts of turrids there may be considerable modification of the above subdivisions, but meanwhile they serve as a workable scheme and form the basis for future discussion.

Phylogeny of the Turridae — The earliest known undoubted turrid is apparently *Clinura anassa* Murphy & Rodda, 1960, from the Bald Hills formation, California, considered to be Cretaceous, late Albian to late Cenomanian. This species, however, is not a *Clinura,* which is a near ally of *Thatcheria.* Its affinity is more likely with the forerunners of the Turriculinae.

The previous earliest record for the family, *Turriculina unica* Gregorio, from the Liassic (Jurassic) of Sicily, is now considered non turrid, and has been placed by Wenz (1938, p. 391), with a query, in the family Coelostylinidae of the Loxonematacea.

The family Turridae is undoubtedly an older one than the Conidae and is considered the main stem from which the several toxoglossate families have at different times arisen.

The prototypic radula found in a number of turrid genera suggests that the derivation of the family was from the taenioglossids rather than from the rachiglossids.

Turrids were already well represented in the Upper Cretaceous, with six of the nine now recognised Recent subfamilies in evidence, and this indicates a much earlier inception for the family, but unfortunately there are no authentic records in support of such an assumption. Since the presence of some form of sinus in the outer lip is the only reliable indicator of a fossil turrid, it is unlikely that the early stages of differentiation for the family will ever be recognised.

Regarding the origin of the subfamily Turrinae, it seems likely that there is much closer affinity among the Turrinae, Turriculinae, Cochlespirinae and Clavatulinae than with the remaining subfamilies.

Detailed phylogenetic discussion will appear at appropriate places throughout the subsequent parts of this work.

Geographical Distribution of the Turrinae — The modern geographical distribution of the Turrinae differs markedly from patterns of the early Tertiary. For instance, *Gemmula* and a number of short-lived offshoots from it, characterized the Eocene horizons of Europe, England and the southern United States, but now Southeast Asia and vicinity has become the focal point for that genus and its allies. In fact, there is in that area an explosive develop-

ment with no less than thirteen living genera of the Turrinae alone represented. The Tertiary faunas of India, Burma, Java and Japan show that the Turrinae were already strongly entrenched in these areas from the Miocene onward.

However, very few members of the Turrinae have managed to penetrate farther eastward into the Pacific than the Western Pacific Arc, that geographical feature running from the Ryukyu Islands through the Philippines, New Guinea and New Caledonia to Fiji. The exceptions are *Lophiotoma acuta*, which has reached the Marshall Islands and Samoa; *Xenurotnrris cingulifera* and *millepunctata*, both of which are represented by derivative species in the Hawaiian group; *Turris spectabilis*, recorded from the Marshall and the Phoenix groups; *Turris cryptorrhaphe*, also from the Marshalls; and a new subspecies of *crispa* from the Hawaiian Islands.

The Turrinae appear to be absent from the Society group and from most of the oceanic islands and atolls of the central Pacific. It is of interest, also, that the Turrinae are very rare at some of the atoll groups of the Indian Ocean, for Miss V. Orr, who recently collected intensively at Cocos-Keeling Islands, located only one member of the Turrinae, although small mangelids and daphnellids were there.

In tropical western America, the Caribbean and Florida, however, there is a development of large Turrinae, particularly in the genus *Polystira*, a shell that closely parallels the Indo-Pacific *Lophiotoma*, but has its own ancestry in that area by undoubted development from *Pleuroliria* of the Eocene and Oligocene of the southeastern United States. The genus *Gemmula*, wide-ranging both geographically and in time, also has representatives in tropical western America and off Florida.

In European–Mediterranean–West African waters, however, *Gemmula* is not represented, although it reached Pliocene times in England. The related *Fusiturris*, however, which has an unbroken ancestry back to the Paleocene, reaches Recent times in the Mediterranean and West Africa, and is the only large genus of the Turrinae still living in those areas.

The larger Turrinae of tropical America, the Mediterranean and the Indo-Pacific have obviously developed independently after the breaking up of that ancient equatorial waterway, the Tethys Sea. The cosmopolitan *Gemmula*, however, has in the main, retained its generic identity despite geographic segregating influences. Certainly a number of mutations have arisen from it at various times during its long life from the Paleocene to the present, but nevertheless the tropical west American type of the genus, *hindsiana* Berry (formerly *gemmata* Reeve) and the deep-water Caribbean *periscelida* Dall, have all the essential characteristics of the Indo-Pacific members.

List of Recognized Taxa in the Turrinae

Below are listed the recognised generic and subgeneric taxa of the *Turrinae*, with species and subspecies. Taxa not represented in the Indo-Pacific are in square [brackets], and with these only the type species is cited. Fossils are prefixed by a dagger. Where a species occurs both Recent and fossil the dagger occurs after the name.

Included in the list are southern Australian Recent and Tertiary *Turrinae*, as well as New Zealand Tertiary members. Such species are not excluded since they have had an Indo-Pacific origin during past periods of the Tertiary when warm waters extended much further south than they do at present.

Subfamily Turrinae

[**Fusiturris** Thiele, 1929]
[*undatiruga* Bivona, 1832]. **Type**
Gemmula Weinkauff, 1875
[*hindsiana* Berry, 1958] (= *gemmata* Reeve, 1843). **Type**
aethiopica (Thiele, 1925)
amabilis (Weinkauff, 1875)
†*bimarginata* (Suter, 1917)
†*birmanica* (Vredenburg, 1921)
†*clifdenensis* (Powell, 1942)
congener (E. A. Smith, 1894)
subsp. *cosmoi* (Sykes, 1930)
subsp. *diomedea* Powell, **new subsp.**
†subsp. *uekranica* (Vredenburg, 1925)
†*miocoronifera* Powell, **new name**
dampierana Powell, **new species**
†*disjuncta* Laws, 1936
ducalis (Thiele, 1925)
†*duplex* (Suter, 1917)
†*gellibrandensis* Chapple, 1934
genumulina (Martens, 1902)
gilchristi (Sowerby, 1902)
graeffei (Weinkauff, 1875)
hawleyi (Iredale, 1931)
hombroni (Hedley, 1922)
†*imitatrix* (Martin, 1916)
†*iris* (Vredenburg, 1921)
†*kaiparaensis* (Marshall, 1918)
†*karangensis* (Martin, 1895)

kieneri (Doumet, 1840)
†subsp. *ryukyuensis* MacNeil, 1960
†subsp. *woodwardi* (Martin, 1884)
†*kishimaensis* Shuto and Ueda, 1963
†*kotorai* (Nomura & Zinbo, 1935)
†*lawsi* Powell, 1942
†*longwoodensis* Powell, 1942
†*margaritata* (Marshall, 1918)
martini (Tesch, 1915)†
monilifera (Pease, 1860)
murrayi Powell, **new species**
†*orba* Marwick, 1931
†*ornata* (Marshall, 1918)
†*pakistanica* (Eames, 1952)
†*peraspera* Marwick, 1931
†*polita* (Marshall, 1919)
praesignis (E. A. Smith, 1895)
†*pulchella* Shuto, 1961
†*reticulata* (Marshall, 1919)
rotatilis (Martens, 1902)
†*samueli* (Tenison-Woods, 1879)
sibogae (Schepman, 1913)
sibukoensis Powell, **new species**
†*sindiensis* (Vredenburg, 1925)
†*soriensis* (Eames, 1952)
speciosa (Reeve, 1843)
†*thyrsus* (Vredenburg, 1921)
vagata (E. A. Smith, 1895)
†*waihaoensis* Finlay, 1924

Unedogemmula MacNeil, 1960 (subgen. of *Gemmula*)
†*bemmeleni* (Oostingh, 1941)
binda (Garrard, 1961)
deshayesii Doumet (1839)
hastula (Reeve, 1843)
†*haydeni* (Vredenburg, 1925)
†*ickei* (Martin, 1906)
†subsp. *virginoides* (Vredenburg, 1925)
indica (Deshayes, 1832)
†*ina* MacNeil, 1960
†*koolhoveni* (Oostingh, 1938)
†*sondeiana* (Martin, 1895)
unedo (Kiener, 1839-40). **Type**

Pinguigemmula MacNeil, 1960
luzonica Powell, **new species**
†*okinavensis* MacNeil, 1960. **Type**
philippinensis Powell, **new species**
thielei (Finlay, 1930)

[**Cryptogemma** Dall, 1918]
[*benthina* Dall, 1908]. **Type**

[**Carinoturris** Bartsch, 1944]
[*adrastia* Dall, 1919]. **Type**

Ptychosyrinx Thiele, 1925
bisinuata (Martens, 1901). **Type**
lobata (Sowerby, 1903)
†*timorensis* (Tesch, 1915)
subsp. *teschi* Powell, **new subspecies**
truncata (Schepman, 1913)

†**Kuroshioturris** Shuto, 1961 (subgen. of *Ptychosyrinx*)
†*asukana* (Yokoyama, 1926)
†*hyugaensis* (Shuto, 1961). **Type**
†*nipponica* (Shuto, 1961)
†*totomiensis* (Makiyama, 1931)

†[**Coronia** Gregorio, 1890]
†[*childreni* Lea, 1833]. **Type**

†[**Trypanotoma** Cossmann, 1893]
†[*terebriformis* Meyer, 1886]. **Type**

†[**Sinistrella** Meyer, 1885]
†[*americanus* Aldrich, 1885]. **Type**

†[**Infracoronia** Harris & Palmer, 1947] (subgen. of *Sinistrella*)
†[*ludoviciana* Vaughan, 1896]. **Type**

†[**Hesperiturris** Gardner, 1945]
†[*nodocarinata* Gabb, 1860]. **Type**

†[**Campylacrum** Finlay & Marwick, 1937
†*debile* Finlay & Marwick, 1937
†*sanum* Finlay & Marwick, 1937. **Type**

†[**Eopleurotoma** Cossmann, 1889]
†*multicostata* Deshayes, 1834. **Type**

†[**Oxyacrum** Cossmann, 1889] (subgenus)
†[*obliterata* Deshayes, 1834]. **Type**

†[**Eoturris** Finlay & Marwick, 1937
†*complicata* (Suter, 1917). **Type**
†*multicincta* (Marshall, 1917)
†*neglecta* (Suter, 1917)
†*uttleyi* Suter, 1917

†[**Epalxis** Cossmann, 1889]
†[*crenulata* Lamarck, 1803]. **Type**

Lucerapex Iredale, 1936
casearia (Hedley & Petterd, 1906). **Type**
subsp. *regilla* Iredale, 1936
carola (Thiele, 1925)
"*denticulata*" (Thiele, 1925)
indagatoris (Finlay, 1927)
molengraaffi (Tesch, 1915)†
†*murrayana* (Pritchard, 1904)
adenica Powell, **new species**

†**Optoturris** Powell, 1944
†*edita* (Powell, 1944)
†*optata* (Harris, 1897). **Type**
†*paracantha* (Tenison-Woods, 1877)
†*kyushuensis* Shuto, 1961

Epidirella Iredale, 1931
xanthophaes (Watson, 1886). **Type**
†*sayceana* (Chapman, 1912)

Epidirona Iredale, 1931
†*adelaidensis* (Ludbrook, 1941)
beachportensis (Cotton & Godfrey, 1938)
candida Laseron, 1954
carinata Laseron, 1954
costifera Laseron, 1954
flindersi (Cotton & Godfrey, 1938
gabensis (Hedley, 1922)
hedleyi Iredale, 1931. **Type**
jaffaeusis (Verco, 1909)
molleri Laseron, 1954
multiseriata (E. A. Smith, 1877)
nodulosa Laseron, 1954
perksi (Verco, 1896)
philipineri (Tenison-Woods, 1877)
†*powelli* Ludbrook, 1957
quoyi (Desmoulins, 1842)
schoutanica (May, 1911)
†*suppressa* (Finlay, 1927)
torquata (Hedley, 1922)
tuberculata Laseron, 1954
†*vardoni* (Tate, 1899)

Lophiotoma Casey, 1904
abbreviata (Reeve, 1843)
subsp. *lifuensis* (Sowerby, 1907)
subsp. *ustulata* (Reeve, 1846)
acuta (Perry, 1811). **Type**
albina (Lamarck, 1822)
†*albinoides* (Martin, 1883)
brevicaudata (Reeve, 1843)
ruthveniana (Melvill, 1923)

Lophioturris Powell, **new subgenus**
indica (Röding, 1798). **Type**
leucotropis (Adams & Reeve, 1850)
†*odengensis* (Martin, 1895)
polytropa (Helbling, 1779)
†*pseudofascialis* (Martin, 1883)

†[**Pleuroliria** Gregorio, 1890]
†[*supramirifica* Gregorio, 1890]. **Type**

[**Polystira** Woodring, 1928]
[*albida* Perry, 1811]. **Type**

†**Echinoturris** Powell, 1942
†*finlayi* Powell, 1935. **Type**

†[**Veruturris** Powell, 1944
†*bisculpta* (Powell, 1944)
†*cochleata* (Powell, 1944)
†*quadricarinata* (Powell, 1944). **Type**
†*subconcava* (Harris, 1897)
†*tomopleuroides* (Powell, 1944)

†[**Cinguliturris** Powell, **new subgenus** of *Veruturris*
†*tatei* (Cossmann, 1896). **Type**

Viridoturris Powell, **new genus**
corona Laseron, 1954. **Type**

Xenuroturris Iredale, 1929
castanella (Tinker, 1952)
cingulifera (Lamarck, 1822). **Type**
subsp. *erythraea* (Weinkauff, 1875)
cerithiformis (Tinker, 1952)
incredula (Iredale, 1931)
kingae Powell, **new species**
millepunctata (Sowerby, 1908)

Turris Röding, 1798
?*aubages* Barnard, 1958
amicta (E. A. Smith, 1877)
annulata (Reeve, 1843)
babylonia (Linnaeus, 1758). **Type**
crispa (Lamarck, 1816)
subsp. *intricata* Powell, **new subsp.**
subsp. *variegata* (Kiener, 1839-40)
subsp. *yeddoensis* (Jousseaume, 1883)
cryptorrhaphe (Sowerby, 1825)
garnonsii (Reeve, 1843)
†*selwyni* (Pritchard, 1904)
†*septemlirata* (Harris, 1897)
spectabilis (Reeve, 1843)
undosa (Lamarck, 1816)
†?*ugalieusis* Makiyama, 1927

[**Antiplanes** Dall, 1902]
[*perversa* (Gabb, 1865)].† **Type**

[**Rectiplanes** Bartsch, 1944] (subgen. of *Antiplanes*)
[*santarosana* (Dall, 1902)]. **Type**

[**Rectisulcus** Habe, 1958] (subgen. of *Antiplanes*)
[*motojinai* (Habe, 1958)]. **Type**

Turrinae to Be Dealt with in the Next Part

Turridrupa Hedley, 1922, *Austroturris* Laseron, 1954, *Micropleurotoma* Thiele, 1929 and *Taranis* (= *Fenestrosyrinx* Finlay, 1926 = *Allo* (Jousseaume) Lamy, 1934). *Bathytoma, Micantapex* and allied genera, despite the peripheral site of the sinus seem to have more in common with the *Borsoniinae*.

Doubtful Taxa in the Turrinae

The following species, mostly from the Tertiary of southeast Asia, cannot be satisfactorily evaluated at present, except that all appear to belong to the Turrinae. They are listed below under the genera to which they were ascribed by their respective authors.

Clavatula striata Gray, 1826

This is the type of the genus *Epideira* Hedley, but the type specimen of *striata* has not been found, and no shell from Western Australia, the presumed type locality, has been found which fits the rather undiagnostic description: "Shell ovate, turreted, whitish brown, with eleven or twelve longitudinal axial interrupted ribs forming long tubercles on the centre of the whorls; the whorls with distant impressed spiral lines near the suture with a rather flattened slightly nodulose band; the mouth rather more than one-third the length of the shell; outer lip thin inside, grooved; tail short, with a linear depression on its columella side; axis ten-twelfths, diameter four-twelfths of an inch." (in King's Narrative of a Survey . . . Coasts of Australia, London, **2,** appendix, p. 485, [1827] 1826).

Genus *Epideira* Hedley, 1918 (Proc. Royal Soc. New South Wales **51,** p. M79). An unrecognised genus with the **type,** by original designation, *Clavatula striata* Gray, 1826.

Pleurotoma (Eopleurotoma) adela Cossmann and Pissarro, 1909. Palaeont. Indica, N.S. 3, Mem. No. 1 (India (Ranikot Series, Tertiary)).

Pleurotoma (Eopleurotoma) jhirakensis Cossmann and Pissarro, 1909. Palaeont. Indica, N.S. 3, Mem. No. 1 (India (Ranikot Series, Tertiary)).

Pleurotoma (Gemmula?) simplicissima Thiele, 1925. Deutsch. Tiefsee-Exped., 17(2), p. 209, pl. 23, figs. 3, 3a; 5 × 1.8 mm. (off West Coast of Sumatra, 470 metres).

This is certainly not a *Gemmula* for the simple median carina is plain, and the rest of the shell smooth except for axials on the first two post-nuclear whorls. It may not even belong to the Turrinae for the nature of the sinus is neither figured nor described.

Pleurotoma (Hemipleurotoma) bonneti Cossmann, 1900. Faune Pliocenique de Karikal, p. 30, pl. 2, figs. 11, 13 (India, Karikal (Pliocene)).

Pleurotoma (Hemipleurotoma) bonneti bhagothorensis Vredenburg, 1925. Mem. Geol. Surv. India **50**(1), p. 51, pl. 12, fig. 5 (N.W. India, Sind, Nari of Bhagothoro Hill (post Eocene)).

Pleurotoma (Hemipleurotoma) humilis iravadica Vredenburg, 1921. Rec. Geol. Surv. India **53,** p. 98, pl. 12, fig. 13 (Burma, Payagyigon (Kama Series, Neogene)).

Pleurotoma yenanensis Noetling, 1895. Mem. Geol. Surv. India **27**(1), p. 42, pl. 10, fig. 3 (Burma (Tertiary)).

Pleurotoma (Hemipleurotoma) yenanensis narica Vredenburg, 1925. Mem. Geol. Surv. India **50**(1), p. 48, pl. 1, fig. 7 (N.W. India, Sind, Nari of Bhagothoro Hill (post-Eocene)).

Turris vandervlerki Beets, 1941. Geol. Mijnbouwk Genoot. voor Nederl. en Kalonien, Geol. Ser. 13, p. 7, pl. 7, figs. 273, 274 (East Borneo, Mangkalihat (Upper Miocene)).

Turris (Gemmula) husamaru Nomura, 1940. Rec. Oceanogr. Works Japan **12,** 1, p. 113, pl. 1, figs. 4a, b (Japan, off Tiba Prefecture). **See pl. 207**

Turris tigrinaeformis Nomura, 1935. Sci. Rep. Tohoku Univ., **18**(2), p. 113, pl. 7, figs. 32a, b Formosa [Taiwan Island] (Pliocene)).

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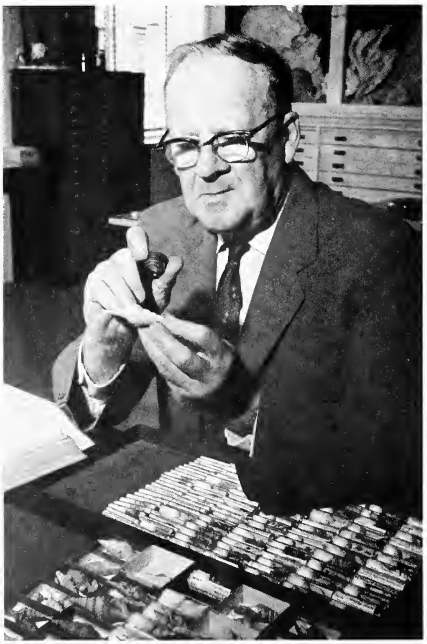

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Dr. A. W. Baden Powell is the Assistant Director of the Auckland Institute and Museum in New Zealand, and is the Curator of its Section of Mollusca. An internationally known conchologist and author of many scientific and popular articles and books on New Zealand molluscs, Dr. Powell has published extensively on land as well as marine forms. He has devoted many years to the study of the family Turridae, both fossil and Recent, and plans to complete his Indo-Pacific studies in a series of monographs for this journal. Dr. Powell is an accomplished artist and an ardent philatelist, specialising in New Zealand and British Commonwealth stamps. He was born in New Zealand on April 4, 1901.

EOCENE: *infraeocaenica* Cossmann, 1889; *laubrierei* Cossmann, 1889; *prestwichi* Edwards, 1861; *wetherelli* Edwards, 1861.

Family Turridae

Subfamily Turrinae

Genus Fusiturris Thiele, 1929

Type: *Pleurotoma undatiruga* Bivona, 1832

Members of this genus still live in the Mediterranean and southward along the equatorial coast of West Africa. It has an European ancestry back to the Paleocene and is the European–West African counterpart of the Indo-Pacific *Lophiotoma*. *Fusiturris* and *Gemmula* have had a parallel development from the European Paleocene upwards, but apparently *Gemmula* is no longer living in the European–West African area.

Shell up to 50 mm. (2 inches) in height, elongate-fusiform, with a tall spire and long straight anterior canal. Protoconch small, narrowly conic and of three smooth whorls. Spire turreted; sculpture of wavy thin axials crescentically thickened at the narrowly rounded periphery. Sinus peripheral, moderately deep and narrowly U-shaped. Operculum leaf-shaped and with an apical nucleus.

Synonymy —

1929 *Fusiturris* Thiele, Handbuch der Systematischen Weichtierkunde, Jena, 1, p. 361 [**type** by monotypy of section of *Turris: T. (F.) undatiruga* (Bivona)].

1929 *Tyrrhenoturris* Coen, Atti. Soc. Ital. Milano, 68: p. 297 (**type** by Powell's 1942, p. 22, subsequent designation: *Pleurotoma undatiruga* Bivona).

Characteristic species —

RECENT: *undatiruga* Bivona, 1832 (= *balteata* and *corrugata* Kiener, 1839-40, = *similis* Dautzenberg, 1891), *torta* Dautzenberg, 1912.

PLIOCENE: *porrecta* Wood, 1848.

MIOCENE: *aquensis* Grateloup, 1832; *inermis* Hoernes, 1856; *mercati* Bellardi, 1877; *reevei* Bellardi, 1847.

OLIGOCENE: *conifera* Edwards, 1861; *difficilis* Giebel, 1864; *duchastelii* Nyst, 1836; *explanata* Koenen, 1890; *flexiplicata* Kautsky, 1925; *koeneni* Glibert, 1860; *plana* Giebel, 1864; *selysi* Koninck, 1837.

Plate 183. *Fusiturris undatiruga* (Bivona, 1832). Recent; Mediterranean. 46 mm. **Type** of *Fusiturris*.

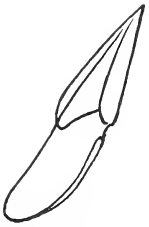

Plate 184. Marginal radular tooth of *Fusiturris undatiruga* (Bivona, 1832) (from J. Thiele, 1929, p. 361, fig. 441).

[These occasional blank areas occur between genera and subgenera to permit the insertion of new material and future sections in their proper systematic sequence.]

The Gemmate Series

The genus *Gemmula* has the most extensive Recent geographical range of any of the Turrinae and it also extends back to at least the beginning of the Tertiary. It is the most vigorous member of the Turrinae and undoubtedly represents the main stem of the subfamily. *Gemmula* is well-represented in the Tertiary of southern United States, Europe, India, Burma, Indonesia, Japan, Australia and New Zealand. The greatest development of *Gemmula* is now in the Indo-West Pacific. Very few species still exist in Caribbean-Panamic waters, and as already mentioned there are none from the Mediterranean and West Africa where the genus is replaced by *Fusiturris*.

Both *Gemmula* and *Fusiturris* seem to have had a common origin in the European Paleocene or earlier and both were well-represented throughout the Tertiary. All of the Eocene-Oligocene derivatives of *Gemmula* were relatively short-lived, as for example the European-American *Eopleurotoma*, the European *Epalxis*, *Hemipleurotoma* and *Oxyacrum*, as well as a group of New Zealand Upper Cretaceous–Eocene genera, *Campylacrum*, *Eoturris* and possibly *Tholitoma*.

Gemmula has the posterior sinus as a deep slit on the peripheral carina and in general the shell resembles *Lophiotoma*, except for the characteristic gemmate sculpture on the peripheral sinus rib.

The radula in *Gemmula* consists of a pair of marginals in the shape of a "wishbone," a type of dentition common to *Turris*, *Lophiotoma*, *Epidirona* and some members of the Turriculinae.

Genus Gemmula Weinkauff, 1875

Type: *Gemmula hindsiana* Berry, 1958

It may appear that only small differences separate the bracket of names, *Turris*, *Gemmula* and *Lophiotoma*, especially the fact that the presence of gemmules on the peripheral carina is the only obvious difference between *Gemmula* and *Lophiotoma*, which has a plain peripheral sinus band. However, these differences, which appear slight when Recent material only is reviewed take on more significance when phylogeny is considered.

Synonymy —

1875 *Gemmula* Weinkauff, Jahrbüch. der Deutschen Mal. Gesell., **2**: p. 287. **Type** by subsequent designation by Cossmann, 1896, p. 62: *Pleurotoma gemmata* Reeve, 1843 (non Conrad, 1835) = *Gemmula hindsiana* Berry, 1958.

Plate 185. *Gemmula hindsiana* Berry, 1958. Gulf of California. Formerly *Pleurotoma gemmata* Reeve, 1843, and Hinds, 1843; non Conrad, 1835 (from Harris, 1937, Paleont. Americana 2 (7), pl. 1. fig. 33). **Type** of *Gemmula*.

Key to the Gemmate Genera

A. Protoconch polygyrate and axially costate; peripheral keel gemmate throughout.
   1. Shell elongate-fusiform, sinus deep and narrow ..... *Gemmula*, p. 22-695
   2. Shell truncated anteriorly; sinus broadly V-shaped ..... *Ptychosyrinx*, p. 22-851
   3. Shell broadly conic; keel placed low; sinus open 45° .... *Pinnigemmula*, p. 22-789

B. Protoconch polygyrate and smooth, except for half whorl of axials; keel gemmate on early whorls only; shell elongate-fusiform ..... *Unedogemmula*, p. 22-761

C. Protoconch paucispiral, globose and smooth; sinus broadly V-shaped.
   1. Shell truncated anteriorly ..... *Kuroshioturris*, p. 22-865
   2. Shell elongate-fusiform and smooth; except for a peripheral row of tubercles. *Lucerapex*, p. 22-837

1931 *Eugemmula* Iredale, Records Australian Mus., **18**(4): p. 226. Type by original designation: *E. hawleyi* Iredale, 1931.

In addition to the large number of Indo-Pacific species either mentioned or described in the following text, *Gemmula* is abundantly represented in the Tertiary of both Europe and the United States of America.

Characteristic European Tertiary Species —

PALEOCENE: *gryi* Ravn, 1939. EOCENE: *acutangularis* Deshayes, 1834; *aspera* Edwards, 1861; *callifera* Edwards, 1861; *cancellata* Deshayes, 1834; *gentilis* Sowerby, 1850; *goosensi* Boury, 1899; *longaeva* Edwards, 1861; *monerma* Edwards, 1861; *nilssoni* Deshayes, 1865; *plebeia* Sowerby, 1850; *reticulosa* Edwards, 1861; *simillima* Edwards, 1861; *subcarinata* Rouault, 1850; *submonilifera* Boury, 1899; *taeniolata* Edwards, 1861; *tenuistriata* Deshayes, 1834; *uniserialis* Deshayes, 1834; *varians* Edwards, 1861.

OLIGOCENE: *bosqueti* Nyst, 1843; *humilis* Koenen, 1890; *laticlavia* Beyrich, 1848; *lunulifera* Koenen, 1890; *nodigera* Koenen, 1890, *odontella* Edwards, 1861; *odontophora* Koenen, 1890; *parkinsoni* Deshayes, 1865; *subdentata* Goldfuss, 1844.

MIOCENE: *annae* Hoernes and Auinger, 1891; *badensis* Hoernes and Auinger, 1891; *contigua* Brocchi, 1814; *coronata* Goldfuss, 1844; *coronifera* Bellardi, 1877; *cossmanni* Peyrot, 1931; *cypris* Orbigny, 1852; *denticula* Basterot, 1825; *disjuncta* Peyrot, 1931; *rotula* Brocchi, 1814; *spiralis* M. de Serres, 1829; *stoffelsi* Nyst, 1843.

PLIOCENE: *antwerpiensis* Vincent, 1890; *monilis* Brocchi, 1814; *turrifera* Nyst, 1853.

Characteristic American Tertiary Species —

EOCENE: *alternata* Conrad, 1833; *carodenta* Harris, 1937; *casteri* Harris, 1937; *conjuncta* Casey, 1904; *coraliger* Harris, 1937; *lancea* Casey, 1904; *lerchi* Vaughan, 1896; *ludocarola* Harris, 1937; *plentopsis* Harris, 1947; *sublerchi* Harris, 1937; *weteletella* Harris, 1937; *weisbordi* Harris, 1937.

OLIGOCENE: *amica* Casey, 1903; *ancilla* Casey, 1903; *tenella* Conrad, 1847.

It is possible that true *Gemmula* is represented in the Eocene-Miocene horizons of the west coast of North America, but material examined so far discounts this. The nearest approach to a *Gemmula* is *Surcula monilifera* Cooper, 1894, but although this Californian Eocene species has a beaded peripheral keel, the smooth conical three-whorled protoconch is atypical.

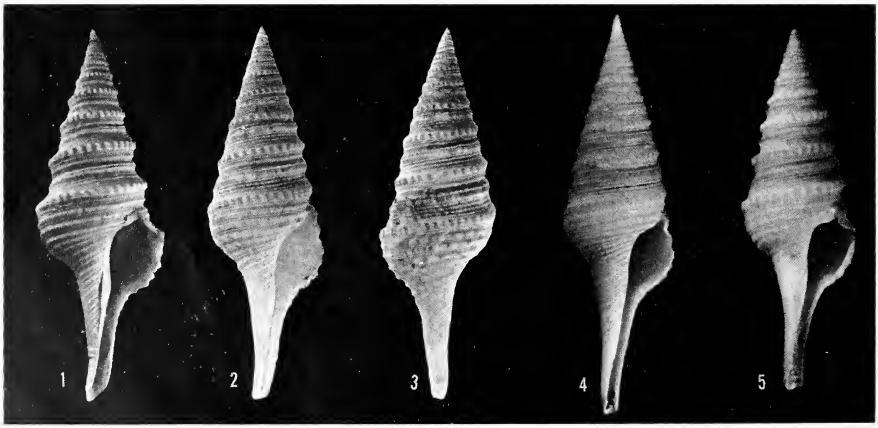

Plate 186

Figs. 1 *Gemmula speciosa* (Reeve). Holotype of *Pleurotoma carinata* Griffith and Pidgeon, 1834, non Link, 1808. Australia. 73 mm.
2, 3 *Gemmula kieneri* (Doumet). 40 fathoms, off Tosa, Japan. 61 mm.
4 *Gemmula murrayi* new species. Holotype. Off Sharam, west coast of the Gulf of Oman, Saudi Arabia. 35.5 mm.
5 *Gemmula dampierana* new species. Holotype. 7 mi. N.N.W. of Anchor Island. Onslow, Western Australia. 35.5 mm.

Gemmula speciosa (Reeve, 1843)

(Pl. 186, fig. 1)

Range — Philippines, China Sea and Arabian Sea.

Remarks — This very distinctive and uncommon species is at once recognized by its broad, cog-wheel-like peripheral keel which is regularly and closely studded with laterally compressed, raised gemmules. Further, there is a distinctive colour pattern of light-brown, continuous, spiral lines confined to the peripheral keel and the primary spiral cords. The closely allied *Gemmula kieneri* (Doumet) differs in having a heavier and less projecting peripheral keel, stronger interstitial spirals, as well as a more prominent subsutural fold. The colour markings of *kieneri* are not continuous lines, but are interrupted dots and dashes occurring between the peripheral gemmules and on the primary spirals.

Considerable confusion exists concerning the correct name to be used for this species, due to the erroneous and repeated statements that *carinata* Gray is synonymous with *kieneri* Doumet. Certainly, Reeve's 1843 *carinata* (Gray) appears to be identical with *kieneri*, but Gray's (in Griffith and Pidgeon, 1834) original *carinata* is undoubtedly the same as Reeve's *speciosa*. The latter name must be employed because Gray's name is preoccupied by *Pleurotoma carinata* Link, 1808. Because of this confusion, literature records of this species are not included here.

Melvill (1917, p. 145) described a *Turris (Gemmula) granosa guadurensis*, from the Mekran Coast in 70 fathoms, as follows: "Testa ut in typo, sed omnino minor, fere immaculata, M. C. Gwadur, one specimen at 70 fathoms. A few others, all much of the same calibre, off Ras Maidani, between Gwadur and Jask. The sculpture of this variety is identical with the type; the size about half, say 38 mm., as against 60-70 mm., the coloration most simple, nearly immaculate."

Although the actual type of *guadurensis* was not located, an apparently authentic topotype from the late Mr. J. R. le B. Tomlin shows this alleged subspecies to be merely an immature *speciosa*, for it fits into the size range of a series of that species from Station 72, John Murray Expedition, from the Gulf of Oman in 73 metres.

These shells are identical in sculpture with *speciosa* but are almost lacking in coloration, although a faint pattern does show faintly in some of the larger examples. The Tomlin specimen is 37 mm. in height and has 7 post-embryonic whorls, in contrast to 8 or 9 in adult *speciosa*. From the above observations it is clear that *guadurensis* is not a dwarf form, as Melvill believed it to be, but merely an immature *speciosa*.

Melvill made *guadurensis* a subspecies of *granosa* (= *kieneri*) but that species has fewer peripheral gemmules. Counts showed that in *speciosa* the gemmules range between 33 and 46 per whorl (43-46 in adults), and in adult *kieneri*, 31-35 per whorl.

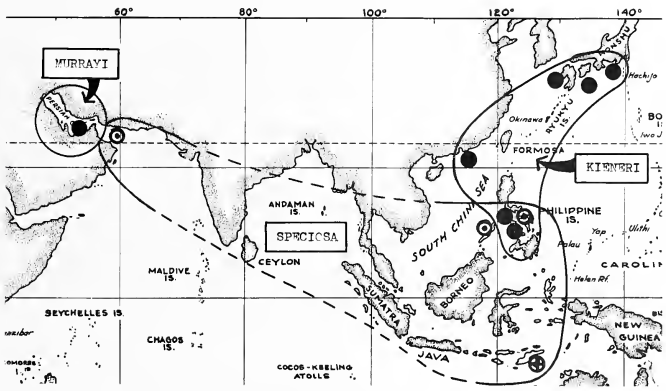

Plate 187. Geographical distribution of *Gemmula kieneri* (Doumet), *G. speciosa* (Reeve) and *G. murrayi* new species.

Fossil specimens are difficult to assign by illustrations alone, but it would appear that of the figured Upper Tertiary shells assigned to *carinata* by Tesch, 1915, only fig. 47a resembles *speciosa*, the remainder on plates 76 and 77 being sculpturally more in accord with *kieneri*.

Description – Adult shell 53.5 to 73 mm. (2 to 3 inches) in height. Fusiform, with tall spire and long tapered and slightly flexed anterior canal. Whorls strongly angulate and carinate at just below middle whorl height; base rather suddenly contracted. Peripheral carina a square-cut prominent flange densely studded with narrow, laterally compressed and peaked nodules which give a regular cog-like effect. Primary spirals plain, thin, but sharply raised, three above the carina, one of which is on a moderate subsutural fold, one or two below the carina, and about six on the base, exclusive of the canal. The secondary sculpture consists of from one to three plain weak threads in the interspaces of the primaries. The surface is crowded with weak, crisp, axial threads. Colour pattern of light-brown spirals on a buff ground.

The whole of the peripheral carina is uniformly coloured and all of the primary spirals are similarly tinted light-brown. There are no interrupted markings, dots or dashes.

Measurements (mm.) –

height	width	
73.0	26.0	type of *carinata* G. and P.
73.0	21.3	Samar Id., 35 fms., Philippines
53.5	19.0	Mantaquin Id., 27 fms.,Philippines

Synonymy –

1834 *Pleurotoma carinata* (Gray) in Griffith & Pidgeon, Moll. & Radiata, arranged by Baron Cuvier, London, p. 599, Pl. 23, f. 2. Non *Pleurotoma carinata* Link, 1808; non *carinata* (Gray); Reeve, 1843, Conch. Icon. **1**, pl. 7, fig. 56.

1843 *Pleurotoma speciosa* Reeve, Conch. Icon., **1**, pl. 2, fig. 9.

1884 *Pleurotoma (Gemmula) speciosa* Reeve, Tryon, Manual of Conch. **6**, p. 173, pl. 4, fig. 48.

1915 *Pleurotoma carinata* Gray, Tesch, Palaont. von Timor, pl. 77, fig. 47a (only).

1917 *Turris (Gemmula) guadurensis* Melvill, Proc. Malac. Soc., **12**, p. 145.

Types – British Museum (Natural History), no locality *(carinata)*.

Records – PHILIPPINES: off Badian Island, west Samar, 35 fms. (Albatross Sta. 5426); off Mantaquin Island, east coast, Palawan, 27 fms. (Albatross Sta. 5207) (USNM); Samar (coll. of A. D'Attilio, New York). ARABIA: Gulf of Oman, 73 metres (John Murray Exped. Brit. Mus. (Nat. Hist.)).

Fossil Records – Recorded from the Upper Tertiary of Timor (Tesch, 1915, p. 25, pl. 77, fig. 47a, only).

Gemmula kieneri (Doumet, 1840)

(Pl. 186, figs. 2, 3)

Range – Japan, China and the Philippines.

Remarks – Under *speciosa* Reeve, I have already pointed out that *kieneri* is very similar, but the peripheral keel in the latter is less projecting, the body whorl not so abruptly or so deeply contracted, and the colour pattern is in the form of maculations between the gemmules of the carina and interrupted dots and dashes on the primary spirals. In *speciosa*, all the colour lines are uninterrupted.

The species name *granosa* Helbling, 1779, has long been in misuse for this species which is common in Chinese and Japanese waters. Helbling's figure, however, depicts a misshapen specimen with a short anterior canal. There is a band of rounded gemmules subsuturally, the peripheral carina is studded with closely spaced, strong, round gemmules and all of the spirals below the peripheral keel are shown to be strongly and closely gemmate. It could be just a case of faulty draftsmanship but on the other hand Helbling's figures of other species in the same work are accurate and the species easily recognized.

No locality was given by Helbling and it is doubtful if the type specimen is still in existence. The wisest course is to drop the name as indeterminable and for this Oriental species employ Doumet's name, *kieneri*. The original reference is *Murex (Fusus) granosa* Helbling, 1779, Abhandl. Priv. Bohm. Math., Prag., **4**, p. 116, pl. 2, fig. 22.

Description – Adult shell 56 to 73 mm. (2¼ to 3 inches) in height, robust, fusiform, with tall spire and long rather straight anterior canal. Adult whorls, 10 or 11, rather tightly coiled. Spire whorls sculptured with a strong square-cut keel, situated below the middle, not prominently projecting and sculptured with numerous closely spaced rectangular nodules, which are laterally compressed. There is a strong subsutural fold bearing one primary cord and two threads, three or four sharply raised slightly imbricate threads between the subsutural fold and the peripheral keel and one primary cord and several threads between the periphery and the lower suture. Base, exclusive of the anterior canal, with about six primary cords and from one to three interstitial threads. Surface covered with dense lamellate axial growth threads which imbricate the secondary spiral threads. Colour maculated in light-brown on a white ground, with some obscure and irregular small blotches on the subsutural fold, with regular squarish spots between the gemmules on

the carina and with irregularly disposed spots on the primary cords of the base.

Measurements (mm.) –

height	width	
73.0	21.0	"India" (ANSP)
59.5	20.0	Tosa, Japan
56.0	17.5	Kii, Japan

Synonymy –

1840 *Pleurotoma kieneri* Doumet, Magasin de Zool. **2**, p. 2, pl. 10.

1843 *Pleurotoma carinata* Gray, Reeve (non Gray, 1834), Conch. Icon. **1**, pl. 7, fig. 56.

1909 *Pleurotoma carinata* Gray, Annandale & Stewart, Illus. Zool. Investigator, Moll. **6**, pl. 20, figs. 3, 4.

1915 *Pleurotoma carinata* Gray, Tesch, Palaont. von Timor, pls. 76 and 77 (all figs. of *carinata* except 47a).

1955 *Gemmula granosa* "Helbling," Kira, Coloured Illus. Shells of Japan, Osaka, pl. 35, fig. 18.

Records – JAPAN: Tosa, 40 fathoms; Kii (ANSP); Sagami Bay, 40 fathoms (USNM). HONGKONG (USNM). PHILIPPINES: West of Pacyan Island, 189 fathoms, green mud (Albatross Sta. 5409); between Cebu and Bohol, 162 fathoms (Albatross Sta. 5412) (USNM).

Fossil Records – Recorded from the Upper Tertiary of Timor (Tesch, 1915, p. 25, as *earinata*), pls. 76 and 77, all figures of "*earinata*," except 47a.

Gemmula kieneri *subspecies* ryukyuensis MacNeil, 1960

(Pl. 188, fig. 3)

Range – Okinawa, Miocene or Pliocene.

Remarks – "This subspecies has a broader subsutural slope than is common for the species and the subsutural collar is weaker. It has fewer and larger nodes on the peripheral carina. All of the specimens at hand have two or three coarse spirals below the periphery, those below on the base of the body whorl and columella becoming much weaker. The latter condition is approached by occasional specimens of the more typical form of the species but on *ryukyuensis* it is consistent" (MacNeil, 1960, p. 103).

MacNeil's figure shows a shell allied to *kieneri* by the presence of a bicordate subsutural fold, reminiscent of *cosmoi* in the three heavier spirals of the upper base, but distinct from both in the fewer peripheral gemmules.

Measurements (mm.) –

height	width	
47	15	holotype, USNM 562975.

Synonymy –

1960 *Gemmula granosa ryukyuensis* MacNeil, U. S. Geol. Surv. Prof. Paper 339, p. 103, pl. 14, fig. 24.

Records – OKINAWA and Takabanare-shima (Miocene, Yonabaru clay member); Okinawa, Shinzato tuff member (Miocene or Pliocene) (Type locality).

Gemmula kieneri *subspecies* woodwardi (Martin, 1884)

(Pl. 188, fig. 2)

Range – Indonesia, Pliocene.

Remarks – Judging from the original illustration, *Pleurotoma woodwardi* Martin is probably a synonym of *kieneri* Doumet, 1840 (= *granosa* auct.). Both Makiyama, (1927, p. 95) and Nomura (1935, p. 114) concur in this view but since Oostingh (1938, p. 27) makes it a subspecies of "*granosa*," and I have not seen the relevant material, Oostingh's view is accepted for the present.

Measurements (mm.) – Size not indicated.

Synonymy –

1884 *Pleurotoma woodwardi* Martin, Samml. Geol. Reichs-Mus., Leiden, Ser. I, **3**, p. 56, pl. 4, fig. 57.

1938 *Turris (Gemmula) granosa woodwardi* Martin, Oostingh, De Ingenieur in Ned.-Indie, Cast. 1(7), p. 27.

Records – PLIOCENE: deep boring (130 metres) near Batavia, Java Id., Indonesia (type locality); South Bantam, Indonesia, Pliocene (Oostingh, 1938).

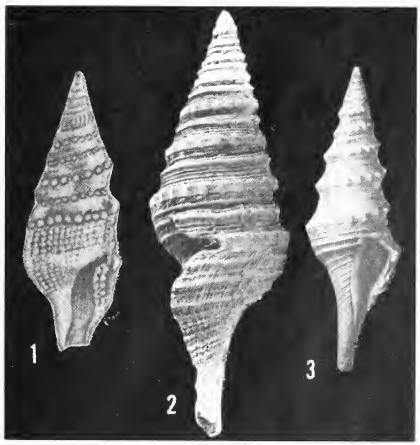

Plate 188. Fig. **1**, "*Murex (Fusus) granosa*" Helbling (from the original), an indeterminate species. Fig. **2**, *Gemmula kieneri woodwardi* (Martin), Pliocene of Sonde, Java. 22.5 mm. (photo courtesy of C. P. Nuttall, Brit. Mus.). Fig. **3**, *Gemmula kieneri ryukyuensis* MacNeil. Holotype. Miocene of Okinawa Id., Ryukyu Ids. 47 mm. (from the original, pl. 14, fig. 24).

Gemmula murrayi *new species*

(Pl. 186, fig. 4)

Range – Persian Gulf.

Remarks – This species stands nearest to *speciosa* (Reeve). It has the same distinctive colour pattern with all the primary spiral cords continuously lined in light-brown on a pale buff ground. It is of smaller adult size and is much narrower than *speciosa* and the peripheral keel is not so prominent.

Description – Adult shell 35 to 40 mm. (about 1½ inches) in height, elongate-fusiform, with a tall spire and long straight canal; spire angle 28° to 30°. Whorls 11-11½, plus a tall narrowly conic axially costate protoconch of 3½ whorls. Spire whorls sculptured firstly with a prominent subsutural fold which is narrowly crested by a smooth spiral cord and has two secondary spiral threads both above and below it, three or four smooth spiral cords on the broad, steep and lightly concave shoulder area to the not very prominent gemmate peripheral sinus ridge, which is composed of two closely spaced cords with the gemmules vertically fused, 39-40 on the penultimate. One primary spiral and a few very weak threads present between the peripheral carina and the lower suture. On the upper part of the base there are six rather wide-spaced primary spirals and below, over the neck and canal, there is an alternation of closely spaced primary and secondary spirals. Sinus moderately deep, U-shaped, its apex wider than the peripheral keel. Colour pale creamy buff, the sinus rib and all major spirals lined in light-brown. The main spiral of the subsutural fold is darker brown than any of the other spirals.

Measurements (mm.) –

height	width	
40.0	11.0	holotype
38.0	11.0	
33.0	9.0	

Type Locality – 25° 38′ 18″ N., 56° 26′ 36″ E., 73 metres (John Murray Expedition, Sta. 72): off Sharam, west coast of the Gulf of Oman.

Types – The holotype is in the British Museum (Natural History).

Gemmula dampierana *new species*

(Pl. 186, fig. 5)

Range – North West Australia, the Dampierian Marine Province.

Remarks – This species is closely allied to the preoccupied *Pleurotoma concinna* Dunker, 1856. Dunker described two species with the specific name *concinna* and confusion later arose through the action of Tryon (1884, p. 335) in combining both species in the synonymy of *reeveana* Deshayes, 1863. Actually, Dunker's two species are very different; that of 1871 in Malak. Blatt. 18, p. 160 is a *Hemidaphne*, and the earlier one, 1856, Proc. Zool. Soc., p. 356, is a *Gemmula*. Dunker's 1856 *concinna* was described from unknown locality but "Andaman Islands" has since been pencilled on the type tablet. This type specimen fits Dunker's description (in Latin) very well, even to the violet staining of the anterior end.

The species name provided above is not a new name for the preoccupied *concinna* but a new proposition for a very constant little *Gemmula* which comes from several dredgings in North West Australia at depths between 46 and 65 fathoms.

This species resembles *murrayi* n. sp. described above but has a wider spire angle, the peripheral gemmules are fewer, the colour pattern is confined to the subsutural fold and to the interstices of the gemmate keel, and the secondary spiral sculpture is stronger.

Nothing exactly matching Dunker's *concinna* is known to the writer, so this preoccupied species is left unnamed until it is rediscovered from some definite locality. A specimen from the Andaman Islands in the United States National Museum, attributed to *concinna*, lacks the overall brown colour and violet stained anterior end, and is in fact inseparable from the South African *gilchristi*.

Description – Adult shell 30 to 35 mm. (about 1¼ inches) in height, elongate-fusiform, with a tall spire and long straight canal. Spire equal to height of aperture plus canal, angle 33° to 35°. Whorls 8, plus a conical protoconch of 3½ whorls, first whorl smooth, remainder axially costate. Spire whorls sculptured firstly with a strong narrowly crested subsutural fold, four crisp spirals on the concave shoulder area, then the prominent gemmate bicarinate peripheral keel, the gemmules vertically fused and numbering 31 or 32 on the penultimate. One strong spiral cord with one or two secondary spirals both above and below it, between the peripheral carina and the lower suture. Upper base with four strong primary cords and one or two intermediates; neck and anterior end with an alternation of closely spaced cords and threads. Sinus deep and narrow, U-shaped, its apex no wider than the peripheral carina. Colour white with the subsutural folds and interspaces of the gemmules on the carina light reddish brown.

Measurements (mm.) –

height	width	
35.5	11.0	holotype
30.7	10.7	

Holotype – Western Australian Museum, Perth.

Records – NORTH WESTERN AUSTRALIA: 7 mi. N.N.W. of Anchor Island, Onslow, 46 fms. (type locality); 10 mi. N.N.W. of Anchor Island, Onslow, 65 fms.; 20 mi. N.W. of Anchor Island, Onslow, 65 fms. (Western Australian-Hawaiian Expedition, 1960).

Gemmula gilchristi (Sowerby, 1902)

(Pl. 189, figs. 1, 2)

Range – South Africa, Zanzibar, Andaman Islands and Japan.

Remarks – This species has been frequently misidentified as *monilifera* Pease, 1860. It was differentiated by Sowerby, 1902, as a new species, *Pleurotoma gilchristi,* a now well-known South African shell.

Description – Adult shell 34 to 37 mm. (1¼ to 1½ inches) in height, elongate-fusiform, with a tall spire and moderately long, slightly flexed anterior canal. Spire greater than height of aperture plus canal; angle 35° to 37°. Adult whorls 9 plus a narrowly conic protoconch of 3½ whorls, smooth at first but strongly axially costate over the last 1½ whorls. Spire whorls with a heavy subsutural fold, a median flange-like gemmate keel and a single strong smooth cord below. The subsutural fold is sharply keeled at the middle and the peripheral or sinus keel is double, densely sculptured with vertically fused gemmules, about 44 on the penultimate. Three interstitial threads between the subsutural fold and the peripheral keel and one in each interspace below the keel. Body whorl with four smooth primary cords below the peripheral keel, number two level with the suture and an alternation of spiral cords and threads over the base. About ten weak closely spaced spirals on the weak anterior fasciole. The whole surface between the spirals is crowded with fine lamellate axial threads. Sinus moderately deep, U-shaped, situated at the termination of the gemmate peripheral keel. Colour uniform golden to light reddish brown for shallow water shells; topotypes (55 fathoms) are white, sometimes with pale-brown between the peripheral gemmules.

Measurements (mm.) –

height	width	
34.6	10.7	Kii, Japan
34.0	10.7	Durban
32.5	10.5	Durban
32.0	11.0	holotype
28.7	9.0	Andaman Ids. (USNM)

Synonymy –

1897 *Pleurotoma monilifera* Pease, Sowerby, Append. Marine Shells S. Africa, p. 2 (non Pease, 1860).

1902 *Pleurotoma gilchristi* Sowerby, Marine Invest. in S. Africa, Cape Town, p. 99, pl. 2, fig. 9.

1958 *Turris gilchristi* Sowerby, Barnard, Ann. S. African Mus. 44, p. 106, fig. 3h, 6d.

Types – The holotype is in the British Museum (Natural History).

Records – SOUTH AFRICA: off mouth of Tugela River, 55 fms. (type locality for *gilchristi*); Zululand and Natal Coast, 27 to 90 fms.; off Cape Natal, 185 to 200 fms.; Hood Point, East London, 49 fms. ZANZIBAR: 1½ mi. W.S.W. of Ras Mungwe, 8 fms., fine sand, grass and shell (ANSP). ANDAMAN ISLANDS: (USNM). JAPAN: Kii (USNM).

Gemmula monilifera (Pease, 1860)

(Pl. 189, figs. 3, 4)

Range – Hawaiian Islands and Fiji Islands.

Plate 189. Figs. 1 and 2, *Gemmula gilchristi* (Sowerby), 55 fms., off the mouth of Tugela River, South Africa. 32 mm. Figs. 3 and 4, *G. monilifera* (Pease). Holotype from Brit. Mus. Hawaiian Ids. 29.4 mm. (photo by Alison Kay).

Remarks – This shell is widely known in collections under Dall's manuscript name, *aelomitra*, and in effect this name was legalised in 1952 by the action of Tinker who figured and described the species under Dall's manuscript name in "Pacific Sea Shells," p. 46.

Dall intended *aelomitra* as a new name for the Hawaiian *Turris monilifera* Pease, 1860, which he presumed was preoccupied by *Pleurotoma monilifera* Lea, 1833, an American Eocene species considered by Harris (1937, p. 31) to be synonymous with *Eopleurotoma sayi* (Lea, 1833). Since Pease and Lea described their respective species under different generic names, and each is now located in a different genus, i.e., *Gemmula* and *Eopleurotoma,* there is no name conflict, and *monilifera* Pease, 1860, may stand.

In 1869, Pease again described a *monilifera* but under the genus name *Pleurotoma;* it also is from the Hawaiian Islands and is presumably the same as his 1860 proposition. This point is of no consequence, however, since the 1869 combination is invalidated by Lea's earlier proposition.

Description – Adult shell 22 to 29 mm. (about one inch) in height, narrowly fusiform, with a tall spire and moderately long, almost straight, anterior canal. Spire greater than height of aperture plus canal; angle 25° to 27°. Adult whorls 8 or 9, plus a narrowly conic protoconch of three brown whorls, the first two smooth, the third closely axially costate. Spire whorls with a prominent but narrowly crested subsutural fold, followed by a deep shoulder concavity, bearing 3 or 4 crisp spiral threads. Then a heavy peripheral sinus-keel, which is closely studded with two series of gemmules, vertically fused, resulting in a cog-wheel effect. A single stout smooth spiral cord below the keel and a second one sometimes emergent over the last whorl. Body whorl with four primary smooth cords, followed by weaker cords below, becoming more closely spaced over the neck and anterior end; one or two spiral threads in each interspace. Anal sinus of moderate depth, U-shaped, its apex occupying the full width of the peripheral carina. Colour yellowish to light reddish brown, with the gemmate peripheral keel and the lower base picked out in white.

Measurements (mm.) –

height	width	
29.4	9.5	holotype
28.0	9.0	all off Waikiki, Oahu Id., Hawaii
25.5	8.5	
23.0	7.5	
22.7	7.5	

Synonymy –

1860 *Turris monilifera* Pease, Proc. Zool. Soc., London, p. 398.

1869 *Pleurotoma monilifera* Pease, Amer. Jour. Conch. **5**, p. 68 (not of Lea, 1833).

1875 *Pleurotoma (Gemmula) monilifera* Pease, Weinkauff, Jahrb. Deutsch. Malak. Ges. **2**, p. 289, pl. 9, figs. 1, 3.

1952 *Turris aelomitra* (Dall, ms.) Tinker, Pacific Sea Shells, p. 46, pl. 1 (lower row).

Types – Pease's holotype is in the British Museum (Natural History). We are indebted to Dr. Alison Kay of Hawaii for its photograph.

Records – HAWAIIAN ISLANDS: "Sandwich Islands," Cuming coll., (type locality); Oahu, off Waikiki, 33-50 fms.; entrance to Honolulu Harbour, 6-8 fms.; entrance to Pearl Harbour, 12-25 fms.; Maui, off Kaanapali; off Mt. Lihau, 4-12 fms. (D. Thaanum coll.); Oahu, off Diamond Head, 100 fms. (P. Burgess). FIJI: Momi Bay, S.E. of Nabilo Light, 13-15 fms. (W. Jennings); "Viti Islands" (A. Garrett, ANSP).

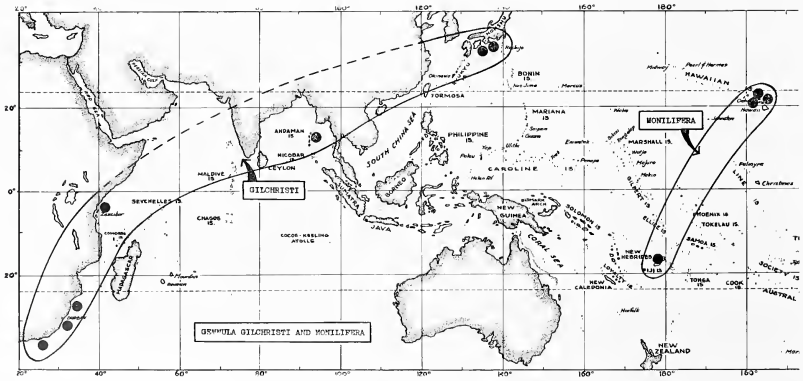

Plate 190. Geographical distribution of *Gemmula gilchristi* (Sowerby) and *G. monilifera* (Pease).

The Congener Series

Key to the Recent subspecies of *G. congener*

A. Base with 4 spirals more prominent than the rest
Shoulder area moderately wide and shallow
Subsutural fold unicarinate, slight
congener cosmoi
Subsutural fold bicarinate, slight
congener diomedea
B. Base with spirals gradually diminishing
Shoulder area a deep and narrow cleft
Subsutural fold bicarinate, massive
congener congener

The distributional areas for this group of three Recent subspecies is in the tropical Indian Ocean and Persian Gulf through the East Indies to the Philippines (for *congener congener*); off the Philippines in 100 to 310 fathoms (for *congener diomedea*) and in Japanese waters, 50 to 100 fathoms (for *congener cosmoi*).

Gemmula congener *subspecies* congener (E. A. Smith, 1894)

(Pl. 191, figs. 1-4)

Range – East Africa to the Philippines, 100 to 185 fathoms.

Remarks – This subspecies is characterised by the massive development of both the subsutural fold and the peripheral carina. So strongly developed are these two features that the shoulder is reduced to a narrow deep cleft. The spire varies in height between 1.2 and 1.3 times the height of the aperture plus the canal.

Specimens from two John Murray Expedition East African stations in 212 to 310 metres, are beautifully maculated in reddish brown on a white ground; they are spotted on all the spirals and those between gemmules on the bicarinate periphery are vertically confluent. The specimens are strongly but sparsely lirate within the outer lip and two examples exhibit tubular distortion of basal spirals. This East African maculated form may yet prove to be subspecifically distinct, for it tends also to have a relatively taller spire. The coloration of *congener* from elsewhere is, as in *cosmoi* and *diomedea*, confined to a light-brown band coincident with the subsutural fold.

Description – Adult shell 44 to 63 mm. (1¾ to 2½ inches) in height. Post-embryonic whorls 9, rather tightly coiled. Subsutural fold of two strong, densely gemmate, closely spaced spiral ridges. The massive peripheral keel is composed of two closely spaced, densely gemmate, rounded heavy spirals. One or two lesser spirals are between the peripheral carinae and the lower suture, and there are about ten primary spirals on the base, plus intermediate threads which extend densely below over the anterior canal. The primary basal spirals diminish gradually with no especially prominent ones. All of the spirals are rendered gemmate to some degree by the crossing of dense strong axial growth lines. Colour (typically) dull-white except for a light-brown band covering the subsutural pair of cords.

Measurements (mm.) –

height	width	
63.0	18.0	Balayan Bay, Luzon, 159 fms.
56.0	18.0	off Taal, Luzon, 177 fms.
56.0	18.0	off East Africa, 310 metres
55.0	16.2	off East Africa, 310 metres
52.0	17.0	Bay of Bengal, 128 fms. (holotype)
48.5	15.0	Opol, Mindanao, 214 fms.
45.0	16.0	off Colombo, 150 fms.
38.0	13.0	Andaman Islands, 185 fms.

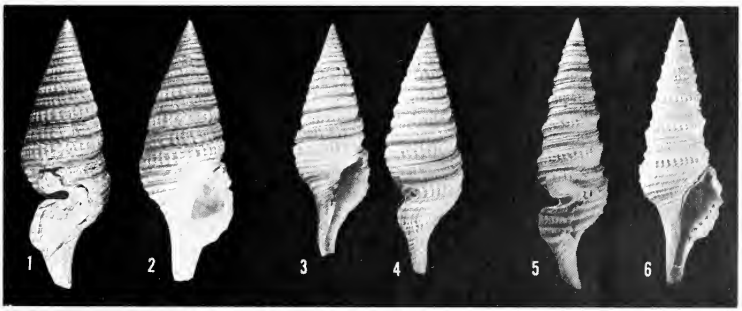

Plate 191. Figs. 1-4, *Gemmula congener congener* (E. A. Smith). Figs. 1, 2, from 150 fms., off Colombo, Ceylon. 45 mm.; figs. 3, 4, from 128 fms., off Arena Point, Luzon Id., Philippines. 44 mm. Figs. 5, 6, *Gemmula congener diomedea* new subspecies. Holotype. 256 fms., off Apo Id., Negros Id., Philippines. 73 mm.

Synonymy –

1894 *Pleurotoma congener* E. A. Smith, Ann. Mag. Nat. Hist., Ser. 6, **14**, p. 160, pl. 3, figs. 4, 5.

1913 *Pleurotoma (Gemmula) congener* Smith, Schepman, Siboga Exped., Pt. 5, 49e, p. 403.

1917 *Turris (Gemmula) congener* Smith, Melvill, Proc. Malac. Soc. **12**, p. 144.

Type – Indian Museum, Calcutta.

Records – PERSIAN GULF (Melvill, 1917). INDIA: Bay of Bengal, 128 fms. (type locality). CEYLON: west of Colombo, 150 fms. (USNM). ANDAMAN ISLANDS: 185 fms. (Investigator Exped., Brit. Mus.). EAST AFRICA: 5° 36′ 12″ S., 39° 13′ 12″ E., 310 metres; 5° 38′ 54″ S., 39° 15′ 42″ E., 212 metres (John Murray Exped., Brit. Mus.). INDONESIA (Schepman, 1913). PHILIPPINES: off Arena Point, Luzon, 128 fms., Sta. 5382; S.W. of Corregidor Lt., Luzon, 118 fms., mud and shell, Sta. 5272; Tayabas Bay, Luzon, 150 fms., dark green mud, Sta. 5372; Batangas Bay, 170 fms., Luzon, Sta. 5268; off Opol, 214 fms., Mindanao, Sta. 5502; Balayan Bay, 159 fms., Luzon, Sta. 5118 (Albatross Exped., USNM).

Gemmula congener *subspecies* mekranica (Vredenburg, 1925)

Range – Post-Eocene of India and Miocene of Java and Sumatra.

Remarks – Despite Vredenburg's detailed description, which occupies 4½ pages, there appears to be no obvious differences in his subspecies that are not covered by the normal limits of variation admissible for the Recent species. In his own summary, following the description, Vredenburg (p. 57) states that "Compared with *Pleurotoma congener* this fossil is distinguished by its somewhat smaller dimensions," i.e., as follows: height, 27; width, 10; height of spire, 15; height of body whorl, 16 mm.

Vredenburg (p. 57) then states: "Judging from the figures and descriptions, no essential difference can be discovered between this fossil (i.e. *mekranica*) and a shell from the Upper Miocene of Java and Sumatra which Martin has described as *coronifer(a)* (a name pre-employed by Bellardi in 1877 for a species from the Miocene of Piedmont)."

Vredenburg's figures of his *mekranica* are small and too indistinct for accurate comparison with the living *congener*, so the subspecies is retained tentatively until comparisons of material can be made.

Incidentally, also on page 57, Vredenburg virtually introduces another new name with the following statement "Compared with Mekran specimens, the Caj specimens are apparently of a still smaller size which, if really characteristic of their horizon, might serve to distinguish them as a variety '*gajensis*.'"

Synonymy –

1925 *Pleurotoma (Gemmula) congener mekranica* Vredenburg, Mem. Geol. Surv. India **50**(1), p. 54.

1925 *Pleurotoma (Gemmula) congener gajensis* Vredenburg, Mem. Geol. Surv. India **50**(1), p. 57 (nomen nudum).

Records – N.W. INDIA: Gaj of Kachh (Mekran beds, post-Eocene); also west of Gharh Hill and between Kanderi and Sari Dasht in Kulanch. JAVA and SUMATRA: (Upper Miocene) (Vredenburg).

Gemmula congener *subspecies* cosmoi (Sykes, 1930)

(Pl. 192)

Range – Japan, 50 to 100 fathoms.

Remarks – This shell resembles *kieneri* but is always separable by its loose coiling, or more rapidly increasing whorls, the single subsutural cord, the form of the peripheral gemmules which are not only fused in vertical pairs but extend "comma"-like below the carina, and the prominence of three or four of the basal spirals, as well as the simplicity of the coloration which is white, except for a single spiral light-brown line on the subsutural cord.

The subspecies *diomedea*, described following, indicates the relationship of *cosmoi* to be with *congener* rather than with *kieneri*.

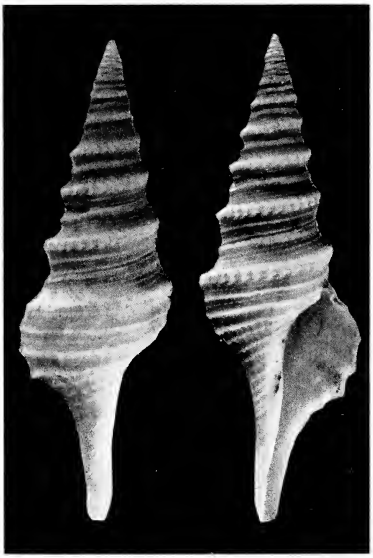

Plate 192. *Gemmula congener cosmoi* (Sykes). 50 fms., off Tosa, Japan. 63 mm.

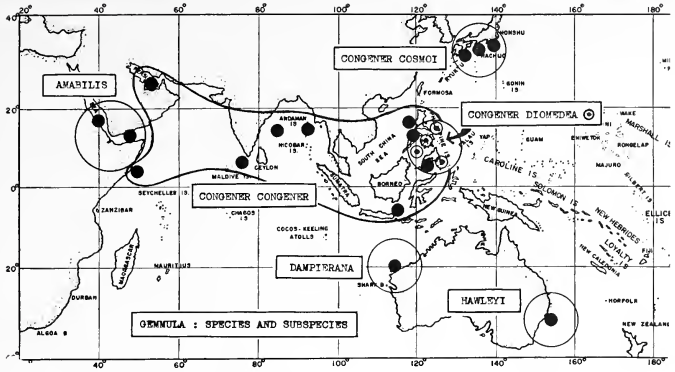

Plate 193. Geographical distribution of *Gemmula congener* and its subspecies, and *Gemmula amabilis* (Weinkauff), *G. hawleyi* Iredale and *G. dampierana* new species.

Description – Adult shell 52 to 67 mm. (2 to 2½ inches) in height, elongate-fusiform, with a tall spire and long tapered anterior canal. Adult whorls 9, strongly angled by a broad square-faced peripheral carina situated just below the middle of whorl height. This carina is densely studded with laterally compressed cog-like axials which extend a little distance below the carina in comma-like fashion. There is a strong but narrow crested subsutural fold and one, sometimes two, smooth primary cords between the carina and the lower suture. Shoulder with three to four fine crisp secondary spiral threads. Body whorl with three or four spiral cords much stronger than the rest, situated on the upper part of the base. Below this the spirals become weaker and rather crowded over the neck and canal. Colour as described above, pure white, except for a subsutural light-brown line. The whole surface crossed by rather dense but weak axial growth lines which tend to crenulate the primary basal spirals.

Measurements (mm.) –

height	width	
67.0	21.5	
64.0	20.7	
63.0	18.7	
52.0	17.0	
46.5	12.0	holotype

Synonymy –

1930 *Turris cosmoi* Sykes, Proc. Malac. Soc. **19**, p. 82, text fig.

1954 *Gemmula cosmoi* Sykes, Kira, Coloured Illust. Shells of Japan, pl. 35, fig. 13.

Type Locality – Kii, Japan.

Records – JAPAN: Tosa and Kii (ANSP); off Tosa, 50 fms. (USNM); off Tosa, 100 fms. (A. W. B. Powell coll.); Sagami Bay (Thaanum coll.).

Gemmula congener *subspecies* diomedea *new subspecies*

(Pl. 191, figs. 5, 6)

Range – Philippines, 100 to 350 fathoms.

Remarks – This subspecies forms a link between the delicately sculptured Japanese *cosmoi* and the robust, heavily carinated Indian Ocean *congener*.

So far *diomedea* is known only from deep water off the Philippines. It resembles *congener* in having a bicarinate subsutural fold but the wide shallow shoulder area and the four extra strong basal spirals are characters more in accord with *cosmoi*. The subspecific name is derived from *Diomedea*, the genus for the wandering albatross.

In a number of instances this subspecies exhibits heavy folds and flutings at the termination of the basal primary cords and these strongly laciniate the outer lip margin.

Description – Adult shell 63 to 88 mm. (2½ to 3½ inches) in height, elongate-fusiform, with a tall spire and long considerably flexed anterior canal. Adule whorls 9, strongly angled at about middle whorl height by a broad square-cut peripheral carina which is densely studded with vertically fused gemmules. Subsutural fold composed of two closely spaced gemmate cords. Threads, 3 to 5, on the deeply concave shoulder, 2 primary cords between the peripheral carina and the lower suture with 2 to 3 weak threads in the interspaces. Body whorl including neck and anterior canal with numerous primary cords and intermediate threads.

Four spiral cords on the upper part of the base much stronger than the rest and in some examples these are developed into heavy meandering and twisted folds that laciniate the margin of the outer lip. Spiral sculpture of dense, strong, axial threads which render all the cords gemmate or crenulate. Colour white except for a subsutural band of light-brown which covers both subsutural cords.

Measurements (mm.) –

height	width	
88.0	27.0	Malocot Pt., Luzon Id., 198 fms.
73.0	20.5	holotype
63.3	18.2	paratype
53.6	16.5	off Panglao Id., 220 fms.

Types – The type locality is Albatross Station 5397, 198 fathoms, off Malocot, West Luzon Island, Philippines. The holotype is in the U. S. National Museum, no. 238878.

Records – PHILIPPINES: S.E. of Pt. Tanon, Cebu Id., 310 fms. (Albatross Sta. 5335); N.W. of Panglao Id., 220 fms. (Albatross Sta. 5198); off Dupon Bay, Leyte Id., 350 fms., green mud (Albatross Sta. 5407); off Apo Id., Negros Id., 256 fms. (Albatross Sta. 5538); off Malocot Pt., West Luzon Id., 198 fms., mud and sand (Albatross Sta. 5397); West of Siquijor Id., 254 fms., green mud (Albatross Sta. 5369); off Tayabas Lt., Luzon Id., 106 fms., black sand (Albatross Sta. 5369); off Tayabas Bay, Luzon Id., 190 fms., green mud (Albatross Sta. 5374); off Opol, Mindanao Id., 214 fms. (Albatross Sta. 5501); off Pt. Sella, Mindanao Id., 219 fms. (Albatross Sta. 5541); off Abgao, Leyte Id., 182 fms., green mud (Albatross Sta. 5403); also the following Albatross Philippine stations – 5118, 5404, 5410, 5508, 5535 and 5589 (USNM).

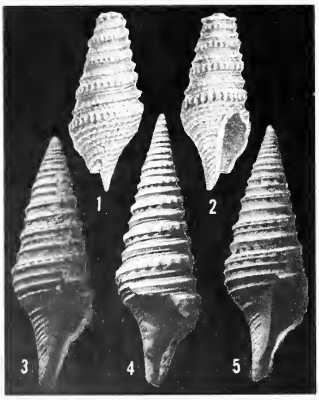

Plate 194. Figs. **1, 2,** *Gemmula miocoronifera* new name. Miocene of Java. Formerly *Pleurotoma coronifer* Martin, 1879, non Bellardi, 1877 (from K. Martin, 1879, pl. 11, figs. 2, 2a). Figs. **3-5,** *Gemmula imitatrix* Martin. Lower or Middle Miocene of Java, Nanggulan Beds. Figs. **3, 4,** original types for *Pl. coronifera* Martin, 1884 (not 1879). Fig. **5,** syntype of *imitatrix* Martin.

Gemmula miocoronifera *new name*

(Pl. 194, figs. 1, 2)

Range – Miocene of Liotjitjankang, Java Island, Indonesia (type locality).

Remarks – This species is characterised by its tall, narrowly tapered spire and double-submargining of the suture, the top spiral cord being the smaller. It seems more closely related to *kieneri* (Doumet) than to *congener,* and is certainly not a synonym of Vredenburg's *mekranica.*

The name *Pleurotoma coronifer* Martin, 1879, must be considered as a homonym of *Pleurotoma coronifera* Bellardi, 1877, for there is no proper Latin form "coronifer," only *coronifera,* a fact which Martin realized in 1884 when he corrected his spelling to *coronifera.* I hereby rename Martin's homonym *Gemmula miocoronifera* new name. Martin did not give any measurements in his original description.

Synonymy –

1879 *Pleurotoma coronifer* Martin, Tertiarschichten auf Java, p. 61, pl. 2, fig. 2 (non Bellardi, 1877).

1884 *Pleurotoma coronifera* Martin, Samml. Geolog. Reichs-Mus. Leiden, Ser. 1, **3,** p. 58 (in part, synonymy only).

Gemmula imitatrix (Martin, 1916)

(Pl. 194, figs. 3-5)

Range – Miocene of Djokdjokarta (Nanggulan), Java Island, Indonesia (type locality).

Remarks – This species is a new name for the same author's *coronifera* of 1884, not *coronifer,* again of the same author, 1879. The species has a wider spire angle and the gemmate keel is less prominent than in the original *coronifer.*

Measurements (mm.) –

height	width
19.0	–

Synonymy –

1884 *Pleurotoma coronifera* Martin, Samml. Geol. Reichs-Mus., Leiden, Ser. 1, **3,** p. 58, pl. 4, fig. 58 (not of Martin, 1879).

1916 *Pleurotoma (Hemipleurotoma) imitatrix* Martin, Die altmiocene Fauna des West-Progogebirges auf Java, Samml. Geol. Reichs-Mus., Leiden, **2,** p. 229, pl. 1, figs. 13, 13a.

1938 *Turris (Gemmula) imitatrix* Martin, Oostingh, Die Moll. Plioc. Sud. Bantam in Java, De Ingen. Ned.-Indie, Gast. **1,** p. 28.

Gemmula sindiensis (Vredenburg, 1925)

(Pl. 195, figs. 1-3)

Range — Post-Eocene of India.

Remarks — This species, which its author "regarded in all probability as a premutation of *Pleurotoma congener*," is in one important respect dissimilar in that the subsutural fold carries only one spiral cord, which allies it instead with *cosmoi*. The Indian fossil, however, is uniformly more strongly spirally sculptured than the Japanese Recent species, yet does not show a selective development of the three or four upper base spirals so characteristic of *cosmoi*.

Measurements (mm.) —

height	width	height of spire	height of body whorl
27	10	16	16

Synonymy —

1925 *Pleurotoma (Gemmula) sindiensis* Vredenburg, Mem. Geol. Surv. India **50**(1), p. 58, pl. 5, figs. 13, 14.

Records — N.W. INDIA (post-Eocene): Gaj of Kachh, near Warsar, north of Jakao.

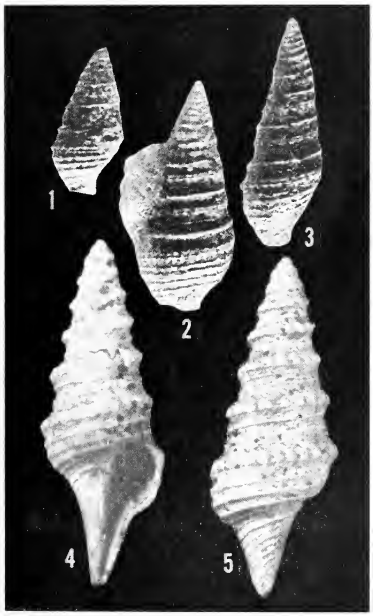

Plate 195. Figs. **1-3**, *Gemmula sindiensis* (Vredenburg). Gaj of Kachh, India. Post-Eocene. Figs. **4, 5**, *Gemmula pulchella* Shuto. Lower Pliocene, Takanabe member, Japan (both holotypes from the original figures).

Gemmula pulchella Shuto, 1961

(Pl. 195, figs. 4, 5)

Range — Lower Pliocene of Japan.

Remarks — This shell was described as a subspecies of *granosa* Helbling (i.e. *kieneri* Doumet) but from figures and the description the alliance seems to be with *cosmoi* Sykes. It is described as having a very small protoconch, 22 gemmules on the penultimate whorl and 29 on the body whorl, and an anal sinus that is broader than the carina, but Shuto's figure (text fig. 4, no. 3) shows a sinus restricted to, if not narrower than, the carina. In *cosmoi* the gemmules range from 25 to 32 and in *kieneri*, 30 to 35 per whorl.

Although the type of *pulchella* is a small shell, only 10.2 mm. in height, it has six adult whorls and is evidently approaching full size. It can be assessed as a forerunner of *cosmoi* characterised by a dwarf size and fewer, stronger gemmules.

Measurements (mm.) —

height	width
10.2	5.6

Synonymy —

1961 *Gemmula granosa pulchella* Shuto, Mem. Fac. Sci. Kyushu Univ. Ser. D, Geol. 11(2), p. 80, pl. 10, figs. 1, 2; text figs. 3, 4.

Records — JAPAN (middle part of Takanabe member, Lower Pliocene): roadside small cliff at Nihonmatsu, Takanabe machi, Koyu gun, Miyazaki Prefecture.

[These occasional blank areas occur between genera and subgenera to permit the insertion of new material and future sections in their proper systematic sequence.]

The Martini Series

Gemmula martini (Tesch, 1915)

(Pl. 196, figs. 1-4)

Range – Pliocene of Timor; Recent, off East Africa and off Borneo in deep water.

Remarks – This species along with *aethiopica* Thiele, *sibogae* Schepman and *sibukoensis* form a group characterised by the peripheral carina set low on the spire whorls, almost at the lower suture, which results in a rather flat-sided profile to each whorl in the spire.

Description – Adult shell 46 to 77 mm. (about 2 to 3 inches) in height, solid, broadly fusiform, uniformly dull-white, without colour markings. Adult whorls 11, outlines straight except for a slightly projecting, broadly rounded sinus-rib set just above the lower suture. Sculpture simple, of smooth narrowly rounded but relatively strong spiral cords. Above the peripheral carina the interspaces are without interstitial spirals but below the carina, over the base, neck and canal, all the cords have one or two spiral threads between them. The peripheral carina is composed of 2 or 3 closely spaced spiral cords which are densely studded with vertically and partially fused gemmules, 38 to 50 per whorl. Spire equal to height of aperture plus canal, angle 35° to 37°.

Measurements (mm.) –

height	width	
77.0	25.0	East Africa, 638 metres (type of *valdiviae*)
68.0	22.5	Sibuko Bay, Borneo, 310 fms.
49.0	16.0	Timor, Noil Aintie (Pliocene)
48.0	16.5	type of *martini* (fig. 48b of Tesch)

Synonymy –

1903 *Pleurotoma (Gemmula) carinata* Gray, Martens, Gast. Deutsch. Tiefsee-Exped., p. 76 (non Griffith & Pidgeon, 1834).

1915 *Pleurotoma* (s.str.) *martini* Tesch, Palaeont. von Timor, p. 26, pl. 77(5), figs. 48, 49.

1925 *Pleurotoma (Gemmula) valdiviae* Thiele, Wissenschaft. Ergebn. Deutschen Tiefsee-Exped., 17, Gastr. 2, p. 208, pl. 23, fig. 1.

Types – The type locality for *martini* (Tesch) is in a Pliocene deposit, station W III, Noil Noni, between Kapan and Niki-Niki, Timor, Indonesia.

Records – TIMOR: (Pliocene) Noil Noni (type locality of *martini*); Noil Aintie, Kolo, Pliocene (Brit. Mus.). EAST AFRICA: off Somaliland, 0° 27.4′ S., 42° 47.3′ E., 638 metres (type locality of *valdiviae*); off Somaliland, 977 and 1134 metres (Thiele, 1925). SUMATRA: off north coast, 6° 56.3′ N., 93° 32.7′ E., 362 metres; off Nias Id., 470, 614 and 660 metres (Thiele, 1925). BORNEO: S.E. of Mabul Id., Sibuko Bay, grey mud and sand (Albatross Sta. 5590, USNM).

Gemmula aethiopica (Thiele, 1925)

(Pl. 196, fig. 5)

Range – Off Somalia, East Africa, 638 metres.

Remarks – From its figure and description this species appears to be closely allied to *martini* Tesch but has sufficient differences to warrant specific separation from that species. Compared with *martini*, the shoulder is not so straight in profile but is inwardly subangled medially by a groove that delimits a broad but flat subsutural collar. The gemmules are fused into oval shapes taller than wide and set across the tricordate peripheral carina. These gemmules are much stronger but less numerous than in *martini*. None of the spiral cords, not even those on the base, appear to have intermediate spirals.

Plate 196

Figs. 1- 3 *Gemmula martini* (Tesch). Pliocene of Timor. Tesch's original figures, pl. 77.

4 *Gemmula martini* (Tesch). Holotype of *Pleurotoma (Gemmula) valdiviae* (Thiele), off East Africa (from Thiele, 1925, pl. 23, fig. 1).

5 *Gemmula aethiopica* (Thiele). Holotype. 638 meters, off East Africa (from Thiele, 1925, pl. 34, fig. 25).

6, 7 *Gemmula sibogae* Schepman. Holotype. 472 meters, between Makjan and Halmahera Ids., Indonesia (from Schepman, 1913, pl. 26, fig. 2).

8, 9 *Gemmula sibukoensis* new species. 310 fms., S.E. of Mabul Id., Sibuko Bay, Borneo. Fig. 8 is holotype, 46.2 mm.

10 *Gemmula vagata* (E. A. Smith). Holotype. 200-350 fms., off Trincomalee, Ceylon (from E. A. Smith, 1895, pl. 1, fig. 3).

Measurements (mm.) –

height	width
47	19

Synonymy –

1925 *Pleurotoma (Gemmula) aethiopica* Thiele, Wissenschaft. Ergebn. Deutschen Tiefsee-Exped., **17**, Gastr. 2, p. 208(174), pl. 34(22), fig. 25.

Types – The type locality is off East Africa, Valdivia Sta. 253, 0° 27.4′ S., 42° 47.3′ E., 638 metres, off southern Somalia.

Gemmula sibogae (Schepman, 1913)

(Pl. 196, figs. 6, 7)

Range – Indonesia, between Makjan and Halmahera, 472 metres.

Remarks – Compared with *aethiopica*, the spire angle is much less, the peripheral gemmules appear to be stouter and rather fewer per whorl, and the base more suddenly contracted. The coloration is described as whitish, faintly yellowish on the keel, between the nodules. The spire angle judged from figures is 42° in *aethiopica* but only 33° in *sibogae*.

Measurements (mm.) –

height	width
27.5	11.5

Synonymy –

1913 *Pleurotoma (Gemmula) sibogae* Schepman, Siboga Exped., Pt. 5, 49e, p. 404, pl. 26, fig. 2.

Types – The type locality is Indonesia, Siboga Sta. 137, channel between Makjan and Halmahera, fine dark muddy sand, 472 metres.

Gemmula sibukoensis *new species*

(Pl. 196, figs. 8, 9)

Range – Borneo, Moluccas and Philippines, 50 to 484 fathoms.

Remarks – This is another member of the group with the peripheral carina set low down on the spire whorls. It appears nearest to *sibogae* Schepman, but differs in having a heavier peripheral carina a little above the lower suture, allowing the emergence of the uppermost basal spiral over the later whorls, and the shape of the body whorl, which is but slowly contracted over the base to a shorter and flexed, not straight canal.

Description – Adult shell 41 to 48 mm. (about 2 inches) in height. Fusiform, with a tall spire, about 1 1/5 times height of aperture, plus canal. Whorls 10, plus a small polygyrate conic protoconch of 3 whorls or more, the last, at least, axially costate. Protoconch eroded and the tip missing in all available specimens. Spire whorls turreted by a strong rather broadly rounded peripheral sinus-rib, which is set low on the whorls, almost at the lower suture, but with a narrow space beneath it, which allows the emergence, over the last few whorls, of the uppermost basal spiral. Peripheral sinus-rib densely sculptured with laterally compressed, concavely arcuate axials, 27 to 31 per whorl, overridden by 2, occasionally 3, weak spirals. Spiral sculpture consisting of rather strong but narrow cords, 3 to 5 on the wide, steeply descending shoulder and 16 to 18 on the base; 3 on the upper part of the base rather stronger than the rest, which diminish in size gradually to the end of the anterior canal. Labial sinus of moderate depth, V to U-shaped, its apex wider than the crest of the sinus-rib. Colour creamy white. Surface crossed by dense sharp axial growth lines.

Measurements (mm.) –

height	width	
47.8	16.2	figured paratype
46.2	16.2	holotype

Types – The type locality is Albatross station 5590, S.E. of Mabul Island, Sibuko Bay, Borneo, in 310 fathoms. The holotype is in the United States National Museum, no. 239111.

Records – BORNEO: S.E. of Mabul Id., Sibuko Bay, 310 fms. (holotype) (Albatross Sta. 5590); off Mabul Id., Sibuko Bay, 260 fms., sandy mud (Albatross Sta. 5589); off Silungan Id., Sibuko Bay, 305 fms., green mud and sand (Albatross Sta. 5592). CELEBES: Gulf of Boni, 484 fms., grey mud (Albatross Sta. 5656); MOLUCCAS: off Kayoa Id., 265 fms., grey mud and fine sand (Albatross Sta. 5626); off Makyan Id., Moluccа Pass, 288 fms., fine sandy mud (Albatross Sta. 5624). PHILIPPINES: off Liangan River, Mindanao Id., 410 fms., grey mud and sand (Albatross Sta. 5511); N. of Biliran Id., 50 fms., mud and sand (Albatross Sta. 5210) (all USNM).

Gemmula vagata (E. A. Smith, 1895)

(Pl. 196, fig. 10)

Range – Indian Ocean from Aden to the Andaman Islands, in deep water.

Remarks – This very distinctive species is at once recognised by its almost vertical-sided whorls between a strongly projecting flange-like peripheral keel.

Description – Adult shell 60 to 65 mm. (about 2 inches) in height, rather heavily built and strongly sculptured. Spire tall and narrow with rather straight and almost vertical sides, interrupted just below the middle by a prominently projecting, heavy, flange-like, gemmate keel. Spire 1.2 to 1.3 times height of aperture plus anterior canal. The sculpture of the spire whorls consists of a moder-

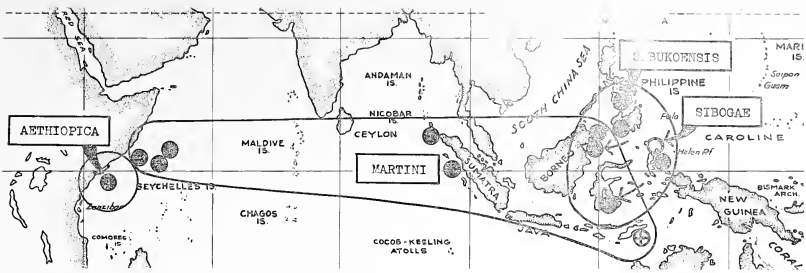

Plate 197. Geographical distribution of *Gemmula aethiopica* (Thiele), *G. martini* (Tesch), *G. sibogae* (Schepman) and *G. sibukoensis* new species.

ately strong subsutural square-cut fold, bearing 2 spiral cords, with 2 or 3 fine spiral threads between them, followed by a deeply concave shoulder, bearing 5 to 9 weak spiral threads between the subsutural fold and the strongly gemmate cog-like peripheral sinus-rib. About 24 gemmules on the penultimate. Below the peripheral sinus-rib, 2 of the basal series of plain narrow spirals are emergent. About 16 to 18 basal spirals present, those above wide-spaced and with sevcral fine threads in each interspace. Colour (Smith, 1904) "The infrasutural keel is generally somewhat reddish and the central carina is spotted with the same colour between the tubercles."

The species seems to be nearest allied to *gemmulina* Martens, a smaller and less solid shell from the Archibenthal of Indonesia and the South China Sea.

Measurements (mm.) —

height	width	
65.0	23.0	Ceylon, 200 to 350 fms. (type)
61.0	18.0	Chagos Archipelago, 494 metres
53.0	17.0	Chagos Archipelago, 494 metres
46.0	15.0	Gulf of Aden, 1022 metres

Synonymy —

1895 *Pleurotoma vagata* E. A. Smith, Ann. Mag. Nat. Hist., Ser. 6, **16**, p. 3, pl. 1, fig. 3; 1904, E. A. Smith, Ann. Mag. Nat. Hist., Ser. 7, **13**, p. 456.

1909 *Pleurotoma vagata* Smith, Annandale & Stewart, Illustr. Zool. Investigator, Calcutta, Moll., **6**, pl. 14, figs. 3, 3a.

Types — Indian Museum, Calcutta.

Records — CEYLON: off Trincomalee, 200-350 fms. (type locality). INDIA: off Travancore coast, 360 fms. (Smith, 1904); off Malabar coast, 295-360 fms. (USNM); GULF OF ADEN: 732 metres, 1022 metres and 1061 metres. 4° 58′ 42″ S., 73° 16′ 24″ E., north of the CHAGOS ARCHIPELAGO, 494 metres (John Murray Exped.) (Brit. Mus.). ANDAMAN ISLANDS: 185 fms. (Smith, 1904).

Gemmula praesignis (E. A. Smith, 1895)

(Pl. 198, fig. 1)

Range — Off Colombo, Ceylon, 675 fathoms.

Remarks — Smith's species, based presumably upon a single imperfect shell minus the protoconch as well as the tip of the anterior canal, does not look very different from that author's *vagata*, described in the same paper from approximately the same area; deep water off Ceylon. From the figure, *praesignis* would appear to differ from *vagata* in having a heavier peripheral carina with more prominent and less numerous nodules, a very strong sharply crested subsutural spiral and fewer secondary spirals in the shoulder concavity.

Description (E. A. Smith) — "The prominent row of tubercles around the middle of the whorls, the keel beneath the suture, and the broad sinus in the labrum are the principal features of this species. The apex of the spire being broken away makes it impossible to state with certainty the exact number of whorls, but they would probably amount to eleven or twelve. The entire surface exhibits fine flexuous lines of growth."

Measurements (mm.) —

height	width	
42.0	15.0	holotype

Synonymy —

1895 *Pleurotoma praesignis* E. A. Smith, Ann. Mag. Nat. Hist., Ser. 6, **16**, p. 4, pl. 1, fig. 4.

Types — Indian Museum, Calcutta.

Records — CEYLON: off Colombo, 675 fms. Schepman, 1913, Siboga Exped., Moll., p. 39, recorded this species from the Flores Sea in 794 metres and Halmahera Sea in 411 metres, but both records are suspect since they were based upon "very young" specimens.

Gemmula ducalis (Thiele, 1925)

(Pl. 198, fig. 2)

Range — Off East Africa, 1134 metres.

Remarks — This juvenile shell is only 6 mm. in

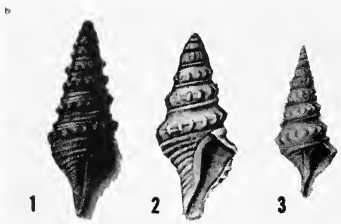

Plate 198. Fig. **1**, *Gemmula praesignis* (E. A. Smith). Holotype. 675 fms., off Colombo, Ceylon (from E. A. Smith, 1895, pl. 1, fig. 4). Fig. **2**, *Gemmula ducalis* (Thiele). Holotype. 1,134 meters, off Somaliland, East Africa (from Thiele, 1925, pl. 23, fig. 2). Fig. **3**, *Gemmula rotatilis* (Martens). Holotype. 1,134 meters, off Somaliland, East Africa (from Martens, 1903, pl. 1, fig. 3).

height, and consists of a typical multispiral, axially costate protoconch and three post-nuclear whorls. It is impossible to say at this stage of our knowledge of the genus if this is really a distinct species or merely a juvenile of one already described.

Synonymy —

1925 *Pleurotoma (Gemmula) ducalis* Thiele, Wissenschaft. Ergebn. Deutschen Tiefsee-Exped., 17, Gastr. 2, p. 209, pl. 23, fig. 2.

Records — Off Somaliland, East Africa, 1° 49′ N., 45° 29.5′ E., 1134 metres.

Gemmula gemmulina (Martens, 1902)

(Pl. 200, fig. 2; pl. 201, figs. 1, 2)

Range — Sumatra to China Sea and the Philippines, 35 to 505 fathoms.

Remarks — The Albatross Expedition material recorded below is claimed with some confidence to represent von Marten's species, the type of which came from off the west coast of Sumatra in 677 metres.

Nothing quite matching *gemmulina* in sculptural detail was found although the Albatross material exhibits a considerable range of sculptural variation. It is possible, of course, that von Marten's figure is over-simplified so far as secondary sculpture is concerned.

A characteristic feature, however, is common to both von Marten's figures and the Albatross specimens and that is the strong crisp nature of the bicarinate subsutural fold.

The discrepancy noted above concerns the subsidiary spirals on the concave shoulder between the subsutural fold and the peripheral carina. In von Marten's figure only one, quite distinct, spiral appears in the shoulder concavity but in the Albatross material these spirals number from 3 to 5, of which never more than 3 are relatively strong. Since there is such variation in a series of 7 Albatross specimens from 5 localities it is likely that a wider series would include such an example as Marten's type within the range of variation admissible for the species.

The species shows relationship with *vagata* (Smith), which differs in having almost vertical-sided whorls, a longer canal, a weaker bicarinate subsutural fold and weaker secondary sculpture, as well as attaining a larger adult size.

Description (based upon the figured Molucca Passage shell) — Adult shell 29 mm. (1 1/8 inches) in height, solid, white, covered by a thin shining light creamy-buff periostracum. Pagodiform, with a tall spire and relatively short anterior canal. Spire about 1.3 times height of aperture plus canal. Adult whorls 10 (protoconch worn in all specimens but indicated as tall, polygyrate and axially costate). Sculptured with two closely spaced crisp spiral cords forming the subsutural fold, a prominent gemmate bicarinate peripheral keel below the middle of whorl height and subsidiary spiral cords, 3 between the subsutural fold and the peripheral keel and 2 to 3 below it. Base with about 17 subequal primary cords and a single weak thread in each interspace over the region of the neck. The peripheral gemmules are vertically fused into laterally compressed nodes giving a cog-wheel effect. The nodes number 20 on the penultimate. Sinus openly U-shaped, not very deep, its apex rather wider than the peripheral keel. The whole surface of the shell crossed by regular thin axial growth threads.

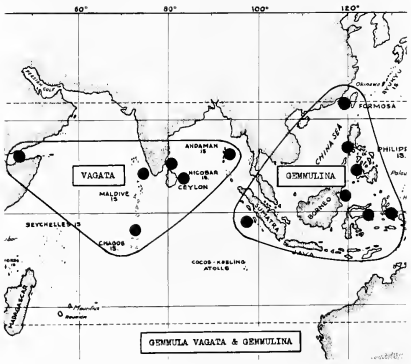

Plate 199. Geographical distribution of *Gemmula vagata* (E. A. Smith) and *G. gemmulina* (Martens).

An extreme variant from 90 fathoms off Luzon Island has a very prominent bicarinate subsutural fold and 5 spiral cords in the shoulder concavity.

Measurements (mm.) —

height	width	
37.5	12.0	Pratas Id., China Sea, 122 fms.
35.7	11.7	Luzon Id., 90 fms.
29.0	10.2	Molucca Passage, 275 fms.
27.0	9.2	Molucca Passage, 230 fms.
23.2	8.0	Molucca Passage, 230 fms.
20.5	6.3	type

Synonymy —

1902 *Pleurotoma (Gemmula) gemmulina* Martens, Sitzungsb. d. Gesell. naturf. Freunde, Berlin, p. 238; 1903 Martens, Gast. der Deutsch. Tiefsee-Exped., 1898-1899, 7, p. 77, pl. 1, fig. 2.

Records — SUMATRA: off west coast, 677 metres (type); off Siberut Id., 750 metres (von Martens). MOLUCCAS: off Makyan Id., Molucca Passage, 275 fms. grey mud, Sta. 5622; off Gillolo Id., Molucca Passage, 230 fms., Sta. 5625. CELEBES: S.E. of Tikola Peninsula, Buton Strait, 37 fms., grey mud, Sta. 5642. BORNEO: S. of Silungan Id., Sibuko Bay, 305 fms., Sta. 5592. CHINA SEA: off Pratas Id., 122 fms. PHILIPPINES: off Cape Santiago, Luzon Id., 280 fms., Sta. 5283; off Pitogo, Luzon Id., 90 fms., grey mud and sand, Sta. 5376; N. of Ambil Id., 102 fms., fine sand and mud, Sta. 5278; Iligan Bay, N. Mindanao Id., 505 fms, grey mud and fine sand, Sta. 5513 (all Albatross stations, USNM).

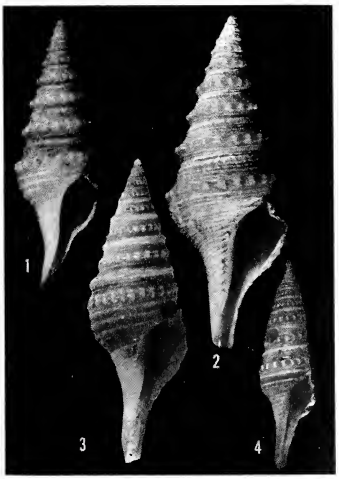

Plate 200. Fig. 1, *Gemmula amabilis* (Weinkauff). 732 meters, in the Gulf of Aden. 18 mm. Fig. 2, *Gemmula gemmulina* Martens. 275 fms., off Makyan Id., Molucca Passage, Albatross station 5622. 29 mm. Fig. 3, *Gemmula graeffei* (Weinkauff). Momi Bay, south of Nabilo Light, Fiji. 22 mm. Fig. 4, *Gemmula hombroni* Hedley. Cebu Id., Philippines, 26 mm.

Gemmula amabilis (Weinkauff, 1875)

(Pl. 200, fig. 1; pl. 201, figs. 3-7)

Range — Red Sea.

Remarks — So far as can be judged from Weinkauff's very sketchy figures of his species and the more detailed figures of Sturany, 1903, presumably the same species, the deep-water John Murray Expedition series of specimens from 732 metres off Aden may at present be considered conspecific. The John Murray specimens are more elongate and when compared with authentic *amabilis* material, may prove to be a bathymetric form of that species, which was probably from shallow water.

Description (Weinkauff, 1875, p. 29) — "Testa fusiformis, solidiuscula, pallide flavefusca, spiraliter cingulata, interstitiis sublente striis incrementi sculpta, cingula una valida, distincte nodosa, carinam distinctam efficiens, noduli albide picti: spira elato-conica, apice acuto, anfractibus 11, unicarinatis, sutura evanescente obliqua divisi, ultimus convexus, canali longo productus; apertura verticalis piriformis, intus sublente costata, margine externo basi producto (Jickeli). Long 18 diam. maj. 6, apert. 4 mm." (See our pl. 201, figs. 3-5).

Description (based upon Aden, 732 metres example) — Adult shell 20 to 26 mm. (¾ to 1 inch) in height, elongate-fusiform with a tall spire whose angle is 26° to 27°, and with a moderately long-flexed anterior canal. Whorls 9, plus a tall narrowly conic protoconch of 3½ whorls, first 2 whorls smooth, remainder strongly axially costate. Postnuclear whorls sculptured with a relatively strong tricordate subsutural fold, the central cord strongest and forming a sharp keel. Shoulder concavity with three crisp spiral threads, followed by a prominent bicarinate gemmate flange which is located a little below the middle of the whorl. Gemmules vertically fused into laterally compressed nodes, 18 on the penultimate. A single smooth cord and a weak thread are above it between the peripheral carina and the lower suture. Body whorl with three strong smooth widely spaced cords above, below which are 13 finer, closely spaced cords and a similar weaker number over the anterior end. Sinus a broadly open shallow "U," its rounded apex occupying the full width of the peripheral carina. Colour uniformly white.

Measurements (mm.) —

height	width	
24.0	7.6	off Aden, 732 metres
18.0	6.0	off Aden, 732 metres
18.0	6.0	type, Massana, Red Sea

Synonymy –

1875 *Pleurotoma amabilis* (Jickeli ms.) Weinkauff, Conch. Cab. **4**(3), p. 29, pl. 6, figs. 4, 6.

1875 *Pleurotoma (Gemmula) amabilis* (Jickeli ms.) Weinkauff, Jahrb. Mal. Ges. **2**, p. 291, pl. 9, figs. 6, 8.

1903 *Pleurotoma (Gemmula) amabilis* Weinkauff, Sturany, Gast. des Rothen Meeres, Exped. S. M. Schiff "Pola," pl. 3, fig. 3 a-c.

Records – RED SEA: Massana (type locality); Gulf of Aden, 732 metres (John Murray Exped. Sta. 176, Brit. Mus.).

Gemmula hombroni (Hedley, 1922)

(Pl. 200, fig. 4; pl. 201, fig. 8)

Range – Andaman Islands and Indonesia to the Philippines, and Japan to northern Australia.

Remarks – This small, slender, uniformly reddish-brown shell is one of the most distinctive of the genus. It has long been recognised under the pre-occupied name of *fusca* Hombron & Jacquinot, but some confusion has occurred through Tryon's (1884) action in erroneously uniting it with *gemmata* Hinds, the Lower California–Panamic type of the genus.

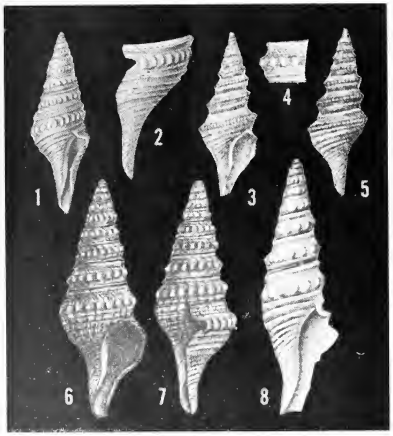

Plate 201. Figs. **1**, **2**, *Gemmula gemmulina* (Martens) (also see pl. 200, fig. 2), 677 meters, off the west coast of Sumatra (from Martens, 1902, pl. 2, figs. 2, 2a). Figs. **3-5**, *Gemmula amabilis* (Weinkauff), Massana, Red Sea (from Weinkauff, 1875, pl. 9, figs. 6, 8). Figs. **6**, **7**, *G. amabilis* (Weinkauff), Red Sea, (from Sturany, 1903, pl. 3, fig. 3). Fig. 8, *Gemmula hombroni* (Hedley), Padang, Sumatra (holotype of *Pleurotoma padangensis* Thiele, original pl. 23, fig. 5).

Description – Adult shell 25 to 27 mm. (about 1 inch) in height, elongate-fusiform, with a tall slender spire and long slightly-flexed anterior canal. Whorls 8 to 8½, exclusive of a tall, narrowly conic, polygyrate protoconch of 3½ to 4 whorls, all but the tip sculptured with concavely-arcuate, stout axials. Adult whorls very strongly and definitely sculptured, firstly by a heavy, smooth, narrowly crested subsutural cord, followed by the flange-like, gemmate peripheral sinus-rib, set below the middle of whorl-height, and finally a single heavy, smooth spiral cord, uppermost of the basal series and emergent between the peripheral carina and the lower suture. Base with about 9 rather wide-spaced, strong, flat-topped spiral cords to about the middle of the neck, after which the spirals rapidly diminish in size and become more closely spaced. The concave shoulder area is encircled by 3 to 5 spiral threads. Spire a little taller than height of aperture plus canal, angle 22° to 25°. Gemmules confined to the peripheral carina, 18 to 22 per whorl, smooth, laterally compressed and cog-like. Sinus at periphery moderately deep, U-shaped. Colour uniform, yellowish brown to reddish brown.

Measurements (mm.) –

height	width	
28.0	8.5	Cavite, Manila Bay, Philippines
27.0	7.5	Cavite, Manila Bay, Philippines
25.5	7.0	Cavite, Manila Bay, Philippines
11.5	2.4	type of *padangensis*

Synonymy –

1853 *Pleurotoma fusca* Hombron & Jacquinot, Voy. Pole sud., Zool., 4, p. 111, pl. 25, figs. 19, 20 (non *Pl. fusca* C. B. Adams 1845).

1884 *Pleurotoma gemmata* Hinds, Tryon, Manual of Conch. **6**, p. 173 (in part).

1913 *Pleurotoma (Gemmula) fusca* H. & J., Schepman, Siboga Exped. **49e**, p. 402.

1922 *Gemmula hombroni* H. and J., Hedley, Rec. Aust. Mus. **13**(6), p. 218, nom. nov. for *Pl. fusca* Hombron & Jacquinot, 1853, non C. B. Adams 1845.

1925 *Pleurotoma (Gemmula) padangensis* Thiele, Wissenschaft. Ergebn. Deutschen Tiefsee-Exped., **17**, Gastr. 2, p. 335, pl. 23, fig. 5.

Records – AUSTRALIA: Torres Strait (type of *fusca*). PHILIPPINES: Mariveles, Bataan, Luzon Id.; ½ mi. off Balibatikan, Papapas Bay, Batangas Province, Luzon Id., 4 fms.; 1 mi. E. of Limey, Bataan, Luzon Id., 9-10 fms.; 3 mi. E.N.E. of San Nicolas Shoals Light, Manila Bay, Luzon Id., 10 fms.; ½ mi. off Matabunkay Beach, Batangas Province, Luzon Id., 3-4 fms.; ½ mi. E. of Cabcaben, S.E. Bataan, Luzon Id., 2 fms. (duPont-Acad. Exped., 1958, ANSP); N. of Corregidor Id., 37 fms. (Albatross Sta. 5109); Opol, Mindanao Id., (USNM); near Cavite, Manila Bay (MCZ). JAPAN: Yenoshima (USNM). ANDAMAN ISLANDS: (USNM). SUMATRA: Padang (type of *padangensis*). Schepman (1913) records the species from 20 Indonesian stations, 9-522 metres, and off western New Guinea, 32 metres.

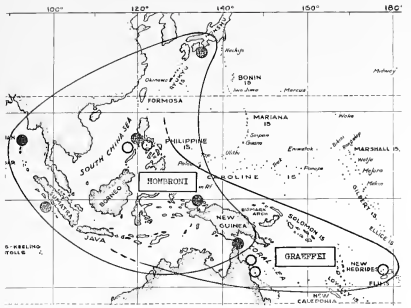

Plate 202. Geographical distribution of *Gemmula hombroni* (Hedley) in solid dots, and *Gemmula graeffei* (Weinkauff) in open circles.

Gemmula graeffei (Weinkauff, 1875)

(Pl. 200, fig. 3)

Range — Fiji, Queensland and Philippines.

Remarks — This species stands nearest to *monilifera*, from which it differs in the spire's height being approximately equal to that of the aperture plus canal, the more slowly contracted base, heavier tricarinate subsutural fold and absence of a zoned colour pattern.

Description (based upon a topotypic specimen) — Adult shell 19 to 22 mm. (about ¾ inch) in height, elongate-fusiform with a tall spire and long, slightly flexed anterior canal. Whorls 8, exclusive of a tall, conical, polygyrate protoconch of 3 to 3½ axially costate whorls. Spire equal to height of aperture plus canal; angle about 30°. Spire whorls with a massive subsutural fold crossed by 3 spiral cords, the central one forming a narrowly crested keel. A moderately deep concavity bearing 2 spiral threads separates the subsutural fold from the peripheral keel which is flange-like and composed of 2 strong gemmate cords. The gemmules are fused vertically into laterally compressed nodules. These nodules, which are cog-like, number 25 on the penultimate whorl. A single strong spiral cord between the peripheral carina and the lower suture with a second cord subemergent toward the termination of the last whorl. Base long and very slowly contracted, crossed above by 4 strong smooth spiral cords, the second of which is in line with or a little above the top of the aperture. Wider-spaced primary cords over the neck, with 2 threads in each interspace and about 16 gradually reduced threads over the anterior end. Entire surface between the spirals with dense, crisp axial threads. Sinus deep, narrow, U-shaped, its apex occupying the full width of the peripheral carina. Colour uniformly light-buff.

Measurements (mm.) —

height	width	
22.0	7.0	Momi Bay, Fiji
21.0	7.0	Pagapas Bay, Philippines
20.0	6.0	type
19.5	5.0	Pagapas Bay, Philippines

Synonymy —

1875 *Pleurotoma (Gemmula) graeffei* Weinkauff, Conch. Cab. 4(3), p. 71, pl. 3, figs. 9, 10; 1875, Jahrb. deut. malak. Ges. **2**, p. 290, pl. 9, figs. 9, 10.

1884 *Pleurotoma (Gemmula) graeffei* Weinkauff, Tryon, Manual of Conch. **6**, p. 173.

Records — FIJI: (type locality); Momi Bay, S. of Nabilo Light, 13-15 fms. (W. Jennings). QUEENSLAND: Low Isles, off Port Douglas; Cairns Reef, 5-8 fms. (Austr. Mus.). PHILIPPINES: ½ mi. off Balibatikan, Pagapas Bay, Batangas Province, Luzon Id., 4 fms.; 1 mi. E. of San Nicolas Shoals Light, Manila Bay, Luzon Id., 10 fms.; E. side Jagoliao Id., N.W. end Bohol Id., 12-24 ft.; E. end of Sisiman Bay, Bataan, Luzon Id., 8 fms.; E. end of Corregidor Id., Manila Bay, 4 fms. (duPont-Acad. Exped., 1958, ANSP).

The species has been recorded from a wide range of localities but all require personal re-examination.

Gemmula hawleyi (Iredale, 1931)

(Pl. 203)

Range — New South Wales, Australia.

Remarks — This is the only known temperate water occurrence of this otherwise tropical genus. Iredale (1931, p. 226) introduced this species as the type of a new genus, *Eugemmula*, claiming that it differed from the West American type of *Gemmula*, which was stated to have a longer canal and a different apex. These alleged differences, however, prove to be too slight to warrant even subgeneric recognition.

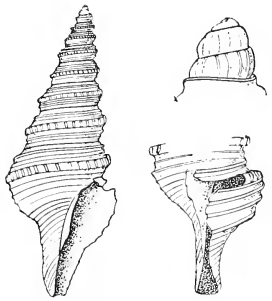

Plate 203. *Gemmula hawleyi* (Iredale). Port Jackson, New South Wales, Australia (from Laseron, 1954, pl. 1, figs. 5-7).

The species *hawleyi* belongs to the group of *monilifera*, *graeffei* and *hombroni* and is in fact doubtfully distinct from the first mentioned species.

Too few examples, all dead shells, are known to afford a critical comparison at present, but if a topotype in the writer's collection proves a constant criterion for the species, then it is distinguished from *monilifera* by having two cords between the periphery and the lower suture, with a third subemergent over the last half whorl. Although all examples known to the writer are dead shells there are traces of a zoned colour pattern typical of that found in *monilifera*.

Measurements (mm.) –

height	width	
35.0	12.0	type of *hawleyi* Iredale
21.2	7.5	Port Jackson, Sydney

Synonymy –

1931 *Eugemmula hawleyi* Iredale, Rec. Aust. Mus. **18**(4), p. 226, pl. 25, figs. 11, 14.
1954 *Eugemmula hawleyi* Iredale, Laseron, The N. S. W. Turridae, Handb. Roy. Zool. Soc. N.S.W., p. 7, pl. 1, figs. 5-7.

Type – Australian Museum, Sydney.

Records – NEW SOUTH WALES: Sow and Pigs Reef, Port Jackson ("Triton" dredgings, type locality); Crowdy Head, dredged; off Port Stephens (Laseron, 1954).

Gemmula rotatilis (Martens, 1902)

(Pl. 198, fig. 3)

Range – Off Somalia, East Africa, 1134 metres.

Remarks – This shell was described from a not fully mature shell as evidenced by the size of the protoconch in relation to the rest of the shell. The protoconch is polygyrate, narrowly conic, and closely and radially ribbed. The general appearance of the shell suggests alliance with the Duntroonian, Upper Oligocene *longwoodensis* Powell, 1942, from Southland, New Zealand. The East African shell, compared with the New Zealand fossil, has larger, peripheral, pointed nodes on the sinus area; and the single subsutural spiral cord is stronger, narrowly crested and more prominently raised. Both species are strongly angulated at the periphery but are not carinate-flanged.

Measurements (mm.) –

height	width	
11.5	5.0	from von Martens

Synonymy –

1902 *Pleurotoma (Gemmula) rotatilis* Martens, Sitzungber. der Gesellsch. nat. Freunde, Berlin, p. 239; 1903, Gast. Deutsch. Tiefsee-Exped., 1898-1899, **7**, p. 78, pl. 1, fig. 3.

Types – The type locality is off Mogadiscio, Somalia, East Africa, 1° 49′ N., 45° 29′ E., in 1134 metres.

Gemmula iris (Vredenburg, 1921)

(Pl. 204, figs. 1, 2)

Range – Burma, Tertiary.

Remarks – This species has a very tall and narrow spire but a somewhat truncated anterior canal. The whorls are evenly and lightly convex, the gemmate double sinus rib projecting less than the subsutural fold. Protoconch tall and conical, first 1½ whorls smooth, the remaining 1½ whorls strongly axially costate. Spire height almost twice the height of aperture plus canal.

Measurements (mm.) –

height	width
19.0	6.0

Synonymy –

1921 *Pleurotoma (Hemipleurotoma)* iris Vredenburg, Rec. Geol. Surv. India **53**(2), p. 98, pl. 12, figs. 14, 15.

Records – BURMA: Kyaungon, Thanga (Tertiary).

Gemmula thyrsus (Vredenburg, 1921)

(Pl. 204, fig. 4)

Range – Burma, Tertiary.

Remarks – This narrowly fusiform shell is characterised by a strong, sharply crested subsutural fold, a strong gemmate peripheral carina and a prominent smooth cord between the periphery and the lower suture. Spire about 1.1 times height of aperture plus canal.

Measurements (mm.) –

height	width	
13.3	4.1	estimated from figure

Synonymy –

1921 *Pleurotoma (Gemmula) thyrsus* Vredenburg, Rec. Geol. Surv. India **53**(2), p. 103, pl. 12, figs. 11.

Records – BURMA: Kyaungon, Myaukmigon, Thanga (Tertiary).

Gemmula birmanica (Vredenburg, 1921)

(Pl. 204, fig. 3)

Range – Burma, Tertiary.

Remarks – The author of this species remarked that it is probably a premutation of *Pleurotoma carinata woodwardi* Martin, a fossil which occurs abundantly in the Pliocene formations of Java. "The Burmese shell appears to be distinguished principally by its smaller size, its decidedly smaller protoconch, its somewhat better developed circumsutural rim, and its generally more elongate spire."

It has a relatively short canal as in *iris* but is distinguished from that species in the greater prominence of the peripheral carina, which angulates the whorls. Height of spire about 1.3 times height of aperture plus canal.

Measurements (mm.) –

height	width	
21.0	8.0	estimated from figure

Synonymy –

1921 *Pleurotoma (Gemmula) birmanica* Vredenburg, Rec. Geol. Surv. India **53**(2), p. 102, pl. 12, fig. 12.

Records – BURMA: Dalabe, Kyaungon, Myaukmigon, Thanga (Tertiary).

Gemmula pakistanica (Eames, 1952)

(Pl. 204, fig. 8)

Range – Eocene of Pakistan, Zinda Pir section (Upper Chocolate Clays).

Remarks – Compared by its author with *Pleurotoma (Gemmula) sindiensis* Vredenburg from the Lower Nari of Bhagothoro Hill, Sind, which has a higher spire, *Pleurotoma (Hemipleurotoma) bonneti bhagothorensis* Vredenburg from the same locality and *Pleurotoma tricincta* Martin, 1935, from the Neogene of Buton, which is more broadly conic.

Measurements (mm.) –

height	width	
6.7+	3.4	holotype

Synonymy –

1952 *Turris (Gemmula) pakistanica* Eames, Phil. Trans. Roy. Soc. London, Ser. B., No. 631, vol. **236**, p. 124, pl. 5, fig. 116.

Gemmula soriensis (Eames, 1952)

(Pl. 204, fig. 5)

Range – Eocene of Pakistan, Zinda Pir section (Ghazij Shales).

Remarks – Compared by its author with *Pleurotoma (Gemmula)* sindiensis Vredenburg from the Lower Nari of Bhagothoro Hill, Sind, and the foregoing species, *pakistanica* Eames, the former having a higher spire and more numerous anterior spirals and the latter a more broadly conic spire and narrower, more projecting peripheral carina than in *soriensis*.

Measurements (mm.) –

height	width	
7.9	3.0	holotype

Synonymy –

1952 *Turris (Gemmula) soriensis* Eames, Phil. Trans. Roy. Soc., London, Ser. B, No. 631, vol. **236**, p. 126, pl. 5, fig. 114.

Gemmula karangensis (Martin, 1895)

(Pl. 204, figs. 6, 7)

Range – Lower Miocene, Karang, Java.

Remarks – This species has a bicarinate moderately projecting keel, distantly crenulated rather than gemmate. From the small and not very distinct figures the subsidiary spirals appear thin and sharply raised. The surface is crossed by thin axial threads which do not appear to render the subsidiary spirals gemmate. The specimen is probably immature. The author compares the species with *coronifera* Martin and *carinata* Gray.

Synonymy –

1895 *Pleurotoma* (s. str.) *karangensis* Martin, Samml. geol. Reichs-Mus., Leiden, **1**, p. 36, pl. 6, figs. 90, 90a.

Gemmula kotorai (Nomura & Zinbo, 1935)

Range – Japan, Yanagawa shell-beds in Hukusima Basin, N.E. Honshu, Miocene.

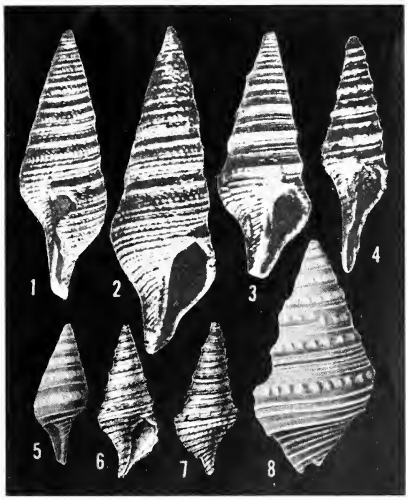

Plate 204. Figs. **1, 2,** *Gemmula iris* (Vredenburg). Holotype. Tertiary: Thanga; Kyaungon, Burma (from Vredenburg, 1921, pl. 12, figs. 14, 15). Fig. **3,** *Gemmula birmanica* (Vredenburg). Holotype. Tertiary: Thanga and Dalabe, Burma (from Vredenburg, 1921, pl. 12, fig. 12). Fig. **4,** *Gemmula thyrsus* (Vredenburg). Holotype. Tertiary: Thanga, Burma (from Verdenburg, 1921, pl. 12, fig. 11). Fig. **5,** *Gemmula soriensis* (Eames). Holotype. Eocene: Ghazig Shales, Zinda Pir section, Pakistan (from Eames, 1952, pl. 5, fig. 114). Figs. **6, 7,** *Gemmula karangensis* Martin. Lower Miocene: Karang, Java (from Martin, 1895, pl. 6, figs. 90, 90a). Fig. **8,** *Gemmula pakistanica* (Eames). Holotype. Eocene: Zinda Pir section, Pakistan (from Eames, 1952, pl. 5, fig. 116).

Remarks — It is impossible to tell from the figure what this unique fossil is like. Its authors state that "This species resembles *T. (Gemmula) granosa* (Helbling), a well-known living and fossil species in Japan and the Malayan Archipelago, but the present shell is smaller with fewer revolving cords and less granular sculpture."

Measurements (mm.) —

height	width	
9	4	holotype

Synonymy —

1935 *Turris (Gemmula) kotorai* Nomura & Zinbo, Saito Ho-on Kai Mus., Res. Bull. No. 6, p. 170, pl. 15, fig. 18.

Gemmula kishimaensis Shuto & Ueda, 1963

Range — Japan, Upper Eocene to Middle Oligocene.

Remarks — From the fairly detailed description and figures of this species it would seem to be a true *Gemmula*, not a member of the subgenus *Hemipleurotoma*, as claimed by its authors. Certainly it is described as having a paucispiral protoconch, but this statement is qualified by the remark "but the details are unknown." However, Glibert (1960, p. 6) considered *Hemipleurotoma* to be a synonym of *Gemmula*.

Description — Adult shell 11 to 15 mm. (about ½ inch). Shell narrowly fusiform with tall spire and presumed long canal. Median carina heavy, strongly gemmate. Shoulder steeply descending. Subsutural fold broad but not prominent and bearing weak spiral lirations. Four primary spirals below the periphery to the basal subangulation.

Measurements (mm.) —

height	width
15.1	9.0
11.5	—

Synonymy —

1963 *Gemmula (Hemipleurotoma) kishimaensis* Shuto and Ueda, Japanese Journal of Geology and Geography 34, no. 1, p. 4, pl. 1, figs. 6, 11.

Types — The holotype is in the Kyushu University, Japan.

Records — JAPAN: Obo, Saga Prefecture, Mazean Stage (Middle Oligocene) (type locality).

New Zealand Tertiary *Gemmula*

The genus *Gemmula* is not found living in New Zealand waters but it was well represented during the warmer periods of the Eocene, Oligocene and Miocene and seems finally to have become extinct here in the lower Pliocene. Following is a list of the New Zealand species.

Gemmula bimarginata (Suter, 1917)

Locality — N.Z.G.S. loc. 630, Teaneraki, Enfield, near Oamaru (probably McCullough's Bridge, South Canterbury; Bortonian, Eocene). The type is in the New Zealand Geological Survey, Wellington.

Synonymy —

1917 *Turris bimarginatus* Suter, N. Z. Geol. Surv. Pal. Bull. **5**, p. 44, pl. 5, fig. 13.

1942 *Gemmula bimarginata* Suter, Powell, Bull. **2**, Auck. Inst. Mus., p. 49.

Gemmula clifdenensis Powell, 1942

(Pl. 205, fig. 1)

Locality — Clifden (6c.), Southland (Altonian, Miocene). The type is in the Auckland Museum.

Synonymy —

1942 *Gemmula clifdenensis* Powell, Bull. 2, Auck. Inst. Mus., p. 49, pl. 13, fig. 14.

Gemmula disjuncta Laws, 1936

Locality — Kaawa Creek, south of Port Waikato (Opoitian, Lower Pliocene). The type is in the Auckland Museum.

Synonymy —

1928 *Turris* cf. *duplex* Suter, Bartrum & Powell, Trans. N. Z. Inst. **59**, p. 151.

1936 *Gemmula disjuncta* Laws, Trans. Roy Soc. N. Z. **66**, p. 120, pl. 17, fig. 82.

Gemmula duplex (Suter, 1917)

Locality — McCullough's Bridge, South Canterbury (Bortonian, Eocene). The type is in the New Zealand Geological Survey, Wellington.

Synonymy —

1917 *Turris duplex* Suter, N. Z. Geol. Surv. Pal. Bull. **5**, p. 45, pl. 5, fig. 15.

Gemmula kaiparaensis (Marshall, 1918)

Locality — Pakaurangi Point, Kaipara (Altonian, Miocene).

Synonymy —

1918 *Turris kaiparaensis* Marshall, Trans. N. Z. Inst. **50**, p. 268, pl. 18, figs. 9, 9a.

Gemmula lawsi Powell, 1942

(Pl. 205, fig. 2)

Locality — Pakaurangi Point, Kaipara (Altonian, Miocene).

Synonymy –

1942 *Gemmula lawsi* Powell, Bull. **2**, Auck. Inst. Mus., p. 50, pl. 13, fig. 12.

Gemmula longwoodensis Powell, 1942

(Pl. 205, fig. 3)

Locality – N.Z.G.S. loc. 2563, Longwood, S. D., Orepuki, Southland (Duntroonian, Upper Oligocene). The type is in the New Zealand Geological Survey, Wellington.

Synonymy –

1942 *Gemmula longwoodensis* Powell, Bull. **2**, Auck. Inst. Mus., p. 49, pl. 13, fig. 13.

Gemmula margaritata (Marshall, 1919)

Locality – Hampden, Otago (Bortonian, Eocene).

Synonymy –

1919 *Turris margaritatus* Marshall, Trans. N. Z. Inst. **51**, p. 230, pl. 17, fig. 2.

Gemmula orba Marwick, 1931

(Pl. 206)

Locality – N.Z.G.S., loc. 1322, Ormond Series, Gisborne (Upper Miocene). The type is in the New Zealand Geological Survey, Wellington.

Synonymy –

1931 *Gemmula orba* Marwick, N. Z. Geol. Surv. Pal. Bull. **13**, p. 133, pl. 15, fig. 277.

Gemmula ornata (Marshall, 1918)

Locality – Pakaurangi Point, Kaipara (Altonian, Miocene).

Synonymy –

1918 *Turris ornatus* Marshall, Trans. N. Z. Inst. **50**, p. 268, pl. 18, figs. 8, 8a.

Gemmula peraspera Marwick, 1931

(Pl. 206)

Locality – N.Z.G.S., loc. 1322, Ormond Series, Gisborne (Upper Miocene). The type is in the New Zealand Geological Survey, Wellington.

Synonymy –

1931 *Gemmula peraspera* Marwick, N. Z. Geol. Surv. Pal. Bull. **13**, p. 133, pl. 15, fig. 276.

Gemmula polita (Marshall, 1919)

Locality – Hampden, Otago (Bortonian, Miocene).

Synonymy –

1919 *Turris politus* Marshall, 1919, Trans. N. Z. Inst. **51**, p. 230, pl. 17, fig. 9.

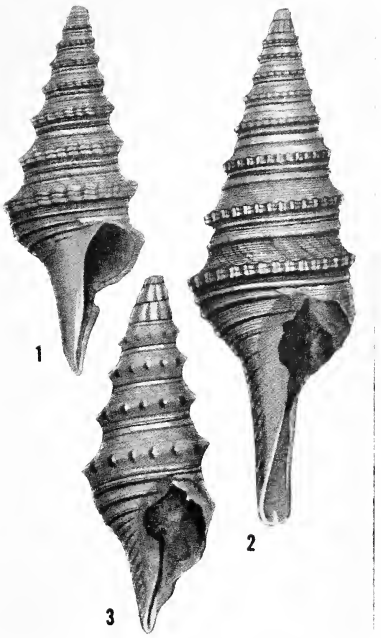

Plate 205. Tertiary New Zealand *Gemmula*. Fig. **1**, *G. clifdenensis* Powell. Altonian, Miocene: Clifden, Southland. Fig. **2**, *G. lawsi* Powell. Altonian, Miocene: Pakaurangi Point, Kaipara. Fig. **3**, *G. longwoodensis* Powell. Duntroonian. Upper Oligocene: Orepuki, Southland (all from Powell, 1942, pl. 13, figs. 14, 12 and 13 respectively).

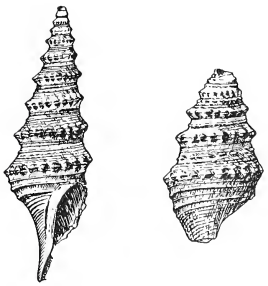

Plate 206. *Gemmula peraspera* Marwick (left fig.) and *G. orba* Marwick (right fig.). Upper Miocene: Gisborne, Ormond Series, New Zealand (from Marwick, 1931, pl. 15, figs. 276, 277).

Gemmula reticulata (Marshall, 1919)

Locality – Hampden, Otago (Bortonian, Eocene).

Synonymy –

1919 *Turris reticulatus* Marshall, Trans. N. Z. Inst. **51**, p. 231, pl. 17, fig. 8.

Gemmula waihaoensis Finlay, 1924

Locality – McCullough's Bridge, South Canterbury (Bortonian, Eocene).

Synonymy –

1917 *Turris regius* Suter, N. Z. Geol. Surv. Pal. Bull. **5**, p. 46, pl. 12, fig. 14 (non Röding, 1798).
1924 *Gemmula waihaoensis* Finlay, Proc. Malac. Soc. **16**, p. 103.

Australian Tertiary *Gemmula*

Gemmula gellibrandensis Chapple, 1934

Remarks – This species is atypical, if Chapple's original description is as stated: "Protoconch of two convex whorls; initial portion slightly inflated, oblique; anterior whorl costate." The type is in the National Museum in Melbourne, Australia.

Locality – Princetown, ¾ mi. W. of Gellibrand River, Victoria (Balcombian, Miocene).

Synonymy –

1934 *Gemmula gellibrandensis* Chapple, Mem. Nat. Mus. Melb. **8**, p. 163, pl. 19, figs. 3, 3a.

Gemmula samueli (Tenison-Woods, 1879)

Remarks – This species is not a typical *Gemmula;* the protoconch, although multispiral, develops axials only over the last 2 whorls, the initial 2½ being smooth and polished. The double peripheral carina is axially costate rather than gemmate and the broad U-shaped peripheral sinus is not so deep as in most species of *Gemmula.* The subsidiary spirals, however, especially those on the base, are truly gemmate where crossed by the relatively weak axials.

In its slender fusiform shape, its tubercular rather than gemmate peripheral sculpture and its open U-shaped sinus, the species approaches *Lucerapex.* Members of the latter genus, however, have a smooth paucispiral protoconch.

The species *samueli* could represent a trend in *Gemmula* from which the prototype of *Lucerapex* could have been derived, or perhaps more likely, *Lucerapex* could be considered as a derivation from *Fusiturris.*

The Victorian *Pleurotoma murrayana* Pritchard, 1904, from the same horizon as *samueli,* appears to be a true *Lucerapex.* It is described as having a protoconch of 2½ whorls, with a blunt apex, smooth and inclined to be angled medially. The whorls are nodosely keeled and there is a broad deep sinus on the shoulder.

Measurements (mm.) –

height	width	
15.5	4.7	Altona Shaft

Locality – Muddy Creek, lower beds, Victoria (Balcombian, Miocene) (type locality); Altona Shaft.

Synonymy –

1879 *Pleurotoma samueli* Tenison-Woods, Proc. Linn. Soc. N. S. W. **3**, p. 226, pl. 20, fig. 3.
1944 *Gemmula samueli* Tenison-Woods, Powell, Rec. Auck. Inst. Mus. **3**(1), p. 13.

Plate 207. *Gemmula husamaru* Nomura. Off Tiba Prefecture, Japan. An indeterminate species (from Nomura, 1940, pl. 1, figs. 4a, b).

Subgenus Unedogemmula MacNeil, 1960

Type: *Turris unedo* Kiener, 1839-40

Originally proposed as a genus, *Unedogemmula* is here reduced to subgeneric status. It is *Lophiotoma*-like in its adult stage, having a plain peripheral keel but the early whorls show distinct gemmulations on the keel. Occasional examples have the gemmules persisting over most of the keel. It could be a *Gemmula* tending towards obsolescence of the gemmules or a *Lophiotoma* exhibiting vestigial evidence of the origin of that group from *Gemmula*. At most, *Unedogemmula* would appear to merit no more than subgeneric status.

Synonymy –

1960 *Unedogemmula* MacNeil, U. S. Geol. Survey Prof. Paper 339, p. 101 (**type** by original designation: *Turris unedo* Kiener).

Gemmula unedo (Kiener, 1839-40)

(Pl. 175, figs. 1, 6; pl. 208, figs. 1, 2)

Range – Japan, to the East Indies and the Persian Gulf.

Remarks – This large attractive *Gemmula* is more common in Japan than elsewhere in its rather wide range. It is characterized by its light yellowish colour over which are numerous, small flecks of darker brown, by sharply indented suture, by its deep, rather large, U-shaped sinus, by the concave upper shoulder, and by the numerous, rough spiral threads on the lower three-fourths of the last whorl. The peripheral carina is weakly gemmate in the first few post-nuclear whorls, although in some specimens the beading may persist to the penultimate whorl. *G. deshayesii,* also from southeast Asia, differs in being an almost solid tan with a few axial, zigzag flames of cream, in being smoother, and in having a proportionately smaller and shallower sinus.

A large series of specimens from the Persian Gulf from the Townsend collection in the British Museum confirm the suspicion that Melvill's *Turris invicta* are young *unedo.*

Description – Adult shell, 75-105 mm. (3-4 inches) in height, solid, fusiform, with a tall spire and long anterior canal. Spire a little more than the height of the aperture plus canal; spire angle 30-35. Sculptured firstly with two narrow, sharply raised, spiral cords submargining the suture, followed by a bimarginate sinus rib which forms the peripheral angle, at a little below median whorl height, then 2-3 primary spiral cords emergent between the sinus rib and the lower suture. On the base and neck there are about seventeen primary spirals. On the concave shoulder area there are from 4 to 7 crisp secondary spirals. All the interspaces carry from one to three spiral threads. Whorls 12-13, exclusive of a multispiral narrowly conic, smooth protoconch of 3-3½ whorls, terminating in a half whorl of brephic axials. The early post-nuclear whorls bear distinct gemmules on the peripheral carina and in a few instances these persist over most of the remaining whorls. Colour pattern consisting of small reddish-brown dots, diffused into slightly larger maculations around the subsutural collar and the sinus rib, the whole loosely and irregularly connected axially by flexuous pale reddish-brown streaks that follow the successive growth lines. Ground colour and interior of aperture white. In occasional specimens from Japan, the sinus rib carries a third but weaker spiral than the two margining ones. This feature is clearly shown in Kiener's illustration of the species. Operculum leaf-shaped, with an apical nucleus.

Measurements (mm.) –

height	width	
105.7	31.0	Tayabas, 190 fathoms, Philippines
94.0	26.5	Tosa, 50 fathoms, Japan
93.5	26.3	Tosa, 50 fathoms, Japan
88.5	27.0	Persian Gulf

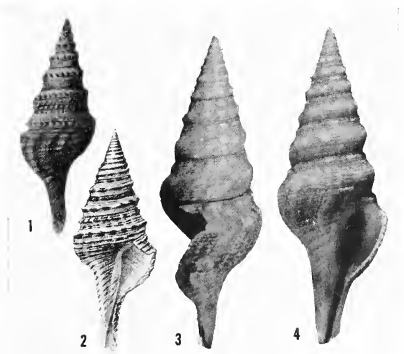

Plate 208. Fig. **1,** *Gemmula (Unedogemmula) unedo* (Kiener). "Mers de l'Inde" (from Reeve, 1843, pl. 2, fig. 12). Fig. **2,** holotype of *invicta* Melvill, a synonym of *unedo* (from Melvill, 1910, pl. 2. fig. 27). Figs. **3, 4,** *G. (U.) binda* (Garrard). Holotype. 75 fms., off Broken Bay, New South Wales, Australia. 77 mm. (photo by D. McMichael).

87.0	28.0	Sagami Bay, Japan
81.4	24.5	Tosa, 50 fathoms, Japan
72.0	24.0	Kii, 40 fathoms, Japan
31.7	12.0	holotype of *invicta* Melvill

Synonymy –

1839-40 *Pleurotoma unedo* Kiener, Coquilles Vivantes, Pleurotome **5**, p. 19, pl. 14, fig. 1.
1843 *Pleurotoma unedo* Kiener, Reeve, Conch. Iconica **1**, pl. 2, fig. 12.
1884 *Pleurotoma unedo* Kiener, Tryon, Manual of Conch. **6**, p. 165, pl. 3, fig. 20.
1910 *Turris invicta* Melvill, Ann. Mag. Nat. Hist., Ser. 8, **6**, p. 15, pl. 2, fig. 27.
1951 *Turris unedo* Kiener, Hirase & Taki, Handb., Illustr. Shells Japan, pl. 115, fig. 2.
1954 *Gemmula unedo* Kiener, Kira, Coloured Illustr. Shells Japan, pl. 35, fig. 17.
1956 *Gemmula unedo* Kiener, Kaicher, Indo-Pacific Sea Shells, pl. 1, fig. 11.
1960 *Unedogemmula unedo* Kiener, MacNeil, U. S. Geol. Surv. Prof. Paper **339**, p. 101.

Types – Kiener's type locality is "mers de l'Inde." Melvill's type of *invicta* is in the British Museum (Natural History).

Records – JAPAN: Tosa, 40-50 fathoms; Sagami Bay; Awa, Nushima, Awaji; Wakayama; Nagasaki (ANSP); Kii, 40 fathoms (A.W.B.P. coll). PHILIPPINES: Tayabas Bay, Luzon, green mud, 190 fathoms; off Lauis Point, E. Cebu, grey mud and sand, 159 fathoms; S. of Tayabas Lt., Luzon, black sand, 106 fathoms; off Point Talin, Luzon, mud, shell and coarse sand, 114 fathoms; off Pt. Dumureg, Masbate, green mud, 153 fathoms; W. of Balabac Island, 148 fathoms; off Davao, Mindanao, 135 fathoms; S.W. of Corregidor Lt., Luzon, mud, shell and coarse sand, 118 fathoms (Albatross, USNM). CHINA SEA: S. of Pratas Island, 153 fathoms (USNM). MOLUCCAS: Molucca Pass, off Makyan Island, grey mud, 275 fathoms (USNM). PERSIAN GULF (Townsend collection; type locality of *invicta*); Gulf of Oman, 73 metres (John Murray Exped., Sta. 72).

Gemmula binda (Garrard, 1961)

(Pl. 208, figs. 3, 4)

Range – New South Wales, 75 fathoms.

Remarks – This species is based upon a single specimen which may yet prove to be identical with the wide-ranging *unedo*. The New South Wales shell appears to differ from *unedo* only in having a more obtusely rounded periphery with a weaker sinus rib and a shallower shoulder concavity. Also the basal spirals are more numerous and therefore more closely spaced. Examination of the type specimen shows the sinus to be moderately deep, V-shaped, on the peripheral carina. At least six of the early post-nuclear whorls are gemmate.

Description (original) – "Shell large, heavily built, with tall slender spire, eleven main whorls, apical whorls missing; outer lip, although damaged, appears to have been sharp, without any folding or thickening, and sinus on peripheral keel; fourteen well developed raised revolving threads visible within the aperture; anterior canal fairly long and straight, small portion missing; whorls sharply angled at periphery, with a broad concave shoulder and well rounded base; sculpture consists of numerous well defined revolving lirae; interspersed with finer threads, crossed by oblique growth lines veering to right above periphery and to left below it, where sculpture has a general granulated appearance; one well defined thread prominent just below suture, two other fairly smooth prominent threads form the peripheral keel, whilst sculpture generally tends to become smoother towards anterior end of shell; colour consists of chestnut spots on prominent thread below suture and on periphery, with more general blotching on lower part of main whorl; background and interior of aperture white."

Measurements (mm.) –

height	width	
77.0	25.0	holotype

Synonymy –

1961 *Turris binda* Garrard, Journ. Malac. Soc. Aust., No. 5, p. 32, pl. 1, fig. 7.

Records – NEW SOUTH WALES: off Broken Bay, 75 fathoms (type locality). The holotype is in the Australian Museum, Sydney.

Gemmula deshayesii (Doumet, 1839)

(Pl. 175, figs. 7, 8; pl. 210, figs. 1, 2)

Range – Japan, China and Hongkong.

Remarks – This moderately common, east Asian species is characterized by an unusually solid shell, by its almost uniform, tawny to olive-brown colour which, however, has flexuous, axial whitish streaks. It differs from *unedo* (Kiener) in having a proportionately shorter anterior canal, in having smoother spiral cords, and in lacking numerous, small brown flecks.

Both Kiener (1839-40) and Reeve (1843) erroneously identified this species as *indica* Deshayes, 1832. The latter species is larger, broader, less solid, with strong flecks and spots of brown, and known only from a single Ceylonese specimen. Tryon (1884) erroneously considered *deshayesii* to be a synonym of *indica* Deshayes because of Kiener's and Reeve's earlier errors. Some Japanese authors have erroneously appied the name of *polytropa* (Helbling) to this species, evidently on von Marten's assumption in 1869 (Malakozool. Blätter **16**, p. 235).

Description – Adult shell 65-70 mm. (2½-2¾ inches) in height, solid, fusiform with a tall spire and long anterior canal. Spire a little more than the height of the aperture plus canal; spire angle

27°-30°. Sculpture rather uniformly and closely lirate except for one smooth primary cord below the suture and a not very prominent bicarinate sinus rib, situated just below the middle of whorl height. Below this and over the base there is a closely packed, rather indefinite assortment of primary and secondary cords and interstitial threads. There are 5 or 6 crisp threads on the shoulder area; and 4 to 6 of the post-nuclear whorls are distinctly gemmate. Whorls of rather straight outline, shoulder weakly concave and sinus rib not prominently projecting. Number of whorls 10-11, exclusive of a polygyrate, narrowly conic, smooth protoconch of approximately four whorls, the last axially costate. None of the available protoconchs are sufficiently well preserved for more accurate description. Colour uniformly olive or yellowish olive with a few white, flexuous, axial streaks which follow the trend of the growth lines and appear to coincide with rest stages of growth. Interior of aperture, columella and anterior canal white.

Measurements (mm.) —

height	width	
64.0	18.5	Hongkong
61.0	18.0	Hongkong
60.0	18.25	Hongkong
54.0	15.5	Kii, Japan

Synonymy —

1839 *Pleurotoma deshayesii* Doumet, Rev. Zool. (Soc. Cuv.) **2**, p. 325 (description only).

1840 *Pleurotoma deshayesii* Doumet, Guérin's Mag. Zool., Anat. Comp. & Zool., pl. 11 (title page dated 1844, plate 1840). "Mers de la Chine."

1843 *Pleurotoma deshayesii* Doumet, Reeve, Conch. Iconica **1**, pl. 3, fig. 19 (China).

1876 *Pleurotoma deshayesii* Doumet, Weinkauff, Conch. Cab. 4(3), p. 26, sp. 22, pl. 5, fig. 7.

1884 *Pleurotoma indica* Deshayes (in part), Tryon, Manual of Conch. **6**, p. 168, pl. 6, fig. 80 only.

1886 *Pleurotoma deshayesii* Doumet, Watson, Challenger Zool. **15**, p. 284.

1960 *Turris polytropa* Helbling, Kira, Coloured Illustr. Shells Japan, pl. 35, fig. 16.

Records — JAPAN: Fukura, Awaji (USNM); Minoshima, Wakayama-ken; Kii (ANSP and A. W. B. Powell coll.). CHINA: Foochow; Amoy; Pei-tai-ho, N. Chihli coast (USNM). TAIWAN: (ANSP). HONG KONG: (USNM; A. W. B. Powell coll.); 20-30 fms., Hong Kong (ANSP); Aap Li Chaau, Hong Kong (R. D. Purchon, ANSP).

Gemmula indica (Deshayes, 1832)

(Pl. 209)

Range — Known only from Ceylon.

Remarks — This large attractive species is evidently known from only one specimen which was collected by Ch. Belanger in Ceylon. I have not had an opportunity to examine the type, and have provisionally placed it in the subgenus *Unedogemmula*. It resembles *unedo* (Kiener), but appears to differ in having a proportionately broader body whorl, a shorter anterior canal, more rounded whorls in the spire and in having a much darker brown coloration. *G. indica* (Deshayes) is umbilicate, but this feature may be due to an abnormality which is known to occur in other species. Should this species be re-discovered and prove to be a true *Turris* or a *Lophiotoma* it will have to be re-named because of *Lophiotoma indica* (Röding, 1798).

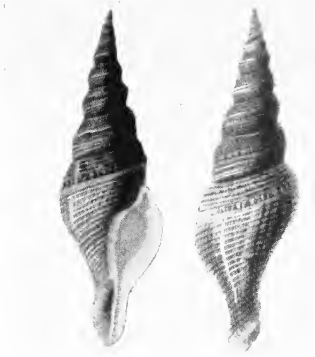

Plate 209. *"Pleurotoma" indica* Deshayes. Ceylon (from Belanger, 1832, pl. 2, figs. 9, 10).

Description — Shell 80 mm. (about 3 inches) in length, fusiform, moderately solid, with a high spire, a broad body whorl, and a rather short an-

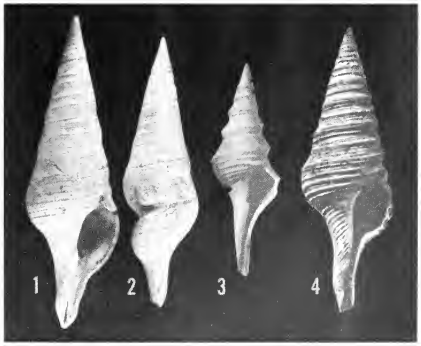

Plate 210. Figs. 1, **2**, *Gemmula (Unedogemmula) deshayesii* (Doumet). Awaji, Japan. 60 mm. Fig. 3, *G. (U.) ina* MacNeil. Miocene of Okinawa Id., Ryukyu Ids. 40.2 mm. (from MacNeil, 1960, pl. 5, fig. 7). Fig. 4, *G. (U.) koolhoveni* Oostingh. Pliocene of South Bantam, Java Id., Indonesia (from Oostingh, 1938, pl. 1, fig. 22).

terior canal which is umbilicate. Sinus deep and U-shaped. Whorls in spire convex and only slightly angulate. Sinus scar appears to be flattish and axially striate. Color of shell yellowish brown with darker brown axial, narrow streaks on the body whorl, and with dark-brown spots and spiral streaks on the sinus scar and on the numerous spiral subsutural threads.

Measurements (mm.) –

height	width	
80	26	from the type figure

Synonymy –

1832 *Pleurotoma indica* Deshayes, in Belanger's Voyage aux Indes-Orientales, Pt. 2, Zoologie, p. 421, Mollusques pl. 2, figs. 9, 10 (December).

Types – The type locality is the "côtes de Ceylan." I do not know the present location of the type.

Records – Known only from Ceylon (Deshayes, 1832).

Gemmula hastula (Reeve, 1843)

(Pl. 211)

Range – Persian Gulf and Arabian Sea.

Remarks – This species is based upon a single well-preserved specimen of unknown locality in the British Museum. However, a series of specimens in the John Murray Expedition material is from the Persian Gulf, and a further locality is added by an undoubted synonym, *Pleurotoma trypanodes* Melvill, 1904, from the Arabian Sea.

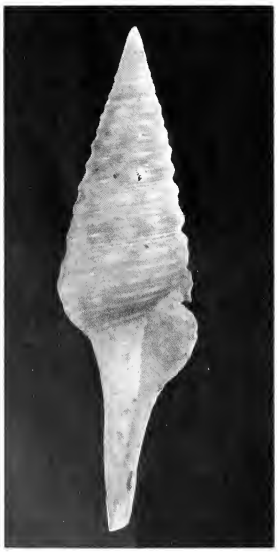

Plate 211. *Gemmula (Unedogemmula) hastula* (Reeve, 1843). Holotype from the British Museum (Natural History). Locality unknown, but probably the Persian Gulf. 38.5 mm.

This species is certainly not a synonym of *indica* Röding, 1798 (= *marmorata* Lamarck, 1822) as claimed by Tryon (1884). From *indica* it is distinguished by more prominent subsutural and less prominent peripheral spirals, resulting in a regularly conic not pagodiform spire. Further, the protoconch of four whorls, two smooth and two axially costate, followed by weak gemmules on the peripheral carina of the first post-nuclear whorl, make the reference of the species to the subgenus *Unedogemmula* positive.

Melvill's *Pleurotoma trypanodes* is based upon a bleached and somewhat worn example of *hastula*. Melvill's illustration gives the impression of rather profuse granulation of the spiral cords, but except for weak granules on the carina of the first 2 or 3 post-nuclear whorls, subsequently it is not the cords that are granulate but a false impression of granulation resulting from dense axial threads between the cords and these are strongest above the peripheral carina.

Description – Shell rather small and slender, 21-32 mm. (about 1 inch) in height, with a tall, narrowly conic spire and a long, almost straight anterior canal. Spire very slightly less than the height of the aperture plus canal. Adult sculpture of regular, smooth, spiral cords, the most prominent being a closely spaced, subsutural pair and a single peripheral one which terminates in a deep, narrow sinus. Three closely spaced spiral threads present between the subsutural and the peripheral carinae, and two pairs of threads, alternately strong and weak, are between the peripheral carina and the lower suture. Base rather densely sculptured with relatively strong and weaker intermediate spirals. Colour whitish, obscurely axially marked and diffused with yellowish-brown.

Measurements (mm.) –

height	width	
21.0	7.0	holotype of *trypanodes* Melvill
28.0	8.0	Persian Gulf, 73 metres
29.0	9.0	Arabian Sea, 40 fathoms
32.5	9.0	holotype of *hastula* Reeve

Synonymy –

1843 *Pleurotoma hastula* Reeve, Conch. Iconica **1**, pl. 17, fig. 139 (locality unknown).

1904 *Pleurotoma trypanodes* Melvill, Proc. Malac. Soc. **6**, p. 57, pl. 5, fig. 2.

1917 *Turris (Tomopleura) trypanodes* Melvill, Proc. Malac. Soc. **12**, p. 148.

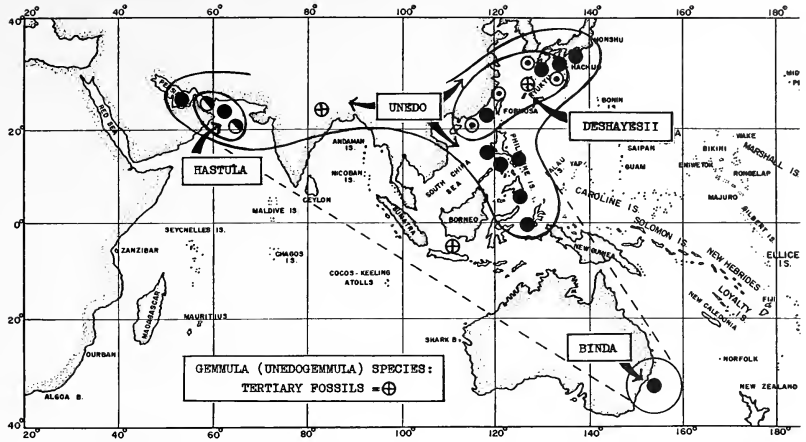

Plate 212. Geographical distribution of *Gemmula (Unedogemmula) unedo* (Kiener), *deshayesii* (Doumet), *hastula* (Reeve), and *binda* (Garrard).

Types — The types of both *hastula* Reeve and *trypanodes* Melvill are in the British Museum (Natural History).

Records — ARABIAN SEA: 18° 58′ N; 71° 45′ E., 40 fathoms (type locality of *trypanodes*); 100 miles W. of Bombay, on cable (Brit. Mus.). PERSIAN GULF: 25° 38′ 18″ N.; 56° 26′ 36″ E., 73 metres (John Murray Exped. Sta. 72; Brit. Mus.).

Gemmula bemmeleni (Oostingh, 1941)

Remarks — The author of this species remarks that it is very close to his *koolhoveni* but it has more numerous spirals. He compares it with "*polytropa* Helbling" (i.e., *Lophioturris leucotropis* Adams & Reeve, 1850), but *bemmeleni* by its gemmate early whorls is clearly a *Unedogemmula*.

Measurements (mm.) —

height	width	spire angle
30	18	35

Synonymy —

1941 *Turris (Gemmula) bemmeleni* Oostingh, De Ingenieur in Ned.-Indie, No. 7, p. 64, fig. 2.

Records — Central JAVA, Semarang (Pliocene).

Gemmula ina MacNeil, 1960

(Pl. 210, fig. 3)

Range — Okinawa (Miocene).

Remarks — This fossil species differs from both *unedo* and *deshayesii* in having the peripheral angle more prominent and situated at about the lower third of whorl height, which gives a pagodiform profile to the spire. Also the shoulder is straight, not deeply concave as in these other Recent species. MacNeil compared his species with *indica* Röding, but that species has a paucispiral protoconch, lacks gemmules on the early whorls and is therefore more satisfactorily located in *Lophioturris*.

Description (original) — "Shell of medium size, fusiform. Protoconch not preserved on type. Aperture about half as long as shell, produced anteriorly to form a straight canal. Anal sinus as determined by growth lines openly V-shaped, slightly broader at the inner end than the peripheral keel. Parietal callus thin. Whorls angulate with a prominent peripheral keel. Sculpture consisting of moderately strong revolving lines on the lower part of the body-whorl with secondary and tertiary threads and less prominent revolving lines on the subsutural slope and columella. Subsutural collar persistent in adult stage, very strong in young gemmulate stage."

Measurements (mm.) —

height	width	
40.2	13.0	holotype

Synonymy —

1960 *Unedogemmula ina* MacNeil, U. S. Geol. Surv. Prof. Paper 339, p. 102, pl. 5, fig. 7.

Type locality — Okinawa (Yonabaru clay, Miocene).

Gemmula koolhoveni (Oostingh, 1938)

(Pl. 210, fig. 4)

Remarks – This species, described as a *Turris (Gemmula),* has gemmules only on the upper spire whorls and in this and in its general likeness to *unedo* Kiener suggests location in the subgenus *Unedogemmula.* From *unedo,* the Javanese Pliocene species differs mainly in its stronger spiral sculpture.

Measurements (mm.) –

height	width	
39	12	holotype
50.5	–	(Oostingh)

Synonymy –

1938 *Turris (Gemmula) koolhoveni* Oostingh, Die Moll. Plioc. Sud. Bantam in Java, De Ingen. Ned.-Indie, Cast. I, p. 28, pl. 1, fig. 22.

Records – JAVA: South Bantam (Pliocene).

Gemmula sondeiana (Martin, 1895)

(Pl. 213, figs. 4-6)

Range – Sonde, Java Island, Indonesia, Pliocene.

Remarks – This is by far the most slender-spired member in the subgenus *Unedogemmula.* The spire is very tall and narrow, but the anterior canal relatively short, and the sculpture is of closely-spaced, smooth spirals, except for the not very prominent peripheral carina which is gemmate over the early whorls. Martin did not give any size for this species.

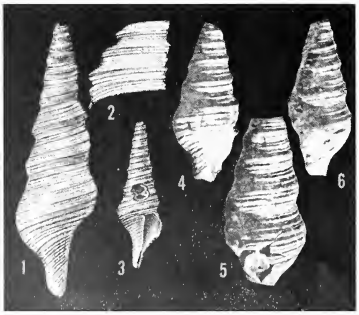

Plate 213. Figs. 1-3, *Gemmula (Unedogemmula) haydeni* (Vredenburg). Post-Eocene, Mekran beds, India (from Vredenburg, 1925, pl. 9, figs. 4, 5). Figs. 4-6, *G. (U.) sondeiana* (Martin). Pliocene of Sonde, Java Id., Indonesia (from K. Martin, 1895, pl. 6, figs. 89, a, b).

Synonymy –

1895 *Pleurotoma sondeiana* Martin, Die Fossilien von Java. Geol. Reichs-Mus., Leiden, 1, p. 35, pl. 6, figs. 89a, b.

Records – JAVA: Sonde (Pliocene). SUMATRA: Pliocene (K. Martin, 1928, p. 12).

Gemmula haydeni (Vredenburg, 1925)

(Pl. 213, figs. 1-3)

Range – India, post-Eocene.

Remarks – The material upon which this species is based is not very well preserved, for all the figured specimens are without the protoconch and most of the anterior canal. Vredenburg compared his species both with the Javanese Pliocene *sondeiana* Martin, 1895, and with the living species *deshayesii* Doumet, 1839. Vredenburg's remark that "the sinus band is more distinctly crenulated at early stages of growth in *Pleurotoma sondeiana* than in *Pleurotoma haydeni*" suggests that both are in *Unedogemmula.*

The species *haydeni,* judging from the illustrations and very full description, differs from the Recent *deshayesii* mainly in the increased strength of the secondary spiral sculpture which renders the sinus rib less conspicuous.

Measurements (mm.) –

height	width
59+	21

Synonymy –

1925 *Pleurotoma haydeni* Vredenburg, Mem. Geol. Surv. India **50**(1), p. 44, pl. 9, figs. 3-5.

Records – INDIA: west of Gharh Hill (Mekran beds, post-Eocene).

Gemmula ickei (Martin, 1906)

(Pl. 214)

Range – Lower Miocene of Java.

Description (from Vredenburg, 1925, p. 40) – Shell rather large, slender, with elongate conical spire, measuring nearly three-fifths of the total height, and with a rather large body whorl, posteriorly globose, anteriorly rather abruptly contracted into a narrow, rather elongate stem, either straight or else steeply tortuous toward its extremity. The protoconch, slightly oblique to the axis of the spire proper, is conoidal and consists of a minute nucleus followed by four convex whorls, the first two of which are smooth, while the two next whorls are decorated with numerous, somewhat oblique ribs stretching from suture to suture.

Synonymy –

1906 *Pleurotoma ickei* Martin, Samml. Geol. Reichs-Mus., Leiden, n.s., **1**, p. 293, pl. 43, fig. 703.

1925 *Pleurotoma ickei* Martin, Vredenburg, Mem. Geol. Surv. India **50**(1), p. 40.

Records – JAVA: Tjadasngampar, Rembang beds, Lower Miocene, type locality.

Plate 214. *Gemmula (Unedogemmula) ickei* (Martin). Lower Miocene of Java Id., Indonesia (from K. Martin, 1906, pl. 43, fig. 703).

Gemmula ickei *subspecies*
virginoides (Vredenburg, 1925)

Range – India, post-Eocene.

Remarks – This subspecific name was introduced in a curious way as follows: "Should it therefore be considered necessary to distinguish the Indian specimens, they might be taken to represent a variety *virginoides*." The comparison was with the typical species from the Miocene of Java.

Vredenburg's figures are very indistinct but his remarks, quoted below, indicate an *Unedogemmula:* "Compared with the specimens of *ickei* Martin from the Miocene beds of Tjadasngampar on the Tji Longan in Java the beautiful shell above described agrees in every essential character, with the exception of the crenulations of the sinus ridge which disappear at an earlier stage in the Indian specimens."

The Indian shell is very slender and the spire whorls are strongly sculptured with three spiral ridges. The protoconch is described as conoidal with a minute nucleus, followed by four convex whorls, the first two smooth and the rest axially costate.

Measurements (mm.) –

height	width
46+	15

Synonymy –

1925 *Pleurotoma ickei virginoides* Vredenburg, Mem. Geol. Surv. India **50**(1), p. 44, pl. 1, figs. 8, 9.

Records – INDIA: Gaj of Kach, Teyra River near Rampur (post-Eocene).

[These occasional blank areas occur between genera and subgenera to permit the insertion of new material and future sections in their proper systematic sequence.]

Genus Pinguigemmula MacNeil, 1960

Type: *Pinguigemmula okinavensis* MacNeil, 1960

This genus resembles *Gemmula* but has a broadly conic spire, a strongly contracted base and a moderately long, straight anterior canal. In general, all of the spirals at and above the periphery are strong and beaded, while those below the periphery are smooth and much weaker. The protoconch unfortunately is not known, but from fragments remaining is judged to be multispiral. It is something more than a bizarre-shaped *Gemmula*, for the sinus is of very different form from the deep narrow peripheral V-shape of that genus. In *Pinguigemmula* the sinus is very shallowly, broadly open, descending straight at about 30° to the axis, over the shoulder area, then sweeping forward tangentially from the peripheral carina, almost at right angles to the upper arm. All of the Miocene-Pliocene specimens of the type species and most of the Recent shells examined exhibit a curious abnormality of growth in the form of twisted flutings of the outer lip, comparable with those observed in some specimens of *Gemmula congener diomedea* (new subspecies) and in two species of *Ptychosyrinx*.

Speculating on the possible reason for this abnormality, MacNeil (1960) suggested that it may represent a response to an oxygen-poor environment in which one or more incurrent siphons are developed. Whatever the cause, it seems to be a gerontic condition which suddenly develops after full size has been achieved. MacNeil's explanation, however, seems unlikely, since most of the flutings are not hollow.

Synonymy —

1960 *Pinguigemmula* MacNeil, U. S. Geol. Survey Prof. Paper 339, p. 103. **Type** by original designation: *P. okinavensis* MacNeil, 1960.

Pinguigemmula okinavensis MacNeil, 1960

(Pl. 215, figs. 1, 2)

Range — Okinawa (Miocene or Pliocene).

Description — Adult shell 41.5 mm. (about 1½ inches) in height, stout, with a broadly conic spire, less than height of aperture plus anterior canal, which is moderately long and straight. Protoconch unknown. Subsutural slope bearing 4 strong beaded spirals with deeply channeled interspaces, the lowest one bearing 2 rows of beads and forming the peripheral carina. Sculpture below the periphery consisting of rounded unbeaded spirals which are coarsest below the periphery and become less coarse on the base of the whorl and columella, those on the columella commonly interspaced with secondary spirals. Suture closed and hidden in a deep groove. Anal sinus terminating on the peripheral carina, asymmetrically V-shaped with the lower limb nearly horizontal and the upper limb inclined nearly 45 degrees. (From MacNeil's original description.)

Measurements (mm.) —

height	width	spire angle
41.5	20.2	45° to 60°

Synonymy —

1960 *Pinguigemmula okinavensis* MacNeil, U. S. Geol. Surv. Prof. Paper 339, p. 104, pl. 9, figs. 12-14.

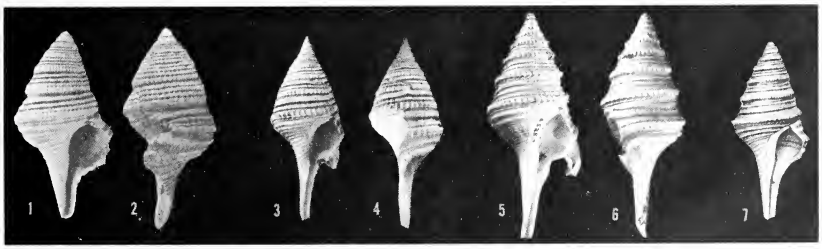

Plate 215

Figs. 1, 2 *Pinguigemmula okinavensis* MacNeil. Holotype, fig. 2. Miocene-Pliocene, Okinawa Id., Ryukyu Ids. 41.5 mm.

3, 4 *Pinguigemmula luzonica* new species. Holotype. 178 fms., off Menor Id., Luzon Id., Philippines. 35.0 mm.

5, 6 *Pinguigemmula philippiuensis* new species. Holotype. 280 fms., off Santiago, Luzon Id., Philippines. 50.2 mm.

7 *Pinguigemmula thielei* (Finlay). Holotype of *Pleurotoma (Gemmula) fusiformis* Thiele, 1925, non Sowerby, 1823. 614 meters off west coast of Sumatra Id., Indonesia.

Types – The type locality is Okinawa (Shinzato tuff, Miocene or Pliocene).

Pinguigemmula luzonica *new species*

(Pl. 215, figs. 3, 4)

Range – Philippine Islands, 178 to 297 fathoms.

Remarks – This species closely resembles the Miocene-Pliocene type of the genus, from which it is distinguished chiefly by its smaller angle of spire, by its slightly longer anterior canal, and in having only two gemmate cords on the spire whorls above the peripheral carina.

Description – Adult shell 35 mm. (about 1½ inches) in height, broadly fusiform, with a squat spire and deeply contracted base, produced into a moderately long tapered and perfectly straight anterior canal. Spire three-fourths of the height of the aperture plus canal. Whorls 9, exclusive of the protoconch of which only the eroded last whorl remains in the holotype. Spire broadly conical, outlines at first slightly concave then lightly convex over the last 4 whorls. Sculpture of spire whorls consisting of 3 very heavy, revolving, flat-topped keels with deeply channelled, narrow, almost linear, interspaces, one subsutural, one peripheral and one intermediate. The subsutural keel bears 3 weak spiral threads; the intermediate keel bears 2 threads; and the third or sinus keel bears 3 threads. All three keels are regularly and very closely gemmate, those of the sinus rib in the form of 3 gemmules fused vertically. Base, including the anterior canal, with 18 smooth primary cords and an intermediate thread in each interspace over the anterior half of the canal. Sinus as described for the genus, with its upper limb descending almost straight, then projecting tangentially forward, but in the case of the holotype, which exhibits the gerontic state mentioned above, the lower edge of the sinus is bent sharply downward along with a fluted and thickened extension of the second basal spiral. Colour uniformly very pale-buff.

Measurements (mm.) –

height	width	spire angle	
35.0	14.0	45°	holotype

Types – The holotype is in United States National Museum, Washington, no. 237784.

Records – PHILIPPINES: off Hermana, Menor Id., Luzon Id., 178 fms., sand, shell and mud (Albatross Sta. 5331) (type locality); off Hermana, Menor Id., 297 fms., green mud (Albatross Sta. 5438, USNM).

Pinguigemmula philippinensis *new species*

(Pl. 215, figs. 5, 6)

Range – Off Santiago, west Luzon Id., Philippines, in 280 fathoms.

Remarks – This species is larger and more slender than either *okinavensis* or *luzonica,* but it is nearer in shape and sculptural details to *thielei* Finlay from which it differs in having three strong spiral keels instead of two, additional to the peripheral carina, which projects flange-like, in *thielei* and *philippinensis,* but not in either *okinavensis* or *luzonica.*

Description – Adult shell 43 to 50 mm. (about 1½ to 2 inches) in height, fusiform, with a spire tall yet broadly conic, with straight outlines, tabulated by the peripheral, broadly rounded, flange-like keel which is situated almost at the lower suture. Base rapidly contracted to a long-tapered, almost straight, anterior canal. Whorls 8 to 9, exclusive of protoconch, which is missing in all examples. Sculpture of spire whorls consists of 4 strong, flat-topped spiral keels with deeply channeled interspaces. The peripheral sinus rib projects as a flange beyond the other three. All four keels gemmate, those on the sinus keel stronger and more regular. Base, including the anterior canal, with 25 to 27 smooth spirals, those on the base rather strong, especially the upper two, but becoming weaker and more closely-spaced over the anterior canal. Spire three-fourths of the height of the aperture plus canal. Sinus broadly and shallowly V-shaped, descending in a straight slope at 30 degrees to the axis, then

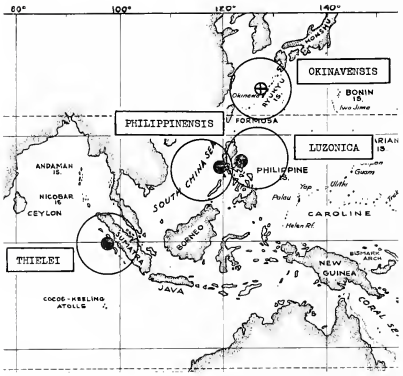

Plate 216. Geographical distribution of *Pinguigemmula okinavensis* MacNeil, *P. philippinensis* new species, *P. luzonica* new species, and *P. thielei* (Finlay).

produced tangentially forward at right angles. A paratype exhibits a massive tubular fluting in the form of a coalescence of the upper two basal spirals. It develops suddenly within 5 mm. of the outer lip edge and projects downward for 5 mm. as a partially closed tube. Colour pale yellowish buff. Parietal callus and interior of aperture white.

Measurements (mm.) —

height	width	spire angle	
50.2	18.7	40°	holotype
43.5	17.2	42°	

Types — The holotype is in United States National Museum, Washington, no. 237563.

Records — PHILIPPINES: off Santiago, west Luzon Id., Philippines, in 280 fms. (Albatross Sta. 5283, USNM, type locality).

Pinguigemmula thielei (Finlay, 1930)

(Pl. 215, fig. 7)

Range — Off west coast of Sumatra, Indonesia in 614 metres.

Remarks — This species and *philippinensis* are obviously closely allied, but unfortunately no examples of *thielei* are available to the writer. Assuming that Thiele's illustration is accurate, *thielei* differs from *philippinensis* in having two instead of three spiral keels in addition to the peripheral flange-like keel. Also, in Thiele's figure, only the peripheral keel is shown to be gemmate, whereas in *philippinensis* all four spiral keels are gemmate to some extent.

Measurements (mm.) —

height	width	spire angle	
44.0	18.0	45°	holotype

Synonymy —

1925 *Pleurotoma (Gemmula) fusiformis* Thiele, Wissenschaft. Ergebn. Deutschen Tiefsee-Exped. **17**, Gastr. 2, p. 210, pl. 22, fig. 24 (non *Pleurotoma fusiformis* J. de C. Sowerby, 1823, non Anton, 1839, non C. B. Adams, 1850).

1930 *Gemmula thielei* Finlay, Trans. N. Z. Inst. **61**, p. 47 (nom. nov. for *Pl. (Gemmula) fusiformis* Thiele, 1925).

Types — The type locality is off the west coast of Sumatra, "Valdivia" Sta. 194; 0° 15.2′ N.; 98° 8.8′ E., 614 metres.

Genus Cryptogemma Dall, 1918

(Pl. 217, fig. a)

Type: *Gemmula benthina* Dall, 1908

Shells of this genus are rather broadly fusiform but with a short twisted anterior canal. Weak axial ribs are produced into rounded nodules on a conspicuous peripheral keel. The sinus is at the periphery, rather slight and square-cut at the apex of a broadly open V. Apical whorls unknown. The outer shell is covered by a greenish grey periostracum. Operculum oval, with an apical nucleus. Radula of the "wishbone type." Recent, deep water, 1200 to 1300 fathoms, Gulf of Panama to Ecuador. Height, 10 to 30 mm.

This genus may later come into use for some at present undescribed species from deep water off Hawaii.

Synonymy —

1918 *Cryptogemma* Dall, Proc. U. S. National Mus. **54** (2238), p. 325. **Type** by monotypy: *Gemmula benthina* Dall, 1908.

Characteristic Species — *C. benthina* Dall, 1908; *quentinensis* Dall, 1919; *serilla* Dall, 1908.

Plate 217. Radulae of (a) *Cryptogemma benthina* (Dall, 1908) and (b) *Carinoturris adrastia* (Dall, 1919). Both drawings prepared by J. P. E. Morrison, U.S. National Museum.

[These occasional blank areas occur between genera and subgenera to permit the insertion of new material and future sections in their proper systematic sequence.]

Genus Carinoturris Bartsch, 1944

(Pl. 217, fig. b)

Type: *Cryptogemma adrastia* Dall, 1919

Very similar to *Cryptogemma* in shape but with a plain narrowly rounded peripheral keel. Anal sinus at periphery, wide and shallow. Shell white, covered with a pale-olive periostracum. Protoconch of one smooth rounded whorl. Operculum small, broadly ovate with an apical nucleus. Radula of "wishbone" type. Height, 14 to 16 mm. Recent, deep-water, 300 to 600 fathoms off California.

Synonymy —

1944 *Carinoturris* Bartsch, Proc. Biol. Soc. Washington **57**, p. 60. **Type** by original designation: *Cryptogemma adrastia* Dall, 1919.

Characteristic Species — C. adrastia Dall, 1919; *fortis* Bartsch, 1944; *polycaste* Dall, 1919.

Genus Hemipleurotoma Cossmann, 1889

Type: *Pleurotoma archimedis* Bellardi, 1878

This name is based upon a very rare fossil from the Helvetian middle Miocene of Italy, but in 1896, Cossmann invalidly proposed *denticula* Basterot, 1825, as neotype of his genus, but the original citation must stand. Based upon this original type designation, about the only distinguishing characteristic of *Hemipleurotoma* is the very broadly open V-shaped sinus, otherwise it conforms with *Gemmula*. Glibert (1960, p. 4) includes *Hemipleurotoma* in the synonymy of *Gemmula*. The genus has been erroneously applied to the Recent *Turris cryptorrhaphe* (Sowerby, 1825).

Synonymy —

1889 *Hemipleurotoma* Cossmann, Ann. Soc. Malac. Belgique **24**, p. 264. **Type** by original designation: *Pleurotoma archimedis* Bellardi, 1878; 1896, Essais de Paléoconch. Comp. **2**, p. 78. **Type** by subsequent designation [invalid]: *Pleurotoma denticula* Basterot, 1825.

Genus Coronia Gregorio, 1890

Type: *Pleurotona childreni* Lea, 1833

This is usually considered a synonym of *Gemmula*, but Gardner, 1945 (Memoir no. 11, Geol. Soc. of America, p. 240) gave it full generic status upon the form of the protoconch, which is of two or more smooth, rapidly enlarging whorls, succeeded by one or more convex whorls sculptured with numerous obliquely arcuate costae. Smooth initial whorls, to a varying degree, however, occur among the Indo-Pacific Recent species of *Gemmula*, and these minor deviations would appear to have no special significance. Claiborne Eocene of the southern United States and northern Mexico.

Synonymy —

1890 *Coronia* Gregorio, Ann. de Geol. et de Paléontologie, Palermo, 7, p. 23. **Type** by subsequent designation by Cossmann, 1896: *Pleurotoma acutirostra* Conrad = (fide Gardner, 1945, p. 240) *childreni* Lea, 1833. [*Coronia* Ehrenberg, 1840, Bericht Verh. Akad. Wiss. Berlin, p. 206, no. 106, is a Diatom and does not preoccupy *Coronia* Gregorio].

Characteristic species — childreni Lea, 1833; *genitiva* Casey, 1904; *margaritosa* Casey, 1904.

Genus Trypanotoma Cossmann, 1893

Type: *Pleurotoma terebriformis* Meyer, 1886

A small shell with a very tall spire but truncated base. Protoconch blunt, of 2½ smooth whorls. Adult whorls almost flat in outline but with a median placed noduliferous peripheral weak carina. Sinus weak, peripheral. Claiborne and Jackson Eocene of Alabama and Louisiana.

Synonymy —

1893 *Trypanotoma* Cossmann, Essais de Paléont. Comp. **2**, p. 109. **Type** by original designation: *Pleurotoma terebriformis* Meyer, 1886. Eocene.

Genus Sinistrella Meyer, 1887

Type: *Triforis americanus* Aldrich, 1885

This genus is usually considered a sinistral form of *Trypanotoma* but Harris & Palmer (1947, p. 423) give it full generic status, but in association with *Coronia*, *Trypanotoma* and *Infracoronia*. Known apparently only from the type species, which is always sinistral and comes from the Jackson Eocene of Mississippi.

Synonymy —

1887 *Sinistrella* O. Meyer, Ber. Senckenb. naturf. Ges., for 1887, p. 18. **Type** by subsequent designation (Cossmann, 1893, p. 110): *Triforis americanus* Aldrich, 1885.

Subgenus Infracoronia Palmer, 1947

Type: *Gemmula indoviciana* (Vaughan) Harris, 1896

This is compared with *Coronia* from which it is stated to differ in having the dentate carina at the base of each whorl, just above the suture, and the absence of a subsutural band. It was proposed, however, as a subgenus of *Sinistrella*. Lower Claiborne and Jackson Eocene of Louisiana, southern United States.

Synonymy —

1947 *Infracoronia* Palmer, in Harris and Palmer, Bull. Amer. Paleont. Inst., Ithaca, **30**(117), Sec. 3, p. 423. **Type** by original designation: *Gemmula indoviciana* (Vaughan) Harris, 1896. Subgenus of *Gemmula*.

Genus Hesperiturris Gardner, 1945

Type: *Turris nodocarinata* Gabb, 1860

This is another member of the *Gemmula* complex which was diagnosed primarily upon the form of the protoconch which was described as of 5 to 5½ volutions, the initial turn minute and largely immersed, the 3 to 3½ succeeding whorls also smooth and shining, broadly rounded, and increasing rather rapidly in diameter, the final whorl in whole or in part axially costate. The adult shell has a tall narrow spire but a truncated anterior canal. The sculpture is of nodules on a peripheral carina just above the lower suture. Sinus broadly U-shaped, moderately deep, the axis running closer to the periphery than to the posterior suture. The genus appears to be confined to the lower Claiborne Eocene of the southern United States and northern Mexico.

Synonymy —

1945 *Hesperiturris* Gardner, Memoirs no. 11, Geol. Soc. America, p. 237. **Type** by original designation: *Turris nodocarinata* Gabb, 1860.

Characteristic Species — H. amichel Gardner, 1945; *nodocarinata* Gabb, 1860; *zacatensis* Gardner, 1945.

Genus Campylacrum Finlay & Marwick, 1937

Type: *Campylacrum sanum* Finlay & Marwick, 1937

This is another member of the *Gemmula* assemblage, nearest to *Eoturris*, but of smaller size, different apex and a twisted canal. So far, it is known only from the Upper Cretaceous (Wangaloan) of New Zealand. There is apparent a relationship also with the Parisian Eocene *Oxyacrum* Cossmann; both have a small, conic, polygyrate protoconch, and a wide, moderately deep, bluntly triangular sinus, situated on the peripheral keel, with the apex of the sinus not encircling the peripheral nodules, but occurring immediately above them.

Synonymy —

1937 *Campylacrum* Finlay and Marwick, N. Z. Geological Survey Paleo. Bull. **15**, p. 84. **Type** by original designation: *C. sanum* Finlay and Marwick, 1937.

Campylacrum debile Finlay & Marwick, 1937

Range — Wangaloa, South Island, New Zealand (Wangaloan, Upper Cretaceous).

Synonymy —

1937 *Campylacrum debile* Finlay & Marwick, N. Z. Geol. Surv. Paleo. Bull. **15**, p. 86, pl. 12, figs. 1, 2.

Types — The holotype is in the Auckland Museum.

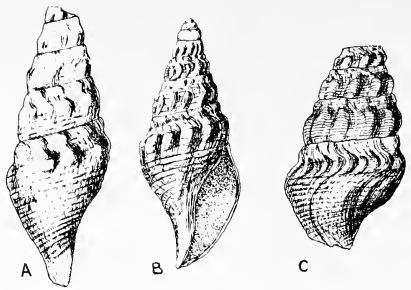

Plate 218. Figs. **a** and **b**, *Campylacrum sanum* Finlay and Marwick. Upper Cretaceous of Wangaloan, New Zealand (from the original, 1937, pl. 12, figs. 3, 4). Fig. **c**, *Eoturris multicinctus* (Marshall, 1917). Eocene: Bortonian of Castle Hill Shaft (?). Otago, New Zealand (from Finlay and Marwick, 1937, pl. 16, fig. 2).

Campylacrum sanum Finlay & Marwick, 1937

(Pl. 218, figs. a, b)

Range — Wangaloa, South Island, New Zealand (Wangaloan, Upper Cretaceous).

Synonymy —

1937 *Campylacrum sanum* Finlay & Marwick, N. Z. Geol. Surv. Paleo. Bull. **15**, p. 86, pl. 12, figs. 3, 4.

Types — The holotype is in the Auckland Museum.

Genus Eopleurotoma Cossmann, 1889

Type: *Pleurotoma multicostata* Deshayes, 1834

This is a Paleocene-Eocene relative of *Gemmula* in which the axial sculpture is in the form of long, narrow flexuous ribs which thicken at the periphery to form a row of laterally compressed oblique nodules.

The shell is 15 to 25 mm. in height, elongate-fusiform, but with a relatively short anterior canal. Protoconch small, smooth and paucispiral. Anal sinus broadly V-shaped, its apex extending a little above the peripheral nodules. It occurs in Europe, south western United States and Peru and is recorded also from the Tertiary of southern and south eastern Asia and Japan, but the species require re-evaluation.

Synonymy —

1889 *Eopleurotoma* Cossmann, Ann. Soc. Malac. Belgique 24, p. 269. **Type** by original designation: *Pleurotoma multicostata* Deshayes, 1834; 1906, Cossmann, Essais de Paléoconch. Comp. 7, pl. 14, fig. 16.

1904 *Eodrillia* Casey, Trans. St. Louis Academy **14**, p. 159, **Type** by subsequent designation (Cossmann, 1904, p. 237): *Pleurotoma depygis* Conrad.

Charaeteristic Speeies – EUROPEAN EOCENE: *bernayi* Boury, 1899; *bezaneoni* Boury, 1899; *bieatenata* Lamarck, 1804; *cedilla* Edwards, 1861; *eurvicosta* Lamarck, 1804; *distans* Deshayes, 1865; *distantieosta* Cossmann & Pissarro, 1900; *expedita* Deshayes, 1865; *flexieosta* Boury, 1899; *fluctuosa* Deshayes, 1865; *franeisci* Raincourt, 1876; *fresvillensis* Cossmann & Pissarro, 1900; *granifera* Deshayes, 1834; *ineulta* Sowerby, 1850; *insueta* Boury, 1899; *lajonkairei* Deshayes, 1834; *larteti* Deshayes, 1865; *lima* Edwards, 1861; *multieostata* Deshayes, 1834; *multinoda* Lamarck, 1804; *oligocolpa* Cossmann, 1889; *pliearia* Deshayes, 1834; *poureyensis* Cossmann, 1901; *propinqua* Deshayes, 1865; *rotella* Edwards, 1861; *rudinscula* Cossmann, 1889; *sealarata* Edwards, 1861; *speeialis* Boury, 1899; *spreta* Deshayes, 1865; *undata* Lamarck, 1804.

NORTH AMERICAN EOCENE: *adoleseens* Harris, 1937; *albirupsis* Harris, 1947; *cainei* Harris, 1937; *carya* Harris, 1937; *eoehlea* Harris, 1937; *depygis* Conrad, 1833; *desnoyersii* Lea, 1833; *gemmavia* Harris, 1937; *hoeninghausii* Lea, 1833; *lisboneola* Harris, 1937; *nupera* Conrad, 1833; *orangeburgensis* Harris, 1937; *ouaehitensis* Harris, 1937; *plumbella* Harris, 1937; *politica* Harris, 1937; *rugatina* Harris, 1937; *rugosa* Lea, 1833; *sabinaria* Harris, 1937; *sayi* Lea, 1833; *thyroidifera* Harris, 1937.

PERU: *paytensis* Olsson, 1930; *wiedeyi* Olsson, 1930.

EUROPEAN PALEOCENE: *selandiea* Koenen, 1885.

Subgenus Oxyacrum Cossmann, 1889

Type: *Pleurotoma obliterata* Deshayes, 1834

Members of this subgenus are very similar to *Eopleurotoma* but have a tall, narrowly conical protoconch of 4½ smooth whorls, plus a whorl of brephic axials. It occurs in the Eocene of Europe and England.

Synonymy –

1889 *Oxyacrum* Cossmann, Ann. Soc. Malac. Belgique **24**, p. 274. **Type** by original designation: *Pleurotoma obliterata* Deshayes, 1834; 1896, Cossmann, Essais de Paléoconch Comp. **2**, p. 82.

Charaeteristic Species – *E. eonstrieta* Edwards, 1861; *contabulata* Deshayes, *inflexa* Lamarck, 1804; *lepta* Edwards, 1861; *obliterata* Deshayes, 1834.

Genus Eoturris Finlay & Marwick, 1937

Type: *Turris complicata* Suter, 1917

This is a New Zealand genus ranging from the Eocene (Bortonian) to the Upper Oligocene (Waitakian). It belongs to the *Gemmula* series but has a considerably broader sinus, spreading above the peripheral keel on to the shoulder as in *Eopleurotoma* from the European and North American Eocene. However, *Eoplenrotoma* is distinct in having a paucispiral protoconch, a short, gently twisted neck and usually a distinct fasciole. The protoconch in *Eoturris* is narrow, elongate-conic, with the axials restricted to the last quarter whorl, instead of being numerous and spread over the last two or three whorls as in *Gemmula*.

Synonymy –

1937 *Eoturris* Finlay and Marwick, New Zealand Geol. Survey Paleo. Bull. **15**, p. 114. **Type** by original designation: *Turris complicatus* Suter, 1917.

Eoturris complicata (Suter, 1917)

Range – New Zealand Bortonian, Eocene.

Synonymy –

1917 *Turris complicatus* Suter, N. Z. Geol. Surv. Paleo. Bull. **3**, p. 45, pl. 5, fig. 14.

1917 *Surcula mordax* Suter, N. Z. Geol. Surv. Paleo. Bull. **3**, p. 51 (non Martin, 1915).

1942 *Eoturris complicatus* Suter, Powell, Bull. no. 2, Auckland Inst. Mus., p. 46.

Types – The type locality is McCullough's Bridge, South Canterbury, New Zealand. The holotype is in the New Zealand Geological Survey, Wellington, New Zealand.

Eoturris multicincta (Marshall, 1917)

(Pl. 218, fig. c)

Range – New Zealand Bortonian, Eocene.

Synonymy –

1917 *Turris multicinctus* Marshall, Trans. N. Z. Inst. **49**, p. 456, pl. 36, fig. 34.

1942 *Eoturris multicinctus* Marshall, Powell, Bull. no. 2, Auckland Inst. Mus., p. 46.

Types – The type locality is "Wangaloa," probably Castle Hill Shaft. The holotype is in the Otago University Museum, Dunedin, New Zealand.

Eoturris neglecta (Suter, 1917)

Range – New Zealand Bortonian, Eocene.

Synonymy –

1917 *Turris neglectus* Suter, N.Z. Geol. Surv. Pal. Bull. **3**, p. 46, pl. 6, fig. 1.

1924 *Turris insensus* Finlay, Proc. Mal. Soc., **16**, p. 103 (nom. nov. for *neglectus* Suter, 1917, non *Pleurotoma* neglecta Reeve, 1842; new name unnecessary).

1942 *Eoturris neglectus* Suter, Powell, Bull, no. 2, Auck. Inst. Mus., p. 46.

Types – The type locality is N.Z.G.S. loc. 630 probably McCullough's Bridge, South Canterbury. The holotype is in the N.Z. Geological Survey.

Eoturris uttleyi (Suter, 1917)

Range – New Zealand Waitakian, Upper Oligocene.

Synonymy –

1917 *Turris uttleyi* Suter, N. Z. Geol. Surv. Paleo. Bull. **5**, p. 47, pl. 6, fig. 2.

1942 *Eoturris uttleyi* Suter, Powell, Bull. no. 2, Auckland Inst. Mus., p. 47.

Types – The type locality is Otiake, Waitaki Valley, North Otago, New Zealand.

Genus Epalxis Cossmann, 1889

Type: *Pleurotoma crenulata* Lamarck, 1803

This European Eocene genus was compared with *Bathytoma* by its author, and, later, Glibert (1960) preserved the association by making *Bathytoma* a subgenus of *Epalxis*. Nevertheless, *Epalxis* seems to fall more naturally into the series of *Eopleurotoma, Eoturris* and *Oxyacrum*. The genus *Bathytoma* by reason of its characteristic columellar callosity seems to have more in common with the Borsoniinae. Also the radula of *Bathytoma* and *Micantapex* do not have the characteristic "wishbone" marginals of the typical Turrinae but slender awl-shaped ones of toxoglossate style. *Epalxis* closely resembles *Eopleurotoma* in adult features and in having a paucispiral protoconch. The chief diagnostic features are the very broadly open anal sinus which occupies most of the spire whorls from suture to suture, and its broadly rounded apex which is wider than the broadly rounded periphery and which bears strong laterally compressed crescentic nodules.

Synonymy –

1889 *Epalxis* Cossmann, Ann. Soc. Malac. Belgique **24**, p. 254. **Type** by original designation: *Pleurotoma crenulata* Lamarck, 1803; 1896 Cossmann, Essais de Paléoconch. Comp., 2, p. 103.

Characteristic Species – *E. bilirata* Boury, 1899; *crenulata* Lamarck, 1803; *lemoinei* Boury, 1899; *multigyrata* Deshayes, 1865; *ventricosa* Lamarck, 1804.

Genus Lucerapex Iredale, 1936

Type: *Pleurotoma cascaria* Hedley & Petterd, 1906

Members of this genus are rather small elongate-fusiform shells, with a very tall spire and moderately long canal, of light build, and rather simple sculpture of a peripheral row of scale-like to tubercular nodes on an angulation or a raised keel. The sinus is peripheral, broadly open, rather shallow, U-shaped and defined over the whole shell in the form of distinct axial growth lines. The protoconch is small, smooth, paucispiral and globular, ending in up to a quarter whorl of protractively arcuate thin axials.

This genus has a wide Indian Ocean distribution in deep water extending from the Gulf of Aden down the East African Coast, through Indonesian waters to the Philippines, and then southward to off the coast of New South Wales. It is represented also in the Quaternary of Timor and the Miocene of South Australia.

This genus seems to be most nearly related to *Fusiturris* which has a Recent range extending from the Mediterranean to West Africa and has European fossil relatives reaching back to as early as the Paleocene.

Both *Fusiturris* and *Lucerapex* are of elongate-fusiform shape, have the same peripheral nodulation, as well as a rather shallow, broadly open, U-shaped sinus which is defined over all post-embryonic whorls by crisp axial growth lines. The protoconch in *Fusiturris* is, however, narrowly conic and of about three whorls, and the shell is, for the most part, larger and of more solid build.

It is confidently assumed that *Lucerapex* is an Indo-Pacific product developed from *Fusiturris,* in isolation, after the closing of that great equatorial waterway of the past, the Tethys Sea.

Synonymy –

1936 *Lucerapex* Iredale, Records Australian Mus. **19**, p. 337. **Type** by original designation: *Pleurotoma cascaria* Hedley and Petterd, 1906.

Lucerapex casearia (Hedley & Petterd, 1906)

(Pl. 219)

Range – Known only from 300 fathoms and 800 fathoms off Sydney, New South Wales, Australia.

Description – Shell small, 13 mm. (½ inch) in height, thin, elongate-fusiform, with a tall spire and a long, slightly flexed, spout-like anterior canal. Protoconch paucispiral with glassy, rounded, smooth whorls. Spire whorls prominently angled at about the lower third by a narrowly rounded keel, produced into regular blunt tubercles, 18 on the penultimate whorl. Sinus on the peripheral keel, of moderate depth, narrowly rounded at the base of a broad U-shaped area. Surface smooth, except for fine axial growth lines which diverge acutely both above and below the keel. Colour varying from pearl-grey to pale-orange (probably due to staining).

Measurements (mm.) –

height	width	
13.0	5.0	holotype

Synonymy –

1906 *Pleurotoma cascaria* Hedley & Petterd, Rec. Aust. Mus. **6**, p. 220, pl. 37, fig. 5.

1936 *Lucerapex cascaria* H. & P., Iredale, Rec. Aust. Mus. **19**(5), p. 320.

1954 *Lucerapex cascaria* H. & P., Laseron, The N. S. W. Turridae, Roy. Zool. Soc. N. S. W. Handb., p. 8, pl. 1, fig. 15.

Types – The holotype is in the Australian Museum, Sydney.

Records – NEW SOUTH WALES: 300 fms. (type locality) and 800 fms. off Sydney.

Lucerapex casearia *subspecies* regilla Iredale, 1936

Remarks – Iredale separated shells from 110 fathoms off Sydney, stating that they were much larger than typical 300 fathom shells, and exhibited wavy lines below the periphery, a feature absent in the typical species. This may be merely an ecologic form.

Plate 219. *Lucerapex cascaria* (Hedley and Petterd). Holotype. 300 fms., off New South Wales, Australia (from Hedley and Petterd, 1906, pl. 35, fig. 5).

Measurements (mm.) –

height	width	
21	–	holotype

Synonymy –

1936 *Lucerapex casearia regilla* Iredale, Rec. Aust. Mus. **19**(5), p. 320.

Types – The holotype is in the Australian Museum, Sydney.

Records – NEW SOUTH WALES: 110 fms. off Sydney (type locality).

Lucerapex denticulata (Thiele, 1925)

(Pl. 220, fig. 2)

Range – Off Somaliland, East Africa and the Gulf of Aden, 732 to 1270 metres.

Remarks – This species is characterised by the simplicity of its sculpture which consists of a row of stout pointed tubercles on a sharp peripheral angle set just below the middle whorl height. The rest of the shell is smooth. It is closer to *carola* Thiele, 1925, than to the type of the genus, *casearia* Hedley & Petterd, 1906, from which it differs in having fewer tubercles on the peripheral keel.

There is a prior *Pleurotoma (Mangelia) denticulata* Smith, 1884, but Thiele's species is not renamed since it is doubtfully distinct from *carola* of the same author.

Measurements (mm.) –

height	width	
19.2 +	7.0	Gulf of Aden, 1270 metres
13.0	4.5	holotype

Plate 220. Fig. 1, *Lucerapex carola* (Thiele). Fig. 2, *L. denticulata* (Thiele). Both holotypes. Both deep-water, off East Africa (from Thiele, 1925, pl. 24). Figs. 3, 4, *Lucerapex molengraaffi* (Tesch). Pliocene of Timor Id., Indonesia (from Tesch, 1915, pl. 77).

Synonymy –

1925 *Pleurotoma denticulata* Thiele, Wissenschaft. Ergebn. Deutschen Tiefsee-Exped. **17**, Gastr. 2, p. 216, pl. 24, fig. 2.

Records – SOMALILAND: 1° 49′ N., 45° 29.5′ E., 1134 metres (type locality). GULF OF ADEN: 14° 36′ 06″ N., 51° 00′ 18″ E., 1270 metres, Sta. 184; 12° 04′ 06″ N., 50° 38′ 36″ E., 732 metres, Sta. 176 (John Murray Exped., Brit. Mus.).

Lucerapex carola (Thiele, 1925)

(Pl. 220, fig. 1)

Range – Off Somaliland, East Africa, 693 metres.

Remarks – This species is known to the writer only from the original figure and description. It seems to be very closely allied to, if not identical with, the same author's *denticulata*. From the figure, the only apparent difference observed is in the form of the peripheral tubercles, which are rounded in *carola* but square-cut in *denticulata*. However, this small difference in sculpture could be resultant from the fact that *carola* appears to be not fully grown.

One refrains from uniting *carola* and *denticulata* without seeing the type material, for there may be matters of minor sculpture and texture that are not revealed in either the descriptions or the figures.

Measurements (mm.) –

height	width	
9.0	3.2	holotype

Synonymy –

1925 *Pleurotoma carola* Thiele, Wissenschaft. Ergebn. Deutschen Tiefsee-Exped. "Valdivia" **17**, Gastr. 2, p. 216, pl. 24, fig. 3.

Lucerapex adenica *new species*

(Pl. 221, fig. 3)

Range – Gulf of Aden, 274 to 1080 metres.

Remarks – This species has a more slender spire than *molengraaffi*, larger peripheral nodules than in any of the other species of the genus, an unusual feature in the presence of weak subsutural gemmules, and numerous weak spirals on the base and anterior end. The peripheral nodules spread across and beyond a broadly rounded peripheral keel. In *molengraaffi* the nodules are restricted to a narrow, sharp-edged, peripheral keel, and to a less degree this is the case with *casearia*. In *denticulata* and *carola* the nodules are in the form of pointed tubercles on a simple peripheral angle.

Description – Shell 25 to 32 mm. (1 to 1¼ inches) in height, narrowly fusiform, with a very tall slender spire, and a moderately long slightly twisted anterior canal. Spire 1.3 times the height

of the aperture plus canal; spire angle 20°. Whorls 11.5, including a small paucispiral protoconch of 1.5 whorls, tip asymmetric and inrolled, last ¼ whorl of arcuate, brephic, axial threads. Spire whorls with a massive, rounded, median peripheral keel which occupies more than one-third of the whorl height; sculptured with heavy crescentic axials, 15 on the penultimate whorl. A row of weak subsutural gemmules is present. Base with 4 widely spaced, weak spirals on the upper part of the base, with only the uppermost emergent over the spire whorls; remainder of base with linear spaced, weak spirals. Sinus peripheral, broadly U-shaped, its scar clearly marked over all the post-nuclear whorls by strong axial growth lines. Colour pure white.

Measurements (mm.) –

height	width	
30.8	8.0	holotype
29.7	8.0	
23.7	7.0	

Types – The holotype is in the British Museum (Natural History).

Records – GULF OF ADEN: 13° 05′ 36″ N., 46° 24′ 42″ E., 1022 metres, Sta. 34 (type locality); 13° 06′ 12″ N., 46° 24′ 30″ E., 1061-1080 metres, Sta. 193; 13° 46′ 30″ N., 47° 48′ 54″ E., 274 metres, Sta. 191 (John Murray Exped., Brit. Mus.).

Lucerapex indagatoris (Finlay, 1927)

(Pl. 221, figs. 4, 5)

Range – Off South India, 360 to 430 fathoms.

Remarks – This species is difficult to place generically without having seen specimens. It would seem, however, on the basis of the published description and figures, to have more claim for inclusion in *Lucerapex* than in *Gemmula*. The nature of the peripheral nodulation and in particular the subsutural series of weak gemmules indicate a shell fairly close to *adenica new species*, but differing chiefly in the low-set position of the peripheral carina. Unfortunately, the apical whorls are unknown.

Measurements (mm.) –

height	width
36.0	10.0

Synonymy –

1899 *Pleurotoma optata* E. A. Smith, Ann. Mag. Nat. Hist., Ser. 7, 4, p. 238.

1909 *Pleurotoma optata* E. A. Smith, Annandale & Stewart, Illust. Zool. Investigator, Moll., pl. 9, figs. 1, 1a.

1927 *Gemmula indagatoris* Finlay, Trans. N. Z. Inst. **57**, p. 517, *nom. nov.* for *Pl. optata* Smith, 1899 (non *Pl. optata* Harris, 1897).

Types – The type is in the Indian Museum, Calcutta.

Records – INDIA: off the south coast, 430 fms. (type locality); off Travancore, 360 fms. (E. A. Smith).

Lucerapex molengraaffi (Tesch, 1915)

(Pl. 220, figs. 3, 4; pl. 221, figs. 1, 2)

Range – Quaternary of Timor and the Recent of Borneo, Celebes and the Philippines, 254 to 559 fathoms.

Remarks – This species which was described from the Quaternary of Timor is identical with Recent deep-water material from "Albatross" dredgings taken in the vicinity of Borneo, Celebes and the Philippines.

From the other species of the genus it differs in having a square-cut, peripheral flange bearing the nodules, which later become scale-like, and in having distinct spiral threads on the base.

Description – Adult shell 30 to 33 mm. (about 1 inch) in height, elongate-fusiform with a tall spire and a long, flexed canal with a spout-like termination; light build; and prominently and medially carinated by a square-cut raised flange bearing regular, closely spaced, squarish nodules, 15 or 16 on the penultimate whorl, but becoming crowded and scale-like over the last half-whorl. Spire slightly greater than the height of the aperture plus canal; spire angle 20° to 22°. Whorls 10, including a small, smooth, globular protoconch of two whorls.

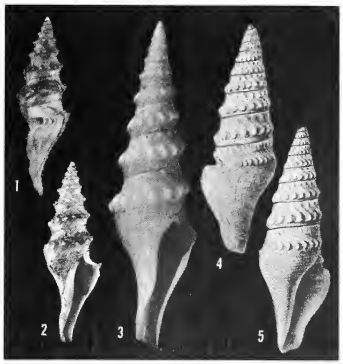

Plate 221. Figs. **1, 2,** *Lucerapex molengraaffi* (Tesch). 254 fms., off west Siquijor Id., Philippines. 32 mm. Fig. **3,** *Lucerapex adenica* new species. Holotype. 1,022 meters, Gulf of Aden. 30.8 mm. Figs. **4, 5,** *Lucerapex indagatoris* (Finlay). Holotype of *Pleurotoma optata* E. A. Smith, 1899, non Harris, 1897. 430 fms., off south coast of India (from Annandale and Stewart, 1909, pl. 9, figs. 1, 1a).

Sinus wide, shallow, U-shaped, and on the peripheral carina. Two, sometimes three, weak wavy spiral threads encircle the upper base. Axial growth lines strong, especially on the base.

Measurements (mm.) –

height	width	
30.25	10.0	
29.0	8.2	Borneo, 305 fms.
28.5	8.7	Noil Tobe, Timor, Pliocene
25.0	8.0	

Synonymy –

1915 *Pleurotoma* (s. str.) *Molengraaffi* Tesch, Palaont. von Timor **5**(9), Jungtert. und Quartare, Moll. von Timor, p. 28, pl. 77, figs. 54-56.

Records – TIMOR: Pliocene (type locality); Noil Tobe (Pliocene) (Brit. Mus.). BORNEO: off Silungan Id. 305 fms., Sta. 5592; off Sipaden Id., Sibuko Bay, 347 fms., Sta. 5586. CELEBES: Buton Strait, 559 fms., Sta. 5648. PHILIPPINES: west of Siquijor, 254 fms., Sta. 5537 (Albatross USNM).

Lucerapex murrayana (Pritchard, 1904)

Range – Balcombian, Miocene, in Victoria, Australia.

Remarks – No specimens of this species have been examined by the writer but the description and not very distinct figure suggest that it belong to *Lucerapex*.

Description (from the original) – "Shell small to medium size with a rather blunt apex, slender elongate spire and a body whorl shorter than the spire. Embryo consisting of about 2½ whorls, blunt apically, smooth and inclined to be angled medially after about the first half turn; this portion is also rather more tumid and protrudes over the remainder of the embryonic whorls; whorls strongly nodosely keeled about the middle of each whorl and forming a well marked shoulder on the body whorl. The keel marks the position of the sinus and is very regularly and acutely nodulose, nodules about 18 to 20 on the penultimate and body whorls. Outer lip thin and sharp, with a broad deep sinus at the shoulder."

Measurements (mm.) –

height	width	
28.0	9.0	holotype

Synonymy –

1904 *Pleurotoma murrayana* Pritchard, Proc. Roy. Soc. Victoria **17**, p. 335, pl. 19, fig. 10.
1944 *Lophiotoma murrayana* Pritchard, Powell, Rec. Auck. Inst. Mus. 3(1), p. 9.

Records – AUSTRALIA: River Murray Cliffs near Morgan, Victoria (Balcombian, Miocene).

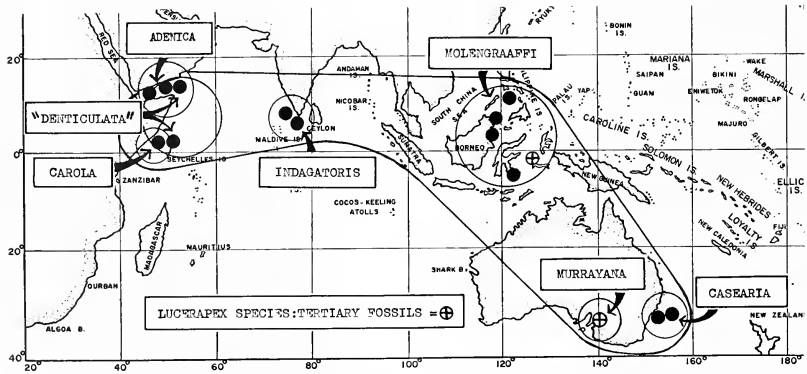

Plate 222. Geographical distribution of *Lucerapex casearia* (Hedley and Petterd), *L. molengraaffi* (Tesch), *L. carola* (Thiele), *L. denticulata* (Thiele), *L. indagatoris* (Finlay), *L. adenica* new species, and *L. murrayana* (Pritchard).

Genus Ptychosyrinx Thiele, 1925

Type: *Pleurotoma (Subulata) bisinuata* Martens, 1901

This is a deep-water genus strongly resembling *Gemmula,* except for the sinus which, although situated on the gemmate peripheral carina, is not deep and narrow, but broadly V to U shaped at its apex and not very deep. Unfortunately the apical whorls, except in the type species, are eroded away in all examples so far examined. Thiele (1925, pl. 23, fig. 4) showed the protoconch of *bisinuata* as narrowly conic with four axially costate whorls.

The radula in the type species, *bisinuata,* figured by Thiele (1929, p. 359, fig. 436) is unlike that of *Gemmula,* in that a large rectangular-based central tooth is present in addition to marginals, similar to the "wishbone" type of typical *Gemmula.* It could be considered prototypic of the Turrinae, comparable with the situation in the Clavinae where certain genera, *Drillia, Clavus* and *Spirotropis* for example, preserve a prototypic radula of central, lateral and marginal teeth. Most of the members of the subfamily Clavinae have a toxoglossate type of dentition consisting only of a pair of slender marginals.

The type species, *bisinuata,* as the name indicates, exhibits a spout-like projection of the lower outer lip as well as an anal siphonal notch. This same feature occurs in an example of *timorensis teschi* new subspecies from deep water in the Gulf of Tomini, Celebes, but it is not a constant feature of that subspecies. It results from a fusing and fluting of the two main basal cords.

The genus *Ptychosyrinx* is evidently of very wide distribution in the deep-sea basins, for apart from the East African and Indonesian occurrences it has been recorded recently from deep water off Bermuda, as *Bathybermudia carynae* Haas, 1949. Haas' genus was proposed under the mistaken impression that the bisinuate character of the type specimen of *Ptychosyrinx* was a diagnostic character of that genus.

Since this is now shown not to be the case, *Bathybermudia* falls as a synonym of *Ptychosyrinx.*

Synonymy —

1925 *Ptychosyrinx* Thiele, Wissenschaft, Ergebnisse Deutschen Tiefsee-Exped. **17**(2), p. 210. **Type** by original designation (fide Powell, 1942, p. 20): *Pleurotoma bisinuata* Martens, 1901.

1949 *Bathybermudia* Haas, Bull. Inst. Catalana d'Hist. Nat., **37**, p. 70. **Type** by monotypy: *B. carynae* Haas, 1949.

Ptychosyrinx bisinuata (Martens, 1901)

(Pl. 223, figs. 1, 2)

Range — Off East Africa, Somaliland to Zanzibar, 818 to 1362 metres.

Remarks — Shell tall-spired but with a rather short and recurved anterior canal. Protoconch polygyrate, narrowly conic, with 4 densely, axially costate whorls. Spire whorls sculptured with a broadly rounded, median carina studded with prominent, laterally compressed nodules. Spiral sculpture consisting of 2 or 3 threads between the upper suture and the peripheral carina, 2 or 3 threads below the carina and 3 strong, smooth cords on the upper part of the base, followed by about 9 threads over the neck and anterior canal. The uppermost of the 3 main basal spirals is emergent over the last whorl. The bisinuate nature of the outer lip exhibited by the type specimen has been shown above to be an abnormality. Colour pale yellowish.

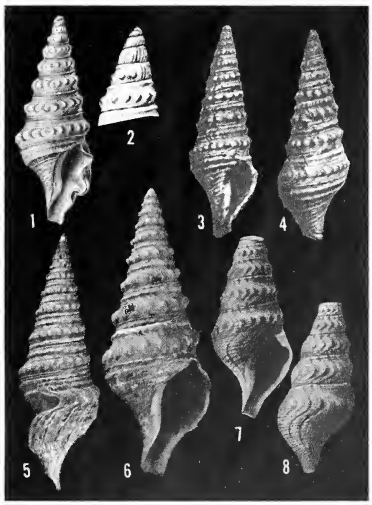

Plate 223. Figs. **1, 2,** *Ptychosyrinx bisinuata* Martens. Holotype. 1,134 meters, off East Africa. Figs. **3, 4,** *Ptychosyrinx timorensis* (Tesch). Pliocene of Timor Id., Indonesia (from Tesch, 1915, pl. 77, figs. 53a, b). Figs. **5, 6,** *Ptychosyrinx timorensis teschi* new subspecies. 415 fms., northwest of Sipadan Id., Borneo. Fig. 5, holotype, 47 mm. Figs. **7, 8,** *Ptychosyrinx truncata* (Schepman). 2,798 meters, Banda Sea, Indonesia (from Schepman, 1913, pl. 26, fig. 1). 19 mm.

Measurements (mm.) –

height	width
33.0	11.5
30.0	9.0

Synonymy –

1901 *Pleurotoma (Subulata) bisinuata* Martens, Sitzungsberichte Gesellsch. nat. Freunde, Berlin, p. 17.
1903 *Drillia (Subulata) bisinuata* Martens, Gast. Deutsch. Tiefsee-Exped., 1898-1899, **7**, p. 82, pl. 1, fig. 8.
1925 *Ptychosyrinx bisinuata* Martens, Thiele, Wissenschaft. Ergebn. Deutschen Tiefsee-Exped. **17**, Gastr. 2, p. 210.

Records – EAST AFRICA: 1° 49′ N., 45° 29′ E., 1134 metres and 2° 58′ N., 46° 50′ E., 1362 metres; off coast of Somaliland, 6° 18′ N., 49° 32′ E., 1079 metres; Pemba Channel, Zanzibar, 818 metres (Martens).

Ptychosyrinx lobata (Sowerby, 1903)

(Pl. 224)

Range – Off Natal and South Africa, 300 to 900 fathoms.

Remarks – Superficially this shell looks identical with *Ptychosyrinx bisinuata* (Martens, 1901), a deep water East African species. Tomlin added a remark to the type tablet of *lobata* in the British Museum, claiming that it is synonymous with Marten's species, but one hesitates to accept this opinion, in view of Barnard's (1958) remarks on the very different nature of the radula in topotypes of *lobata*.

Plate 224. *Ptychosyrinx lobata* (Sowerby, 1903). Holotype from the British Museum (Natural History). 440 fms., off Cape Natal, South Africa. 31 mm.

Thiele (1929, p. 359) figured a radula for *bisinuata*, which has a very large unicuspid rectangular-based central in addition to a pair of marginals. However, in all the *lobata* specimens examined by Barnard, the central tooth of the radula was found to be missing. The radula of an East London specimen was described as "with c. 75 pairs of teeth, no central plate, laterals broadly cuneiform, one margin sharply angular (in edge view) no appendage" (his "lateral" tooth should read "marginal").

Unfortunately none of Barnard's specimens had the protoconch intact, nor was it preserved in Sowerby's holotype. The operculum is described by Barnard as oval, with an apical nucleus, again discordant with Thiele's "eiformig konzentrisch."

In the face of the above evidence *lobata* and *bisinuata* cannot be considered conspecific, probably not even congeneric, but for the present, *lobata* is included in *Ptychosyrinx* until more is known concerning its type species.

The thought arises that Thiele could have mixed up his radula preparations, for the type of radula he figured for *bisinuata* is of similar style to that of both *Aforia magnifica* Strebel and *Turridrupa jubata* Hinds, both of which have a large-based, unicuspid central tooth.

Measurements (mm.) –

height	width
31	11

Synonymy –

1903 *Pleurotoma (Surcula) lobata* Sowerby, Marine Invest. South Africa **2**, p. 213, pl. 4, fig. 9.
1958 *Turris lobata* Sowerby, Barnard, Ann. South African Mus. **44**, p. 107; 1963, Ann. South African Mus. **46**, p. 419.

Types – The type is in the British Museum (Natural History).

Records – SOUTH AFRICA: Cape Natal, N. by E., 24 mi., 440 fms. (type locality); Buffalo River, N. 15 mi., 310 fms. (Sowerby); off Cape Point, 380-900 fms. (Barnard).

Ptychosyrinx timorensis *subspecies* timorensis (Tesch, 1915)

(Pl. 223, figs. 3, 4)

Range – Pliocene of Timor Island, Indonesia.

Remarks – The known examples of this species also lack the apical whorls but the adult shell, judged from Tesch's figures, closely resembles a Recent Indonesian deep-water shell described below. The Timor fossil is more slender than either *bisinuata* or the Recent Indonesian subspecies and the peripheral sculpture is of rounded rather than the laterally compressed nodules of *bisinuata*.

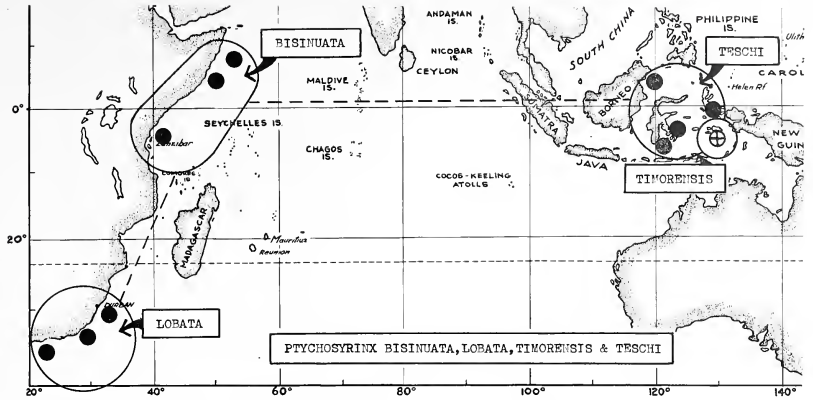

Plate 225. Geographical distribution of *Ptychosyrinx bisinuata* (Martens), *P. lobata* (Sowerby), *P. timorensis timorensis* (Tesch), and *P. timorensis teschi* new subspecies.

Measurements (mm.) —

height	width	
32-54	–	Tesch
53.0	17.5	from Tesch's fig. 53b

Synonymy —

1915 *Pleurotoma* (s. str.) *timorensis* Tesch, Palaeont. von Timor, p. 27, pl. 77(5), figs. 52, 53.

Types — The type locality is Timor Island, Pliocene.

Ptychosyrinx timorensis *subspecies* teschi *new subspecies*

(Pl. 223, figs. 5, 6)

Range — Indonesia, Celebes, Moluccas and Borneo, 347 to 559 fms.

Remarks — This subspecies appears to be the direct Recent descendant of the Pliocene *timorensis*. It differs from that species mainly in being proportionately broader, resulting in a greater spire angle, in having a shorter spire and a more capacious body whorl.

Description — Adult shell 46 to 53 mm. (about 2 inches) in height, with a tall spire but a short and flexed anterior canal. Colour uniformly dull white. Whorls 9 to 10½, exclusive of the embryonic whorls which are missing in all specimens examined. Spire whorls sculptured with a strong subsutural cord and a weaker spiral above it, the latter forming the margin of the suture. There are 2 or 3 threads between the subsutural cord and the peripheral carina. The latter is studded with closely-spaced, prominent, squarish nodules, 18 to 22 per whorl, obscurely overridden by 3 flat-topped linear-spaced spirals. Two spiral threads and one primary cord are between the peripheral carina and the lower suture. Base with 2 or 3 strong spiral cords above, and 8 or 9 spiral threads below on the neck and anterior canal. Spire about 1.3 times the height of the aperture plus canal; spire angle 30° to 33°. Sinus broadly V-shaped, relatively shallow, with a broadly rounded apex at the peripheral sinus angulation. Operculum leaf-shaped with an apical nucleus.

In *timorensis timorensis* the spire angle is 24° to 25°, and the height of the spire is almost twice that of the aperture plus canal.

An example from the Gulf of Tomini, Celebes (Albatross Sta. 5601) exhibits the "bisinuate" abnormality of a second sinuation of the outer lip caused by the fusing and fluting of the two main basal cords.

Measurements (mm.) —

height	width	
53.7	17.0	Albatross Sta. 5586; Borneo
53.0	18.7	Albatross Sta. 5648; Celebes
47.0	17.0	holotype, Albatross Sta. 5587

Types — The holotype is in the United States National Museum, Washington, D. C. The type locality is at the Albatross Station 5587, N.W. of Sipadan Id., Borneo, in 415 fms. USNM no. 239068

Records – CELEBES: off North Id., Buton Strait, 519 fms., green mud (Albatross Sta. 5647); off North Id., Buton Strait, 559 fms., green mud (Albatross Sta. 5648); Gulf of Boni, 15 mi. S.E. of Tg Olang, 484 fms., grey mud (Albatross Sta. 5656); Gulf of Tomini, (Albatross Sta. 5601). MOLUCCAS: March Id., Molucca Pass, 417 fms., grey mud (Albatross Sta. 5618). BORNEO: E. of Sipadan Id., Sibuko Bay, 347 fms., green mud (Albatross Sta. 5586); N.W. of Sipadan Id., 415 fms., green mud, sand and coral (holotype, Albatross Sta. 5587), (all USNM).

Ptychosyrinx truncata (Schepman, 1913)

(Pl. 223, figs. 7, 8)

Range – Known only from the Banda Sea, Indonesia.

Remarks – All four specimens mentioned by Schepman are lacking their upper whorls, and without knowledge of the protoconch the generic location of this species is conjectural. The broadly open, shallow peripheral sinus and rather short anterior canal suggest location in *Ptychosyrinx* rather than in *Gemmula*. Sculpture consisting of strongly-waved, axial, fold-like ribs becoming weaker over the last whorl, and crossed throughout by numerous spiral threads.

Measurements (mm.) –

height	width
19+	8

Synonymy –

1913 *Pleurotoma (Gemmula) truncata* Schepman, Siboga Exped., Monog. 49(1)e, p. 404, pl. 26, fig. I.

Records – INDONESIA: Banda Sea, 2798 metres (type locality).

Subgenus Kuroshioturris Shuto, 1961

Type: *Gemmula (Kuroshioturris) hyugaensis* Shuto, 1961

When Shuto proposed this subgenus he associated it with *Gemmula* because of its similar sculpture and sinus. However, the smooth, globose paucispiral protoconch of *Kuroshioturris* suggests that it is more closely related to *Ptychosyrinx,* rather than to *Gemmula* which has a multispiral, axially costate protoconch.

The species from the Upper Miocene–Lower Pliocene of Japan described as *Gemmula (Ptychosyrinx) nipponicus* Shuto, 1961, seems to fit better into his subgenus *Kuroshioturris.* The protoconch is described as rather large and composed of a depressed, rounded and smooth first volution and a convex and inflated second one, which is smooth except for the last quarter whorl with brephic axials. His figure of the protoconch, however, gives the impression that the embryo terminates abruptly with the commencement of adult sculpture.

Synonymy —

1961 *Kuroshioturris* Shuto, Mem. Faculty Sci., Kyushu Univ., Series D, Geol. **11**(2), p. 83. Subgenus of *Gemmula;* **type** by original designation: *G. (K.) hyugaensis* Shuto, 1961.

Ptychosyrinx nipponica (Shuto, 1961)

(Pl. 226, figs. 3, 4)

Range — Japan, near Yamaji (Upper Miocene-Lowest Pliocene).

Remarks — This shell closely resembles typical *Ptychosyrinx* in its adult facies, recalling *tinoreusis teschi new subspecies,* but with greater simplicity of sculpture, having a peripheral row of stout but more distant nodules and 2 very prominent spiral cords on the upper base. The only other spiral sculpture consists of weak threads, several submargining the suture and a number on the neck and anterior canal. There is a tendency toward "bisinuation" of the outer lip at the termination of the upper basal cords.

Measurements (mm.) —

height	width
12.9	7.2
12.2	7.5
11.1	6.3

Synonymy —

1961 *Gemmula (Ptychosyrinx) nipponicus* Shuto, Mem. Fac. Sci. Kyushu Univ. Ser. D, Geol. **11**(2), p. 81, pl. 3, figs. 7, 8, 13, 19; pl. 8 (not 7), fig. 14, text figs. 3, 4.

Records — JAPAN: entrance cutting to tunnel, 400 metres north of Yamaji, Mino mura, Koyu gun, Miyazaki Prefecture (Kawabaru member, lower Takanabe member, lower Upper Miocene to Lowest Pliocene) (type locality).

Ptychosyrinx hyugaensis (Shuto, 1961)

(Pl. 226, figs. 1, 2)

Range — Japan, Miyazaki Prefecture (Lowest Pliocene).

Remarks — The early whorls have a peripheral carina studded with rounded nodules but these become obsolete over the body whorl. The basal cords are also obsolete to subobsolete but are represented by an angulation. A blunt biangulation of the body whorl results.

Plate 226. Figs, 1, 2, *Ptychosyrinx (Kuroshioturris) hyugaensis* (Shuto). Lower Pliocene of Miyazaki Pref., Japan (from Shuto, 1961, pl. 3, figs. 2, 3). Figs. 3, 4, *Ptychosyrinx nipponica* (Shuto). Lowest Pliocene of Miyazaki Pref., Japan (from Shuto, 1961, pl. 3, figs. 7, 8).

Measurements (mm.) –

height	width
13.5	7.8
12.9	7.6

Synonymy –

1961 *Gemmula (Kuroshioturris) hyugaensis* Shuto, Mem. Fac. Sci. Kyushu Univ. Ser. D, Geol. **11**(2), p. 83, pl. 3, figs. 2, 3, 4; text figs. 3, 4.

Records – JAPAN: roadside cutting at Hagenoshita, Miyazaki Prefecture (lower part of Takanabe member, Lowest Pliocene), (type locality).

Ptychosyrinx totomiensis (Makiyama, 1931)

Range – Japan, Kakegawa and Miyazaki groups (Lower Pliocene).

Remarks – This species closely resembles a *Ptychosyrinx timorensis teschi* of optimum sculptural development. The subsutural ridge is strong and sharply projecting, the peripheral nodules are strong and closely spaced and all of the upper basal spirals are strong cords. Except for the relatively large, paucispiral protoconch, without brephic axials, the species would fit into *Ptychosyrinx* typical.

Measurements (mm.) –

height	width	
12.0	6.7	Hagenoshita

Synonymy –

1931 *Turris (Gemmula) totomiensis* Makiyama, Mem. Coll. Sci. Kyoto Imp. Univ. Ser. B, **7**(1), p. 46, pl. 1, figs. 10, 11.

1961 *Gemmula (Kuroshioturris) totomiensis* Shuto, Mem. Fac. Sci. Kyushu Univ., Ser. D, Geol. **11**(2), p. 84, pl. 6, figs. 1, 2, 3, 10; text figs. 3, 4.

Records – JAPAN: roadside cutting at Hagenoshita, Miyazake Prefecture (lower part of Takanabe member, Lowest Pliocene) (type locality).

Ptychosyrinx asukana (Yokoyama, 1926)

Range – Japan (Pliocene) and Okinawa (Miocene-Pliocene).

Remarks – MacNeil (1960, p. 103) writes of this species: "There seems to be little doubt that the specimen Yokoyama referred to this species in 1928 is a true *Gemmula*. However, doubt has been raised over the identity of the species described under this name in 1926. Hatai and Nisiyama (1952, p. 198) place it in *Clavatula*. Yokoyama's figure is poor but nevertheless he says in the description that 'the angle is the place where the old sinus band is present, on which the periodic ends of the sinus remain as tubercles.' If this description is accurate it would almost certainly place the shell in the Turrinae and probably in the genus *Gemmula*."

However, MacNeil overlooked that Yokoyama stated in his original description "Whorls about seven of which one and a half are nuclear, smooth and rounded." This rules out the species as a *Gemmula* and also renders inapplicable MacNeil's comparison of the species with my *longwoodensis* (Powell, 1942) from the Duntroonian Upper Oligocene of Southland, New Zealand, not Australia, as stated by him.

Description – Adult shell about 40 mm. (about 1½ inches) in height, slender and rather simple in sculptural characters. Angulate below the middle of whorl height, the periphery not carinated or flanged but studded with round to slightly pointed tubercles. In the Okinawan specimen there is a subsutural fold traversed by 3 weak spiral cords and 3 rather massive plain spirals encircle the upper part of the base, after which the spiral cords become weaker and more closely spaced. The surface, including the peripheral angle and its tubercles, as well as the interstices of the 3 main basal spirals, is crowded with spiral threads.

This species is likely to prove rather closely allied to *nipponica* Shuto, 1961. The measurements for the holotype below are estimated.

Measurements (mm.) –

height	width	
40.0	6.7	holotype
12.5	4.9	Okinawa

Synonymy –

1926 *?Drillia asukana* Yokoyama, Journ. Tokyo. Imp. Univ. Fac. Sci., Sec. 2, **1**(9), p. 331, pl. 38, fig. 18 (not *Pleurotoma asukana* Yokoyama, 1928).

1960 *Gemmula* aff. *asukana* Yokoyama, MacNeil, U. S. Geol. Surv. Prof. Paper **339**, p. 103, pl. 5, fig. 12.

Records – JAPAN: Asuka (Satsuka beds, Pliocene) (type locality). OKINAWA: (Yonabaru clay member, Miocene).

Genus Optoturris Powell, 1944

Type: *Pleurotoma optata* Harris, 1897

This is an Australian Miocene genus which is also recorded from the Lower Pliocene of Japan. Protoconch paucispiral of 1½ smooth whorls plus a half whorl of curved axials, the entire protoconch peg-like in shape but with the tip small and asymmetric. The sinus is broadly U-shaped, not very deep and extends over more than half the shoulder, with its lower edge situated at the weak peripheral carina. The genus seems to have no living representatives.

Synonymy –

1944 *Optoturris* Powell, Records Auckland Inst. and Museum **3**(1), p. 12. **Type** by original designation: *Pleurotoma optata* Harris, 1897.

Optoturris optata (Harris, 1897)

Range – Janjukian and Balcombian Miocene of Victoria, Australia.

Description – Adult shell 15 to 17 mm. (less than ¾ inch) in height, elongate-fusiform, with a tall spire and a moderately long canal. Whorls slightly convex, except for a weak peripheral angulation at about one third of the whorl height. Sculpture of dense thread-like spirals crossed by numerous axial growth lines which thicken at the rest stages, especially in the troughs of the sinus, imparting a rather dense comma-shaped sculptural pattern to the sinus area. Interior of outer lip deeply fluted within.

Measurements (mm.) –

height	width	
16.9	6.0	Balcombe Bay
16.5	6.0	holotype
15.0	5.3	Balcombe Bay

Synonymy –

1897 *Pleurotoma optata* Harris, Cat. Tert. Moll. Brit. Mus. **1**, p. 44, pl. 3, figs. 4, a, b.
1944 *Optaturris optatus* Harris, Powell, Rec. Auck. Inst. Mus. **3**(1), p. 12.

Types – The type is in the British Museum (Natural History) in London, England.

Records – AUSTRALIA: Hobson's Bay, Victoria, "Eocene" = Balcombian, Miocene (type locality); Muddy Creek, lower beds, Victoria (Balcombian) (Auck. Mus.).

Optoturris edita (Powell, 1944)

(Pl. 227)

Range – Balcombian Miocene of Victoria, Australia.

Remarks – Related to *optata* but larger, 25 mm. (1 inch) in height, narrower, with taller spire and longer canal. Sinus and sculpture similar to that of *optata*.

Measurements (mm.) –

height	width	
25.0	6.5	holotype

Synonymy –

1944 *Optoturris editus* Powell, Rec. Auck. Inst. Museum **3**(1), p. 12, pl. 7, fig. 3.

Types – The type locality is Grice's Creek, Victoria (Balcombian, Miocene). The holotype is in the Auckland Museum, New Zealand.

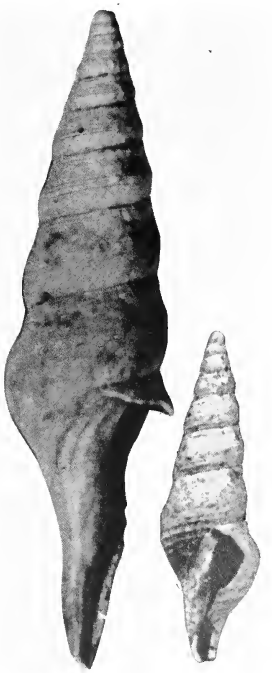

Plate 227. Left fig., *Optoturris edita* Powell, Balcombian Miocene of Grice's Creek, Victoria, Australia (from Powell, 1944, pl. 7, fig. 3). 25 mm. Right fig., *Optoturris kyushuensis* Shuto, Lower Pliocene of Hagenoshita, Japan (from Shuto, 1961, pl. 4, fig. 12).

Optoturris paracantha (Tenison-Woods, 1877)

Range – Janjukian Miocene of Tasmania and Victoria, Australia.

Remarks – Shell larger, broader and of more solid build than the other two Australian species; similarly sculptured but more strongly and with a broad deeply concave sulcus between the suture and the sinus area. Also, the thickened growth-lines, where they cross the sinus area, resolve into a regular gemmate series, reminiscent of *Gemmula*.

Measurements (mm.) –

height	width	
25.6	10.0	Table Cape, Tasmania

Synonymy –

1877 *Pleurotoma paracantha* Tenison-Woods, Proc. Roy. Soc. Tasm., for 1876, p. 105.
1898 *Bathytoma paracantha* T.-Woods, Tate, Proc. Roy. Soc. N.S.W. **31**, p. 398.
1944 *Optoturris paracanthus* T.-Woods, Powell, Rec. Auck. Inst. Mus. **3**(1), p. 12

Records – AUSTRALIA: Table Cape, Tasmania (type locality); Torquay, Victoria (Janjukian, Miocene).

Optoturris kyushuensis Shuto, 1961

(Pl. 227)

Range – Takanabe Lower Pliocene of Japan.

Remarks – Shell small, 16.9 mm. (about ½ inch) in height. It appears from the description and figure to be undoubtedly of the above genus, and closely resembles the Australian Balcombian *edita*, from which it is distinguished chiefly by both stronger primary spirals on the base and more definite granules or gemmules on the sinus rib.

Measurements (mm.) –

height	width
16.9	5.1

Synonymy –

1961 *Optoturris kyushuensis* Shuto, Mem. Fac. Sci. Kyushu Univ. Ser. D, Geol. **11**(2), p. 75, pl. 4, fig. 12.

Records – JAPAN: Hagenoshita, unconsolidated grey fine sandstone (Takanabe member, Lower Pliocene) (type locality).

Genus Epidirella Iredale, 1931

Type: *Pleurotoma xanthophaes* Watson, 1886

This genus appears to be more nearly allied to *Ptychosyrinx* than to *Gemmula*, but examination of the radula will be necessary to determine its true relationship. In *Gemmula* the radula is of the same type as in *Turris*, that is, a pair of "wishbone-shaped" marginals, whereas in *Ptychosyrinx* Thiele it is with a large unicuspid central tooth in addition to modified "wishbone" marginals but no laterals.

The sinus in *Epidirella* resembles that of *Ptychosyrinx* in being a peripheral, shallow, broadly-open "V," but the sculpture is prominently bicarinate-gemmate; that of *Ptychosyrinx* is gemmate only on the peripheral keel. There is, in addition to the two gemmate keels, a closely spaced pair of subsutural cords and these also are gemmate, the sculptural effect on the spire whorls being an entire covering of gemmules.

The protoconch is tall, with three whorls, the first smooth and narrowly dome-shaped, followed by weak, oblique axials, crossed on the last whorl by an incipient bicarination. Operculum leaf-shaped, with apical nucleus.

The shell is white, covered by a light horny periostracum, and this also is true of *Ptychosyrinx*.

The known distribution of *Epidirella* is the east Australian Continental Shelf, Tasmania and New South Wales, but it is likely that the genus may be found to extend into the Indo-Pacific in deep water. A fossil species, *sayceana* Chapman, 1912, from the Kalimnan, Lower Pliocene of Victoria, is tentatively referred to this genus.

Synonymy –

1931 *Epidirella* Iredale, Records Australian Mus. **18**(4), p. 226. Type by original designation: *Hemipleurotoma tasmanica* May, 1911 = *Pleurotoma xanthophaes* Watson, 1886.

Epidirella xanthophaes (Watson, 1886)

(Pl. 228)

Range – Southeast Australia and Tasmania.

Remarks – Hedley (1922, p. 231) referred this species to his genus *Epideira* and cited *Hemipleurotoma tasmanica* May, 1911, as a synonym. Iredale (1931, p. 225) could not reconcile May's species with Watson's description and figure of *xanthophaes*, and in erecting a new genus, *Epidirella*, cited *tasmanica* as type. Laseron (1954, p. 7), obviously unaware of Iredale's genus, provided another new genus, *Austrogemmula*, for May's species and at the same time remarked that Watson's species has never been recognized since its first recording.

A photograph of the type of *xanthophaes* Watson, here reproduced, shows the sculpture to be stronger and more noticeably gemmate than it appears in Watson's figure, but not so pronounced as in most examples attributed to *tasmanica* that the writer has seen. Nevertheless, the strength of the sculpture seems to be rather variable, and so upon the available material separation from Watson's species appears unwarranted.

Measurements (mm.) –

height	width	
26.5	9.5	Twofold Bay
25.0	–	Crookhaven (Laseron)
24.0	8.4	holotype of *xanthophaes*
20.0	7.0	Disaster Bay

Synonymy –

1886 *Pleurotoma xanthophaes* Watson, Challenger Zool. **15**, p. 282, pl. 26, fig. 1.
1911 *Hemipleurotoma tasmanica* May, Proc. Roy. Soc. Tasm., 1910, p. 391, pl. 13, fig. 16.
1922 *Epideira xanthophaes* Watson, Hedley, Rec. Aust. Mus. **13**(6), p. 231.
1931 *Epidirella tasmanica* May, Iredale, Rec. Aust. Mus. **18**(4), p. 226.
1954 *Austrogemmula tasmanica* May, Laseron, N.S.W. Turridae, Handb. Roy. Zool. Soc. N.S.W., p. 7, pl. 1, figs. 8, 9.

Plate 228. *Epidirella xanthophaes* (Watson). Holotype. 30-35 fms., off Port Jackson, New South Wales, Australia. 24.0 mm.

Types – The holotype of Watson's *xanthophaes* is in the British Museum (Natural History), London.

Records – NEW SOUTH WALES: 30-35 fms., off Port Jackson (type locality for *xanthophaes*); Disaster Bay, 5 fms.; off Crookhaven, 30-35 fms. (Laseron, 1954); off Cape Everard, 70-80 fms. (Aust. Mus.); off Twofold Bay, 5-8 fms. (T. Gerrard). TASMANIA: off Schouten Id., 40 fms. (type locality for *tasmanica*). VICTORIA: Lakes Entrance, 20 fms. (Macpherson & Gabriel).

Epidirella sayceana (Chapman, 1912)

Range – Lower Pliocene of Victoria, Australia.

Synonymy –

1912 *Pleurotoma sayceana* Chapman, Proc. Roy. Soc. Vict. **25**(n.s.), p. 191, pl. 12, fig. 7.

1944 ?*Epidirella sayceana* Chapman, Powell, Rec. Auck. Inst. Mus. **3**(1), p. 16.

Records – VICTORIA: Lakes Entrance (type locality); Jemmy's Point (Kalimnan, Lower Pliocene).

Genus Epidirona Iredale, 1931

Type: *Epidirona hedleyi* Iredale, 1931

The genus *Epidirona*, despite its resemblance to the Clavinae, belongs in the Turrinae as shown both by the peripheral location of the sinus and by the radula which is a modified "wishbone" type. These shells have a tall acuminate spire but a truncated body whorl; the anterior canal is not produced but ends in a broad shallow notch at the termination of a well-marked fasciole. The anal sinus is a moderately deep, narrowly rounded "U," situated at the periphery. The protoconch is small and of two smooth turbinate whorls. The post-nuclear sculpture is typically of fine spiral cords and threads, crossed obliquely by weak axials which are strengthened into elongate, laterally-compressed nodes over both the subsutural fold and the peripheral carina. The outer lip is thin, without a varix, and there is no parietal tubercle. Interior of aperture spirally fluted. For radula, see pl. 229.

The Recent geographical range of the genus is mostly southern Australia to Tasmania and New South Wales but there is evidence that it occurs much farther afield as instanced by E. A. Smith's *multiseriata* which has been recorded from Ceylon, Persian Gulf and China Seas.

Four Tertiary species are known from southern Australian horizons, extending from the Janjukian Miocene to the Adelaidean Lower mid-Pliocene.

The type species of this genus, a well-known New South Wales shell, has been the subject of much confusion both at the generic and the specific level. When Hedley (1918, p. M79) proposed *Epideira* he cited *Clavatula striata* Gray, 1827, as type, but later (1922, p. 230, pl. 43, figs. 18-20) showed that he had in mind the New South Wales shell previously known as either *striata* Gray (but not Gray of 1827) or *owenii* Reeve, 1843.

Iredale (1931, p. 225) rejected *Epideira* in connection with the *striata* of Hedley, stating that Gray's description did not fit the New South Wales shell and that Gray's species, at present indeterminate, probably came from Western Australia.

Watson (1886, p. 312) used *Pleurotoma owenii* (Gray ms.) Reeve, 1843, for the New South Wales shell, citing *Clavatula striata* Gray as a synonym, but Reeve's species was stated to be from the East Coast of Africa. The specimen used by Reeve to illustrate his *owenii* certainly resembles the New South Wales shell but he based the name upon a specimen in Gray's cabinet and remarked that it "is of unusually large size, at least one-third longer than that selected for illustration."

The types of both *striata* and *owenii* seem to be lost and this induced Iredale to clarify the situation by providing a new genus and species name for the New South Wales shell.

Synonymy —

1931 *Epidirona* Iredale, Records Australian Mus. 18(4), p. 225. **Type** by original designation: *Epidirona hedleyi* Iredale, 1931.

A full treatment of *Epidirona* is planned for a future paper, and for the present I am considering in detail only the sole, strictly Indo-Pacific species, *multiseriata* (E. A. Smith, 1877). The others, mainly from southeast Australia, are listed here alphabetically by species, but in their original generic combinations.

Epidirona multiseriata (E. A. Smith, 1877)

(Pl. 230, fig. 3)

Range — Persian Gulf to the South China Sea.

Remarks — This species closely resembles the type of *Epidirona* in most essentials; the sculpture is much stronger but of similar style, the form of the sinus, anterior canal features, thin outer lip, presence of fluting within the aperture and lack of a parietal tubercle all match very closely. The only deviation from typical *Epidirona* is in the protoconch which is carinate on whorls two and three.

Description — Adult shell, 15 to 19 mm. (½ to ¾ inches) in height, solid, drilliaform, with tall acuminate spire but truncated body whorl. Whorls eight, plus a small depressed-turbinate protoconch of three whorls, the first whorl smooth, the second carinated below the middle and the third crossed by regular arcuate axials in addition to the carina. Sculpture strong, consisting of spiral gemmate cords crossed by weaker axials. On the spire there are two massive gemmate folds, one subsutural and the other forming the sinus ridge; both are com-

Plate 229. Radula of *Epidirona hedleyi* Iredale. From specimen from ANSP, Port Jackson, New South Wales, Australia (courtesy of V. Orr).

posed of two fused cords. The gemmules also are fused to form tall, narrowly rectangular nodes, the subsutural series slightly retractive and the sinus series slightly protractive; they number about twenty per whorl. Between the two folds is a deep sulcus bearing one or two spiral threads. On the base below the periphery there are eight strong spiral gemmate cords and a further series of six plain spiral cords on the anterior end.

The body whorl is truncated and has a very short anterior canal with a wide shallow notch at the termination of a well-defined fasciole. Outer lip thin, fluted within. Sinus moderately deep, narrowly U-shaped, occupying the upper portion of the broad peripheral carina. Colour dull creamy white.

Measurements (mm.) –

height	width	
19.0	7.0	Mekran Coast (Brit. Mus.)
15.0	5.0	Ceylon (holotype)
14.2	5.6	Singapore

Synonymy –

1877 *Pleurotoma multiseriata* E. A. Smith, Ann. Mag. Nat. Hist. (ser. 4) **19**, p. 491.

1917 *Turris (Gemmula) multiseriata* E. A. Smith, Melvill, Proc. Malac. Soc. **12**, p. 145, pl. 8, fig. 3.

Types – The type locality is Ceylon. The holotype is in the British Museum (Natural History), London.

Records – CEYLON: (type locality); INDIA: Madras (Winckworth coll., Brit. Mus.); PERSIAN GULF: Mekran Coast (Townsend coll., Brit. Mus.); MALAYA: Johore Strait (Winckworth coll., Brit. Mus.); Singapore (Powell coll.). THAILAND: 4 mi. E. of Phuket Harbour, 80 ft. (R. Tucker Abbott, 1963).

List of Recent *Epidirona* species

beachportensis (Cotton & Godfrey, 1938), *Epideira*, Rec. S. Aust. Mus. **6**(2), p. 205, pl. 17, fig. 4 (150 fms. off Beachport, South Australia).

candida Laseron, 1954, *Epidirona*, N.S.W. Turridae, Handb. Roy. Zool. Soc. N.S.W., p. 10, pl. 2, fig. 30 (70-80 fms. off Cape Everard, N.S.W., Australia). See pl. 230, fig. 9.

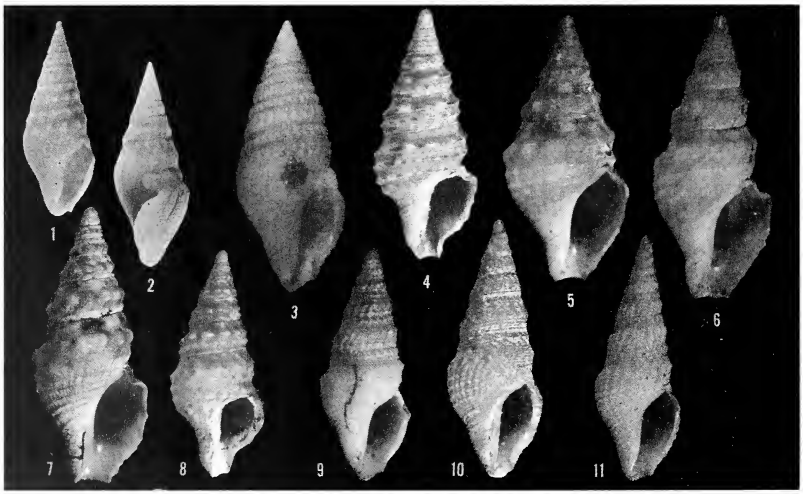

Plate 230

Figs. 1, 2 *Epidirona hedleyi* Iredale. Port Jackson, New South Wales, Australia. 27 mm.
3 *Epidirona multiseriata* (E. A. Smith). Holotype. Ceylon. 15 mm. Type in Brit. Mus. (Nat. Hist.)
4 *Epidirona carinata* Laseron. Holotype. 40-50 fms., off New South Wales, Australia. 17 mm.
5 *Epidirona nodulosa* Laseron. Holotype. 50 fms., off New South Wales, Australia. 19.5 mm.
6 *Epidirona gabensis* (Hedley). Holotype. 80 fms., off Gabo Id., Victoria, Australia.
7 *Epidirona torquata* (Hedley). Holotype. Port Arthur, Tasmania.
8 *Epidirona molleri* Laseron. Holotype. 50 fms., off New South Wales, Australia. 16 mm.
9 *Epidirona candida* Laseron. Holotype. 70-80 fms., off New South Wales, Australia. 15 mm.
10 *Epidirona tuberculata* Laseron. Holotype. 40-50 fms., off New South Wales, Australia. 15.5 mm.
11 *Epidirona costifera* Laseron. Holotype. 40-50 fms., off New South Wales, Australia. 16 mm.
(all types except fig. 3 in the Australian Museum, Sydney)

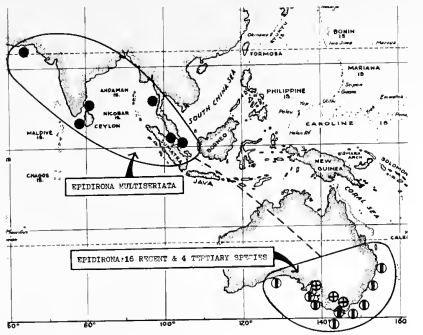

Plate 231. Geographical distribution of *Epidirona multiseriata* (E. A. Smith) and 16 Recent and 4 Tertiary Australian species.

carinata Laseron, 1954, *Epidirona*, N.S.W. Turridae, Handb. Roy. Zool. Soc. N.S.W., p. 9, pl. 2, figs. 24-26 (40-50 fms. off Manning R., N.S.W., Australia). See pl. 230, fig. 4.

costifera Laseron, 1954, *Epidirona*, N.S.W. Turridae, Handb. Roy. Zool. Soc. N.S.W., p. 10, pl. 2, fig. 29 (40-50 fms. off Manning R., N.S.W., Australia). See pl. 230, fig. 11.

flindersi (Cotton & Godfrey, 1938), *Epideira*, Rec. S. Aust. Mus. **6**(2), p. 205, pl. 17, fig. 1 (80 mi. west of Eucla, 75 fms., South Australia).

gabensis (Hedley, 1922) *Epideira*, Records Australian Mus. **13**(6), p. 228, pl. 53, fig. 16 (80 fms., Gabo Id., Victoria, Australia). See pl. 230, fig. 6.

hedleyi Iredale, 1931, *Epidirona*, Records Australian Mus. **18**(4), p. 225 (Port Jackson, New South Wales). See pl. 230, figs. 1, 2.

jaffaensis (Verco, 1909), *Drillia*, Trans. Roy. Soc. South Australia **33**, p. 298, pl. 26, figs. 7-9 (130 fms. off Cape Jaffa, South Australia).

molleri Laseron, 1954, *Epidirona*, N.S.W. Turridae, Handb. Roy. Zool. Soc. N.S.W., p. 11, pl. 2, figs. 31, 32 (50 fms. off Crowdy Head, N.S.W., Australia). See pl. 230, fig. 8.

monile (Kiener, 1839-40), *Pleurotoma*, Coq. Viv. Pleurot. **5**, p. 52, pl. 15, fig. 3 (non Brocchi, 1814; see *quoyi* Desmoulins, 1842).

nodulosa Laseron, 1954, *Epidirona*, N.S.W. Turridae, Handb. Roy. Zool. Soc. N.S.W., p. 9, pl. 1, figs. 21-23 (50 fms. off Crowdy Head, N.S.W., Australia). See pl. 230, fig. 5.

perksi (Verco, 1896), *Surcula*, Trans. Roy. Soc. South Australia **20**, p. 224, pl. 7, fig. 3, a-c (15 fms. off Thistle Id., South Australia).

philipineri (Tenison-Woods, 1877), *Pleurotoma*, Proc. Roy. Soc. Tasmania, p. 136 (N.W. coast of Tasmania).

quoyi (Desmoulins, 1842), *Pleurotoma*, Actes Soc. Linn. Bordeaux **12**, p. 167, nom. nov. for *Pl. monile* Kiener, 1839-40 (non *Pl. monile* Brocchi, 1814). (Western Port, Victoria).

schoutanica (May, 1911), *Drillia*, Proc. Roy. Soc. Tasmania (1910), p. 391, pl. 14, fig. 17 (80 fms., off Schouten Id., Tasmania).

striata Gray, Hedley, 1922, *Epideira*, (not of Gray, 1827), Records Australian Mus. **13**(6), p. 230, pl. 43, fig. 18-20 (is now *hedleyi* Iredale, 1931) (New South Wales).

torquata (Hedley, 1922), *Epideira*, Records Australian Mus. 13(6), p. 230, pl. 43, fig. 21 (Port Arthur, Tasmania). See pl. 230, fig. 7.

tuberculata Laseron, 1954, *Epidirona*, N.S.W. Turridae, Handb. Roy. Zool. Soc. N.S.W., p. 10, pl. 2, figs. 27, 28 (30-35 fms., off Port Stephens, New South Wales, Australia). See pl. 230, fig. 10.

List of fossil *Epidirona* species

adelaidensis (Ludbrook, 1941), *Bathytoma*, Trans. Roy. Soc. South Australia **65**(1), p. 97, pl. 5, fig. 17 (Abattoirs Bore, 400-500 ft., Adelaide, South Australia; Pliocene).

laevis Pritchard, 1904, var. of *Pleurotoma selwyni*, Proc. Roy. Soc. Victoria **17**, p. 328 (non *laevis* Bell, 1890; see *suppressa* Finlay, 1927).

powelli Ludbrook, 1957, *Epidirona*, Trans. Roy. Soc. South Australia **81**, p. 86, pl. 5, fig. 3 (Weymouth's Bore, 310-530 ft., Adelaide, South Australia; Lower mid-Pliocene).

suppressa (Finlay, 1927), var. of *Epideira selwyni*, Trans. N.Z. Inst. **57**, p. 516, nom. nov. for *laevis* Pritchard, 1904 (non Bell, 1890) (Victoria, Australia; Miocene).

vardoni (Tate, 1899), *Surcula*, Trans. Roy. Soc. South Australia **23**, p. 108, pl. 1, fig. 3, a-b (Murray Desert, Victoria, Australia (Janjukian?, Miocene).

[These occasional blank areas occur between genera and subgenera to permit the insertion of new material and future sections in their proper systematic sequence.]

Genus Lophiotoma Casey, 1904

Type: *Pleurotoma acuta* Perry, 1811.

This is a well-known group of Indo-Pacific turrids closely resembling *Turris* but with the sinus always on the peripheral keel, not on a subsidiary ridge above the periphery, as in true *Turris*. For shells identical with *Lophiotoma* in adult features, but with a blunt paucispiral protoconch, see the subgenus *Lophioturris*, following.

The counterparts of this genus in the tropical Eastern Pacific, the Caribbean and the Tertiary of the South Eastern United States are the genera *Pleuroliria* and *Polystira*, the former Eocene and Oligocene and the latter Miocene to Recent. A more shallow and broadly V-shaped sinus, and protoconch differences, separate these two from *Lophiotoma*, but there was probably a common ancestry.

Protoconch light reddish brown, tall, polygyrate, narrowly conical of 3½ to 4 whorls, strongly sculptured with numerous crisp flexuous axials over the last 2½ whorls, crossed by numerous faint spiral threads, which are visible only on the axials, not in the interstices. The first 1½ whorls are smooth, probably due to erosion, for no very well preserved apices were found. A non-eroded protoconch is probably axially costate throughout, as in *Xenoturris*. The weak nodulation or undulation of the peripheral sinus rib on the first post-embryonic whorl, shown in the figure, does not persist over subsequent whorls, nor is it a common feature in other material examined. The protoconch figure is from a Persian Gulf specimen.

Synonymy –

1904 *Lophiotoma* Casey, Trans. Academy Sci. St. Louis 14(5), p. 130.

1928 *Lophiotoma* Casey, Woodring, Publ. no. 385, Carnegie Inst. Washington, pt. 2, p. 146. **Type** by subsequent designation: *Plcurotoma tigrina* Lamarck, = *acuta* Perry, 1811.

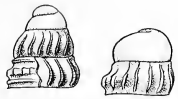

Plate 232. Nuclear whorls of *Lophiotoma* s.s. and the subgenus *Lophioturris*. Left fig., *Lophiotoma (Lophiotoma) acuta* (Perry) from the Persian Gulf. Right fig., *Lophiotoma (Lophioturris) indica* (Röding) from Yeppoon, Queensland, Australia.

Lophiotoma acuta (Perry, 1811)

(Color pl. 180; pl. 233; pl. 234)

Range – Recent: Red Sea and East Africa to Japan and Melanesia. Fossil: Pliocene and Pleistocene of Indonesia.

Remarks – This species, better known as *tigrina* Lamarck, is the most widespread of the turrids. It is also most variable in shape, sculpture and in colour pattern. The more stable of these variants conform vaguely to geographic patterns over marginal areas but in no hard and fast manner, for not only do forms integrate and coalesce at the crossroads between the Indian and Pacific Oceans but odd forms are likely to crop up in an otherwise constant assemblage for an area.

This is true of *jickelii* Weinkauff, the type locality for which is the Red Sea. The *jickelii* form tends to coarser sculpture than in *acuta* typical, the trend being a reduction in strength of the peripheral carina and increased prominence of the primary cords. See pl. 180, figs. 14, 19.

The writer has seen only two Red Sea examples so is not competent to state what the overall characteristics of the Red Sea populations may be. The few Persian Gulf specimens examined show slight carinal reduction but are nevertheless nearer to typical *acuta*. Forms resembling *jickelii* were noted also from Zanzibar, Philippines and Buchan's Point, Cairns, Queensland, but in all cases either in asso-

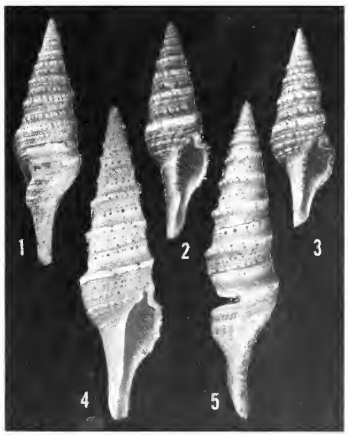

Plate 233. Figs. 1-3, *Lophiotoma acuta* (Perry) form *jickelii* (Weinkauff). Cebu Id., Philippines. Figs. 4, 5, *Lophiotoma acuta* (Perry). Cotype of *L. microsticta* Casey, 1904. Cebu Id., Philippines (U.S. Nat. Mus.).

ciation with or in close proximity to a population of typical *acuta*.

If the Red Sea populations should prove to be predominantly *jickelii* type then there may be a case for considering that population a geographical subspecies which tends to infiltrate eastward to Zanzibar, the South China Sea and north Queensland, but the evidence at present is against such an assumption.

What little is known of the ecological conditions under which the respective forms live shows this factor to be of importance both in respect to the proportions of the shell and the coloration. The elongated, pale, sparsely-spotted form, *microsticta* Casey from the Philippines, for instance, is the common and apparently exclusive form in the Marshall Islands where it occurs in shallow water on white coral sand. Similar shells range northward to Japan.

A narrow but profusely-maculated form is found in East Indies waters and these closely resemble Lamarck's Encyclopédie méthodique figure (pl. 439, fig. 6) of his *marmorata* (non *marmorata* Lamarck, 1822). It is significant that shells of this form from Koeroedoi Island, Dutch New Guinea, were found living on black sand and silt.

A broad heavily-maculated shell is the common form at Zanzibar, East Africa and Madagascar, and this form spreads across the Indian Ocean and infiltrates strongly throughout the East Indies, the Philippines and Queensland.

Sowerby's *Pleurotoma notata* from Hong Kong resembles the *jickelii* form of *acuta*, but in this case suppression of the peripheral carina is due to shell injury at the commencement of the antepenultimate whorl. See pl. 234.

Another synonym of *acuta* is Weinkauff's *picturata* which fits the pale, sparsely patterned shells with a relatively short canal, found on sand in many shallow-water locations along the north Queensland coast. These are nearest to *acuta* typical, but the broad heavily maculated form of *acuta*, the narrow heavily maculated form *(maculata)* and the coarsely sculptured *jickelii* form also occur along the Queensland coast and on the offshore islands. All occur in sandy locations, but the *maculata* form seems to favour deeper water on a shelly bottom.

In Fiji, the typical, the *maculata* and the *picturata* forms all occur. Specimens, with field notes, from the collection of Mr. W. Jennings show that the typical form occurs in sand at 2 or 3 feet below low water, the *picturata* form from 4 or 5 fathoms and the *maculata* form from 4 or 5 feet below low tide off the edge of coral reefs.

Still another probable synonym of *acuta* is Dunker's *Pleurotoma peaseana*, the type of which is supposed to be in the Godeffroy Museum, Hamburg. It was referred to the synonymy of *marmorata* (= *acuta*) by Hedley (1922, p. 216).

Specimens which approach nearest to Perry's figure in proportions, sculptural detail and coloration come from the islands of the tropical Southwest Pacific. Typical *acuta* is a relatively broad shell, strongly carinate and with a sparse pattern of small brown dots on a pale ground.

Description of Typical Form — Adult shell 45 to 50 mm. (1¾ to 2 inches) in height, of light build, fusiform, with a tall spire, 27° to 34°, and with a long rather straight canal. Spire slightly taller than the height of the aperture plus canal. Whorls 10 or 11, plus a tall narrowly-conic protoconch of 3½ to 4 whorls, of yellowish brown colour and strongly sculptured with closely spaced, slightly oblique and arcuate axials which are crossed at right angles by faint spiral threads. Spire whorls dominated by the centrally placed sinus carina, consisting of an upper and a lower sharp-edged keel with a smooth concavity between. The upper keel projects slightly more than the lower one. The primary cords consist of a strong subsutural one, and three below the carina, the second one emergent at the suture and the third below the level of the top of the aperture. The secondary sculpture forms a dense surface-cover of spiral threads of varying strength, 8 to 10 in number on the shoulder from between the subsutural cord and the sinus rib. Ground colour, creamy-white, sparsely speckled with small, dark-brown, rectangular spots, most prominent on the subsutural cord, both edges of the sinus rib and on the three primary cords below it. Most of the secondary spirals are minutely speckled.

Measurements (mm.) —

(a) Typical sparsely speckled form

height	width	spire angle	
50.0	16.0	32°	Fiji
46.0	15.5	34°	Fiji
44.0	13.0	28°	Low Isles, Queensland
43.5	14.0	33°	Fiji
30.0	11.0	32°	Samoa

Spire angle 28° to 34° = average 31.8°

(b) Narrow, sparsely maculated form (*microsticta*)

59.7	14.6	23°	Cebu, cotype of *microsticta*
51.4	13.0	25°	Kii, Japan
48.7	13.5	25°	Ryukyu Ids.
44.0	12.3	25°	Palau Ids.

Spire angle 23° to 25° = average 24.5°

(c) Broad, heavily maculated form (*tigrina* Lamarck)

66.5	17.0	28°	Chwaka, Zanzibar
65.0	18.0	30°	Kiwengwa, Zanzibar
60.0	16.7	30°	Mozambique
58.0	17.7	29°	Mozambique
57.5	16.0	29°	Ko Phuket, W. Thailand
53.0	16.0	30°	Mozambique
43.5	13.2	28°	Low Isles, Queensland
41.5	13.0	30°	King's Reef, N. Queensland
39.5	12.0	27°	Tutuila, Samoa

Spire angle 27° to 30° = average 29.1°

(d) Narrow, heavily maculated form (*marmorata* Lamarck, 1816)

48.0	13.0	28°	all Kaipoeri, Dutch New Guinea
46.2	12.5	27°	
42.5	11.0	26°	
30.1	7.7	24°	
25.2	7.0	26°	

Spire angle 24° to 28° = average 26.2°

Description of *jickelii* form — The *jickelii* form is a narrow shell with the sinus rib formed of two closely spaced, rounded cords and with the secondary sculpture quite strongly developed. The sinus rib is not strongly projecting as in the typical species and the upper margining cord does not project farther than the lower one. The colour pattern is in the form of numerous dark, reddish brown, rectangular patches and spots roughly connected longitudinally with wavy lines, reminiscent of the *crispus* pattern. Adult shell 42 to 47 mm. (about 1½ to 2 inches) in height, fusiform, with a tall spire, 22° to 25°, and a long canal. Spire approximately equal to the height of the aperture plus canal. Spire whorls weakly carinated medially by the sinus ridge which is bordered below by a rounded cord. Subsutural fold well-developed as a broad collar, almost as strong as the sinus rib. The whole surface crossed by strong, rounded, spiral cords and crisp threads. Whorls 11 or more.

Measurements (mm.) —

height	width	spire angle	
53.0	13.0	—	(Weinkauff)
49.0	14.0	25°	
47.0	13.7	22°	
41.7	11.6	24°	

Synonymy —

1811 *Pleurotoma acuta* Perry, Conchology, London, pl. 54, fig. 5 (no locality).
1816 *Pleurotoma marmorata* Lamarck, Tableau Encyclopédique et Méthodique, Paris, pl. 439, fig. 6, Le Liste, p. 8.
1822 *Pleurotoma tigrina* Lamarck, Hist. Nat. Anim. sans Vert. **7**, p. 95.
1829 *Pleurotoma punctata* Schubert & Wagner, Suppl. Conch. Cab. **12**, p. 155, pl. 234, figs. 4103, a, b (no locality).
1839-40 *Pleurotoma tigrina* Lamarck, Kiener, Coquilles Vivantes **5**, p. 10, pl. 8, fig. 1 (Indian Ocean and Madagascar).
1843 *Pleurotoma tigrina* Lamarck, Deshayes, Anim. sans Vert. **9**, p. 352, sp. 20 (no locality).
1843 *Pleurotoma tigrina* Lamarck, Reeve, Conch. Iconica **1**, pl. 1, fig. 3 (Philippines, sandy mud).
1871 *Pleurotoma (Turris) peaseana* Dunker, Malak. Blatt. **18**, p. 154.
1875 *Pleurotoma jickelii* Weinkauff, Conch. Cab. 4(3), p. 20, pl. 4, figs. 2, 3.
1876 *Pleurotoma peaseana* Dunker, Weinkauff, Conch. Cab. 4(3), p. 69, pl. 15, figs. 1-3.
1876 *Pleurotoma picturata* Weinkauff, Conch. Cab. 4(3), p. 66, pl. 2, fig. 10.
1884 *Pleurotoma tigrina* Lamarck, Tryon, Manual of Conch. **6**, p. 164, pl. 2, fig. 10.
1888 *Pleurotoma notata* Sowerby, Proc. Zool. Soc., p. 566, pl. 28, fig. 17.
1904 *Lophiotoma microsticta* Casey, Trans. Acad. Sci. St. Louis **14**, p. 130 (not figured; Cebu, Philippines).
1915 *Pleurotoma* (s.str.) *tigrina* Lamarck, Tesch, Palaeontologie von Timor **9**, Stuttgart, p. 24, pl. 76(4), fig. 36 (Pliocene, Timor).
1931 *Pleurotoma tigrina* Lamarck, van der Vlerk, Leidsche Geol. Meded. Rijksmus. Geol. Min. Leiden **5**, p. 219 (Sumatra, Java, Timor and Celebes. Miocene, Pliocene and Pleistocene records).
1956 *Lophiotoma tigrina* Lamarck, Kaicher, Indo-Pacific Sea Shells, section 5, Toxoglossa, pl. 1, fig. 5.
1961 *Turris tigrina* Lamarck, Habe, Shells of Japan **2**, pl. 38, fig. 18 (microsticta form).
1961 *Turris notata* Sowerby, Habe, Shells of Japan **2**, pl. 38, fig. 16.

Types — The type of *notata* is in the British Museum (Natural History); it measures 55 × 16mm.

Plate 234. *Lophiotoma acuta* (Perry). Holotype of *Pleurotoma notata* Sowerby, 1888. Hong Kong.

Records – RED SEA: Massaua (type of *jickelii*); (Calvert coll., MCZ). PERSIAN GULF: (Brit. Mus.). ANDAMAN ISLANDS: Port Blair (Winckworth coll., Brit. Mus.). SEYCHELLES: N.W. Bay, Mahé (Winckworth coll., Brit. Mus.). CEYLON: (USNM). ZANZIBAR: Chwaka, 0-4 ft.; 1½ mi. W.S.W. Ras Mungwe, 8 fms.; 1 mi. W.N.W. Ras Mbweni, 7 fms.; S. side of Pwakuu Id., 11-18 fms.; between Mwamba, Ukombi and Chumbe Ids., 4-6 fms.; Kizimkazi, 0-3 ft.; Kiwengwa, 0-3 ft. (ANSP). MADAGASCAR: 9-12 ft., Pte. du Cratere, S.W. Nossi Bé; 9 fms., 3 mi. N.N.E. of Nossi Fali, E. of Nossi Bé (ANSP). MAURITIUS: (USNM). PORTUGUESE EAST AFRICA: Mozambique City (ANSP). NORTH BORNEO: shore at Kudat (Mrs. M. Saul, ANSP). MALAYA: Singapore (ANSP). THAILAND: 4 mi. E. of Phuket Harbour, 80 ft. (R. Tucker Abbott). DUTCH NEW GUINEA: 3 ft., black sand and silt, ¾ mi. S. of Kaipoeri Village, Koeroedoi Id. (nearest to Lamarck's 1816 *marmorata*); N.E. Ambai Id., Japen Id., 5 ft., old reef; 2 mi. N.W. Rani Id., Schouten Ids., 4-40 ft.; island off N.E. tip of Ambai, Japen Id., 10-15 ft.; 1.3 mi. S.W. of Cape Mantoewoeri, Koeroedoi Id., 4 fms.; ½-1 mi. E. of Mios Woendi Id., 3-30 ft. (ANSP); near Hollandia (USNM). HONG KONG: (type of *notata*). JAPAN: Osima Osumi (USNM); Kii (ANSP) (A. W. B. Powell coll.). RYUKYU ISLANDS: Ohama Bay; Nago; Taketomi Id. (D. Thaanum coll.). PHILIPPINES: Island of Cebu (cotype of *microsticta*); Port Binang, Subic Bay (USNM); Tabaco, Albay Province, Luzon; Zamboanga, Mindanao Id.; 12-24 ft., E. side Jagoliao Id., N.W. end of Bohol Id.; Calatagan, Batangas, Luzon Id. (ANSP); Davao, Mindanao Id.. (A. W. B. Powell coll.). PALAU ISLANDS: S.E. corner of Eil Malk, Kayangel Lagoon, 5-15 ft.; E. of Ferry Dock, Peleliu, dredged; N. of entrance to Karamando Bay, West Babelthuap; 3 mi. N.E. of Eil Malk, E. of Yoo Passage, Malakal Harbour, dredged; E. lagoon off Melekeiok, East Babelthuap Id.; 1 mi. S. of West Passage, Babelthuap Id.; Kossol Passage, west entrance, 20 fms. (all ANSP). MARSHALL ISLANDS: Taka Id., Taka Atoll; Bikini Id., N.E. shore; E. side Enyer Id., Bikini; 2 mi. W. of Busch, 20 fms.; 2 mi. N. of Ime, Arno Atoll; 1-2 mi. N. of Jiyabo Lagoon, Arno Atoll (USNM) (all *microsticta* form). NEW HEBRIDES: (Australian Mus.). SOLOMON ISLANDS: Ugi Id., (USNM). NEW CALEDONIA: 4-10 ft., barrier reef, Touho Bay (ANSP). AUSTRALIA: Queensland: Challenger Bay, Palm Id. (ANSP); Dunk Id.; King's Reef (A. W. B. Powell coll.); Hope Id., 5-10 fms.; Lizard Id.; Murray Id.; Palm Id.; Mast Head Ids.; Rocky Ids.; Cape Flattery; Crescent Reef (Australian Mus.); Moreton Bay (Mrs. J. Kerslake). FIJI: Bega Id.; Vatulele Id. (D. Thaanum coll.); Yasawas Id. (USNM); Akuilau Id., 2-5 ft.; Wading Id.; Namotu Id., 4-5 fms. (W. Jennings). SAMOA: Toala, N.W. Upolu Id.; 10 ft., sand, lagoon off Mulifanua, Upolu Id.; Tutuila (ANSP).

Fossil Records – ?Miocene, West Sumatra; Pliocene, Sonde beds, Java; Timor. Pleistocene, Celebes (van der Vlerk, 1931, p. 219).

Lophiotoma albina (Lamarck, 1822)

(Color pl. 180, figs. 11, 12; pl. 235)

Range – Madagascar to the Carolines, Micronesia.

Remarks – Although closely allied to *acuta* this species is remarkably constant. The chief distinguishing points are the triple-corded sinus rib, relatively weak spiral sculpture, strong overlay of dense axial folds, a very distinctive pattern consisting of an overall sprinkling of minute brown dots, and a peripheral row of regularly spaced dark-brown rectangular markings, each of which is in the form of three horizontal lines defining each of the three sinus cords. The general appearance of the shell is white with a revolving row of peripheral maculations. Whorls 10, plus the protoconch, a remnant of which remains in one specimen, suffice to show that it is of a similar multispiral form as that of *acuta*. Adult size 37 to 41.5 mm. (about 1½ inches) in height. Spire about three-fourths the height of the aperture plus canal, angle 23° to 25°. Whorls only slightly angled by the peripheral carina.

Measurements (mm.) –

height	width	spire angle	
74.0	–	–	Balabac, Philippines
57.0	14.5	–	Andaman Ids.
41.5	11.2	23°	Moluccas
37.0	11.0	25°	Moluccas

Synonymy –

1822 *Pleurotoma albina* Lamarck, Anim. sans Vert. 7, p. 96. (no locality).

1843 *Pleurotoma albina* Lamarck, Reeve, Conch. Iconica 1, pl. 9, fig. 77.

Records – MADAGASCAR: Mayotte, 50 metres, coarse sand in lagoon (ANSP). ANDAMAN ISLANDS: (Tomlin coll., Nat. Mus. Wales). MOLUCCAS: (Casey coll., USNM). Java: (Tomlin coll.). Caroline Islands: Yap (C. Kile, 1960, ANSP). PHILIPPINES: Balabac, Palawan Id. (coll. A. D'Attilio, New York); Lubang Id. (Tomlin coll.).

Lophiotoma albinoides (Martin, 1883)

(Pl. 246, figs. 1, 2)

Range – Java, Tji Longan, near Selatjan, Njalindoeng beds, Lower Miocene.

Remarks – This species appears to be quite distinct judging from the illustrations which also show an enlargement of the sculptural detail. The shell is slender like the Recent *albina*, but the

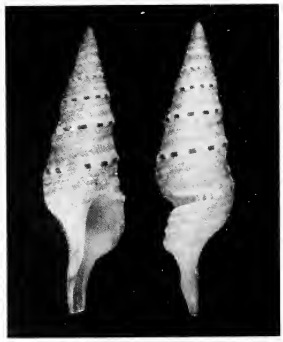

Plate 235. *Lophiotoma albina* (Lamarck). Molucca Islands. 41 mm.

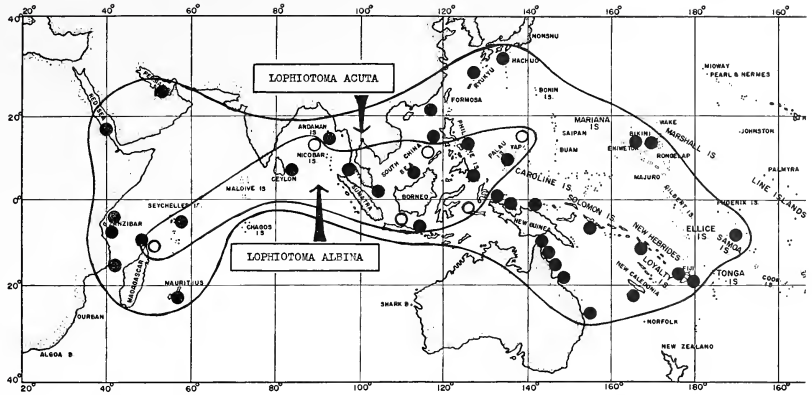

Plate 236. Geographical distribution of *Lophiotoma (Lophiotoma) acuta* (Perry) in solid dots and *L. (L.) albina* (Lamarck) in open circles.

whorls are not rendered so angulate by the spiral keels. Also, it would appear from the figures that the sinus rib is above the middle and consists of two closely spaced, beaded spirals with a heavier smooth one below. The subsutural spirals are weak. It is more likely, however, that the smooth peripheral carina will prove to be coincident with the sinus, the shape and nature of which is not apparent in the illustrations.

Until the type is critically examined, the generic status of this species cannot be determined. It is referred to *Lophiotoma* mainly on account of Martin's comparison of the species with *albina* Lamarck. No measurements were given.

Synonymy —

1883 *Pleurotoma albinoides* Martin, Samml. Geol. Reichsmus., Leiden, **1**, p. 227, pl. 10, figs. 23, 23a.
1921 *Pleurotoma albinoides* Martin, Vredenburg, Rec. Geol. Surv. India **53**(2), p. 97.

Lophiotoma abbreviata *subspecies* abbreviata (Reeve, 1843)

(Pl. 237, figs. 1, 2; pl. 238, figs. 1, 2)

Range — Mauritius to Fiji.

Remarks — This species closely resembles *acuta* except for the truncated anterior canal, more broadly conic spire and heavier sinus rib. The latter is composed of two strong, closely spaced, smooth spiral cords. The coloration is similar, except that the subsutural maculations are heavier.

This species seems to occur only in shallow water on coral reefs and in sandy pockets. A variant in populations at Rodriguez Island, Mauritius and the Andaman Islands has the sinus rib less prominent, coupled with a pattern in which the speckles are more prominent and the subsutural maculations less so, but they seem to occur along with the typical form.

Description — Adult shell 25 to 36 mm. (1 to 1½ inches) in height. Spire 1.3 times the height of the aperture plus canal, angle 28° to 35°. Whorls 8 or 9, exclusive of the protoconch which is missing in

Plate 237. Figs. 1, 2, *Lophiotoma abbreviata* (Reeve). Near Suva, Viti Levu Id., Fiji. 36 mm. Figs. 3, 4, *L. abbreviata lifuensis* (Sowerby). Lifu Id., Loyalty Islands. 19 mm.

all examples examined. Spire rather broadly conic and strongly angulated at the middle by a bicarinate sinus rib. Spire whorls with a broadly convex subsutural fold and a secondary cord between the periphery and the lower suture. On the base there are two closely spaced primary cords or sub-keels, the uppermost emergent at the suture, plus 4 or 5 weaker primary cords on the middle area of the base, plus 5 or 6 from the neck to the tip of the anterior canal. The whole surface is crowded with fine, crisp, spiral threads. The sinus rib is composed of a pair of smooth rounded cords, with a slight concavity between. Aperture strongly lirate a little distance within the outer lip. Sinus narrow, of moderate depth. Colour creamy white, speckled with light-brown on the spirals, plus prominent dark-brown rectangular maculations which are serially arranged around the subsutural fold.

Measurements (mm.) —

height	width	
36.0+	14.5	Fiji
32.0	12.3	Philippines
29.5	11.5	Fiji
26.5	11.0	Andaman Ids.
25.0	11.0	lectotype
24.5	10.5	Fiji

Synonymy —

1843 *Pleurotoma abbreviata* Reeve, Conch. Icon. **1**, pl. 10, fig. 86.

1884 *Pleurotoma abbreviata* Reeve, Tryon, Manual of Conch. **6**, p. 167, pl. 3, fig. 25.

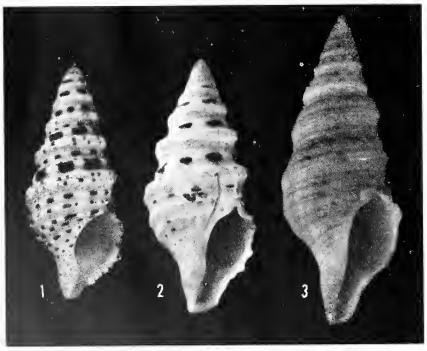

Plate 238. Figs. **1**, **2**, *Lophiotoma abbreviata* (Reeve, 1843). Two of four syntypes in the British Museum (Natural History). Reefs at low water, Masbate Island, Philippines. Lectotype, fig. 1, is 25 × 11 mm. Fig. **3**, *L. abbreviata ustulata* (Reeve, 1846). Holotype, no locality, Brit. Mus., 31 × 12 mm.

Types — Lectotype, one of four syntypes here selected, is in the British Museum (Natural History).

Records — MAURITIUS: ex N. Pike (USNM); Rodriguez Id. (USNM). ANDAMAN ISLANDS: (USNM). HALMAHERA GROUP: Morotai (USNM). PHILIPPINES: Masbate Id., on reefs at low water (type); Mariveles, Bataan, Luzon Id. (ANSP); Lubang (Winckworth coll., Brit. Mus.). PALAU ISLANDS: S. end of Gorokottan Id.; 1 mi. S. of West Passage, Babelthuap Id. (ANSP). NEW CALEDONIA: Touho Bay, 0-1 ft., fringe reef, with sand pockets; La Roche Percée, Burail (ANSP). FIJI: ex Garrett (ANSP); Bega Id. (D. Thaanum coll.); reef at Suva, Viti Levu Id. (A. W. B. Powell coll.); Levuka, Vanua Levu Id. (USNM).

Lophiotoma abbreviata *subspecies* lifuensis (Sowerby, 1907)

(Pl. 237, figs. 3, 4)

Range — Lifu, Loyalty Islands.

Remarks — This form which is known only from the type locality of Lifu is much broader-spired and more squat than the typical subspecies. The peripheral keel is more prominently projecting and the two basal sub-keels are much stronger. It may be only an ecological form, but so far it has not turned up from other localities.

Description — Adult shell 17 to 20 mm. (about 1 inch) in height. Whorls 5+, exclusive of protoconch, missing in all examples examined. Spire a little more than the height of the aperture plus canal, angle 40° to 50°. Coloration and sculptural detail as in the typical subspecies, except that the peripheral keel, which is the sinus rib, strongly projects, flange-like, giving a ledged appearance to the shoulder.

Measurements (mm.) —

height	width	
19.7	10.0	
19+	11.0	
17.0	10.0	holotype

Synonymy —

1907 *Pleurotoma abbreviata lifuensis* Sowerby, Proc. Mal. Soc. **7**, p. 300, pl. 25, fig. 5.

Records — LOYALTY ISLANDS: Lifu (type locality); (ANSP, Brit. Mus.; USNM).

Lophiotoma abbreviata *subspecies* ustulata (Reeve, 1846)

(Pl. 238, fig. 3)

Range — Probably Indian Ocean, Mauritius and Andaman Islands.

Remarks — It is likely that this shell will prove to be a synonym of *abbreviata*, or at most a geographic subspecies of it. Reeve's type is from an

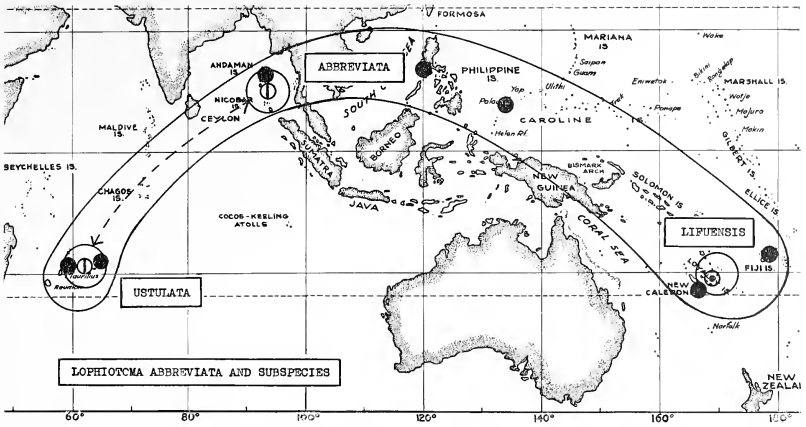

Plate 239. Geographical distribution of *Lophiotoma (Lophiotoma) abbreviata* (Reeve) and its subspecies *ustulata* (Reeve) and *lifuensis* (Sowerby).

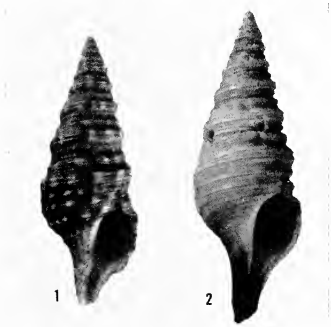

Plate 240. Fig. 1, *Lophiotoma brevicaudata* (Reeve). Gulf of Suez. 22 mm. Fig. 2, *Lophiotoma ruthveniana* (Melvill). Holotype. Mauritius. 41.5 mm.

unknown locality but similar shells are known from the two Indian Ocean localities mentioned above; not from the Pacific range of the typical species, however.

The type specimen is badly faded but the characteristic colour pattern of the typical species, particularly the subsutural maculations, is still discernable. The sculpture, however, is much weaker than is normal for *abbreviata*, the bicingulate peripheral keel being more like that of *acuta;* the anterior canal, however, is truncated. Until more is known of this form it had better be admitted as a probable subspecies of *abbreviata.*

Measurements (mm.) —

height	width	
31	12	holotype

Synonymy —

1846 *Pleurotoma ustulata* Reeve, Conch. Iconica **1**, pl. 40, fig. 369 (no locality).

1884 *Pleurotoma ustulata* Reeve, Tryon, Manual of Conch. **6**, p. 167, "Mauritius."

Types — The holotype is in the British Museum (Natural History).

Records — INDIAN OCEAN: Mauritius; Andaman Ids. (USNM).

Lophiotoma ruthveniana (Melvill, 1923)

(Pl. 240, fig. 2)

Range — Mauritius.

Remarks — This handsome shell appears closely allied to *abbreviata* and is distinguished from that species mainly by the overall strongly tessellated colour pattern. In *abbreviata* the larger maculations are confined to the subsutural fold but in *ruthveniana* the peripheral carina bears heavier maculations. In the absence of well-preserved apical whorls in the four examples seen, including the holotype, the species is only provisionally placed in *Lophiotoma.*

Description (from Melvill) — "Shell fusiform, thick; whorls, especially the upper, somewhat compressed, being ten in number, inclusive of the two apical. Colour bright chestnut brown, with squarrose, fairly regular, white tessellations on the spiral

carinae. These revolving keels appertain throughout—one, in particular, central, and subdivided by a shallow sulcus; the lesser tornate keels increase numerically in each of the lower whorls, till, on the body whorl, they total five or six, all beautifully variegated with white and chestnut alternately, as mentioned above. Mouth ovate-oblong, canal wide, abbreviate, sinus well developed, wide and deep, columellar margin fairly straight. Long. 41.5, lat. 14 mm.

"A handsome species, standing somewhat alone, and conspicuous for its bright coloration and tessellated carinal ornamentation."

Synonymy —

1923 *Turris ruthveniana* Melvill, Proc. Mal. Soc. **15**, p. 162, pl. 4, fig. 2.

Types — The type locality is Mauritius. The holotype is in the British Museum (Natural History), London.

Lophiotoma brevicaudata (Reeve, 1843)

(Pl. 240, fig. 1)

Range — Gulf of Suez, New Guinea, the Philippines and New Caledonia.

Remarks — Three syntypes of Reeve's species are in the British Museum and there is little to add to his original description: "Shell shortly fusiform, solid, yellowish, brown at the base and apex; whorls convex, encircled with a single keel round the upper portion and a double keel round the lower; last whorl encircled with single and double keels alternately down to the base, lip simple and acute, sinus large; aperture small, short, canal rather short. Hab. Island of Ticao (found on reefs), Cuming."

It is an easily recognized little shell due to its regular smooth spirals and uniform yellowish brown colour, except for the brown staining of the anterior end. The apical whorls are eroded in all three syntypes.

Tryon (1884, p. 169) made this species a synonym of *fascialis* Lamarck = *polytropa* Helbling, but they are certainly not con-specific.

Apart from the type material and imperfect specimens from New Guinea and New Caladonia, the best preserved example seen is one from the Gulf of Suez (ex McAndrew coll., Brit. Mus.) in the Museum of Comparative Zoölogy, Harvard, and a description of the specimen follows:

Description (Red Sea specimen) — Adult shell 22 mm. (slightly under 1 inch) in height, fusiform, with a tall spire, but with a relatively short anterior canal. Whorls 7, exclusive of the protoconch, sufficient of which remains in one specimen to indicate that it is narrowly conic of several whorls. Spire 1.3 times the height of the aperture plus canal. Adult sculpture of narrow, sharp cords and threads, one cord on a moderately inflated subsutural fold, five threads over a deeply concave shoulder. There is a double-corded peripheral keel, enclosing a concave interspace with a single thread in the middle. There is one primary cord and two threads between the peripheral carina and the lower suture. Three cords, stronger than the rest, are on the upper part of the base, with each interspace having three threads, followed by an alternation of cords and threads over the neck, and finally closely-spaced threads over the anterior canal. Sinus deep, U-shaped, on the peripheral carina. Colour pale yellowish buff, with all the spirals continuously lined in light-brown and with a dark-brown staining on the anterior canal.

Measurements (mm.) —

height	width	
24.0	8.3	lectotype
22.2	7.6	Gulf of Suez

Synonymy —

1843 *Pleurotoma brevicaudata* Reeve, Conch. Iconica **1**, pl. 15, fig. 126.

1884 *Pleurotoma fascialis* Lamarck, Tryon, Manual of Conch. **6**, p. 169 (non Lamarck, 1822).

Types — British Museum (Nat. Hist.), three syntypes, lectotype, 24 × 8.3 mm., here selected. The type locality is Ticao Id., Philippines, Hugh Cuming, collector.

Records — PHILIPPINES: Ticao Id. (type locality); Calapan, Mindoro Id. (MCZ). NEW CALEDONIA: (Australian Mus.). WEST NEW GUINEA: Geelvink Bay, ½ mi. S. of Maroepi, Ambai, Japen Id., 14-25 fms., blue mud, shell and coral (ANSP). RED SEA: Gulf of Suez (MCZ).

Subgenus Lophioturris *new subgenus*

Type: *Turris indica* Röding, 1798

The adult shell is identical to that of typical *Lophiotoma,* in that it is fusiform, with a tall spire, usually with a long straight anterior canal, and with a deep and narrow sinus situated on the peripheral keel. However, the protoconch is paucispiral, blunt-tipped, smooth and rounded.

I hereby designate *Turris indica* Röding, 1798, as the type of this new subgenus.

Lophiotoma indica (Röding, 1798)

(Color pl. 175, figs. 2, 3, 9, 16; pl. 242)

Range — Ceylon to Australia and Fiji.

Remarks — This shell is better known by the name *Pleurotoma marmorata* Lamarck, 1822, a name, however, which cannot be used because Lamarck had already employed it in 1816 for a different shell which now falls under the synonymy of *Lophiotoma acuta* (Perry).

MacNeil (1960, p. 101) referred this species to his new genus *Unedogemmula* (type species, *unedo* Kiener), but *indica* has a paucispiral, smooth, dome-shaped protoconch and none of the examples I have seen exhibit granulation of the peripheral keel at any stage of growth. The diagnostic characteristics for *Unedogemmula* are a conical, multispiral protoconch, as in Gemmula, and there are peripheral gemmules on the early whorls, sometimes persisting over all the whorls.

Sowerby, 1888, p. 211, described a *Pleurotoma bulowi* from the China Sea as follows: "P. testa elongata-fusiformi utrinque attenuata, pura alba. Anfractus 13, primi 2 rotunde convexi, politi; caeteri acute carinati, ubique dense spiraliter lirati; spira acutissima. Anfractus ultimus leviter convexus, ad basin valde contractus et multo productus. Apertura ovata, sinu elongato, angusto emarginata; canali gracili, elongato. Long. 35, maj. diam. 10."

"A pure white, keeled, and closely ridged species of the typical form of *P. babylonica.*"

A specimen labelled *bulowi,* from Hong Kong, in the British Museum, not the type which could not be found, is here figured. Bleached and eroded examples from Darwin, N.W. Australia are of similar appearance to the above and others from Gladstone, Queensland, are pure white also, but not eroded, which suggests that *bulowi* is merely an albinistic form of *indica.* Typical maculated shells occur within the range of these albino records.

Description — Adult shell 85 to 93 mm. (about 3 to 4 inches) in height, elongate-fusiform, with a tall spire and a long, straight anterior canal, closely simulating *Fusinus.* Whorls 14, plus a small blunt, smooth, paucispiral protoconch of 1½ whorls, followed by a half-whorl of brephic axials. Sculpture consisting of a strong but narrowly-rounded, smooth, peripheral carina located at a little below median whorl height, a subsutural fold carrying a moderately strong smooth spiral cord at its lower extremity, plus a weaker cord and several threads above it. One to three smooth primary spiral cords are present between the periphery and the lower suture, and there are 18 to 20 primary spirals on the body whorl from the periphery to the end of the anterior canal. The whole of the interstitial surface is crowded with smooth, spiral threads of varying

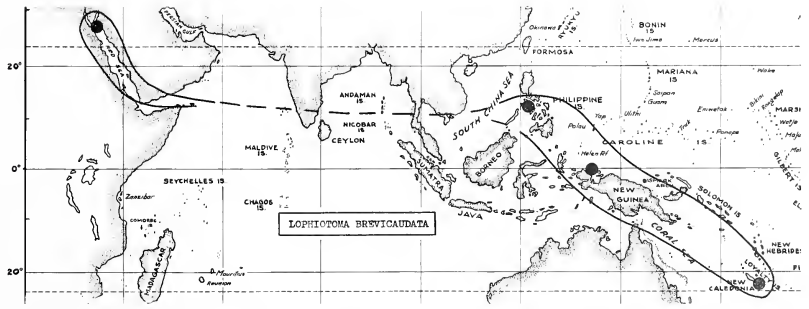

Plate 241. Geographical distribution of *Lophiotoma (Lophiotoma) brevicaudata* (Reeve).

Plate 242. Fig. **1**, *Lophiotoma (Lophioturris) indica* (Röding). Cotype of *Pleurotoma bulowi* Sowerby, 1888. Hong Kong (Brit. Mus. (Nat. Hist.)). Figs. **2**, 3, *L. (Lophioturris) leucotropis* (Adams and Reeve). 60 fms., off Kii, Japan.

strength. Spire a little less than the height of the aperture plus canal. Colour pattern profusely spotted with dark-brown on a white ground. The maculations are confined to the primary spirals but they diffuse vertically and present a sinuous axial pattern, giving a marbled effect. The peripheral maculations are stronger than the others. In some examples the markings resolve into continual sinuous axial flames.

Measurements (mm.) —

height	width	spire angle	
91.7	23.0	30°	Philippines
85.0	24.5	32°	New Guinea
70.5	18.5	30°	New Guinea

Synonymy —

1798 *Turris indica* Röding, Museum Boltenianum, Hamburg, pt. 2, p. 124, based upon Conch. Cab. **4**, pl. 145, figs. 1345, 1346.
1822 *Pleurotoma marmorata* Lamarck, Hist. Nat. anim. sans Vert. 7, p. 95 (non 1816).
1839-40 *Pleurotoma marmorata* Lamarck, Kiener, Coq. Viv., Pleurotome, p. 9, pl. 6, fig. 1; pl. 7, fig. 2.
1842 *Pleurotoma neglecta* Reeve, Conch. Syst. **2**, p. 189, pl. 235, fig. 2.
1843 *Pleurotoma marmorata* Lamarck, Reeve, Conch. Icon. 1, pl. 3, figs. 21a, b. (Straits of Malacca, 10 fms.).
1888 *Pleurotoma bulowi* Sowerby, Proc. Zool. Soc., p. 211, pl. 11, fig. 16.
1895 *Pleurotoma gendinganensis* Martin, Samml. Geol. Reichsmus., Leiden, new folio—p. 32, pl. 5, figs. 79-84.
1915 *Pleurotoma gendinganensis* Martin, Tesch, Pal. Timor **5**, p. 23, pl. 75, figs. 30-33.
1922 *Turris indica* Röding, Hedley, Rec. Australian Mus. 13(6), p. 215.
1948 *Turris indica* Röding, Cox, Schweizer Pal. Abhandl. **66**, p. 54, pl. 5, figs. 8a, b.
1956 *Lophiotoma marmorata* Lamarck, Kaicher, Indo-Pacific Sea Shells, pt. 5, Toxoglossa, pl. 1, fig. 4.
1960 *Unedogemmula indica* Röding, MacNeil, U.S. Geol. Surv. Prof. Paper **339**, p. 101 (but not the Okinawa Pliocene record which has gemmate early whorls).
1961 *Turris (Polystria) indica* Röding (sic = Polystira), Habe, Coloured Illustr. Shells of Japan **2**, pl. 38, fig. 20.

Records — CEYLON: Trincomalee (USNM). JAVA: (ANSP). CELEBES: Buton Strait, S.E. of Tikola Peninsula, 37 fms., grey mud (Albatross Sta. 5642). MALACCA: (ANSP). THAILAND: 4 mi. E. of Phuket Harbour, 80 ft. (R. Tucker Abbott). PHILIPPINES: Cuyo Id., Palawan; Badang near Gubat, Sorsogon Province, S. Luzon Id. (du-Pont-Acad. Exped., ANSP); Cebu Id.; 28 fms., off Polloc, Mindanao Id.; W. of Bucas Grande Id., 44 fms.; off Corregidor Id., 28 fms., grey mud; off Dumalag Id., Davao, Mindanao Id., 100 fms., soft mud (Albatross, USNM). NEW GUINEA: Hoods Bay (D. Thaanum coll.). JAPAN: Hirado Hizen (USNM). FIJI: Suva (USNM); Suva Point (D. Thaanum coll.). AUSTRALIA: Onslow, N.W. Australia (A. W. B. Powell coll.); Darnley Id., 25 fms., and Cape York (Hedley, 1922).

Fossil Records — If the material has been correctly assigned, the species *indica* has a time range from the Miocene to the Recent. MIOCENE: Tjilanang, Java. PLIOCENE: Java, Sumatra, Timor and Ceram Ids. NEOGENE: Philippines; British North Borneo. QUATERNARY: Celebes (Cox, 1948).

MacNeil (1960, p. 102) doubts if all the specimens figured by Martin (1895) and Tesch (1915) are conspecific or even congeneric. None, however, from the figures, show peripheral gemmation. Only an examination of the actual material can elucidate the situation. Although the Javanese Pliocene *Pleurotoma gendinganensis* Martin is included in the above synonymy, on the authority of Cox, a doubt is raised regarding the true generic location of Martin's species by a long series of specimens in the British Museum, from Kolo, Timor (Pliocene), which, although ascribed to *gendinganensis*, have the nuclear and early spire gemmulation of *Unedogemmula*. Critical re-examination of Martin's type specimen is now necessary to determine the exact status of *gendinganensis*.

Lophiotoma leucotropis (Adams & Reeve, 1850)

(Color pl. 175, figs. 4, 5; pl. 242)

Range — Recent, Japan, China, Hong Kong and Philippines. Fossil, Okinawa (Miocene-Pliocene); Formosa (Pliocene).

Remarks — This species has been frequently misidentified as *oxytropis* (Sowerby), but that species is confined to Panama and Central America, and belongs to *Polystira*, a genus with a shallower, widely open peripheral sinus.

Description — Adult shell 50 to 66 mm. (2 to 2½ inches) in height, solid, elongate-fusiform, carinate. Spire about equal to the length of the aperture plus canal, angle 28° to 30°. Whorls 11 or 12, plus a

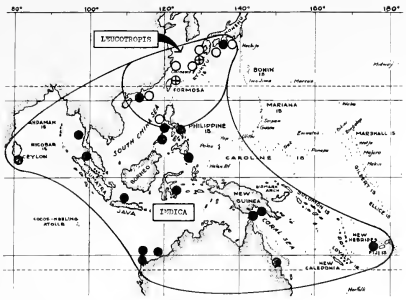

Plate 243. Geographical distribution of *Lophiotoma (Lophioturris) indica* (Röding) in solid dots and *leucotropis* (Adams and Reeve) in open circles.

small, smooth, blunt, paucispiral protoconch of 1¼ whorls, followed by a half-whorl of brephic axials. Post-nuclear sculpture of a thin, sharply raised, subsutural cord; the peripheral keel which is a broad, smooth, projecting sinus rib is situated below the middle of whorl height, and 0 to 2 smooth spiral cords are emergent between the sinus rib and the lower suture. On the base, from below the sinus rib, there are about 8 primary cords and a variable number of spiral threads; the uppermost four of the primary cords are more prominent than the others. Sinus deep, on the peripheral cord. Colour uniformly light golden brown with the spirals white. Operculum leaf-shaped with an apical nucleus.

Measurements (mm.) —

height	width	
66.0	19.0	all Japan
53.8	16.4	
51.0	15.3	
49.2	15.2	
46.8	13.8	

Synonymy —

1850 *Pleurotoma leucotropis* Adams & Reeve, Zool. Voy. Samarang, p. 40, pl. 10, fig. 7.
1904 *Lophiotoma leucotropis* Adams & Reeve, Casey, Trans. St. Louis Acad. Sci. **14**(5), p. 130.
1928 *Pleurotoma oxytropis* Schumacher, Yokohama, Imp. Geol. Surv. Japan Rep. **101**, p. 31, pl. 1, fig. 11 (non Schumacher).
1951 *Turris leucotropis* Adams & Reeve, Taki, Handb. Illustr. Shells Japan (Hirase, revised Ed.), pl. 115, fig. 3.
1960 *Lophiotoma* cf. *leucotropis* Adams & Reeve, MacNeil, U.S. Geol. Surv. Prof. Paper **339**, p. 100, pl. 5, figs. 8, 9; pl. 14, figs. 15, 21.
1961 *Turris leucotropis* Adams & Reeve, Habe, Coloured Illustr. Shells Japan **2**, pl. 38, fig. 19.

Types — The type locality is the China Sea.

Records — JAPAN: Tosa; Kii; Sagami Bay; Tokyo Harbour (ANSP); Kii, 60 fms.; Wakanura; Fukura; Awaji; Enoshima; Suruga Gulf (USNM). RYUKYU ISLANDS: (ANSP). CHINA: Fukien Province (ANSP). ANNAM: Ba Lang (A. W. B. Powell coll.); HONG KONG: (USNM and MCZ). PHILIPPINES: Baler, Tayabas, Luzon Id. (MCZ).

Fossil Records — OKINAWA: Yonabaru clay (Miocene); Shinzato tuff (Miocene or Pliocene). FORMOSA: Byoritzu beds (Pliocene) (MacNeil, 1960, p. 100).

Lophiotoma polytropa (Helbling, 1779)

(Color pl. 175, figs. 10, 11; pl. 244)

Range — Philippines, Moluccas and New Caledonia, shallow water.

Remarks — It is unfortunate that the name *fascialis* Lamarck, so long in use for this well-known shell, has to be supplanted by Helbling's earlier name *polytropa*. Helbling's figure of this shell is unmistakable and the description full and adequate. It is even more unfortunate that recent Japanese writers have misapplied the name *polytropa* to a form of *deshayesii* (Doumet, 1834) (see under *Unedogemmula*). It is no doubt the obscurity of Helbling's reference that has resulted in the belated recognition of *polytropa*.

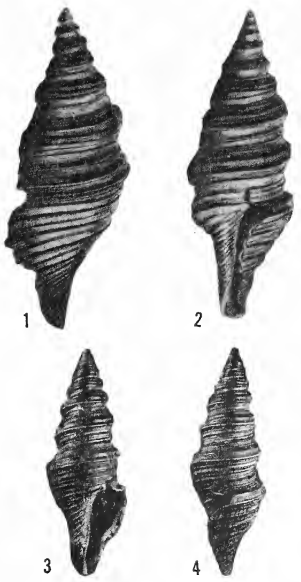

Plate 244. Figs. 1-4, *Lophiotoma (Lophioturris) polytropa* (Helbling). Figs. 1, 2, original Helbling figures, pl. 2, figs. 24, 25. Figs. 3, 4, Philippine Islands. 46 mm. (photo by V. Orr).

This species is generally found in shallow water in pockets in the reef where the bottom is of sand, silt and weed.

Description – Adult shell 42 to 50 mm. (1½ to 2 inches) in height, solid, with a tall spire and a short canal; dark purplish brown; encircled with prominent but narrow, sharply raised spiral cords. Whorls 9 or 10 (exclusive of the protoconch, eroded in all available specimens). Spire tall, 1½ times the height of the aperture plus canal, angle 27° to 30°. Spire whorls sculptured with strong, narrowly rounded, spiral cords and interstitial threads. Firstly, a single primary cord just below the suture, then a deeply concave shoulder which flares out almost horizontally to a prominent bi-cingulate sinus rib, situated above the mid point of the whorl. The spirals delimiting the sinus area are relatively wide-spaced, with a concavity between. Walls below the sinus area straight and undercut, bearing one or two primary cords and a secondary spiral in each interspace. On the base from below the sinus area there are about seven primary cords, each with a secondary spiral in between, plus a further 7 or 8 closer-spaced spiral cords on the neck and fasciole. Two to four fine spiral threads occupy the shoulder concavity. Sinus deep and located on the peripheral keel. Colour either uniformly dark purplish brown or with the addition of a pale-grey zone extending from the sinus ribs to just below the top of the aperture. Spiral cords crossing this pale zone are, however, lined in dark-brown. The interior of the aperture is dull bluish grey.

Measurements (mm.) –

height	width	
50.3	17.0	Philippines
50.0	17.0	type of *elegans* Wood
46.0	16.0	Philippines
42.0	14.0	Philippines

Synonymy –

1779 *Murex (Fusus) polytropus* Helbling, Abhandl. Priv. Bohm. Math. Prag. **4**, p. 119, pl. 2, figs. 24, 25.
1822 *Pleurotoma fascialis* Lamarck, Anim. sans Vert. **7**, p. 93.
1828 *Murex elegans* Wood, Index Test., Suppl., p. 15, pl. 5, fig. 8b (no locality).
1839-40 *Pleurotoma fascialis* Lamarck, Kiener, Coq. Viv., Pleurotome, p. 27, pl. 4, fig. 2 ("Red Sea").
1843 *Pleurotoma fascialis* Lamarck, Reeve, Conch. Icon. **1**, pl. 4, fig. 24a, b. (Philippines).
1884 *Pleurotoma fascialis* Lamarck, Tryon, Manual of Conch. **6**, p. 169, pl. 4, fig. 40.
1956 *Lophiotoma fascialis* Lamarck, Kaicher, Indo-Pacific Sea Shells, Section 5, Toxoglossa, pl. 1, fig. 3.

Types – British Museum (Natural History) (*elegans*). The where-abouts of Helbling's type is unknown to me.

Records – PHILIPPINES: Batangas, Luzon Id.; N. end San Miguel Id., Tabaco, Albay Province, Luzon Id.; mud-flat on island in Tabaco Harbor; Cebu (duPont-Academy Exped., 1958); Samar Id.; Davao Bay, Mindanao Id.; Mindoro (USNM); Lubang Id. (MCZ). MOLUCCAS: (ANSP). NEW CALEDONIA: 4-12 fms., Noumea (G. and M. Kline, ANSP).

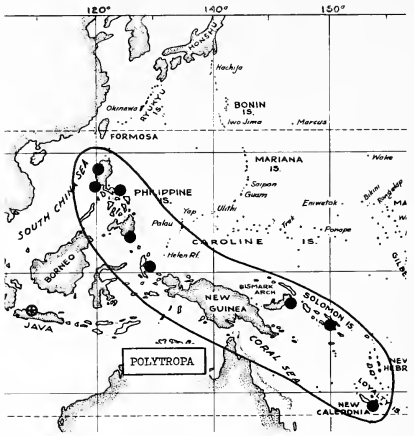

Plate 245. Geographical distribution of *Lophiotoma (Lophioturris) polytropa* (Helbling).

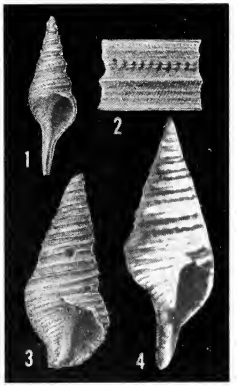

Plate 246. Figs. **1, 2,** *Lophiotoma (Lophiotoma) albinoides* (Martin). Lower Miocene of Njalindoeng beds, Java Id., Indonesia (from K. Martin, 1883, pl. 10, figs. 23, 23a). Fig. **3,** *L. (Lophioturris) pseudofascialis* Martin. Lower Miocene of Java Id., Indonesia (from K. Martin, 1883, pl. 10, fig. 22). Fig. **4,** *Lophiotoma* species A, "*Pleurotoma fascialis*" Abrard, 1942, pl. 8, fig. 4. Pleistocene, Somalia.

Lophiotoma pseudofascialis (Martin, 1883)

(Pl. 246, fig. 3)

Range — Java, Lower Miocene.

Remarks — As the author of this species states, this species could be closely related to the Recent "*fascialis Lamarck*" (i.e. *polytropa* Helbling, 1779). It seems to differ only in the peripheral keel being less prominent. No measurements were given.

Synonymy —

1883 *Pleurotoma pseudofascialis* Martin, Samml. Geol. Reichmus., Leiden, 1, p. 226, pl. 10, fig. 22.

Records — JAVA: Tji Longan near Selatjau (Njalindoeng beds, Lower Miocene).

Lophiotoma odengensis (Martin, 1895)

Range — Upper Miocene of Java.

Remarks — This species was compared with *Pleurotoma gendinganensis* Martin, 1895, by its author, but from the illustration the species appears to be more nearly allied to *leucotropis* (Adams and Reeve, 1850).

Synonymy —

1895 *Pleurotoma* (s.str.) *odengensis* Martin, Die Fossilien von Java, Samml. Geol. Reichsmus., Leiden, p. 33, pl. 5, figs. 85, 86; pl. 6, fig. 87.

Records — JAVA: Kampong Odeng, Palabuan district (Upper Miocene).

Lophiotoma *species A*

(Pl. 246, fig. 4)

Range — Somali Coast, Pleistocene.

Remarks — This species was recorded by Abrard as the Recent "*Pleurotoma fascialis* Lamarck" (i.e. *polytropa* Helbling, 1779), but it has a shorter spire and more rounded whorls. Its whorls have more the outline of those of *pseudofascialis* (Martin, 1883) from the Lower Miocene of Java, but that species is more attenuate. When more material is available, this Somali fossil will probably prove to be a new species.

Synonymy —

1942 *Pleurotoma fascialis* Lamarck, Abrard, Archiv. du Mus. D'Hist. Nat. (ser. 6) **18**, p. 86, pl. 8, fig. 33 (non Lamarck, 1822).

Records — SOMALIA: Ravin de Baghenda, Obock, 1500 metres, Pleistocene.

Genus Pleuroliria de Gregorio, 1890

Type: *Pleurotoma supramirifica* Gregorio, 1890

Very similar to the Miocene-Recent, *Polystira*, and evidently a forerunner of that genus. Smaller than *Polystira*, with a less prominent peripheral keel. The chief difference is in the protoconch which is of about four whorls, the first very small, the last 2½ with numerous axial riblets. Eocene and Oligocene, southeastern United States.

Synonymy —

1890 *Pleuroliria* de Gregorio, Monogr. Faune Eocene Alabama, Annales de Geol. et de Paleont., Palermo **7**, p. 38. **Type** by original designation: *Pleurotoma (Pleuroliria) supramirifica* de Gregorio.

Characteristic Species —

OLIGOCENE: *cochlearis* Conrad, 1847; *subsimilis* Casey, 1904; *waynensis* Mansfield, 1890. EOCENE: *crenulosa* Casey, 1904; *jacksonella* Casey, 1904; *simplex* Casey, 1904; *subdeviata* Gregorio, 1890; *supramirifica* Gregorio, 1890; *tizis* Gregorio, 1890.

Genus Polystira Woodring, 1928

Type: *Pleurotoma albida* Perry, 1811

This genus is the Panamic-Caribbean equivalent of the Indo-Pacific *Lophiotoma*. Its range extends from the Miocene to the Recent.

The type species, *albida* Perry, was erroneously recorded by its author from the "South Seas, being frequently found at New Zealand and Lord Hood's Island." It is, however, confined to the Caribbean, and the rather numerous instances of this shell in museum collections, with Indo-Pacific localities cited, can be disregarded. It was common practice among dealers to attach the locality of the original reference or assumed locality whenever the actual source of a specimen was not known.

Plate 247. Radula of *Polystira albida* (Perry). Caribbean, Recent (prepared and drawn by J. P. E. Morrison, U.S. Nat. Mus.).

Shell large, up to 110 mm. (4½ inches) in height, elongate-fusiform, very solid, sculptured with numerous smooth spiral keels. Protoconch stout, cylindrical, of about two whorls, last ¼ whorl axially ribbed. Sinus on the peripheral carina, shallow, broadly V-shaped. Operculum leaf-shaped with apical nucleus. Radula, a pair of "wishbone"-shaped marginals. (See pl. 247).

Synonymy –

1928 *Polystira* Woodring, Publ. no. 385, Carnegie Inst. Washington, p. 145. **Type** by original designation: *Pleurotoma albida* Perry.

Characteristic Species –

RECENT: *albida* Perry, 1811 (= *virgo* Wood, 1818); *albicarinata* Sowerby, 1870; *formosissima* Smith, 1915; *nobilis* Hinds, 1843; *oxytropis* Sowerby, 1834; *picta* Reeve, 1843; *tellea* Dall, 1889; *vibex* Dall, 1889. PLIOCENE: *panamensis* Olsson, 1942. MIOCENE: *barretti* Guppy, 1866.

The *Xenuroturris* Group

Relationship appears to have existed within a group of Miocene to Recent Austro-Neozelanic genera which exhibit either alliance to or analogy with the wide-ranging Indo-Pacific Pliocene to Recent *Xenuroturris*.

Of the five genera in this group only *Xenuroturris* has a polygyrate protoconch; the others have a blunt cylindrical-sided, paucispiral protoconch, the tip smooth, followed by regular or brephic axials.

The New Zealand Miocene *Echinoturris* has a relatively short canal and distinctive sculpture of a bicarinate series of sparse prickly nodules. The V-shaped sinus is on the upper carina.

The southern Australian Miocene to Pliocene *Veruturris* has a relatively short canal compared with *Turris* but not truncated to the extent exhibited by *Xenuroturris*.

A third group, for which a new subgenus *Cinguliturris* is provided, is represented by the Australian Miocene (Balcombian) species *Asthenotoma tatei* Cossmann, which is *Xenuroturris*-like with its truncated canal but has a paucispiral protoconch and the sinus rib as a simple spiral cord, not duplicate or margined in any way.

Finally, the New South Wales Recent species, *Xenuroturris corona* Laseron, for which a new genus *Viridoturris* is provided, is another member of the paucispiral-apiced group, standing nearest to *Xenuroturris* in its truncated anterior end and defined sinus rib, but lacking the characteristic polygyrate, axially costate protoconch of that genus.

If the above association of genera is a correct assumption, it would then appear that these presumed offshoots have arisen independently at different times in two areas marginal to the present tropical Indo-Pacific range of *Xenuroturris* typical.

Genus Echinoturris Powell, 1942

(Pl. 248)

Type: *"Turris" finlayi* Powell, 1935

The genus is so far known only by one species, the type locality for which is volcanic tuffs of Altonian Miocene age from Motutara, west coast, Auckland, New Zealand.

The genus is characterised by small size, 8 to 10 mm., moderately long canal, blunt, round-topped, cylindrical-sided, smooth protoconch of two whorls, ending with a few closely spaced thin axials.

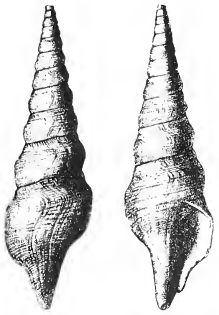

Plate 248. *Echinoturris finlayi* (Powell). Holotype. Altonian Miocene of Motutara, Auckland, New Zealand.

Key to the Xenuroturris group

Protoconch polygyrate
- Sinus rib margined
  - Canal truncated ..... *Xenuroturris*

Protoconch paucispiral
- Sinus rib margined or defined
  - Canal truncated ..... *Viridoturris* nov.
  - Canal moderately long ..... *Veruturris*
- Sinus rib not margined
  - Canal short
    - Sculpture cingulate ..... *Cinguliturris*
  - Canal moderately long
    - Sculpture bicarinate-spinose ..... *Echinoturris*

The most distinctive features are the bicarinate series of sparse prickly nodules and the rather deep V-shaped sinus situated on the upper carina, which like the lower carina is a simple rounded cord, not margined. The relationship, if any, with *Xenuroturris* is certainly not close.

Synonymy –

1942 *Echinoturris* Powell, Bull. 2, Auckland Inst. and Mus., p. 50. **Type** by monotypy: *"Turris" finlayi* Powell, 1935 (Awamoan, Middle Miocene, New Zealand).

Genus Veruturris Powell, 1944

Type: *Xenuroturris (Veruturris) quadricarinatus* Powell, 1944

This is a Miocene-Pliocene group from South Australia and Victoria, characterised by moderate size, 14 to 50 mm., a tall spire but only moderately long canal; paucispiral blunt protoconch of 2 to 2½ smooth whorls followed by a half-whorl or so of brephic axials. Sinus deep, broadly V-shaped, on sinus rib situated above the middle of whorl height. This rib may be a single cord as in the type species and as in *tomopleuroides,* or two almost fused cords. The genus *Xenuroturris* differs in having a polygyrate protoconch and a very short anterior canal.

The species of this genus and other turrid representatives of the Australian Tertiary are included since they are members of past faunas climatically analogous to the present tropical Indo-Pacific fauna.

Synonymy –

1944 *Veruturris* Powell, Records Auckland Inst. and Mus. 3(1), p. 9 (subgenus). **Type** by original designation: *Xenuroturris (V.) quadricarinatus* Powell, 1944.

Veruturris bisculpta (Powell, 1944)

Range – Abattoirs (type locality) and Weymouth Bores, Adelaide, Adelaidean, Lower Mid-Pliocene.

Remarks – Upper half of spire whorls sculptured with about 17 vertical fold-like axials, crossed by three spiral cords which are rendered nodulose by the axials; lower half of each whorl with 2 or 3 heavy, closely spaced, plain spirals. Sinus area a deep narrow groove between two of the cords at about two-thirds whorl height.

Measurements (mm.) –

height	width	
26.7	6.5	
13.9	4.5	holotype

Plate 249. *Veruturris subconcava* (Harris). Miocene, Janjukian, of Victoria, Australia (from Harris, 1897, pl. 3, figs. 2a, b).

Synonymy –

1944 *Xenuroturris (Veruturris) bisculptus* Powell, Rec. Auck. Inst. Mus. 3(1), p. 11, pl. 1, fig. 4.
1958 *Xenuroturris (Veruturris) bisculptus* Powell, Ludbrook, Trans. Royal Soc. South Australia **81,** p. 85.

Types – The holotype is in the Auckland Museum (Finlay collection).

Veruturris cochleata (Powell, 1944)

(Pl. 250)

Range – Balcombian, Miocene of Muddy Creek, lower beds, Victoria (type locality); Altona shaft and Clifton Beach, Victoria.

Remarks – Spire whorls with strong narrowly rounded cords, one linear-spaced pair submargining the suture, then a second pair, forming the sinus rib, situated at three-quarters whorl height, followed by five or six smooth, rounded, spiral cords. Sinus narrowly V-shaped.

Measurements (mm.) –

height	width
52	14

Synonymy –

1944 *Xenuroturris (Veruturris) cochleatus* Powell, Rec. Auck. Inst. Mus. 3(1), p. 10, pl. 7, fig. 11.

Types – The holotype is in the Auckland Museum (Finlay collection).

Veruturris quadricarinata (Powell, 1944)

Range – Balcombian, Miocene of Muddy Creek, lower beds, Victoria (type locality), and Altona shaft, Victoria.

Remarks – Spire whorls with evenly spaced, strong, rounded cords, middle pair stronger than the other two. Sinus broadly V-shaped, situated on upper of the middle pair of cords.

Plate 250. *Veruturris cochleata* Powell. Balcombian Miocene of Muddy Creek, Victoria, Australia. 52 mm.

Measurements (mm.) —

height	width
14.5	4.2

Synonymy —

1944 *Xenuroturris (Veruturris) quadricarinatus* Powell, Rec. Auck. Inst. Mus. 3(1), p. 11, pl. 1, fig. 5.

Types — The holotype is in the Auckland Museum (Finlay collection).

Veruturris subconcava (Harris, 1897)

(Pl. 249)

Range — Janjukian Miocene, Victoria. Locality cited "Merribee River" = Werribee River; probably incorrect.

Remarks — The largest member of the genus, resembling *cochleata* in shape and size but much more smoothly and finely sculptured.

Measurements (mm.) —

height	width
58	16

Synonymy —

1897 *Pleurotoma subconcava* Harris, Cat. Tert. Moll. Brit. Mus., pt. 1, p. 41, pl. 3, figs. 2a, b.
1944 *Xenuroturris (Veruturris) subconcavus* Harris, Powell, Rec. Auck. Inst. Mus. 3(1), p. 10.

Types — The holotype is in the British Museum (Natural History) in London.

Veruturris tomopleuroides (Powell, 1944)

Range — Abattoirs (type locality) and Weymouth Bores, Adelaide, South Australia, Adelaidean, Lower Mid-Pliocene.

Remarks — Spire whorls with two spiral threads submargining the suture, a moderately strong cord at three-fourths whorl height and the peripheral carina at less than one-third whorl height, followed by a third strong spiral at the lower suture. Sinus rib not margined.

Measurements (mm.) —

height	width
17.5	5.5

Synonymy —

1944 *Xenuroturris (Veruturris) tomopleuroides* Powell, Rec. Auck. Inst. Mus. 3(1), p. 11, pl. 1, fig. 3.
1958 *Xenuroturris (Veruturris) tomopleuroides* Powell, Ludbrook, Trans. Royal Soc. South Australia 81, p. 84.

Types — The holotype is in the Auckland Museum (Finlay collection).

Subgenus Cinguliturris *new subgenus*

Type by monotypy: *Asthenotoma tatei* Cossmann, 1896

This subgenus is known only by the type species which comes from the Muddy Creek lower beds and other localities of the Balcombian Miocene of Victoria. It resembles *Xenuroturris* in the truncation of the base and anterior canal but has a blunt paucispiral smooth protoconch followed by a full whorl of strong brephic axials.

A feature of the subgenus is the evenly developed, strong, spiral cinguli, the one bearing the sinus being neither different from the others in size nor is it margined or duplicate.

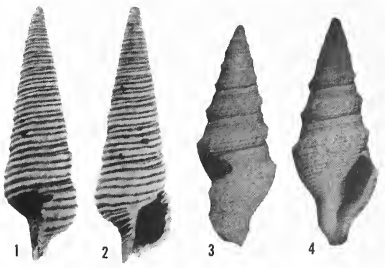

Plate 251. Figs. **1, 2,** *Veruturris (Cinguliturris) tatei* (Cossmann). Balcombian Miocene of Muddy Creek, Victoria, Australia, 22 mm. Figs. **3, 4,** *Viridoturris corona* Laseron. Holotype. 50-70 fms., off New South Wales, Australia.

Veruturris tatei (Cossmann, 1896)

(Pl. 251, figs. 1, 2)

Range — Balcombian Miocene of Muddy Creek lower beds (type locality) and other localities in Victoria, Australia.

Description — Protoconch paucispiral, blunt, depressed at tip, of 2½ whorls, first smooth, followed by axials rendered subnodose at the periphery. The most striking feature of the shell is the evenly developed, sharply raised, spiral cinguli, 4 or 5 on the spire whorls, with the sinus rib second from the top, not differentiated in any way. The anterior canal is short as in *Xenuroturris.*

Measurements (mm.) —

height	width	
22.0	7	Balcombe Bay, Victoria
17.6	6	Balcombe Bay, Victoria
15.0	4	holotype of *tatei*
10.5	4	holotype of *trilineata*

Synonymy —

1896 *Asthenotoma tatei* Cossmann, Essais Pal, Comp. **2**, p. 173, pl. 6, fig. 29.
1897 *Pleurotoma trilineata* Harris, Cat. Tert. Moll. Brit. Mus., pt. 1, p. 40, pl. 3, figs. 1a-d.
1898 *Asthenotoma tatei* Cossmann, Tate, Proc. Roy. Soc. N.S.W. **31**, p. 398.
1944 *Xenuroturris tatei* Cossmann, Powell, Rec. Auck. Inst. Mus. 3(1), p. 9.

Types — The type of *trilineata* Harris is in the British Museum (Natural History).

Genus Viridoturris *new genus*

Type by monotypy: *Xenuroturris corona* Laseron, 1954

This genus is known only by the type species which is a Recent shell from 50 to 70 fathoms off Green Cape, New South Wales. It is similar in facies to *Xenuroturris* except for the protoconch which is paucispiral, a broad smooth dome of one whorl followed by less than one whorl of axial threads. There is a well-defined sinus rib margined by a pair of sharply raised spirals.

The genus is probably a modern local offshoot from *Xenuroturris,* again indicating a tendency for mutations to occur in areas marginal to the tropical Indo-Pacific area of distribution for the group.

Viridoturris corona Laseron, 1954

(Pl. 251, figs. 3, 4)

Range — Recent, New South Wales, 50 to 70 fathoms off Green Cape.

Remarks — Since Laseron's pen and ink sketches often give a misleading impression of sculptural detail, due to stylised treatment, his full and adequate description is given also.

"Shell of moderate size, conical with a long spire, pure white. Protoconch blunt, a broad, smooth, dome-shaped apex, followed by a short whorl with axial threads. Mature whorls 6, sharply angled at the periphery, the shoulder broad and concave, base not excavate. Sculpture predominantly spiral, of numerous strong cords, fine threads on the shoulder and columella. The peripheral cord and to a lesser extent the one below it are broken into elongated laminae, the others are nearly smooth, except where indented by the fine axial threads. These cross the whorls obliquely and are most marked on the shoulder or fasciole area, where they are closely packed and curved forward to the suture. Aperture pyriform, the columella and outer margin strongly twisted making the short deep canal oblique. Outer margin thin, the sinus on the shoulder, deep and round. Inner margin with a narrow callus."

Measurements (mm.) —

height	width
15	6.5

Synonymy —

1954 *Xenuroturris corona* Laseron, The New South Wales Turridae, Handbook, Roy. Zool. Soc., N.S.W., p. 6, pl. 1, figs. 1, 2.

Types — The holotype is in the Australian Museum, Sydney.

Genus Xenuroturris Iredale, 1929

Type: *Pleurotoma cingulifera* Lamarck, 1822

A group of moderately large, stoutly built shells reminiscent of *Lophiotoma*, tall-spired but with a truncated base and anterior canal. Both *Lophiotoma* and *Xenuroturris* have a multispiral, axially costate protoconch but the sinus ridge in the former is concave, margined top and bottom by a raised rim, while in the latter the sinus ridge is composed of two or three linear-spaced, strong, spiral cords. Sinus deep, U-shaped, situated on the peripheral carina.

The genus *Xenuroturris* extends from the Red Sea over most of the tropical Indian Ocean and much of the tropical Pacific as far east as Hawaii.

Two groups have emerged within this vast distributional pattern and it is around the perimeter of the range that local species and subspecies have arisen. Basically there seems to have been a *cingulifera* distribution over most of the tropical Indian Ocean and a *millepunctata* distribution over much of the tropical Pacific Ocean.

The species *cingulifera* (Lamarck) was probably based upon a Mauritius shell and this location is now nominated as type locality. Shells from all western Indian Ocean localities are very uniform and do not run to large size; adults range between 35 and 40 mm.

Typical *cingulifera* appears to have spread vigorously eastward invading territory occupied by a Pacific species, *millepunctata*.

In a number of areas, New Caledonia in particular, both *cingulifera* and *millepunctata* occur together, and Miss Virginia Orr, who found both living side by side in the same ecological environment is of the opinion that they are distinct species, not varieties of a single species.

This contention is strengthened by the fact that the *millepunctata* type seems to be unknown in the Indian Ocean but is strongly represented marginally in the Pacific. It occurs with a *cingulifera* form in Japan, as an extreme southern outlier at the Kermadecs and is probably the source of one of the three distinct regional species that have developed at the Hawaiian Islands.

The situation is confused by another factor, the occurrence of a large-sized form of coarsely granular sculpture which appears to be merely an oversized *cingulifera*. This form, *legitima* Iredale, is the type of the genus, and it came from Michaelmas Cay, North Queensland. Similar shells which attain a height of over 70 mm. range from New Caledonia to Japan but nothing of comparable size is known in the Indian Ocean.

Since these large forms can occur along with typical *cingulifera* notably at New Caledonia, they seem to have no significance other than representing the optimum development of the species. In *Turris crispa*, for instance, that species attains its optimum for size in the South China Sea.

Iredale separated *legitima* mainly upon the na-

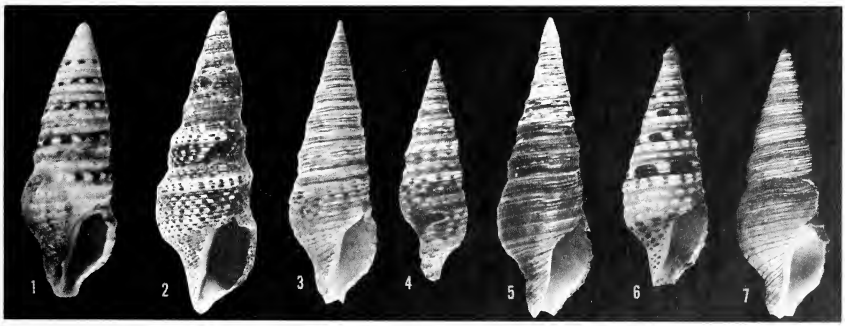

Plate 252

Figs. 1 *Xenuroturris cingulifera erythraea* (Weinkauff). Port Sudan, Red Sea. 19 mm.
2 *Xenuroturris millepunctata* (Sowerby). Voh, New Caledonia. 35 mm.
3, 4 *Xenuroturris cerithiformis* (Tinker). 6-8 fms., off Honolulu, Hawaii. 38.5 mm.
5 *Xenuroturris castanella* (Tinker). 6-8 fms., off Honolulu, Hawaii. 36.4 mm.
6 *Xenuroturris kingae* new species. 20-40 fms., off Keehi, Hawaii. 18.3 mm.
7 *Xenuroturris incredula* (Iredale). Holotype. Port Jackson, New South Wales, Australia.

ture of the sinus ridge which was described as trilirate instead of bilirate. However, quite small examples of *cingulifera,* even from the selected type locality often exhibit this trilirate feature.

Arising out of this distributional complex the following patterns emerge: (1) typical *cingulifera* (35 to 40 mm.), Indian Ocean, infiltrated strongly into the Pacific where it attains its optimum size of about 70 mm. in Queensland, New Caledonia, the Philippines and Japan; (2) a Red Sea subspecies *erythraea* (Weinkauff); (3) two species of the *cingulifera* group at the Hawaiian Islands; (4) *millepunctata,* representing an earlier Pacific distribution now broken up marginally into distinct regional species, namely, *certhiformis* in the Hawaiian Islands and *incredula* from Sydney, New South Wales.

Synonymy —

1929 *Xenuroturris* Iredale, Memoirs Queensland Mus. **9**(3), p. 285. Type by original designation: *X. legitima* Iredale, 1929 = *Pleurotoma cingulifera* Lamarck, 1822.
1931 *Clamturris* Iredale, Rec. Australian Mus. **18**(4), p. 226. Type: *incredula* Iredale, 1931.
1960 *Xenuloturris* (sic) Kuroda, A Catalogue Moll. Fauna Okinawa Islands, p. 37 (as a subgenus of *Turris*).

Xenuroturris cingulifera *subspecies* cingulifera (Lamarck, 1822)

(Color pl. 175, figs. 12, 19, 20)

Range — Tropical Indian Ocean and Pacific Ocean; Japan to New Caledonia and eastward as far as the Marshall Islands and Fiji.

Description — Adult shell 40 to 70 mm. (1½ to 2¾ inches) in height. Tall-spired but with a very short anterior canal. Whorls 12, plus a multispiral, narrowly conic protoconch of 4 to 4½ whorls, brown, densely sculptured with slightly curved, strong, rounded axials crossed at right angles by weak spiral lirae. Spire tall, 20° to 24°, twice height of aperture plus canal, outlines rather straight, with sinus rib only slightly projecting. Adult sculpture consisting of a dense covering of spiral cords and threads, 4 or 5 crisp cords on the rather broad but inconspicuous subsutural fold; 2 or 3 heavier cords forming the sinus rib, situated above middle whorl height; 2 to 4 primary cords and an indefinite number of weaker spirals between the sinus area and the lower suture; and about 10 primary and many weaker spirals over the base and neck. The body whorl is subangulated at about half apertural height and strongly excavated between this and a distinct fasciole, often showing a false umbilical chink. Sinus deep and narrow. Colour creamy-white, minutely peppered with reddish brown dots and dashes on all spirals. Stronger darker brown dashes on the component ribs of the sinus area resolved by diffusion into rather prominent regularly-spaced peripheral maculations.

Measurements (mm.) —

height	width	
72.0	23.0	*"legitima," Michaelmas Cay*
69.6	20.0	Philippines
62.5	19.5	Japan
58.9	16.7	Okinawa
57.0	18.0	type of *legitima*
37.7	11.0	Zanzibar

Synonymy —

1822 *Pleurotoma cingulifera* Lamarck, Anim. sans Vert. **7**, p. 94 (no locality).
1839-40 *Pleurotoma cingulifera* Lamarck, Kiener, Coq. Viv. 5, Pleurotome, p. 17, pl. 17, fig. 1.
1843 *Pleurotoma cingulifera* Lamarck, Reeve, Conch. Icon. 1, pl. 1, sp. 1.
1884 *Pleurotoma cingulifera* Lamarck, Tryon, Manual of Conch. **6**, p. 166, pl. 3, fig. 23.
1914 *Pleurotoma cingulifera flammulata* Bouge & Dautzenberg, Jour. de Conchyl. **61**, p. 127 (not figured).
1929 *Xenuroturris legitima* Iredale, Mem. Queensland Mus. 9(3), p. 285, pl. 31, figs. 3, **4**.
1954 *Xenuroturris cingulifera* Lamarck, Kira, Coloured Illustr. Shells of Japan, pl. 35, fig. 9.
1956 *Xenuroturris cingulifera* Lamarck, Kaicher, Indo-Pacific Sea Shells, Section 5, pl. 1, fig. 1.

Types — Type locality not known. Mauritius here selected.

Records — NATAL: (A. W. B. Powell coll.); Durban and off Umkomaas River, 40 fms. (Barnard, 1958). TANGANYIKA: Mombasa Id. (ANSP). ZANZIBAR: 1 mi. W.N.W. of Ras Mbweni, 7 ft.; S. side Pwakuu Id., 11-18 fms.; outer reef, Kiwengwa, 0-10 ft.; 2 mi. W. of Nyange Id., 11 fms.; 1½ mi. W.S.W. of Ras Nungwe, 8 fms. (NSF, 1957, ANSP). MAURITIUS: (USNM). ANDAMAN ISLANDS: (USNM); Port Blair (Winckworth coll., Brit. Mus.). SEYCHELLES: Mahé (Winckworth coll., Brit. Mus.). CEYLON: 3 mi. S. of Colombo Harbour (ANSP). INDONESIA: Mosotai, Halmahera Group (USNM). CAROLINE ISLANDS: outer reef, 1 mi. S.E. of Helen Id. (NSF, 1956, ANSP); Fasserai Ids., Ulithi Atoll (USNM); Yap Id. (ANSP). PALAU ISLANDS: N. end of reef, Kayangel (ANSP). GUAM ISLAND: Port Merizo (ANSP); Apra Harbour, dredged (USNM); Cocos Id., S.W. of Guam Id. (ANSP). BORNEO: Taganaki Id. (USNM). DUTCH NEW GUINEA: near Hollandia (USNM). PAPUA: Yule Id. (D. Thaanum). PHILIPPINES: Salpa Id., 2 kms. S. of Olango Id.; East Cebu Id.; Calapan, Mindoro (ANSP); off N.E. Tablas, 37 fms. (USNM). MARSHALL ISLANDS: Wolpo Id., Wolpo Atoll; Kwajalein Atoll; Boek Id., Rongeriji; 1 mi. W. of Rongelap Id., 20 fms. (USNM); Ebon Id. (ANSP). JAPAN: Sagami Bay; Kii (A. W. B. Powell coll.). RYUKYU ISLANDS: (ANSP); Ohama Bay, Osigaki Id.; off Itoman, Okinawa, 25-40 fms. (D. Thaanum). NEW HEBRIDES: Pentecost (A. W. B. Powell coll.). NEW CALEDONIA: Plage de Poe, 1-14 ft., Bourail (ANSP). LOYALTY ISLANDS: Lifu (A. W. B. Powell coll.). FIJI ISLANDS: Namotu Id., 3-5 fms. (W. Jennings). QUEENSLAND: Michaelmas Cay (Iredale, type of *legitima*).

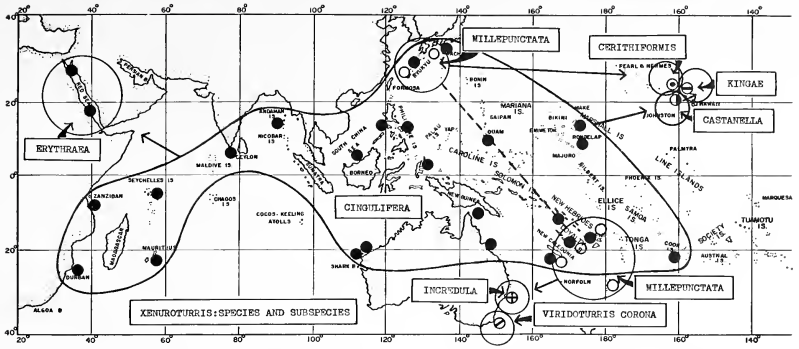

Plate 253. Geographical distribution of *Viridoturris corona* Laseron and members of the genus *Xenuroturris*.

Xenuroturris cingulifera *subspecies* erythraea (Weinkauff, 1875)

(Pl. 252, fig. 1)

Range — Red Sea.

Remarks — It is likely that the Red Sea populations may represent a good regional subspecies differing from *cingulifera* typical mainly in the much stronger and fewer spiral cords and a characteristic purple staining in adults of the anterior canal and pillar. Unfortunately, I have seen insufficient material to determine if the above mentioned characters are constant and if *cingulifera* typical is absent from the area.

Description — Adult shell 23 to 25 mm. (about 1 inch) in height. Whorls about 8, plus protoconch (missing in material examined). Spire twice the height of the aperture plus canal, angle 18° to 20°. Spire whorls with three heavy spiral keels and a fourth emergent over the latter part of the body whorl. Spiral cords on the base, 4 or 5 and strong, interspaces each with 3 or 4 crisp, spiral threads and 4 or five rounded cords on the fasciole. In two of the three specimens I have examined all the keels including the sinus one are narrowly arched but in the third specimen the sinus rib is composed, as in *cingulifera*, of two closely spaced cords. Colour pattern of small brown speckles on the primary cords and large regularly spaced, rectangular patches of dark-brown on the sinus rib, or paired dashes in one example. Pillar and anterior canal stained bright violet but this staining absent in the example with the bifid sinus rib.

Despite these variations, the Red Sea form would appear on the scant material available to represent a regional subspecies on the basis of stronger and fewer spirals and a tendency to violet staining of the anterior end.

Measurements (mm.) —

height	width	
25.0	9.0	Port Sudan
23.5	8.5	Type, Massaua
23.5	8.0	Port Sudan
19.0	7.5	Port Sudan

Synonymy —

1875 *Pleurotoma crythraea* Weinkauff, Conch. Cab., p. 22, pl. 4, fig. 10.

1884 *Pleurotoma erythraea* Weinkauff, Tryon, Manual of Conch. 6, p. 166, pl. 3, fig. 24.

Records — RED SEA: Massaua and Dahlack (Weinkauff) (type locality); Port Sudan (MCZ).

Fossil Records — Somali coast (Pleistocene) (Abrard, 1942, p. 86, recorded and figured as *cingulifera*).

Xenuroturris millepunctata (Sowerby, 1908)

(Color pl. 175, figs. 13, 17, 18; pl. 252)

Range — New Caledonia, Fiji, Kermadec Islands, Ryukyu Islands and Japan.

Description — Adult shell 25 to 50 mm. (1 to 2 inches) in height. Whorls 9 or 10, plus protoconch of 4 to 4½ axially costate whorls, as in *cingulifera*. Spire about 1¾ times the height of the aperture plus canal, angle 22° to 24°. The differentiating characters from those of *cingulifera* are the colour pattern of rather sparse brown speckles, minus maculations on the sinus area, the more prominent sinus ribs and a distinct angulation of the base.

Measurements (mm.) —

height	width	
50.0	15.0	Kii, Japan
34.7	11.0	New Caledonia
25.0	9.0	New Caledonia

Synonymy —

1908 *Pleurotoma millepunctata* Sowerby, Proc. Malac. Soc. London **8**, p. 198, text fig.
1914 *Pleurotoma cingulifera zonifera* Bouge & Dautzenberg, Journ. de Conchyl. **61**, p. 128 (not figured).

Records — JAPAN: Kii (A. W. B. Powell coll.); Ikenodan, Izu (D. Thaanum). RYUKYU ISLANDS: Gima, Kumejima Id., Okinawa (D. Thaanum). LOYALTY ISLANDS: (D. Thaanum). NEW CALEDONIA: Ile Monac (type locality); Voh, on sea-grass tidal flat, Miss V. Orr, ANSP). KERMADEC ISLANDS: Raoul Id. (W. R. B. Oliver, Australian Mus.). FIJI ISLANDS: Namotu Id., 13-15 fms. (W. Jennings).

Xenuroturris cerithiformis (Tinker, 1952)

(Color pl. 175, figs. 14, 15; pl. 252)

Range — Hawaiian Islands.

Remarks — This subspecies has long been known from distributed material bearing Dall's manuscript name, *cerithiformis*, which was quoted along with figures and a description by Tinker (1952).

Tinker did not intend to describe this and several other of Dall's manuscript species in his book, but his action does measure up to the requirements of the International Rules and amounts to formal description.

This Hawaiian species is close to *millepunctata* but differs consistently in having more rounded whorls, neither sharply angled on the base nor deeply excavated at the neck.

Description — Adult shell 33 to 53 mm. (1¼ to 2 inches) in height, whorls 10 or 11, plus a multispiral narrowly conic protoconch of 4 to 4½ whorls, brown, densely sculptured with slightly curved strong rounded axials crossed at right angles by weak spiral lirae. Spire tall, almost twice the height of the aperture plus canal, 24° to 27°, outlines lightly convex except for bulging subsutural fold and sinus rib. Sculpture of spire whorls consisting of a broadly-convex subsutural fold bearing 3 to 5 weak spiral threads, separated by a narrow deeply channeled concavity from the sinus rib, situated at about middle whorl height and composed of two moderately strong, rounded, spiral cords with a concavity between. Below the sinus area there are 2 to 4 crisp cords of varying strength. About 10 primary cords and occasional interstitial threads on the base from below the sinus area plus 4 cords on the weak fasciole. Sinus deep and narrow. Colour white, rather evenly speckled with reddish brown dots and dashes; larger maculations not present.

Measurements (mm.) —

height	width	
53.0	18.0	Pearl and Hermes Reefs, Hawaii
45.0	14.5	Kalaekiki, Hawaii
38.5	11.4	Honolulu, 6-8 fms. (type)
33.4	11.0	Honolulu, 6-8 fms.
32.0	10.2	Honolulu, 6-8 fms.

Types — I hereby select the specimen in USNM 338601 as the holotype. It is figured in our plate 175, fig. 14. The type locality, here designated, is 8-10 fms., entrance to Honolulu Harbor, Oahu Id., Hawaii.

Synonymy —

1869 *Pleurotoma lirata* Pease, Amer. Jour. Conch., Philadelphia, **5**, p. 68 (non *Pl. lirata* Reeve, 1845).
1952 *Turris cerithiformis* (Dall, ms.) Tinker, Pacific Sea Shells, Honolulu, p. 46, pl. 47, fig. (upper row).

Records — HAWAIIAN ISLANDS: entrance to Honolulu Harbour, 6-8 fms., Oahu (holotype, USNM) (D. Thaanum coll.) (ANSP); off Fort Armstrong, Honolulu, 15-20 ft. (ANSP); Ka Lae Kiki Koloa, Kauai (ANSP); Pearl and Hermes Reef, Hawaii (ANSP); off Kaanapali, West Maui, 25-75 ft.; Keaukaha Ponds, Hawaii; off Kewalo, Oahu, 20 fms. (D. Thaanum coll.).

Xenuroturris castanella (Tinker, 1952)

(Color pl. 175, figs. 21, 22; pl. 252)

Range — Hawaiian Islands.

Remarks — Again this species has long been known from distributed material bearing Dall's manuscript name. (See remarks concerning Tinker's use of Dall's manuscript names, above.)

This is a member of the *cingulifera* series but an endemic Hawaiian one sufficiently distinct in its sculpture and coloration to warrant full specific status.

Description — Adult shell, 35 to 45 mm. (1¼ to 1¾ inches) in height. Whorls about 10, plus a multispiral, narrowly conic protoconch of 4 to 4½ whorls, brown, densely sculptured with slightly curved, strong, rounded axials crossed at right angles by weak spiral lirae. Spire tall, 1½ to 1¾ times the height of the aperture plus canal, 22° to 24°, outlines lightly convex. Sculpture of spire whorls of closely spaced, rather evenly developed, moderately strong but narrow, crisp, spiral cords. Three cords on a slightly raised subsutural fold, 3 forming the sinus rib, situated above middle of whorl height and 2 primary cords with 3 threads in each inter-

space from below the sinus rib to the lower suture. On the base, from the sinus area to the fasciole, there are 7 to 9 primary cords with a varying small number of secondary cords or threads in the interspaces; 5 spiral cords on the fasciole. Sinus deep and narrow. Colour chestnut-brown with the primary cords slightly darker. Faint traces of regular rectangular darker-brown maculations on the sinus rib. Parietal callus, columella and interior of aperture white.

Measurements (mm.) —

height	width	
44.0	12.7	Honolulu, 6-8 fms.
39.0	12.0	Honolulu, 6-8 fms.
36.4	11.7	Honolulu, 6-8 fms. (holotype)

Types — I hereby select as holotype the specimen in USNM no. 338610, which is figured on our pl. 175, fig. 21. The type locality, here designated, is 6-8 fms., entrance to Honolulu Harbor, Oahu Id., Hawaii.

Synonymy —

1952 *Turris castanella* (Dall ms.) Tinker, Pacific Sea Shells, Honolulu, p. 46, pl. 47, fig. (middle row, right).

Records — HAWAIIAN ISLANDS: Honolulu Harbour entrance, 6-8 fms. (D. Thaanum) (USNM, holotype), (ANSP); off Kaanapali, West Maui, 25-75 ft.; off Launiupoko Camp, West Maui, 25-75 ft. (D. Thaanum).

Xenuroturris kingae *new species*

(Pl. 252, fig. 6)

Range — Hawaiian Islands.

Remarks — This handsome little shell belongs to the *cingulifera* series. It is easily distinguished by the almost complete absence of secondary spiral sculpture and by the heavy, rectangular, dark-brown maculations which are on the subsutural fold, not on the peripheral sinus rib, as in *cingulifera*. This species is named for Mrs. M. E. King of Honolulu who generously made available the turrids from her "Pele II" dredgings.

Description — Adult shell 15 to 18 mm. (about ¾ inch) in height. Whorls 6½ to 7 plus a tall, narrowly conic, dark-brown protoconch of 4½ whorls, sculptured with closely spaced regular axials. Sculpture of spire whorls consisting of a heavy subsutural fold bearing 2 smooth spiral cords, followed by a heavy projecting sinus rib, margined top and bottom by smooth rounded cords. Below this is a weaker spiral cord with a second emergent over the last whorl. Six smooth cords below the level of the top of the aperture and a further four closely-spaced cords on the weak anterior fasciole. Interstices of all the spiral cords smooth, except for an occasional thread. Sinus a deep narrow square-cut slit. Colour creamy white with a spiral series of large dark red-brown rectangular maculations on the subsutural fold and a tessellation of spots on all the other spiral cords, those on the base and fasciole dark reddish brown, the rest light-brown.

Measurements (mm.) —

height	width	
18.2	6.4	holotype
15.5	5.4	

Types — The type locality is 20 to 40 fms. on fine sand, off Keehi, Oahu Id., Hawaii. Collected by Mrs. M. E. King on Mar. 1, 1962, on the "Pele II." The holotype is in the B.P. Bishop Museum in Honolulu.

Records — HAWAIIAN ISLANDS: Oahu Id., 20-40 fms. on fine sand (Mrs. M. King, "Pele II," Mar. 1, 1962, holotype); Mokolea Rock, Kailua Bay, 10 fms. (C. Weaver, Nov., 1962); Oahu, off Waikiki, dredged (D. Thaanum).

Xenuroturris incredula (Iredale, 1931)

(Pl. 252, fig. 7)

Range — A single imperfect specimen from deep dredging of the sea bed in Port Jackson, Sydney, Australia (type locality).

Remarks — This species was introduced as the type of a new genus, *Clamturris* Iredale, 1931, but since the apical whorls are unknown there is no reason at present for separating the species from *Xenuroturris*. Specifically it is distinct from *cingulifera* in its sculptural detail of numerous plain spirals, none of which are nodular, the rather ill-defined peripheral sinus rub and the uniformly rich reddish brown colour. The only other species of similar coloration is *castanella* (Tinker) from Hawaii.

Until more material is available this species cannot be properly evaluated. Laseron (1954, p. 7) pointed out that the unique specimen may be from a subrecent deposit and possibly now extinct.

Measurements (mm.) —

height	width
60	21

Synonymy —

1931 *Clamturris incredula* Iredale, Rec. Australian Mus. 18(4), p. 226, pl. 25, fig. 21.

1954 *Clamturris incredula* Iredale, Laseron, The New South Wales Turridae, Handbook, Roy. Zool. Soc., N.S.W., p. 7, pl. 1, fig. 10.

Types — The holotype is in the Australian Museum, Sydney.

[These occasional blank areas occur between genera and subgenera to permit the insertion of new material and future sections in their proper systematic sequence.]

Genus Turris Röding, 1798

Type: *Murex babylonius* Linné, 1758

This is a genus of large-sized shells of 100 to 140 mm., of narrowly fusiform shape with tall spire and having a long anterior canal. Sinus deep and narrow, situated, typically, on a special rib above the peripheral carina. Protoconch paucispiral, small, blunt, globular, of 1½ to 2 smooth whorls. Operculum leaf-shaped with apical nucleus. Radula, 1 + 0 + 0 + 0 + 1, marginals only which are "wishbone"-shaped.

The genus is widespread in the tropical Indo-Pacific and is known fossil, with certainty, from the Pliocene of Karikal, Southern India, and probably includes a series of Australian Miocene species that stand nearer to *Turris* than to *Lophioturris*. The genus name, *Turris*, is feminine.

Synonymy —

[1766 *Turris* Müller, Delic. Natur. Selectae, Munich, pt. 1, p. 129. **Type:** *Turris Babylonica* Rumphius, A nonbinomial work].

1798 *Turris* Röding, Museum Boltenianum, Hamburg, pt. 2, p. 123. **Type** by Dall's subsequent designation (1909, U. S. Geol. Survey Prof. Paper **59**, p. 24): *Murex babylonus* Gmelin [sic] = *Murex babylonius* Linné, 1758.

1799 *Pleurotoma* Lamarck, "Prodrome," Mem. Soc. d'Hist. Nat. de Paris **1**, p. 73, no. 26. **Type** by monotypy: *Murex babylonius* Lin.

1810 *Pleurotomus* Montfort, Conchyl. Systém., Paris **2**, p. 535. **Type** by monotypy: *Murex babylonius* Linn.

1834 *Pleurostoma* (Gray ms.) Griffith and Pidgeon, Cuvier's Animal Kingdom, Moll. **12**, p. 599. Error for *Pleurotoma* Lamarck, 1799. Non Roemer, 1840, a sponge.

Turris babylonia (Linnaeus, 1758)

(Color pl. 181, figs. 1-6)

Range — Philippines and Indonesia to the Solomon Islands, Melanesia.

Remarks — Some rather distinct forms of this species occur, but since the material available to me is scant, and, further, since these variants upon the available evidence do not seem to relate exclusively to geographical areas, it is not possible to judge if the several forms have arisen in response to ecological conditions, segregation, or are accountable just as variation within acceptable specific limits.

Typical form — As described below, with a spire angle of 29° to 32°. Most records of this form come from the vicinity of the Philippines but it spreads westward through Indonesia and south eastward to the Solomons.

Narrow form — This is identical with the typical form in rib development and in colour pattern but is a much more slender shell with a spire angle of from 22° to 25°. It is a common form in the Philippines but indications are that the two forms do not occur in one breeding colony which suggests that the differences are ecologic. By the form of the subsutural cord, shown in his illustration, Tapparone-Canefri's *Pleurotoma raffrayi* would appear to

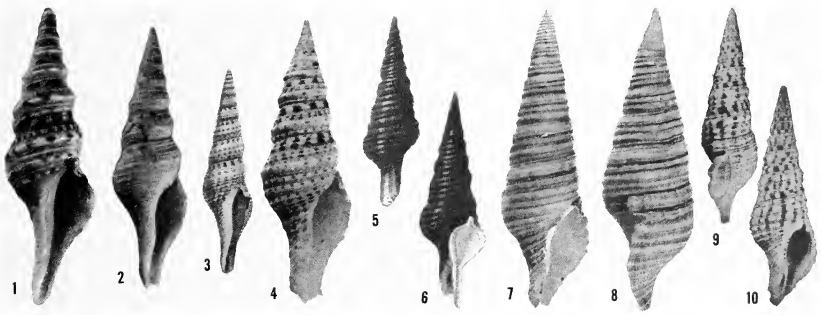

Plate 254

Figs. 1 *Turris garnonsii* (Reeve). Holotype. Cebu Id., Philippines. 47.5 mm.
2 *Turris crispa variegata* (Kiener). Madras, India. 63.5 mm.
3 *Turris crispa yeddoensis* (Jousseaume). Japan (from Jousseaume, 1883, pl. 10, fig. 7).
4 *Turris crispa intricata* new subspecies. Holotype. 12 fms., off Honolulu, Hawaii. 44 mm.
5, 6 *Turris annulata* (Reeve). Original figs. of *Pleurotoma fagina* Adams and Reeve, 1850, from the "China Sea."
7, 8 *Turris amicta* (E. A. Smith). Bombay, India. 46 mm.
9, 10 *Turris undosa* (Lamarck). Philippines. 88.2 mm.

be a synonym of the narrow form of *babylonia,* rather than a synonym of *garnonsii,* as claimed by Tryon, 1884, p. 163.

Sparsely pale-spotted form – This form has all the shell features of the typical form but has a more sparse colour pattern in dark- and pale-brown, resembling that of *garnonsii.* The dark-brown maculations are restricted to the subsutural cord and the basal cords but all those associated with the sinus cord, the peripheral cord and the one beneath it are pale-brown. This form is known to me only from the Geelvink Bay area, Dutch New Guinea, but the typical form occurs in that area also. Field records for the Geelvink Bay area indicate that both the typical and the pale form occur in shallow water on fine coral sand, down to a depth of at least twenty feet.

Description – Adult shell 75 to 85 mm. (about 3 inches) in height, solid, elongate-fusiform, rather smooth and shining white, with a bold pattern of clear-cut black spots and rectangular maculations. Sculpture prominent, of broad rounded spiral ribs with intermediate narrow cords. On the spire whorls there is a broad massive subsutural fold-like rib, weakly carinate in the middle and margined both above and below by a thin sharp cord. Between this and the sinus rib there is a rather stronger narrow sharply raised cord. Sinus rib narrow, flat, slightly bevelled along its upper margin. Another sharp narrow cord separates the sinus rib from the broad massive fold-like peripheral spiral which is weakly carinate also, and by its prominence imparts a distinct angulation to the whorls. Below this, on the base and anterior canal, there is an alternation of moderately strong carinate primary ribs and narrow sharply raised secondary cords. Below the periphery on the last whorl there are 7 or 8 primary ribs and one or two narrow cords in each interspace. On the spire whorls only one secondary cord and part of one primary rib appear between the peripheral cord and the lower suture. Aperture plus canal, which is moderately long, about three-fourths the height of the spire. The maculations occur only upon the primary cords and on the sinus rib; they are large and squarish on the subsutural fold, tending to be smaller and more rounded on the other cords and as a series of dashes on the sinus rib.

Measurements (mm.) –

height	width	
82.0	18	Philippines (narrow form)
79.0	20	Jagoliao Id., Philippines
75.5	21.7	Philippines
66.0	17	Abroeki Id., Dutch New Guinea
58.2	16	Bismarck Archipelago.

Synonymy –

1758 *Murex babylonius* Linnaeus, Systema Naturae, ed. 10, p. 753. Based upon Lister, Conch., pl. 917, fig. 11; Rumphius Mus., pl. 29, fig. L; Gualteri, pl. 52, fig. N.N.; Argenville Conch., pl. 12, fig. M.

1791 *Murex babylonius* Linn., Gmelin, Systema Naturae **1**(6), p. 3541, sp. 52. Based upon Lister, Rumphius, Gualteri, Argenville, etc.

1798 *Turris babylonica* Röding, Museum Boltenianum, Hamburg **2**, p. 123. Based upon *Murex babylonius* Gmelin, sp. 52 and Martini, **4**, pl. 143, figs. 1331, 1332.

1816 *Pleurotoma babylonia* Linn., Lamarck, Encycl. Meth., pl. 439, figs. la, b. Liste, p. 8.

1817 *Murex babylonius* Linn., Dillwyn, Desc. Cat. Recent Shells, London **2**, p. 714, sp. 66.

1839-40 *Pleurotoma babylonia* Linn., Kiener, Coquilles Vivantes **5**, Pleurotome, p. 4, pl. 1, fig. 1, but not fig. 2.

1843 *Pleurotoma babylonia* Linn., Reeve, Conch. Iconica **1**, pl. 1, sp. 5.

1843 *Pleurotoma venusta* Reeve, Conch. Iconica **1**, pl. 9, sp. 79 (has all the characters of typical *babylonia* but not fully grown; 54.5 × 18 mm.)

1878 *Pleurotoma raffrayi* Tapparone-Canefri, Bull. Soc. Zool. France **3**, p. 246, pl. 6, fig. 1 (Port Dorey, New Guinea).

1884 *Pleurotoma babylonia* Linn., Tryon, Manual of Conch. **6**, p. 162 (in part, exclusive of *spectabilis*), pl. 1, fig. 1.

1956 *Turris babylonius* Linn., Kaicher, Indo-Pacific Sea Shells, Section **5**, Toxoglossa, pl. 1, fig. 6.

Types – The holotype of *venusta* Reeve from Siquijor Island, Philippines, is in the British Museum (Natural History) in London.

Records (Typical form) – PHILIPPINES: Siquijor Id. (type locality of *venusta*); Calapan, Mindoro Id.; Masingin, Jetafe, Bohol Id.; Bongao Channel, S.W. end of Sanga Sanga Id., Sulu Arch.; Balabac Id., Palawan; Jagoliao Id., N.W. end of Bohol Id. (duPont-Acad. Exped., 1958, ANSP). CELEBES: Buton Strait, Gr. Tobca Id. (USNM). DUTCH NEW GUINEA: islands 2 mi. N.W. of Sowek, Soepiori, Schouten Ids., sand and rock; Cape Tekopi, W. side Samberbaba, Japen Id.; island off N.E. tip of Ambai, Japen Id., 10-15 ft., sand and grass (NSF, 1956, ANSP). ADMIRALTY ISLANDS: Koruniat Id. (ANSP). BISMARCK ARCHIPELAGO: Umboi Id., Siassi Ids. (MCZ). SOLOMON ISLANDS: Pavavu Id.; Russell Id. (USNM); Ata District, Malaita (ANSP).

(Narrow form) – PHILIPPINES: Calatagan, Batangas, Luzon Id.; E. side of Jagoliao Id., N.W. end of Bohol Id., 12-24 ft. (duPont-Acad. Exped., 1958, ANSP).

(Sparsely spotted form) – DUTCH NEW GUINEA: shore reefs, 5 mi. N.W. of Rani Id., Biak Id., Schouten Ids.; N. shore of Matas Id., Aoeri Ids., Geelvink Bay; Abroeki Isle, Maransabadi Id., Aoeri Ids.; Sakfondoe Id., 1½ mi. W. of

Plate 255. Nuclear whorls of *Turris crispa yeddoensis* (Jousseaume). Japan.

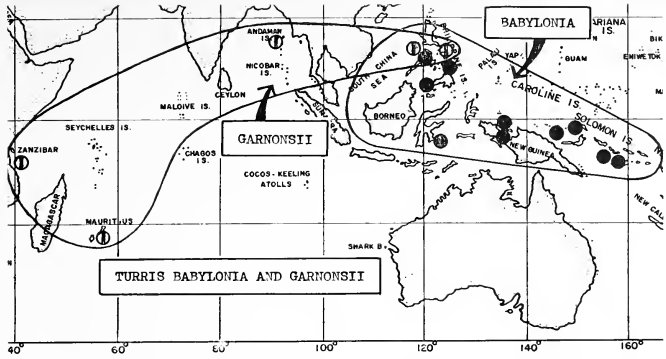

Plate 256. Geographical distribution of *Turris babylonia* (Linnaeus) and *Turris garnonsii* (Reeve).

Sowek, Soepiori, Schouten Ids., dredged, sand and grass; S.W. side of Maransabadi, Aoeri Ids., 10-20 ft., sand; N. side of Matas Id., Aoeri Ids., 2-4 ft., fine sand and grass; ¾ mi. S.W. of Pai Isle, Mios Woendi Atoll, Padaido Ids., dredged, 12-16 ft., sand (NSF, 1956, ANSP).

Turris garnonsii (Reeve, 1843)

(Color pl. 181, figs. 7, 8, 18; pl. 254)

Range — Western Indian Ocean, eastward to the Philippines. Pleistocene, Somali coast and upper Tertiary, British North Borneo.

Remarks — The shell of *garnonsii* is more slender than that of *babylonia* and has a much weaker angulation. The sculpture, although basically similar to that of *babylonia,* consists of narrower but more strongly carinate cords and the whole surface, including the cords, is crossed by dense lamellate axial threads. The subsutural fold is low in profile but is carinated at the middle by a sharply-raised, strong, spiral thread and margined both above and below by a weaker but distinct thread. Between this and the sinus rib there are one or two sharply-raised, spiral threads. Sinus rib narrow, flat, its top margin projecting a trifle more than the lower margin. The peripheral cord is sharply carinate but only slightly stronger than the other cords and thus forms only a weak angulation of the whorl outline. There are two primary carinate cords below the angulation, the uppermost of which is emergent at the suture. One or two crisp narrow threads between each pair of primaries. Below the lowest primary there are 14 to 16 subequal crisp narrow threads extending down to the weak fasciole.

Although typical *garnonsii* is found in many museum and private collections with the locality "Zebu," it is doubtful if the data is correct in all cases since it was common practice with dealers to cite a published locality when the actual source of a specimen was unknown. The distributional centre of *garnonsii* is the western Indian Ocean and it becomes uncommon and of sporadic occurrence to the east where it is in competition with *babylonia.*

A very slender form of this species occurs in the Philippines but insufficient material is available to decide its status. See Plate 181, fig. 18, one of two such specimens in the Museum of Comparative Zoölogy, Harvard. Weinkauff (1875, Conch. Cab., pl. 2, figs. 3, 4) figured a similar specimen, also from the Philippines.

Description — Adult shell 58 to 75 mm. (2¼ to 3 inches) in height, of rather light build, elongate-fusiform, with whorls only slightly angulate. Spire angle 20° to 23°. Colour pattern of chestnut-brown oblong maculations checquering the subsutural fold and a more or less coalescent band of similar colour encircling the base below the level of the aperture. Sinus rib with closely-spaced dots; remaining cords with irregularly-disposed small dots. Ground colour ivory-white. The species replaces *babylonia* over the western tropical Indian Ocean.

Measurements (mm.) —

height	width	
74.0	17.2	Zanzibar
71.0	19.0	"Philippines" (ex Sowerby)
67.0	17.0	Zanzibar, 12-14 fms.
56.0	13.4	Zanzibar
47.5	13.7	Cebu Id., Philippines (holotype)

Synonymy —

1839-40 *Pleurotoma babylonia* var., Kiener, Coq. Viv. 5, Pleurotome, pl. 1, fig. 2.

1843 *Pleurotoma garnonsii* Reeve, Conch. Iconica **1**, pl. 1, sp. 4.
1875 *Pleurotoma garnonsii* Reeve, Weinkauff, Martini-Chemn., Conch. Cab., ed. 2, 4, p. 12, pl. 2, figs. 1-4.
1884 *Pleurotoma garnonsii* Reeve, Tryon, Manual of Conch. **6**, p. 163, pl. 2, fig. 5.
1948 *Turris garnonsii* Reeve, Cox, Schweiz. Pal. Abhand. **66**, p. 54, pl. 6, fig. 1.
1956 *Turris garnonsii* Reeve, Kaicher, Indo-Pacific Sea Shells, Section 5, Toxoglossa, pl. 1, fig. 8.

Types — The holotype is in the British Museum (Natural History), and is based upon a single specimen in the Cuming collection from low water, Island of "Zebu" = Cebu, Philippines.

Records — ZANZIBAR: 1½ mi. W.S.W. of Ras Mungwe, 8 fms.; ¾ mi. W. of Chumbe Id., 12-14 fms.; 1 mi. S.W. of Ngurwe Id., 5-11 fms.; S. side of Pwakuu Id., 11-18 fms.; 2 mi. W. of Nyange Id., 11 fms.; 1 mi. E. of Nyange Id., 18-20 fms.; 1 mi. W.N.W. of Ras Mbweni, 7 fms.; between Mwamba, Ukombi and Chumbe Ids. (NSF, 1957, ANSP). MAURITIUS: (Australian Mus.). ANDAMAN ISLANDS: (MCZ); Port Blair (Winckworth coll., Brit. Mus.). PHILIPPINES: between Siasi and Bongao Ids. (USNM); Calapan, Mindoro Id. (MCZ); "Zebu" = Cebu Id., type, Brit. Mus.).

Fossil Records — SOMALI (Pleistocene) (Abrard, 1942, p. 85). BRITISH NORTH BORNEO: Neogene, Dent Peninsula (Cox, 1948, p. 54).

Turris crispa (Lamarck, 1816)

Including its subspecies, *crispa* has an extensive range extending from Madagascar to Japan and the Hawaiian Islands. It has been recorded fossil from the Pliocene of Southern India.

It is around the perimeter of this vast distributional area that subspeciation is evident, i.e.—*variegata* from the west coast of India, *yeddoensis* from Japan and *intricata* (n. subsp.) from the Hawaiian Islands.

The optimum development of the species, so far as size is concerned, is in the South China Sea and from no other area has the writer seen examples more than half the height of such specimens, adults of which range between 120 and 160 mm.

Key to subspecies of *crispa*

A. Peripheral carina weak or absent
  Adult size 120 to 160 mm.
    Pattern connected by axial streaks (in young stages only)
      crispa crispa (Lamarck)
  Adult size 60 to 90 mm.
    Pattern not connected by axial streaks
      crispa yeddoensis (Jousseaume)

B. Peripheral carina distinct
  Adult size 60 to 82 mm.
    Spirals in shoulder concavity, 2 to 4
      Canal relatively long
        crispa variegata (Kiener)
  Adult size 34 to 44 mm.
    Spirals absent from shoulder concavity
      Canal relatively short
        crispa intricata Powell

Turris crispa *subspecies* crispa (Lamarck, 1816)

(Color pl. 181, figs. 9-12)

Range — Madagascar to Australia and Fiji.

Remarks — In the adult size (form *grandis*) this is the largest of the Recent turrids which attains a height of at least 160 mm. (6 inches).

Description — The sculpture resembles that of *garnonsii* more than that of *babylonia*, particularly in the dense pattern of lamellate axial growth lines which cross the entire surface. The carinate primary cords are more regular in development than in either of the above-mentioned subspecies, and on the base there is a more regular alternation between primary cords and pairs of threads in each interspace. The most distinctive differences are,

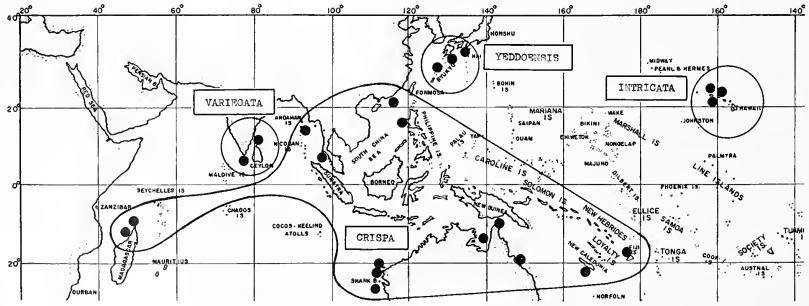

Plate 257. Geographical distribution of *Turris crispa* (Lamarck) and its subspecies *variegata* (Kiener), *yeddoensis* (Jousseaume) and *intricata* new subspecies.

however, in the subsutural fold which is composed of two primary cords only, and the lack of distinct angulation of the whorls. Spire angle 21° to 22°. Anterior canal plus aperture almost equal to the height of the spire. Colour pattern of the young shell consisting of narrow flexuous dark-brown lines forming an overall haphazard vertically flowing pattern. In adult shells the maculations tend to widen into dashes, thus destroying the vertical flowing pattern.

Measurements (mm.) –

height	width	
156.0	31.0	"Indian and Chinese Seas" (Brit. Mus.)
140.0	26.5	type of *grandis*, G. and P.
137.0	27.0	Philippines (AMNH)
130.0	26.5	Hong Kong (USNM)
124.0	24.0	Hong Kong (ANSP)
87.0	19.5	Albay Prov., Philippines (ANSP)
61.5	14.0	Noumea, New Caledonia (ANSP)

Synonymy –

1816 *Pleurotoma crispa* Lamarck, Encycl. Meth., pl. 439, fig. 4. Le Liste, p. 8.
1834 *Pleurotoma grandis* (Gray ms.) Griffith and Pidgeon, Cuvier's Animal Kingdom 12, Mollusca, p. 599, pl. 23, fig. 1.
1843 *Pleurotoma crispa* Lamarck, Reeve, Conch. Icon. I, pl. 2, fig. 11.
1843 *Pleurotoma grandis* Gray, Reeve, Conch. Icon. I, pl. 2, fig. 13.
1875 *Pleurotoma gracillima* Weinkauff, Conch. Cab. 4(3), p. 26, pl. 5, figs. 4, 5.
1884 *Pleurotoma grandis* Gray, Tryon, Manual of Conch. 6, p. 163, pl. 1, figs. 6, 7.
1922 *Turris crispa* Lamarck, Hedley, Rec. Australian Mus. 13(6), p. 215.
1956 *Turris crispa* Lamarck, Kaicher, Indo-Pacific Sea Shells, Section 5, Toxoglossa, pl. 1, fig. 7.
1959 *Turris crispa* Lamarck, Kira, Coloured Illustr. Shells of Japan (ed. 2), p. 71, pl. 35, fig. 5.

Types – The holotype of *grandis* "Gray" G. and P., is in the British Museum (Natural History) in London.

Records – MADAGASCAR: 3 mi. N.N.E. of Nossi Fali, E. of Nossi Bé, 9 fms.; Andilana and Nosy Antsaibory, N.W. Nossi Bé, 0-5 ft. (ANSP). ANDAMAN ISLANDS: Port Blair (Winckworth coll., Brit. Mus.). THAILAND: Ko Phuket (F. N. Crider). HONG KONG: (USNM); 20° 15′ N, 112° 36′ E, 50 fms. (F.R.V. "Alister Hardy," ANSP). PHILIPPINES: Tabaco, Albay Province, E. side Luzon Id. (duPont-Acad. Exped., ANSP); Cebu (USNM); Batangas Bay, Luzon Id. (MCZ). AUSTRALIA: Queensland: Darnley Id., 20 fms.; Mapoon, Gulf of Carpentaria, 10 fms., (Australian Mus.); trawled off Townsville (Mrs. J. Kerslake); Western Australia: Onslow (Mrs. J. Kerslake); W. of Flat Id., near Onslow, 6-10 fms.; off Legendre Id., Dampier Archipelago, 23 fms.; between Malus and Gidley Id., Dampier Archipelago, 10-14 fms.; 10 mi. W. of Bernier Id. (W. Austr.-Hawaiian Exped., 1960). NEW CALEDONIA: mouth of stream, Anse Vata Bay, Noumea, 2-6 ft., sand and rocks; Baie de Citron, Noumea, 1-6 ft., rocks, sand and silt (ANSP). FIJI: Vunivundra Id., 4-5 fms., sand; Akuilau Id., 3-4 ft. at low tide (W. Jennings, 1961-62).

Fossil Records – Recorded from the Pliocene of Karikal, Southern India (Cossmann, 1900, p. 17) but since the writer has not seen this material it is uncertain whether Cossman's specimens were *crispa crispa* or *crispa variegata*.

Turris crispa *subspecies* yeddoensis (Jousseaume, 1883)

(Color pl. 181, fig. 13; pl. 254, fig. 3)

Range – Japan and the Ryukyu Islands.

Remarks – All the Japanese forms of *crispa* the writer has seen are rather uniform and seem to represent a regional subspecies for which Jousseaume provided a name.

A specimen in the British Museum (Winckworth coll.) has a "foreign" operculum affixed. It is of the medio-lateral nucleus type as in *Turricula javana* (Linnaeus); the operculum in all species of *Turris* is leaf-shaped with an apical nucleus.

Description – Shell characterized by finer and more uniform development of the spiral ribbing, especially over the base. The peripheral spiral cord is no heavier than the rest, and the colour pattern consists of relatively sparse to crowded dots and dashes on all the spiral cords. Only rarely does the pattern resolve into larger subsutural maculations and all examples lack the vertical, flexuous, narrow, dark lines so characteristic of the younger stages of *crispa*. Height 60 to 82 mm. (2¼ to 3¼ inches). Spire angle 23°, spire greater than height of aperture plus canal. Protoconch paucispiral, smooth, of two whorls, with a blunt dome-shaped apex. The subspecies appears never to attain the size of typical *crispa*.

Measurements (mm.) –

height	width	
82.0	22.0	Japan, Enoshima (British Mus.)
82.0	18.5	Japan
70.0	15.3	Okinawa
67.2	15.7	Japan

Synonymy –

1883 *Pleurotoma yeddoensis* Jousseaume, Bull. Soc. Zool. France 8, p. 196, pl. 10, fig. 7 (Japan).
1884 *Pleurotoma yeddoensis* Jousseaume, Tryon, Manual of Conch. 6, p. 319, pl. 34, fig. 7.
1951 *Turris crispa* Lamarck, Hirase and Taki, Handb. Illustr. Shells, revised ed. of "A Collection of Japanese Shells," pl. 115, fig. 1.

Types – The type locality is "Japan." The type is probably in the Paris Museum.

Records – JAPAN: Tanabe (D. Thaanum coll.); Enoshima (Brit. Mus.); off Tanabe, 30 fms. (Powell coll.); Wakanura; Kishiu and Kii (USNM). OKINAWA: off Itoman (D. Thaanum coll.).

Turris crispa *subspecies* variegata (Kiener, 1839)

(Pl. 254, fig. 2)

Range – Indian Ocean, probably restricted to the west coast of India.

Remarks – For the present this shell is admitted as a subspecies of *crispa*. Very few specimens are available and nowhere has the writer seen a series from any one locality. These odd occurrences could be individual variants exhibiting a shorter, slightly twisted canal and a somewhat pagodiform spire, due to more prominence of the peripheral angle. On the other hand, the few examples seen are all from Madras and vicinity and true *crispa* seems to be absent from that area.

This may reasonably be considered an Indian regional subspecies of *crispa* comparable with two other subspecies occupying areas marginal to the *crispa* typical range, i.e., *yeddoensis* Jousseaume from Japan and *intricata* n. subsp. from Hawaiian Islands.

Description – Adult shell about 57 to 64 mm. (2¼ to 2½ inches) in height. Whorls 12+ (protoconch missing). Spire 1.2 times the height of the aperture plus canal; spire angle 24° to 25°. Anterior end relatively short and slightly flexed. Sculpture of the spire's whorls consisting of a subsutural pair of spiral cords, followed by 2 to 4 spiral threads in the concave interspace preceding the sinus rib which is concave, margined both above and below by a narrow sharply raised cord. Next comes the prominent, broad, but narrowly arched peripheral carina. Below this is an alternation of closely spaced smooth primary and secondary cords. The relatively prominent peripheral carina is just below middle whorl height and gives a pagodiform outline to the spire. Surface somewhat worn in all examples seen but there is evidence of dense axial lamellate threads as in the typical species. Colour creamy white, finely speckled with light-brown, not connected vertically in a flowing pattern as in the typical subspecies; some larger maculations on the subsutural fold and in one example (Madras) a spiral zone of light-brown encircles the base.

Measurements (mm.) –

height	width	
82.5	22.0	"Cebu," correct?
63.5	17.0	Madras (Brit. Mus.)
59.0	15.5	Tuticorin, 9 fms. (Brit. Mus.)
57.0	15.0	Madras (A. W. B. Powell coll.)

Synonymy –

1839-40 *Pleurotoma variegata* Kiener, Coq. Viv. 5, Pleurotome, pl. 9, fig. 1.

?1843 *Pleurotoma variegata* Kiener, Reeve, Conch, Icon. 1, pl. 1, fig. 2.

Records – INDIAN OCEAN (type locality): INDIA: Madras; Tuticorin, 9 fms. (Brit. Mus., Winckworth coll.). A large example from the McAndrew collection in the British Museum belongs here but the locality "Zebu" = Cebu, is doubtful. Along with it is a small specimen of *garnonsii*.

Turris crispa *subspecies* intricata *new subspecies*

(Pl. 254, fig. 4)

Range – Hawaiian Islands.

Remarks – This is a Hawaiian subspecies in the *crispa* complex which is characterized by its small size, the prominence of the peripheral carina, the truncated and twisted anterior end, and the speckled pattern which is not connected by flexuous axial colour lines. The Japanese *yeddoensis* differs mainly in the more even development of the spiral cords, the sinus rib being more prominent than the peripheral one below it.

Description – Adult shell about 44 mm. (1¾ inches) in height, solid, fusiform and prominently keeled at lower third of whorl height. Whorls 11+ (protoconch missing). Spire 1.2 times the height of the aperture plus canal; spire angle 27°. Anterior end relatively short and slightly flexed. Sculpture of spire's whorls consisting of a subsutural pair of spiral cords followed by the concave sinus rib which is margined top and bottom by a smooth rounded cord. Next comes the massive peripheral carina which is narrowly arched and is margined both above and below by spiral threads. Below the periphery there is one primary cord and a second one half emergent at the lower suture. On the body whorl, base and fasciole, from below the peripheral carina, there are 16 primary spiral cords, the upper 3 with a single thread in each interspace. The whole surface is crowded with relatively strong lamellate axial growth lines. The sinus is deep and situated on a ridge above the peripheral carina. Colour creamy-white, speckled with dots and dashes, confined to the spiral cords and threads. There are no connecting axial colour lines and streaks as in the younger forms of *crispa*. On the two subsutural cords and on three consecutive cords on the upper part of the base, the maculations consist of more closely-spaced dashes which imparts a slightly banded appearance to the shell.

Measurements (mm.) –

height	width	
44.0	13.5	holotype
34.0	10.0	off Maui
27.0	8.5	off Waikiki

Types – The holotype is in the United States National Museum, Washington. The type locality is 12 fms., entrance to Honolulu Harbor, Oahu Id., Hawaii. USNM no. 338617.

Records – HAWAIIAN ISLANDS: entrance to Honolulu Harbor, 12 fms. (holotype); off Kaanapali, 4-12 fms., (USNM); West Maui, off Launiupoko Camp (D. Thaanum coll.); off Kewalo, 20-30 fms. (Mrs. M. King, "Pele II," Apr. 23, 1962).

Turris annulata (Reeve, 1843)

(Color pl. 181, fig. 19; pl. 254)

Range – Persian Gulf to Japan, and Pliocene of Java and Timor, Indonesia.

Remarks – This species name has often been misapplied to a South India shell which should bear the name of *Turris amicta* (E. A. Smith, 1877). Uncertainty regarding the true identity of *annulata* was due to the fact that Reeve's type specimen has long been missing from the British Museum collection.

Reeve's figure is not very detailed and his description, as follows, is very brief: "Shell solid, subulate, brown; whorls slightly convex, encircled with a number of smooth paler ridges, like rings; canal rather long."

However, the writer found a small specimen in the Tomlin collection at the Welsh National Museum, Cardiff, which is almost certainly the missing type of *annulata*. This specimen matches Reeve's figure very well for size, coloration and general appearance. It is brown, with the sinus rib paler, the operculum is leaf-shaped with an apical nucleus and the shell measures 49.5 × 14 mm. It is labelled *Pleurotoma annulata* but has no locality data.

Without doubt *Pleurotoma fagina* Adams and Reeve, 1850, from China Seas is a synonym of *annulata*. The type specimen of *fagina* differs from that of *annulata* only in being fully adult and in exhibiting two pathological features, a more deeply excavated base, the result of an early injury to the shell, and a twisted pillar with an associated false umbilical chink. The twisted pillar signifies a gerontic condition also found occasionally in *babylonia* and normally in *cryptorrhaphe*.

Very few examples of *annulata* are available. The presumed type is an immature shell but there is an adult unlocalised shell in the Powell collection, the type of *fagina* is adult but gerontic and abnormal, due to injury, and deep-water shells from off Japan, presumed to be this species differ in their pale coloration. It is likely that when more material is available the Japanese deep-water form may prove to be subspecifically distinct.

Descriptions follow of (a) the typical brown form, which is probably shallow water, and (b) the light-coloured form from deep water off Japan.

Tryon's figure of *annulata* (1884, pl. 6, fig. 83), a copy of Reeve's fig. 35, is misleading in that the sinus rib appears gemmate, which is not the case, nor is it in accord with the original figure.

Description (a) Typical form – Shell 64 to 74 mm. (2½ to 3 inches) in height; whorls lightly convex; spire tall, 1.3 times the height of the aperture plus canal, angle 24° to 25°, sculptured with heavy rounded spiral ridges, separated by deep narrow interspaces, one, rarely two spiral threads in each interspace. The spiral ridges are rather smooth and angulate at the crest, except for the sinus ridge, which is biangulate. On the spire the spiral ridges number three, with a fourth emergent toward the aperture. Spirals diminish rapidly in strength over the lower base and pillar. Sinus of moderate depth, on the biangulate ridge which is situated slightly above middle whorl height. Colour uniform reddish brown, interior of aperture and parietal wall white. Described from a specimen of unknown locality (Powell coll.).

Description (b) White deep-water form – Shell up to 77 mm. (3 inches) in height, whorls lightly convex, spire tall, 26°, sculptured with heavy, rounded, spiral ridges separated by deep narrow interspaces, with one (rarely two) crisp spiral threads in each interspace. On the early whorls there are 3 spiral ridges, and these increase to 4 from the antepenultimate onward. On the base and neck there are a further 15 primary ridges, the two uppermost stronger than those following. In detail, the sculpture on the later whorls of the spire is as follows: subsutural ridge or fold consisting of a closely spaced pair of spiral cords, the next, which is the sinus rib, consists of two fused cords, followed by numbers three and four, each of which consists of a heavy cord fused to a narrow one immediately below. On the body whorl, number three spiral is clearly shown as peripheral. The whole surface is crossed by dense thread-like axial growth lines. Aperture relatively narrow, ovate, with a moderately long straight canal. Spire 1.3 times the height of aperture plus canal. Colour dull white in general

but tinted pale yellowish brown in the rib interstices of the spire's whorls. Described from a specimen from 50 fathoms off Tosa, Japan (ANSP).

Measurements (mm.) —

height	width	
77.0	20.0	Tosa, Japan
73.5	21.0	holotype (*fagina* Adams and Reeve)
49.5	14.0	holotype? (*annulata* Reeve)
46.5	15.1	Bombay, India
39.5	11.0	Henjam, Persian Gulf, 46 fms.

Synonymy —

1843 *Pleurotoma annulata* Reeve, Conch, Iconica 1, pl. 5, fig. 35.
1850 *Pleurotoma fagina* Adams and Reeve, Zool. Voy. "Samarang," p. 40, pl. 9, figs. 2, a, b.
1884 *Pleurotoma fagina* Adams, Tryon, Manual of Conch. **6**, p. 167, pl. 3, fig. 22 (copy of Adams and Reeve's figure).
1884 *Pleurotoma annulata* Reeve, Tryon, Manual of Conch. **6**, p. 240, pl. 6, fig. 83 (copy of Reeve's figure).
1917 *Turris (Tomopleura) fagina* Adams and Reeve, Melvill, Proc. Malac. Soc., London **12**, p. 146 (the Henjam specimen).
1938 *Turris (Turris) fagina* Adams and Reeve, Oostingh, De Ingenieur in Ned.-Indie, 4, Mijnb. Geol., **5**(2), Gast. 1, p. 27.
1942 *Turris fagina* Adams and Reeve, Yen, Proc. Malac. Soc., London **24**, p. 238, pl. 25, fig. 184 (photograph of holotype).

Types — What is probably the holotype of *annulata* Reeve is in the National Museum of Wales, Cardiff. The holotype of *fagina* is in the British Museum (Natural History) in London.

Records — PERSIAN GULF: Henjam Id., 46 fms., sand (Sykes coll., Brit. Mus.). INDIA: Bombay (MCZ). CHINA SEA: (holotype of *fagina*). JAPAN: 50 fms. off Tosa (ANSP). THAILAND: 4 mi. E. of Phuket Harbour, 80 ft. (R. T. Abbott, ANSP).

Fossil Records — JAVA: South Bantam, Pliocene (Oostingh, 1938, p. 27). TIMOR: Koto, Neogene (Brit. Mus., Geol. Dept.).

Turris amicta (E. A. Smith, 1877)

(Pl. 254, figs. 7, 8)

Range — Aden, west coast of India and Ceylon.

Remarks — The relationship of this species seems to be with *annulata* and in fact it appears in many collections under that name. The truncated canal suggests *Xenuroturris* but inclusion in *Turris* is influenced by the nature of the sinus rib which is of subsidiary strength, situated above the periphery and also by the nature of the sculpture which is very similar to that of *annulata*.

This species is of intertidal occurrence, evidently a shallow-water relative of *annulata*, which differs in having a much longer canal, dark-brown coloration and apparently no periostracum.

The type lot in the British Museum consists of three specimens and printed on the tablet is "Sandwich Is., W. H. Pease coll., two spec. M. C. [i.e. Museum Cuming] and smallest presented by Pease." An addition in pencil on the front of the tablet indicates Bombay as the locality and on the back of the tablet, also in pencil, is inscribed "Bombay (Abercrombie), certain!" All three specimens are of the well-known Indian shell, even the smallest one from Pease, so the "Sandwich Island" originally cited type locality can now be dismissed and Bombay substituted.

Description — Adult shell 45 to 53 mm. (about 2 inches) in height, white, devoid of colour pattern and covered by a yellowish olive periostracum. Adult whorls 10 to 11 (protoconch worn way in all available specimens). Spire tall, 1.5 times the height of the aperture plus canal. Whorls very lightly convex, sculptured with heavy spiral ridges separated by narrow interspaces. On the spire whorls there is a massive subsutural ridge traversed by 3 spiral cords, followed by the much weaker and narrower concave sinus rib which is margined top and bottom by weak cords. Below this is a third spiral ridge and a fourth becomes emergent toward the last whorl. About 10 spiral cords on the base with 1 to 3 secondary spirals in each interspace. Five more closely spaced spirals on the weak anterior fasciole. Body whorl elongate but with excavated base and short slightly-flexed anterior canal. Sinus moderately deep, narrow, U-shaped, situated slightly above the periphery.

Measurements (mm.) —

height	width	
52.0	17.0	Eluvativu Id., Ceylon
49.0	16.5	Bombay, India
46.0	14.5	Bombay, India
40.0	12.0	Bombay, India

Synonymy —

1877 *Pleurotoma amicta* E. A. Smith, Ann. Mag. Nat. Hist. (ser. 4) **19**, p. 488.

Types — The holotype is in the British Museum (Natural History) in London. The type locality of "Sandwich Islands" is undoubtedly erroneous.

Records — ADEN: (Brit. Mus.). WEST PAKISTAN: (ANSP). INDIA: Bombay (Winckworth coll., Brit. Mus.); Bandra, north of Bombay (USNM). CEYLON: Eluvativu Id. (G. and M. Kline, 1957, ANSP).

Turris undosa (Lamarck, 1816)

(Color pl. 181, fig. 20; pl. 254)

Range — Southern India, Philippines, Japan and Queensland.

Remarks — This very distinctive species is easily recognised by its long spire, with almost straight

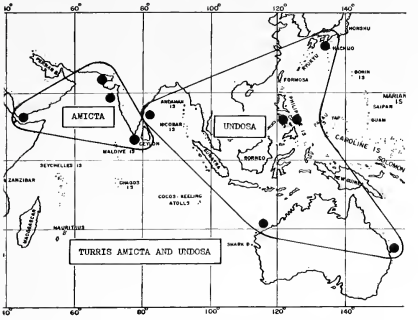

Plate 258. Geographical distribution of *Turris amicta* (E. A. Smith) and *Turris undosa* (Lamarck).

outlines, and by its very short anterior canal, profuse dark-brown wavy vertical maculations and violet-tinted aperture.

Tryon's figure of this species, which is copied from Reeve (1843, pl. 3, fig. 18), gives a false impression, since the maculations appear as prominent nodes, which they are not.

Description – Adult shell 65 to 83 mm. (about 2½ to 3 inches) in height. Spire angle 24° to 25°. Height of aperture plus canal about three-fourth the height of the spire. The sculpture consists of a prominent, broad, subsutural fold bearing 5 narrow, sharply raised, spiral threads. Immediately below this is the rather prominent sinus rib which is slightly rounded; on the body whorl it develops 3 weak spirals. Below the sinus rib and over the base there is an assorted arrangement of spiral cords and threads, 4 more prominent that the rest, bunched in the peripheral area, and 7 or 8 primaries irregularly disposed over the neck, with from 1 to 3 threads in the interspaces. Colour pattern of dark reddish brown, vertical, wavy, dense maculations on a white ground. Interior of aperture, parietal callus and pillar stained bright violet.

Measurements (mm.) –

height	width	no. whorls	
83.0+	22.5	12+	Kii, Japan
76.0	22.0	–	Moluccas
65.3+	16.7	12+	Mindoro Id., Philippines

Synonymy –

1816 *Pleurotoma undosa* Lamarck, Encyclop. Méth., pl. 439, fig. 5, Le Liste, p. 8.
1822 *Pleurotoma undosa* Lamarck, Anim. sans Vert. 7, p. 95.
1839-40 *Pleurotoma undosa* Lamarck, Kiener, Coq. Viv. 5, Pleurotome, p. 13, pl. 3, fig. 2.
1843 *Pleurotoma undosa* Lamarck, Reeve, Conch. Iconica 1, pl. 3, sp. 18.
1884 *Pleurotoma undosa* Lamarck, Tryon, Manual of Conch. 6, p. 166, pl. 3, fig. 21.

Records – INDIA: Madras (Winckworth coll., Brit. Mus.). JAPAN: Kii (ANSP). PHILIPPINES: Masbate Id., on coral reef (Cuming coll., Brit. Mus.); Calapan, Mindoro Id., (MCZ). AUSTRALIA: Queensland: trawled, Tin Can Bay, south of Fraser Id. (Mrs. J. Kerslake); Western Australia: between Malus and Gidley Ids., 10-14 fms., Dampier Arch. (W. Austr.-Hawaiian Exped., 1960).

Turris cryptorrhaphe (Sowerby, 1825)

(Color pl. 181, figs. 14, 15)

Range – Philippines, East Indies, New Guinea, Marshall Islands and Fiji.

Remarks – Although described as early as 1825, this handsome species is known from relatively few specimens. It is characterised by its rather short and usually pseudo-umbilicate siphonal canal, by its lavender aperture, and by its smoky brown color which is overlaid by numerous, fine, spiral, dark-brown lines. Some specimens may be light-tan and with light-brown spiral lines.

Description – Adult shell 65 to 78 mm. (2½ to 3 inches) in height, with a tall, attenuate, pagodiform spire and a short, twisted anterior canal. Colour uniformly chestnut or yellowish brown, the aperture and parietal callus tinged with violet. Spire angle 15° to 17°, outlines angulated at the lower third of whorl height by a prominent, smooth, narrowly rounded cord, a weaker one above and a third, a stronger one, emergent on the base, just

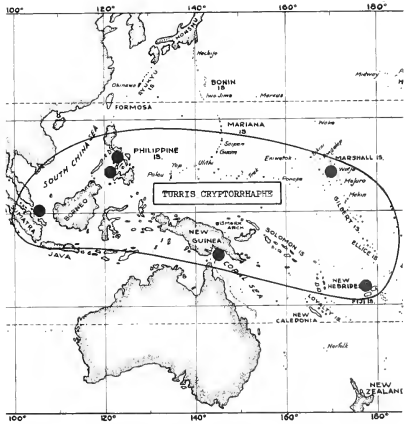

Plate 259. Geographical distribution of *Turris cryptorrhaphe* (Sowerby).

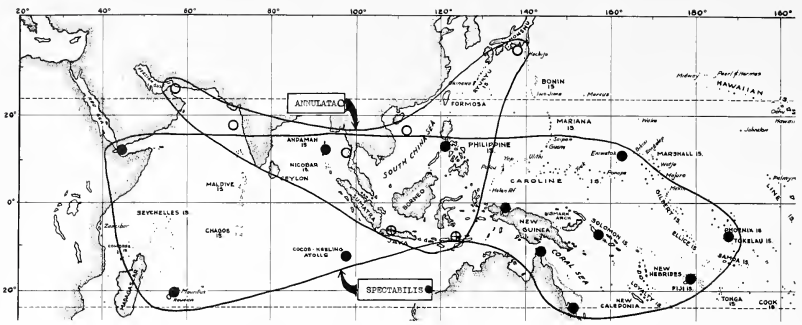

Plate 260. Geographical distribution of *Turris spectabilis* (Reeve) in solid dots, and *Turris annulata* (Reeve) in open circles.

covered by the last whorl. Sinus rib narrow, low and inconspicuous on the spire's whorls and situated immediately below the weak subsutural fold. Surface further sculptured with fine threads, 2 or 3 on the subsutural fold, 2 to 4 between the peripheral keels of the last whorl and 12 to 15 on the base and neck. Aperture plus canal half the spire height. Pillar twisted and with a prominent fasciole and false umbilical chink.

Measurements (mm.) –

height	width	no. whorls	
78.0	21.0	14+	Bohol, Philippines
67.0+	21.0	–	holotype of *cryptorrhaphe* Sby.
67.0	17.7	11+	Philippines
59.0	16.5	–	Bohol, Philippines

Synonymy –

1825 *Pleurotoma cryptorrhaphe* Sowerby, Tankerville Cat., Append., p. 14, no. 1503 (no locality).
1828 *Murex bicarinatus* Wood, Index Testaceol. Suppl., p. 15, pl. 5, fig. 7 (no locality).
1839-40 *Pleurotoma woodii* Kiener, Coq. Viv. **5**, Pleurotome, p. 12, pl. 7, fig. 1 (new name for *bicarinatus* Wood).
1842 *Pleurotoma cryptorrhaphe* Sowerby, Reeve, Conch. Syst. **2**, p. 188, pl. 234, fig. 16 (15 in error on plate).
1843 *Pleurotoma cryptorrhaphe* Sowerby, Reeve, Conch. Icon. **1**, pl. 1, fig. 7.
1875 *Pleurotoma cryptorrhaphe* Sowerby, Weinkauff, Conchyl.-Cab., 2nd series, Pleurotomidae **4**(3), p. 20, pl. 4, figs. 4-7.
1884 *Pleurotoma cryptorraphe* (sic) Sowerby, Tryon, Manual of Conch. **6**, p. 168, pl. 3, figs. 30, 31.
1913 *Pleurotoma (Hemipleurotoma) cryptorhaphe* (sic) Sowerby, Schepman, Siboga Exped., pt. 5, **49e**, p. 400.

Types – The holotype is in the British Museum (Natural History) in London.

Records – INDONESIA: North Ubian, 16-23 metres (Schepman, 1913). PHILIPPINES: 12-24 ft., E. side of Jagoliao Id., N.W. end of Bohol Id. (duPont-Acad. Exped., 1958, ANSP); Zamboanga City, Mindanao Id. (MCZ); Masbate Id. (Brit. Mus.). NEW GUINEA: Milne Bay (Stanford Univ.); MARSHALL ISLANDS: Kwajalein Atoll (USNM). FIJI: Ngualito Id., off north coast, under rocks partially buried in sand (W. Jennings, 1961).

Turris spectabilis (Reeve, 1843)

(Color pl. 181, figs. 16, 17)

Range – Western Indian Ocean to Melanesia and the Phoenix Islands.

Remarks – This gaily painted shell was relegated to the synonymy of *babylonia* by Tryon (1884, p. 162) but it is distinct from that species in having a shorter anterior canal, different sculpture and a characteristic colour pattern. It resembles *garnonsii* in its slender whorls and tendency toward wide dash-like maculations but differs in the shorter canal and broad light-brown zones both on the shoulder and on the base. It is evidently an uncommon species.

Description – Shell up to 80 mm (3 inches) in height. Spire 30° to 32°, tall but rather broad, 1.2 times the height of the aperture plus canal. Spire whorls with a single, narrowly rounded, spiral cord in place of the subsutural fold. Sinus rib narrow and rounded, weakly gemmate over the early whorls. Peripheral carina massive, followed below by a less prominent spiral keel, just emergent at the lower suture. On the base there are 6 additional primary cords which are strong, although narrowly rounded and wide-spaced. Colour variegated, basically golden-brown except for a broad, white, peripheral band. All primary spirals maculated with dark-brown dashes and dots.

Measurements (mm.) —

height	width	
80.2	22.3	Direction Id., Cocos-Keeling (ANSP)
76.0	20.0	Cebu Id., Philippines (Brit. Mus.)
68.5	20.0	Cebu Id., Philippines (Brit. Mus.)
64.0	19.5	Mios Woendi, Dutch New Guinea (ANSP)
55.0	16.5	Cebu Id., Philippines (Brit. Mus.)
42.0	15.0	Mauritius (Powell coll.)

Synonymy —

1843 *Pleurotoma spectabilis* Reeve, Conch. Iconica **1**, pl. 1, fig. 6, a, b.
1875 *Pleurotoma spectabilis* Weinkauff, Martini and Chemn., Conch.-Cab., Pleurotomidae 4(3), p. 22, pl. 4, fig. 9.
1922 *Turris spectabilis* Hedley, Rec. Australian Mus. **13**(6), p. 217.

Types — The type locality is Ticao Id., Philippines, Hugh Cuming, collector. The type was not located in the British Museum (Natural History). There are three specimens in the Cuming collection fastened to a wooden tablet and the middle one resembles Reeve's figure, but they are labelled "Island of Zebu."

Records — MAURITIUS: (A. W. B. Powell coll.). ADEN: (Australian Mus.). COCOS-KEELING: Direction Id. (V. Orr and R. Ostheimer, 1963, ANSP). ANDAMAN ISLANDS: near Port Blair (Natal Mus.). PHILIPPINES: Ticao Id. (type); Cebu Id. (Cuming coll., Brit. Mus.). DUTCH NEW GUINEA: reef 1 mi. N.E. of Mios Woendi Id., Padaido Ids. (NSF, 1956, ANSP). SOLOMON ISLANDS: Malaita Id. (Powell coll.). AUSTRALIA: Queensland: 20 fms., Darnley Id. (Australian Mus.); Tryon Id., Capricorn Group (Mrs. J. Kerslake). MARSHALL ISLANDS: Eniaetok Id., Rongelap (USNM). FIJI: Ngualito Id., off north coast, under rocks partially buried in sand (W. Jennings, 1961). PHOENIX ISLANDS: Canton Id. (Cal. Acad. Sci.).

Turris ambages Barnard, 1958

Range — Off Natal and Zululand, South Africa.

Remarks — No figure of the complete shell is given, just two line drawings, one of the protoconch and one of the sculptural detail of one whorl (which whorl not stated). The only clue to the location of this species is the author's comparison of it with *fagina*.

Nothing further can be done with this species without recourse to the type specimens and from the description it would appear that all of these are immature.

Description (from the original) — "Protoconch 3 whorls, diam. 1.25 to 1.3 mm., alt. 1.3 to 1.5 mm., with axial riblets (as in *Turris*). Postnatal whorls with four strong spiral keels (profile of whorl 4-lobate), 1st rather sharp, forming the cingulum, 2nd rounded forming the lip sinus, with growth-lines producing more or less conspicuous squamiform nodules, 3rd the most prominent, rounded, forming the periphery, below this the smaller 4th keel; base with about 10 additional lirae. 17 × 7 mm. (protoconch and 7 whorls); 25 × 8 (protoconch and 8 whorls); a broken specimen 30 mm. long, with 5 whorls corresponding to the 5th to 8th whorls plus a portion of the 9th whorl. The 17 mm. example is whitish, with traces of irregular brown spots and streaks."

Measurements (mm.) — (See above)

Synonymy —

1958 *Turris ambages* Barnard, Ann. South African Mus., 44, p. 148, fig. 23b.

Types — The holotype is in the South African Museum.

Records — SOUTH AFRICA: Off Cape Natal (Durban), 54 fms., 2 broken specimens; off Umkomaas River, 41 fms., 1 (17 mm. long); off O'Neil Peak (Zululand), 90 fms., 1 (25 mm. long).

Australian Tertiary Species

Turris selwyni (Pritchard, 1904)

Range — Balcombian Miocene of Victoria, Australia.

Remarks — Related to *septemlirata* but a smaller shell, 28 to 38 mm. (1 to 1½ inches) in height, proportionately broader, with the spire less than height of aperture plus canal. Sculpture consisting of spiral keels, two on early whorls, three medially and a fourth half-emergent over the last half-whorl. The sinus rib is composed of a pair of sharp cords with a smooth, narrow, concavity between, and this is situated just above the greatest convexity, at about two-thirds whorl height.

This and the following Australian Miocene species resemble Recent *annulata*.

Measurements (mm.) —

height	width	
38.0	17	holotype
32.7	14	Balcombe Bay, Victoria

Synonymy —

1904 *Pleurotoma selwyni* Pritchard, Proc. Roy. Soc. Vict. **17**, p. 326, pl. 19, fig. 1.
1944 *Turris selwyni* Pritchard, Powell, Rec. Auck. Inst. Mus. 3(1), p. 8.

Records — AUSTRALIA: Muddy Creek, lower beds, Victoria (type); Balcombe Bay, Victoria (Balcombian, Miocene).

Turris septemlirata (Harris, 1897)

Range – Balcombian Miocene of Victoria, Australia.

Description – Adult shell 50 to 60 mm. (2 to 2¾ inches) in height, broadly fusiform, with an attenuated spire but a somewhat truncated and twisted anterior canal. Spire 1.3 times the height of the aperture plus canal. Sculpture of prominent, rounded spiral keels, 4 on the penultimate; the rather deep and narrow sinus is situated on the second keel from the top, which is the one just above the greatest convexity of the whorls. The species bears some resemblance to the Recent *annulata* Reeve.

Measurements (mm.) –

height	width	
60.0	22.0	holotype
46.0	16.0	Muddy Creek, lower beds

Synonymy –

1896 *Pleurotoma perarata* (Tate ms.) Cossmann, Ess. Pal. Comp. **2**, p. 77.
1897 *Pleurotoma septemlirata* Harris, Cat. Tert. Moll. Brit. Mus. **1**, p. 39, pl. 2, figs. 10a-d.
1898 *Pleurotoma septemlirata* Harris, Tate, Proc. Roy. Soc. N.S.W. **31**, p. 392.
1944 *Turris septemliratus* Harris, Powell, Rec. Auck. Inst. Mus. **3**(1), p. 8.

Types – The holotype is in the British Museum (Natural History).

Records – AUSTRALIA: Muddy Creek, Victoria, "Eocene" = Balcombian, Miocene (type); Muddy Creek, lower beds; Grice's Creek and Altona Shaft, Victoria (Balcombian).

? Turris ugaliensis Makiyama, 1927

Range – Japan, Kakegawa Series (Lower Pliocene) and Tano (Middle Miocene).

Remarks – This species should not have been described, for the type specimen consists solely of a broken shell of which only the body whorl remains. The Miocene material ascribed to this species, with reservation, by Shuto (1961, p. 79) is also imperfect.

The original author compared his species with *unedo* Kiener (which is an *Unedogemmula*) to *leucotropis* (which is a *Lophioturris*) and *gendinganensis* Martin (which is considered to be a synonym of *Lophiotoma* (*Lophioturris*) *indica* (Röding)). No useful purpose can be served by trying to evaluate this species on the evidence at present available.

Synonymy –

1927 *Turris ugaliensis* Makiyama, Mem. Coll. Sci. Kyoto Imp. Univ., Ser. B, **3**(1), p. 93, pl. 4, fig. 18.
1952 *Turris ugaliensis* Makiyama, Hatai and Nisiyama, Sci. Rep. Tohoku Univ., 2nd Ser., Geol. Spec. **3**, p. 263.
1961 *Turris* cf. *ugariensis* (sic) Makiyama, Shuto, Mem. Fac. Sci. Kyushu Univ., Ser. D, Geol., **11**(2), p. 78.

Genus Antiplanes Dall, 1902

(Pl. 261)

Type: *Pleurotoma voyi* Gabb, 1866

This moderately large, sinistral shell and its dextral forms *Rectiplanes* and *Rectisulcus* are mostly deep-water and characteristic of low temperatures. They range from off the Californian coast to Alaska and around the Bering Sea to Kamchatka and Japan. Also post-Pleistocene of California.

The genus could be regarded as a benthic, Boreal, cold-water development from *Turris*, in which a great reduction in sculpture and the acquisition of a thick periostracum has taken place, this latter feature being typical of high latitude shellfish that have to contend with the greater erosive action of ice-diluted sea water.

The sinus is broadly open, extending from the suture to below the periphery but the actual apex of the sinus is immediately above the greatest peripheral convexity. The shell ranges to 55 mm. (2¼ inches) in height, has a tall narrow spire but a truncated anterior end. Operculum leaf-shaped, with apical nucleus. Protoconch smooth, paucispiral and globular with an asymmetric inrolled top. Radula a pair of "wishbone"-shaped marginals plus a vestigial central tooth.

Plate 261. *Antiplanes voyi* (Gabb, 1866). Eastern Pacific Recent, deep-water. 40 mm. (*perversa* Gabb, 1865, non Philippi, 1847).

Although this genus occurs off the coasts of warm temperate localities, Japan for instance, it is confined to the colder waters of the sea bottom, and thus cannot be considered inclusive in the Indo-Pacific fauna.

Synonymy —

1902 *Antiplanes* Dall, Proc. U. S. National Mus., 24, p. 513. **Type** by original designation: *Pleurotoma perversa* Gabb, 1865 (non Philippi, 1847) = *voyi* Gabb, 1866.

Characteristic Species — POST-PLIOCENE TO RECENT: *voyi* Gabb, 1866; *contraria* Yokoyama, 1928; *kamchatica* Dall, 1919; *major* Bartsch, 1944.

Subgenus Rectiplanes Bartsch, 1944

(Pl. 262)

Type: *Pleurotoma (Antiplanes) santarosana* Dall, 1902

This subgenus differs from *Antiplanes* in being dextral instead of sinistral.

Synonymy —

1944 *Rectiplanes* Bartsch, Proc. Biol. Soc. Washington, 57, p. 59. **Type** by original designation: *Pleurotoma (Antiplanes) santarosana* Dall, 1902.

Characteristic Species — RECENT: *litus* Dall, 1919; *rotula* Dall, 1921; *sanctiioannis* E. A. Smith, 1875; *santarosana* Dall, 1902; *thalaea* Dall, 1902; *kawamurai* Habe, 1938.

Subgenus Rectisulcus Habe, 1958

Type: *Rectiplanes (Rectisulcus) motojimai* Habe, 1958

This subgenus differs from *Rectiplanes* only in having spiral cords on the surface and in lacking longitudinal cords on the early whorls. Recent, Japan. It seems to have insufficient distinction from *Rectiplanes*.

Synonymy —

1958 *Rectisulcus* Habe, Venus, Tokyo **20**(2), p. 184. **Type** by original designation: *Rectiplanes (Rectisulcus) motojimai* Habe, 1958.

Characteristic Species — RECENT: *isaotakii* Habe, 1958; *motojimai* Habe, 1958 (both off Choshi, Chiba Pref., Honshu Id., Japan).

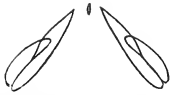

Plate 262. Radula of *Rectiplanes santarosana* Dall. Eastern Pacific, Recent (prepared and drawn by J. P. E. Morrison, U.S. Nat. Mus.).

[These occasional blank areas occur between genera and subgenera to permit the insertion of new material and future sections in their proper systematic sequence.]

INDEX TO *TURRINAE* NAMES IN VOL. 1, NO. 5

Looseleaf subscribers should place this index at the beginning of the family Turridae. The subfamily Turrinae begins on p. [22-661].

In this index, the number following the name refers to the pagination found at the top of the page in vol. 1, no. 5. The column at the right is the looseleaf pagination.

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THE FAMILY TRIDACNIDAE IN THE INDO-PACIFIC

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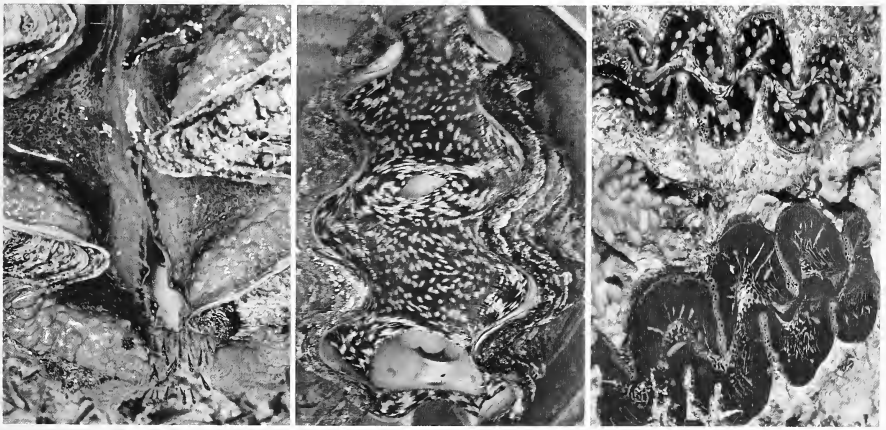
Washington, D. C.

The Giant Clams of the family Tridacnidae are highly specialized bivalves which today are restricted to the Indo-Pacific faunal region. The family is geologically young, having existed from Eocene to Recent times, and evidently having arisen from some cardiid-like ancestor in the Eocene. Only six species are living today.

These bivalves are obligatory inhabitants of the shallower waters of coral reefs. As adults they are incapable of locomotion and rest with the umbos and hinge downward and the free edge of the shell uppermost. Depending upon the species they are either unattached or in burrows in the coral, tightly fastened with a byssus. When covered by the tide, the valves are opened and the mantle lobes protrude in two parallel, often highly colorful, undulate bands.

Life History

Members of the family Tridacnidae are protandrous hermaphrodites (Stephenson 1934; Grobben, 1898; and Wada, 1942, 1952, 1954). Fertilization experiments with *Hippopus hippopus* conducted by Stephenson *(ibid.)* failed to produce normally developing young. The adults spawned during the warmest months of the Australian summer. Wada examined the gonads of 6 species in the Palau Islands and found both male and female sex cells in larger individuals, He found most younger individuals to be males with the hermaphroditic condition becoming apparent as maturity was reached. He also described the spawning reaction, apparently typical for the family, which is triggered by some factor contained in a suspension of the ani-



1 2 3

Plate 263. Mantles of *Tridacna*

Fig. 1, *Tridacna (Tridacna) gigas* (Linné). Close-up of inhalent siphon; note school of small, dark-green fish (at lower center) oriented to the respiratory current.

Fig. 2, *Tridacna (Chametrachea) squamosa* Lamarck. Note gaping siphons and withdrawn mantle, probably indicating fatigue. Palau Islands; photo by George F. Kline.

Fig. 3, *Tridacna (Chametrachea) maxima* (Röding). Two variations in color pattern. Both figs. 1 and 3 from Great Barrier Reef; photos courtesy of the National Geographic Society (copyrighted).

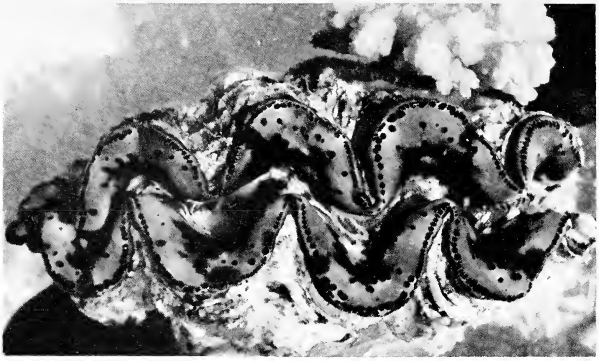


Plate 264. Valves agape showing the fleshy mantle expanded in *Tridacna (Chametrachea) maxima* (Röding). Dorsal view of living animal 150 mm. (6 inches) in length from Eniwetok Atoll, Marshall Islands. (J. Rosewater photo from *Turtox News*, vol. 41, no. 12, 1963).

mals' eggs and which causes repeated contractions of the adductor muscle and closure of the valves coupled with the release of the sex cells for a period of an hour or more. I repeated these spawning reaction experiments successfully with *Tridacna squamosa* at Eniwetok, Marshall Islands, but attempts to observe the development of the apparently fertilized eggs failed when they degenerated (personal observations, February-March 1963). In nature, spawning in ripe individuals is probably triggered by an optimum temperature which supports the normal embryological development, and many other factors may be involved. As yet the embryology, larvae and early development of the Tridacnidae are unknown, although Vaillant (1865), on the basis of morphology, suggested that an incubation period may be passed within the parent.

Estimates on the duration of life in *Tridacna* range from 8 years (Pelseneer, 1894) to several hundred years (Comfort, 1957). No well documented observations have been made on the growth rate or age attained.

Bartsch (1945) suggested that *Tridacna* must grow at the same rate as Pacific corals, i.e., about 2 inches a year. My preliminary growth data from specimens placed in the lagoon off Eniwetok Island, Eniwetok Atoll, indicate that Bartsch's estimate may be nearly correct for medium-sized specimens under "normal conditions" (personal observations, 1963). Specimen "A" of *Tridacna gigas* increased 6.7 percent in length (559 to 597 mm.) in 135 days (March 20 to August 2, 1963). It increased an additional 2.3 percent in length during the next 6 months (610 mm. by February 8, 1964), thus having made a total increment of 51 mm. (9 percent) in 11.5 months. Specimen "B" of *Tridacna gigas* (597 mm.) and a *Hippopus hippopus* (254 mm.) unfortunately died at some time before the second measuring, so that the respective increments of 3 percent and 4 percent are inconclusive. If the growth rate of *T. gigas* "A" remained constant throughout life at 2 inches per year, the specimen measuring 610 mm. (= 24 inches) could be 12 years old. It is probable that rate of growth changes during the life of a *Tridacna*, being faster in young individuals than in older ones (cf. Comfort, *ibid.*, p. 232). The experimental animals were placed in the lagoon near the Eniwetok Marine Biological Laboratory after having been moved a considerable distance from their original locations and were observed in the laboratory for several weeks. It is, therefore, doubtful that their condition was normal (two died); and it cannot be assumed that their growth proceeded naturally. Other unfavorable factors are that the three measurements were made by different persons, and the second and third measurements were made under water. It is hoped that persons permanently located in the Indo-Pacific regions will undertake long-range studies of the life history and growth of the Tridacnidae so that reliable data may be accumulated.

Algal Symbiosis

The specialized habit, habitat and morphology of the Tridacnidae may be considered adaptations to a singular method of feeding which has become

highly developed in this group. Most lamellibranchs are ciliary feeders on minute particles of plant life present in the water. These are carried into the mantle cavity by a respiratory-feeding current generated by ciliary tracts on the gills. Food is carried to the region of the mouth and sorted on the labial palps. Desirable particles are consumed and rejected ones cast off. But the Tridacnidae do not entirely depend on food removed from the surrounding water for nourishment. As shown by Yonge (1936) the Tridacnidae are able to "farm" much food in their own tissues due to an unusual association with large numbers of unicellular, symbiotic algae, called zooxanthellae (see Yonge, 1963, pp. 232-245).

Zooxanthellae are known to be present in a variety of marine organisms, the best known being the reef corals. They also live in association with protozoa, flatworms, other coelenterates and nudibranchs, where their presence is said to be correlated with positive phototropism in these animals (Kawaguti, 1944; Hornell, 1909). The only other bivalve known to harbor zooxanthellae is *Corculum cardissa* (Linné) (Kawaguti, 1950).

In species of *Tridacna* and to a lesser extent in *Hippopus* the zooxanthellae are "farmed" within the great expanse of thickened mantle edge exposed by the animals when they are covered by the tide. In the shallow water in which these bivalves live, the plants are provided with maximum light for photosynthesis. Special structures in the mantle surface of *Tridacna* only, called hyaline organs (see pl. 265), increase the translucency of the tissue, and around these the zooxanthellae are found in greatest numbers. The algae are always contained in the phagocytes of the clam, and when required for food, the zooxanthellae are carried through blood spaces to the digestive gland. There digestion occurs, still within the phagocytes, and the products of digestion are probably stored in the digestive diverticula. The members of this family, therefore, have at their disposal a ready source of nourishment. This type of feeding is probably supplemented by food obtained in the normal manner. However, in most species portions of the normal feeding apparatus appear to have undergone degeneration, indicating a great dependence upon the zooxanthellae.

It would be of interest to learn how the original association of the giant clams with the algae came about, and how the clam receives its zooxanthellae during individual development. In the first case, Yonge (1936) has suggested that this might have occurred by chance infestations with zooxanthellae of the siphonal areas of ancestors of *Tridacna*. These may have been the same algae as those inhabiting coral animals, although a similar feeding relationship of corals with their algae does not appear to exist (but see Goreau, 1964; also Yonge, 1963). Individuals able to utilize this additional food probably were more prone to survive. The capacity was enhanced in time through natural selection and exists today in its highly developed form. The clam-alga relationship may be termed a symbiotic mutualism (Allee, et al., 1949), an association which is beneficial to both parties, but in the end is at least partially detrimental to one of its members. The zooxanthellae are provided a

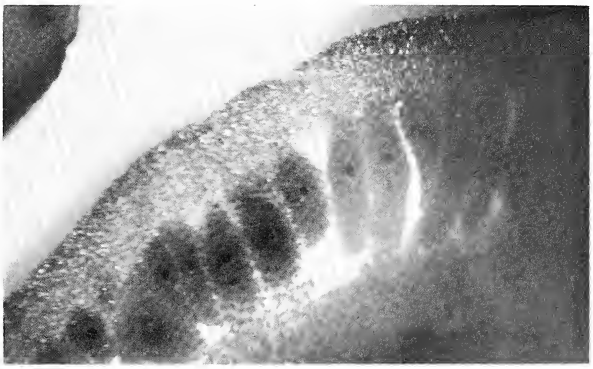


Plate 265. Enlarged view of the edge of the mantle of *T. maxima* showing the hyaline organs (dark spots) at the centers of aggregations of zooxanthellae algae. (J. Rosewater photo from *Turtox News*, vol. 41, no. 12, 1963).

place to live, raw materials from the catabolism of the clam for the manufacture of their food and special provision for intensification of sunlight for photosynthesis. Eventually they may be digested. However, the numbers consumed are probably never sufficient to deplete a colony in an individual clam. Obviously the clam benefits from this relationship. It has a constant supply of living food, and its waste products are partially removed by the algae. Possibly, because of these factors, some of the species have attained an extremely large size. In order to use this special source of food to optimum advantage, the Tridacnidae have evolved unique morphological modifications (see Morphology).

Commensalism

In addition to the zooxanthellae contained in their tissues, the Tridacnidae serve as hosts to a number of other organisms which live on the surface of the valves, burrow into the shell, or inhabit the mantle cavity. As mentioned by Roscoe (1962) the valves are often encrusted with a wide variety of smaller coral reef denizens. In spite of the hardness of the shell it is common to find burrows of such bivalves as *Lithophaga* and *Gastrochaena*. Since *Lithophaga* burrows by chemically dissolving limy materials (Yonge, 1955; Turner and Boss, 1962) the hardness of the shell would not prevent its penetration.

Holthuis (1952) listed the shrimps of the family Palaemonidae, subfamily Pontoniinae, which are known commensals with Tridacnidae. None of these species is the same as those commensal with members of the family Pinnidae (Holthuis, op. cit.; Rosewater, 1961). The same three genera are involved, however: *Paranchistus*, *Anchistus*, and *Conchodytes*. Most of the species are enumerated later in this paper under their *Tridacna* hosts, but two, *Anchistus maculatus* (Stimpson), and *A. spinuliferus* (Miers), are reported from *Tridacna* "sp." only.

Morphology of the Tridacnidae

The shell of a "normal" bivalve can be anatomically oriented by holding its valves together in their naturally opposed position with the umbos uppermost and pointing away from the holder. In this position, the right side of the mollusk and its shell are to the holder's right, and the left to the holder's left. The umbos and hinge are uppermost or dorsal, and the free edges of the valves are below or ventral. The ends of the valves pointing away from the holder are the front or anterior end, and those opposite are the hind or posterior end. The body within the valves is oriented similarly. Its mouth is anterior; the siphons are posterior; the foot projects antero-ventrally from between the free edges of the valves.

Orientation of the valves of the Tridacnidae is somewhat different from the procedure followed for a "normal" bivalve. Certain changes have taken place during the evolution of the giant clams in regard to the morphology of the shell and of the animal as a result of the special feeding relationship with zooxanthellae (Yonge, 1936; 1953a). These changes are easily understood when explained in terms of functional anatomy (see pls. 266 and 269).

Natural selection for more efficient means of farming zooxanthellae has led to an increase in the size of the mantle. The original infestation with the algae probably occurred in the siphonal region,

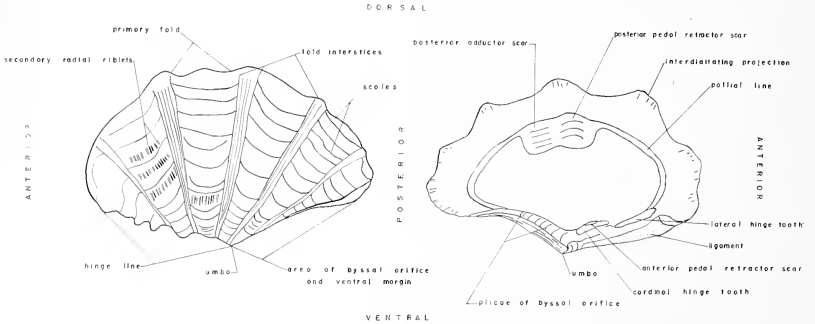


Plate 266. Diagrammatic sketch of the anatomical features of the valves of *Tridacna*.

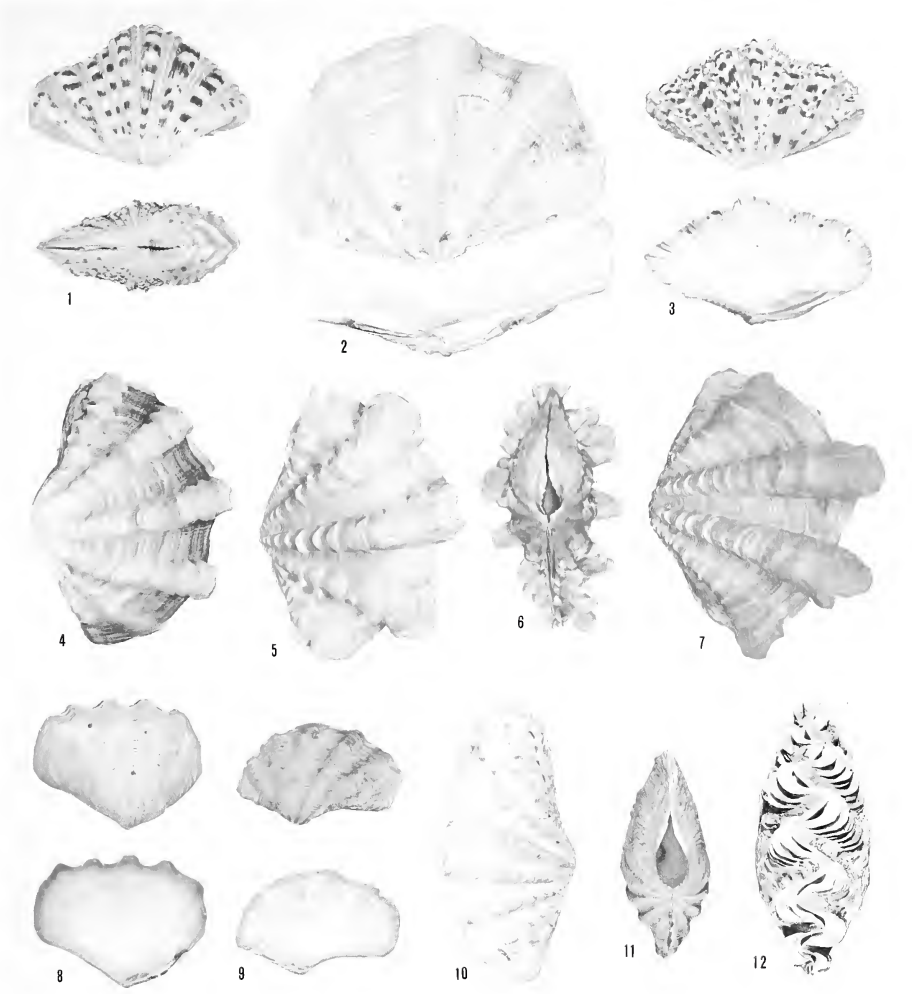


Plate 267

Figs. 1, 3 *Hippopus hippopus* (Linné). Near Cebu City, Cebu Island, Philippines.
2 *Tridacna (Tridacna) gigas* (Linné). Young specimen from Noekori Island, East Padaido Islands, New Guinea.
4-7 *Tridacna (Chametrachea) squamosa* Lamarck. Malakal Harbor, Koror Island, Palau Islands.
8 *Tridacna (Chametrachea) crocea* Lamarck. Near Zamboanga, Mindanao Island, Philippines.
Figs. 9-12 *Tridacna (Chametrachea) maxima* (Röding).
9 Near Zamboanga, Mindanao Island, Philippines.
10 Moluccas Islands, Indonesia.
11 Gigmoto, Catandnanes Island, Philippines.
12 Near Darwin, Northern Territory, Australia.
(all approximately 1/3 natural size)

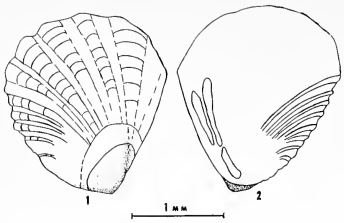


Plate 268. Nepionic valves of *Tridacna (Chametrachea) maxima* (Röding) from Raroia, Tuamotu Islands. Fig. 1, exterior. Fig. 2, interior.

posteriorly located in the tridacnid ancestor. From that location they spread to surrounding mantle tissues. To provide additional area, and more beneficial lighting conditions for farming, individuals with genes for larger and more dorsally located siphonal regions were selected. During the evolution of *Tridacna,* but not *Hippopus,* hyaline organs were developed and proved of value in increasing penetration of light through the mantle surface for growth of the algae. Eventually, the excurrent siphon became located mid-dorsally, and the incurrent siphon moved to a position high on the posterior end. During this forward and dorsal movement, associated mantle-siphon tissue spread over the dorsal, open edges of the shell, also spread laterally, and became considerably thickened. Because the mantle produces the shell, any change in the former structure is reflected in the latter. The umbos, hinge, and ligament have been pushed anteroventrally by the anterior growth of the plant-farming tissues. Thus, in relation to the body of *Tridacna,* which is fixed by the byssus during the early stages of its existence, the mantle and shell have come to take a position so that the umbos are ventral instead of dorsal, and point posteriorly instead of anteriorly. The anterior hinge teeth are lost and the posterior ones are actually located anterior to the umbos. The open edges of the shell, usually ventral, are dorsal-most in position. The foot and byssus protrude from an area of the shell, once the antero-ventral slope, which is now posterior to the umbos, but still ventral in position. This area has probably undergone the least amount of "rotation" because of the presence here of the byssus which attaches to the substrate ventrally.

Valves of Tridacnidae may be oriented anatomically by holding them in an opposed position with the umbos down and the hinge away from the holder. In this position, the hinge end is anterior; the opposite end is posterior; the open edges of the valves are uppermost (dorsal), and the umbos and byssal orifice are down (ventral in position). The right valve is to the holder's right and the left to the holder's left (see plate 266).

With the exception of the expansion of the mantle-siphon tissues, the remainder of the soft anatomy of Tridacnidae is grossly similar to that of other bivalves. There is evidence of slight depression antero-ventrally of some organs, notably the ctenidia and palps, and there is forward displacement of the anus (Yonge, 1953b).

During the "revolution" of the mantle and shell

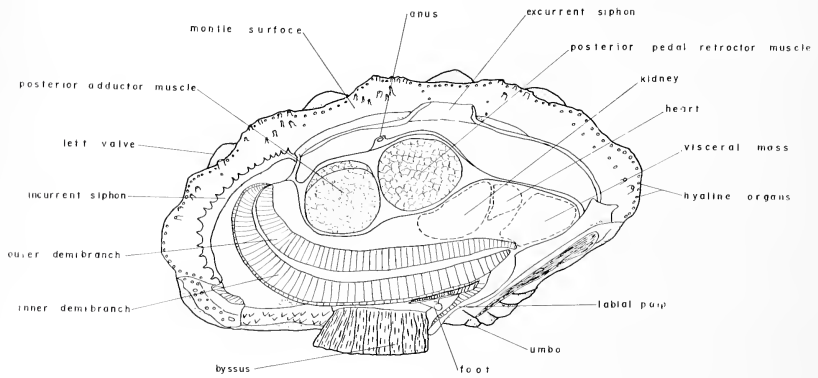


Plate 269. Diagrammatic sketch of *Tridacna (Chametrachea) maxima;* right valve and half of mantle removed to show organs of mantle cavity (after Stasek, 1962).

which brought the normally dorsal umbos to a ventral position, the anterior adductor muscle was lost, and the anterior pedal retractor was displaced posteriorly and ventrally to its present location on the superior surface of the cardinal tooth (Stasek, 1962). There remain only two major, circular muscle scars in each valve. The posterior pedal or byssal retractor muscle scar is contiguous with and located anterior to the posterior adductor scar. Both are located somewhat subcentrally and vary in size depending on the species (see plate 269).

Mantle retractor muscles are thickly produced and their scars are evident as a broad band extending from the anteriorly located hinge around each valve subperipherally to a point near the posterior end of the byssal orifice (pallial line; see pl. 269). This long, broad muscle attachment enables the animal to retract the large amount of mantle-siphon tissue which is exposed to light during farming of the zooxanthellae.

Stasek (1962, pp. 15-21, figs. 8, 9) by reference to the extinct genera *Goniocardium*, *Avicularium* and *Byssocardium*, has shown how members of the Recent genera *Hippopus* and *Tridacna* may have evolved from a cardiid-like form to their present modified condition (see plate 270). The tridacnoid shell has "rotated" relative to the body proper in the sense that, allometrically, the postero-ventral margin of the mantle/shell greatly enlarges, thereby greatly changing its position relative to the body proper.

Sawkinsia Cox, 1941, which was assigned to the Tridacnidae by Vokes [1953] seems to represent a side branch in the evolution of the family, not fitting into Stasek's theory of a "gradual shift in the central tendency of succeeding populations towards more familiar 'tridacnoid' forms."

Geographic Distribution of Tridacnidae

Recent Species — The geographic distribution of Tridacnidae almost appears to be correlated with maximum shell size and with ecology, but undoubtedly many other factors are involved. Larger species, *Tridacna gigas*, *T. derasa* and *Hippopus hippopus*, are limited to the western Pacific and Micronesia. These species, when mature, depend on weight alone to anchor them in position on the reef. Ecological requirements and possibly short larval life may confine them to their present range. *Tridacna crocea*, a deep burrower in coral, has a rather narrow range similar to the larger species. The range of *T. squamosa*, a medium-sized species, extends from central Polynesia (165° w. long.) westward to East Africa. This species depends for stabilization on its weight and the lodging of its valves, with their projecting scales, among the reef corals. A gelatinous byssus anchors *T. squamosa*, although not so firmly as in the burrowing species. *Tridacna maxima* is nearly pandemic in the Indo-Pacific, ranging from East Africa to southeastern Polynesia. This species protects itself and prevents dislodgement by boring shallow pockets in coral. Although details of its reproduction and development are unknown at present, it is suspected to have a longer larval life than other members of the family.

Fossil Taxa — There are few fossil records of forms resembling Recent species in areas other than the Indo-Pacific. *Tridacna media* Pusch and *T. wol-*

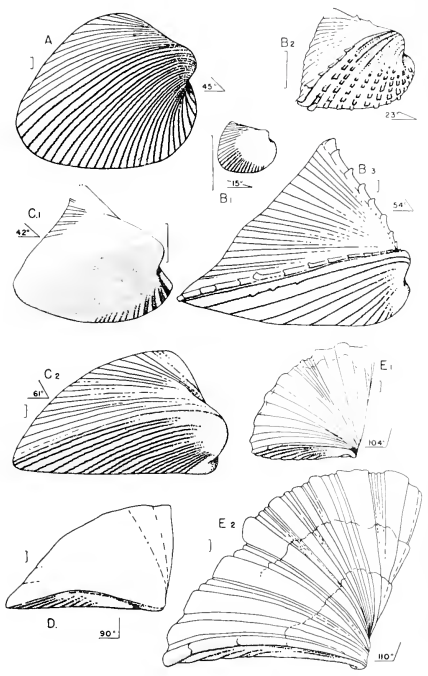


Plate 270. Fossil Tridacnidae. Right valves of various genera showing the gradual increase in the dorso-ventral angle as the relative length of the inferior or byssal edge increases. **A**, *Goniocardium rachitis* (Deshayes). **B**, *Avicularium avicularе* (Lamarck). **C**, *Avicularium cymbulare* (Lamarck). **D**, *Byssocardium emarginatum* (Deshayes). **E**, *Hippopus hippopus* (Linné) from the Recent. Stems of brackets indicate 1 mm. (from C. R. Stasek, 1962, fig. 8).

farti Chenu, both from Europe, are very similar to *T. maxima* and to *T. gigas* respectively. These fossil species inhabited this area during the middle Tertiary apparently when arms of warmer seas extended into northern Europe. The fossil *Hippopus* (?) *gunteri* Mansfield from the Tampa Limestone is the only Western Atlantic representative of this Recent genus. It probably inhabited reefs on the shores of the Tethys Sea during the Lower Miocene.

Wholly extinct fossil genera and species which have been associated with Tridacnidae are all European with the exception of *Avicularium trechmanni* Cox, 1941 (see Stasek, 1962) and *Sawkinsia matleyi* Cox, 1941 (fide Vokes [1953, p. 121]), both from the Eocene of Jamaica (see *List of Recognized Taxa*).

Economic Importance

Species of Tridacnidae are used as food in many parts of the Indo-Pacific. *Tridacna maxima* is the most popular species, and records of its consumption range from southeast Asia (Abbott, 1950) to the Tuamotus (H. A. Rehder, oral communication, 1962). The natives eat them raw or cooked, and there is some commerce in dried *Tridacna* flesh. Although some peoples probably consume the entire animal, the mantle is thick and leathery and is said to have an unpleasant flavor due to the presence of the symbiotic algae; therefore, as a rule, it is the large posterior adductor and pedal retractor muscles which are eaten.

On Onotoa Atoll, Gilbert Islands, *Hippopus hippopus* and species of *Tridacna* are either eaten raw, boiled with water or coconut milk, or dried and preserved with salt. The valves of *Hippopus* are also used as wash basins. Live specimens are sometimes held in underwater pens to keep them fresh and allow them to reach a larger size (Banner, 1952). On Arno Atoll, Marshall Islands, the natives infrequently eat *Tridacna*, but they do use giant clams to fertilize breadfruit trees. There they are considered less desirable to eat than fish (Hiatt, 1951).

The hard shells of *Tridacna* are used by natives of the Pacific Islands for making various tools, such as mallets, hoes, scrapers, betel-nut pounders and ceremonial fetishes (personal communication, Mrs. R. T. Gallemore, W. Caroline Islands, 1962). Centrally perforated discs of *Tridacna* shell have been used as money in the Solomon Islands. Some of these discs reach 9 inches (228 mm.) in diameter and are 2 inches thick (personal communication, H. A. Rehder, 1964). Hedley (1921) reported the use of *Tridacna* valves as catch basins for water on Warrior Island, Torres Strait.

Non-nacreous pearls of Tridacnidae have little market value, except as curiosities and momentos, although one was valued at between 200 and 300 English Pounds in 1814 (Dillwyn, 1817, p. 215). The largest known *Tridacna* pearl came from a specimen of *T. gigas* collected in the Philippines. The "Pearl of Allah", as the concretion came to be called, weighed 14 pounds and measured 9½ by 5½ inches. The clam which formed the pearl is supposed to have been responsible for the death of the diver who found it, and there is an interesting story connected with the acquisition of the pearl (Cobb, 1939). A 14-pound pearl, undoubtedly the "Pearl of Allah", was shown in a 1964 telecast and is now displayed in the shop of a Los Angeles, California jeweler ("Between the Tides," 1963). So-called coconut pearls of the East Indies have been traced to *Tridacna* (Reyne, 1947).

A fairly recent economic use of the Tridacnidae is in the aquarists' trade. Living specimens of one of the smaller species, *T. maxima,* are occasionally on sale in the Washington, D. C. area, and probably in other cities. These specimens are imported from Singapore several times a year. An inquiry made at the store of a local dealer revealed that the *Tridacna* were maintained in aquaria constructed of heavy plastic which were filled with aerated artificial seawater. According to the dealer, for the "Giant Killer Clam" to survive, it was necessary to include in the aquarium a piece of algae-covered coral "rock" for the clam to rest on and attach its byssus (see Nicol, 1963). *Tridacna* and *Hippopus hippopus* were kept in running seawater aquaria at the Eniwetok Marine Biological Laboratory for 5 or 6 weeks without coral "rocks." *Tridacna maxima,* a species which normally fastens tightly to coral by its byssus, always attached byssal threads to the floor of the aquaria. Specimens were removed, sometimes daily, for examination, and usually were found to have secreted new attachments. Specimens seemed to survive well in aquaria, but near the end of the period of captivity showed signs of diminished vigor and mantle coloration (personal observation). It is believed that this was due to the reduced light in the laboratory failing to support normal growth of zooxanthellae in the mantle tissues. The clams probably were slowly starving. It is not anticipated that *Tridacna* will become a common household pet. The price of a living specimen is currently about 20 dollars, and unless given painstaking care it is doubtful that the clam would survive in captivity longer than a few

months.

It may be of considerable interest to philatelists that species of *Tridacna* have been figured on postage stamps of at least four countries of the Indo-Pacific region. Binker (1964) illustrated two of these: *T. squamosa* (French Somalia); *T. maxima* (Comoro Islands); and mentioned that a stylized *T. gigas* has been used on three stamps issued by the Cook Islands. A species (*maxima* Röding) is shown on the 20 F stamp of French Polynesia.

Probably the single most economically important use of the valves of the Tridacnidae is for their display value. Anywhere in the world one is liable to see a pair of valves of *Tridacna gigas* ornamenting the front steps of a home, used on the lawn as a bird bath, or as a receptacle for a small flower bed. Large valves of *Tridacna* have been used in churches as baptismal fonts. Lamarck (1819, p. 105) mentioned this use, in the Church of Saint Sulpice in Paris, of a specimen given to Francis I by the Republic of Venice (36 inches in length; seen by R. T. Abbott, personal communication, 1962). A substantial fishery exists for display specimens of *Tridacna* in the Palau Islands and the Philippines. These and many other species of mollusks are listed for sale, either singly or in bulk, in various shell dealers' catalogues. If it were not for the large reproductive potential of most marine mollusks, we should look forward to the early extinction of many of them in the areas where they are collected in such enormous quantities.

Taxonomy of the Tridacnidae

In the systematic portion of this paper genera and species are placed in what is believed to be an order of increasing phylogenetic complexity. This placement has been suggested by evaluating the primitiveness or complexity of a group or species through a consideration of the animals' anatomy in relation to its environment and ecology.

The geologic history of Recent genera gives little help in determining placement, since both *Hippopus* and *Tridacna* arose in the early Miocene. Stasek (1962) has discussed the relationships of Recent Tridacnidae and their probable fossil ancestors and proposed that *Hippopus* and *Tridacna* arose independently from some *Byssocardium*-like ancestor. He is undoubtedly correct in stating that the two arose separately, rather than the latter evolving from the former. *Hippopus* is placed first here because it resembles more closely in shape the fossil *Byssocardium*, possesses a fully developed outer demibranch and lacks a definitive byssal orifice, although immature *Hippopus* is byssally attached, and there is a considerable gape in the ventral margin even in living adult specimens when they are relaxed and siphoning. Hyaline organs are lacking in *Hippopus*, which also may indicate a primitive situation. Zooxanthellae are present beneath a fairly transparent mantle surface which may be a substitute for the lens-like structures found in *Tridacna*.

The genus *Tridacna sensu lato* is the only other major taxon in the family. On the basis of its anatomy and ecology, *Tridacna gigas*, the type-species of *Tridacna sensu stricto*, is the least specialized species of the genus. It has a complete outer demibranch and a small byssal orifice. Adult individuals live unattached on sandy bottoms and attain a very large size (1370 mm.). Hyaline organs are very numerous in the mantle surface.

Tridacna derasa differs sufficiently from other Recent species to justify the acceptance of the subgenus *Persikima* for it. This species is considered intermediate between *T. (T.) gigas* and the remaining species because it attains a considerable size (514 mm.), has a very small byssal orifice and lives, in adulthood, unattached on the reef. Peculiar morphological characteristics of the subgenus are the posterior displacement of the umbos and the probably related anterior growth of the ctenidia which, in addition, lack complete outer demibranchs.

Other living tridacnids are similar in lacking complete outer demibranchs and the associated food groove, although the latter structure is present on the complete inner demibranch of all species. This structure may have been lost with the increase in efficiency of algal feeding. The latter specialization parallels a tendency to bore deeper into coral. *Tridacna squamosa* lives attached to coral rubble by weak, mucus-covered byssal strands. *Tridacna maxima* excavates shallow depressions in coral boulders, or occurs nearly at the surface of the substrate, but is always tightly attached by a stout byssus. *Tridacna crocea* is usually deeply imbedded in coral and is also tightly anchored. For the above reasons, the last 3 species are placed in the subgenus *Chametrachea*.

Taxonomic distinctions nearly always can be made among these species on the basis of the shells or the anatomy. But such distinctions are helped by and are closely related to the ecology of the species. Mantle-color distinguishes some species at some localities (see individual species descriptions). At Eniwetok, *H. hippopus*, *T. gigas*, *T. squamosa* and *T. maxima* were clearly separable on the basis

of mantle-color and pattern, although variation was considerable, especially in the last two species. In the Andaman Sea and Mentawai Islands, *T. maxima* and *T. crocea* were observed alive and few, if any, distinctions were noted in the colors and patterns of their mantles. *Tridacna gigas* and *H. hippopus* were relatively stable in color and pattern where they were seen alive in these two widely separated regions (personal observations in the Malayan Archipelago and Marshall Islands, 1963).

Spurious Names in Tridacnidae

1773 *Concha indica* Buonnani, Rerum Naturalium Historia in Mus. Kircheriano, Rome, part 2, p. 46, pl. 13, figs. 80, 81. Prashad (1932) in the Pelecypoda section of the Siboga Expedition, monograph 53c, gave extensive synonymies, but included a number of pre-Linnaean and non-binomial names as if they were valid names. *Concha imbricata* Rumphius, 1741; *Chama aspera* Regenfuss, 1748; *Chama striata* Petiver, 1767, are examples of names which do not belong in binomial literature.

1797 *Tridachna multifolia* Humphrey, Museum Calonnianum, p. 50 (China); rejected work; name unassignable to any species.

1798 *Tridachnes arcinella* Röding, Museum Boltenianum, part 2, p. 172, no. 98 [198]; refers to Gmelin [1791, Systema Naturae, ed. 13, p. 3303] species 14, Martini [Chemnitz, vol. 7, pl. 52] figs. 522, 523, and to Knorr [Vergnügen der Augen und des Gemuths, etc., part 6] pl. 36, figs. 1, 2 [= *Echinochama arcinella* (Linné) from the tropical Western Atlantic].

1819 *Tridacna pustulosa* Lamarck, Histoire Naturelle des Animaux sans Vertèbres, vol. 6, part 1, p. 107 [= *Productus giganteus* Sowerby, 1822, a branchiopod, fide Deshayes 1836, *ibid.*, ed. 2, vol. 7, p. 385, and Lamy, 1932, Bull. Mus. National d'Histoire Naturelle, series 2, vol. 4, no. 3, p. 308].

The first two of the three following names of F. S. Voigt were listed under *Tridacna* by Sherborn (1933, part 33, p. 1047). The third name is listed here, since Voigt did not credit it to any other author, although as in the cases of the first two names it is ascribable to Lamarck. For some reason Voigt prefixed with the letters "Tr." [= *Tridacna*] not only species belonging to that family, but also members of the Chamidae and Isocardiidae.

1834 *Tridacna (Chama) asperella* F. S. Voigt (in Cuvier) Das Thierreich, Leipzig, vol. 3, p. 508 [= *Chama asperella* Lamarck, 1819].

1834 *Tridacna (Chama) crenulata* F. S. Voigt, *ibid.* [= *Chama crenulata Lamarck*, 1819].

1834 *Tridacna (Isocardia) moltkiana* F. S. Voigt, *ibid.* [= *Isocardia moltkiana* Lamarck, 1801].

1856 *Tridacna latissima* Bianconi, Memorie della Accademia delle Scienze dell Istituto di Bologna, vol. 7, p. 409 (name only, not figured) [nomen nudum].

1932 *Hippopus pennicornis* Sherborn, Index Animalium, section 2, part 31, p. 564 [listed in error as *Hippopus;* see *ibid.* part 19, p. 4835 = *Hippopsis pennicornis,* Insecta].

1933 *Tridacna punctulosa* Sherborn, *ibid.* part 33, p. 1047 [error for *T. pustulosa* Lamarck, 1819, q. v.].

List of Recognized Taxa in the Tridacnidae

Below are listed the recognized taxa of fossil and Recent Tridacnidae. Only members of the genera *Tridacna* and *Hippopus* are treated in full in the main text. A dagger † precedes fossil genera and species.

Genus †*Goniocardium* Vasseur, 1880, Middle and Upper Eocene
- †*rachitis* (Deshayes, 1829). **Type.** Middle Eocene, France
- †*heberti* Vasseur, 1880. Eocene, France

Genus †*Avicularium* Gray, 1853. Middle Eocene — Lower Oligocene
- †*aviculare* (Lamarck, 1805). **Type.** Middle Eocene, France
- †*cymbulare* (Lamarck, 1819). Middle Eocene, France
- †*trechmanni* Cox, 1941. Upper Eocene, Jamaica

Genus †*Byssocardium* Munier-Chalmas, 1882. Upper Eocene — Lower Miocene
- †*emarginatum* (Deshayes, 1829). **Type.** Upper Eocene, France
- †*andreae* Tournouer, 1882. Lower Miocene, France

Genus †*Sawkinsia* Cox, 1941. Upper Eocene
- †*matleyi* Cox, 1941. **Type.** Upper Eocene, Jamaica

Genus *Hippopus* Lamarck, 1799. Lower Miocene — Recent
- *hippopus* (Linné, 1758). **Type.**
- †*gunteri* Mansfield, 1937. Lower Miocene, Florida

Genus *Tridacna* Bruguière, 1797. Lower Miocene — Recent

Subgenus *Tridacna* s.s.
- †*wolfarti* Chenu, 1845. Lower Miocene, Germany
- *gigas* (Linné, 1758). **Type**

Subgenus *Persikima* Iredale, 1937. Recent
- *derasa* (Röding, 1798). **Type**

Subgenus *Chametrachea* Mörch, 1853. Pliocene — Recent
- †*loczyi* Kutassy, 1934. Pliocene, Indonesia
- †*mbalavuana* Ladd, 1934. Neogene, Fiji
- †*aegyptiaca* Chenu, 1845. Pliocene, Egypt
- *squamosa* Lamarck, 1819
- †*besairiei* Collignon, 1951. Upper Cretaceous (?), Madagascar
- †*media* Pusch, 1837. "Tertiary," Poland
- *maxima* (Röding, 1798)
- *crocea* Lamarck, 1819. **Type**

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Key to the Recent Tridacnidae

1. Opposed valves with well defined byssal orifice; byssal orifice without tightly fitting teeth ..... *Tridacna* (2)
   Opposed valves without well defined byssal orifice; area of byssal orifice with tightly fitting teeth ... *Hippopus hippopus*
2. Concentric sculpture lacking or limited to a few tubular spines near umbos; shell equilateral; interdigitating processes elongate-triangular; radiating sculpture deeply folded *Tridacna gigas*
   Concentric sculpture present or absent; shell usually inequilateral; interdigitating processes bluntly triangular or rounded; radiating sculpture broad and low ..... (3)
3. Umbos nearer anterior end or nearly central; concentric sculpture projecting, bladelike, or appressed and low ..... (4)
   Umbos nearer posterior end; concentric sculpture absent or in low erect ridges ..... *Tridacna derasa*
4. Concentric sculpture projecting, bladelike; valves nearly equilateral ..... *Tridacna squamosa*
   Concentric sculpture appressed and low; valves inequilateral ..... (5)
5. Posterior pedal retractor and adductor muscle scars subequal *Tridacna maxima*
   Posterior pedal retractor muscle scar less than half the size of posterior adductor muscle scar ..... *Tridacna crocea*

Smithsonian Institution photo

About the author

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Family Tridacnidae Goldfuss, 1820

Genus Hippopus Lamarck, 1799

Type: *Hippopus hippopus* (Linné, 1758)

The genus *Hippopus* is now limited to the Indo-Pacific region and is easily recognized by the elongate-triangular outline and strawberry spots on the shell of the single Recent species *H. hippopus*. In maturity and old age the shells usually become heavy and thickened, lose many distinguishing characters, and may reach a rather large size (397 mm. or 15.4 inches).

Hippopus differs from *Tridacna* in the lack of hyaline organs in the dorsal exposed part of the mantle. The posterior adductor muscle scar is located centrally in the valves, while in *Tridacna* it is slightly posterior. There is a tendency for the hinge margin to become longer relative to the ventral margin in old *Hippopus*. Both inner and outer demibranchs of the ctenidia are complete.

Synonymy —

[1787 *Hippopodes* Meuschen, Museum Geversianum, p. 428; a plural noun and also, a non-binomial work.]

1799 *Hippopus* Lamarck, Mémoires de la Société d'Histoire Naturelle de Paris, p. 86. Type by absolute tautonymy: *Chama hippopus* Linné, 1758.

[1807 *Hippopigenus* Renier, Tavole per service alla Classificazione e Connoscenza degle Animali, tav. 7 (rejected name).]

1811 *Pelvis*, Megerle, Gesellschaft naturforschender Freunde, Berlin, vol. 4, p. 67. Type by monotypy; *Pelvis hippopus* [= *Hippopus hippopus* (Linné, 1758)].

1848 *Cerceis* Cistl, Naturgeschichte des Thierreichs für höhere Schulen, Stuttgart, p. 172 (new name for *Hippopus* Lamarck, 1799).

Hippopus hippopus (Linné, 1758)

(Pls. 267, 270, 271)

Range — Malay Peninsula to eastern Melanesia.

Remarks — The Horse's Hoof, Bear Paw or Strawberry Clam is one of the best known species in the Indo-Pacific faunal region. A combination of characters, which include its distinctive coloration, sculpture, size and shape, prevent the confusion of most small- and medium-sized *Hippopus hippopus* with any other species.

In shells of adults of this species the byssal orifice, which gapes slightly in the young, loses its identity and its edges become tightly closed with interlocking teeth. This change may be correlated with a loss of the byssal attachment in adult specimens. Large animals of *Hippopus* (310 mm. in length) have no byssus, but smaller specimens (145 mm.) often attach byssal strands to coral rubble. The need for attachment probably diminishes as the animal attains a larger size and greater weight.

Statements regarding the ease of recognition of medium-sized specimens of *H. hippopus* do not always hold true when the species reaches old age. Depending on conditions under which the animals live, individuals apparently may reach a considerably larger size than was previously suspected. Smith (1898) reported what he considered to be an unusually large and thick specimen from the Philippines, 13¼ inches long (336 mm.) and weighing 16½ pounds. According to Smith, this specimen varied from the "typical" *H. hippopus* because it had a peculiar posterior [anterior?] elongation of the valves causing the umbos to become less centrally located (i.e., they were nearer the posterior end) and unusually incurved. Hedley (1923) described a large specimen of *H. hippopus* which he and H. A. Pilsbry collected from Pandora Reef, near Palm Islands, off Queensland. This specimen was 15⅝ inches long (397 mm.) and weighed 28 lbs., 9 oz. In the same paper Hedley reported he had heard of an even larger specimen measuring over 18 inches in length (457 mm.), although I suspect the latter specimen may possibly have been confused with *T. derasa*, which may resemble *hippopus*.

Some populations from the southern Philippines have a high proportion of a smooth, rather thin-shelled form which if seen separately can cause speculation regarding the existence of a second living species or subspecies of *Hippopus*. This form intergrades completely with *H. Hippopus* and does not deserve a name.

Habitat — *Hippopus* lives on a sandy substrate in coral reef waters down to 20 feet in depth. Adults are unattached, but young specimens are found byssally attached to coral heads.

Color notes — The mantle (in a living specimen at Eniwetok Atoll) is irregularly mottled along its edges and in the center with *deep yellowish green* (Kelly and Judd, 1955, ISCC-NBS color name; C553 number: 132) which appears to be caused by aggregations of zooxanthellae. Between mottlings are interspersed areas of somewhat non-descript color ranging between *moderate olive* and *light grayish*

olive (C553 numbers: 107-109) with some whitish blotching. Narrow white vermiculate markings are often present. Under a dissecting microscope, these are seen to be made up of iridescent white granules. The mantle is quite translucent, and this condition may function as the hyaline organs present in *Tridacna* in allowing light to penetrate for growth of the zooxanthellae.

Activity – Reactions to stimuli administered in the laboratory were similar to those observed in other species of Tridacnidae (see observations under *T. gigas*). When undisturbed the animals rested on the bottom of a large cement tank in running seawater with the valves open and the mantle tissues filling the space between (see plate 271, figs. 1, 2). The excurrent siphon was held in a flattened-

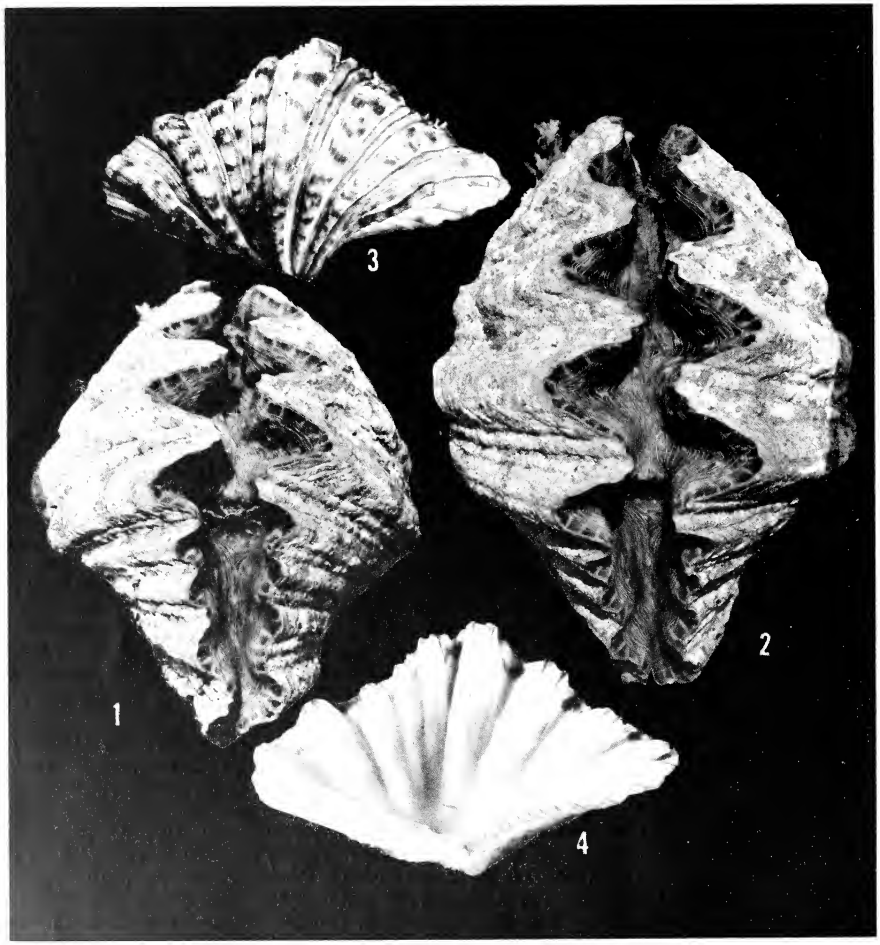

Plate 271. *Hippopus hippopus* (Linné). Figs. 1, 2. Dorsal views of living animal from Enwetok, Marshall Islands. Note plate-like excurrent siphon and mantle pattern. Figs. 3, 4. Exterior and interior views of left and right valves, respectively (97.2 mm. in length). Specimen from Zoological Museum, Copenhagen, figured by Schumacher, 1817, pl. 12, fig. 2 (Figs. 1, 2, author's photos; figs. 3, 4, courtesy of R. T. Abbott).

disclike position, the aperture circular. The incurrent siphon was open, but its right and left edges partially obscured the aperture with blunt tentaclelike projections. When disturbed by changes in light intensity, vibration, or prodding, the animal was capable of rapid contraction and closing of its valves. Since the mantle edges are not protruded over the edges of the valves, *Hippopus* is able to close more rapidly than species of *Tridacna*.

Description — Shell reaching 397 mm. (15⅝ inches, Hedley, 1923) in length; elongate- to ovate-triangular or sub-rhomboidal in shape; usually strongly inflated; with valves opposed, the byssal orifice is tightly closed in large specimens or only slightly gaping in young ones. Valves heavy, thick, usually colored with strawberry blotches arranged in irregular concentric bands, often obscured by incrusting vermetids, annelid tubes, coral, coralline algae, other organisms and debris; color otherwise grayish white with yellowish orange tinges. Surface of valves dull or faintly shining in cleaned specimens. Primary radial sculpture consisting of 13 or 14 moderately convex rib-like folds over surface of valve, extending on to ventral slope where they become obsolete. Secondary radial sculpture consisting of low riblets on both primary folds and their interstices. Riblets varying somewhat in width and sometimes bearing rows of small- to moderately-sized, semi-tubular spines. When present, spines protrude in all directions giving valves a highly prickly appearance. Concentric sculpture consisting of fine, wavy lines of growth. Dorsal margin undulate, with series of 8 to 12 squarish, medially projecting interdigitating processes representing extremities of rib interstices. Hinge line as long or longer than half the length of valve. One oblong cardinal tooth in each valve; 2 elongate posterior laterals in right and a single blunt one in left valve. Ligament secondarily prosodetic. Umbos directed postero-medially. Edge of byssal orifice with a series of 6 to 12 yellowish orange, distinct to nearly obsolete plicae becoming slightly larger posteriorly. Ventral slope flat in young specimens, becoming concave in old individuals. Interior of valves porcelaneous, usually white but often flushed with yellowish orange along posterior margin and in region of hinge and ventral margin; the external strawberry blotches commonly showing through. Pallial line entire, only moderately wide. Muscle scars central, medium-sized; scars kidney-shaped in left valve and extending over the internal width of the 2 fold interstices; scars roundly oval in right valve and extending over only one interstice. Posterior pedal retractor muscle scar less than half the size of posterior adductor scar and located anterior to it. Both scars contiguous to pallial line. Area within pallial line, excluding muscle scars, dull; pallial line, muscle scars and areas to the periphery of shell shiny. Prodissoconch unknown. Byssus present in young individuals but not older ones.

Measurements (mm.) — Tridacnidae are indiscriminately inequivalved, and the figure given under "length" and "height" is always the maximum measurement. "Width" indicates the greatest distance through opposed valves.

length	height	width	
397	273	259	large; Pandora Reef, Queensland (Hedley, 1923)
329	189	187	large: Galero Bay, Mindoro, Philippines
315	243	235	large: Rojoa Id., Eniwetok, Marshall Islands
278	172	177	average; Oyster Bay, Philippines
251	243	231	average; Aomoen Id., Bikini, Marshall Islands
223	145	147	average; Koror Id., Palaus
140	93	101	small; Panganan Id., Philippines

Synonymy —

1758 *Chama hippopus* Linné, Systema Naturae, ed. 10, p. 691 (in M. Asiatico); refers to Buonnani, Recr. 2, figs. 81, 82; Rumphius, pl. 42, fig. C, and others.

1788 *Chama asinus* Barbut, Genera Vermium, p. 47, pl. 6, fig. 5 (no locality given).

[1797 *Tridachna ursina* Humphrey, Museum Calonnianum, p. 50 (China); refers to *Chama hippopus* Linné; rejected work.]

1798 *Tridachnes ungula* Röding, Museum Boltenianum, p. 172, no. 197 (no locality given); refers to Gmelin, *Chama hippopus*, species 3, and to Chemnitz, vol. 7, pl. 50, figs. 498, 499.

1801 *Hippopus maculatus* Lamarck, Système Animaux sans Vertèbres, p. 117 (no locality given); refers to Lister, pl. 349, fig. 187, pl. 350, fig. 188 and others; 1835 *Tridacna maculata* Quoy and Gaimard, Astrolabe, Zoologie, vol. 3, p. 491; Atlas, pl. 80, figs. 4-6.

1801 *Hippopus brassica* Bosc, Histoire Naturelle des Coquilles, Deterville ed., vol. 3, p. 91 (pl. 21, fig. 6) (dans la mer des Indes); refers to Rumphius, pl. 42, fig. C, and others.

1808 *Camus hyppopus* Bournon, Traité complet de la Chaux Carbonatée et de l'Arragonite, London, vol. 1, p. 326 [nomen nudum].

1853 *Hippopus equinus* Mörch, Catalogus Conchyliorum Comes de Yoldi, part 2, p. 56 (Ind. or.); refers to *Chama hippopus* Linné, *T. ungula* Bolten [Röding], and *Hippopus maculatus* Lamarck.

Types and Nomenclature — The probable holotype of *Chama hippopus* Linné is in the Linnaean Collection, London (Dodge, 1952). There seems no need to restrict Linné's type locality, "In M. Asiatico." This well-known species is widely distrib-

uted in the western Pacific region and such a restriction would have little meaning as Linné's type could have come from one of many different localities. Locations of the type specimens of species described by Röding, Bosc and Mörch are unknown. The type figures of *H. maculatus* Lamarck, here selected, are Chemnitz, vol. 7, pl. 50, figs. 498, 499.

The only possible source of confusion in the synonymy of this species is the name *Hippopus brassica* Bosc. The name *brassica* was apparently taken from Linné's translation of d'Argenville's vernacular for the species, "la feuille de choux" viz. "Folium brassicae," which means "the cabbage leaf." Bosc refers to his own pl. 21, fig. 6 (a copy of d'Argenville's (1757) pl. 23, fig. E). But this is probably a poor specimen of *Tridacna squamosa*. His reference to "Dargenville, 1757 pl. 23, fig. 11." is a misprint for fig. H. This figure and the remaining plate references are all definitely assignable to *H. hippopus*. Therefore *brassica* is an absolute synonym of *hippopus*. The name *brassica* is a feminine substantive noun and must not be made to agree in gender with the masculine genus *Hippopus*.

Records — Literature records from Madagascar and other western Indian Ocean Islands (von Martens, 1880; Dautzenberg, 1923, 1929; all based on Szanzin, 1843) are considered erroneous, and a single dead valve recorded from Tern Island, French Frigate Shoal is probably adventitious. MALAYA: Singapore (USNM; MCZ; Reyne, 1947; Purchon, 1955). RYUKYU ISLANDS: Kana (MCZ); Shioya, Shana Wan; Shuri, all Okinawa (both USNM); northeast of Iheya Shima (ANSP). Philippines: Bantan Id., Batanes Group; Port San Pio Quinto, Camiguin Id., Babuyanes Group (both USNM); Subic Bay, Zambales Province (MCZ); Badang, near Gubat, Sorsogon Province, both Luzon (ANSP; MCZ); Tilig, Lubang (MCZ; USNM); Galero Bay, Mindoro (USNM); Masbate, Masbate Id. (ANSP); Nasog Point, Panay; Guimaras (both USNM); Cebu City, Cebu (A. B. Franco, ANSP; USNM); Panganan Id., between Cebu and Bohol; Cajoagan Id. off northern Samar; Hilongas, Leyte (all USNM); Zamboanga (ANSP; USNM); Malabang, Cotabato Province, both Mindanao (USNM); Tara Id.; Linapacan Id.; Culion Id.; Port Colton, Busuanga, all Calamianes Group (all USNM); Puerto Princessa, Palawan (duPont-Academy Expedition, ANSP); Cagayan Id., Cagayanes Group (USNM); Cuyo Id., Cuyo Islands (ANSP); Jolo (USNM); Bongao Channel, southwest end Sanga Sanga Id.; Sibutu Id., both Sulu Archipelago (both ANSP). INDONESIA: Pulau Melila, south of Udjung Batu, Banjak Islands; Pulau Bai, Batu Group, both southwest of Sumatra (both International Indian Ocean Expedition, 1963, USNM); Tjiperwagaran, Bantam, Java (USNM); Pulau Kasiruta; Amboina; Pulau Batjan; Pulau Karakelong, Talaud Islands; Pulau Manipa, all Moluccas (all MCZ). NORTH BORNEO: Kukuban; Pulau Mandidarah; Pulau Silingaan (all Mary Saul, USNM). WESTERN AUSTRALIA: Augustus Island, (MCZ). QUEENSLAND: Torres Strait (ANSP); Portland Roads; Green Island, near Cairns (both MCZ); Brook Id.; Pandora Reef (both H. A. Pilsbry, 1933, ANSP); Hayman Id., off Bowen (USNM, MCZ); Lupton Id., Cumberland Group (MCZ). NEW GUINEA: Biak, Schouten Islands (USNM, ANSP); Seroei Bay, Japen (ANSP) both West Irian; 10-15 miles east of Aitape, North-East New Guinea (USNM); Oro Bay, Papua (ANSP). BISMARCK ARCHIPELAGO: Koruniat Id., north coast Manus Id., Admiralty Islands; Gumlun Id., southwest of New Britain (both ANSP). SOLOMON ISLANDS: Kieta, Bougainville; Choiseul Bay, Choiseul; Ataa District, Malaita (all ANSP); Pavuvu, Russell Islands (USNM). NEW HEBRIDES: Espiritu Santo Island (MCZ); Efate (USNM). FIJI ISLANDS: Suva, Vitilevu (USNM). NEW CALEDONIA: Ile Mouac, Poume; Plage de Poe, Bourail; Anse Vata Bay, Noumea; near Touho; Yate (all G. and M. Kline, ANSP). PALAU ISLANDS: Ngajangel, Kayangel Islands (USNM); 1 mile south of West Passage, Babelthuap (ANSP); Malakal Harbor, Koror (USNM; ANSP; MCZ); Angaur (USNM). CAROLINE ISLANDS: Tomil Harbor, Yap; Fassarai Id., Ulithi; Eauripik; Ifalik; Elato; Lamotrek; Satawal; Ponape; Kapingamarangi (BPBM; all USNM). MARSHALL ISLANDS (many atolls; see map); Eniwetok; Ujelang; Kwajalein; Jaluit; Bikini; Rongelap; Utirik; Ailuk; Majuro (all USNM). GILBERT ISLANDS: Abemama (USNM); Onotoa Atoll (MCZ; USNM). TONGA: (BPBM)

Fossil Records — FIJI: Late Pleistocene, Ravuka, Viti Levu (Ladd, 1934). MARIANAS ISLANDS: Miocene, Togpochau limestone, Saipan; Pliocene-Pleistocene, Marianas limestone, Guam (both U. S. Geological Survey). PALAU ISLANDS: Neogene (U. S. Geological Survey).

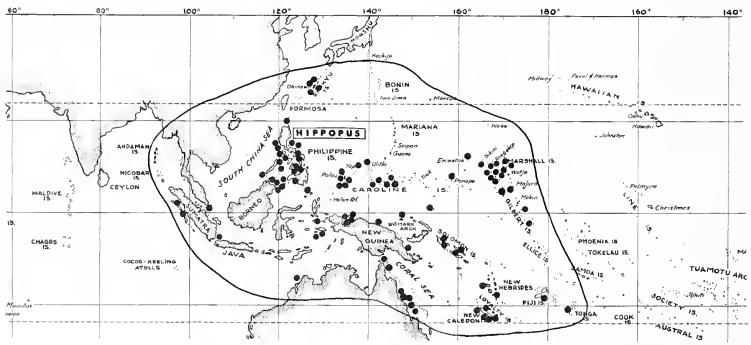

Plate 272. Geographical distribution of *Hippopus hippopus* (Linné).

Hippopus? gunteri Mansfield, 1937

(Pl. 273)

Range – Fossil (Tampa Limestone: Lower Miocene) of Florida.

Remarks – The type and several additional specimens from the same horizon consist of fairly well preserved molds of external sculpture in the region of the umbo and ventral slope. It is extremely difficult to distinguish the sculptural pattern of these fossils from that of the Recent species, *Hippopus hippopus* (Linné). However, as noted by Mansfield, final generic disposition must await the discovery of specimens showing the dentition. It would be very helpful also to find specimens showing more completely the shapes of the valves. If this is actually a *Hippopus*, speculation is invited regarding the former distribution of the genus which is now confined to the central and western Pacific. If confirmed it can be stated that during the middle Tertiary this member of the genus did inhabit the region which is now northwestern Florida, perhaps then a portion of the shore of the Tethys Sea. There is a vague similarity between the sculpture of this species and *Avicularium trechmanni* Cox, 1941 from the Upper Eocene of Jamaica.

Synonymy –

1937 *Hippopus? gunteri* W. C. Mansfield, Geological Bulletin, State of Florida Department of Conservation, no. 15, p. 258, pl. 20, figs. 2, 4; Type: USNM 495963 (Station 12,300, along the channel of a disappearing stream, 1½ miles northeast of Lloyd, Jefferson County, Fla).

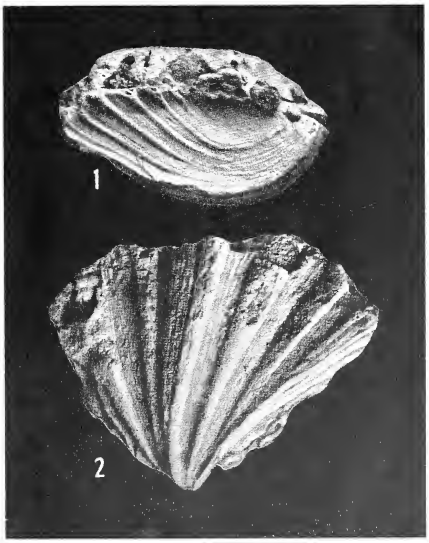

Plate 273. *Hippopus? gunteri* Mansfield, from 1½ miles northwest of Lloyd, Jefferson County, Florida, Lower Miocene (40 mm.) (from Mansfield, 1937, pl. 20, figs. 2, 4; Smithsonian photos).

[These occasional blank areas occur between genera and subgenera to permit the insertion of new material and future sections in their proper systematic sequence.]

Genus Tridacna Bruguière, 1797

The genus *Tridacna* is confined to the Indo-Pacific area. It contains the species of true Giant Clams which are identified by their large size and distinctive ecology, always being located on or near reef-forming corals. Three subgenera may be distinguished: *Tridacna s.s., Persikima* Iredale and *Chametrachea* Mörch.

Subgenus Tridacna Bruguière, 1797

Type: *Tridacna gigas* (Linné, 1758)

Mature *Tridacna gigas* can be distinguished from species of *Chametrachea* and *Persikima* by its larger size, more equilateral valves, deeply folded sculpture, and free living habits (not byssally attached). *Tridacna* lacks the strawberry spots, elongate-triangular shape and neatly interdenticulated ventral margin of *Hippopus*. An anatomical distinction in *Tridacna sensu stricto* is the possession of a complete outer demibranch, a character lacking in both *Chametrachea* and *Persikima*. *Hippopus* lacks the hyaline organs which are present in species of all subgenera of *Tridacna*.

Synonymy —

[1775 *Tricdane* d'Herbigny, Dictionnaire d'Histoire Naturelle, vol. 3, p. 408; *Tricdana*, p. 411 (non-binomial).]

[1776 *Tridacna* Da Costa, Elements of Conchology, p. 294, p. 7, fig. 4 (non-binomial).]

[1792 *Tridacne* Bruguière, Encyclopédie Méthodique, Histoire Naturelle des Vers, vol. 1, p. 386 (vernacular name).]

[1797 *Tridachna* G. Humphrey, Museum Calonnianum, p. 50; (rejected work).]

1797 *Tridacna* Bruguière, Tableau Encyclopédique et Méthodique, Vers Testacées, heading of pl. 235. Type by subsequent monotypy (Lamarck, 1799): *Chama gigas* Linné [= *Tridacna gigas* (Linné, 1758)].

1798 *Tridachnes* Röding, Museum Boltenianum, part 2, p. 171. Type by subsequent designation (Iredale, 1937): *Chama gigas* Linné.

1807 *Tridacne* Link, Beschr. Nat. Samml., Univ. Rostock, part 3, p. 153.

[1807 *Tridacnigenus* Renier, Tavole per servire alle Classificazione e Connescenza degli Animali, Padua, tav. 7 (rejected name).]

1823 *Tridacnodites* Krüger, Geschichte der Urwelt, part 2, p. 464; type by monotypy: *Tridacnodites gigas* = *Tridacna gigas* (Linné)].

1827 *Gataron* 'Adanson' Berthold (in Latreille) Natürliche Familien des Thierreichs, p. 207 (nomen nudum); in Chamidae, fide Vokes [1955, p. 130].

1848 *Tridacnoides* 'Krüger' Bronn, Index Palaeontologicus, Stuttgart, p. 1279 "= *confusio rerum*" [not listed in Krüger, 1823, but credited to him by Scudder (1882), Sherborn (1931), Neave (1940), and Vokes [1951]] nomen nudum.

1875 *Tridachnus* Paetel, Die bisher veröffentlichten Familien und Gattungsnamen der Mollusken, p. 211 [error for *Tridachnes* Röding].

1898 *Tridachne* Dall, Trans. Wagner Free Instit. Sci. Philadelphia, vol. 3, part 4, p. 572 (emendation for *Tridacne* Link, 1807).

1937 *Dinodacna* Iredale, Australian Zoologist, vol. 8, part 4, p. 238. Type by original designation: *D. cookiana* Iredale, 1937 [= *Tridacna gigas* (Linné)].

1940 *Tridachna* 'Lamarck' Neave, Nomenclator Zoologicus, vol. 4, p. 552 [error for *Tridacna* Bruguière, Lamarck, 1799; perpetuated by Vokes [1951, p. 77]].

Nomenclature — The generic name *Tridacna* was proposed validly for the first time in 1797 on the plate heading of Tableau Encyclopédique et Méthodique, pl. 235 (I. C. Z. N., Article 16 (a) (vii)). In spite of arguments to the contrary by Dodge (1947) it is quite probable that Bruguière personally approved the plates bearing the name *Tridacna* and should, therefore, be listed as the author.

Tridacna wolfarti Chenu, 1845

(Pl. 274)

Range — Upper Tertiary, Hesse, Germany.

Remarks — This species is very closely allied with *T. gigas*. The occurrence of fossils such as *T. wolf-*

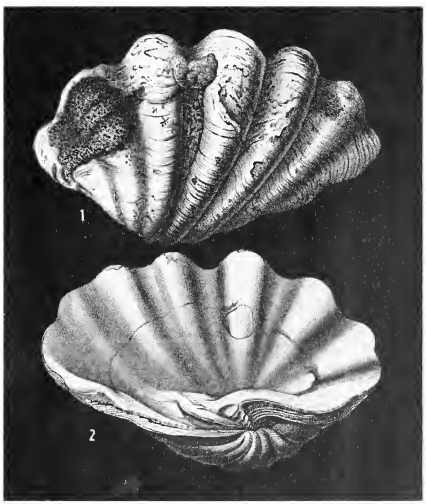

Plate 274. *Tridacna (Tridacna) wolfarti* Chenu, from Hesse-Inférieure, Tertiary (reduced from Chenu, 1845, pl. 8, figs. 5, 6; Smithsonian photos).

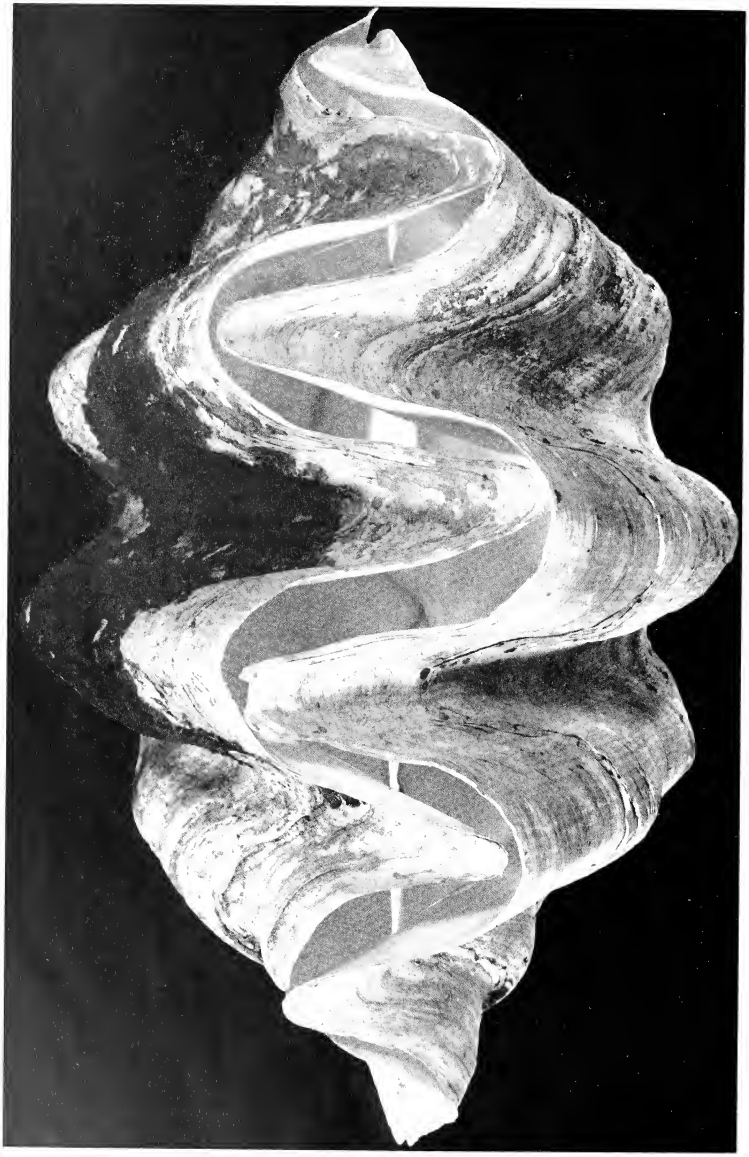

Plate 275. *Tridacna (Tridacna) gigas* (Linné). Dorsal view to show elongate-triangular valve interdigitations. Specimen from Linapacan Island, north of Palawan, Philippines (length: 370 mm.; 14.6 in.) (Smithsonian photo).

arti and *T. media* in Tertiary deposits of Europe seemingly indicates the presence in that area during the Tertiary of a flourishing tropical fauna much like that in the Indo-Pacific.

Synonymy —

1845 *Tridacna wolfarti* Chenu, Illustrations Conchyliologiques, vol. 2, **Tridacna**, p. 2, pl. 8, figs. 5-6 (. . . montagnes de la Hesse-Inférieure).

Tridacna gigas (Linné, 1758)

(Pls. 263, 267, 275-278)

Range — Philippines to Micronesia.

Remarks — *Tridacna gigas* Linné is the largest known species of bivalve. In the phylum Mollusca it is surpassed in size and weight only by the Recent giant squids and some fossil nautiloids and ammonites. The largest pair of valves on record measured 4 feet, 6 inches in length (about 137 cm.) and weighed 507 pounds. They were brought from Tappanooly [Teluk Tapanuli?], Sumatra, and were seen at Arno's Vale, Ireland (Dillwyn, 1817, p. 214). The heaviest reliably recorded specimen of *T. gigas*, one with valves weighing 579½ pounds, is in the collection of the American Museum of Natural History, New York (Miner, 1938). Only somewhat lighter are the valves weighing 550 pounds which serve as holy water fonts in the Church of St. Sulpice in Paris and which were presented by the Republic of Venice to Francis I in the 16th Century (Lamarck, 1819). The latter are 36 inches long (about 91.5 cm.; in litt., R. T. Abbott, 1962). In his original description of *T. gigas*, Linné listed the weight of the Museum Ulricae specimen as 532 pounds. There is some disagreement over the exact value of the Swedish pound in Linné's day, and this weight was quoted as 498 pounds by Smith (1898). Roscoe (1962) listed additional records for large *T. gigas*. It is possible that even larger and heavier individuals may be found in the future, but reports that the giant clam can reach half a ton or more are probably exaggerated (Buchsbaum and Milne, 1960; Hawaiian Shell News, 1962, vol. 10, no. 10, p. 2).

Tridacna gigas can be distinguished from *T. crocea* and *T. maxima* by the larger size of the former, by the more central position of the umbos, by its lack of a large byssal orifice, by the lack of crowded, undulate sculpture, and by the absence of "boring" tendencies. The mantle coloration in living *T. gigas* is yellowish-brown to olive-green with blue-green spots, while in *crocea* and *maxima* the mantle usually is more brilliantly colored.

Certain specimens of *T. gigas* and *T. derasa* appear very similar in shell characters. The two species can be distinguished by differences in ctenidial anatomy, *derasa* lacking a complete outer demibranch. The shell of *gigas* is usually less obese; the free margins of the valves have sharply triangular interdigitating processes, whereas these are undulate in *derasa* which also has much lower radial sculpture.

The giant clam is larger than and lacks the scales of *T. squamosa*. McLean (1947) traced the development of *T. gigas* through a graded series ranging from very young juveniles to moderately large adults. All specimens were found to lack scales except near the byssal orifice where small ones are present. *Tridacna squamosa* has widely spaced, erect scales. Although certain specimens of *gigas* and *squamosa* agree in many characters, the two are unquestionably distinct (see subgenus *Tridacna*).

Holthuis (1952) reported the following shrimps of the family Palaemonidae to be commensal with *T. gigas: Anchistus mirabilis* (Pesta), *Conchodytes*

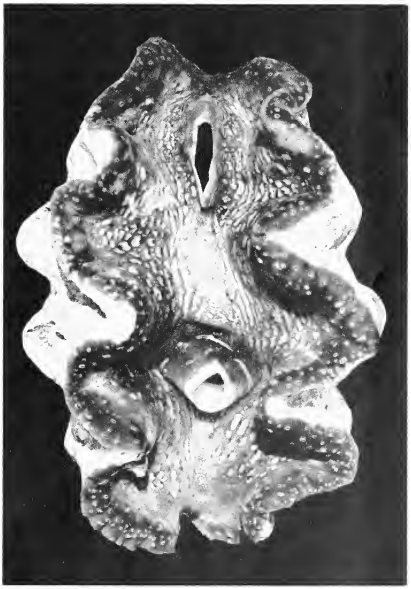

Plate 276. *Tridacna (Tridacna) gigas* (Linné). Dorsal view of living animal to show mantle pattern and appearance of siphonal openings. Note that byssal opening is directly beneath incurrent siphonal opening (total length: 559 mm.) (author's photo at Eniwetok, Marshall Islands).

tridacnae Peters, and *Paranchistus biunguiculatus* (Borradaile); the latter species was also present in *T. gigas* collected by the writer at Eniwetok Atoll, Marshall Islands (identified by Dr. F. A. Chace, USNM).

The giant clam suffers a bad reputation from stories describing the fate of unwary persons caught between its valves. C. W. Johnson (1930) presented one view of this supposed phenomenon, implying that the giant clam is not as dangerous as the stories suggested. There are apparently very few documentations of the giant clam killing men, although Cobb (1939) insisted that the specimen of *T. gigas* which yielded the "Pearl of Allah" killed the diver who found it; and there is an elderly east coast Malaysian who attributes the loss of one of his legs to *Tridacna gigas* (personal communication, Johnnie Johnson, Singapore, 1963). If a diver were so unlucky as to catch an appendage between the valves of a closing *T. gigas,* doubtless he could

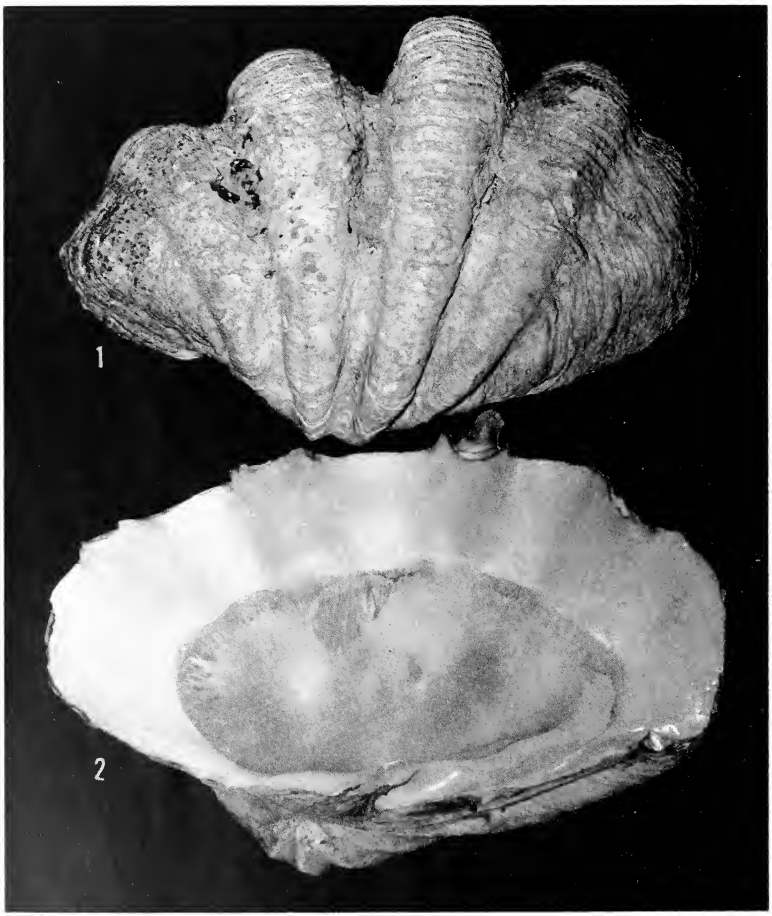

Plate 277. Lectotype of *Tridacna (Tridacna) gigas* (Linné).
Fig. 1. External view of right valve (length: 93.5 cm.).
Fig. 2. Internal view of left valve (length: 90 cm.). (Photos courtesy of Zoological Institute, Uppsala).

drown before being released. The growing edges of valves of living *Tridacna* are extremely sharp and capable of inflicting deep and painful cuts if handled carelessly. Persons also have been injured by having fingers squeezed in the byssal orifice when lifting the clams (personal communication, John Roberts, 1963).

Habitat – Lives on coral reefs, usually on sand, in depths of from only a few feet to several fathoms; the depth at which this species lives may be limited by the penetration of light strong enough to permit growth of the algae contained in its tissues.

Color Notes (see plate 263) – Main ground color of mantle (living specimen from Eniwetok) of medium-sized and adult *T. gigas* is *dark yellow* (Kelly and Judd, 1955, ISCC-NBS color name; C553 number 88); the outer edge, or border of mantle is usually darker, closest to *dark olive brown* (C553 number 96) but blotches of the former, *dark yellow*, may be interspersed. Along darker outer border are found in considerable numbers small rings of color, each surrounding from one to several hyaline organs; a continuous line of smaller, colored rings is found along the mantle edge at its periphery. Rings are numerous also around siphonal openings where numbers of hyaline organs may be surrounded by these irregular to elongate enclosures. When rings are viewed by refracted light (i.e., specimen is located between light source and observer) their color appears closest to *strong greenish blue* (C553 number 169) or *strong blue* (number 178). But when viewed by reflected light (i.e., observer is between light source and specimen) the color of rings is *brilliant bluish green* (number 159). This difference in color, based on viewing

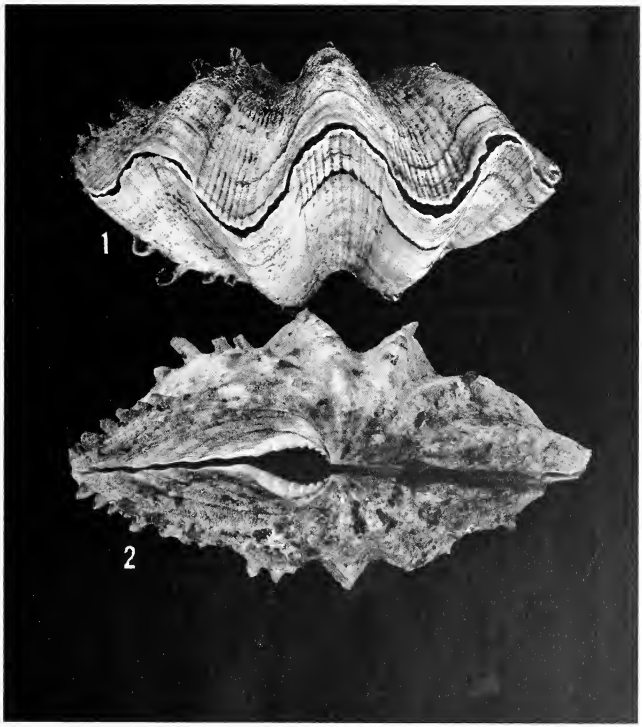

Plate 278. *Tridacna (Tridacna) gigas* (Linné). Young specimen from Green Island, near Cairns, Queensland, Australia, showing semitubular spines on summits of folds. Fig. 1. Dorsal view. Fig. 2. Ventral view, showing small byssal orifice (123 mm. in length) (Smithsonian photo).

position, may be responsible for some of the varied statements regarding mantle color in *T. gigas*. Even in the same specimen, the viewer may see rings of both blue and green at the same time when the mantle is somewhat contracted and it is struck by light from different angles. This phenomenon was not noted in *T. squamosa, T. maxima* or *Hippopus hippopus*.

Toward the center of exposed mantle surface the *dark yellow* diminishes, becoming grayish white in spots. Scattered rather regularly over the central portion of the mantle are hyaline organs without color rings. Darker color of outer mantle edge is repeated on edges of the siphons where, as previously mentioned, the blue or green colored enclosures surround clumps of hyaline organs.

Small specimens of *T. gigas* 150-200 mm. long, were observed to lack the *dark olive brown* coloration, being more uniformly *dark yellow* or lighter, but with a few color rings present.

Activities and Habits — Valves of *Tridacna gigas* remain widely gaping most of the time, except when the clam is disturbed. In the expanded condition the dark edges of the mantle are reflected over the edges of the valves. The incurrent siphon remains open and gaping, as does the pedal opening (see plate 276). It is theorized that the pedal opening can serve as a direct outlet for any large particles of debris which may fall or be drawn into the incurrent opening. The excurrent siphon also is held open and gaping "hoselike" and the aperture is usually pointed anteriorly, probably in order to direct the excurrent stream away from the incurrent opening.

In *T. gigas* the ctenidia are comparatively large. Through the incurrent siphonal opening the inner demibranch is easily seen hanging ventrally within the mantle cavity. The outer demibranch is deflected obliquely and laterally, so that the character of the food groove is not easily visible externally.

When stimulated by a change in light intensity, such as a shadow over the excurrent siphonal area, the siphon rolls inward and closes. There follows a sudden contraction of the valves causing a great surge of water to be squirted out of the incurrent siphon. The reaction can be initiated also by touching the mantle. It is probable that the reaction is a "surprise" and defensive one and may be very useful in frightening away fish which come to browse on the clam's mantle (see Stasek, 1962, pp. 30, 31). The initial closing is usually retarded by the presence of a considerable quantity of water within the mantle cavity. The majority of this is expelled by the initial closing, and subsequent closings bring the valve edges into closer proximity.

Water Current through Mantle Cavity — An attempt was made to measure the rate of flow of water through the mantle cavity of *T. gigas*. A quantity of neutral red mixed with seawater to form a dense red dye was introduced to the area of the incurrent siphon. The intake appeared to be very slow. The dye dropped into the opening and appeared to be guided laterally, down the sides of the mantle cavity to the base of the ctenida. None was pumped out of the excurrent opening, but there was a rejection reaction, i.e., a counter current was forced out of the incurrent opening several times expelling the dye. The fact that the current through the mantle cavity is slow may indicate that little "normal bivalve feeding" is taking place and that

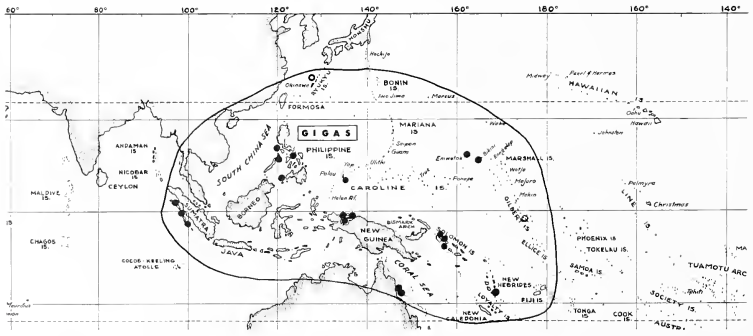

Plate 279. *Geographical distribution of Tridacna (Tridacna) gigas* (Linné); solid dots: specimens examined; open circles: from the literature.

the major part of the animals' food is obtained from the zooxanthellae. A large amount of water is maintained within the mantle cavity with some continuous exchange, and this apparently suffices for respiratory purposes. A specimen of *T. gigas* 305 mm. (12 inches) in length contained approximately 1.2 liters of water. This amount of water could be very useful to the clam in performing the defensive reaction mentioned above.

Description — Shell reaching about 137 cm. (4 feet, 6 inches) in length; suboval to fan-shaped in outline; angle formed at umbos by hinge line and ventral margin usually exceeding 150°; moderately to strongly inflated and with small to nearly closed byssal orifice. Valves moderately thin in small specimens to extremely heavy and thick in large individuals; color grayish white; encrusted with vermetids, annelid tubes, coral, coralline algae and other organisms. Surface of valves dull or faintly shiny in cleaned specimens. Primary radial sculpture consists of from 4 to 6 strongly convex, rib-like folds which are crowded and indistinct on the ventral slope. Four of the folds are usually very large. Secondary radial sculpture consists of rather evenly-spaced riblets on both folds and their broad interstices (often grouped into bands of 3 or 4 riblets in interstices); radial riblets interrupted by fine concentric lines of growth resulting in minute reticulations. Where secondary and radial concentric sculptures cross, nodules may be formed. Sculpture becoming obsolete in later growth in large individuals. Scales limited to summits of folds near umbos; scales small, semitubular but usually worn away. Dorsal shell margins broadly fan-shaped in outline, undulate, with series of 4-5 usually rather sharply pointed, medially projecting interdigitating processes representing extremities of rib interstices, often crenulate at their edges. Hinge line somewhat longer than half the length of shell. Hinge teeth becoming obsolete in large individuals. A single, oblong cardinal tooth present in each valve; 2 elongate posterior lateral teeth in right valve and 1 in the left. Ligament secondarily prosodetic. Umbos directed posteromedially. Ventral margin nearly straight, but may be slightly concave in region of byssal orifice. Edge of byssal orifice with series of 4-7 nearly obsolete plicae, usually evenly spaced and becoming less distinct posteriorly. Ventral margin posterior to byssal orifice weakly crenulate. Ventral slope flattened to concave in larger specimens, often largely covered by overgrowth of porcelaneous material from edge of byssal orifice. Interior of valves porcelaneous and white. Interior of convexities of primary radial sculpture closed as sharp folds within pallial line, smoothly concave without. Pallial line entire, wide, roughened. Posterior adductor muscle scar large, subcircular, adjacent to pallial line dorsally and located posterior to center. Posterior pedal retractor muscle scar less than half the size of posterior adductor, and contiguous to upper portion of latter; located just anterior to center. Area within pallial line, excluding muscle scars, dull; area of line, muscle scars, and to periphery of shell, shiny. Prodissoconch unknown.

Measurements (mm.) —

length	height	width	
1370	—	—	large; Tappanooly [Teluk Tapanuli?], Sumatra
1016	—	—	average; Singapore, Malaysia
1003	—	—	average; Bikini, Marshall Islands
750	440	—	average; Pulau Siburu, north of Sipora, off southwest Sumatra
445	270	270	small; Pulau Bai, Batu Group, off southwest Sumatra
370	230	228	small; Palawan, Philippines
123	80	67	small; Green Island, near Cairns, Queensland, Australia

Synonymy —

1758 *Chama gigas* Linné, Systema Naturae, ed. 10, p. 691 (Habitat in M. Asiatico); refers to specimen in "Museum Ulricae"; not *T. gigas* 'Linné' Reeve, 1862, Conchologia Iconica, vol. 14, **Tridacna**, pl. 1, fig. 1a, pl. 2, figs. 1b, c which is *T. maxima* Röding.

1801 *Tridacna gigas* Lamarck, Système des Animaux sans Vertèbres, p. 117 (no locality given) (part).

1807 *Tridacne imbricata* Link, Beschreibung Naturalien Sammlung Univ. Rostock, (3) p. 153 (no locality given); refers to *Chama gigas* 'Linné,' Gmelin, p. 3299, and to Chemnitz, vol. 7, pl. 49, figs. 492-493 [= *T. squamosa*] 494 [= *T. maxima*] (part).

1808 *Camus gigantus* Bournon, Traité Complet de la Chaux Carbonatée et de l'Arragonite, London, vol. 1, p. 325 [nomen nudum].

1811 *Chama gigantea* Perry, Conchology, Introduction, p. 2 (no locality given).

1819 *Tridacna gigas* Lamarck, Histoire Naturelle des Animaux sans Vertèbres, vol. 6, part 1, p. 105 (l'Océan indien) (part).

1819 *Tridacna mutica* Lamarck, *ibid.*, p. 106 (l'Océan des grandes Indes) (part); Chenu, vol. 2, pl. 4, figs. 1, 1a [= *T. gigas*], pl. 6, fig. 1 [= *T. maxima*].

1903 *Tridacna lamarcki* Hidalgo, Memorias Real Academia de Ciencias, Madrid, vol. 21, p. 385 (Mindoro, Cebu, Mindanao and Paragua Ids.) (part); refers to Quoy and Gaimard, pl. 79, figs. 4, 5 and others [= *T. gigas*]; new name for *T. gigas* Lamarck, not Linné.

1921 *Tridacna gigas* 'Linné,' Hedley, Records of the Australian Museum, vol. 13, no. 4, p. 168, pl. 227, fig. 1 [but not fig. 2 = *T. maxima*].

1937 *Dinodacna cookiana* Iredale, Australian Zoologist, vol. 8, part 4, p. 238 (Gilbert Islands); refers to Sowerby, Thesaurus Conchyliorum, vol. 5, pl. 488, fig. 11 (type figure; Samoa [a doubtful record]).

Types — Linné's reference to a large specimen of *T. gigas* weighing 532 pounds, preserved in the "Museum Ulricae," is the only clue to the location of the type of this species. None of the plate references listed with the original description shows a clear-cut example of *T. gigas*. All of them, except one, are referrable to either *T. squamosa* or *T. maxima*. Gualtieri's pl. 92, fig. G. may represent a young individual of either *T. gigas* or *T. squamosa*. There is present in the collection of the "Museum Ulricae," at the University of Upsala, a large specimen of *T. gigas* measuring 93.5 cm. in length. The 532 Roman pounds mentioned by Linné (1 Roman pound = 12 ounces) has an English equivalent of 399 pounds, a possible weight for a giant clam measuring nearly 94 cm. Hedley (1921, p. 169) has already suggested that the type is the large specimen said by Linné to be present in the "Museum Ulricae." Although great care must be exercised in the recognition of type material from this collection, there should be little difficulty in recognizing this specimen as the name-bearer for this species (Dodge, 1952). It is here designated the lectotype of *Chama gigas* Linné, 1758 (plate 277). The type locality given by Linné, "M. Asiatico," is here restricted to Amboina, Moluccas, a locality from which material was available at that time.

The locations of the types of *T. mutica* Lamarck and *T. imbricata* Link are unknown, and both of these are composite species.

Nomenclature — The name *Tridacna gigas* (Linné) is universally connected with the giant clam of the Indo-Pacific. However, the name has a confused early history. As emphasized by Dodge (1952), *Chama gigas* Linné, 1758, is a composite species. The references given by Linné refer to the true giant clam and the species later named *T. squamosa* by Lamarck and *T. maxima* by Röding. If it were not for the reference in the original description to the goliath specimen in the "Museum Ulricae," weighing 532 pounds, the applicability of the name *gigas* would be in considerable doubt. However, because of that fortunate reference, the name can be restricted to this species.

Such useful works as Reeve's Conchologia Iconica show the extent of confusion regarding the true identity of *T. gigas*. The fine figures in this work are often cited as examples of species. Dodge (loc. cit., p. 131) referred to Reeve's **Tridacna,** pl. 1, fig. 1a, pl. 2, figs. 1b, 1c, as representing *T. gigas*. As already indicated by McLean (1947), these figures do not represent *gigas*. The short hinge line, sculpture and delicate coloration show them to be *T. maxima*. *Tridacna gigas* was figured only once by Reeve (Conch. Icon., vol. 14, pl. 6, fig. 6, a young specimen; not *T. serrifera* Lamarck = *T. derasa*). This species was seldom well-figured in early works. Most species were drawn natural size, which would have been impossible in the case of larger specimens of *gigas*. Smaller individuals were selected, therefore, and in many cases these were other species.

Lamarck's *T. mutica* apparently belongs as a synonym under *T. gigas* at least in part. The description is not particularly helpful, but in his remarks Lamarck cites the lack of sculpture, small "lunule" aperture (= byssal opening) and relatively large size, 37 cm. of this species.

Records — RYUKYU ISLANDS: Itoma Jima (Pilsbry, 1895, p. 181). PHILIPPINES: Looc Bay, Lubang (P. de Mesa, MCZ); Busín Harbor, Burias Id.; Santa Cruz Id., off Zamboanga, Mindanao; Linapacan Id., Calamianes Group (all USNM). INDONESIA: Pulau Melila, south of Udjung Batu, Banjak Islands; Pulau Bai, Batu Group; Pulau Siburu, north of Sipora, all southwest of Sumatra (all International Indian Ocean Expedition, 1963, USNM). AUSTRALIA: Brook Island (H. A. Pilsbry, 1933, ANSP); Green Island, near Cairns, both Queensland (J. K. Howard, MCZ). NEW GUINEA: Poelau Rouw; Poelau Maransabadi, both Aoeri Group, Geelvink Bay; Poelau Noekori, east Padeaido Islands, all West Irian (all ANSP). BISMARCK ARCHIPELAGO: Kumbun Island, southwest of New Britain (ANSP). SOLOMON ISLANDS: Kieta, Bougainville Id.; Choiseul Bay; Bambatana, both Choiseul (all ANSP). NEW HEBRIDES: Efate (USNM). PALAU ISLANDS: Koror (BPBM). MARSHALL ISLANDS: Bikini; Eniwetok (both USNM). GILBERT ISLANDS: Onotoa (Banner, 1952 [as *Hippopus*]).

Fossil records — INDONESIA: Lower and Upper Miocene (Tjilanang beds), Java (K. Martin, 1880, p. 119, pl. 19, fig. 3). MARIANAS ISLANDS: Pliocene-Pleistocene, Marianas limestone, Guam (U. S. Geological Survey).

Subgenus Persikima Iredale, 1937

Type: *Tridacna derasa* (Röding, 1798)

The genus *Persikima* was established by Iredale for the peculiar species he named *P. whitleyi* (= *derasa*). Sufficient characters appear to be present to allow a subgeneric distinction. These are an extreme posterior displacement of the umbos and an anterior extension of the ctenidia. In other subgenera of *Tridacna* the umbos are either about central or displaced anteriorly; the ctenidia usually terminate at about the level of the mouth. *Persikima* appears to occupy an intermediate position between *Tridacna* s.s. and *Chametrachea*.

Synonymy —

1937 *Persikima* Iredale, Australian Zoologist, vol. 8, part 4, p. 237. Type by original designation: *P. whitleyi* Iredale, 1937 [= *T. derasa* (Röding, 1798)].

Tridacna derasa (Röding, 1798)

(Pls. 280-282)

Range — Philippines, East Indies, Cocos-Keeling Islands and western Micronesia.

Remarks — This species is distinguished easily by its low primary and secondary radial sculpture, its often massive umbonal area and long hinge line causing the umbos to be displaced far posteriorly. Anatomically the most striking feature is the anterior displacement of the ctenidia which terminate far forward of the mouth. This necessitates extremely elongate distal oral grooves (terminology of Kellogg, 1915; Stasek, 1962; ? = lateral oral grooves of Purchon, 1955) which lead posteriorly and ventrally to the labial palps and mouth.

Because of the absence of spiny sculpture and the considerable variation in shell shape, young specimens of *T. derasa* can be confused with certain specimens of *T. gigas*. The confusion may be

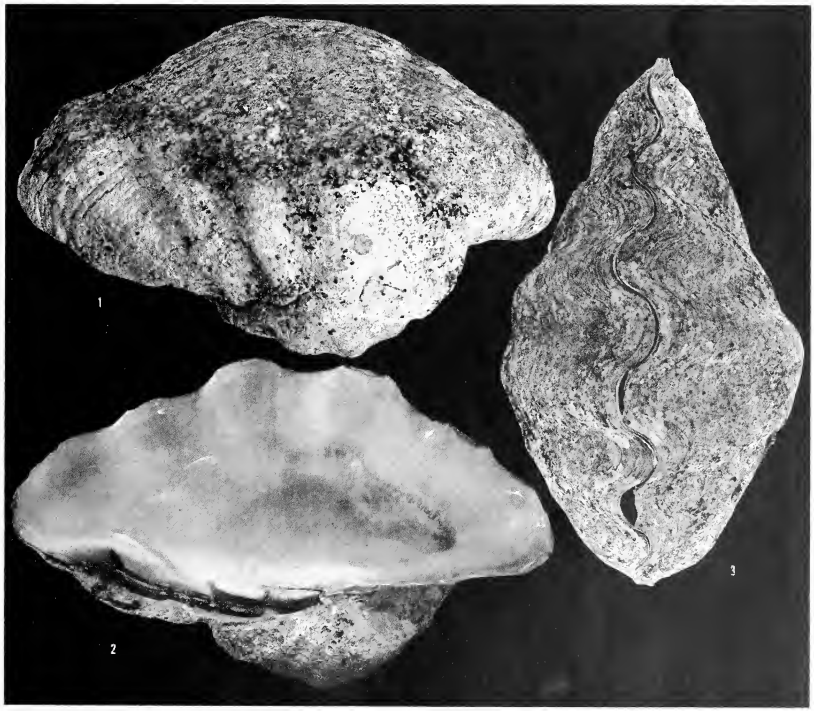

Plate 280. *Tridacna (Persikima) derasa* (Röding). Mature specimen from outer reef, off Noumea, New Caledonia (length: 408 mm.). Fig. 1. External view left valve. Fig. 2. Internal view right valve; note long hinge line and posteriorly displaced umbos. Fig. 3. Dorsal view to show interdigitating projections (Smithsonian photos).

dispelled by a careful comparison of shell characters. Where anatomical material is available there can be no doubt of its identity, for *T. gigas* has complete outer demibranchs while *T. derasa* has these structures incomplete. Also, *T. derasa* never reaches the size of large specimens of *T. gigas*. The peculiar anterior displacement of the ctenidia in *derasa* is a feature distinguishing this species from all other Tridacnidae.

Although there are similarities in the massive rolled-in umbos of some specimens of *T. derasa* and *Hippopus hippopus*, and also in the occurrence of orange coloration in the hinge region, there is little danger of confusing these species as they are so different in other respects.

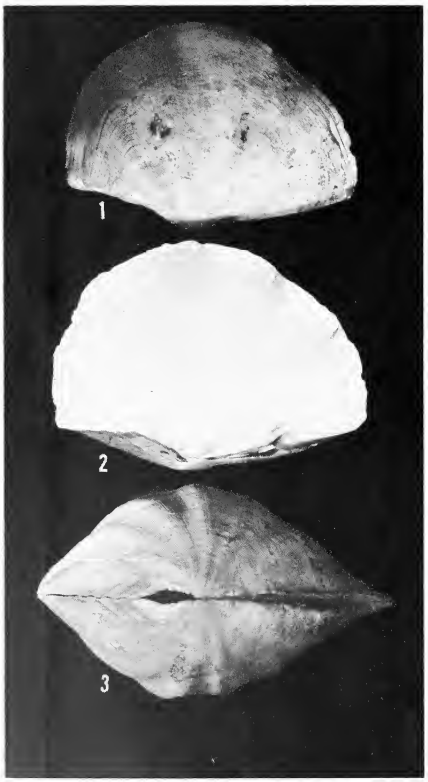

Plate 281. *Tridacna (Persikima) derasa* (Röding). Holotype of *T. obesa* Sowerby, from the Philippines (length: 158 mm.; BM(NH) 1899.4.22.81). Fig. 1. Exterior of right valve. Fig. 2. Interior of left valve. Fig. 3. Ventral view; note small byssal orifice and depressed folds. (photo courtesy of R. T. Abbott).

Tridacna derasa is quite rare in collections and I have examined material from only about ten localities. Collecting data with specimens from Noumea, New Caledonia, indicate that *T. derasa* lives there on the outer edge of the barrier reef. Hazards of collecting in such localities may account for the shell's variety in collections. In the Cocos-Keeling Islands, this species was collected in quantity from the atoll lagoon. It is interesting to note that there, in a more protected habitat, specimens developed strong concentric sculpture.

So far as is known from present locality data, the range of *T. derasa* does not extend eastward into Micronesia as far as the eastern Caroline, Marshall or Gilbert Islands.

Habitat — Lives on the outer edges of barrier reefs and in coral atoll lagoons; usually unattached.

Description — Shell reaching 514 mm. (about 20¼ inches) in length; semicircular in outline, angle formed at umbos by margins of hinge line and ventral border usually equaling or exceeding 150°; weakly to strongly inflated and having a very small byssal orifice. Valves usually very heavy and often greatly thickened at umbos, color grayish white, and to a limited degree encrusted with coralline algae, other organisms and debris. Primary radial sculpture consisting of from 7-12 broad, often nearly obsolete rib-like folds (usually 6-7 main folds) which become crowded and indistinct on ventral slope. Secondary radial sculpture consisting of fine riblets about equally distributed over folds and their equally broad interstices. Concentric sculpture consisting of closely-spaced, undulate lines of growth which upon intersecting secondary riblets may impart locally a faint nodular appearance visible under low magnification. Occasionally, as in the Cocos-Keeling population, concentric sculpture can be strongly expressed, producing continuous, undulate, erect ridges. Dorsal valve margins undulate, with series of 6-7 terminally rounded, medially projecting, interdigitating processes representing extremities of rib interstices. Hinge line usually longer than half the length of shell; umbos located considerably posterior of center. Ligament secondarily prosodetic. Ventral margin only slightly concave, byssal orifice narrow and short; plicae 6-7, elongate, often nearly obsolete. Ventral slope narrow to broadly concave, depending on obesity of specimen. Interior of valves white; hinge area often orange-tinged. Posterior adductor muscle scar large and subcircular in outline. Posterior pedal retractor

muscle scar one fourth to one third the size of and anterior to dorsal border of posterior adductor.

Animal: A small byssus was present in an immature specimen measuring 60 mm. in length. Two larger preserved specimens showed no sign of a byssus. In other respects, the animal is similar to *T. maxima, crocea* and *squamosa* in having incomplete outer demibranchs and guard tentacles surrounding the incurrent siphon. The ctenidia extend anteriorly beyond the mouth about one third of their length. Very long distal oral grooves lead downward and posteriorly from ctenidia to bases of labial palps.

Measurements (mm.) —

length	height	width	
513	292	315	large; "East Indies," U. S. Exploring Expedition, USNM
408	246	231	large; reef off Noumea, New Caledonia
236	150	129	average; Cocos-Keeling Islands
213	151	144	average; Cocos-Keeling Islands
133	86	56	small; Palau Islands
60	31	15	small; Palau Islands

Synonymy —

1798 *Tridachnes derasa* Röding, Museum Boltenianum, part 2, p. 172, no. 195 (no locality given; Amboina, Moluccas, here designated); refers to Gmelin, *Chama gigas*, sp. 2β, and to Chemnitz, vol. 7, pl. 49, fig. 497 [type figure; a young specimen]; Hedley, 1921, Records of the Australian Museum, vol. 13, no. 4, p. 167, pl. 28, fig. 4.

1807 *Tridacne glabra* Link, Beschreibung Naturalien Sammlung Univ. Rostock (3) p. 153 (no locality given); refers to *Chama gigas*, var. β Linné, Gmelin, and to Chemnitz, vol. 7, pl. 49, fig. 497.

1819 *Tridacna serrifera* Lamarck, Histoire Naturelle des Animaux sans Vertèbres, vol. 6, p. 107 (l'Océan indien?); refers to Tableau Encyclopédique Méthodique, pl. 235, fig. 3 [this and Chenu's pl. 8, fig. 4, are copies of Chemnitz, vol. 7, pl. 49, fig. 497]; not Reeve, vol. 14, Tridacna, pl. 6, fig. 6 (= *T. gigas*).

1899 *Tridacna obesa* Sowerby, Proceedings of the Malacological Society of London, vol. 3, p. 210, figs. pp. 210-211 (Philippines); type in British Museum (N. H.).

1937 *Persikima whitleyi* Iredale, Australian Zoologist, vol. 8, part 4, p. 237, pl. 15 (Middleton Reef, Coral Sea); type in Australian Museum, Sydney.

Plate 282. *Tridacna (Persikima) derasa* (Röding). Figs. 1, 2. Highly sculptured form from 3 miles southwest of Home Island, Cocos-Keeling Islands (length: 238 mm.). Figs. 3, 4. Young specimen from 1½ miles west of Eil Malk, Palau Islands (length: 133 mm.) (Smithsonian photos).

Nomenclature – Röding based *T. derasa* on the figure of Chemnitz, which was also referred to by Link for *T. glabra*, and a copy of which served as the basis for Lamarck's *T. serrifera* (see *Synonymy*). The figure is of a young specimen of this species, as evidenced by the low sculpture and undulating shell margins. The specimen which served as the basis for Sowerby's *T. obesa* was a highly inflated but not particularly large individual, 16 cm. in length, whereas Iredale's type of *P. whitleyi* is 12 inches (about 30.5 cm.) long.

Hedley (1921, p. 167) was the first to suggest a synonymy for *derasa*, which included *serrifera* Lamarck and *obesa* Sowerby, although the figure of Reeve which he cited for *serrifera* is probably not this species, but young *T. gigas*. I cannot agree that *T. mutica* Lamarck is this species. The description of the latter recalls no known species and Chenu's plates are of young *T. gigas* and *T. maxima*.

Records – (solid dots on map: specimens examined; open circles: from the literature) – PHILIPPINES: Butauanan Island, Ambos Camarines, Luzon (USNM). EAST INDIES: Pulau Mandidarah, North Borneo, Malaysia (USNM; ANSP). COCOS-KEELING ISLANDS: (Gibson-Hill, USNM); 3 miles southwest of Home Island (International Indian Ocean Expedition, V. Orr, 1963, ANSP, USNM). AUSTRALIA: Murray Island, Torres Strait (Hedley, 1921); Gillett Cay, Swain Reefs (Aust. Mus.; USNM) both Queensland; Middleton Reef, off New South Wales (Iredale, 1937). NEW GUINEA: Poelau Rouw, Aoeri Group, West Irian (ANSP). NEW CALEDONIA: barrier reef off Noumea (ANSP; USNM). PALAU ISLANDS: Malakal Harbor, Koror (ANSP); Abappaomogan, west of Eil Malk (USNM); southeast Eil Malk (ANSP).

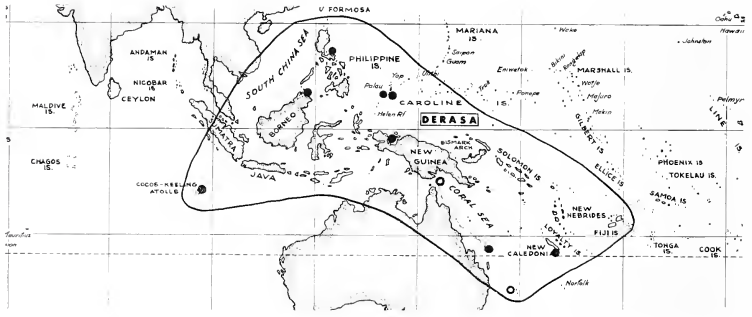

Plate 283. Geographical distribution of *Tridacna (Persikima) derasa* (Röding); solid dots: specimens examined; open circles: from the literature.

Subgenus Chametrachea Mörch, 1853

Type: *Tridacna crocea* Lamarck, 1819

Tridacna crocea displays in accentuated form the characteristics of this subgenus which are shown in varying degrees by all its members. They are byssiferous, possess guard tentacles around the edge of the incurrent opening, have reduced outer demibranchs which lack a food groove, and their valves range from being nearly equilateral with the umbos nearly central in position *(T. squamosa)* to strongly inequilateral (*T. maxima* and *crocea*) with the umbos displaced far anteriorly, never posteriorly as in *Persikima*. All species of *Chametrachea* bore into coral, this tendency being most evident in *crocea*. All possess a capacity for producing scaly shell sculpture, the scales becoming more reduced as the boring habit is intensified. The Recent species are arranged here in order of increasing specialization.

Synonymy –

[1753 *Chamaetrachaea* Klein, Tentamen Methodi Ostracologicae, p. 149 (pre-Linnaean).]

1853 *Chametrachea* Mörch, Catalogus Conchyliorum Comes de Yoldi, part 2, p. 56. Type by subsequent designation (Iredale, 1937): *Tridacna crocea* Lamarck.

1857 *Chametrachaea* H. and A. Adams, The Genera of Recent Mollusca, vol. 2, p. 464; refer to *C. scapha* Meuschen as an example, and their plate 113, fig. 2, 2a, 2b [= *T. maxima* Röding].

1937 *Flodacna* Iredale, Australian Zoologist, vol. 8, part 4, p. 238. Type by original designation: *Tridacna squamosa* auct. [= *T. squamosa* Lamarck].

1937 *Sepidacna* Iredale *ibid.*, p. 239. Type by original designation (*ibid.*, p. 261): *Tridacna troughtoni* Iredale, 1927 [= *T. maxima* Röding].

1937 *Vulgodacna* Iredale, *ibid.*, p. 239. Type by original designation: *Tridacna maxima* var. *fossor* Hedley, 1921 [= *T. maxima* Röding].

Tridacna loczyi Kutassy, 1934

Range – Pliocene (?) of Celebes, Indonesia.

Remarks – *Tridacna loczyi* is probably ancestral to *T. squamosa*. The worn scales and shape of the fossil resemble those of large, old specimens of the latter species, as does its length of 380 mm.

Synonymy –

1934 *Tridacna loczyi* A. von Kutassy, Verhandelingen Geologisch-Mijnbouwkundig Genootschap voor Nederland en Koloniën, Geologische Ser., deel 10, p. 313, pl. 6, fig. 5, pl. 7, fig. 1 (Kaoeroe, Celebes).

Tridacna mbalavuana Ladd, 1934

(Pl. 284)

Range – Upper tertiary, Viti Levu, Fiji.

Remarks – As Ladd suggested, the holotype of *T. mbalavuana* is apparently a young specimen, and it is difficult to determine its relationship with any

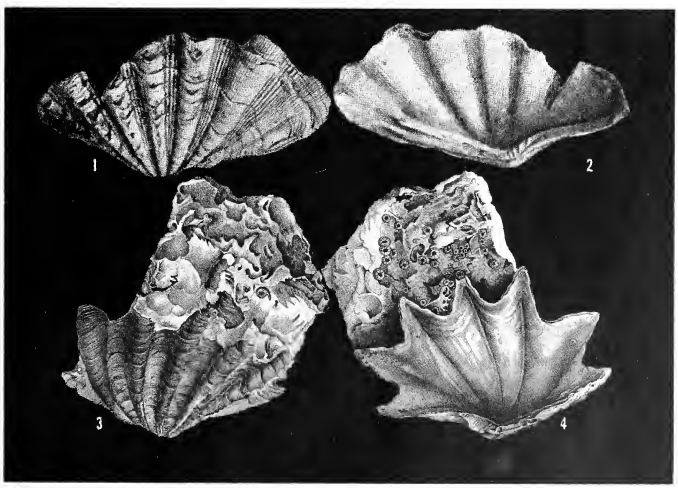

Plate 284. Figs. 1, 2. *Tridacna (Chametrachea) mbalavuana* Ladd, from south side Walu Bay, Viti Levu, Fiji; Neogene; Holotype (53.1 mm., BPBM Geol. No. 1124) (from Ladd, 1934, pl. 31, figs. 2, 3. Figs. 3, 4. *Tridacna (Chametrachea) aegyptiaca* Chenu, from Gulf of Suez, Egypt; Pleistocene (?) (reduced from Chenu, 1845, pl. 7, figs. 1, 2) (Smithsonian photos).

Recent species. The elongation of the hinge line, and posterior displacement of the umbos, suggest a relationship with *Persikima*. However, the widely spaced scales and characteristics of the radial sculpture indicate that the species is closer to *T. squamosa* in the subgenus *Chametrachea*.

Synonymy —

1934 *Tridacna mbalavuana* Ladd, Bernice P. Bishop Museum Bull. 119, p. 185, pl. 31, figs. 2, 3; holotype: BPBM Geol. No. 1124 (south side Walu Bay, Viti Levu, Fiji).

Tridacna aegyptiaca Chenu, 1845

(Pl. 284)

Range — Fossil (?), Gulf of Suez.

Remarks — This well-worn specimen closely resembles *Tridacna squamosa*. The single striking feature, the deeply cut fold interstices, may be the result of breakage and weathering. It is doubtful that *T. aegyptiaca* lived earlier than the Pleistocene, and this conjecture is made more plausible by the statement of Chenu that the specimen is embedded in a matrix of recent conglomerate.

Synonymy —

1845 *Tridacna aegyptiaca* Chenu, Illustrations Conchyliologiques, Paris, vol. 2, Tridacna, p. 2, pl. 7, figs. 1, 2 (Gulf of Suez, Egypt).

Tridacna squamosa Lamarck, 1819

(Pls. 263, 267, 285)

Range — East Africa to eastern Melanesia.

Remarks — The Scaly or Fluted Giant Clam is one of the strikingly beautiful inhabitants of tropical Indo-Pacific coral reefs. The shell can display exquisite flutes, and certain of the animals' patterns of coloration are extremely lovely (see plates 263 and 285).

Tridacna squamosa can be distinguished from all other species in the family by its characteristic sculpture of projecting, broad, leaf-like scales ("fluted sculpture," R. D. Turner in Shrock and Twenhofel, 1953, p. 378). Its shell is more equilateral then those of *T. crocea* and *maxima*, the other members of the subgenus *Chametrachea*, and it has a smaller byssal orifice. From *T. gigas* and *H. hippopus* it differs in lacking a complete outer demibranch, in its fluted sculpture, and in having a heavier shell for its size. *Tridacna squamosa* is also usually attached by a weak but copious byssus, whereas the former two species usually lack this attachment as adults. *Tridacna (Persikima) derasa* can be confused with *T. squamosa*, since *T. derasa* sometimes produces low (though continuous) projecting concentric sculpture. The shell of *T. derasa*,

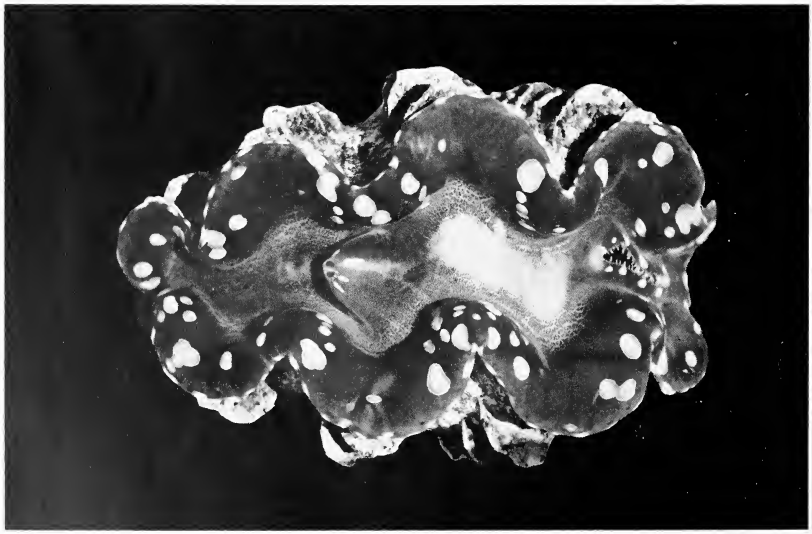

Plate 285. *Tridacna (Chametrachea) squamosa* Lamarck. Dorsal view of living animal from Muti Island, Eniwetok Atoll, Marshall Islands (on coral head in 12 feet of water); note cone-like excurrent siphon (center) and guard tentacles of incurrent siphon (right [posterior]) (length: 235 mm.) (author's photo).

however, is usually inequilateral with the umbos displaced posterior to center. Umbonal displacement in *T. squamosa,* when present, is usually anterior. The distinctive arrangement of the anterior ctenidial tracts of *derasa* can be depended upon to distinguish it further from *squamosa* (see *Remarks* and *Description, T. derasa*).

Due to the plasticity of the shells of Tridacnidae, it was implied by Hedley (1899) that *T. gigas* and *T. squamosa* are the same species and (in 1921) that "two or more species distinct in youth may converge in age til they are alike Giant Clams" (also see Dautzenberg, 1929, p. 586). Although McLean (1947) maintained *squamosa* and *gigas* as separate species, he admitted the possibility "that *T. squamosa* may in senility lose the scales and become a 'giant clam' resembling the adult *gigas.*" The largest specimen of *squamosa* known to me (40.8 cm., from Thailand) bears little resemblance to *gigas.* Despite the fact that the scales of large individuals of *T. squamosa* can become worn down to some degree, these individuals are always distinguishable from *T. gigas.*

The species *elongatissima,* described by Bianconi from Mozambique, has an elongate shell and normally has one or two additional radial folds. This apparent phenotype of *squamosa* is also present in the Red Sea and occurs occasionally elsewhere in the range of the species. Because it does not have any geographic limitations and appears to intergrade with the typical *squamosa, elongatissima* is not recognized even as a subspecies.

Holthuis (1952) reported the following shrimps of the family Palaemonidae to be commensal with *T. squamosa: Anchistus miersi* (DeMan) and *Conchodytes tridacnae* Peters. An additional species of *Anchistus,* near *A. demani* Kemp, was present in *T. squamosa* collected by the writer at Eniwetok Atoll, Marshall Islands (identified by Dr. F. A. Chace, USNM). A brachyuran crab, *Xanthasia murigera* White (Pinnotheridae), was also found in the mantle cavity of a specimen of *squamosa* collected by the writer at Ko Sindarar Nua, Thailand (identified by Dr. R. B. Manning, USNM).

Habitat — On the surface of coral reefs, usually in somewhat protected localities; in reef moats (Stephenson, et al., 1931).

Color Notes — Mantles of *Tridacna squamosa* are variable in color and pattern. The following notes were made from a young and perhaps atypical specimen collected at Eniwetok Atoll measuring 24 cm. in length (see pl. 285).

The main ground color of the mantle is *dark grayish purple* (Kelly and Judd, 1955, ISCC-NBS color name, C553 number 229); along the outer mantle margin is a row of rhomboidal spots which are *very light bluish green* (C553 number 162); the larger irregularly-circular spots toward the center of the mantle are multicolored, their outer periphery being *pale yellow* (number 89), inside of which is a band of *dark yellow* (number 88), and entire center is nearest to *light blue* (number 181). Around edges of incurrent opening there is a series of the larger spots and elongate ones are also present on excurrent opening.

In older specimens the main, purple ground color seems to persist, although only one other specimen resembling that described above was seen by the writer at Eniwetok (Feb.-Mar. 1963) and none were seen later in the year (Oct.-Dec.) in waters of Malaysia, Thailand or Indonesia. The more typical pattern seems to consist of smaller overall speckling, blotching and striping with yellow or tan (see plate 263). Posteriorly within the mantle cavity, the ctenidia of all specimens examined were brown.

Appearance and Activity: Visible hyaline organs are distributed solely along the edges of the mantle. There is an irregular row of small ones on the mantle margin, and medially another more sparse row of larger ones, some of which are on small mounds of mantle tissue.

When undisturbed the mantle is reflected over the edges of the gaping valves (plate 285). The incurrent opening is elongate and partially obscured by the tentacles guarding it. The excurrent opening is located on a cone-shaped mound of mantle tissue and is usually directed anteriorly. When the clam is disturbed a forceful jet of water can be emitted from the excurrent opening. The tissues surrounding the excurrent opening appear to be quite sensitive to an interruption of light rays. The animal portrayed in plate 263 does not appear normal and may have been near death.

Description — Shell reaching 408 mm. (about 16 inches) in length; semicircular in outline; the angle formed at the umbos by the hinge line and ventral margin usually greater than 150°; strongly inflated and having medium-sized to small byssal orifice. Valves moderately heavy and thick; color usually grayish white but occasionally tinged with orange; encrusted with vermetids, annelid tubes, coral, coralline algae, other organisms and debris. Surface of valves dull. Primary radial sculpture consists of

from 4 to 12 strongly convex, rib-like folds which become crowded and obsolete on ventral slope; one fold, usually the second to fourth from anterior end, is positioned almost vertically; the others slant obliquely in an anterior or posterior direction. Usually 5 or 6 of the folds are very strong. Secondary radial sculpture consists of evenly-spaced riblets on both convex folds and their relatively broad interstices (more noticeable on the latter), interrupted by fine concentric lines of growth resulting in either a minute reticulate sculpture or in the formation of small nodules where riblets and growth lines cross. Concentric sculpture consists of undulate lines of growth which produce widely spaced, broadly leaf-like, projecting scales on primary folds (in young specimens scales are usually semitubular). Scales usually worn or broken on ventral half of shell; but everywhere are quite delicate and easily broken. Dorsal shell margins broadly fan-shaped in outline, undulate, with series of 4-6 pointed to bluntly rounded, medially projecting, crenulated, interdigitating processes which represent extremities of rib interstices. Hinge line usually about half the length of shell. A single, oblong cardinal tooth present in each valve; 2 elongate posterior lateral teeth present in right valve and 1 in left. Ligament secondarily prosodetic. Umbos directed postero-medially. Ventral margin slightly concave in region of byssal orifice, convex posteriorly. Edge of byssal orifice with series of 6-8 distinct to obsolete plicae, usually about evenly spaced. Posterior to byssal orifice ventral margin can be crenulate. Ventral slope relatively broad, flat, with crowded radial sculpture and often partially covered by overgrowth of porcelaneous material from edge of byssal orifice. Interior of valves porcelaneous; white or occasionally tinged with orange. Pallial line entire, moderately wide. Posterior adductor muscle scar large, subcircular, adjacent to pallial line dorsally and located posterior to center. Posterior pedal retractor muscle scar usually about half the size of posterior adductor scar (or smaller) and contiguous to it; located just anterior to center. Area within pallial line, excluding muscle scars, dull; pallial line, muscle scars and areas to the periphery of shell shiny. Prodissoconch unknown.

Measurements (mm.) —

length	height	width	
408	320	280	large; Ko Sindarar Tai, Thailand
387	263	240	large; Eniwetok, Marshall Islands
276	179	186	large; Rongerik, Marshall Islands
208	149	122	average; Onotoa, Gilbert Islands
129	78	60	small; Zanzibar
89	60	47	small; Zanzibar

Synonymy —

[1787 *Hippopodes scaphe* Meuschen, Museum Geversianum, p. 430 (part); non-binomial].

1798 *Tridacnes imbricata* var. α Röding, Museum Boltenianum, p. 172, no. 191, refers to Chemnitz, vol. 7, figs. 492-493.

1807 *Tridacne imbricata* Link, Beschreibung Naturalien sammlung Univ. Rostock (3) p. 153 (no locality given); refers to *Chama gigas* Linné, Gmelin, p. 3299, and to Chemnitz, vol. 7, pl. 49, figs. 492(-493) [= *T. squamosa*] 494 [= *T. maxima*] (part). Non Röding, 1798.

1819 *Tridacna squamosa* Lamarck, Histoire Naturelle des Animaux sans Vertèbres, vol. 6, part 1, p. 106 (l'Océan indien [Amboina, Moluccas, here restricted]); refers to Rumphius, pl. 43 [42], fig. A; Tableau Encyclopédique Méthodique, pl. 235, fig. 4, pl. 236, fig. 1a, b; and others.

1845 *Tridacna squamoza* 'Lamarck' Chenu, Illustrations Conchyliologiques, vol. 2, **Tridacna**, caption, pl. 6, fig. 5 [misspelling].

1856 *Tridacna elongatissima* Bianconi, Memorie della Accademia delle Scienze dell 'Instituto di Bologna, vol. 7, p. 408, pl. 25, fig. 2 (Mozambique).

1903 *Tridacna lamarcki* Hidalgo, Memorias Real Academia de Ciencias, Madrid, vol. 21, p. 385 (Mindoro, Cebu, Mindanao, Paragua [Palawan] (part); refers to Sowerby, Thes. Conch., pl. 485 (**Tridacna**, pl. 1) fig. 2, and others.

Types — The location of the holotype of *Tridacna squamosa* Lamarck is unknown. It is not in the Museum National d'Histoire Naturelle, Paris, according to Lamy (1932), nor is it in Geneva (E. Binder, *in litt.*, 1961). Rumphius' plate 43 [42], fig. A, is here designated the lectotype of *Tridacna squamosa* Lamarck, 1819. The type locality, "l'Océan indien," mentioned by Lamarck, may be interpreted to include the East Indies. It is here restricted to Amboina, Moluccas, from which Rumphius' specimen undoubtedly came. The locations of the types of *T. imbricata* var. α Röding and *T. imbricata* Link are unknown.

Nomenclature — This species has been recognized generally without question under the name *squamosa* since it was described. Lamarck's words (here translated): "large, erect, distant scales; interstices of the ribs multistriate," leave little doubt as to its identity. Of the figures cited by Lamarck, Rumphius, pl. 43 [42], fig. A; Gualtieri pl. 92, fig. F; and those from the Encyclopédique Méthodique are undoubtedly this species; Gualtieri, pl. 93, fig. B and the Knorr and Chemnitz figures, unfortunately, are of *T. maxima*.

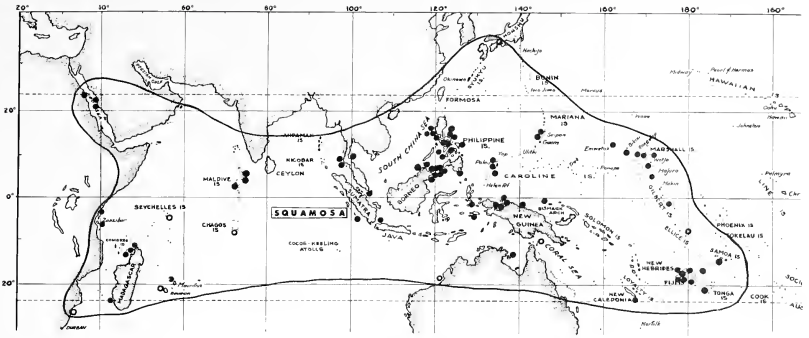

Plate 286. Geographical distribution of *Tridacna (Chametrachea) squamosa* Lamarck; solid dots: specimens examined; open circles: from the literature.

Records – MOZAMBIQUE: Saco coral reef, Inhaca Island, Delagoa Bay (Macnae and Kalk, 1958). ZANZIBAR: Mnazi Mmoja, Zanzibar City (ANSP; USNM); Fumba; Chango Island (both ANSP). KENYA: Diani Beach, Mombasa (USNM). RED SEA: Ras Banas, Egypt; Sharm Ubhar and Jidda, both Saudi Arabia (all USNM). MADAGASCAR: between Ambariotelo and Ambariobe, southeast Nosy Bé (ANSP; USNM); Grand Récif, Tulear (R. W. Foster, ANSP). SEYCHELLES: (Rost and Soot-Ryen, 1955, p. 14). MAURITIUS: (USNM); REUNION: (Deshayes, 1863, pp. 21-22). MALDIVE ISLANDS: Kagi Island; Imma Island, both North Male Atoll; Wala Island, South Nilandu Atoll (all International Indian Ocean Expedition, 1964, R. Robertson, ANSP). CHAGOS ARCHIPELAGO: (Melvill, 1909, p. 135). THAILAND: Ko Sindarar Nua (Chance Island); Ko Sindarar Tai (both International Indian Ocean Expedition, 1963, USNM); Ko Phuket, (MCZ; ANSP), all Andaman Sea; Ko Tao (USNM); Ko Khram (G. M. Moore, MCZ) both Gulf of Siam. MALAYSIA: Pulau Tekukor, northwest of St. John's Island, Singapore (International Indian Ocean Expedition, 1963, USNM). JAPAN: Hiogo [Kobe area] (Pilsbry, 1895, p. 130, *ex* Lischke, 1869, p. 160). PHILIPPINES: Grand Island Reef, Subic Bay; Corregidor, Manila Bay (both USNM); Matabungkay Cove, 14 km. south of Nasugbu, Batangas Province; Tabaco, Albay Province; Barrio Lupi, Prieto Diaz, Sorsogon Province (all ANSP); Badang, near Gubat, Sorsogon Province, all Luzon (MCZ; USNM); Lubang Island (USNM); Ambil Island, both Lubang Islands (MCZ); Boac; near Cabuyo, both Marinduque (both USNM); Ibajay, Panay (MCZ); along Rio Jordan, Guimaras; Cebu, Cebu (both USNM); Olango Island, east side of Cebu (ANSP); Cagayan [off Negros Occidental]; Siaton, Negros Oriental (both USNM); Borongan Village, east side of Samar Island (ANSP); Santa Cruz Island, off Zamboanga (USNM); Gulf of Davao, Mindanao Island (ANSP); Mantangal, Basilan; Lampinigan Island, off northwest Basilan; Chase Head, Endeavor Strait, Palawan; Marongas Island, off Jolo (all USNM); Bongao Channel, southwest end Sanga Sanga Island, both Sulu Archipelago (ANSP). INDONESIA: South Pagi Island, Veeckens Bay, southwest of Sumatra (International Indian Ocean Expedition, 1963, USNM); Tjiperwagaran, Bantam, Java (USNM); Batjan Island; Amboina, both Moluccas (both MCZ). NORTH BORNEO: Jesselton (ANSP); Pulau Tiga (USNM); Pulau Mandidarah (ANSP); off Pulau Bohaydulong, Semporna (USNM) (all Mary Saul, collector). AUSTRALIA: Broome, Western Australia; Murray Id., Torres Straits, Queensland (both Hedley, 1921, p. 172); Little Lagoon. Groote Eylandt, Gulf of Carpentaria (USNM). NEW GUINEA: Poelau Rouw; Poelau Maransabadi, both Aoeri Islands; 1½ miles southwest of Biak, Poelau Biak, Schouten Islands; Poelau Noesi; Poelau Konori, both Mios Woendi, Padaido Islands (all ANSP); near Hollandia (USNM) (all West Irian). ADMIRALTY ISLANDS: Seeadler Harbor, Manus Island (MCZ). NEW CALEDONIA: Noumea (ANSP; USNM). FIJI: Yasawa Islands (USNM); Nananu I-Ra; Ngaloa, 3 miles west of Rovondrau Bay (both MCZ); Suva (USNM) all Viti Levu; Mbengga Island; outer reef, 3 miles southeast of Tunuloa, Vanua Levu; Dravalau, Totoya (all MCZ). MARIANAS ISLANDS: Unai Dikiki Matuis, Saipan (USNM); east Tinian (MCZ). PALAU ISLANDS: Babelthuap (USNM; MCZ); Koror (BPBM; MCZ; ANSP; USNM); Abappaomogan, 1½ miles west of Eil Malk (F. M. Bayer, 1955, USNM); Eomogan (MCZ). MARSHALL ISLANDS: Igurin Island, Eniwetok; Yurochi Island, Bikini; Burok Island, Rongelap; Letoback Island, Rongerick; Taka; Ailuk (all USNM); Majuro (BPBM); GILBERT ISLANDS: Onotoa (USNM). ELLICE ISLANDS: Funafuti (Hedley, 1899, p. 504). SAMOA: (ANSP). TONGA: Sopu Reef (L. J. Lancaster, USNM); Niuafou (USNM). TUAMOTUS: doubtful record and possibly fossil specimens.

Fossil records – FRENCH SOMALIA: Pleistocene, 1.5 meters west of Obock (Abrard, 1942). DAITO ISLANDS (south of Japan): Pliocene-Pleistocene, Kita Daito Jima (Nomura and Zinbo, 1935). EAST INDIES: Quaternary, Celebes (Schepman, 1907, p. 197). TONGA: Pleistocene (?), Vavau (Mansfield, 1926; USNM 352426). TUAMOTUS: Pleistocene, (?), Toau Atoll (ANSP); Pleistocene (?), Raroia Atoll (USNM).

Tridacna besairiei Collignon, 1951

(Pl. 287)

Range – Upper Cretaceous, Antonibe, Madagascar.

Remarks – The worn and broken fragment (pl. 287) of this species resembles most closely *T. maxima* (Röding). Collignon remarked in the description of the species that the age of this fossil is questionable because no other members of the family have been found in strata older than the Tertiary. If the age is valid, then *T. besairiei* is the oldest fossil tridacnid.

Synonymy –

1951 *Tridacna besairiei* M. Collignon, Annales Géologiques Du Service Des Mines, Bureau Géologique de Madagascar, Fascicule No. 19, Paris, p. 98, pl. 15 (3), figs. 15, 15a (Antonibe, Madagascar).

Tridacna media Pusch, 1837

(Pl. 287)

Range – Upper Tertiary beds of Warsaw, Poland.

Remarks – This fossil species appears to be most closely allied with *T. maxima,* although the surface sculpture of the specimen illustrated is very worn. This and *T. wolfarti* Chenu are the only fossil species reported from European deposits closely resembling Recent Tridacnidae. These species inhabited what must have been more expansive and tropical European seas during the Tertiary.

Synonymy –

1836 *Tridacna media* Pusch, Polens Paläontologie (1), p. 55, pl. 6, fig. 6a, b, c (Tertiary beds, Warsaw, Poland).

Tridacna maxima (Röding, 1798)

(Pls. 263-265; 267-269; 288-290)

Range – East Africa to eastern Polynesia except Hawaii.

Remarks – This species is the most ubiquitous of the family, inhabiting reefs throughout the tropical Indo-Pacific. Both the color of the exposed mantle and the shape and sculpture of the valves are extremely variable (see plate 263).

Tridacna maxima can easily be distinguished from *T. gigas* and *T. squamosa* by its strongly inequilateral valves, the hinge line being considerably shorter than the ventral margin; sculptural differences also readily separate *maxima* from these species. It is most closely related to *T. crocea,* but differs in having more raised external valve sculpture, subequal posterior adductor and byssal retractor muscle scars, and a byssal orifice which is usually relatively shorter than that of *crocea.*

Field observations indicate that there is consider-

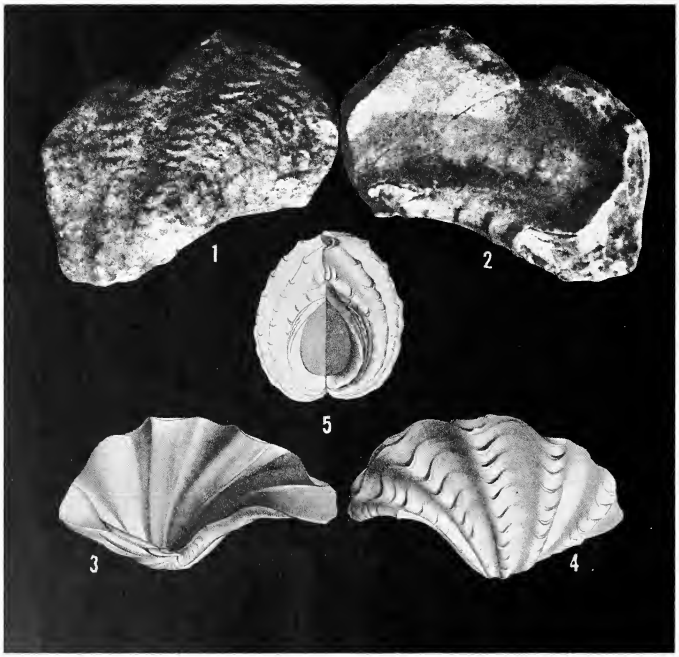

Plate 287. Figs. 1, 2. *Tridacna (Chametrachea) besairiei* Collignon, from Antonibe, Madagascar, Upper Cretaceous; Holotype (36 mm.) (from Collignon, 1951, pl. 15 (3), figs. 15, 15a). Figs. 3-5. *Tridacna (Chametrachea) media* Pusch, from Tertiary beds, Warsaw, Poland; Holotype (from Pusch, 1836, pl. 6, fig. 6a, b, c) (Smithsonian photos).

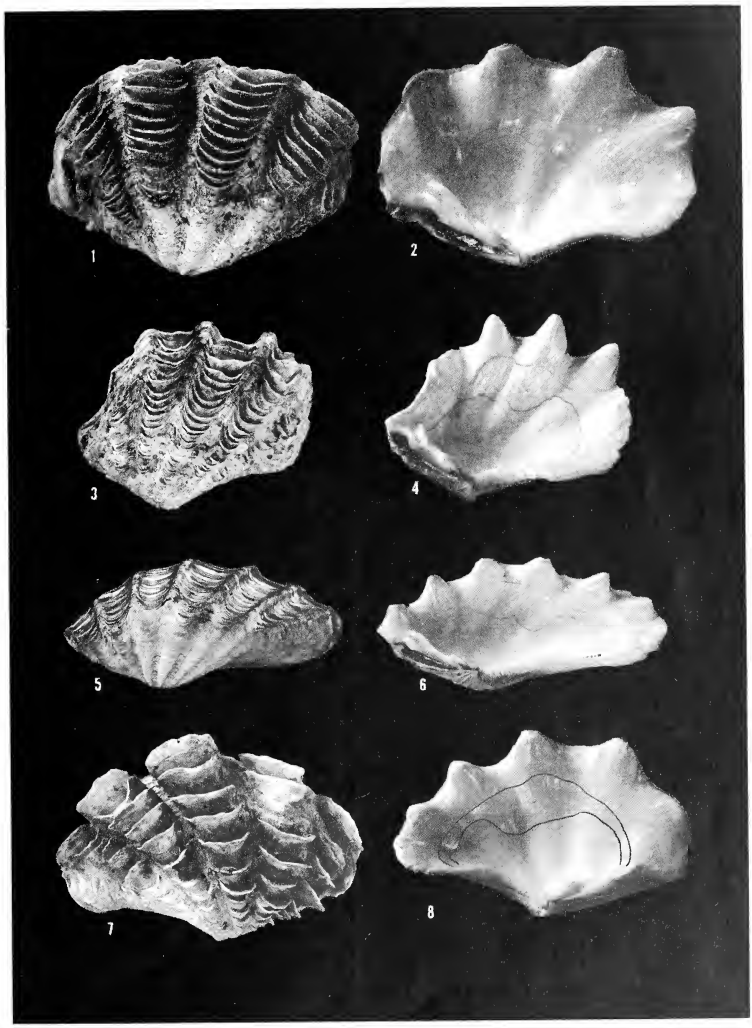

Plate 288. *Tridacna (Chametrachea) maxima* showing variation in shape and sculpture of shell. Figs. 1, 2. Specimen from Eniwetok, Marshall Islands (133 mm. length). Figs. 3, 4. From Ani Jima, Bonin Islands (injured anterodorsally; 105 mm. length). Figs. 5, 6. From Celeo Island, off North-East New Guinea (120 mm. length). Figs. 7, 8. From Nosy Be, Madagascar (127 mm. length). Muscle scars and pallial lines outlined. Figs. 1, 3, 5, 8 are left valves; figs. 2, 4, 6, 7 are right valves (Smithsonian photos).

able overlap in mantle coloration and pattern between *maxima* and *crocea*. Both species are exceedingly variable in these characters, but this may be due to convergence where these characters are subject to no strong selective pressures. Mantle color in *T. maxima* runs the gamut of brilliant green, blue, purple and brown with great pattern variation (see plate 263, fig. 3; and plate 264; also Gillett and McNeill, 1959, p. 87; for comparison with *T. crocea*, see Franc, 1960, pl. 9).

In widely separated geographic regions color brilliancy may vary in *T. maxima*. At Eniwetok, Marshall Islands, the mantle colors were observed to be extremely bright (personal observation, Feb.-March, 1963). This seems also to be true on the Great Barrier Reef of Australia (Gillett, et al., op. cit.). But on the shores of the Andaman Sea in Malaysia and Thailand, and off southern Sumatra (Oct.-Dec., 1963) the colors were noted to be more subdued (similar to *crocea*, Franc, op. cit.). This phenomenon may be due to differences in the conditions of the animals at the time the observations were made, to a real geographic variation based on genetic difference, or to environmental factors.

It is evident from the study of a large series of *T. maxima* from many localities throughout its range that several well-known forms intergrade with this species (see Synonymy). Outstanding among the forms here considered synonyms of *maxima*, is *T. elongata* Lamarck. This, as the name suggests, tends to be elongate (see plate 289). Forms like this occasionally occur throughout the Indo-Pacific and show no particular geographic pattern. McLean (1947) distinguished this form from *maxima*. However, no consistent differences have been noted in the present study. The elongate form can be connected with more typical *maxima* by intermediates.

The extreme variability of *T. maxima*, responsible at least in part for the many named forms, can be explained on the basis of the species' ecology. The clam lives firmly attached to the coral reef. Where sufficient space is available anteriorly and posteriorly, the valves may become more or less elongate; but where growth is blocked by a coralline obstacle, the valves may become stunted or malformed. Such malformations are common. (see plate 288). Also, apparently depending on the substrate, individuals may burrow fairly deeply, although never becoming imprisoned as does *T. crocea*. The depth to which a clam has burrowed can be interpreted from the parts of the valves which have been smoothed by erosion.

The gross morphology of *T. maxima* is very similar to that of *T. crocea*. At maturity both are smaller animals than other Tridacnidae; the outer demibranchs are incomplete and grossly similar in structure. Hyaline organs tend to be concentrated along the edge of the mantle on papillae in *maxima*, while in *crocea* they are more diffuse on the mantle surface. In *maxima* posterior pedal retractor and adductor muscles are subequal in circumference, while in *crocea* the posterior pedal retractor is about half the size of the adductor.

The following species of shrimps (Palaemonidae: Pontoniinae) were found commensal in the mantle cavity of *T. maxima: Conchodytes tridacnae* Peters (Ko Huyong, Similan Islands, Thailand); and *Anchistus demani* Kemp (Ko Sindarar Nua, Thailand) (identified by Dr. R. B. Manning, U. S. National Museum).

Habitat — Lives in shallow water on reefs, partially imbedded in coral.

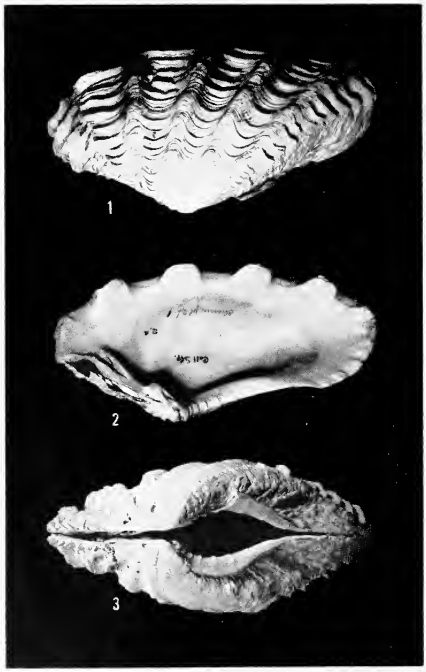

Plate 289. *Tridacna (Chametrachea) maxima* (Röding). Lectotype of *T. elongata* Lamarck. Fig. 1. Exterior of left valve. Fig. 2. Interior of right valve. Fig. 3. Ventral view showing byssal orifice. (15 cm. length) (photo courtesy of E. Binder, Muséum d'Histoire Naturelle, Geneva).

Color notes – Mantles of *T. maxima* (from Eniwetok) showed great variation in color and pattern (see plate 263, fig. 3; and plate 264). Often there is a peripheral band of color containing numerous hyaline organs; the main mantle color occurs medially and is sometimes spotted and streaked with other colors. Some of the main mantle colors noted were: *grayish yellow* (Kelly and Judd, 1955, ISCC-NBS Color Name; C553 number 90); *light bluish green* (C553 no. 163); *blackish blue* (C553 no. 188); *grayish violet* (C553 no. 215); and *blackish purple* (C553 no. 230). Narrow peripheral bands were noted in the following colors: *light olive brown* (C553 no. 94); *grayish greenish yellow* (C553 no. 105); and *brilliant green* (C553 no. 140). Spots and streaks over the surface of the mantle were noted to be: *brilliant bluish green* (C553 no. 159); and *brilliant blue* (C553 no. 177). Other colors were observed and it is unlikely that any two specimens of *T. maxima* are exactly alike in this regard.

The cause of mantle coloration in *Tridacna* is especially interesting in the cases of the variable species *T. maxima* and *crocea*. It is probably caused by the zooxanthellae. Specimens of *Tridacna, maxima,* were observed "with dead coral slabs resting on their shells, beneath which the mantles lacked pigmentation, i.e., were cream-white" (personal communication R. Robertson, 1964, in Maldive Islands). It appears that the zooxanthellae were unable to live in the shaded portions, thus leaving only the whitish mantle color. Mantle pattern variation apparently is based on the distribution of the algae in the tissues.

Activities – Specimens of *T. maxima* were collected from the reef of Eniwetok Atoll and maintained in the laboratory for 5-6 weeks in running water aquaria. Specimens were removed periodically for photographing and examination. It was noted that the animals reattached byssal threads to the aquarium floor each time they were replaced. *Tridacna maxima* reacted to an interruption in light intensity by withdrawing the mantle and closing its valves.

Description – Shell reaching 353 mm. (about 13 7/8 inches) in length; elongate- to short-obtuse-triangular in shape, angle formed at umbos by margins of hinge and ventral border usually less than 150°, moderately to strongly inflated and having a large

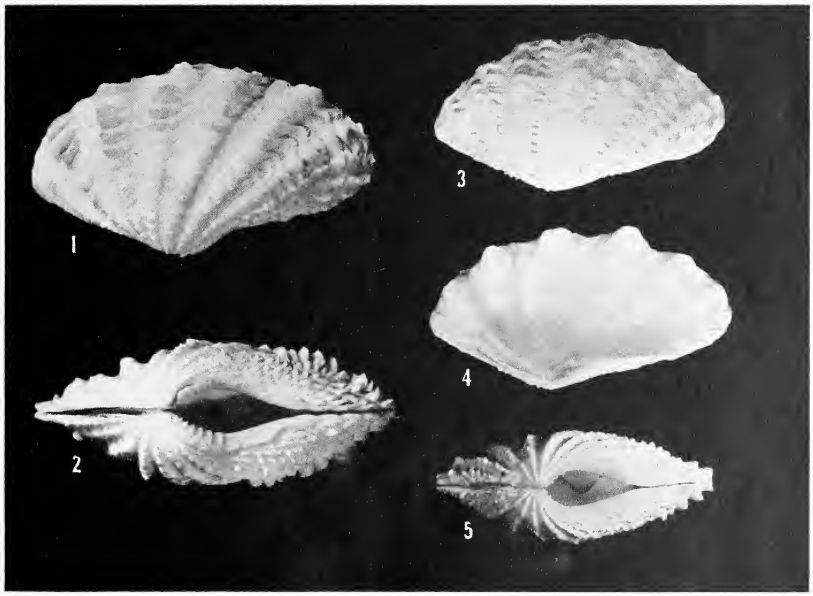

Plate 290. *Tridacna (Chametrachea) maxima* (Röding). Figs. 1, 2. Lectotype of *T. compressa* Reeve (length: 107 mm.). Figs. 3-5. Holotype of *T. acuticostata* Sowerby, from the Philippines (length: 132 mm.) (photos courtesy of R. T. Abbott).

byssal orifice. Valves heavy, thick, color usually grayish white but often tinged with yellow or pinkish orange; often incrusted with vermetids, annelid tubes, coral, coralline algae, other organisms and debris. Surface of valves dull or faintly shiny in cleaned specimens. Primary radial sculpture consisting of from 6 to 12 broad, moderately convex riblike folds becoming crowded and obsolete on ventral slope. Usually 6 or 7 of these folds are very strong. Secondary radial sculpture consisting of from 10-20 evenly spaced riblets on folds and 3-7 in their narrow interstices, often interrupted on primary folds by concentric sculpture and here having nodular appearance; in smooth specimens, where folds are low or worn down, secondary sculpture in interstices appears more prominent and here groups of riblets may simulate raised radiating bands. Concentric sculpture consisting of closely spaced undulate lines of growth which produce crowded, but usually low scales on primary folds. Scales often worn off near umbos and here undulate pattern is most evident. Dorsal valve margins undulate, with a series of about 5 usually sharply triangular, medially projecting, interdigitating processes which represent extremities of rib interstices. Hinge line short, less than one half length of shell. A single, oblong cardinal tooth is present in each valve; 2 elongate posterior lateral teeth present in right valve and 1 in left. Ligament secondarily prosodetic. Umbos directed posteromedially. Ventral margin varying from considerably to only slightly concave in region of byssal orifice and convex posteriorly. Edge of byssal orifice with series of 4 to 9 (usually about 6-7) distinct to obsolete plicae closely spaced near umbos and becoming more distantly separated posteriorly. Ventral slope narrow, rounded or hardly to considerably flattened. Interior of valves porcelaneous, usually white but occasionally tinged with yellow or pinkish orange near dorsal margin. Pallial line entire and relatively wide. Posterior adductor muscle scar large, subcircular, adjacent to pallial line dorsally and located posterior to center. Posterior pedal retractor muscle scar larger than half the size of posterior adductor scar (usually subequal) anteriorly contiguous to the latter, and approximately centered over byssal orifice. Area within pallial line, excluding muscle scars, dull; area of line, muscle scars and from there to periphery of shell shiny. Prodissoconch with its umbones directed medially and slightly anteriorly, somewhat inflated; in shape reminiscent of *Cardium;* with slight anterior wing and sculptured with microscopic, incised, concentric lines; 1.0 mm. in length (plate 268).

Measurements (mm.) —

length	height	width	
329	177	186	large; Palmyra, Line Islands
267	167	137	large; Canton Island, Phoenix Islands
202	107	103	average; Port Blair, Andaman Islands
169	78	81	average; Inner Sindu Island, Tanganyika
118	76	63	small-average; Uterik Island; Uterik Atoll, Marshall Island
85	60	44	small; Onotoa Atoll, Gilbert Islands

Synonymy —

[1787 *Hippopodes scutra* Meuschen, Museum Geversianum, p. 430; non-binomial].

[1797 *Tridachna elongata* Humphrey, Museum Calonnianum, p. 50 (Madagascar); rejected work.]

1798 *Tridachnes maxima* Röding, Museum Boltenianum, part 2, p. 171, no. 184 (no locality given [Mauritius, here designated]); refers to Gmelin, *Chama gigas,* species 2 [= Argenville, pl. 23, fig. E, a foliate specimen], and to Chemnitz, vol. 7, pl. 49, fig. 495 [a smooth specimen].

1798 *Tridachnes noae* Röding, *ibid.,* p. 171, no. 186 (no locality given); refers to Gmelin, *Chama gigas,* species 2, and Chemnitz, vol. 7, pl. 49, fig. 494.

1798 *Tridachnes imbricata* Röding, *ibid.,* p. 172, no. 190 (no locality given); refers to Gmelin, *Chama gigas* species 2.

1801 *Tridacna gigas* Lamarck, Système des Animaux sans Vertèbres, p. 117 (no locality given) (part); refers to Chemnitz, vol. 7, pl. 49, fig. 495, and to Tableau Encyclopédique et Méthodique, pl. 235, fig. 1; Reeve, 1862, Conchologia Iconica, vol. 14, **Tridacna**, pl. 1, fig. 1a, pl. 2, figs. 1b, c (Indian and Pacific Seas).

1807 *Tridacne imbricata* Link, Beschreibung Naturalien Sammlung Univ. Rostock (3) p. 153 (no locality given); refers to *Chama gigas* Linné, Gmelin, p. 3299, and to Chemnitz, vol. 7, pl. 49, figs. 492(-493) [= *T. squamosa*] 494 [= *T. maxima*] (part).

1807 *Tridacne maxima* Link, *ibid.,* p. 153 (no locality given); refers to *Chama gigas* Linné, Gmelin, and to Chemnitz, vol. 7, pl. 49, fig. 495.

1819 *Tridacna gigas* Lamarck, Histoire Naturelle des Animaux sans Vertèbres, vol. 6(1), p. 105 (l'Océan indien).

1819 *Tridacna elongata* Lamarck, *ibid.,* p. 106 (l'Océan indien?); Chenu, 1845, Ill. Conch., vol. 2, pl. 1, fig. 2, var. *β*; pl. 2, figs. 1-3.

1819 *Tridacna mutica* Lamarck, *ibid.,* p. 106 (l'Océan des grandes Indes) (part); Chenu, *ibid.,* pl. 4, figs. 1, 1a [= *T. gigas*], pl. 6, fig. 1 [= *T. maxima*].

1845 *Tridacna squamosa* 'Lamarck' Chenu, *ibid.,* pl. 3, fig. 2.

1853 *Chametrachea scutrum* 'Meuschen' Mörch, Catalogus Conchyliorum Comes de Yoldi, fascicle 2, p. 56 (East Indies); refers to Gualtieri, pl. 92, fig. E; H. and A. Adams, 1857, Genera of Recent Mollusca, vol. 2, p. 465.

1857 *Chametrachea scapha* 'Meuschen' H. and A. Adams, *ibid.,* p. 465, pl. 113, figs. 2, 2a, 2b (Pacific and Indian Oceans, and China Sea); not *C. scapha* 'Meuschen' Mörch = *T. crocea* Lamarck.

1862 *Tridacna rudis* Reeve, Conchologia Iconica, vol. 14, **Tridacna**, pl. 5, fig. 4a, b, c (Philippine Islands).

1862 *Tridacna compressa* Reeve, *ibid.*, pl. 6, fig. 5; pl. 7, fig. 5b, (no locality given [Philippines here designated]).

1862 *Tridacna cumingii* Reeve, *ibid.*, pl. 7, fig. 7b [not fig. 7a = *T. crocea*] (Philippine Islands) (part).

1884 *Tridacna lanceolata* Sowerby, Thesaurus Conchyliorum, vol. 5, p. 181, **Tridacna,** pl. 6, fig. 19 [18] (Philippines).

1902 *Tridachnes umbricata* Sherborn, Index Animalium, section 1, part 2, p. 1189 [error for *T. imbricata* Röding, 1798].

1903 *Tridacna lamarcki* Hidalgo, Memorias Real Academia de Ciencias, Madrid, vol. 21, p. 385 (Mindoro, Cebu, Mindanao, Paragua Islands [= Palawan]) (part); new name for *T. gigas* Lamarck, not Linné.

1903 *Tridacna reevei* Hidalgo, *ibid.*, p. 389 (Philippines); new name for *T. elongata* Reeve, not Lamarck.

1912 *Tridacna acuticostata* Sowerby, Proceedings Malacological Society of London, vol. 10, p. 30, fig. (p. 31) (Philippines).

1921 *Tridacna maxima* var. *fossor* Hedley, Records of Australian Museum, vol. 13, no. 4, p. 171, pl. 29, fig. 6; pl. 30, fig. 7; pl. 33, fig. 11 (Mast Head Island, Capricorn Group).

1927 *Tridacna troughtoni* Iredale, *ibid.*, vol. 16, p. 75, pl. 5, figs. 9-10 (Vanikoro); [a young specimen].

1939 *Tridacna corallicola* 'Valenciennes' Lamy, Journal de Conchyliologie, vol. 83, no. 4, footnote, p. 291 [nomen nudum].

Types — Röding's only figure reference for *T. maxima* was to Chemnitz, vol. 7, pl. 49, fig. 495, and this is here selected as the lectotype. Röding did not designate a type locality for *maxima*. However, in the text accompanying the type figure, Chemnitz, vol. 7, p. 124, stated that this species lives in abundance on the shores of St. Maurice (Mauritius, fide Martens, 1880, p. 183). The island of Mauritius is here designated as the type locality for *Tridacna maxima* Röding.

Three syntypes of *T. elongata* Lamarck are in the Museum d'Histoire Naturelle, Geneva. Of these the specimen marked "2*a*" (15 cm. in length) is here designated lectotype (plate 289, figs. 1-3). The length measurement matches exactly that given by Lamarck. It does not seem necessary to restrict the type locality of a synonym of the widespread *T. maxima*. The types of *T. mutica* are presumed lost, and the figures of Chenu indicate that it is probably a composite species.

Reeve figured three syntypes of *T. compressa* with the original description, and that figured in his plate 6, fig. 5, is here designated lectotype (plate 290, figs. 1, 2). The type locality here designated is the Philippines, a logical place from which this specimen could have come. The types of Reeve and Sowerby are in the British Museum (N.H.), with the exceptions of *T. rudis* Reeve and *T. lanceolata* Sowerby which are also apparently lost. These species must be based on the figures of the respective authors. Types of Hedley and Iredale are in the Australian Museum, Sydney.

Nomenclature — *Tridacna maxima* Röding appears commonly in the literature under several synonyms, of which perhaps the best known is *T. elongata* Lamarck. The name *maxima,* however, has priority. Röding's figure reference shows the ventral portion of the valves of a smooth specimen. Ironically, Röding called this species "the largest Clawmussel." Although it does not reach anything like the overall dimensions of *T. gigas* Linné, *maxima* shares with *T. crocea* Lamarck the capacity for developing larger byssal orifices than other *Tridacna.*

Records — SOUTH AFRICA: Chaka's Rock, north coast Natal (Barnard, 1964). MOZAMBIQUE: Ilha da Inhaca; Ilha do Bazaruto (both MCZ; ANSP); Ilha Santa Carolina, both Bazaruto Bay (MCZ); Mozambique City (ANSP). TANGANYIKA: Mboa Magi, 9 miles south of Dar es Salaam (R. T. Abbott, USNM). ZANZIBAR: Jembiani, 5 miles south of Paje; Chumbe Island; Kizimkazi; Mnazi Mmoja; Kiwengwa (all ANSP). KENYA: Diana Beach, 20 miles south of Mombasa (USNM; MCZ; ANSP). RED SEA: Suez (USNM); Faraun Island, Gulf of Aqaba (Rees, et al., 1952, p. 199); Sharm Ubhar; Jidda Harbor, both Saudi Arabia (both USNM); Massawa, Eritrea (MCZ). PERSIAN GULF: (Mevill and Standen, 1907, p. 840). MADAGASCAR: Between Ambariotelo and Ambariobe, southeast Nosy Bé (ANSP; USNM); northeast end Nosy Kalakajoro, Radama Islands; Grand Récif, Tulear (both ANSP); southeastern point Ile Ste. Marie (MCZ); Tamatave (ANSP). SEYCHELLES: (ANSP). MAURITIUS: barrier reef, 1 mile southeast of Aigrette Island, Mahebourg; Flic en Flacq (both V. Orr, ANSP). MALDIVE ISLANDS: Hulule (E. A. Smith, 1903, p. 624); Kagi Island; Imma Island, both North Male Atoll (both International Indian Ocean Expedition, R. Robertson, 1964). CHAGOS ISLANDS: (Melvill, 1909, p. 135). CEYLON: Ara Point, Nilaveli, Trincomalee (USNM); Galle (G. and M. Kline, 1956, ANSP). ANDAMAN ISLANDS: Port Blair (USNM). THAILAND: Ko Sindarar Nua (Chance Island); Ko Huyong, Similan Islands (both International Indian Ocean Expedition, 1963, USNM); Ko Phuket, all Andaman Sea (MCZ; ANSP; USNM); Ko Khram, Gulf of Siam (G. M. Moore, MCZ). MALAYA: Singapore (ANSP). CHINA: Mirs Bay, Honk Kong (ANSP). JAPAN: Tosa, Shikoku (ANSP). RYUKYUS: Okinawa (USNM; MCZ; ANSP); northeast coast Iheya Shima (ANSP). TAIWAN: west coast Lan Yü, 45 miles southeast of Taiwan (USNM). PHILIPPINES: Basco, Batan Island, Batanes Group; Port San Pio Quinto, Camiguin Island (both USNM); Bolinao, Pangasinan Province; Iba, Zambales Province; Tabaco, Albay Province; Gigmoto, Catanduanes Island (all ANSP); Barrio Rizal, near Gubat, Sorsogon Province, all Luzon (ANSP; MCZ; USNM); Tagbac Point; Tilic, both Lubang Island (both MCZ; USNM); Calapan, Mindoro (P. de Mesa, MCZ); Cebu City, Cebu; Olango Island, between Cebu and Bohol (both ANSP); Calangaman Island (USNM); Escalente, Negros Occidental (ANSP); Calicoan Island, off southeast Samar (MCZ); Lampinigan Island, off northwest Basilan (USNM); Cuyo Island, Cuyo Group (ANSP); Cagayancillo, Cagayan Islands (USNM); Bongao Channel, southwest end Sanga Sanga Island, Sulu Archipelago (ANSP). INDONESIA: Pulau Melila, south of Udjung Batu, Banjak Islands; Pulau Bai, Batu Islands; southwest tip Sanding Island, Mentawai Islands (all International Indian Ocean Expedition, 1963, USNM); Pulau Tikus, near Bengkulu, all south Sumatra (USNM); Pulau Batjan; Pulau Amboina; Pulau Kasiruta; Pulau Buru, all Moluccas (all MCZ). NORTH BORNEO: Pulau Mandidarah (Mary Saul,

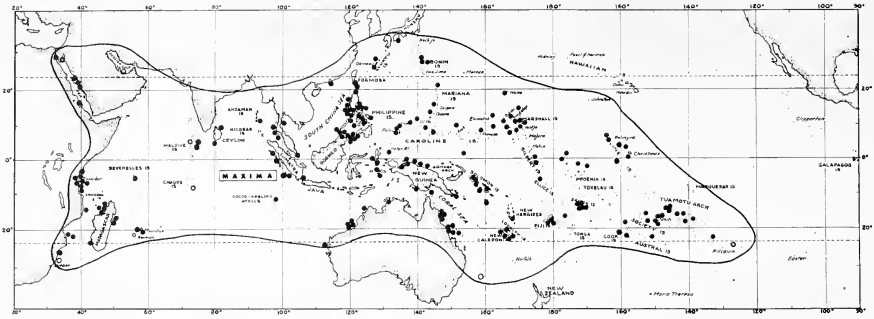

Plate 291. Geographical distribution of *Tridacna (Chametrachea) maxima* (Röding); solid dots: specimens examined; open circles: from the literature.

USNM; ANSP). COCOS-KEELING ISLANDS: reef off southeast end West Island and Pulo Maria; 3 miles southwest of New Selma (Home) Island (both International Indian Ocean Expedition, V. Orr, 1963, ANSP; USNM). WESTERN AUSTRALIA: Augustus Island (MCZ); James Price Point, 35 miles north of Broome; ½ mile south of Willie Creek 17 miles north of Broome; Broome (MCZ); mouth of False Cape Creek, La Grange Bay; Quobba Point, 40 miles north of Carnarvon (all V. Orr, ANSP). NORTHERN TERRITORY: Arafura Sea, near Darwin (A. R. Cahn, ANSP). QUEENSLAND: Murray Islands, Torres Strait; Burkitt Island, Cape York (both MCZ); Hinchinbrook Island; Pelorus and Orpheus Islands, both Palm Islands; Holbourne Island (all H. A. Pilsbry, 1923, ANSP); Hook and Bait Reef, northeast of Hayman Island; Langford Reef, Whitsunday Group; Lupton Island; Hamilton Island, both Cumberland Group (all MCZ); Tryon Island; Heron Island, both Capricorn Group (both USNM). NEW GUINEA: Ambai Anchorage, Ambai Island (ANSP); Poelau Biak, Schouten Islands (ANSP; USNM); Mios Woendi (ANSP; MCZ); Poelau Noesi, both Padaido Islands (ANSP); near Hollandia (USNM) all West Irian; Celeo Island, 5 miles off Aitape, North-East New Guinea (USNM); near Gamadodo, Milne Bay, Papua (USNM). SOLOMON ISLANDS: Bambatana, Choiseul (ANSP); Roviana Lagoon, New Georgia (MCZ); Ataa District, Malaita (J. van der Riet, ANSP); Kunggava Bay, Rennell Island (ANSP). NEW HEBRIDES: Efate (USNM). NEW CALEDONIA: 5 miles west south west of Gatope Island, Voh; Bourail; Récif Larégnère, east of Noumea; Koe, near Touho; Yate (all G. and M. Kline, ANSP). FIJI: south shore Makondronga Island, Makongai Islands (R. T. Abbott, 1940, MCZ); entrance to Suva Harbor, Viti Levu; reef off Tohalau, Kambara Island, Lau Group (both H. S. Ladd, USNM). LORD HOWE ISLAND: (Iredale and Allen, 1940, p. 449). BONIN ISLANDS: Muko Jima (ANSP); Ani Jima; Chichi Jima (both Y. Kondo, 1949, USNM). MARIANAS ISLANDS: Maug Islands (USNM); Saipan (USNM; MCZ; ANSP); Guam (BPBM; USNM; MCZ; ANSP). PALAU ISLANDS: Kayangel Islands; Babelthuap; Malakal Harbor, Koror (all ANSP; MCZ; USNM). CAROLINE ISLANDS: Helen Reef (ANSP); Yap; Fasserai Island, Ulithi; Faraulep; Ifalik; Elato; Ponape; Kapingamarangi (all USNM). WAKE ISLAND: (ANSP; BPBM; USNM). MARSHALL ISLANDS: Eniwetok; Ujelang; Bikar; Kwajalein; Jaluit (all USNM). GILBERT ISLANDS: Abemama; Onotoa (both USNM). LINE ISLANDS: Kingman Reef (BPBM); Palmyra Island (BPBM; USNM; MCZ; ANSP); Washington Island; Fanning Island; Christmas Island (all BPBM; ANSP); Jarvis Island (BPBM; MCZ). ELLICE ISLANDS: Nanumea (USNM). BAKER ISLAND: (BPBM). HOWLAND ISLAND: (BPBM; MCZ) PHOENIX ISLANDS: Canton Island (BPBM; MCZ; USNM); Enderberry Island (ANSP). TOKELAU ISLANDS: Manihiki (fide R. T. Abbott, ANSP). SAMOA: Apia (USNM); Lufilufi (BPBM), both Upolu; Pago Pago, Tutuila (ANSP; USNM). TONGA: Niuafou (USNM). COOK ISLANDS: Aitutaki (USNM; ANSP; MCZ); Rarotonga (ANSP; MCZ); Mangaia (USNM). SOCIETY ISLANDS: Bora Bora (R. Robertson, ANSP; H. A. Rehder, USNM); Raiatea (ANSP); Point Tefaao, Huahine; Moorea (both USNM; Tahiti (ANSP; USNM). AUSTRAL ISLANDS: Rurutu (Aubert de la Rue, ANSP). TUAMOTU ISLANDS: Takaroa; Pukapuka (both ANSP); Tikehau (H. A. Rehder, USNM); Toau (ANSP); Raroia (J. P. E. Morrison, USNM); Fakarava (ANSP; USNM); Tauere (ANSP); Mangareva (MCZ; USNM). HENDERSON ISLAND: (E. A. Smith, 1913).

Fossil records – FRENCH SOMALIA: Pleistocene, 1.5 meters west of Obock (Abrard, 1942, p. 27, as *crocea* Lamarck). EAST INDIES: Upper Miocene, Tjilanang beds, Java (K. Martin, 1880, p. 119, pl. 19, fig. 4, as *T. rudis*). MARIANAS ISLANDS: Pleistocene, Tanapag limestone, Saipan; Pliocene-Pleistocene, MARIANAS limestone, Guam (both U. S. Geol. Survey Coll.). PALAU ISLANDS: Upper Tertiary, Angaur Id. (U. S. Geol. Survey coll.). TONGA: Pleistocene, Nukualofa, Tongatabu (Ostergaard, 1935; BPBM).

Tridacna crocea Lamarck, 1819

(Pls. 267, 292)

Range – Western coast of the Malay Peninsula eastward to Micronesia.

Remarks – In its natural habitat, *T. crocea* (the Crocus or Saffron-colored Giant Clam) can be recognised by its habit of being completely imprisoned in coral pockets. In order to remove the clam, the coral must be broken away and the stout byssus undercut. This species differs, therefore, from the apparently closely related *T. maxima*, which lives in relatively more shallow burrows in coral, but which is also tightly fastened to the substrate by a byssus. Other differences between the two are: the shapes of the adductor-retractor muscle scar complexes; characteristics of the interdigitating projections of the dorsal margins of the valves, the differing numbers of riblets on the radial folds, and the relative lengths

of byssal orifices (see descriptions). Valves of *T. crocea* are usually quite smooth and obese with depressed sculpture and are strongly triangularly ovate in shape; *T. maxima*, although sometimes nearly scaleless, usually does not have the shell sculpture so reduced and its valves tend to be more triangularly elongate in shape. Many of these differences appear to be correlated to some degree with the ecology of the species.

Museum records indicate a much more limited range for *crocea* than for *maxima*. The latter is found throughout the tropical Indo-Pacific faunal region, but the former seems restricted to the northeastern Indian Ocean and western Pacific. It is probable that the range of *crocea* as indicated here is nearly correct, despite the fact that it is exceedingly difficult to collect.

A brachyuran crab, *Xanthasia murigera* White (Pinnotheridae), was found as a commensal in the mantle cavity, attached to the ctenidia of *T. crocea* collected by the writer at Ko Sindarar Nua, Thailand (identified by Dr. R. B. Manning, USNM).

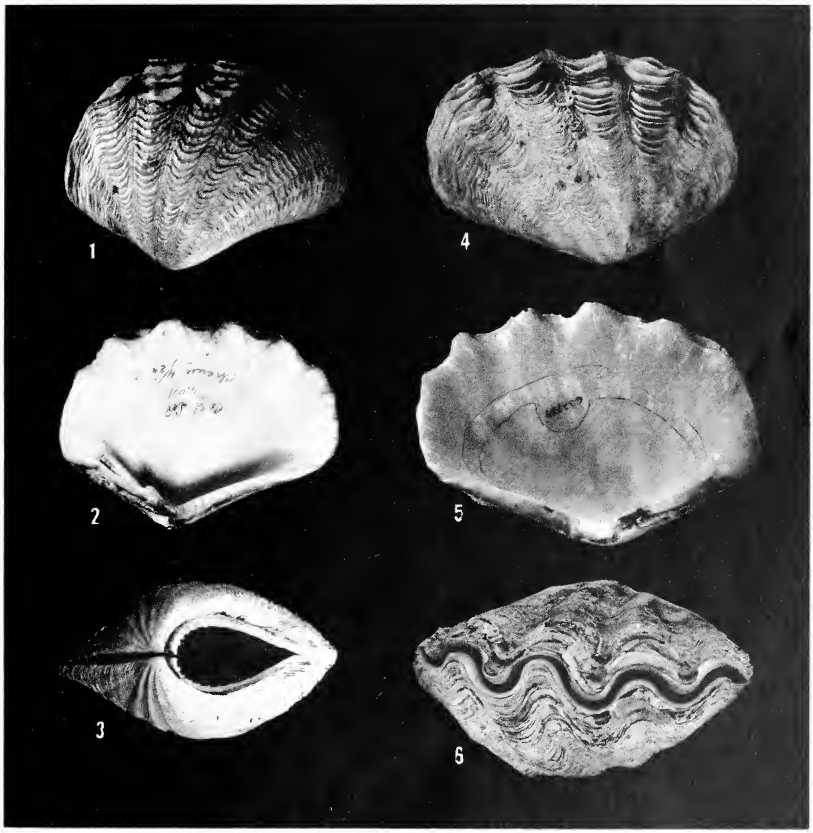

Plate 292. *Tridacna (Chametrachea) crocea* Lamarck, Figs. 1-3. Lectotype of *T. crocea* (96 mm. length); fig. 1. external view left valve; fig. 2. internal view right valve; fig. 3. ventral view showing byssal orifice (photo courtesy of E. Binder, Muséum d'Histoire Naturelle, Geneva). Figs. 4, 5. Specimen from Sak Van, North Borneo; fig. 4. external view right valve; fig. 5. internal view left valve (99 mm. length). Fig. 6. Specimen from Mandidarah Island, North Borneo; dorsal view to show characteristics of interdigitating projections (105 mm. length) (Smithsonian photos).

Habitat – Lives on reef flats and coral heads in water from a few inches to several fathoms in depth. Usually it is found deeply ensconced in coral pockets, the free margins of its valves nearly flush with the substrate.

Description – Shell reaching 150 mm. (about 5-7/8 inches) in length; triangularly ovate in outline; angle formed at umbos by margins of hinge and ventral border usually less than 150°; moderately to strongly inflated and having an extremely large byssal orifice. Valves moderately heavy and thick; color usually grayish white but often tinged with yellow or pinkish orange; often encrusted with organisms and debris near free valve margins, but rubbed clean and nearly smooth ventrally. Surface of valves dull or faintly shiny in cleaned specimens. Primary radial sculpture consisting of from 6-10 broad, rather flattened, rib-like folds which become crowded and obsolete on ventral slope. Of these folds, 4 or 5 are very strong. Secondary radial sculpture consisting of from 6-8 evenly spaced riblets on folds and 3-4 in their narrow interstices, often interrupted on primary folds by concentric sculpture and here having nodular appearance. Concentric sculpture consists of closely spaced, undulate lines of growth which can produce crowded, usually low scales on primary folds. Scales usually restricted to area directly adjacent to dorsal free margins of valves and all sculpture is worn progressively smoother as umbos are approached; specimens entirely encased in coral pockets completely lack projecting sculpture and undulate growth lines are pronounced. Dorsal valve margins undulate, with 4 or 5 bluntly triangular, medially projecting, interdigitating processes which represent extremities of rib interstices. Hinge line short, less than half the shell length. A single oblong cardinal tooth present in each valve; 2 elongate posterior lateral teeth present in right valve and one in left. Hinge teeth often somewhat obliterated by erosion of valves at umbos and encroachment of ligament. Ligament secondarily prosodetic. Umbos directed postero-medially. Ventral margin slightly to moderately concave. Edge of byssal orifice with series of 4-9 plicae which are closely spaced near umbos and become more distantly spaced posteriorly. Ventral slope narrow, rounded or only slightly flattened. Interior of valves porcelaneous, usually tinged with yellow or pinkish orange especially near dorsal margin. Pallial line entire and relatively wide. Posterior adductor muscle scar large, subcircular, adjacent to pallial line dorsally and located posterior to center. Posterior pedal retractor muscle scar usually smaller than half the size of the main scar. Area within pallial line, excluding muscle scars, dull; area of the pallial line, the muscle scars, and the area extending to periphery of shell is shiny.

Description of animal: Externally observable details of form and coloring are similar to *Tridacna maxima*.

Measurements (mm.) –

length	height	width	
150	104	77	large; Canmahana Bay, Luzon, Philippines
106	93	64	average; Pulau Mandidarah, North Borneo
82	66	45	average; Helen Reef, Caroline Islands
38	27	20	small; Port Ciego, Balabac, Philippines

Synonymy –

[1787 *Hippopodes scaphe* Meuschen, Museum Geversianum, p. 430 (part); non-binomial.]

1798 *Tridacnes maxima* var. α Röding, Museum Boltenianum, p. 171, no. 185 (no locality given); refers to Chemnitz, vol. 7, pl. 49, fig. 496.

1801 *Tridacna gigas* Lamarck, Système des Animaux sans Vertèbres, p. 117 (no locality given) (part); refers to Rumphius, 1741 ed., pl. 43, fig. B; to Gualtieri, pl. 92, fig. A, and others; 1819, Histoire Naturelle des Animaux sans Vertèbres, vol. 6 (1), p. 105 (l'Océan indien) (part); refers to Favanne, pl. 51, fig. B4, and others.

1819 *Tridacna crocea* Lamarck, Histoire Naturelle des Animaux sans Vertèbres, vol. 6 (1), p. 106 (l'Océan indien [Philippines, here restricted]); refers to Lister, pl. 353, fig. 190, Chemnitz, vol. 7, pl. 49, fig. 496, Tableau Encyclopédique et Méthodique, pl. 235, fig. 2 and to Gualtieri, pl. 92, fig. A.

1845 *Tridacna gigas* 'Lamarck' Chenu, Illustrations Conchyliogiques, vol. 2, pl. 1, figs. 1, 1a.; *T. crocea* Lamarck, *ibid.* pl. 4, figs. 2, 2a.

1853 *Chametrachea scapha* 'Meuschen' Mörch, Catalogus Conchyliorum Comes de Yoldi, fascicle 2, p. 56 (no locality given); refers to Lister, pl. 353, fig. 190.

1862 *Tridacna cumingii* Reeve, Conchologia Iconica, vol. 14, **Tridacna**, pl. 7, fig. 7a [not fig. 7b = *T. maxima*] (Philippine Islands) (part).

1862 *Tridacna ferruginea* Reeve, *ibid.*, pl. 8, fig. 8a, b (no locality given [Philippines here designated]).

903 *Tridacna lamarcki* Hidalgo, Memorias Real Academia de Ciencias, Madrid, vol. 21, p. 385 (Mindoro, Cebu, Mindanao, Paragua [Palawan] (part); refers to Favanne, pl. 51, fig. B4, and others; new name for *T. gigas* Lamarck, not Linné.

Types – Since no holotype was designated by Lamarck, a probable syntype from the Lamarck Collection, Museum d'Histoire Naturelle, Geneva, is here designated as lectotype of *Tridacna crocea* (pl. 292, figs. 1-3). In the original description, Lamarck gave 102 mm. as the length of his specimen. The lectotype was found to measure 96 mm. by Dr. E. Binder, who provided the photograph. This speci-

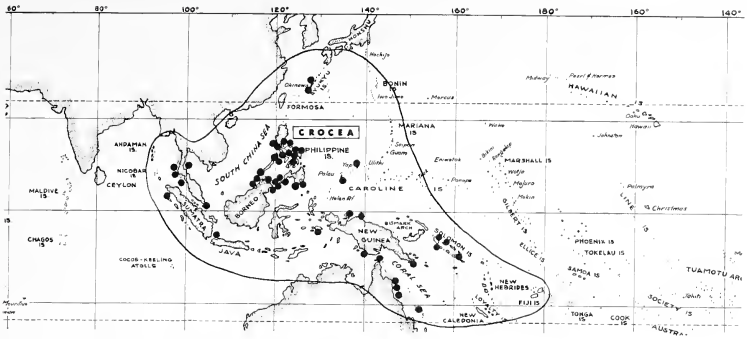

Plate 293. Geographical distribution of *Tridacna (Chametrachea) crocea* Lamarck.

men is probably the same one portrayed by Chenu (1845, pl. 4, figs. 2, 2a.) The type locality "l'Océan indien" given by Lamarck is here restricted to the Philippines since available records indicate that the range of *T. crocea* barely extends into the Indian Ocean.

The location of the syntypes which formed the basis for Reeve's description of *T. ferruginea* is unknown, and this species must be based on his figures, both of which unquestionably are specimens of *T. crocea*. Of these, the larger specimen (Reeve's pl. 8, fig. 8a) is here designated the lectotype of *T. ferruginea*. The type locality for *ferruginea* is here designated as the Philippines.

Records – THAILAND: Ko Sindarar Nua (Chance Island); Pulau Tanga, Butang Islands (both International Indian Ocean Expedition, 1963, USNM); airport beach, Ko Phuket, (R. T. Abbott, F. N. Crider, ANSP) all Andaman Sea; Ko Phangan, Gulf of Siam (USNM). MALAYA: Singapore (USNM). RYUKYU ISLANDS: Okinawa (USNM); northeast coast Iheya Shima (ANSP). PHILIPPINES: Port Binamga, Subic Bay, Bataan Province; Nasugbu, Batangas Province; Canmahana Bay (all USNM); Tabaco, both Albay Province; Prieto Diaz, Sorsogon Province (both ANSP) all Luzon; Polillo Islands (USNM); Tilic, Lubang Island; Ambil Island, both Lubang Islands (both MCZ; USNM); Olango Island, between Cebu and Bohol (ANSP); Cahayagan Island, Samar (USNM); Davao City; Balut Island, Sarangani Islands; Sarangani Bay; Santa Cruz Island; off Zamboanga, all Mindanao (all USNM); Port Caltom, Busuanga, Calamian Group (USNM); Cuyo Island (ANSP); Araceli, Dumaran Island (MCZ); Port Ciego, Balabac. (USNM) all Cuyo Group; Tubigan, Pangutaran Group; Tataan, Tawi Tawi, both Sulu Archipelago (both USNM). INDONESIA: Pulau Penju, northeast of P. Simalur, South Sumatra (I.O.E., 1963, USNM) Tjiperwagaran. Bantam, Java (USNM); Amboina, Moluccas (MCZ). NORTH BORNEO: Pulau Mandidarah; Pulau Tiga, west of Banguey; Pulau Tigabu; Sak Van, 9 miles north of Kudat (all Mary Saul, USNM; ANSP). AUSTRALIA: Torres Strait (MCZ); Brook Islands; Pandora Reef; Challenger Bay, Palm Islands; Lindeman Island, Cumberland Group, all Queensland (all H. A. Pilsbry, ANSP). NEW GUINEA: Mios Woendi, Padaido Group, Schouten-Eilanden; Insoemanai, Wakde-Eilanden; Merauke, all West Irian (all MCZ); near Gamadodo, Milne Bay, Papua (USNM). SOLOMON ISLANDS: Kieta, Bougainville; Faisi, Shortland Islands; Choiseul Bay, Choiseul; Auki, Malaita (all ANSP). PALAU ISLANDS: Koror (USNM; MCZ). CAROLINE ISLANDS: Helen Reef (ANSP); Tomil Harbor, Yap (USNM).

Fossil Records – MARSHALL ISLANDS: Pleistocene (?) Elugelab, Eniwetok Atoll (U. S. Geological Survey).

An Effective Anesthetic for Giant Clams

While carrying out taxonomic studies of Tridacnidae on Eniwetok Atoll, Marshall Islands, it became necessary to make microscopic observations without any movements on the part of the clam. The most effective anesthetic is propylene phenoxetol. A large globule of the viscous compound was dropped to the bottom of the aquarium in an amount equal to about 1% of the water volume. The chemical diffuses very slowly, so that its immediate effect is not felt by the animal until too late for it to contract.

After a period of about four hours, six-inch-long clams are nearly insensitive to vibration or changes in light intensity. They may be examined for several hours under a dissecting microscope, prodded, and looked into without their contracting. By replacing the animals in fresh running seawater, apparently complete recovery is affected. The compound is also effective on certain species of gastropods, including Olividae and Conidae. Propylene phenoxetol is a compact chemical, a fluid pound making about 20 liters or 25 quarts of 1% solution, or producing directly a large number of globules. It is distributed by Nipa Laboratories, Ltd., Roman Wall House, 1 Crutched Friars, London E.C. 3, England, and the Goldschmidt Chemical Corp., 153 Waverly Place, New York 14, N.Y., for about $10.00 per pound.

[These occasional blank areas occur between genera and subgenera to permit the insertion of new material and future sections in their proper systematic sequence.]

INDEX TO *TRIDACNIDAE* NAMES IN VOL. 1, NO. 6

Looseleaf subscribers should place this index at the beginning of the family Tridacnidae. The family begins on p. [62-007].

In this index, the number following the name refers to the pagination found at the top of the page in vol. 1, no. 6. The column at the right is the looseleaf pagination.

INDEX TO COMMENSAL **CRUSTACEA** IN TRIDACNIDAE

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STROMBUS (TRICORNIS) OLDI *NEW SPECIES*

by William K. Emerson

Chairman and Associate Curator
Department of Living Invertebrates
American Museum of Natural History

Strombus oldi *new species*
(Pl. 294, figs. 1-4)

Range — Known only from the Somalian coast of East Africa.

Remarks — Although the fauna of the Somalian coast is not well known, it seems remarkable that this very distinctive species has not been previously discovered. It was first brought to light by my associate, Mr. William E. Old, Jr., who was curating a small collection of marine mollusks that was labeled "50 miles north to 60 miles south of Obbia, Italian Somaliland [Republic of Somalia], East Africa, November 21, 1956." Recently, other specimens have been found near Mogadishu [Mogadiscio]. One of these was kindly forwarded by Mrs. Orville R. Davis for examination.

Of the known species of *Strombus,* the shell of *S. oldi* most closely resembles *Strombus (Tricornis) sinuatus* Humphrey, 1786, but it lacks the 3 or 4 tongue-like blades on the upper end of the outer lip and a thickened outer lip. In spire angle and nodulation and in the spiral ornamentation of the shell, *S. oldi* closely resembles *Lambis (Millepes) digitata* (Perry, 1811) from the Indian Ocean, but lacks the strong labial and parietal wall ornamentation of that *Lambis.* This new species is characterized by the wing-like projection on the upper end of the outer lip, by the relatively high, noduled spire, by the strong, rounded cords on the back of the outer lip, by the dark-brown blotches within the smoothish aperture, and by the rich chestnut coloring of the outer shell.

Strombus solitaris Perry, 1811 (Arcana, London, vol. 1, part 2, signature Dd[1], [pl. 52] is a poorly illustrated and inadequately described species from "Africa and the East Indies," and, although somewhat resembling *S. oldi,* is undoubtedly a synonym of the Caribbean *S. gallus* Linné, 1758, by virtue of the lower spire, the larger and fewer shoulder knobs and the slender, narrow wing-like projection on the upper end of the outer lip. Perry's locality is undoubtedly erroneous.

I take pleasure in naming this new species in honor

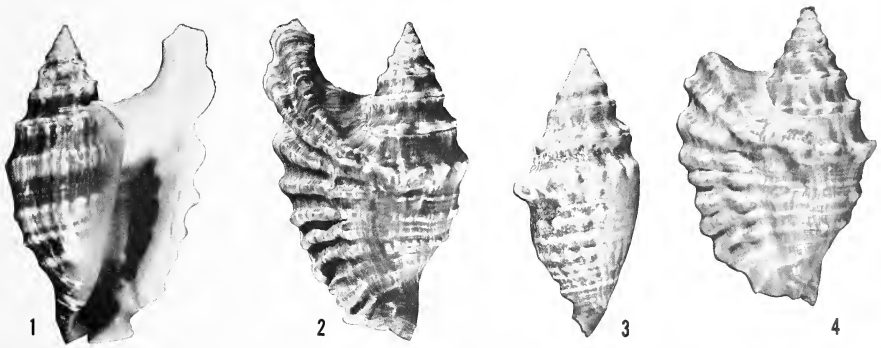

Plate 294. *Strombus oldi* Emerson (*new species*). Figs. 1, 2, holotype, 112 mm. in length, ANSP no. 299730, Figs, 3, 4, paratype, 109 mm. in length, AMNH no. 97346. Both from Republic of Somalia, northwest Indian Ocean.

of Mr. Old, who immediately recognized the significance of his discovery.

Description — Adult shell 95 to 112 mm. (about 3¾ to 4½ inches) in length, solid, moderately heavy, with a dark-brown stain within the aperture and with 8 to 10 strong, nodular raised ribs between the anal and siphonal canals on the back of the outer lip. Color of shell is whitish with a pattern of narrow axial bands of yellowish brown on ventral portion of the body whorl and with an overlay of yellowish brown interrupted by the ribs and nodules on the dorsum. Whorls number 7 to 10; nuclear whorls are worn off. Post-nuclear whorls are ornamented by numerous, low, whitish knobs on the periphery and are colored with axial blotches between the knobs and on the concave portions of the whorls. The knobs are more prominent on the later whorls and are largest on the body whorl, which is also ornamented on the dorsum with numerous rows of smaller spiral ridges, two of which possess rounded beads. Between the spiral ridges are fine spiral threads. Parietal wall is weakly glazed. Columella is stained with dark-brown and is smooth except for three small plications at the upper end of the columella, adjacent to the anal canal. Interior of the outer lip is thickened in the region where the previous lip terminated. Siphonal canal is short, relatively broad and slightly twisted to the right. Stromboid notch is moderately deep and is slightly flaring to the right. Operculum, periostracum and soft parts are unknown.

Measurements (mm.) —

length	width	no. whorls	
112	73	10+	holotype from Mogadiscio
109	72	8+	paratype, AMNH no. 97346
105	47	8+	paratype, AMNM no. 97346b
95	65	7+	paratype, AMNM no. 97346a

Types and Records — The type locality is "Mogadiscio, Republic of Somalia." It was obtained by M. Ramazzotti, and given to the Academy of Natural Sciences of Philadelphia (no. 299730) by Mrs. Orville Davis. Paratypes, all from the vicinity of Obbia, are in the American Museum of Natural History (New York); AMNH nos. 97346, 97346a, and 97346b (immature).

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STROMBUS (EUPROTOMUS) LISTERI T. GRAY — NEW RECORDS; ANATOMY

by Takashi Okutani

Tokai Regional Fisheries Research Laboratory, Tokyo, Japan

Since the 1960 treatment of *Strombus listeri* T. Gray by Abbott in *Indo-Pacific Mollusca,* vol. 1, no. 2, p. 115 [looseleaf p. 09-967], new records and new anatomical information have come to hand. The known range of this species is now extended to the Gulf of Oman, and, on the basis of the penis and radulae, *listeri* is removed from the subgenus *Doxander,* and placed in the subgenus *Euprotomus.* I am indebted to Mr. S. Shimura, who was in charge of the Japanese Fisheries Agency research vessel, *Shoyo-Maru,* in 1958, for the opportunity of examining preserved soft parts, and to Dr. R. Tucker Abbott and the late Mr. Richard W. Foster for records obtained from the cruises of the United States research vessel *Anton Bruun.*

Strombus listeri T. Gray, 1852

(Pls. 295, 296)

(also see p. 116 [09-968])

Range — Gulf of Oman, northwest Indian Ocean, and the Bay of Bengal.

Description — Adult shell 100 to 150 mm. (about 4 to 6 inches) in length, rather thin but strong, with a high spire; nuclear whorls 3, smooth, convex, translucent lavender; post-nuclear whorls 10 in number. First 6 whorls with numerous axial ribs all over, and fine spiral cords in between; these give the shell a cancellated appearance. The lower whorls rather angulated at the shoulder and smooth except for several spiral striae near the anterior canal area. Outer lip moderately quadrangularly expanded and with a nearly straight margin which is somewhat thickened; the inner surface smooth, polished, enamel-white with golden tint. There is a peculiar thickened part (ridge) on the central area of the

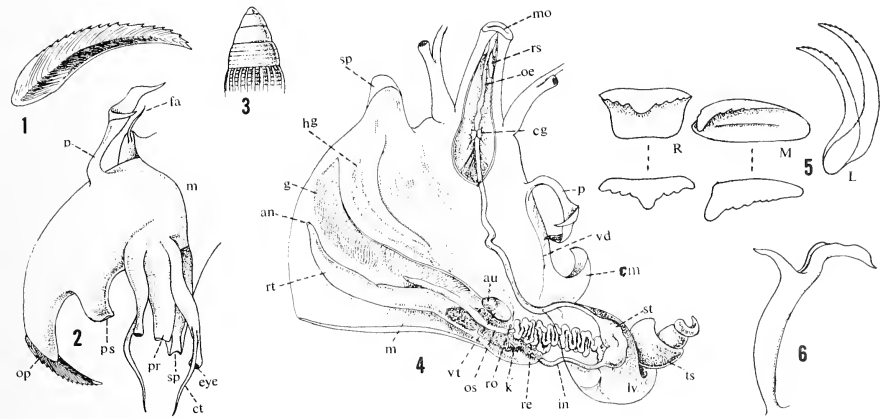

Plate 295. Gross anatomy of *Strombus listeri* from the Bay of Bengal (shell 102 mm. in length). Fig. **1,** operculum, length 22 mm. Fig. **2,** external features: *ct,* cephalic tentacle; *fa,* fleshy appendage on posterior corner of the mantle; *m,* mantle; *op,* operculum; *p,* penis; *pr.* proboscis; *ps,* pedal slit at anterior end of foot; *sp.* siphon. Fig. **3,** protoconch of shell.

Fig. **4,** internal anatomy. *an,* anus; *au,* auricle of heart; *cg,* cerebral ganglion; *cm,* columellar muscle; *g,* gills; *hg,* hypobranchial gland; *in,* intestine; *k,* kidney; *lv,* liver; *m,* mantle; *mo,* mouth; *oe,* oesophagus; *os,* osphradium; *p,* penis; *re,* receptacle seminis; *ro,* renal opening; *rs,* radular sheath; *rt,* rectum; *sp,* siphon; *st,* stomach; *ts,* testes; *vd,* vas deferens; *vt,* ventricle of heart.

Fig. **5,** radulae showing rhachidian *(R),* marginal *(M)* and lateral teeth *(L).* Fig. **6,** penis.

outer lip. Posterior canal very deep, so that the posterior corner of the outer lip protrudes very prominently; anterior siphonal canal well-developed; stromboid notch very deep, U-shaped. The external surface brown and whitish overlaid with chestnut undulating axial stripes and speckled bands; periostracum yellowish, very thin. Operculum stromboid, strongly curved, with about 17 serrations on the margin; arch length 22 mm.; width, 5 mm.

Measurements (mm.) —

length	width	
150.0	56.8	holotype of *mirabilis* Sowerby, Brit. Mus.
103.5	40.0	Bay of Bengal (*Shoyo-Maru* coll.)
102.0	41.0	Bay of Bengal (" coll.)

Radula — Radular ribbon delicate, 5.5 mm. in length, 1.8 mm. in width with about 50 rows of teeth. Radula of taenioglossate type; rhachidian tooth trapezoidal in shape, with 8 to 10 obtuse cusps at the tip; lateral oblong subovate in outline, curved at the tip with 6 to 8 obtuse cusps, of which the innermost one is the largest; two marginals sickle-shaped with inconspicuous dentations near the distal extremities; formula 2-1-C-1-2.

General observations on the soft parts — Head, foot, mantle, proboscis, siphon and cephalic tentacles uniformly fleshy in color; snout long; eyes black, pedunculated; cephalic tentacles long, tapered; anterior end of the foot rather cylindrical with a narrow sole; columellar muscle small. There is a short fleshy appendage on the posterior corner of the mantle. *Alimentary canal:* proboscis cylindrical, interior of it longitudinally grooved; eosophagus thin-walled slender tube; salivary gland indistinct in the present specimen; radula sheath short, situated on the ventral side of the buccal mass; stomach apparently consisted of two parts and situated between anterior and posterior lobes of the liver; intestine thin-walled; rectum very thick in diameter, filled with debris-like faeces; kidney medium in size. *Genital organ:* penis large, keeled, with two pointed tips. *Pallial organ:* osphradium slender, about 15 mm. in length, situated well within the mantle cavity; gill very thin and broad; hypobranchial gland irregularly ovate in outline.

Records — ARABIA: off Khawr, Trucial Oman, Gulf of Oman, 40 fms., 26° 35'N. Lat.; 56° 25'E. Long. Station 259A *Anton Bruun*, Dec. 1, 1963. INDIA: 18 mi. S.E. of Vizagapatnam, 79 meters. Station 90, *Anton Bruun*, April 28, 1963. BURMA: 17 mi. S.S.E. of Akyab, 55 meters. Station 49, *Anton Bruun*, April 5, 1963; 50 mi. S.W. of Irrawaddy River, Preparis North Channel, 53 meters, Gray mud. Station 43, *Anton Bruun*, April 1, 1963. THAILAND: 65 mi. N.N.W. of Phuket Id., Andaman Sea. Station 20, *Anton Bruun*, Mar. 23, 1963.

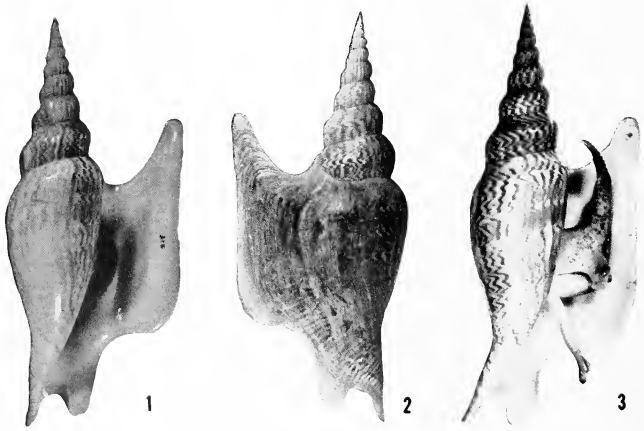

Plate 296. *Strombus listeri* T. Gray. Figs. 1 and 2, from the Bay of Bengal (103 mm. in length). Fig. 3, live specimen from off Khawr, Gulf of Oman, 40 fms.; photo by Bruce Rogers.

MIOCENE STROMBUS (DOLOMENA) FROM INDIA

by R. Tucker Abbott

Pilsbry Chair of Malacology
Academy of Natural Sciences of Philadelphia

In his 1962 report on *The Miocene Mollusca from Quilon, Kerala (India)*, A. K. Dey described three new fossil species of *Strombus* which we are including in this supplement to vol. 1, no. 2 of Indo-Pacific Mollusca. All three belong to the subgenus *Dolomena* Iredale, 1931, and are closely related to previously described Tertiary species from India and Indonesia. A fourth species, "*Strombus* ? sp." (1962, p. 66, pl. 6, figs. 4, 8) appears to be an immature specimen of a species in the subgenus *Laevistrombus* Kira, 1955.

Strombus sedanensis
subspeeies daviesi Dey, 1962

(Pl. 297, figs. 1, 2)

Range — Known only from the Miocene Quilon beds of Kerala, S. W. India.

Remarks — *S. daviesi* closely resembles the Miocene *S. sedanensis* K. Martin, 1899 of Java and West Pakistan. [see *Indo-Paeific Mollusea*, vol. 1, no. 2, looseleaf p. 09-940], and I believe should be considered a subspecies of it. In *daviesi* the outer lip is less developed at the posterior end, hence giving the spire an appearance of being proportionately higher. This character is quite variable in some Recent as well as fossil *Strombus*. Vredenburg (1928, p. 313) reported *S. sedanensis* K. Martin from the Miocene Gaj beds, near Karachi, West Pakistan, and his specimens may be *daviesi* Dey. This subspecies was named in honor of the British paleontologist, A. Morley Davies.

Description — Adult shell 45 mm. (1¾ inches in length); spire moderately high; whorls about 9 in number, of which the first 3 form the protoconch; whorls shouldered; suture bordered anteriorly by a narrow cord. The ornamentation of the earlier whorls consists of close-set axial ribs and spiral threads; the ribs change to swollen nodes or blunt spines on the shoulder of the later whorls; aperture long, wide, deeply emarginate at its base; siphonal canal recurved; inner lip and parietal wall coated with a thin, light-brown deposit or callus; outer lip thick, expanded, having a shallow, wide notch at its posterior end, which does not reach the suture of the preceding whorl, and a deep stromboid notch near the base; on the interior of the outer lip is a ridge which corresponds to the wrinkles on the exterior (from A. K. Dey, 1962, p. 64).

Measurements (mm.) —

length	width	no. whorls	
45	29	9	holotype

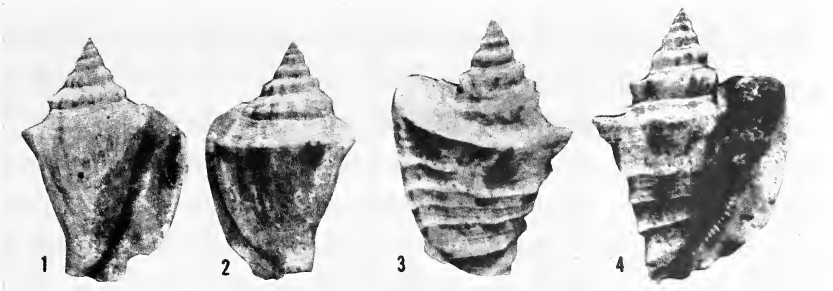

Plate 297. Figs. 1, 2, holotype of *Strombus daviesi* Dey; Miocene of Kerala, India. 45 mm. Figs. 3, 4 holotype of *Strombus quilonensis* Dey; Miocene of Kerala, India. 53 mm. (from Dey, 1962, pl. 6).

Synonymy —

1962 *Strombus daviesi* Dey, Palaeontologia Indica, Memoirs Geol. Survey India, new series, vol. 36, p. 64 (pl. 6, figs. 10, 15; pl. 9, fig. 1).

Types and records — The type locality is the Quilon limestone bed at Padappakara, Kerala State, southwest India; Miocene. The holotype and paratypes are in the Geological Survey of India collections, nos. 16437 and 16438. It is known only from the type locality.

Strombus preoccupatus

***subspecies* quilonensis Dey, 1962**

(Pl. 297, figs. 3, 4)

Range — Known only from the Miocene Quilon beds of Kerala, S. W. India.

Remarks — I can find few differences between Dey's *quilonensis* and *S. preoccupatus* Finlay, 1927 (for illustrations see Indo-Pacific Mollusca, vol. 1, no. 2, p. 123, looseleaf page 09-979). The latter is known from the Miocene of Java and Borneo. The Indian subspecies seems to have stronger spiral threads and the spines on the lower part of the body whorl appear to be less strongly developed. I believe that Dey's *Strombus cossmanni*, described in the same paper and from the same locality as that of *quilonensis*, merely represents juvenile specimens of the latter. Dey believed that his *cossmanni* was the same as a young specimen from the Pliocene of Karikal figured in 1903 by Cossmann (Journ. de Conchyl., vol. 51, pl. 6, figs. 29, 30). However, I believe that Cossmann's specimen was probably a young form of *variabilis* Swainson.

I am transferring *Strombus preoccupatus* Finlay from the subgenus *Lentigo* to the subgenus *Dolomena*.

Description — Adult shell about 53 mm. in length, stout, spinose, and with a rather high, pointed spire; suture bordered anteriorly by a cord, most conspicuous on the early whorls; ornamentation of early whorls consisting of closely-spaced axial ribs with occasional varices and spiral threads. As the shell grows the axials are reduced to nodes and finally become spines on the well-marked shoulder-angle of the body-whorl. Below the shoulder-angle there are 4 main spiral ridges of which the upper 3 are nodose, with irregularly distributed spiral threads in their interspaces; siphonal canal slightly recurved; aperture long, wide, deeply emarginate at base and extending posteriorly beyond the suture of the preceding whorl; inner lip and parietal wall coated with a deposit or callus; outer lip having internally a strong crenate cord corresponding with a swollen wrinkle on the exterior (from A. K. Dey, 1962, p. 64).

Measurements (mm.) —

length	width	no. whorls	
53	36	—	holotype of *quilonensis*
34.5	17	—	holotype of *cossmanni*

Synonymy —

1962 *Strombus quilonensis* Dey, Palaeontologia Indica, Memoirs Geol. Survey India, new series, vol. 36, p. 64, pl. 6, figs. 1, 5.

1962 *Strombus cossmanni* Dey, *loc. cit.*, p. 65, pl. 6, figs. 16, 17.

Types and Records — The type locality for both *quilonensis* and *cossmanni* is the Quilon limestone bed at Padappakara, Kerala State, southwest India; Miocene. The types are in the Geological Survey of India collections: *quilonensis* (no. 16439); *cossmanni* (no. 16440).

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The *Xenuroturris* Group

Relationship appears to have existed within a group of Miocene to Recent Austro-Neozelanic genera which exhibit either alliance to or analogy with the wide-ranging Indo-Pacific Pliocene to Recent *Xenuroturris*.

Of the five genera in this group only *Xenuroturris* has a polygyrate protoconch; the others have a blunt cylindrical-sided, paucispiral protoconch, the tip smooth, followed by regular or brephic axials.

The New Zealand Miocene *Echinoturris* has a relatively short canal and distinctive sculpture of a bicarinate series of sparse prickly nodules. The V-shaped sinus is on the upper carina.

The southern Australian Miocene to Pliocene *Veruturris* has a relatively short canal compared with *Turris* but not truncated to the extent exhibited by *Xenuroturris*.

A third group, for which a new subgenus *Cinguliturris* is provided, is represented by the Australian Miocene (Balcombian) species *Asthenotoma tatei* Cossmann, which is *Xenuroturris*-like with its truncated canal but has a paucispiral protoconch and the sinus rib as a simple spiral cord, not duplicate or margined in any way.

Finally, the New South Wales Recent species, *Xenuroturris corona* Laseron, for which a new genus *Viridoturris* is provided, is another member of the paucispiral-apiced group, standing nearest to *Xenuroturris* in its truncated anterior end and defined sinus rib, but lacking the characteristic polygyrate, axially costate protoconch of that genus.

If the above association of genera is a correct assumption, it would then appear that these presumed offshoots have arisen independently at different times in two areas marginal to the present tropical Indo-Pacific range of *Xenuroturris* typical.

Genus Echinoturris Powell, 1942

(Pl. 248)

Type: *"Turris" finlayi* Powell, 1935

The genus is so far known only by one species, the type locality for which is volcanic tuffs of Altonian Miocene age from Motutara, west coast, Auckland, New Zealand.

The genus is characterised by small size, 8 to 10 mm., moderately long canal, blunt, round-topped, cylindrical-sided, smooth protoconch of two whorls, ending with a few closely spaced thin axials.

Plate 248. *Echinoturris finlayi* (Powell). Holotype. Altonian Miocene of Motutara, Auckland, New Zealand.

Key to the Xenuroturris group

Protoconch polygyrate
- Sinus rib margined
  - Canal truncated ..... *Xenuroturris*

Protoconch paucispiral
- Sinus rib margined or defined
  - Canal truncated ..... *Viridoturris* nov.
  - Canal moderately long ..... *Veruturris*
- Sinus rib not margined
  - Canal short
    - Sculpture cingulate ..... *Cinguliturris*
  - Canal moderately long
    - Sculpture bicarinate-spinose ..... *Echinoturris*

The most distinctive features are the bicarinate series of sparse prickly nodules and the rather deep V-shaped sinus situated on the upper carina, which like the lower carina is a simple rounded cord, not margined. The relationship, if any, with *Xenuroturris* is certainly not close.

Synonymy —

1942 *Echinoturris* Powell, Bull. 2, Auckland Inst. and Mus., p. 50. **Type** by monotypy: *"Turris" finlayi* Powell, 1935 (Awamoan, Middle Miocene, New Zealand).

Genus Veruturris Powell, 1944

Type: *Xenuroturris (Veruturris) quadricarinatus* Powell, 1944

This is a Miocene-Pliocene group from South Australia and Victoria, characterised by moderate size, 14 to 50 mm., a tall spire but only moderately long canal; paucispiral blunt protoconch of 2 to 2½ smooth whorls followed by a half-whorl or so of brephic axials. Sinus deep, broadly V-shaped, on sinus rib situated above the middle of whorl height. This rib may be a single cord as in the type species and as in *tomopleuroides*, or two almost fused cords. The genus *Xenuroturris* differs in having a polygyrate protoconch and a very short anterior canal.

The species of this genus and other turrid representatives of the Australian Tertiary are included since they are members of past faunas climatically analogous to the present tropical Indo-Pacific fauna.

Synonymy —

1944 *Veruturris* Powell, Records Auckland Inst. and Mus. 3(1), p. 9 (subgenus). **Type** by original designation: *Xenuroturris (V.) quadricarinatus* Powell, 1944.

Veruturris bisculpta (Powell, 1944)

Range — Abattoirs (type locality) and Weymouth Bores, Adelaide, Adelaidean, Lower Mid-Pliocene.

Remarks — Upper half of spire whorls sculptured with about 17 vertical fold-like axials, crossed by three spiral cords which are rendered nodulose by the axials; lower half of each whorl with 2 or 3 heavy, closely spaced, plain spirals. Sinus area a deep narrow groove between two of the cords at about two-thirds whorl height.

Measurements (mm.) —

height	width	
26.7	6.5	
13.9	4.5	holotype

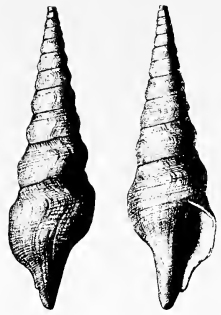

Plate 249. *Veruturris subconcava* (Harris). Miocene, Janjukian, of Victoria, Australia (from Harris, 1897, pl. 3, figs. 2a, b).

Synonymy —

1944 *Xenuroturris (Veruturris) bisculptus* Powell, Rec. Auck. Inst. Mus. 3(1), p. 11, pl. 1, fig. 4.

1958 *Xenuroturris (Veruturris) bisculptus* Powell, Ludbrook, Trans. Royal Soc. South Australia **81**, p. 85.

Types — The holotype is in the Auckland Museum (Finlay collection).

Veruturris cochleata (Powell, 1944)

(Pl. 250)

Range — Balcombian, Miocene of Muddy Creek, lower beds, Victoria (type locality); Altona shaft and Clifton Beach, Victoria.

Remarks — Spire whorls with strong narrowly rounded cords, one linear-spaced pair submargining the suture, then a second pair, forming the sinus rib, situated at three-quarters whorl height, followed by five or six smooth, rounded, spiral cords. Sinus narrowly V-shaped.

Measurements (mm.) —

height	width
52	14

Synonymy —

1944 *Xenuroturris (Veruturris) cochleatus* Powell, Rec. Auck. Inst. Mus. 3(1), p. 10, pl. 7, fig. 11.

Types — The holotype is in the Auckland Museum (Finlay collection).

Veruturris quadricarinata (Powell, 1944)

Range — Balcombian, Miocene of Muddy Creek, lower beds, Victoria (type locality), and Altona shaft, Victoria.

Remarks — Spire whorls with evenly spaced, strong, rounded cords, middle pair stronger than the other two. Sinus broadly V-shaped, situated on upper of the middle pair of cords.

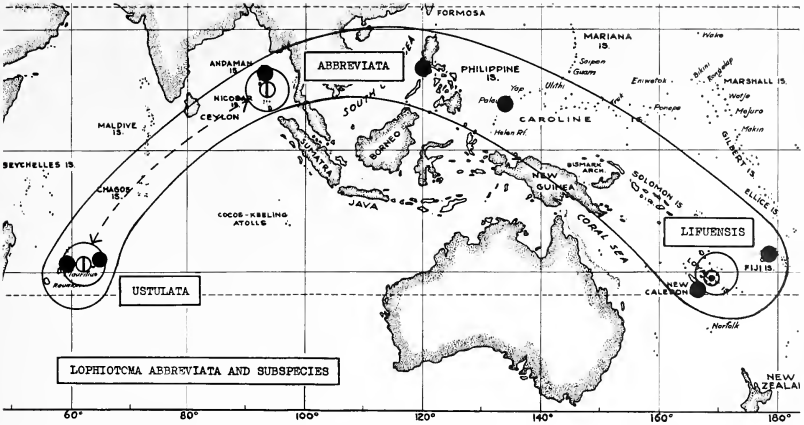

Plate 239. Geographical distribution of *Lophiotoma (Lophiotoma) abbreviata* (Reeve) and its subspecies *ustulata* (Reeve) and *lifuensis* (Sowerby).

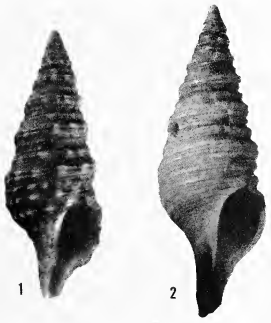

Plate 240. Fig. 1, *Lophiotoma ruthveniana* (Melvill). Holotype. Mauritius. 41.5 mm. Fig. 2, *Lophiotoma brevicaudata* (Reeve), Gulf of Suez. 22 mm.

unknown locality but similar shells are known from the two Indian Ocean localities mentioned above; not from the Pacific range of the typical species, however.

The type specimen is badly faded but the characteristic colour pattern of the typical species, particularly the subsutural maculations, is still discernable. The sculpture, however, is much weaker than is normal for *abbreviata*, the bicingulate peripheral keel being more like that of *acuta;* the anterior canal, however, is truncated. Until more is known of this form it had better be admitted as a probable subspecies of *abbreviata.*

Measurements (mm.) —

height	width	
31	12	holotype

Synonymy —

1846 *Pleurotoma ustulata* Reeve, Conch. Iconica 1, pl. 40, fig. 369 (no locality).

1884 *Pleurotoma ustulata* Reeve, Tryon, Manual of Conch. 6, p. 167, "Mauritius."

Types — The holotype is in the British Museum (Natural History).

Records — INDIAN OCEAN: Mauritius; Andaman Ids. (USNM).

Lophiotoma ruthveniana (Melvill, 1923)

(Pl. 240, fig. 1)

★

Range — Mauritius.

Remarks — This handsome shell appears closely allied to *abbreviata* and is distinguished from that species mainly by the overall strongly tessellated colour pattern. In *abbreviata* the larger maculations are confined to the subsutural fold but in *ruthveniana* the peripheral carina bears heavier maculations. In the absence of well-preserved apical whorls in the four examples seen, including the holotype, the species is only provisionally placed in *Lophiotoma.*

Description (from Melvill) — "Shell fusiform, thick; whorls, especially the upper, somewhat compressed, being ten in number, inclusive of the two apical. Colour bright chestnut brown, with squarrose, fairly regular, white tessellations on the spiral

carinae. These revolving keels appertain throughout—one, in particular, central, and subdivided by a shallow sulcus; the lesser tornate keels increase numerically in each of the lower whorls, till, on the body whorl, they total five or six, all beautifully variegated with white and chestnut alternately, as mentioned above. Mouth ovate-oblong, canal wide, abbreviate, sinus well developed, wide and deep, columellar margin fairly straight. Long. 41.5, lat. 14 mm.

"A handsome species, standing somewhat alone, and conspicuous for its bright coloration and tessellated carinal ornamentation."

Synonymy —

1923 *Turris ruthveniana* Melvill, Proc. Mal. Soc. **15**, p. 162, pl. 4, fig. 2.

Types — The type locality is Mauritius. The holotype is in the British Museum (Natural History), London.

Lophiotoma brevicaudata (Reeve, 1843)

★ (Pl. 240, fig. 2)

Range — Gulf of Suez, New Guinea, the Philippines and New Caledonia.

Remarks — Three syntypes of Reeve's species are in the British Museum and there is little to add to his original description: "Shell shortly fusiform, solid, yellowish, brown at the base and apex; whorls convex, encircled with a single keel round the upper portion and a double keel round the lower; last whorl encircled with single and double keels alternately down to the base, lip simple and acute, sinus large; aperture small, short, canal rather short. Hab. Island of Ticao (found on reefs), Cuming."

It is an easily recognized little shell due to its regular smooth spirals and uniform yellowish brown colour, except for the brown staining of the anterior end. The apical whorls are eroded in all three syntypes.

Tryon (1884, p. 169) made this species a synonym of *fascialis* Lamarck = *polytropa* Helbling, but they are certainly not con-specific.

Apart from the type material and imperfect specimens from New Guinea and New Caladonia, the best preserved example seen is one from the Gulf of Suez (ex McAndrew coll., Brit. Mus.) in the Museum of Comparative Zoölogy, Harvard, and a description of the specimen follows:

Description (Red Sea specimen) — Adult shell 22 mm. (slightly under 1 inch) in height, fusiform, with a tall spire, but with a relatively short anterior canal. Whorls 7, exclusive of the protoconch, sufficient of which remains in one specimen to indicate that it is narrowly conic of several whorls. Spire 1.3 times the height of the aperture plus canal. Adult sculpture of narrow, sharp cords and threads, one cord on a moderately inflated subsutural fold, five threads over a deeply concave shoulder. There is a double-corded peripheral keel, enclosing a concave interspace with a single thread in the middle. There is one primary cord and two threads between the peripheral carina and the lower suture. Three cords, stronger than the rest, are on the upper part of the base, with each interspace having three threads, followed by an alternation of cords and threads over the neck, and finally closely-spaced threads over the anterior canal. Sinus deep, U-shaped, on the peripheral carina. Colour pale yellowish buff, with all the spirals continuously lined in light-brown and with a dark-brown staining on the anterior canal.

Measurements (mm.) —

height	width	
24.0	8.3	lectotype
22.2	7.6	Gulf of Suez

Synonymy —

1843 *Pleurotoma brevicaudata* Reeve, Conch. Iconica **1**, pl. 15, fig. 126.

1884 *Pleurotoma fascialis* Lamarck, Tryon, Manual of Conch. **6**, p. 169 (non Lamarck, 1822).

Types — British Museum (Nat. Hist.), three syntypes, lectotype, 24 × 8.3 mm., here selected. The type locality is Ticao Id., Philippines, Hugh Cuming, collector.

Records — PHILIPPINES: Ticao Id. (type locality); Calapan, Mindoro Id. (MCZ). NEW CALEDONIA: (Australian Mus.). WEST NEW GUINEA: Geelvink Bay, ½ mi. S. of Maroepi, Ambai, Japen Id., 14-25 fms., blue mud, shell and coral (ANSP). RED SEA: Gulf of Suez (MCZ).

ISSUES AND CHANGES

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List of Issues	00-005
Guide to Contents	00-100
Phasianellidae	04-000
Strombidae	09-650
*Cassidae	12-400
Vasidae	20-400
Turridae	22-500
Pinnidae	53-500
Tridacnidae	62-000
Replaced Pages	95-000

List of Issues

Volume 1		*Subject*	*Author*	*Date of Publication*	*no. pp.*	*First page of looseleaf*
no. 1, pp.	1- 14	Introduction	Editors	Mar. 31, 1959	14	00-003
	15- 32	Vasidae	R. T. Abbott	"	18	20-403
2,	33-146	Strombus	R. T. Abbott	Nov. 23, 1960	114	09-831
3,	147-174	Lambis	R. T. Abbott	Sept. 28, 1961	38	10-051
4,	175-226	Pinnidae	J. Rosewater	"	52	53-501
5,	227-346	Turrinae	A. W. B. Powell	Mar. 31, 1964	120	22-661
6,	347-396	Tridacnidae	J. Rosewater	Apr. 30, 1965	50	62-003
	397-398	Strombus oldi	W. K. Emerson	"	2	09-881
	399-400	Strombus listeri	T. Okutani	"	2	10-001
	401-402	Miocene Indian Strombus	R. T. Abbott	"	2	09-945
	**403-406	Turrinae (replacement)	A. W. B. Powell	"	4	22-947
	407-408	Issues and Changes	Editors	"	2	00-005

* Formerly spelled "Cassididae," but there is an earlier and currently used family by that name in Insecta.

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THE FAMILY TURRIDAE IN THE INDO-PACIFIC

Part 1a. The subfamily Turrinae concluded

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In this section, the Turrinae of the Indo-Pacific is concluded by the inclusion of five genera of rather uncertain relationships which, upon the available evidence, seem to have more in common with the Turrinae than with any of the other subfamilies. New Hawaiian *Gemmula* and *Xenuroturris* are also included.

Below are listed the recognized taxa for the remainder of the Turrinae. The earlier list appeared in volume 1, no. 5, on pages 235-237 [pp. 22-669 to 22-671]. As before, taxa not represented in the Indo-Pacific are in square brackets, and with these only the type species is cited. Fossils are prefixed by a dagger (†). When a species occurs both Recent and fossil, the dagger occurs after the name.

Included in the list are southern Australian and New Zealand Recent and Tertiary Turrinae. Such species are not excluded, since they have had an Indo-Pacific origin during past periods of the Tertiary when warm waters extended farther south than they do at present.

List of Recognized Taxa in the Turrinae
(concluded)

Subfamily TURRINAE

Heteroturris Powell, **new genus**
sola Powell, **new species. Type**

Turridrupa Hedley, 1922
acutigemmata (E. A. Smith, 1877). **Type**
albofasciata (E. A. Smith, 1877)
armillata (Reeve, 1845)
astricta (Reeve, 1843)
subsp. *consobrina* Powell, **new subspecies**
bijubata (Réeve, 1843)
cerithina (Anton, 1839)
cincta (Lamarck, 1822)
decceptrix Hedley, 1922
diffusa Powell, **new species**
jubata (Hinds, 1843)
†*waoria* Powell, 1942
prestoni Powell, **new name**
weaveri Powell, **new species**

Austroturris Laseron, 1954
stcira (Hedley, 1922). **Type**

Taranis Jeffreys, 1870
[*wörchi* Malm, 1863]. **Type**
allo (Jousseaume) Lamy, 1934
benthicola (Dell, 1956)
bicarinata (Suter, 1915)†
gratiosa (Suter, 1908)
imporcata (Dell, 1962)
waayi (Verco, 1909)
†*nexilis* (Hutton, 1885)
subsp. *rcccus* (Fleming, 1948)
percarinata Powell, **new species**
spirulata (Dell, 1962)
ticaonica Powell, **new species**
turritispira (E. A. Smith, 1882)
vestalis (Hedley, 1903)

Micropleurotoma Thiele, 1929
?†*ashiyacnsis* Shuto & Ueda, 1963
spirotropoides (Thiele, 1925). **Type**

Additional Species

Gemmula Weinkauff, 1875 [p. 22-703]
pscudomonilifera Powell, **new species**
interpolata Powell, **new species**
congener **new subsp.** *unilincata* Powell
tessellata Powell, **new species** [p. 22-734a]
microscelida (Dall, 1895)

Xenuroturris Iredale, 1929 [p. 22-967]
gemmuloides Powell, **new species**

[These occasional blank areas occur between genera and subgenera to permit the insertion of new material and future sections in their proper systematic sequence.]

Genus Heteroturris Powell, *new genus*

Type: *H. sola* Powell, 1967

A new genus is required for a species represented by only one specimen, which was dredged in 162 fathoms off the Philippines by the *Albatross* Expedition. This shell is problematic in its relationships but appears to be most nearly allied to *Lophiotoma*.

The general appearance of an elongate-fusiform shell with a tall spire, narrow body-whorl tapered to a long straight anterior canal, and with sculpture of a few strong smooth keels, suggests *Polystira*, but both the protoconch and the sinus negate inclusion in that genus. The single thread bisecting the sinus area of the shoulder slope and the polygyrate, axially-costate protoconch recall *Turridrupa*, but again both the sinus and the long, tapered anterior end do not match that genus. The regular, crisp axial threads which cross the sinus area resemble those of *Microdrillia* but otherwise there is no similarity to that genus. The deep parallel-sided posterior sinus is not like that in the subfamily Turriculinae. However, it does appear to be a member of the Turrinae with a modified *Lophiotoma*-type sinus which, instead of being narrow and peripheral, occupies the greater part of the shoulder slope between a heavy subsutural margining cord and the peripheral carina. The polygyrate, tall, conical, axially-costate protoconch and the elongate-fusiform shell show close affinities to *Lophiotoma*.

Heteroturris sola Powell, *new species*

(Pl. 298)

Range — Philippines, south east of Talicayo, Cebu, in 162 fathoms.

Description — Shell rather small, 18 mm. (¾ inch) in height, narrowly fusiform with tall spire and long straight unnotched anterior canal. Whorls 8, plus a tall, narrowly conic protoconch of approximately 4-4½ whorls, strongly sculptured with closely spaced, somewhat flexed, axial ribs; initial whorls, estimated at 1½, missing. The protoconch passes abruptly into the post-nuclear sculpture, which is strongly bicarinate. The lower or peripheral carina is undulatingly nodulose for the first 2-2½ post-nuclear whorls, after which the carinae are smooth and rounded. The uppermost of the two initial carinae resolves into a strong but narrowly crested subsutural margining cord, the lower one into the heavier smooth medial peripheral carina. There is a third smooth cord on the later whorls, between the peripheral carina and the lower suture. On the last two whorls a fourth cord is half-emergent at the lower suture. About 13 smooth cords are on the base and neck from below the peripheral carina, and there is an occasional weak intermediate thread. Between the spirals there is a dense surface sculpture of distinct, crisp, axial threads, strongest on the shoulder slope where they mark the successive positions of the apex of the sinus. These are crossed medially by a single smooth thread. Spire and aperture plus canal of about equal height. Aperture long and narrow, slowly tapered below. Posterior sinus broad and deep, with parallel sides, its apex square-cut, the whole occupying the entire shoulder slope from between the subsutural margining cord to the peripheral carina. Colour uniformly ivory-white.

Measurements (mm.) —

height	width	
18.0	5.5	holotype

Types — The unique holotype is in the United States National Museum, Washington (*Albatross* Sta. 5412; USNM 232702).

Plate 298. *Heteroturris sola* Powell, *new genus* and *new species*. 162 fms., off Cebu Id., Philippines. 18 mm. Holotype, USNM no. 232702.

Genus Austroturris Laseron, 1954

Type: *Filodrillia steira* Hedley, 1922

"A genus much more closely related to *Turridrupa* than to *Filodrillia*, from which the sinus alone distinctly separates it. In *Filodrillia* the sinus is subtubular like that of *Etrema*, in *Austroturris* it is wide and open immediately above the peripheral keel and with a thin inner margin. This sinus is similar to that of *Turridrupa*, as is the sculpture consisting primarily of a strong peripheral keel, with lesser spiral keels below and fine axial threads between the keels. The protoconch, however, is different, of only two smooth whorls, and without a third whorl with axial riblets. It is also distinguished from *Turridrupa* by a well marked fasciole area crossed by fine curved axial threads." (Laseron)

Synonymy –

1954 *Austroturris* Laseron, The New South Wales Turridae. Zool. Handb. Royal Zoological Society of N.S.W., p. 6: Type by original designation: *Filodrillia steira* Hedley, 1922.

Austroturris steira (Hedley, 1922)

(Pl. 299)

Range – New South Wales, 30-50 fathoms.

Measurements (mm.) –

height	width
5.8	2.6

Synonymy –

1922 *Filodrillia steira* Hedley, Rec. Aust. Mus., 13(6), p. 224, pl. 42, fig. 11.

1954 *Austroturris steira* (Hedley), Laseron, The N.S.W. Turridae, Handbook Roy. Zool. Soc. N.S.W., p. 6, pl. 1, figs. 3, 4.

Records – NEW SOUTH WALES: off Cape Three Points, 50 fathoms (type locality); off Sydney, 30-50 fathoms (Laseron).

Types – The holotype is in the Australian Museum, Sydney.

Plate 299. *Austroturris steira* (Hedley). 5.8 mm. 30-50 fms., New South Wales, Australia (from Hedley, 1922, pl. 42, fig. 11).

Genus Turridrupa Hedley, 1922

Type: *Pleurotoma acutigemmata* E. A. Smith, 1877

This is a problematic genus since several subfamily alternatives suggest themselves. In general appearance, these shells resemble small stout clavinids, and in accord with that subfamily, the sinus is situated, typically, at about the middle of the shoulder slope. Here, however, comparison ends, for the clavinid sinus is spout-like, constricted above, either by a heavy subsutural fold, a strong parietal tubercle, or both. In *Turridrupa* the sinus is simple U-shaped, not restricted above by either a subsutural fold or by a parietal tubercle, but has its apex, normally, at the termination of one or two spiral cords or threads that bisect the shoulder area. The sinus is, therefore, comparable with that of *Turris,* which has its apex situated on a rib above the peripheral carina.

It is of interest to note that Thiele (1929) placed *Turridrupa* as a section of *Gemmula,* an undoubted member of the *Turrinae.*

The radula, however, presents another problem, for it has a formula of $1+0+1+0+1$ *(jubata);* the marginal is massive and neither "wishbone-shaped" nor bifid; the lateral is absent; and the central large and broad-based.

This enlargement of the central tooth to compensate for the missing lateral is a common feature of the *Cochlespirinae,* i.e., *Aforia,* and in some species ascribed to *Leucosyrinx* (not the type species), but in all these, the marginals are bifid-based, wishbone-shaped, or separated into two components. All other characters exclude *Turridrupa* from the Cochlespirinae.

The protoconch, typically, has about three whorls, the first two being smooth, the last one distinctly axially costate. The operculum is leaf-shaped, with a terminal nucleus.

The Recent geographical range of *Turridrupa* covers most of the Indo-Pacific. A New Zealand fossil species, *maoria* Powell, 1942, takes the genus back to the upper Miocene.

Of the Recent species listed by Hedley (1922) as belonging to *Turridrupa,* five belong elsewhere. To the clavinid genus *Microdrillia,* I add *commentica* (Hedley, 1915), *fastoda* (Hedley, 1907) and *pertinax* (Hedley, 1922). To the turriculinid genus *Vexitomina* I add *rougeyroni* Souverbie, which is a synonym of *regia* (Reeve, 1842). The species *sibogae* (Schepman, 1913) is probably a clavinid. It superficially resembles *Turridrupa cerithina* (Anton, 1839), but has two smooth whorls in the protoconch. Several Japanese species referred to *Turridrupa* in Kuroda and Habe (1952, Check List and Bibliography of the Recent Marine Mollusca of Japan) would also be better accommodated in the subfamily Clavinae.

Synonymy —

1922 *Turridrupa* Hedley, A revision of the Australian Turridae, Records of the Australian Museum, vol. 13, no. 6, p. 226. **Type:** by original designation: *Pleurotoma acutigemmata* E. A. Smith, 1877.

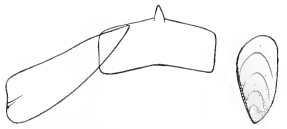

Plate 300. *Turridrupa jubata* (Hinds). Radula and operculum from specimen from Bohol Ids., Philippines.

Key to species and subspecies of Turridrupa

A. Sinus apex at end of mid-shoulder cord
  Sinus cord finely gemmate
    Colour whitish with subsutural brown band
      armillata (Reeve)
    Colour yellowish brown; anterior end, white
      jubata (Hinds)
  Sinus cords of elongated knots
    Small narrow shell (17-21 mm.)
      Knots large; few, 13-14 per whorl
        acutigemmata (E. A. Smith)
    Large broad shell (25-33 mm.)
      Knots weak, 17 per whorl ..... *prestoni* Powell
  All cords smooth
    Shell broad; unicoloured yellowish brown
      cincta (Lamarck)
    Shell tall, narrow; unicoloured buff .. *deceptrix* (Hedley)
  All cords smooth to waved
    Cords buff on dark brown ground .... *bijubata* (Reeve)
  Peripheral cord tuberculate
    Reddish brown; pale subperipheral zone
      albofasciata (E. A. Smith)
B. Sinus apex at end of several mid-shoulder threads
  All spirals gemmate
    Colour pattern checquered ..... *cerithina* (Anton)
C. Sinus apex at end of peripheral cord
  Peripheral cord only maculated
    Alternate white and brown dashes .... *astricta* (Reeve)
    Unicoloured dashes, defined by blotches .. *diffusa* Powell
  All spire cords maculated
    Alternate light and dark dots .. *astricta consobrina* Powell
    Spire brown-streaked; base pale ..... *weaveri* Powell

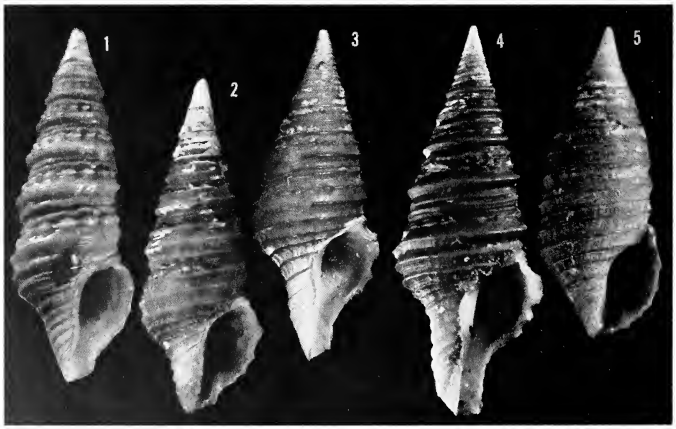

Plate 301. Fig. 1, *Turridrupa acutigemmata* (E. A. Smith). Holotype, 21 mm., no locality. Fig. 2, *T. deccptrix* Hedley. 14 mm. Darnley Id., Queensland, Australia. Fig. 3, *T. jubata* (Hinds). 22.5 mm. Off Arakabesan Id., Palau Islands. Fig. 4, *T. prestoni* Powell, *new name*. 33 mm. Port Blair, Andaman Islands. Fig. 5, *T. cincta* (Lamarck). 16.5 mm. Mauritius.

Turridrupa acutigemmata (E. A. Smith, 1877)

(Pl. 301, fig. 1)

Range – Persian Gulf to East Indies, Japan and north Queensland.

Remarks – This species is easily recognized by its slender shape, tall spire and comparatively few, strong, laterally elliptical gemmules on the sinus rib; each gemmule is buttressed top and bottom by a swelling. In *jubata*, the nearest related species, the gemmules are more numerous, less conspicuous, and somewhat oblique, which imparts the appearance of a strand of unravelled rope.

Description – Shell small, 17-21 mm. (about ¾ inch) in height, narrowly fusiform, with a tall spire, almost twice the height of the aperture and canal. Spire whorls sculptured with three strong keels and a fourth emergent, or half emergent, over the last two or three whorls. Base with an additional seven keels, from below the lower sutural one to the anterior fasciole, which bears several indistinct spirals. Subsutural keel smooth, moderately strong, sinus keel strong, with laterally elliptical gemmules, about 13 or 14 per whorl, which are buttressed top and bottom by swellings, followed by a massive smooth peripheral keel; all keels other than the sinus one are smooth. Interstices of keels with two or three fine spiral threads. Sinus deep, U-shaped, its apex at the termination of the gemmate keel. Colour uniformly yellowish brown to reddish brown.

Measurements (mm.) –

height	width	
21.0	7.5	holotype
17.0	6.0	New Britain

Synonymy –

1877 *Pleurotoma acutigemmata* E. A. Smith, Ann. Mag. Nat. Hist., Ser. 4, **19,** p. 489.

1884 *Pleurotoma jubata* (non Hinds) (pars), Tryon, Man. of Conch., **6,** p. 171.

1896 *Pleurotoma acutigemmata* Smith, Melvill and Sykes, Proc. Malac. Soc. **2,** p. 165.

1904 *Pleurotoma acutigemmata* var. *minor* E. A. Smith, Ann. Mag. Nat. Hist., Ser. 7, **13,** p. 457 (non *Pl. minor* C. B. Adams, 1845; Evans and Schumard, 1857, nor Jeffreys, 1867).

1913 *Pleurotoma (Hemipleurotoma) acutigemmata* Smith, Schepman, Siboga Exped., Pt. 5, **49e,** p. 400.

1917 *Turris (Tomopleura) acutigemmata* (Smith), Melvill, Proc. Malac. Soc., **12,** p. 146, pl. 8, fig. 1.

1922 *Turridrupa acutigemmata* (Smith), Hedley, Rec. Aust. Mus., **13**(6), p. 226, pl. 42, figs. 12, 13.

1940 *Turris (Turridrupa) acutigemmata* var. *minor* (Smith), Winckworth, Proc. Malac. Soc., **24**(1), p. 24.

1960 *Turridrupa jubata* (non Hinds) (pars), Oyama and Takemura, The Molluscan Shells, **4,** fig. 9 (=*acutigemmata,* non fig. 10, which is *jubata*).

Records – Locality unknown (type); PERSIAN GULF: Gulf of Oman, Muscat, 20-40 fathoms (Melvill, 1917). CEYLON: off south coast (type of var. *minor*). INDONESIA: Bay of Bima, 55 metres; near south coast of Timor, 34 metres (Schepman, 1913). WEST NEW GUINEA: straits north of Misool Id. (Schepman, 1913). NEW BRITAIN (AWBP coll.). JAPAN: Izu Peninsula (Oyama and Takemura, 1960). QUEENSLAND: Darnley Island, 20 fathoms; Hope Island, 5-10 fathoms (Aust. Mus.); Low Isles, near Port Douglas; Lindeman Island (AWBP coll.). FIJI: main reef, Navula Passage, 2 feet (W. Jennings, Aug., 1963).

Types – The holotype of *acutigemmata* is in the British Museum (Natural History).

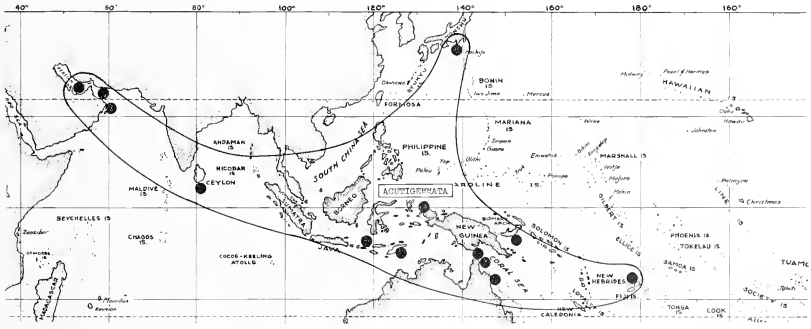

Plate 302. Geographical distribution of *Turridrupa acutigemmata* (E. A. Smith).

Turridrupa albofasciata (E. A. Smith, 1877)

(Pl. 303, figs. 3, 4)

Range — Hawaiian Islands, Japan and New Caledonia.

Remarks — This common Hawaiian turrid occurs in many collections under a manuscript name of Dall's, which I do not quote, since to the best of my knowledge the name has not as yet appeared in print. Elsewhere in his manuscript Dall referred to *albofasciata* Smith as an indeterminate species, since it had never been figured. However, the well-preserved holotype, in the British Museum, leaves no doubt that *albofasciata* is the name to be used for this Hawaiian shell.

The species stands close to *bijubata,* from which it differs in the very strong undulations of the peripheral keel, a different form of subsutural margin, fewer and stronger interstitial spiral threads, and the presence of a pale band between the peripheral and lower keels.

The species *bijubata* occurs in the Hawaiian group also but not commonly. Also, although some forms of *bijubata,* notably those from both Mauritius and New Caledonia, develop strong undulations, the form of the subsutural margin and the coarser, decussated interstitial sculpture remain constantly exclusive to *albofasciata,* as also does, apparently, the pale submedian band.

It is likely that Hervier's *gatchensis* from the Loyalty Islands is a synonym of *albofasciata* rather than a nodulose form of *bijubata.* Hervier's figure, which is small and indistinct, shows a deep violet-grey shell with a subperipheral reddish brown spiral band, and both the peripheral and subperipheral spirals appear to be undulating and subnodose. Also the Japanese shells ascribed to *gatchensis* by Oyama and Takemura (1960, pt. 4, figs. 6-8) appear to be Smith's species.

Description — Shell small, 14-22 mm. (about ¾ inch) in height, claviform, very solid. Spire-whorls sculptured firstly with a rather wide subsutural band, composed of four spirals, three of them threads, but the fourth is a moderately strong cord; then a strong median cord which is conspicuously undulated and thickened where it crosses rather distant axial folds, which spread as buttresses above the peripheral cord but not below it, and finally, another strong but smooth cord between the periphery and the lower suture. Base with six strong cords, distantly spaced between the periphery and the anterior fasciole, which is sculptured with 5 or 6 irregular linear-spaced cords. Interstices of the keels and cords with 3 or 4 distinct spiral lirations, densely decussated by finer crisp axial threads. Spire almost twice height of aperture plus canal. Sinus deep, U-shaped, and situated at the termination of the peripheral keel. Colour dark chocolate to dark purplish brown, with a pale buff or light-brown band between the peripheral and lower keels. In partially bleached specimens the pale band is more conspicuous. Operculum leaf-shaped with a terminal nucleus.

Measurements (mm.) —

height	width	
22.0	8.0	holotype
21.0	8.0	Honolulu, dredge deposits
18.2	7.3	Honolulu, dredge deposits
14.0	6.0	Honolulu, off Waikiki beach

Synonymy —

1877 *Pleurotoma albofasciata* E. A. Smith, Ann. Mag. Nat. Hist., Ser. 4, **19,** p. 491.

1895 *Surcula gatchensis* Hervier, Journ. de Conch., **44,** p. 61, pl. 1, fig. 7.

1914 *Surcula bijubata gatchensis* Hervier, Bouge and Dautzenberg, Journ. de Conch., **61,** p. 145.

1960 *Turridrupa gatchensis* (Hervier), Oyama and Takemura, The Molluscan Shells, pt. 4, figs. 6-8.

Records — HAWAIIAN ISLANDS (type locality); Hawaii, Keokea, Hilo, in sand under seaweed (Thaanum coll., Bishop Mus.); Oahu, off Waikiki, 25-50 fathoms; Honolulu Harbour entrance, 5-8 fathoms; Paumalu (USNM); Pupukea Beach and Waialua (USNM); Maui, off Launiupoko Camp, 4-12 fathoms (Thaanum coll., USNM); Maalaea Bay, 50 feet, in coralline algae (A. Tiedeman, 1964); McGregor's Landing, Madaea Bay, 25-30 feet (A. Tiedeman, 1964); French Frigate Shoal (ANSP). JAPAN: Amami-Oshima Islands (Oyama and Takemura). LOYALTY ISLANDS: Lifu (Hervier, 1895). NEW CALEDONIA: (Bouge and Dautzenberg, 1914).

Types — The holotype of *albofasciata* is in the British Museum (Natural History); that of *gatchensis* in the collection of the Journal de Conchyliologie, Mus. d'Hist. Nat., Paris.

Turridrupa armillata (Reeve, 1845)

(Pl. 305, fig. 2)

Range — Philippine Islands.

Remarks — This species belongs to the *acutigemmata-jubata-prestoni* series, in which the sinus keel, between the subsutural fold and the periphery is gemmate. In *jubata* and *prestoni* the gemmules are rather distant, laterally elongated and knot-like, but in *armillata* they are numerous, closely-spaced beads.

The holotype in the British Museum is the only specimen known to me, and this has a distinctive colour pattern: whitish, with a subsutural band of

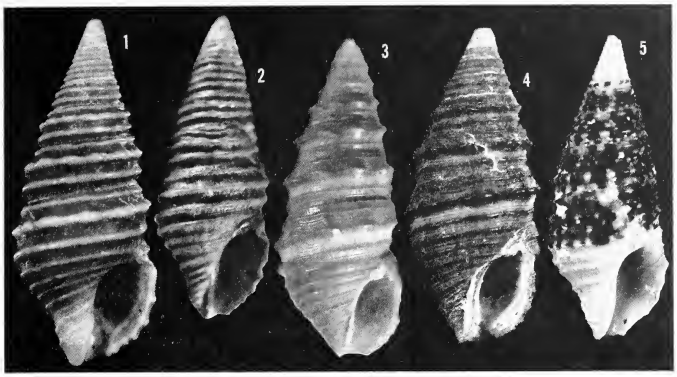

Plate 303. Figs. 1, 2, *Turridrupa bijubata* (Reeve). Fig. 1, Mauritius, 24 mm. Fig. 2, Island of Burias, Philippines. Syntype, 21 mm. Figs. 3, 4, *T. albofasciata* (E. A. Smith). Fig. 3, Hawaiian Islands, holotype, 22 mm. Fig. 4, French Frigate Shoals, 22 mm. Fig. 5, *T. weaveri* Powell, *new species*, holotype, 21.7 mm. 45 ft. off Rabbit Island, Oahu, Hawaiian Islands.

light-brown. It seems most nearly related to *jubata*, but unfortunately the type of that species, which should be in the British Museum, could not be located.

Description – Shell small, 18.5 mm. (¾ inch) in height, somewhat broadly fusiform, with spire about 1⅓ times height of aperture plus canal. Spire whorls sculptured with three strong subequal keels, first smooth and submargining the suture, second, the sinus keel, densely gemmate, followed by the smooth peripheral keel; base with the addition of seven strong smooth keels to the anterior fasciole, which has 4-5 closely spaced cords. Colour as described above.

Measurements (mm.) –

height	width
18.5	7.25

Synonymy –

1845 *Pleurotoma armillata* Reeve, Conch. Iconica, 1, pl. 21, fig. 176.

Types – The holotype is in the British Museum (Natural History). The type locality is "Philippines."

Turridrupa astricta *subspecies*
astricta (Reeve, 1843)

(Pl. 305, fig. 4)

Range – Tuamotu Archipelago.

Remarks – This species differs from the other members of the genus in having a maculated peripheral sinus rib. This rib is a single smooth keel, quite unlike the double keel of *Lophiotoma*. In the form of the sculpture and in the style of U-shaped sinus, the species is not very dissimilar from *cincta*. Unfortunately only a few worn shells are available and all have the apical whorls missing.

Description – Shell small, 14 mm. (½ inch) in height, drilliaform, somewhat cylindrical, very solid, sculptured with strong smooth spiral keels, the peripheral sinus keel maculated. Spire almost twice height of aperture plus canal. Spire-whorls with three equidistant keels, the median one stronger than the other two, which are subequal. Base with an additional five keels, and 4 or 5 more closely spaced spiral cords on the anterior fasciole. Interspaces with 3 or 4 fine, crisp, spiral threads. Sinus U-shaped, its apex at the termination of the peripheral keel. End of the subsutural keel somewhat thickened, but no parietal tubercle or callus-pad. Anterior canal very short, with an oblique shallowly-notched end. Colour bright, yellowish buff, except for the peripheral keel which is white and regularly maculated with dark reddish brown dashes. A Japanese shell ascribed to *astricta*, by Oyama and Takemura, 1969 (see under *modesta*, following), has the peripheral maculations more numerous and in the form of squarish dots.

The colour pattern and truncated anterior end recalls some members of *Lophiotoma* of the *abbreviata* series, but as already remarked, the sinus in that genus is a deep narrow slit and its associated keel is double-edged with a concavity in the middle.

Measurements (mm.) –

height	width	
14.0	5.5	Tuamotu Archipelago (ex Garrett)
13.5	5.0	Lectotype; one of two co-types

Synonymy –

1834 *Pleurotoma interrupta* Sowerby, Proc. Zool. Soc., London, for 1833, p. 138 (non Lamarck, 1816).

1843 *Pleurotoma astricta* Reeve, Conch. Iconica, **1**, pl. 12, fig. 98 (nom. nov. for *Pl. interrupta* Sowerby, 1834; non Lamarck, 1816).

Records – "Island of Annaa, Chain Island" = Island of Anaa, Tuamotu Archipelago, under coral on reefs (type locality); "Paumotu Isles" = Tuamotu Archipelago (Garrett coll., B. P. Bishop Mus.).

Types – Two co-types, one selected as lectotype, in the British Museum (Natural History).

Turridrupa astricta *subspecies* consobrina Powell, *new subspecies*

(Pl. 305, fig. 3)

Range – Hawaiian Islands and Amami-Oshima Islands, Japan.

Remarks – This seems to be a North Pacific subspecies of *astricta*, differing slightly but constantly from the typical South Pacific species in having all three cords of the spire-whorls of equally strong development, and smaller, more numerous maculations, which are not confined to the sinus rib. In *astricta* typical, the maculations are more widely spaced, elongated dashes, confined to the sinus cord, which is of heavier build than the two other cords of the spire-whorls.

Description – Shell rather small, 19 mm. (¾ inch) in height. Spire twice height of aperture plus canal. Whorls 14 including a narrowly conic protoconch of 4½ whorls, which are closely sculptured with concavely arcuate axials crossed by minute indistinct spiral lirae. Spire-whorls with three equally strong but narrowly ridged spiral cords. Five similar cords on the body-whorl from the sinus cord to the neck and a further three on the anterior fasciole. From 2-5 very fine spiral threads in each interspace, except for a wider interspace on the neck, which bears about nine threads. Entering parietal callus-pad heavy. Sinus deep, U-shaped, at the termination of the middle cord of the spire-whorls. Colour buff to pale golden-brown, maculated with dark reddish brown spots, about 15 per whorl on the sinus cord but irregularly disposed also on the other cords of both the spire and the base.

Measurements (mm.) –

height	width	
19.0	7.0	holotype
14.5	5.0	paratype

Synonymy –

1960 *Turridrupa astricta* (Reeve), Oyama and Takemura, The Molluscan Shells, 4, figs. 11, 12 (non Reeve, 1843).

Records – HAWAIIAN ISLANDS: Maalaea Bay, Maui Id., in and under calcareous algae, 40 to 50 feet (J. Kern and A. Tiedemann, ex. C. Weaver) (holotype). JAPAN: Amami-Oshima Islands (Oyama and Takemura, 1960).

Types – The holotype and paratypes presented to the B. P. Bishop Museum, Honolulu, by Mr. J. Kern.

Turridrupa bijubata (Reeve, 1843)

(Pl. 303, figs. 1, 2)

Range – Mauritius, Japan to Hawaiian Islands, Philippines, Queensland, New Caledonia and Fiji.

Remarks – This strongly keeled, solid, small shell has the keels buff-coloured on a dark chocolate ground. Three keels encircle the spire-whorls; these are not gemmulate but often the sinus keel is somewhat waved and thickened on the crests of low axial folds.

Description – Shell small, 18-21 mm. (about ¾ inch) in height, drilliaform, very solid, sculptured with strong, sharply raised spiral keels, three on spire-whorls, one subsutural and slightly weaker than the other two; median one, the sinus rib, undulating and slightly thickened at the crests of very weak broad axial folds; base with an additional four keels and five more closely-spaced, weaker spirals on the anterior end. Interstices of the keels with 4 or 5 very fine, crisp, spiral threads. Spire almost twice height of aperture plus canal. Sinus U-shaped, its apex on the second or middle keel of the spire-whorls. Anterior canal very short, flexed, with an oblique shallowly notched termination. Colour dark purplish brown or chocolate, with the keels buff to light-brown.

Measurements (mm.) –

height	width	
21.0	8.25	one of three syntypes
18.5	8.0	Low Isles, Queensland
18.0	7.0	San Cristoval, Solomon Islands

Synonymy –

1843 *Pleurotoma bijubata* Reeve, Conch. Iconica, **1**, pl. 10, fig. 87.

1914 *Surcula bijubata* (Reeve), Bouge and Dautzenberg, Journ. de Conch., **61**, p. 144.

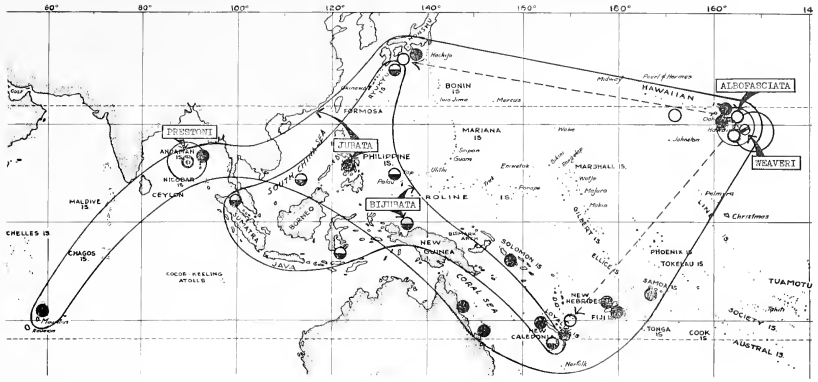

Plate 304. Geographical distribution of *Turridrupa jubata* (Hinds), *T. bijubata* (Reeve), *T. albofasciata* (E. A. Smith), *T. prestoni* Powell and *T. weaveri* Powell.

1914 *Surcula bijubata nodulosa* Bouge and Dautzenberg, Journ. de Conch., 61, p. 145.

1960 *Turridrupa bijubata* (Reeve), Oyama and Takemura, The Molluscan Shells, pt. 4, figs. 3-5.

Records – MAURITIUS (AWBP. coll.). ANDAMAN ISLANDS: Long Island, Port Blair, dredged (Winckworth coll., Brit. Mus.). PHILIPPINES: Island of Burias, under stones at low water (type locality). JAPAN: (Oyama and Takemura) Oshima-Osumi (USNM). HAWAIIAN ISLANDS: Oahu, Mokolea Rock, Kailu Bay, 55-65 feet, in sand pockets under coral (C. Weaver, Dec., 1963); Maui, 50 feet, in coralline algae (A. Tiedeman and J. Kern, 1964). SOLOMON ISLANDS: San Cristoval (Aust. Mus.). QUEENSLAND: Low Isles; North West Island (Mrs. J. Kerslake). NEW CALEDONIA: Poindimie (Mrs. J. Kerslake). LOYALTY ISLANDS: Lifu (Aust. Mus.). FIJI: (Garrett coll., ANSP); Korolevu (Mrs. J. Kerslake); Navula Passage, main reef, 2 feet (W. Jennings, Aug., 1963). SAMOA: Vailele Beach (AWBP. coll.).

Types – There are three syntypes in the British Museum (Natural History). The type locality is the Island of Bureas [Burias], Philippines.

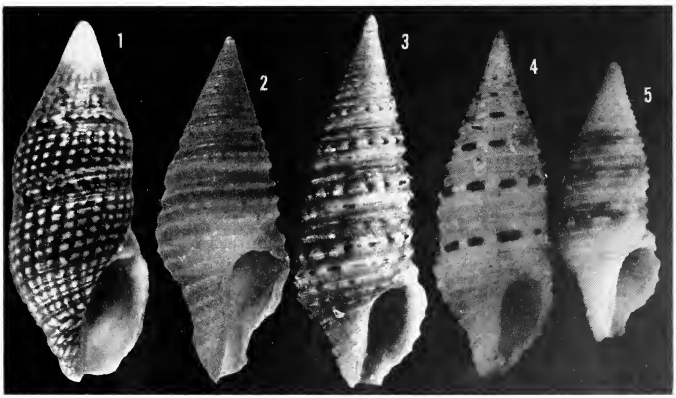

Plate 305. Fig. 1, *Turridrupa cerithina* (Anton), syntype of *Pleurotoma digitale* Reeve, 24 mm. Island of Burias, Philippines. Fig. 2, *T. armillata* (Reeve), holotype, 18.5 mm., Philippine Islands. Fig. 3, *T. astricta consobrina* Powell *new subspecies*, holotype, 19 mm. 40-50 ft., Maui Id., Hawaiian Islands. Fig. 4, *T. astricta astricta* (Reeve), 14 mm., Tuamotu Archipelago. Fig. 5, *T. diffusa* Powell *new species*, holotype, 12 mm., Samoa.

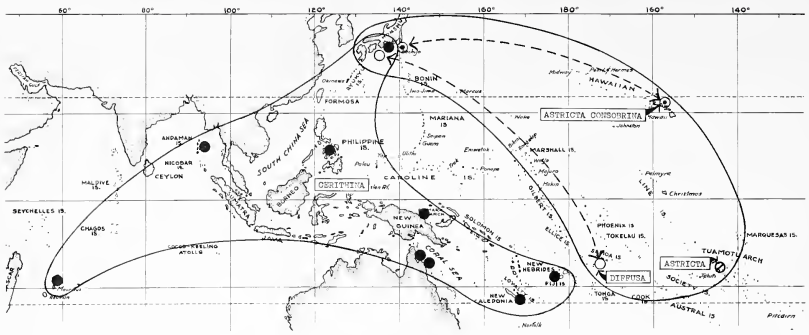

Plate 306. Geographical distribution of *Turridrupa cerithina* (Anton), *T. astricta* (Reeve), its subspecies *consobrina* Powell and *T. diffusa* Powell.

Turridrupa cerithina (Anton, 1839)

(Pl. 305, fig. 1)

Range – Mauritius to Japan, Philippines, Queensland, New Caledonia and Fiji.

Remarks – In this species all the spiral keels and cords are gemmate at the points of intersection with the numerous narrow flexuous axials. Colour dark chocolate with the gemmules picked out in white. The apex of the normal U-shaped sinus is at the termination of one or two spiral threads which bisect the shoulder sulcus.

Description – Shell of moderate size, 18-24.5 mm. (¾-1 inch) in height, solid, drilliaform, with a tall spire but with a truncated anterior end. Sculpture of spiral keels and cords which are densely gemmulate at the points of intersection with numerous narrow flexuous axial ribs. The suture is submargined by a closely spaced pair of spirals, the upper one weak but the lower one massive. This is followed by the rather narrow, deeply concave shoulder sulcus which bears one or two fine spiral threads. Peripheral spiral on the site of a slight angulation, below which the spirals continue over the base to the anterior fasciole.

There are from 1-3 spirals between the peripheral keel and the lower suture or 7-10 between the periphery and the anterior fasciole; 5 or 6 weaker, linear-spaced, smooth cords on the anterior fasciole. Spire about 1½ times height of aperture plus canal.

Anterior canal very short and weakly notched, with an oblique termination. In senile specimens the subsutural fold thickens at its termination to form a callosity, slightly restricting the U-shaped sinus which is at the termination of the one or two threads bisecting the shoulder sulcus. Colour dark chocolate with the gemmules picked out in white; pillar light reddish brown; interior of aperture light purplish grey.

Measurements (mm.) –

height	width	
24.5	9.0	Japan
24.0	9.0	one of three syntypes
20.0	7.5	Mauritius

Synonymy –

1839 *Pleurotoma cerithina* Anton, Verzeichniss der conchylien, p. 73, sp. 2504.

1843 *Pleurotoma digitale* Reeve, Conch. Icon., **1**, pl. 17, fig. 138.

1884 *Drillia (Crassispira) digitalis* (Reeve), Tryon, Man. of Conch., **6**, p. 191. pl. 13, fig. 75.

1914 *Drillia (Crassispira) digitalis* (Reeve), Bouge and Dautzenberg, Journ. de Conch., **61**, p. 143.

1922 *Turridrupa cerithina* (Anton), Hedley, Rec. Aust. Mus. 13(6), p. 226.

Records – PHILIPPINES: Island of Burias, under stones at low water (type locality). JAPAN: Oshima-Osumi (USNM). NEW GUINEA: Finschafen (T. Garrard). QUEENSLAND: Low Isles (AWBP coll.); Buchan's Point (Mrs. J. Kerslake). NEW CALEDONIA: (Bouge and Dautzenberg, 1914). FIJI (USNM). ANDAMAN ISLANDS: Port Blair (Winckworth coll., Brit. Mus.). MAURITIUS: (ANSP and AWBP coll.).

Types – Three syntypes of *digitale* are in the British Museum (Natural History).

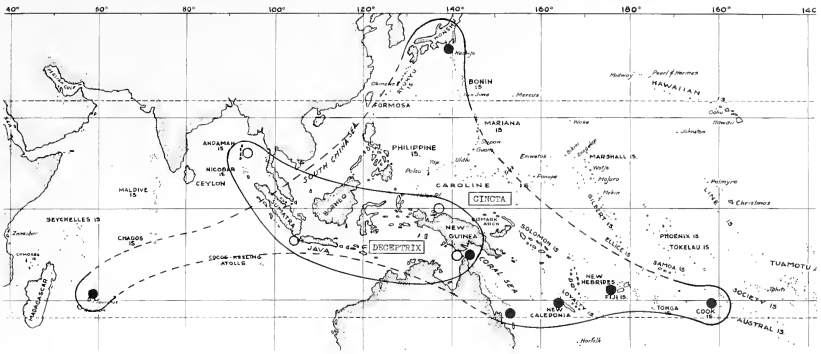

Plate 307. Geographical distribution of *Turridrupa cincta* (Lamarck) and *T. decceptrix* Hedley.

Turridrupa cincta (Lamarck, 1822)

(Pl. 301, fig. 5)

Range – Mauritius, Queensland, Japan and Fiji.

Remarks – This shell stands nearest to *bijubata* in size and general appearance but is easily distinguished from that species by the uniform yellowish brown colour, lack of axial undulations, and different arrangement of the keels on the spire-whorls, the subsutural one being far heavier than the other two, of which the median sinus one is quite weak.

Description – Shell small, 14.5-16.5 mm. (about ¾ inch) in height, drilliaform, very solid, sculptured with strong spiral keels, with 3 or 4 fine, crisp, spiral threads in each interspace. Spire-whorls with a massive subsutural keel, followed by a very weak median one, the sinus rib, and then a strong one below it; four more strong keels on the base, uppermost emergent at the suture, and five closely-spaced cords on the anterior end. Spire more than 1½ times height of aperture plus canal. Apical whorls acuminate. Sinus small, narrowly U-shaped, its apex on the weak median spiral. Anterior canal very short, with an oblique, shallowly-notched termination. Colour uniform light yellowish brown.

Measurements (mm.) –

height	width	
16.5	7.0	Mauritius
16.0	6.5	Mauritius
14.5	6.5	Fiji

Synonymy –

1822 *Pleurotoma cincta* Lamarck, Hist. nat. anim. sans Vert., ed. 1, 7, p. 92.

1939-40 *Pleurotoma cincta* (Lamarck), Kiener, Icon. Coq. Viv., Pleurotome, p. 60, pl. 19, fig. 5.

1960 *Turridrupa cincta* (Lamarck, Oyama and Takemura, The Molluscan Shells, pt. 4, figs. 1, 2.

Records – "les mers de l'ile de France" = Mauritius (type locality) (AWBP coll.); Barkley Island (Mrs. J. Kerslake). JAPAN: Amami-Oshima Islands (Oyama and Takemura). QUEENSLAND: North West Island (Mrs. J. Kerslake); Portland Roads, Cape York Peninsula (T. Garrard). FIJI: (A. Garrett, ANSP). "HERVEY ISLANDS" = COOK ISLANDS: (B. P. Bishop Mus.). NEW CALEDONIA: Poindimie (Mrs. J. Kerslake).

Turridrupa modesta (Sowerby, 1834)

Localities – "Real Llejos [Nicaragua] et ad Insulam Annaa" [Tuamotu Archipelago].

Remarks – Upon the available evidence, the status of this species cannot be determined, for the type, which should be in the British Museum, cannot be found. Reeve in 1843 (Conch. Icon. 1, pl. 12, fig. 99) and Tryon (1884, Man. of Conch. 6, p. 241) considered it a synonym of *cincta* Lamarck, 1822, and said the first mentioned locality, "Real Llejos," was probably erroneous. Shells in the Garrett collection at the B. P. Bishop Museum, labelled "*Pl. modesta* Sowerby, Hervey Islands" are undoubtedly *cincta*, and since Garrett probably relied upon the British Museum for his identifications, Sowerby's species may well be a synonym of *cincta* as Reeve claimed.

Also, Sowerby made no mention of peripheral maculations in his original description of *modesta*, but he did mention "cingulo mediano nigro, albo articulata" for his *interrupta* (i.e., *astricta*), also from the Island of Anaa, and described in the same paper.

On the other hand, Oyama and Takemura (1960, The Molluscan Shells, pt. 4, figs 13, 14), figured a maculated Japanese shell as *modesta*, and this is certainly not *cincta*. A shell very similar to Oyama and Takemura's "*modesta*" from Samoa (AWBP coll.) likewise has the peripheral dashes uncoloured, but defined by surrounding diffused blotching in brown. See *T. diffusa* Powell, new species.

Synonymy —

1834 *Pleurotoma modesta* Sowerby, Proc. Zool. Soc., London, for 1833, p. 136.

1843 *Pleurotoma cincta* Lamarck, Reeve, Conch. Icon., 1, pl. 12, fig. 99.

Turridrupa deceptrix Hedley, 1922

(Pl. 301, fig. 2)

Range — North Queensland and New Guinea to the Andaman Islands.

Remarks — This species resembles *jubata* in its crisp, narrow, spiral keels but has more the shape of *acutigemmata*. It differs from both, however, in the lack of gemmules.

Description (original) — "Shell elongate-conic, very solid, contracted at the base, constricted and channelled at the suture, last whorl about half the total length; eleven whorls, including the protoconch. Colour pale ochraceous-buff, aperture lighter. Sculpture: — Last whorl with thirteen, penultimate with four, and earlier whorls with three prominent spiral keels, the furrows between which carry faint radial striae, and sometimes a small interstitial thread. Aperture: — There is a thin callus sheet on the inner lip, and a solid callus plug at the angle of the aperture; outer lip simple; sinus a semicircular notch with reflected margin; canal short, open, and slightly recurved; deep within the throat are five revolving raised threads."

Measurements (mm.) —

height	width	
19.0	6.5	Japen Island, West New Guinea
14.0	6.0	holotype

Synonymy —

1922 *Turridrupa deceptrix* Hedley, Rec. Aust. Mus., 13(6), p. 227, pl. 42, fig. 14.

Records — QUEENSLAND: Darnley Island, 30 fathoms (type locality). WEST NEW GUINEA: 1 mi. S.E. of Cape Dgarwawoffi, Japen Island, 10-16 fathoms, coarse gravel and silt (NSF, ANSP). ANDAMAN ISLANDS: Port Blair (Winckworth coll., Brit. Mus.). INDONESIA: Sunda Strait, 30 metres (Th. Mortensen, 1922, Zool. Mus., Copenhagen).

Types — The holotype is in the Australian Museum, Sydney.

Turridrupa diffusa Powell, *new species*

(Pl. 305, fig. 5)

Range — Samoa and Japan.

Remarks — This species belongs to the *astricta* group. It is readily distinguished by its narrow form and the reversed colour pattern, in that the peripheral nodes are colourless, being defined by a surrounding diffused brown blotching. The Japanese record, based upon Oyama and Takemura's figures, shows a shell with smaller and more numerous nodes. When more material is available this may prove to be distinct from typical *diffusa*.

Description — Shell small, 12 mm. (½ inch) in height, drilliaform, narrowly subcylindrical, solid, sculptured with strong spiral cords, smooth except for the sinus one, which bears laterally elongated slightly raised losenge-shaped nodes. These nodes are accentuated by being picked out by a surrounding diffusion of pale reddish brown blotches on an otherwise creamy-white ground. Spire less than twice height of aperture plus canal. Postnuclear whorls about 10 (apex eroded). Spire-whorls sculptured with a heavy, narrowly ridged, subsutural cord, followed by the weakly nodulose sinus rib, and two plain, narrowly ridged cords between it and the lower suture. The subsutural cord is strongest, but those following it diminish only slightly in strength; seven cords on the body-whorl from below the sinus rib to the end of the anterior canal; one or two intermediate spiral threads over the region of the neck. There are about nine nodes on the sinus cord of the last whorl. Parietal callus-pad heavy. Sinus deep, U-shaped, at the termination of the nodulose rib.

Measurements (mm.) —

height	width	
12.0	4.5	holotype

Synonymy —

1960 *Turridrupa modesta* (Sowerby), Oyama and Takemura, The Molluscan Shells, pt. 4, figs. 13, 14 (non Sowerby, 1834).

Records — SAMOA (ex A. J. Garrett) (holotype). JAPAN: Amami-Oshima Islands (Oyama and Takemura, 1960).

Types — The holotype is in the Powell collection, Auckland Museum.

Turridrupa jubata (Hinds, 1843)

(Pl. 301, fig. 3)

Range — Japan to Melanesia.

Remarks — It is difficult to be positive about the identity of *jubata* since the holotype can no longer be found, but there seems to be little doubt that the species is closely allied to *acutigemmata*, from which it differs in being more broadly fusiform and in having more numerous and smaller gemmules on the sinus rib. These gemmules are not only laterally compressed but are slightly oblique as well, which gives something of the appearance of a strand unravelled from a rope.

Description — Shell small, 26 mm. (1 inch) in height, rather broadly fusiform with tall spire, about 1¼ times height of aperture plus canal, which is relatively long for the genus. Sculpture of narrow, sharply raised spiral keels, three on the spire-whorls; first smooth and subsutural; second, the sinus rib is delicately beaded (about 25 per whorl); third keel smooth. On the base are seven additional and equally strong smooth keels, plus five weak but crisp spiral cords on the fasciole. Surface smooth except for excessively fine axial growth lines. Sinus deep, narrowly U-shaped, its apex at the termination of the beaded keel. Colour pale yellowish brown, sometimes with the anterior end white.

Measurements (mm.) —

height	width	
26.0	—	fide Hinds
22.5	8.5	Palau Is., Arakabesan Id., dredged
22.0	8.0	Palau Is., Malakal Harbour, 25-30 fathoms

Synonymy —

1843 *Pleurotoma jubata* Hinds, Proc. Zool. Soc. for 1843, London, p. 37.

1843 *Pleurotoma jubata* Hinds, Reeve, Conch. Iconica, **1**, pl. 7, fig. 52.

1844 *Pleurotoma jubata* Hinds, Voy. H.M.S. Sulphur, **2**, p. 15, pl. 5, fig. 3.

1913 *Pleurotoma (Hemipleurotoma) jubata* Hinds, Schepman, Siboga Exped., Pt. 5, **49e**, p. 400.

1960 *Turridrupa jubata* (Hinds), Oyama and Takemura, The Molluscan Shells, pt. 4, fig. 10 (not fig. 9, which is *acutigemmata*).

Records — STRAITS OF MALACCA: found in mud at the depth of eighteen fathoms (type locality). JAPAN: Izu Peninsula (Oyama and Takemura, 1960); Shionomizaki, Kii (ANSP). PALAU ISLANDS: dredged off Arakabesan Island (ANSP); off Malakal Harbour, 25-30 fms. (ANSP). WEST NEW GUINEA: ½ mi. S. of Maroepi, Ambai Islands, Japen Island, 14-25 fms.; 2 mi. N. of Matas, Aocri Islands, Geelvink Bay, 18-20 fms. (ANSP). CELEBES: between islands of Wowoni and Buton, 75-94 metres (Schepman, 1913). NEW CALEDONIA: Poindimie (Mrs. J. Kerslake).

Turridrupa prestoni Powell, *new name*

(Pl. 301, fig. 4)

Range — Andaman Islands.

Remarks — The name *Pleurotoma rimata* Preston, 1908, is preoccupied by *Pleurotoma (Drillia) rimata* E. A. Smith, 1888, so a new name is hereby provided. This species stands between *jubata* and *acutigemmata*. It has the general shape of *jubata* but attains a much larger size. The interstices of the keels are spirally lirate, not smooth, and the gemmules are laterally elongated as in *acutigemmata*, and there are more of them, 17, compared with 13 or 14 in the latter species.

Description — Shell large for the genus, 25-33 mm. (1-1¼ inches) in height, broadly fusiform with tall spire, almost 1⅓ times height of aperture plus canal, which is relatively long for the genus. Sculpture of stout but narrowly crested keels, of varying strength, with from 1-4 fine crisp spiral threads in most interspaces. Spire-whorls with three keels and a fourth sometimes emergent over the last two whorls; firstly a moderately strong smooth subsutural keel, followed by the gemmate sinus keel, also moderately strong, and then a massive smooth peripheral keel just above the lower suture. On the base, from level with the top of the aperture to the anterior fasciole, are a further eight spiral keels, followed by five cords on the fasciole. Sinus deep, U-shaped, its apex at the termination of the gemmate median keel. Colour yellowish brown, paler over neck and anterior end.

Measurements (mm.) —

height	width	
33.0	12.5	Port Blair, Andaman Islands
33.0	12.0	Port Blair, Andaman Islands
25.5	10.0	holotype

Synonymy —

1908 *Pleurotoma rimata* Preston, Rec. Indian Mus., **11**, p. 190, pl. 17, fig. 62 (non *Pleurotoma (Drillia) rimata* E. A. Smith, 1888).

Records — ANDAMAN ISLANDS (type locality): Port Blair (Winckworth coll., Brit. Mus.).

Turridrupa weaveri Powell, *new species*

(Pl. 303, fig. 5)

Range — Hawaiian Islands.

Remarks — This species is not very closely allied to any other described member of the genus. It does, however, show some resemblance to *cerithina* (Anton, 1839) in that both have a tessellated pattern in dark-brown upon a pale ground, but in

cerithina the pattern is over the entire shell, whereas in *weaveri* it is absent from both the early spire-whorls and the base. Other points of difference between the two species are that the keels are gemmate in *cerithina* but smooth in *weaveri;* also there are 1-3 spiral threads in the shoulder sulcus of *cerithina* but none in *weaveri.*

The species is named for Mr. Clifton Weaver of Hawaii, who generously made available all the Hawaiian turrids in his collection.

Description – Shell comparatively large, 18-23 mm. (about 1 inch) in height. Spire tall, almost twice height of aperture plus canal. Protoconch eroded away in the holotype, but in a not fully adult specimen from Mokumanu Island, Oahu, it is conical, with a low dome-shaped smooth initial whorl, followed by 1½ whorls sculptured with strong, closely-spaced, vertical axials which terminate abruptly as the tricarinate post-nuclear sculpture commences. Spire-whorls sculptured with three cords plus a fourth, emergent over the last whorl. Subsutural cord massive, followed by the sinus cord of less than half that strength, and one or two cords below, which are slightly heavier than the sinus cord. Three or four strong widely spaced cords on the base, with 3 or 4 threads in each interspace, followed by 5 or 6 irregular cords on the anterior fasciole. Colour creamy white, heavily maculated with dark reddish brown in an irregular tessellated pattern. The maculations are absent from the early spire-whorls and cease abruptly at the lower suture, which leaves the base unicoloured.

Measurements (mm.) –

height	width	
18.0	7.0	Mokumanu Id., Oahu
21.7	8.75	holotype
23.0	9.0	off Kewalo, Oahu

Records – HAWAIIAN ISLANDS: 45 feet, off Rabbit Island, Oahu (type) (C. Weaver, Nov., 1961); off Pokoi Bay, 40 feet, sand and coral; off Kewalo, Oahu, 20 fathoms (Mrs. M. King, March 28, 1962); off Waikiki, Oahu, 100-190 fathoms (P. Burgess, April-June, 1953); Mokumanu Island, Oahu, 65-75 feet, attached to base of small coral chunk (A. Tiedeman and C. Weaver, March 26, 1965).

Types – The holotype is presented to the B. P. Bishop Museum, Honolulu by Mr. Clifton Weaver.

FOSSIL SPECIES

Turridrupa maoria Powell, 1942

Range – New Zealand, upper Miocene.

Remarks – The record of this genus in the New Zealand upper Miocene is based upon a single imperfect specimen. However, the presence of a spiral rib traversing the sinus area, the tuberculate peripheral spiral keel, and evidence of axial costae on what remains of the nuclear whorls, make the generic reference almost certain.

Measurements (mm.) –

height	width
5.3	2.25

Synonymy –

1942 *Turridrupa maoria* Powell, Bull. No. 2, Auck. Inst. Mus., p. 117, pl. 11, fig. 10.

Records – NEW ZEALAND: N. Z. Geol. Surv. loc. 1340, tuffaceous arenaceous mudstone, 2000′-3000′ above the Waikokopu sandstone, 0.35 mi. up north-flowing nameless stream from road bridge, block 12, Ngatapa S.D. (base of Mapiri series, upper Miocene).

Types – The unique holotype is in the New Zealand Geological Survey, Wellington.

Genus Taranis Jeffreys, 1870

Type: *Trophon mörchi* Malm, 1863

A very widely distributed genus of miniature *Bathytoma*-like shells, but with a much shallower sinus, the apex of which is on the peripheral keel. Angles of approach of sinus unequal, being steep and straight above but protractively arcuate below.

Protoconch paucispiral, of barely two whorls, papillate, slightly globose, apparently smooth, but under high magnification there is a dense sculpture of minute stippled lirae. Pillar abruptly twisted at the commencement of a short shallowly notched anterior canal. Post-nuclear sculpture clathrate; distant keels or strong spiral cords, crossed by crisp lamellate axials. There is no operculum, according to Jeffreys, in his original description of the genus.

The type species of *Taranis* (pl. 308, fig. 1) has a wide distribution in moderately deep water from Norway to the Mediterranean and the Atlantic coast of the United States to the Gulf of Mexico.

The Australasian genus *Fenestrosyrinx* is identical with *Taranis* both in general appearance and also in the form and sculpture of the protoconch. Another apparent synonym is the genus *Allo* (from a manuscript of Jousseaume), and a substitute name for it, *Feliciella*, both published in the same paper by Lamy (1934, *l.c.*) and based upon a small Red Sea shell.

In addition to the species dealt with here, other members of the genus are: *alexandrina* Sturany, 1896, from off Alexandria, Egypt; *cirrata* Brugnone, 1862, Pleistocene of Sicily and elsewhere in Europe; *strongi* Arnold, 1903, and *inculta* Moody, 1916, both from the Pleistocene of California.

The Recent range of *Taranis* is now known to cover the North Atlantic, the Mediterranean and the Red Sea, and extends also to Hongkong, Japan, Queensland, eastern Australia, South Australia and New Zealand. Fossil occurrences are known from the Pleistocene of England, Sicily, New Zealand and California, and the Pliocene of Italy. Probably many other species, both Recent and fossil, will later be recognized as members of this wide ranging genus.

Although *Taranis* resembles a *Bathytoma* or *Micantapex*, in miniature, there is probably no close relationship. The genus is referred to the subfamily Turrinae solely because of the peripheral position of the sinus, but this feature is not an infallible guide to the Turrinae, as evidenced by *Bathytoma* and *Micantapex*, both of which have a different style of radula.

Synonymy –

1870 *Taranis* Jeffreys, Ann. Mag. Nat. Hist., Ser. 4, 5, p. 447. **Type** by monotypy: *Trophon mörchi* Malm, 1863.

1926 *Fenestrosyrinx* Finlay, Trans. N. Z. Inst., **56**, p. 254. **Type** by original designation: *Turris nexilis bicarinatus* Suter, 1915.

1934 *Allo* (Jousseaume ms.) Lamy, Journ. de Conch., **78**, pp. 67-71. **Type** by original designation: *Allo allo* (Jousseaume ms.) Lamy, 1934.

1934 *Feliciella* Lamy, Journ. de Conch., **78**, p. 67 (unnecessary name for *Allo allo*). **Type** by original designation: *Feliciella jousseaumei* Lamy, 1934.

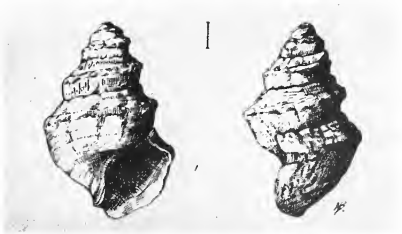

Plate 308. *Taranis allo* (Jousseaume), 4 mm., Djibouti, Red Sea (from Lamy, Journ. de Conch., **78**, p. 67, text fig.).

Key to species of Taranis

A. Periphery angulate, but not flanged
  Axials obsolete, fine growth-lines at most
    Periphery sharply angulate
      Keels strong, two on spire, two more on base
        imporcata (Dell)
    Periphery weakly angulate
      Keels suppressed, cords moderate, subequal
        spirulata (Dell)
  Axial and spiral sculpture subequal, dense, fenestrate
    Shell wide
      Peripheral angle medial ..... *mayi* (Verco)
    Shell narrow
      Peripheral angle at about two thirds whorl height
        Sculpture crisply fenestrate ..... *benthicola* (Dell)
        Sculpture indistinct, fenestrate
          turritispira (E. A. Smith)
B. Periphery angulate but only weakly flanged
  Shell wide
    Subsidiary spiral cords weaker than peripheral one
      ticaonica Powell
  Shell narrow
    Subsidiary spiral cords weaker than peripheral one
      bicarinata (Suter)
    Subsidiary spiral cords almost as strong as peripheral
      gratiosa (Suter)
C. Periphery a projecting heavy flange
  Peripheral flange crenulated by axial lamellae
    Shoulder lirate
      Subsidiary spiral between periphery and lower suture
        Axials about 16 per whorl ..... *percarinata* Powell
        Axials about 22 per whorl .. *nexilis nexilis* (Hutton)
    Shoulder without lirae ..... *nexilis recens* (Fleming)
  Peripheral flange undulated by distant broad low axials
    Subsidiary spirals sparse and weak ... *allo* (Jousseaume)

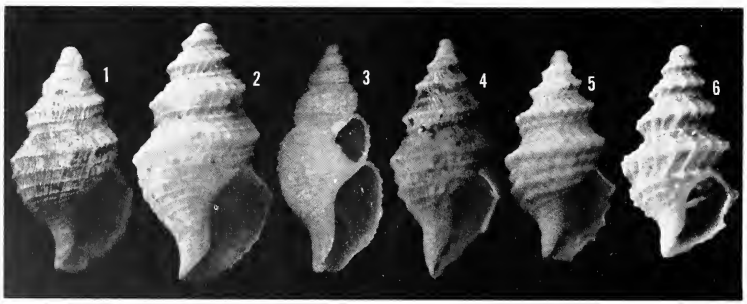

Plate 309. Fig. 1, *Taranis morchi* Malm, West Norway. 3 mm. Fig. 2, *T. ticaonica* Powell *new species*, 2.3 mm., Ticao Island, 226 fms., Philippines, holotype. Fig. 3, *T. turritispira* (E. A. Smith), 6 mm., Japan, co-type in British Museum. Fig. 4, *T. bicarinata* (Suter), 23 fms. off Ahipara, New Zealand. Fig. 5, *T. nexilis* (Hutton), Castlecliff, New Zealand. Pleistocene. Fig. 6, *T. percarinata* Powell *new species*, 3 mm., east of Masbate, 135 fms., Philippines, holotype.

Taranis allo Jousseaume, 1934

(Pl. 308)

Range – Known only from Djibouti, Red Sea.

Remarks – This species appears insufficiently distinct from the type of *Taranis* to warrant even subgeneric segregation. Jousseaume's genus *Allo* and species *allo* were described and published posthumously. Authorship by Jousseaume is clearly intended by the editor, Ed. Lamy, particularly since the names appear in the index to that particular volume of the Journal de Conchyliologie as belonging to Jousseaume. Lamy added additional remarks deriding the name *Allo allo,* and illegally proposed the substitute names *Feliciella jousseaumei.* I consider them synonyms.

Description – Shell very small, 4 mm. in height, rather broadly ovate-biconic, with a moderately tall spire and truncated body-whorl. Protoconch eroded but evidently paucispiral. Spire-whorls strongly angulated just above the middle by an irregularly nodulose raised keel. Four or five rather indistinct spiral cords on the body-whorl, from below the peripheral carina and over the base. Axial sculpture of weak, rather irregular and distant lamellae. Sinus broadly open, V-shaped, very shallow, its apex on the peripheral carina. The anterior canal is very short, its shallowly-notched extremity being very oblique to the axis.

Measurements (mm.) –

height	width
4.0	3.0

Synonymy –

1934 *Allo allo* Jousseaume, Journ. de Conch., **78,** p. 67.
1934 *Feliciella jousseaumei* Lamy, Journ. de Conch., **78,** p. 67 (unnecessary substitute name for *Allo allo* Jousseaume).

Records – Known only from the type locality, Djibouti, French Somalia.

Taranis percarinata Powell, *new species*

(Pl. 309, fig. 6)

Range – Philippines in 80 to 135 fathoms.

Remarks – This species, with its prominent sharp peripheral keel, more closely resembles the New Zealand *nexilis* (Hutton, 1885) than it does the European type of the genus, *mörchi* Malm, which has semi-inflated weakly carinated whorls. From the New Zealand species the Philippine shells differ in having a still more prominent peripheral keel and fewer, stronger axial lamellae.

Description – Shell very small, 3 mm. in height, with prominently carinated whorls, overridden by lamellate axials and with a truncated anterior end. Spire 1½ times height of aperture plus canal. Whorls 5½, including a papillate protoconch of 1½ whorls, densely sculptured with minute, stippled lirae. Post-nuclear whorls strongly and bluntly carinated below, and a second carina, almost as strong, is emergent over the last half-whorl, followed by two much weaker spirals on the base and five oblique lirae on the anterior end. Prominent lamellate axials, about 16 per whorl, cross the whole surface; these are retractively slanting and very broadly V-shaped over the spire-whorls, but are recurved arcuately over the base. They crenulate the main carinae and render the secondary spirals gemmate. The sinus is weak, very broadly V-shaped, as defined by the axial lamellae and has its apex on the peripheral carina. The aperture is obliquely subquadrate and is produced below into a very short but strongly flexed, unnotched anterior canal. Colour dull-white.

Occurring in this species is a form which differs in having a sharp, relatively strong, subsutural spiral and another on the body-whorl between the two main carinae. However, there is insufficient material to determine the status of this form.

Measurements (mm.) –

height	width
3.0	1.5

Types – The holotype is in the United States National Museum, Washington (USNM 281739f.).

Records – PHILIPPINES: south of Adyagan Island, east Masbate, 135 fathoms (holotype; Albatross Sta. 5392). Off Destacado Island, east Masbate, 80 fathoms (Albatross Sta. 5213).

Taranis ticaonica Powell, *new species*

(Pl. 309, fig. 2)

Range – Off Ticao Island, Philippines, in 226 fathoms.

Remarks – This species is very similar to the European *mörchi* Malm, both in shape and in sculpture. In fact, the only differences in the Philippine shell are a slightly more pronounced peripheral carina, more numerous basal spirals, fewer and slightly stronger axial lamellae, and a thicker, less excavated, anterior end.

Description – Shell very small, 2.3 mm. in height, white, biconic, with a tabulated spire, slightly taller than the height of the aperture plus the canal. Whorls 5, including a subglobose protoconch of 1½ whorls, delicately sculptured with closely spaced, minute, stippled lines. Post-nuclear whorls medially

strongly carinate. Suture channelled and submargined by a moderately strong spiral cord; two slightly weaker cords between the subsutural cord and the periphery, and 1 or 2 between the periphery and the lower suture; about 8 cords on the body-whorl, plus 5 weaker and more closely spaced spirals on the anterior end. The whole crossed by crisp, axial, chevron-shaped lamellae, which follow the outline of the sinus which is a widely open V, with its apex at the peripheral carina.

Measurements (mm.) –

height	width	
2.3	1.3	holotype

Types – The holotype is from Albatross Sta. 5388 and is in the United States National Museum, Washington (USNM, no. 285237).

Taranis turritispira (E. A. Smith, 1882)

(Pl. 309, fig. 3)

Range – Japan.

Description – Shell small, of light build, 6 mm. in height, elongately ovate, with rounded whorls, weakly angulated at the shoulder. Height of spire slightly greater than height of aperture plus canal. Sculpture clathrate, not very prominent, the spirals dominant, and the axials tending to become subobsolete over the last whorl. Three spiral cords are on the upper whorls, with a fourth emergent over the last whorl. Protoconch paucispiral and with about two whorls (not examined for micro-sculpture). Sinus and other apertural features typical.

Measurements (mm.) –

height	width
6.0	2.0

Synonymy –

1882 *Pleurotoma (Taranis?) turritispira* E. A. Smith, Ann. Mag. Nat. Hist., Ser. 5, **10** (not figured), p. 306.

1952 *Taranis turritispira* (Smith), Kuroda and Habe, Check List and Bibliogr. Rec. Mar. Moll. Japan, p. 88.

Types – Three co-types in the British Museum (Natural History). The specimen illustrated here is the lectotype. The type locality is Japan.

RECENT AND PLEISTOCENE SPECIES FROM SOUTHERN AUSTRALIA AND NEW ZEALAND

Taranis benthicola (Dell, 1956)

Range — New Zealand, off Eastern Otago, 300 fathoms (type locality); Chatham Rise, 200 fathoms, and Pitt Island, 155 fathoms.

Synonymy —

1956 *Fenestrosyrinx benthicola* Dell, Domin. Mus. Bull., No. 18, p. 141, fig. 197.

Types — Holotype and paratypes in the Dominion Museum, Wellington.

Taranis bicarinata (Suter, 1915)

(Pl. 309, fig. 4)

Range — New Zealand, Wanganui (Castlecliffian Pleistocene) *(bicarinata);* Recent, off Hen and Chicken Islands *(thomsoni);* off Ahipara, 23 fathoms.

Synonymy —

1885 *Clathurella nexilis* Hutton (partim), Trans. N. Z. Inst., **17,** p. 317 (=5 of Hutton's syntypes of *nexilis*).

1915 *Turris (Hemipleurotoma) nexilis bicarinatus* Suter, N. Z. Geol. Surv. Pal. Bull., No. 3, p. 34.

1919 *Leueosyrinx thomsoni* Mestayer, Trans. N. Z. Inst., **51,** p. 133, pl. 8, fig. 5.

1942 *Fenestrosyrinx nexilis bicarinata* (Suter), Powell, Bull. No. 2, Auck. Inst. Mus., p. 57.

Types — The holotype of *bicarinata* is in the Canterbury Museum and the holotype of *thomsoni* is in the Dominion Museum, Wellington.

Taranis gratiosa (Suter, 1908)

Range — New Zealand, Port Pegasus, 18 fathoms, Stewart Island (type locality) to Dusky Sound.

Synonymy —

1908 *Bathytoma gratiosa* Suter, Proc. Malac. Soc., **8,** p. 186, pl. 7, fig. 19.

1942 *Fenestrosyrinx gratiosa* (Suter), Powell, Bull. No. 2, Auck. Inst. Mus., p. 57.

Types — The holotype is in the New Zealand Geological Survey, Wellington.

Taranis imporcata (Dell, 1962)

Range — New Zealand, off Taiaroa Head, 300 fathoms.

Synonymy —

1962 *Fenestrosyrinx imporcata* Dell, Rec. Domin. Mus., **4**(15), p. 73, fig. 4.

Types — Holotype and paratypes in the Dominion Museum, Wellington.

Taranis mayi (Verco, 1909)

Range — South Australia, 35 miles south-west of Neptune Islands, 104 fathoms.

Remarks — This very small shell, 4.6 mm. in height, is biconical, with medially sharply angled whorls, sculptured with a dense clathrate pattern of numerous thin but sharply raised spirals, crossed by equally strong and numerous axials. Protoconch typical, of two convex apparently smooth but microscopically finely spirally lirate and interstitially punctate. Known only from the type locality.

Synonymy —

1909 *Hemipleurotoma mayi* Verco, Trans. Royal. Soc. S. Aust., **33,** p. 295, pl. 25, fig. 2.

Taranis nexilis *subspecies* nexilis (Hutton, 1885)

(Pl. 309, fig. 5)

Range — New Zealand, Wanganui (Castlecliffian Pleistocene).

Synonymy —

1885 *Clathurella? nexilis* Hutton, Trans. N. Z. Inst., **17,** p. 317, pl. 18, fig. 9.

1942 *Fenestrosyrinx nexilis* (Hutton), Powell, Bull. No. 2, Auck. Inst. Mus., p. 57.

Types — The holotype is in the Canterbury Museum, Christchurch, New Zealand.

Taranis nexilis *subspecies* recens (Fleming, 1948)

Range — New Zealand, Dusky Sound, 22 fathoms (type locality), and Edwardson Sound, 58 fathoms.

Synonymy —

1948 *Fenestrosyrinx nexilis recens* Fleming, Trans. Royal Soc. N. Z., **77,** p. 91, pl. 8, fig. 7.

Types — The holotype is in the New Zealand Geological Survey, Wellington.

Taranis spirulata (Dell, 1962)

Range – New Zealand, off Taiaroa Head, 300 fathoms.

Synonymy –

1962 *Fenestrosyrinx spirulata Dell, Rec. Domin. Mus.*, 4(15), p. 73, fig. 5.

Types – Holotype and paratypes in the Dominion Museum, Wellington.

Genus Micropleurotoma Thiele, 1929

Type: *Pleurotoma spirotropoides* Thiele, 1925

The type species of this genus is a small, rather featureless shell (4.5 mm.), from deep water off South Africa.

The protoconch is relativcly large, globose, dome-shaped, smooth and paucispiral. The adult whorls are smooth except for a prominent rounded smooth peripheral keel. The sinus is shallow, its apex on the peripheral keel. Anterior canal short, spout-like and unnotched.

The genus may be near to *Taranis*, which differs in the protoconch being microscopically granulose-lirate and in having the anterior canal shallowly notched.

I have not seen material relevant to this genus, so have no remarks to add to the rather meagre original description.

An alleged second species of the genus, *M. ashiyaensis* Shuto and Uedo, 1963, from the Ashiya group, upper Oligocene of Japan is very doubtfully a member of the genus. The incomplete holotype is very much larger (23.4 mm.) than *spirotropoides*, and in addition to the smooth rounded peripheral carina, has a dense surface pattern of spiral lirations. Except for the lack of peripheral nodes, the Japanese species shows possible affinity with *Lucerapex*.

Synonymy –

1929 *Micropleurotoma* Thiele, Handbuch der systematischen Weichtierkunde, **1**, p. 362. **Type** by original designation: *Pleurotoma spirotropoides* Thiele, 1925.

Micropleurotoma spirotropoides (Thiele, 1925)

(Pl. 310, fig. 1)

Range – Off South Africa, 126 and 2750 metres.

Measurements (mm.) –

height	width
4.5	2.3

Synonymy –

1925 *Pleurotoma spirotropoides* Thiele, Wissenschaft Ergebn. Deutschen Tiefsee-Exped., **17**, Gast. 2, p. 213(179), pl. 23, fig. 18.

1929 *Epideira (Micropleurotoma) spirotropoides* (Thiele), Handb. system. Weichtierkunde, **1**, p. 362.

Records – SOUTH AFRICA: 35° 19′ S; 20° 12′ E, 126 metres. Agulhas Bank, 35° 32.8′ S; 18° 20.1′ E, 2750 metres.

?Micropleurotoma ashiyaensis Shuto and Ueda, 1963

(Pl. 310, figs. 2, 3)

Range – Japan, coastal cliff north of Taya, Ashiya machi, Onga gun, Fukuoka Prefecture (Ashiya group, Nishisonogian, upper Oligocene).

Remarks – Very doubtfully a member of the genus.

Measurements (mm.) –

height	width
23.4 mm. (incomplete)	13.5

Synonymy –

1963 *Micropleurotoma ashiyaensis* Shuto and Ueda, Jap. Journ. Geol. and Geogr., 34(1), p. 2, pl. 1, figs. 1, 2.

Types – The holotype is in the Department of Geology, Kyushu University.

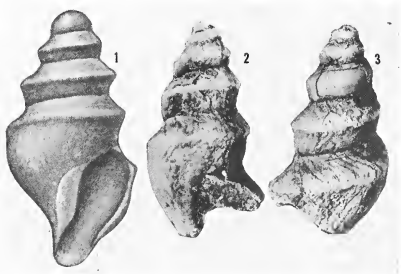

Plate 310. Fig. 1, *Micropleurotoma spirotropoides* (Thiele), 4.5 mm., South Africa, 2750 metres (from Thiele, 1925, Gast. deutsch. Tiefsee-Exped., **17**, pl. 23, fig. 18). Figs, 2, 3, *?Micropleurotoma ashiyaensis* Shuto and Ueda, 23.4 mm., Japan, upper Oligocene (from Shuto and Ueda, 1963, Jap. Journ. Geol. and Geogr., 34(1), pl. 1, figs. 1, 2).

[These occasional blank areas occur between genera and subgenera to permit the insertion of new material and future sections in their proper systematic sequence.]

ADDITIONS AND CORRECTIONS TO GEMMULA AND XENUROTURRIS

[looseleaf subscribers should place the next 12 pages in their proper places by following the pagination at the bottom of the pages.]

Plate 175 (opposite page)

Corrections made on May 15, 1967 (see stars).

Figs. 1, 6 *Gemmula (Unedogemmula) unedo* (Kiener). Japan (see text p. 22-761).
2, 3 *Lophiotoma (Lophioturris) indica* (Röding). Cuyo Id., Philippines (p. 22-931).
4, 5 *Lophiotoma (Lophioturris) leucotropis* (Adams and Reeve) (p. 22-932).
7, 8 *Gemmula (Unedogemmula) deshayesii* (Doumet). Hongkong (7), Japan (8) (p. 22-762).
9 *Lophiotoma (Lophioturris) indica* (Röding). Philippines (p. 22-931).
10, 11 *Lophiotoma (Lophioturris) polytropa* (Helbling). Luzon Id., Philippines (p. 22-933).
12 *Xenuroturris cingulifera* (Lamarck). Zanzibar (p. 22-962).
13 *Xenuroturris millepunctata* (Sowerby). New Caledonia (p. 22-963).
14, 15 *Xenuroturris ceritliformis* Powell. Hawaiian Islands (p. 22-964). ★
16 *Lophiotoma (Lophioturris) polytropa* (Helbling). Moluccas. ★
17, 18 *Xenuroturris millepunctata* (Sowerby). New Caledonia (p. 22-963).
19, 20 *Xenuroturris cingulifera* (Lamarck). Japan (p. 22-962).
21, 22 *Xenuroturris eastanella* Powell. Hawaiian Islands (p. 22-964). ★
(all 2/3 natural size)

Gemmula interpolata Powell, *new species*

(Pl. 311, figs. 1-3)

Range – Known only from the Hawaiian Islands; 10 to 355 fathoms.

Remarks – This one- to two-inch *Gemmula* appears to be allied to *G. gilchristi* (Sowerby) of the Indian Ocean and Japan [p. 22-701]. This Hawaiian species is also broadly fusiform, but has a more regular outline due to the subsutural fold being more prominent than the peripheral carina. The colours consist of sparse but bright brown maculations.

Description – Shell moderately broadly fusiform, 25 to 52 mm. (about 1 to 2 inches) in height, with a tall narrow spire with an angle of 34 to 36 degrees, and a long, almost straight, unnotched anterior canal. Spire height a little less than that of the aperture plus the canal. Protoconch narrowly conical, of 3½ dark-brown whorls, smooth at first but strongly and closely axially costate over the last 1½ whorls. Post-nuclear whorls 8. Spire-whorls sculptured firstly with a prominent, narrowly-crested, smooth, subsutural fold, followed by a straight, steeply descending shoulder slope, which bears three narrow, crisp, smooth spiral threads; then appears the low-set peripheral carina, which is composed of two linear-spaced spiral cords, which are rendered cog-like by vertically fused nodes. Below the carina there is one smooth cord just emergent at the lower suture. On the body-whorl, below the peripheral carina, there are 8 or 9 distant, smooth, prominent cords, a single thread in each interspace, and 12 to 14 closely-spaced threads on the anterior end. Peripheral nodes 26 to 28 per whorl. Sinus deep, U-shaped, its apex occupying the whole width of the peripheral keel. Colour ivory-white, sparsely maculated in dark reddish brown under a thin pale-buff periostracum. The maculations are large and squarish, and occurring in a peripheral series regularly alternating with the nodes. Other spots are sparsely disposed, both on the subsutural fold and on the primary spirals. Inside the outer lip there are distinct spiral lirations. Average-sized specimens are about 25 mm. in height but occasional ones from deep water reach a height of over 50 mm. In such specimens the maculations are paler and there is a tendency for the peripheral keel to become less prominent over the later whorls.

Measurements (mm.) –

height	width	
52.4	16.1	paratype
26.5	9.2	holotype; off Laysan Id.

Types – The holotype, from Laysan Island (USNM 190417) and other paratypes are in the United States National Museum, Washington.

Records – HAWAII: near Laysan Id., 59-70 fms., bottom temperature 70° F. (Albatross Sta. 3940; USNM 190417) (holotype); Near Laysan Id., 130-148 fms., bottom temperature 63° F (Albatross Sta. 3937; USNM 335269); Oahu, off Waikiki, 100-190 fms.; Keehi Lagoon, 20-30 fms.; off Ala Aesava, 10-40 fms. (C. M. Burgess); off N.E. coast of Maui Id., 143-178 fms., bottom temperature 60.8° F. (Albatross Sta. 4079; USNM 335271); Pailolo Channel, Maui, 128 fms., bottom temperature 62.5° F. (Albatross Sta. 3857; USNM 206003); Kaiwi Channel, 350-355 fms., bottom temperature 41.6° F. (Albatross Sta. 4107; USNM 338272); off S. coast of Molokai Id., 169-182 fms., bottom temperature 55° F. (Albatross Sta. 3835; USNM 335275); near Ranai Id., 233-240 fms., bottom temperature 48.5° F. (Albatross Sta. 3982; USNM 335270).

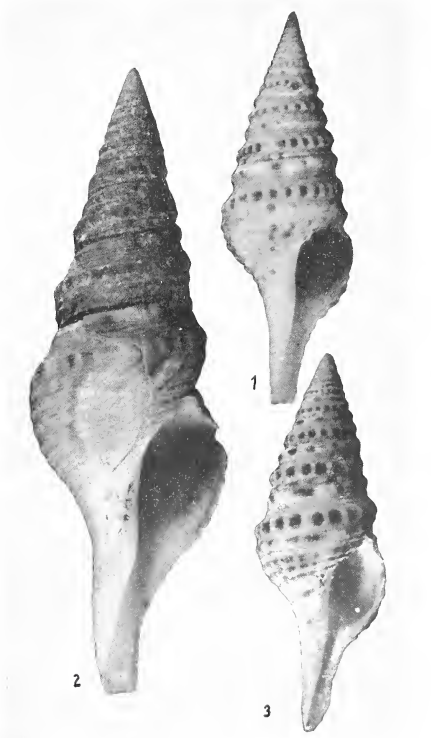

Plate 311. *Gemmula interpolata* Powell, *new species*. Fig. 1, holotype, USNM 190417, 59-70 fms., off Laysan Island, Hawaii; 26.5 mm. Fig. 2, paratype, 143-178 fms., off Maui Island, Hawaii; C. M. Burgess; 52.4 mm. Fig. 3, paratype, 20-30 fms., Keehi Lagoon, Oahu Island, Hawaii; C. M. Burgess; 25.4 mm.

Gemmula pseudomonilifera Powell, *new species*

(Pl. 312)

Range – Known only from the Hawaiian Islands; 20 to 67 fathoms.

Remarks – This attractive, ¾-inch turrid resembles *monilifera* (Pease, 1860) from Hawaii and Fiji [p. 22-701], but has a buff colored shell with light-brown, peripheral nodes in contrast to *monilifera* which is always broadly zoned in brown and with a white anterior end. *G. pseudomonilifera* also has a more gradually contracted base, more widely spaced basal spirals, and a shorter anterior canal. This new species also shows close affinities to *hombroni* (Hedley, 1922) from the southwest Pacific [p. 22-734]. A specimen from 253 fathoms off Maui Island exhibits a tubular labial outgrowth of a basal spiral, as is sometimes found in specimens of *Pinguigemmula*.

Description – Shell small (17 mm.), narrowly fusiform, with a tall spire and a moderately long, very slightly flexed anterior canal. Spire-height slightly greater than half the length of the entire shell. Protoconch conical and with about 4 whorls, the first two smooth, the remainder closely and strongly axially costate. Post-nuclear whorls 6. Spire-whorls sculptured firstly with a prominent sharply carinated subsutural fold, followed by a deep shoulder concavity bearing two fine smooth spiral threads, then by the low-set peripheral keel, which is composed of two gemmate cords. Over the last two whorls, between the peripheral keel and the lower suture, a strong plain spiral cord becomes emergent. On the base and neck the primary spirals are few, strong, plain and wide-spaced, with occasional fine interstitial threads, after which there are closely spaced, but indistinct, spiral lirae on the anterior end. Sinus moderately deep; rather broadly U-shaped, its apex on the peripheral keel. Colour buff, with the protoconch and peripheral nodes tinged with light-brown and most of the body-whorl diffused with the same colour.

Measurements (mm.) –

height	width	
17.7	6.3	holotype
16.0	5.9	paratype

Records – HAWAII: Oahu, Keehi Lagoon, 20-30 fms. (type locality); off Waikiki, 100-190 fms. (P. Burgess); off N.E. coast of Maui Id., 253-267 fms., bottom temperature 46° F. (Albatross Sta. 4084; USNM 338283); S. coast of Molokai Id., 64-60 fms., bottom temperature 71.5° F. (Albatross Sta. 3846; USNM 338282); near Ranai Id., 233-240 fms., bottom temperature 48.5° F. (Albatross Sta. 3982; USNM 338284).

Plate 312. *Gemmula pseudomonilifera* Powell, *new species*. Holotype, Auckland Museum. 20-30 fms., Keehi Lagoon, Oahu Island, Hawaii; 17.7 mm.

Gemmula congener *subspecies*
unilineata Powell, *new subspecies*

(Pl. 313)

Range – Known only from the Hawaiian Islands, 100 to 312 fathoms.

Remarks – This subspecies differs from typical *congener* as well as from the subspecies *cosmoi* and *diomedea,* in that the spiral lirations of the shoulder-slope are knotted or beaded, not plain. In the strong development of the subsutural fold and peripheral carina, *unilirata* is nearest to the typical subspecies, but the shoulder sulcus is wider, bearing three spirals. In typical *congener* the shoulder sulcus is deep and narrow, with only one or two smooth spirals. In *cosmoi* and *diomedea* there is a very wide shoulder slope that bears 4 to 6 smooth spiral threads. The only other subspecies that has a brown-banded subsutural fold is *cosmoi,* but it is unicarinate and smooth, not tricarinate and beaded.

Description – Shell rather broadly fusiform, with a tall spire, with an angle of 34 or 35 degrees, and a moderately long, straight and unnotched anterior canal. Spire height a little more than that of the aperture plus the canal. Protoconch narrowly conical of about three whorls, the first two smooth and the last closely axially costate. Post-nuclear whorls 8. Spire-whorls sculptured firstly with a massive subsutural fold, which is composed of three gemmate spirals, the middle one strongest, followed by a moderately wide shoulder slope, which is sculptured with three knotted to gemmate sub-cords; then the low-set strong peripheral carina, which is composed of two closely-spaced cords, studded with about 32 closely-spaced series of nodes which are vertically fused; from the carina to the lower suture there is a single strong smooth cord. From the carina to the anterior end there are about sixteen cords, which are strong above, then gradually diminishing, the uppermost undulating, the median ones more or less gemmate, the lower ones smooth, with a thread in most interspaces. Sinus moderately deep, with a rather broadly V-shaped entrance, its U-shaped apex occupying the full width of the peripheral carina. Interior of outer lip finely lirate. Ground colour ivory-white under a pale straw-coloured periostracum; subsutural fold dark reddish brown, and pale reddish brown between the peripheral nodes.

Measurements (mm.) –

height	width	
31.0	10.7	holotype
28.0	10.2	off Diamond Head, 240-260 fms.

Types – The holotype is in the B. P. Bishop Museum, Honolulu. The type locality is 200 fathoms, mud bottom, off Waikiki, Oahu Island, Hawaii. Pele Expedition, June 13, 1964, C. Weaver, collector. Paratypes are in the U. S. National Museum from other Albatross stations (see records).

Records – HAWAII: 100-190 fms., off Waikiki; 240-260 fms., off Diamond Head (both Oahu Island; Pat Burgess); 147-198 fms., bottom temperature 49° F. (Albatross Sta. 4045; USNM 338280); near Kauai Id., 309-257 fms., 43.7° F. (Albatross Sta. 4151; USNM 173042); near Kauai Id., 283-309 fms., 46.1° F. (Albatross Sta. 4130; USNM 338273); near Kauai Id., 257-312 fms., 46.8° F. (Albatross Sta. 4132; USNM 338274); south coast of Molokai Id., 238-255 fms., 48° F. (Albatross Sta. 3836; USNM 338278); south coast of Oahu Id., 211 fms., 47.7° F. (Albatross Sta. 3810; USNM 338277). (Most of the Albatross specimens are dead bleached shells, but one from Sta. 4045 exhibits the characteristic brown subsutural band. All temperatures were taken at the bottom.)

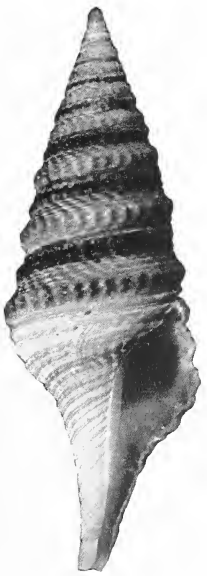

Plate 313. *Gemmula congener* new subspecies *unilineata* Powell. Holotype, B. P. Bishop Museum. 200 fms., off Waikiki, Oahu Island, Hawaii; 31.0 mm.

[These occasional blank areas occur between genera and subgenera to permit the insertion of new material and future sections in their proper systematic sequence.]

Gemmula hombroni (Hedley, 1922)

(Pl. 200, fig. 4; pl. 201, fig. 8; pl. 314)

Remarks — I add new locality records and new illustrations of unusual specimens with a double sinus on the outer lip.

Three specimens of this species taken at Batangas Bay, Philippines, and forwarded for inspection by Mr. Donald Dan of Manila, exhibit an unusual feature, in that there is a second, properly formed sinus, situated in the lower part of the outer lip. This sinus is of the same character as the anal sinus but is not quite so deep; it is, however, slightly rim-margined and is certainly not just an accidental cleft due to injury.

This extra sinus does not seem to be quite comparable with the irregular flutings often found in *Gemmula* and the related genera *Pinguigemmula* and *Ptychosyrinx*. In all such cases the flutings have a projecting rounded or spout-like termination, and in most instances they are filled with callus. The solid nature of most of these flutings negates the suggestion made by MacNeil (1960), that they may represent a response to an oxygen-poor environment into which one or more incurrent siphons are developed. Unfortunately there are no animals available from specimens with either the flutings or the extra sinus. Only an examination of these animals associated with these shell abnormalities would elucidate the problem.

New records — PHILIPPINES: Batangas Bay, Luzon Island (Donald Dan, Auck. Mus.). FIJI: dredged in 80 to 90 ft., muddy sand, Momi Bay, Viti Levu Id. (Bill Jennings, 1962, ANSP).

Plate 314. *Gemmula hombroni* Hedley, Batangas Bay, Philippines; showing a second sinus in the outer lip. 24.0 mm.

Gemmula tessellata Powell, *new species*

(Pl. 315)

Range — Known only from the Hawaiian Islands.

Remarks — This small, attractive species most closely resembles the more slender *Gemmula amabilis* (Weinkauff) from the Red Sea, from which it is distinguished by its stouter outline, tuberculate subsutural fold and its shorter, straighter anterior canal. This species belongs to *Gemmula sensu stricto*.

Description — Shell less than an inch in size, fusiform, with a tall spire which is slightly more than half the length of the entire shell. Protoconch tall, narrowly conical, of 4½ whorls, the tip smooth, the remaining whorls sculptured with closely spaced stout axials, the whole crossed by delicate spiral threads, more prominent on the axials than in the interspaces. Post-nuclear whorls 6. Spire-whorls bicarinate, sculptured with a prominent, narrowly crested and tuberculate subsutural fold, which is separated by a narrow, deep shoulder sulcus from the massive peripheral keel, composed of two almost coalescent cords and bearing prominent, vertically fused, cog-like nodes. Below the low-set peripheral keel there is a single smooth cord emergent

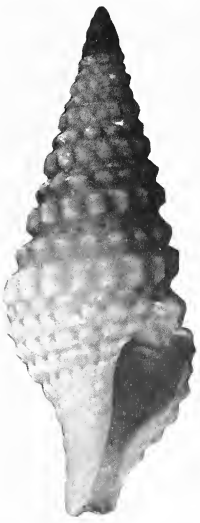

Plate 315. *Gemmula tessellata* Powell, *new species*. Holotype, Auckland Museum. 100-120 fms., off Waikiki, Oahu Island, Hawaii. 15.8 mm.

at the lower suture of the penultimate whorl, and a second one appears over the last half-whorl. Body-whorl with rather widely spaced, flat-topped cords above, four weaker cords, the upper two with intermediate threads, over the neck, and closely spaced fine threads over the anterior end. Sinus moderately deep, U-shaped, its apex occupying the whole width of the peripheral carina. Interior of outer lip strongly lirate. Colour ivory white with the protoconch tinted light reddish brown, and a regular tessellation in the same colour over the remainder of the shell. The tessellations alternate with the tubercles on the subsutural fold, and are regularly spaced on the primary spirals. Inner-lip callus and interior of the aperture white.

Measurements (mm.) –

height	width	whorls	
15.7	9.5	10.5	holotype

Types – The type locality is 100 to 120 fathoms, in mud and sand, off Waikiki, Oahu Island, Hawaii. Collected by Dr. Pat Burgess. The holotype, and only known specimen, is deposited in the Auckland Museum and Institute, New Zealand.

Gemmula microscelida (Dall, 1895)

(Pl. 316, figs. 1-3)

Range – Hawaiian Islands, deep water from 253 to 528 fathoms.

Remarks – This deep water, rather common species bears some resemblance to *graeffei* (Weinkauff) from the southwest Pacific in its form and sculpture, but the canal is much shorter and is decidedly twisted. Judging from the poor specimens selected as holotype and paratype, the full range of material listed below could not have been available to Dall when he wrote his 1895 paper. A much better specimen from Albatross station 4083 is now figured along with the type specimens.

Description – Shell about an inch in size, rather broadly fusiform, with the spire being more than half the entire length of the shell. Protoconch usually missing, but consists of about 4 narrowly-conical whorls, the last two of which are closely and axially costate. Post-nuclear whorls about 7. Sculpture of spire whorls consisting firstly of a rather prominent, rounded, smooth subsutural cord, then a rather wide, moderately concave shoulder slope, bearing 1-3 weak spiral threads, followed by the low-set prominent peripheral keel, which is composed of two linear-spaced cords, rendered cog-like by numerous vertically fused nodes. These nodes frequently extend a little beyond the keel, both above and below, where they coalesce with the axial growth lines. The nodes number between 20 and 22 per whorl. Between the periphery and the lower suture there is a single smooth spiral cord. On the body whorl, from the periphery downward, there are about 11 narrow smooth cords, extending to the bottom of the neck, after which there are weak indefinite closely-spaced threads over the anterior end. Surface smooth except for numerous, fine, crisp axial growth lines; surface covered by a pale to moderately dark olivaceous periostracum. Sinus rather broadly V-shaped at its entrance, the apex U-shaped and occupying the full width of the peripheral carina.

Measurements (mm.) –

height	width	
22.0	8.5	holotype
22.2	10.0	paratype
23.5	9.0	paratype

Types – The holotype is in USNM 127122. The type locality is 351 fathoms, sand bottom, off the Hawaiian Islands, Albatross station 3475.

Synonymy –

1895 *Pleurotoma microscelida* Dall, Proc. U. S. Nat. Mus., **17**, p. 677 (not figured).

Records – (All off the Hawaiian Islands, all dredged by the *Albatross*, and all lots in the United States National Museum. All temperatures mentioned were taken at the bottom.) Station 4041, 382-253 fms., 41.6° F., west coast of Hawaii Id.; sta. 4131, 309-257 fms., 43.7° F., off Kauai Id.; sta. 4083, 238-253 fms., off N.E. Maui Id.; sta. 3992, 528 fms., 39.6° F., off Ranai Id.; sta. 3883, 277-284 fms., 45.2° F., Pailolo Channel; sta. 3839, 259-266 fms., 46.3° F., off south Molokai Id. Also from Albatross stations 4130. 4133, 4090, 3866, 3865, 3867, and 4027.

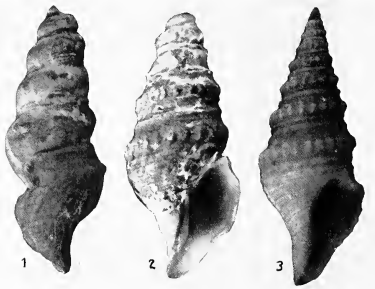

Plate 316. *Gemmula microscelida* (Dall, 1895). Fig. 1, holotype, USNM 127122, 351 fms., off the Hawaiian Islands; 22.0 mm. Fig. 2, paratype, Albatross station 3475, off Hawaiian Islands; 22.3 mm. Fig. 3, 238-253 fms., off N.E. coast of Maui Island, Albatross station 4083, USNM 173038; 23.5 mm.

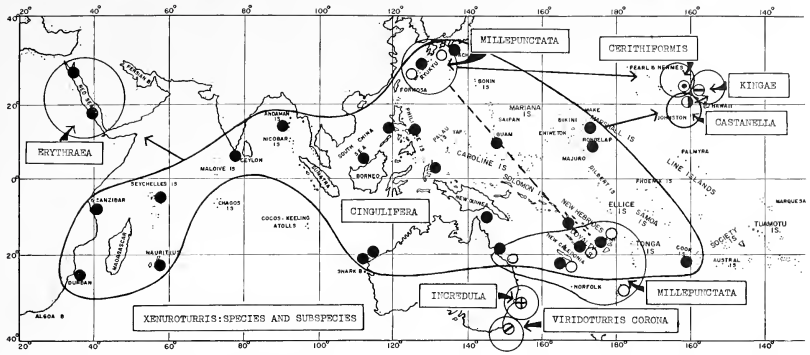

Plate 253. Geographical distribution of *Viridoturris corona* Laseron and members of the genus *Xenuroturris*.

Xenuroturris cingulifera *subspecies* erythraea (Weinkauff, 1873)

(Pl. 252, fig. 1)

Range — Red Sea.

Remarks — It is likely that the Red Sea populations may represent a good regional subspecies differing from *cingulifera* typical mainly in the much stronger and fewer spiral cords and a characteristic purple staining in adults of the anterior canal and pillar. Unfortunately, I have seen insufficient material to determine if the above mentioned characters are constant and if *cingulifera* typical is absent from the area.

Description — Adult shell 23 to 25 mm. (about 1 inch) in height. Whorls about 8, plus protoconch (missing in material examined). Spire twice the height of the aperture plus canal, angle 18° to 20°. Spire whorls with three heavy spiral keels and a fourth emergent over the latter part of the body whorl. Spiral cords on the base, 4 or 5 and strong, interspaces each with 3 or 4 crisp, spiral threads and 4 or 5 rounded cords on the fasciole. In two of the three specimens I have examined all the keels including the sinus one are narrowly arched but in the third specimen the sinus rib is composed, as in *cingulifera*, of two closely spaced cords. Colour pattern of small brown speckles on the primary cords and large regularly spaced, rectangular patches of dark-brown on the sinus rib, or paired dashes in one example. Pillar and anterior canal stained bright violet but this staining absent in the example with the bifid sinus rib.

Despite these variations, the Red Sea form would appear on the scant material available to represent a regional subspecies on the basis of stronger and fewer spirals and a tendency to violet staining of the anterior end.

Measurements (mm.) —

height	width	
25.0	9.0	Port Sudan
23.5	8.5	Type, Massaua
23.5	8.0	Port Sudan
19.0	7.5	Port Sudan

Synonymy —

1875 *Pleurotoma erythraea* Weinkauff, Conch. Cab., p. 22, pl. 4, fig. 10.

1884 *Pleurotoma erythraea* Weinkauff, Tryon, Manual of Conch. **6**, p. 166, pl. 3, fig. 24.

Records — RED SEA: Massaua and Dahlack (Weinkauff) (type locality); Port Sudan (MCZ).

Fossil Records — Somali coast (Pleistocene) (Abrard, 1942, p. 86, recorded and figured as *cingulifera*).

Xenuroturris millepunctata (Sowerby, 1908)

(Color pl. 175, figs. 13, 17, 18; pl. 252)

Range — New Caledonia, Fiji, Kermadec Islands, Ryukyu Island, Japan and Australia. ★

Description — Adult shell 25 to 50 mm. (1 to 2 inches) in height. Whorls 9 or 10, plus protoconch of 4 to 4½ axially costate whorls, as in *cingulifera*. Spire about 1¾ times the height of the aperture plus canal, angle 22° to 24°. The differentiating characters from those of *cingulifera* are the colour pattern of rather sparse brown speckles, minus maculations on the sinus area, the more prominent sinus ribs and a distinct angulation of the base.

Measurements (mm.) —

height	width	
50.0	15.0	Kii, Japan
34.7	11.0	New Caledonia
25.0	9.0	New Caledonia

Synonymy —

1908 *Pleurotoma millepunctata* Sowerby, Proc. Malac. Soc. London **8**, p. 198, text fig.
1914 *Pleurotoma cingulifera zonifera* Bouge and Dautzenberg, Journ. de Conchyl. **61**, p. 128 (not figured).

Records — JAPAN: Kii (A. W. B. Powell coll.); Ikenodan, Izu (D. Thaanum). RYUKYU ISLANDS: Gima, Kumejima Id., Okinawa (D. Thaanum). LOYALTY ISLANDS: (D. Thaanum). NEW CALEDONIA: Ile Monac (type locality); Voh, on sea-grass tidal flat, Miss V. Orr, ANSP). KERMADEC ISLANDS: Raoul Id. (W. R. B. Oliver, Australian Mus.). FIJI ISLANDS: Namotu Id., 13-15 fms. (W. Jennings). AUSTRALIA: 30 fms., off Southport, Queensland (T. Garrard, coll. 1965). ★

★ **Xenuroturris cerithiformis Powell, 1964**

(Color pl. 175, figs. 14, 15; pl. 252)

Range — Hawaiian Islands.

Remarks — This subspecies has long been known from distributed material bearing Dall's manuscript name, *cerithiformis,* which was quoted along with figures and a description by Tinker (1952).

Tinker did not intend to describe this and several other of Dall's manuscript species in his book. His action does not measure up to the requirements of ★ the International Rules and Powell, 1964, not Tinker, 1952, must be the author.

This Hawaiian species is close to *millepunctata* but differs consistently in having more rounded whorls, neither sharply angled on the base nor deeply excavated at the neck.

Description — Adult shell 33 to 53 mm. (1¼ to 2 inches) in height, whorls 10 or 11, plus a multispiral narrowly conic protoconch of 4 to 4½ whorls, brown, densely sculptured with slightly curved strong rounded axials crossed at right angles by weak spiral lirae. Spire tall, almost twice the height of the aperture plus canal, 24° to 27°, outlines lightly convex except for bulging subsutural fold and sinus rib. Sculpture of spire whorls consisting of a broadly-convex subsutural fold bearing 3 to 5 weak spiral threads, separated by a narrow deeply channeled concavity from the sinus rib, situated at about middle whorl height and composed of two moderately strong, rounded, spiral cords with a concavity between. Below the sinus area there are 2 to 4 crisp cords of varying strength. About 10 primary cords and occasional interstitial threads on the base from below the sinus area plus 4 cords on the weak fasciole. Sinus deep and narrow. Colour white, rather evenly speckled with reddish brown dots and dashes; larger maculations not present.

Measurements (mm.) —

height	width	
53.0	18.0	Pearl and Hermes Reefs, Hawaii
45.0	14.5	Kalaekiki, Hawaii
38.5	11.4	Honolulu, 6-8 fms. (type)
33.4	11.0	Honolulu, 6-8 fms.
32.0	10.2	Honolulu, 6-8 fms.

Types — I hereby select the specimen in USNM 338601 as the holotype. It is figured in our plate 175, fig. 14. The type locality, here designated, is 8-10 fms., entrance to Honolulu Harbor, Oahu Id., Hawaii.

Synonymy —

1869 *Pleurotoma lirata* Pease, Amer. Jour. Conch., Philadelphia, **5**, p. 68 (non *Pl. lirata* Reeve, 1845).
1952 *Turris cerithiformis* (Dall, ms.) Tinker, Pacific Sea Shells, Honolulu, p. 46, pl. 47, fig. (upper row).

Records — HAWAIIAN ISLANDS: entrance to Honolulu Harbour, 6-8 fms., Oahu (holotype, USNM) (D. Thaanum coll.) (ANSP); off Fort Armstrong, Honolulu, 15-20 ft. (ANSP); Ka Lae Kiki Koloa, Kauai (ANSP); Pearl and Hermes Reef, Hawaii (ANSP); off Kaanapali, West Maui, 25-75 ft.; Keaukaha Ponds, Hawaii; off Kewalo, Oahu, 20 fms. (D. Thaanum coll.).

Xenuroturris castanella Powell, 1964 ★

(Color pl. 175, figs. 21, 22; pl. 252)

Range — Hawaiian Islands.

Remarks — Again this species has long been known from distributed material bearing Dall's manuscript name. (See remarks concerning Tinker's use of Dall's manuscript names, above.)

This is a member of the *cingulifera* series but an endemic Hawaiian one sufficiently distinct in its sculpture and coloration to warrant full specific status.

Description — Adult shell, 35 to 45 mm. (1¼ to 1¾ inches) in height. Whorls about 10, plus a multispiral, narrowly conic protoconch of 4 to 4½ whorls, brown, densely sculptured with slightly curved, strong, rounded axials crossed at right angles by weak spiral lirae. Spire tall, 1½ to 1¼ times the height of the aperture plus canal, 22° to 24°, outlines lightly convex. Sculpture of spire whorls of closely spaced, rather evenly developed, moderately strong but narrow, crisp, spiral cords. Three cords on a slightly raised subsutural fold, 3 forming the sinus rib, situated above middle of whorl height and 2 primary cords with 3 threads in each inter-

Xenuroturris gemmuloides Powell, *new species*

(Pl. 317)

Range – Known only from the Hawaiian Islands from 16 to 267 fathoms.

Remarks – Although this species has the general characters of the genus *Xenuroturris*, it has the gemmate or beaded peripheral keel of a *Gemmula*. It has the high spire and sinus of a *Xenuroturris*. This species differs from *X. cerithiformis* Powell, 1964 [p. 22-964a] in having the peripheral keel minutely gemmate.

Description – Shell about 19-25 mm. (about one inch) in length, with a very tall spire and a truncated, decidedly flexed anterior canal, but with a gemmulate carina. Spire height almost twice that of the aperture plus the canal. Protoconch narrowly conical of about 3½ whorls, the first two smooth, the remainder strongly and closely axially costate. Postnuclear whorls 10. Spire-whorls sculptured, firstly with a broad but low subsutural fold, bearing three closely-spaced crisp cords, then a narrow shallow shoulder sulcus bearing two more cords, followed by a broad but rather weakly projecting sinus-keel, which is composed of two rather weak gemmate cords and an intermediate thread, the gemmules vertically fused, and closely spaced in cog-like fashion. From the peripheral carina to the lower suture there are two smooth spiral cords and several intermediate threads. From the peripheral keel to the neck there is a regular alternation of relatively strong smooth cords and weak threads; 10-12 closely-spaced smooth threads are on the anterior end. The anterior canal is strongly twisted and has an oblique shallowly-notched termination. The sinus is very deep, narrow and parallel-sided, its squarish apex occupying the full width of the peripheral keel. Colour of protoconch creamy white; remainder of shell dull-white, irregularly maculated and streaked with reddish brown. Odd squarish spots are disposed upon the subsutural fold and upon the peripheral carina, and there is a broad ill-defined zone on the base.

Measurements (mm.) –

height	width	
24.7	7.7	holotype
19.2	6.5	paratype

Types – The holotype is in the B. P. Bishop Museum, Honolulu. The type locality is 16.5 fathoms, off Waianae, Oahu Island, Hawaii. Clifton Weaver, collector.

Records – HAWAII: off Waianae, 16½ fms., Oahu (C. Weaver) (type); off Honolulu, 60 fms. ("Pele II"; Mrs. M. King); off Waikiki, 100-120 fms., mud and sand (C. M. Burgess); off N.E. coast of Maui Island, 253-267 fms., bottom temperature 46° F. (Albatross Sta. 4084; USNM 338284).

Plate 317. *Xenuroturris gemmuloides* Powell, *new species*. Holotype, B. P. Bishop Museum. 16.5 fms., off Oahu Island, Hawaii; 24.8 mm.

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THE GENUS TEREBELLUM (GASTROPODA: STROMBIDAE)

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Academy of Natural Sciences of Philadelphia

The strombid genus *Terebellum* is represented in the Recent fauna by a single species which is confined to the shallow waters of the Indo-Pacific region. Both the shell and the soft parts are highly modified. The animal is very active and is capable of darting rapidly through the water or rolling over sideways with great alacrity. It normally lives buried in coral sand in waters from low tide to a depth of 50 meters. Its egg laying and feeding habits are unknown, although from the nature of the stomach contents and the delicate radula it may be assumed that it is an herbivore like other strombids.

Its manner of travelling under the surface of the sand while still maintaining contact with the watery world above has been described by D. P. Abbott (1962):

"As each animal ploughed down into the sand, one of its eyestalks was extended upward and back over the shell. As this raised eyestalk was contacted by the sand which came to cover the anterior dorsal region of the shell, the organ was moved in such a way that the terminal blue eyeball was placed just above the sand surface. The animals continued to move forward and down, burying themselves, but each one 'left behind itself' one eye protruding above the surface. Since the exposed eye remained stationary relative to the sand around it, the eyestalk hidden below the sand was clearly elongating at a rate which matched the forward movement of the animal. When the shell was largely buried and its anterior end was judged to be approximately one inch ahead of the exposed eye, the siphon was extended upward through the sand at this point, the siphonal folds closely appressed to form a closed cone. Once at the surface, the siphonal folds flared open terminally, and a swift current of water was drawn down into the mantle cavity. Following this inhalation, the second eye, thus far concealed below the surface of the sand with the rest of the animal, passed upward through the lumen of the siphon. With the second eye now exposed, the siphon folds unrolled and the siphon was pulled down out of sight, leaving the blue eyeball just at the surface of the sand. Simultaneously, the first eye, an inch to the rear, was withdrawn below the surface and disappeared. These actions were observed to be repeated with only minor variations as the animals burrowed along, their shells covered by a layer of sand perhaps a centimeter in depth. Forward progression below the sand was nearly continuous, but the eyes were 'walked' forward, with one of them always stationary and exposed at the surface like a periscope during the burrowing."

The gross anatomy of *Terebellum* is very unusual in several respects. The foot is extremely compressed laterally and only the small anterior portion has a flat sole. The four-toothed operculum is almost entirely encased in a cape-like operculigerous lobe. The ommatophores are very long, and the tentacles (not previously noticed by other workers) are extremely small and located just behind the distally-located eyeball. In *Strombus*, which rarely burrows, the tentacles are much larger and face downwards to prevent the ommatophore from bumping against the bottom. This function would not be required in the sand-burrowing *Terebellum*.

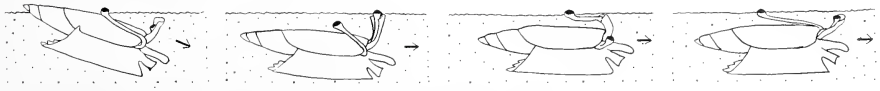

Plate 318. *Terebellum* digs into the sand and travels forward, keeping one or the other of its eyeballs at the surface at all times. (Hypothetical drawing based upon an account by D. P. Abbott, 1962, and upon our anatomical studies.)

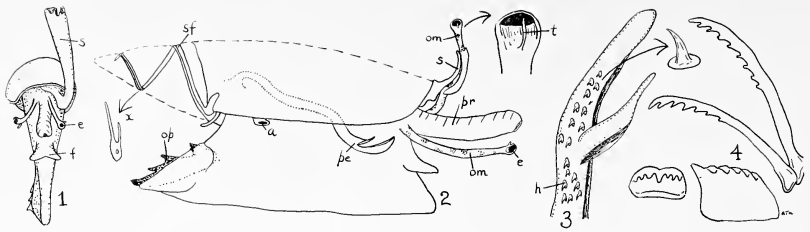

Plate 319. Gross anatomy of *Terebellum terebellum* Linné. Fig. 1, front view showing upheld siphonal appendage (s), eye (e) and foot (f). Fig. 2, right side of animal with shell removed, showing anus (a), eye (e), ommatophores (om), operculum (op), penis (pe), proboscis (pr), siphonal appendage (s), sutural filament (sf), and its cross-section (x), and the minute tentacle (t). Fig. 3, distal end of penis showing chitinous hooks (h). Fig. 4, radula teeth (greatly enlarged).

The posterior end of the mantle edge is modified into three appendages, two of them being short filaments. The third is extremely long and forms the deep sutural gutter almost all the way to the apex of the shell. We presume that this exposed filament is tactile in function and serves to inform the animal whether the shell is fully buried or not. A similar gutter is present in the suture of the shell of the sand-burrowing Olividae.

The sexes are separate. The female has a thin-walled flap bordering the egg channel which runs anteriorly from the oviduct to the right anterior side of the foot. It is similar to that in female *Strombus,* and it is likely that the egg strands of *Terebellum* are long, thin, coiling and sand-encrusted like those of *Strombus.* The penis is half the length of the entire animal. It has a narrow, open gutter for the passage of sperm running up to the two-lobed distal end. The sides of the distal end of the penis are studded with about 20 to 30 proportionately large, chitinous hooks which are turned backwards. Presumably, these barbs prevent the active female from escaping during copulation. A somewhat comparable penial armament is found in the pyramidellid snail, *Eulimella laevis* (Brown) of northwestern Europe (D. Maas, 1964, Zool. Anzeiger, **173,** pt. 2, p. 143). The only other prosobranch genus bearing a chitinous, hooked armament is *Stenothyra,* a fresh-water hydrobiid (R. T. Abbott, 1951, Jour. Wash. Acad. Sci., **41,** p. 14).

The radula is small, delicate, and located at the anterior end of the pharynx. It is very similar to that of some *Strombus* and *Lambis,* and has 35 rows of teeth. Both the inner and the outer marginal teeth are long and narrow. The stomach and intestine contain detritus, coral sand, foraminifera and microscopic bits of shell.

The shell of *Terebellum* is elongate and smooth, features which would permit rapid darting through the water. There is no stromboid notch in the edge of the shell for the protuberance of the right eyestalk. Evidently, the eyestalks are protruded up through the lumen of a very specialized siphonal extension of the anterior portion of the mantle edge. This "eyestalk sheath" is a separate organ, much like the siphonal flaps developed in the mantle of the Volutidae.

Plate 320. Operculum of *T. terebellum* from New Caledonia. Dautzenberg collection, Institut Royal des Sciences Naturelles de Belgique, Brussels. 4 ×.

Plate 321 (color plate on opposite page). *Terebellum terebellum* (Linné) showing the variability in color patterns in one species. Figs. 1-6, 13 and 15 from near Noumea, New Caledonia. Figs. 1, 2 and 14 are forma *lineatum* Röding. Figs. 3, 5 and 6 are forma *punctulorum* Röding. Figs. 9, 10 are forma *delicatum* Kuroda and Kawamoto from Honshu Id., Japan. Fig. 11 is forma *nebulosum* Röding from Oman, S. E. Arabia. Fig. 14, Upolu Id., Samoa. All natural size.

Lower figure is a living *Terebellum terebellum* (Linné) from the Palau Islands attempting to dig into the sand. (× 3.)

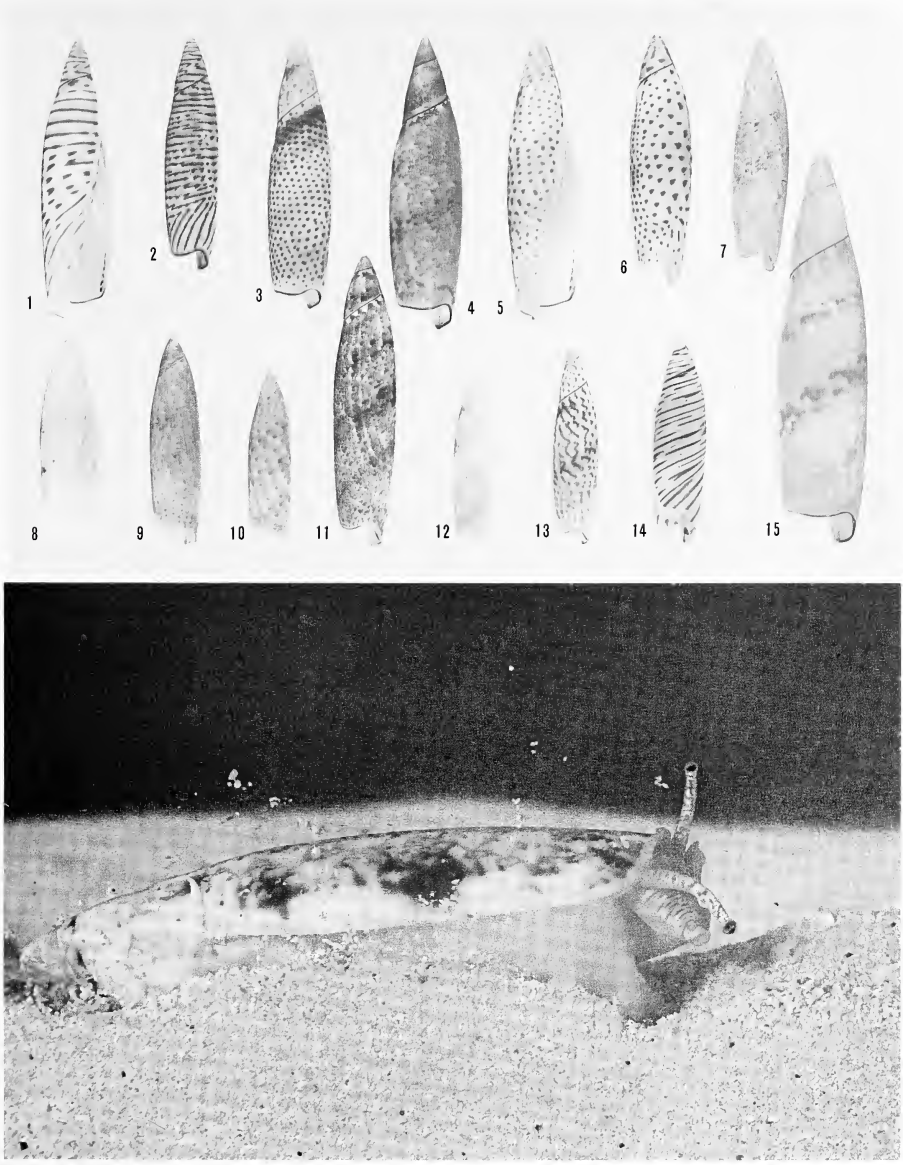

Plate 321. *Terebellum* (see opposite page for explanation).

Geological History

The genus *Terebellum* came into existence during the early Tertiary. It represents a predominantly Tethyan group with the center of its evolution lying in the Indo-European region. The earliest records date back to the Palcocene. The interval from the Paleocene to the middle Eocene was characterized by a rapid morphological development and a geographic expansion which was mainly directed toward the west.

During that period the genus split into what we recognize today as three subgenera: *Terebellum s.str.*, *Seraphs* Montfort (type species: *Bulla sopita* Solander), and *Mauryna* de Gregorio (type species: *Terebellum (Mauryna) plicatum* d'Archiac and Haime). *Seraphs*, which is mainly characterized by its involute shell, is known from the Paleocene, but *Mauryna*, which carries more or less accentuated axial plicae appeared in the Eocene only. *Seraphs* was apparently more successful than *Mauryna*, as it is known from many species distributed almost all over the tropical zones of the world, whereas *Mauryna*, which did not reach the New World, is represented by a few species restricted to Europe, India and Java.

In the middle Eocene the genus reached the Caribbean (Jamaica) and Central America (Panama), and during the late Eocene times it spread over the entire Caribbean, Florida, and as far as California. Towards the east the genus did not get farther than Java during the late Eocene.

Mauryna became extinct before the Oligocene, whereas *Seraphs* is known from a few early Oligocene localities, but did not survive the Oligocene.

The transition from the Palcogene to the Neogene was not only marked by a rapid decline in morphological variety and number of species, but also by a considerable restriction of the geographical range of *Terebellum s.str.*, the only surviving subgenus. In the Western Hemisphere, *Terebellum* is absent in post-oligocene deposits with the exception of an unconfirmed record from the early Miocene of Florida. In Europe there are no Miocene records at all.

In late Miocene to Pliocene times the Recent species came into existence. Although fossil records of *T. terebellum* are rare, it seems that its distribution was about the same as that of today.

From these facts it appears that the Recent *Terebellum* represents a highly specialized, dwindling group compared with the morphologically rich and widely distributed fossil group of over 50 described taxa.

Acknowledgments

We are indebted to the following persons for the loan of or information on material: W. Adam, Institut Royal des Sciences Naturelles, Brussels, Belgium; C. O. van Regteren Altena, Leiden, Netherlands; W. J. Clench, Museum of Comparative Zoölogy, Cambridge, Mass.; B. R. Wilson, Western Australian Museum, Perth. The drawings of the opercula and shells were made by O. Garraux, Basel, Switzerland.

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Genus Terebellum Röding, 1798

Type: *Terebellum terebellum* Linné, 1758

Subgenus Terebellum Röding, 1798

Although several Recent species have been described, it is our opinion that there is only one living species, namely *terebellum* Linné, 1758. The subgenus *Terebellum sensu stricto* is characterized by its elongate, narrow, strong shell, lacking a stromboid notch, and having no axial sculpture. The type by indirect tautonomy is based on both *Terebellum nebulosum* Röding, 1798, and *lineatum* Röding, 1798, both of which are color forms of *Bulla terebellum* Linné, 1758. If legalistic doubt exists, we hereby designate *T. nebulosum* Röding, 1798, as the type of the genus.

Synonymy —

1798 *Terebellum* Röding, Museum Boltenianum, Hamburg, pt. **2**, p. 135.

1799 *Terebellum* Lamarck, Memoires Soc. d'Hist. Naturelle de Paris, **1**, p. 69, no. 4 (type by tautonomy: *Bulla terebellum* Linné, 1758).

1810 *Terebellum* Montfort, Conchyliologie Systématique, **2**, p. 379 (type: *subulatum* Lamarck).

1815 *Terebrina* Rafinesque, Analyse de la Nature, Palermo, p. 145 (emendation for *Terebellum* Lam.).

1848 *Lucis* Gistel, Naturgeschichte des Thierreichs für höhere Schulen bearbeitet, Stuttgart, p. 170 (type by monotypy: *L. subulatus*).

1848 *Artopoia* Gistel, *ibidem*, explanation to pl. 7, fig. 8 (type by monotypy: *A. subulata*).

1887 *Artopoja* Gistel, Paetel, Catalog der Conchyl.-Samml., Berlin, **1**, p. 315.

Plate 322. The original specimen of "*Terebellum punctatum* Chemnitz" illustrated by Chemnitz in Neues Systematisches Conchylien-Cabinet, vol. 10, pl. 146, figs. 1362, 1363. 43.1 mm. in length. Zool. Mus. Copenhagen.

Terebellum terebellum (Linné, 1758)

(Pls. 318-327)

Range — East Africa to Samoa; Japan to Australia.

Remarks — This is a colorful, moderately common species found in shallow water throughout most of the tropical Indo-Pacific. The color patterns are very variable, even on the same specimen. This has led to a large number of synonyms, some of which we list below as mere color forms:

typical form (Linnaeus' type): (pl. 323). Unfortunately the type specimen is an old beach-worn and almost colorless specimen. Linnaeus described it as "white." The name *album* Link, 1807, is based on a similar form. Lamarck's *subulatum* is merely a substitute name for this form.

forma nebulosum Röding, 1798: (pl. 321, fig. 11). Refers to Conchyl. Cab., vol. 2, figs. 568, 569, the "banded borer." Characterized by three spiral, brown bands of color.

forma lineatum Röding, 1798: (pl. 321, figs. 1, 14). Refers to Lister, pl. 736, fig. 31, which is characterized by strong, numerous, narrow, zigzag brownish lines.

forma punctulorum Röding, 1798: (pl. 321, fig. 6). Refers to Lister, pl. 737, fig. 32. Characterized by numerous, small, red-brown dots over the entire surface. This is the same as the shell illustrated in Martini and Chemnitz, vol. 10, figs. 1362, 1363, later referred to as "*punctatum*" Chemnitz by Reeve, K. Martin, Lamarck, and others.

forma delicatum Kuroda and Kawamoto, 1961, in Habe: (pl. 321, figs. 9, 10). Characterized by its soft-brown background which is covered with brown dots which have a white half-moon surrounding the anterior side of each dot. Most common in Japan and Madagascar.

Other forms, including the large, New Caledonian and Arabian shells, with a brown line on the suture and on the anterior edge of the body whorl, have not had names applied to them. In our opinion, they are not valid subspecies.

Dodge (1955, pp. 41-45) has given a very lengthy account of the history of the nomenclature of *Terebellum terebellum* Linné, with which we agree in the details he sets forth. There is little worth repeating, except perhaps to say that Linnaeus' 1764 re-description is an accidental mixture of *terebellum* and a species of *Conus*.

Plate 323. *Bulla terebellum* (Linné). Specimen from Linnaean collection. Lectotype. Length 37.5 mm., maximum diameter 10.6 mm. Courtesy of the British Museum (Natural History).

The general shape of the shell is also variable to some degree. Usually the spire is flat-sided and the body whorl but little convex. Somewhat stouter shells with slightly convex spire whorls occur mainly in the areas of New Guinea and the Samoan Islands. The height of the spire is about one third, and the maximum width about one fourth of the total height. These proportions are disturbed in stouter forms.

Immature specimens have different proportions. The height of the spire is much smaller compared to the total height. In addition, they have a number of incised, spiral lines near the base which are lacking in full-grown shells (see under ontogeny).

It must be remembered that adult *T. terebellum* is much more resistant mechanically which means that immature shells are not likely to be preserved on the shore, i.e., in the zone of heavy wave action or other mechanical influences. Thus it is not astonishing to find lots consisting only of adult shells in the collections. A glimpse at the depth data shows that the majority of immature specimens has been dredged at depths greater than 15 meters.

Habitat – *T. terebellum* seems to prefer a bottom of silt, sand or sandy mud between some coral, rock, and patches of algae. It has been collected dead from a few feet down to 50 fathoms, and live specimens have been recovered from a water depth of a few inches to 18 fathoms.

Ontogeny – The ontogenetic development of *T. terebellum* can be subdivided into 4 stages, namely a protoconch stage, a first terebelloid stage, seraphoid stage, and a second terebelloid stage. The limits betwen these stages are not sharp, of course, but transitional.

The protoconch (see pl. 326, figs. 1, 2; pl. 325, fig. 2) consists of about one volution of glassy shell material. The two characteristic features are its almost planispiral coiling, and its subcircular cross section. The inner walls of the protoconch touch to form a "protoconchal columella."

The beginning of the first terebelloid stage (see pl. 326, figs. 1, 2; pl. 325, fig. 2) is marked by an accelerated growth in height, i.e., the tube gradually becomes more than twice as high as wide. This stage is evolute with the suture descending at a low angle. The shell material is still entirely glassy and translucent, but two structural elements appear: faint growth lines, and a thin callus on the inner lip. This stage comprises almost two volutions.

The seraphoid stage (see pl. 326, figs. 3, 4; pl. 325, fig. 2) is produced by the appearance of a spiral band of callus just above the suture which soon ascends spirally toward the apex. The suture of the first terebelloid stage then is covered, and the shell becomes entirely involute. The seraphoid stage consists of 1 to 1½ volutions, and is further characterized by the appearance of the first color patterns which are more or less pronounced, however. In

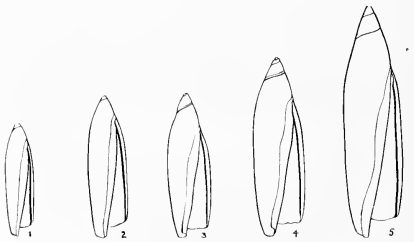

Plate 324. Variability of general outline. Fig. 1. Immature. Bawi Id., W. Zanzibar. ANSP 213721. Fig. 2. Immature. Honshu Id., Japan. ANSP 234910. Fig. 3. Almost adult. Tutuila Id., Samoa Ids. ANSP 209255. Fig. 4. Adult. Semporna, North Borneo. ANSP 295409. Fig. 5. Adult. Noumea, New Caledonia. ANSP 237367. Slightly enlarged.

Plate 325. Fig. 1. Cross section through shell at suture showing prismatic and nacreous layer, sutural callus and organic matter (black). 50×. Fig. 2. Cross section through early ontogenetic stages showing protoconch, the first terebelloid stage, and the involute coiling of the seraphoid stage. The cross section of the tube changes with growth. 50×.

addition, two sculptural elements are introduced: faint, somewhat irregular, axial lines on the spire, and fine incised, spiral lines near the base. The interspaces between these lines may be regular or irregular in width. Some of the upper lines may be crossed by growth lines to form small rhombs. Specimens from the seraphoid stage look like minute members of the Paleocene to Oligocene subgenus *Seraphs*.

The second terebelloid stage (see pl. 326, figs. 5, 6; pl. 325, fig. 2) starts when the shell becomes evolute again. The angle between the axis and the suture is smaller than in the first terebelloid stage, i.e., the suture now descends more rapidly. The spiral band of callus above the suture is conspicuous. The incised lines near the base, which appear in the seraphoid stage, continue into this stage, but they gradually disappear as the shell grows larger. In full-grown specimens this stage consists of about 2½ volutions.

The above remarks on the ontogeny are based on a rich sample from near Nossi Bé, N.W. Madagascar (ANSP 261971), containing about 70 specimens representing all growth stages.

Description — Shell usually between 40 and 50 mm. in length (about 1.5 to 2 inches), slender, cylindrical, moderately heavy, and without a stromboid notch. Immature shells delicate. Aperture narrow, pointed above, regularly widening toward the base. Spire usually almost flat-sided, pointed, about half as high as the rest of the shell. Base of body whorl higher than base of columella. Outer lip slightly thickened. Inner lip with a callus which continues as a spiral band above the suture. Suture with a very deep, narrow channel running from the apex to the outer lip. Surface of adult shell smooth with the exception of faint growth lines. Adults with about 7 whorls (see under ontogeny). The predominant color is brown to yellowish brown. The variation of the intensity of the color and the color patterns is considerable (see under remarks).

Measurements (mm.) –

length	width	spire height	
57.6	14.2	19.0	Oman, S.E. Arabia
49.1	12.5	16.6	Mindanao Id., Philippines
44.0	11.0	14.3	Sanga Sanga Id., Sulu Archipelago
41.7	12.7	11.6	Schouten Ids., New Guinea

The largest specimen seen has a length of 77.1 mm. (New Caledonia: ANSP 30215).

Synonymy –

1758 *Conus terebellum* Linné, Systema Naturae, ed. 10, p. 718, no. 284 (in Asia); 1764, Museum Ludovicae Ulricae, p. 564, no. 178.

1767 *Bulla terebellum* Linné, Systema Naturae, ed. 12, p. 1185.

[1788 *Terebellum punctatum* Chemnitz, Neues systematisches Conchylien-Cabinet, **10,** p. 124, pl. 146, figs. 1362, 1363. [Non-binomial.]

1791 *Conus terebellum* Gmelin, Systema Naturae, ed. 13, **1,** pt. 6, p. 3390.

1798 *Terebellum nebulosum* Röding, Museum Boltenianum, pt. 2, p. 135 (refers to *Bulla terebellum* and to Lister, pl. 736, fig. 30).

1798 *Terebellum lineatum* Röding, Museum Boltenianum, pt. 2, p. 135 (refers to *Bulla terebellum* and to Lister, pl. 736, fig. 31).

1798 *Terebellum punctulorum* Röding, Museum Boltenianum, pt. 2, p. 135 (refers to Lister, pl. 737, fig. 32).

1799 *Terebellum terebellum* Linné, Lamarck, Mém. Soc. Hist. Nat. Paris, **1,** p. 69.

1801 *Terebellum terebra* Bosc. Histoire naturelle des coquilles, tome 5, p. 72, pl. 38, fig. 7 (refers to *Bulla terebellum* Linné and to Lister, pl. 736, figs. 30, 31).

1807 *Terebellum variegatum* Link, Beschreibung der Naturalien-Sammlung der Universität zu Rostock, p. 99 (refers to *Conus terebellum* Linné).

1807 *Terebellum album* Link, *ibidem*, p. 99.

1810 *Terebellum sabulatum* (sic) Lamarck, Montfort, Conchyl. Syst., **2,** p. 379, in text.

1811 *Terebellum subulatum* Lamarck, Ann. Mus. Hist. Nat. Paris, **16,** p. 301 (refers to Lister, pl. 736, figs. 30, 31; pl. 737, fig. 32, and to others); 1822, Lamarck, Histoire naturelle des animaux sans vertèbres, **7,** p. 410.

1811 *Terebellum lineatum* Perry, Conchology, London, pl. 37, fig. 1 (no locality).

1811 *Terebellum spirale* Perry, *ibidem*, pl. 37, fig. 2 (Eastern Ocean).

1848 *Terebellum subulatum* Lamarck, Adams and Reeve, Mollusca. In: Adams, A.: The zoology of the voyage of H.M.S. Samarang, p. 36, pl. 9, fig. 6; 1859, Sowerby, Thesaurus Conchyliorum. *Terebellum*, pl. 218, figs. 1-5; 1874, Lischke, Japanische Meeres-Conchylien, 3. Theil, p. 21; 1880, K. Martin, Notes from the Leyden Museum, **3,** Note 7, p. 19.

1863 *Terebellum punctatum* Reeve, Conch. Icon., **14,** *Terebellum*, pl. 1, figs. 1a-g.

1886 *Terebellum punctatum* Chemnitz, Watson, Report . . . Challenger, **15,** p. 421; 1899, K. Martin, Samml. geol. Reichsmus. Leiden, N.F., Bd. 1, p. 195, pl. 31, figs. 452, 452a; 1908, Boettger, in:

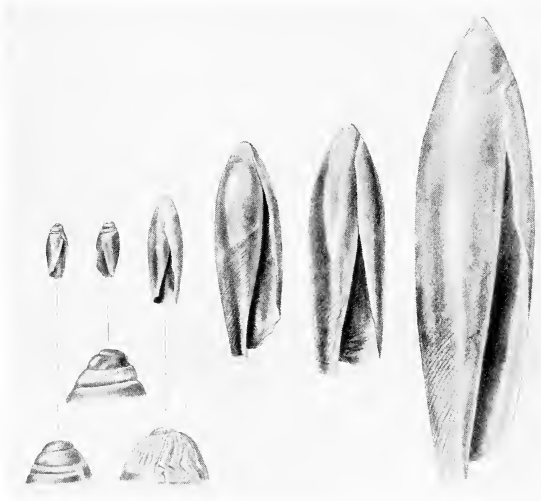

Plate 326. Ontogenetic development of shell. Two left figs. Protoconch and first terebelloid stage. Middle two figs. Beginning of seraphoid stage and full seraphoid stage. Two right figs. Beginning of second terebelloid stage and final terebelloid stage. All specimens from near Nossi Bé, N.W. Madagascar (ANSP 261971). 4×.

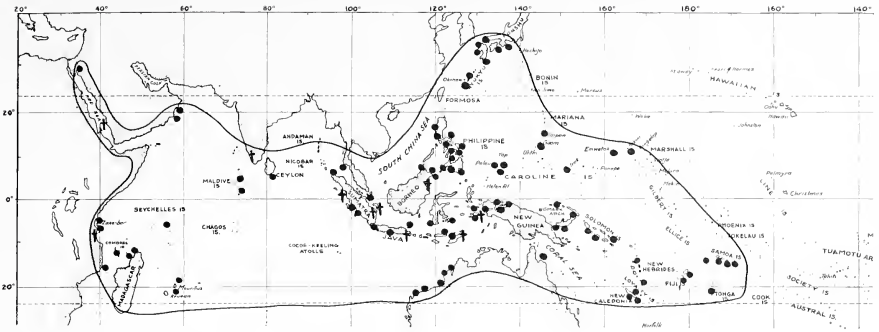

Plate 327. Geographical distribution of *T. terebellum*. Solid circles: Recent occurrences. Crosses: fossil occurrences (partly according to literature).

Verbeek: Molukkenverslag. Jaarb. Mijnwezen Nederl. O.-Indie, Jg. 37, p. 674.

1910 *Terebellum subulatum* Lamarck, Koert and Tornau, Abh. K. Preuss. Geol. Landes-anstalt, N.F., Heft 63, p. 10.

1911 *Terebellum punctatum* Chemnitz, Martin-Icke, in: Salenka and Blanckenhorn: Die Pithecanthropus-Schichten auf Java, pp. 47, 49; 1919, K. Martin, Unsere palaezoologische Kenntnis von Java, pp. 92, 133, 141; 1928, K. Martin, Wet. Meded. Dienst Mijnbouw, No. 10, pp. 8, 25.

1931 *Terebellum terebellum* (Linné) (*subulatum* Lamarck), Cox, Geol. Mag., **68**, p. 7.

1931 *Terebellum punctatum* Chemnitz, Van der Vlerk, Leidsche Geol. Meded., deel 5, p. 248.

1931 *Terebellum subulatum* Lamarck, Van der Vlerk, *ibidem*, p. 248.

1931 *Terebellum punctatum* Chemnitz, van Es, The age of Pithecanthropus. Thesis, Delft, p. 51.

1935 *Terebellum terebellum* (Linné), Oostingh, Wet. Meded. Dienst Mijnbouw Nederl. Indie, No. 26, p. 58; 1947, Wissema, Young Tertiary and Quaternary Gastropoda from the Island of Nias (Malay Archipelago). Thesis, Leiden, p. 92; 1948, Cox, Schweiz. Pal. Abh. **66**, p. 31, pl. 1, figs. 6a, b; 1950, Beets, Leidse, Geol. Meded., deel 15, p. 244; 1959, Kira, Coloured illustrations of the shells of Japan, p. 34, pl. 15, fig. 1; 1961, Nuttall, Brit. Borneo Geol. Survey, Ann. Rep. 1960, p. 92; 1962, D. P. Abbott, Veliger, **5**, No. 1, pp. 1-3; 1962, Dey, Palaeont. Indica, N.S., **36**, p. 67; 1962, Kira, Shells of the Western Pacific in color, p. 34, pl. 16, fig. 1; 1965, Nuttall, Geol. Survey, Borneo Region, Malaysia, Memoir 16, p. 170.

1961 *Terebellum terebellum delicatum* Kuroda and Kawamoto, Habe, Coloured illustrations of the shells of Japan, **2**, p. 38, pl. 17, fig. 1 (manuscript name?); 1964, Habe, Shells of the Western Pacific in color, **2**, p. 58, pl. 17, fig. 1.

Lectotype selection – The specimen from the Linnaean collection at present at the British Museum (Natural History), marked with the remnants of the number '388,' is here selected as lectotype. The number '388' corresponds to that with the species name in the 12th edition of the Systema Naturae according to written communication from S. P. Dance. The lectotype measures 37.5 mm. in length, and has a maximum diameter of 10.6 mm. There is no locality information.

Selected records (see map) – RED SEA: Eilet, Gulf of Aqaba, Israel (USNM). MOZAMBIQUE: off dock, Nacala (Franz Steiner, ANSP). ZANZIBAR: 1 mi. N. of Bawi Id.; 1½ mi. W.S.W. Ras Mungwe; between Mwamba Ukombi and Chumbe Ids. (all ANSP). COMORE IDS.: Lagon de Mayotte (ANSP). MADAGASCAR: 2-3 mi. S. of Nosy Iranja, 32 mi. S.W. of Nossi Bé (ANSP). MAURITIUS: (MCZ, USNM). SEYCHELLES: 15-40 ft., sand and algae, Baie Ternay, West Mahé Id., Feb. 9, 1966, R. E. Ostheimer and Minerva Buerk (ANSP). ARABIA: Oman (ANSP, USNM). MALDIVE IDS.: Fadiffolu Atoll; Addu Atoll (both ANSP). THAILAND: 25 mi. N.N.W. of Phuket Id., Andaman Sea (*Anton Bruun* Cruise 1, ANSP). BORNEO: Kudat Bay, North Borneo; Semporna, North Borneo (both Mary Saul, ANSP, USNM). PHILIPPINES: frequent throughout the archipelago on Luzon, Cebu, Leyte, Mindanao, etc. (ANSP, USNM). JAPAN: Baso Peninsula, Chiba Pref., Honshu (ANSP); Tatsugahama, Wakayama Pref., Honshu (ANSP); Southern Kyushu (ANSP). RYUKYU IDS.: Okinawa Id. (ANSP, MCZ, USNM). MARIANAS: N. side of Apra Harbor, Guam Id. (ANSP, USNM). ENIWETOK ATOLL: (USNM). CAROLINE IDS.: frequent throughout the archipelago. MARSHALL IDS.: Bikini Atoll (USNM); Kwajalein Atoll (USNM). INDONESIA: Ambon (Amboina) Id. (MCZ); 35 meters, Sunda Straits (Copenhagen Mus.). NEW GUINEA: Aoeri Ids., Geelvink Bay (ANSP, MCZ); Japen Id. (ANSP); Schouten Id. (ANSP, MCZ); Finschhafen Bay (MCZ). NEW BRITAIN: Matapi Id., 5 mi. from Rabaul (ANSP); Rabaul Harbor (ANSP); Kumbun, near Kandrian (ANSP). SOLOMON IDS.: Atao District, Malaita Id. (Rev. J. van der Riet, ANSP); Roviana Lagoon, New Georgia (MCZ). AUSTRALIA: Broome, Western Australia (MCZ); Cape Leveque, Western Australia (USNM); Lizard Id., 80 mi. N.E. of Cooktown, Queensland (ANSP). NEW CALEDONIA: Noumea (ANSP, MCZ, USNM); Ile des Pins (MCZ). LOYALTY IDS.: Ouvea Id., D. Getz, 1949 (BPBM). NEW HEBRIDES: Aore Id. (MCZ). FIJI IDS.: (ANSP, MCZ). SAMOA IDS.: Tutuila Id. (ANSP, MCZ, USNM). TONGA IDS.: Tongatapu Id. (USNM). [A record of "Marquesas Islands" in the Dautzenberg collection in Brussels is open to question.]

Fossil records – MIOCENE: Java (Martin, 1928, p. 25); Quilon, Kerala, India (Dey, 1962, p. 67). NEOGENE: Java (Oostingh, 1935, p. 59); Saonek besar near New Guinea (Boettger, 1908, p. 674; Oostingh, 1935, p. 59). PLIOCENE: Java (Oostingh, 1935, p. 59, and others); Sumatra (Martin, 1928, p. 8); North Borneo, Dent Peninsula (Cox, 1948, p. 31; Nuttall, 1965, p. 170); Borneo, North Kutei (collections of the Natural History Museum Basel); Timor (Cox, 1948, p. 31); East Ceram (collections of the Natural History Museum Basel). PLIO-PLEISTOCENE: Nias (Wissema, 1947, p. 93). QUATERNARY: Farsan Kebir, Red Sea (Cox, 1931, p. 7); Dar es Salaam, Tanganyika (Koert and Tornau, 1910, p. 10); Belitung Id. (Billiton Id.) (Martin, 1880, p. 19); Bunju Id., East Borneo (Beets, 1950, p. 244).

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STROMBUS (CANARIUM) WILSONI *NEW SPECIES* FROM THE INDO-PACIFIC

by R. Tucker Abbott

Pilsbry Chair of Malacology
Academy of Natural Sciences of Philadelphia

Strombus wilsoni Abbott, *new species*

(Pl. 328, figs. 1-3)

Range — East Africa and Australia to Fiji.

Remarks — A small, inch-long *Strombus* has been recently collected in several widely scattered parts of the Indo-Pacific, which appears to be a new sympatric relative of the well-known *S. mutabilis* Swainson [p. 09-900] and *S. microurceus* (Kira, 1959) [p. 09-899]. This species is rare in Zanzibar and Fiji, but is moderately common off the coast of Western Australia in water from 1 to 23 fathoms in depth.

Strombus wilsoni is characterized by 5 to 7 equal-sized, elongate, short, rounded nodules on the shoulder of the last half of the body-whorl, by the squarish penultimate whorl which bears about 20 neat, elongate, smooth riblets, and by a columella which is smooth and whitish at the center. The base of the columella bears 7 to 10 minute brownish to purple-brown teeth. *S. microurceus* differs in having the interior half of the columella colored purple-brown, and in having a blue-green splotch on the shoulder of the last whorl just below the suture and just behind the apertural varix. *S. mutabilis* differs in having no nodules immediately behind the upper part of the apertural varix, and in having a white-striped columella.

This species is named after the Australian malacologist, Dr. Barry Wilson, and also after Mr. Wilson Darwin of Philadelphia.

Description — Adult shell 18 to 28 mm. (about an inch) in length, solid, elongate-quadrate, nodulated and mottled with light yellow-brown. Whorls 8 or 9. Nuclear whorls 3, glassy, smooth, translucent lavender or whitish and bulimoid in shape. Postnuclear whorls glossy, minutely mallcated and with a small but distinct subsutural cord. The spire has about 9 to 11 tan, former varices. Penultimate whorl square-shouldered, with about 15 to 22 minute, elongate, axial riblets. Body-whorl rounded and smooth on the parietal side, but bears 5 to 7

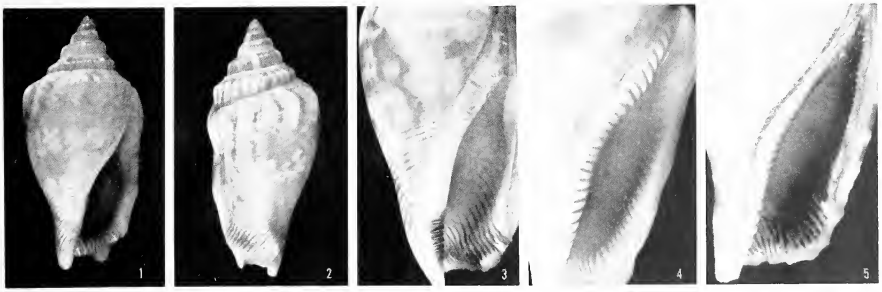

Plate 328. *Strombus wilsoni* Abbott, *new species*, Figs. 1, 2, paratype, 23 fathoms, off Legendre Island, Dampier Archipelago, Western Australia, 1960. W.A. Museum no. 847-66, 22.1 mm. Fig. 3, apertural view of holotype from Zanzibar. ANSP no. 253088. Total length: 22.2 mm. Fig. 4, *Strombus mutabilis* Swainson, showing columellar sculpturing. Fig. 5, *Strombus microurceus* (Kira), showing columellar sculpturing.

equal-sized, short, rounded, elongate nodules at the shoulder on the last half of the whorl. Varix behind the outer lip is swollen and spirally threaded. Columella whitish to tan, smooth at the center and bounded above and below by minute tan to purplish teeth. Interior of aperture with numerous, raised, wavy, brown to purple lirae or threads. The aperture is narrowly constricted at its posterior end. Stromboid notch rather shallow and near the base of the outer lip. Color of shell whitish to cream, with red-brown to tan maculations and spiral rows of small, sparse, brown or white dots. Periostracum very thin and translucent. Operculum stromboid, barely arching, light-brown, and with 10 to 12 small, sharp serrations.

Measurements (mm.) —

length	width	no. whorls	
22.3	10.1	8	holotype; Zanzibar
28.4	13.5	9	paratype; Zanzibar
23.7	11.5	8	paratype; Legendre Id.
22.2	10.5	8	paratype; Legendre Id.
19.5	9.0	7	paratype; Legendre Id.
18.4	9.5	7	paratype; Nandi Bay, Fiji

Types and Records — The type locality is Zanzibar. The holotype is in ANSP no. 253088. Paratypes come from: ZANZIBAR: 8 fms., fine grass and shell bottom, 1.5 miles W.S.W. of Ras Mungwe, Feb. 20, 1960; A. J. Ostheimer, 3rd, V. Orr (Maes) and Richard Thorington, coll. (ANSP 212695). WESTERN AUSTRALIA: 23 fms., off Legendre Island, Dampier Archipelago (Western Australian Mus. 847-66); low tide, Eaglehawk Island (W.A. Mus. 840-66); 14 fms., 14 miles west of Eaglehawk Island (W.A. Mus. 838-66); 6-10 fms., west of Flat Island, near Onslow (W.A. Mus. 851-66; ANSP). Paratypes also in B. P. Bishop Mus.

Strombus rugosus Sowerby, 1825

(Pl. 20, figs. 11, 12; p. 09-840)

Range — Fiji, the Ellice, Samoan and Tonga Islands.

Remarks — I concur with Cernohorsky (1965, p. 5) that this taxon should be considered as a species, rather than as a subspecies of *erythrinus* Dillwyn, 1817 (see p. 09-909), since it has now been shown that the two forms co-exist without seeming hybridization. New Fijian records of *rugosus* are added below.

I do not think it wise to consider the New Caledonian populations of *erythrinus* as subspecifically different from those of Fiji or other neighboring islands, since many New Caledonian species possess darker colors, stronger sculptural features, and greater average sizes, probably due to environmental conditions.

Since the appearance of my 1962 monograph on *Strombus* (Indo-Pacific Mollusca, vol. 1, no. 2), three other species have been recorded from Fiji by Cernohorsky (1965): *S. labiosus* Wood, 1828, *S. thersites* Swainson, 1823, and *S. haemastoma* Sowerby, 1842.

Synonymy —

1962 *Strombus erythrinus* subsp. *rugosus* Sowerby, Abbott, Indo-Pacific Mollusca, 1, no. 2, p. 81 [09-909].
1965 *Strombus rugosus* Sowerby, Cernohorsky, Records of the Fiji Museum, 1, no. 1, p. 5 (type locality designated: Viti Levu, Fiji).

Records — FIJI: 20-30 ft. Namotu Id., Vanua Levu Id. (A. Jennings, 1962), Wading Id., Viti Levu Id. (A. Jennings, 1962); beach, Tivoa Id., N.W. of Viti Levu Id. (A. Jennings, 1961). All ANSP. Common on sand and algae substrate, 0-100 ft.; also sand pockets on coral reef flats (fide Cernohorsky, 1965, p. 5).

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THE GENUS CYPRAEA (SUBGENUS ZOILA JOUSSEAUME)

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The generic classification within the family Cypraeidae is a controversial subject. Several subfamilies and many genera and subgenera have been described, primarily on shell characters of living and fossil species, but the diagnostic features supposed to distinguish these taxa are difficult to apply with any satisfactory degree of consistency. The result has been a number of confusing and contradictory classifications. Most of the taxa have not been clearly diagnosed, and we have found that the only key to the genera so far published (Steadman & Cotton, 1946) is unworkable.

Kay (1960a) has shown that available anatomical data do not confirm the conchological classifications. She proposed to revert to the generic name *Cypraea* Linnaeus, 1758, for all cowries as a temporary measure until such time as additional anatomical data may permit a new and more comprehensive re-assessment of the problem. This seems to be a reasonable expediency, if not a practical solution. It is true that, if this procedure is widely and permanently adopted, many nomenclatural difficulties (particularly homonymy) will arise (Schilder, 1963b). However, this is no justification for an unsatisfactory classification and only highlights one unfortunate consequence of premature splitting. In order to expedite solution of the problem of generic classification of the Cypraeidae, anatomical data are urgently needed for many more species.

In this paper, observations on the anatomy, shell morphology, habitats and distributions of five cow-

Plate 329

Living *Cypraea (Zoila) venusta* Sowerby from 3 fathoms, off Sorrento Beach, Perth, Western Australia. B. R. Wilson, collector and photographer, 1962. Natural size.

ries endemic to Western Australia and South Australia are presented. Previously these five species have been grouped together to form the genus *Zoila* Jousseaume, 1884. *Zoila* has often been allied with *Bernaya* Jousseaume, 1884 and *Siphocypraea* Heilprin, 1887. Some authors (e.g. Schilder, 1965) have placed these three genera in the subfamily Cypraeorbinae, thus separating them from other cypraeids; other authors (e.g. Steadman & Cotton, 1946) have used the subfamily name Zoilinae for them.

The status and relationships of *Zoila* are evaluated here. It is shown that four of the five species have several apparently distinctive characters in common and may be regarded as a phyletic cluster of species. The relationship of the fifth species remains somewhat doubtful. This evidence seems to justify retention of *Zoila* as a taxon. However, because of the weakness of the diagnostic shell characters and the lack of comparative anatomical data for other cowries, we support Kay (1960a) in recognising a single genus, *Cypraea*, but rank *Zoila* as a subgenus. This procedure we regard as a temporary expediency and hope that our data and discussion may contribute toward a better understanding of the relationships of species within the Cypraeidae.

Anatomy

Kay (1960a) observed that the 52 species of cowries she examined could be divided into two groups on the basis of certain characteristics of the radula and the female genital system. With the help of senior zoology students at the University of Western Australia we studied the anatomy of *friendii*, *venusta* and *decipiens* in detail, paying particular attention to the reproductive system and the radula. Observations were also made on the anatomy of *marginata* and *rosselli*. The anatomy of *friendii*, type of the subgenus, is described here and comparisons are made with the other species of *Zoila*. Comparisons are also made with other cypraeids, notably *C. caputserpentis* L., the anatomy of which was described in detail by Kay (1960a), and *C. (Siphocypraea) mus* L., which has been said to be closely related to *Zoila*.

Materials and methods

Living specimens of *friendii* and *venusta* were collected at Cockburn Sound and Sorrento Beach respectively, narcotized with isotonic magnesium chloride, fixed in formal-saline and preserved in 1% propylene phenoxetol. Dissections were prepared of preserved specimens. Tissues for histological work were embedded in paraffin; serial sections were cut at 10 to 15 μ and stained with haemotoxylin and eosin or Triple Mallory's. Specimens of *decipiens* were collected by pearl divers off Broome and were fixed and preserved in methylated alcohol. Dissections and preparations of histological sections of this material were not entirely satisfactory due to the contraction and hardening of the tissues.

For comparative purposes, dissections were prepared of specimens of *Cypraea caputserpentis* from intertidal reefs at Cape Vlaming, Rottnest Island,

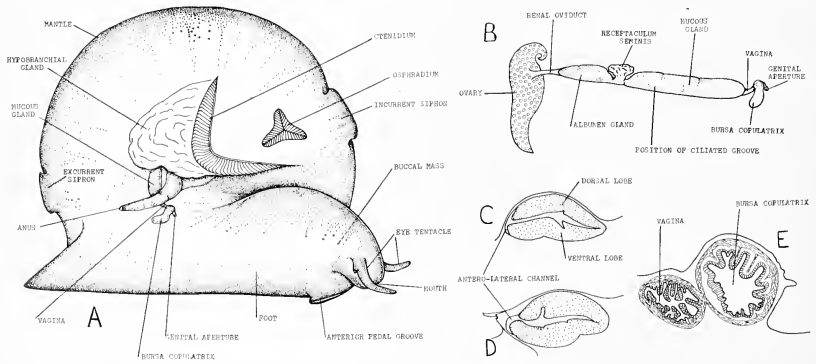

Plate 330. Female *Cypraea (Zoila) friendii*. **a**, semidiagrammatic drawing of animal with shell removed and with mantle lifted back; b, female reproductive tract; **c**, section through mucous gland; **d**, section through mucous gland of *C. venusta;* **e**, section through vagina and bursa copulatrix of *C. venusta*.

Western Australia. Two specimens of *Cypraea mus*, a male and a female, from 1-2 ft., Amuay Bay, Venezuela (courtesy of Dr. R. Tucker Abbott) were also examined.

The mantle and the mantle cavity

Vayssière (1923, 1927) has described the mantle cavity of several cypraeids and Schilder (1936) published a condensed survey of the characteristics of the mantle throughout the family. Kay (1960b) describes the mantle complex of *caputserpentis* L.

The mantle cavity and associated organs of *friendii* (plate 330) is typical of the Cypraeacea and shows the results of regulative detorsion during development (see Naef, 1911 and Ghiselin and Wilson, 1966). It is elongate with anterior incurrent and posterior excurrent siphons. The respiratory currents flow in a direct path from the incurrent siphon, across the tripartite osphradium, over the ctenidium and hypobranchial gland and out the excurrent siphon. The ctenidium is curved and lies across the path of the incoming respiratory currents with the osphradium nestling in the curve. The anus and genital apertures are situated posteriorly. The organization of the organs within the mantle cavities of *venusta* and *decipiens* show no notable differences.

The mantles of most cowries bear simple or branched papillae and the margins of the siphons are denticulate, flabellate or serrate (Schilder, 1936). In *mus* there are numerous conical or tentacular mantle papillae and the siphonal margins are serrate. The mantle of *rosselli* bears a few simple wart-like or conical papillae but the margins of the siphons are smooth and entire. In *friendii* the mantle bears a few very small nodule-like papillae, only visible when the mantle is fully extended. Small black flecks on the mantle of *decipiens* may be similar nodular papillae in a contracted condition (the mantles of living specimens of that species were not examined).

In *venusta* the mantle is thin and smooth, without papillae.

There is no evidence of papillae on the mantle of preserved *marginata* or in a photograph of a living specimen taken by Mr. Max Cramer. The margins of the siphons are entire in all 5 species of *Zoila*.

Female genital system

The ovary of *friendii* is orange and forms a large part of the visceral whorl with an anterior extension on the left side as in other cowries. The renal oviduct runs from the ovary on the left side, laterally across the body to join the pallial oviduct. It is lined with a ciliated columnar epithelium thrown into deep folds, and enlarges before entering the pallial oviduct.

A gono-pericardial duct runs parallel with the renal oviduct and appears to enter the latter a short distance before it enters the pallial oviduct. The gono-pericardial duct has an epithelium similar to that of the renal oviduct.

As in other members of the superfamily Cypraeacea (Fretter, 1941; Kay, 1960b; Ghiselin and Wilson, 1966), the pallial oviduct in *friendii* is a swollen tube with glandular walls and some diverticula. It is divided by a constriction into a proximal and a distal lobe. The proximal lobe has been called an albumen gland (Kay, 1960b) although Ghiselin and Wilson (1966) showed that this structure contains both albumen and membrane glands in the ovulid *Cyphoma*. The distal lobe has been called the capsule gland (Kay, 1960b) but Ghiselin and Wilson (1966) preferred the name mucous gland and this name is used here. Distally the mucous gland leads into a short vagina which enters the mantle cavity and terminates in a genital aperture just anterior to the anus.

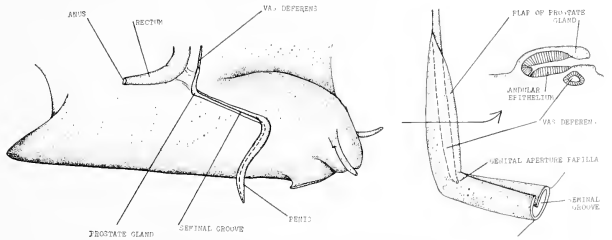

Plate 331. (left) Male *Cypraea (Zoila) friendii* showing position of penis on right side. (right) Enlargement showing details of prostate gland and seminal groove.

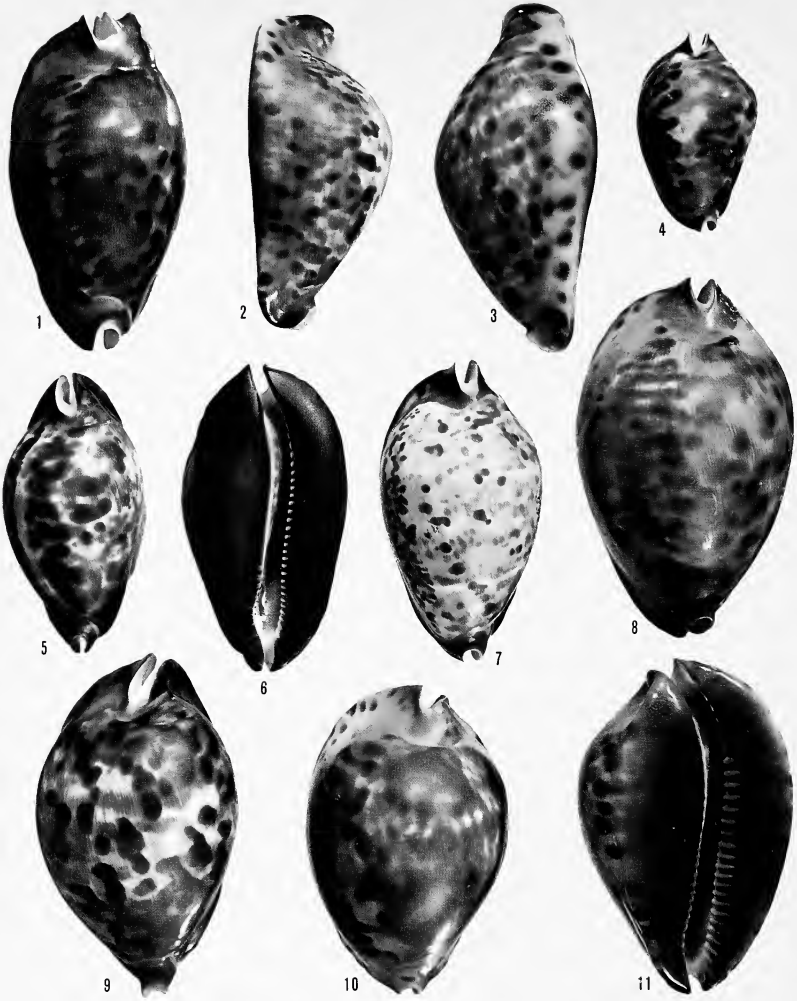

Plate 332

Cypraea (Zoila) friendii friendii Gray, showing variations in color patterns and shell shapes. Fig. **1**, 2 fms., off Sorrento Beach; **2**, 6 fms., Eagle Bay, Cape Naturaliste; **3** and **4**, Quindalup jetty, Geographe Bay; **5**, Woodman's Point, Cockburn Sound, on pilings; **6**, Parmelia, Cockburn Sound, on pilings; **7**, 4 fms., Easter Saturday Reef, Geographe Bay (ANSP); **8**, 20-30 fms., 10 mi. south of False Entrance; **9**, Esperance, on jetty pilings; **10** and **11**, trawled in 60 fms., west of Dorre Island by Poole Bros., 1965. All, except fig. **7**, in Western Australian Museum. (p. 10 - 474.) (About 2/3 natural size.)

Plate 333

Figs. **1-3.** *Cypraea (Zoila) friendii friendii* **forma** *contraria* Iredale. **1,** 80-100 fms., off Fremantle; **2,** 90 fms., off Eyre (Delaware Natural History Museum); **3,** 80-100 fms., 50 miles S.E. of Esperance, W.A. (p. 10 - 475.)

Figs. 4-6. *Cypraea (Zoila) friendii* subspecies *thersites* Gaskoin. **4,** Sir Joseph Banks Group South Australia; **5,** Stansbury, St. Vincent Gulf, South Australia; **6,** 20 ft., Lusby Rocks, Sir Joseph Banks Group, South Australia. (p. 10 - 476.)

Figs. **7-10.** *Cypraea (Zoila) venusta* Sowerby. **7,** 6 fms., Eagle Bay, Cape Naturaliste, W.A.; **8-10,** 2-5 fms., ½ mi. off Sorrento Beach, W.A. All, except fig. 2, in Western Australian Museum. (p. 10 - 477.) (All 2/3 natural size.)

In cross section the albumen gland is oval with the dorsal, ventral and postero-lateral walls thickened by gland cells, but the antero-lateral wall is formed by a single layer which is an extension of the epithelium lining the lumen of the gland. This epithelium consists of ciliated columnar cells with basal nuclei. Beneath these columnar cells lie large, irregularly developed glandular cells from which ducts run to the lumen. The lumen of the albumen gland is simple with no major ciliated grooves or channels running along its length.

The cream-colored mucous gland is contiguous with the albumen gland but is readily distinguished from the latter by both macroscopic appearance and histological detail of the epithelial lining. The mucous gland consists of thickened dorsal and ventral lobes, fused at their postero-lateral edges. In *friendii* the thin antero-lateral wall is formed by a continuation of the epithelium lining the lumen of the gland. This thin wall is folded so as to form a deep, strongly ciliated groove (the capsule duct of Kay, 1960b) running along the antero-lateral edge of the mucous gland between its dorsal and ventral lobes (plate 330, fig. c). The lumen of the mucous gland is lined with epithelium similar to that of the albumen gland; the wall is traversed by several longitudinal grooves. Beneath the epithelium are small gland cells forming strands a few cells wide alternating with ducts running to the lumen. The respective functions of the folded antero-lateral duct and the longitudinal grooves along the inner walls of the mucous glands are unknown.

There are two sperm-containing diverticula of the pallial oviduct. Proximally there is a receptaculum seminis closely appressed to the dorsal side of the albumen gland and the proximal end of the mucous gland. Distally there is a large bursa copulatrix, a diverticulum of the vaginal duct within the mantle cavity.

Macroscopically, the receptaculum seminis looks like a yellow granular mass. Microscopically, it is a mass of tubules embedded in a connective tissue. The epithelium of the tubules consists of tall, glandular, columnar cells with median nuclei. When stained with "Triple Mallory's," these cells are packed with yellow granules. The wide main duct of the receptaculum seminis enters the postero-lateral wall of the albumen gland at its extreme end distal to the ovary. The epithelium of this duct is much folded and composed of non-glandular, densely ciliated cells. Many tubules of the receptaculum seminis contained spermatozoa; it could not be determined whether resorption was taking place there.

The bursa copulatrix is a thick-walled, muscular sac attached along its whole length to the wall of the mantle cavity. It is situated very close to the genital aperture. The vagina enters and leaves the bursa copulatrix at its antero-ventral end (plate 330, fig. b).

The female genital tracts of *venusta* and *decipiens* are similar to those in *friendii* but several minor differences were observed. The mature ovary of *venusta* is yellow and in *decipiens* it is bright-orange. The receptaculum seminis of *venusta* is a relatively large black, granular structure. In *decipiens* the passageway through the albumen gland is not simple but a channel is formed in the antero-lateral wall similar to that in the mucous gland. In *venusta* the fold of the thin antero-lateral wall of the mucous gland is displaced ventrally so that the duct comes to lie along the lateral edges of the ventral lobe (plate 330, fig. d) instead of medially between the two lobes as in *friendii* (plate 330, fig. c) and *decipiens*. We have no data on the detailed structure of the female genital tract of *marginata* and *rosselli*.

In *venusta*, *decipiens* and *marginata* there is a bursa copulatrix very like that of *friendii*. The bodies of only two specimens of *rosselli* have been examined; both were in a poor condition. No penis was present in either specimen and it is assumed they were both females. However, due to decomposition and damage, neither the female genital aperture nor the bursa copulatrix could be located. The bursa copulatrix at least should have been visible in spite of the damage; it seems likely that a bursa is absent in *rosselli*.

Male genital system

The mature testes are cream-colored and are situated in the visceral whorl. In *friendii*, the coiled ampulla (seminal vesicle of Kay, 1960b) abuts broadly onto the anterior left side of the testes. The thin vas deferens leaves the medial regions of the ampulla and crosses the body just behind and below the pericardium emerging in the mantle cavity of the right side. In the mantle cavity it forms an open seminal groove which turns sharply anteriorly and runs forward to the penis on the right side of the head. The groove continues along the ventral surface of the penis to its pointed tip.

In most respects the male genital tract is similar to that of *caputserpentis*. However, in *caputserpentis* there is a short duct from the testes to the ampulla and the relative size and structure of the prostate gland is different. Kay (1960b) stated that the prostate of *caputserpentis* is "closed." By this

she means closed off from the mantle cavity by an expansion of the posterior wall of the seminal groove so as to cover the body wall (Kay, personal communication). We have checked this in male *caputserpentis* from Rottnest Island, Western Australia. At the bend where the vas deferens opens into the seminal groove there is an extension and expansion of the posterior wall of the groove forming a wide flap covering the distal end of the vas deferens. Beneath the flap (i.e. between the flap and the body wall) is a cavity lined with ciliated, glandular epithelium. The cavity, which appears to be homologous with the prostate gland of *Trivia* (Fretter, 1941), is open along its anterior edge.

In *friendii* the prostate, which is much smaller, is similarly formed by a flap-like extension of the posterior wall of the seminal groove (shown in section, plate 331). Also in *friendii* the vas deferens projects as a short papilla into the prostate cavity (plate 331).

The male genital tracts of *venusta* and *decipiens* were also examined in detail; that of *marginata* was examined superficially. No notable differences were observed between the males of three species and *friendii*.

Radula

The radula of the *friendii* species complex has been described and illustrated in detail by Wilson and Summers (1966) and the following description is taken from that paper. The radula is typical of Cpyraeidae in bearing 7 tricuspid teeth per row with 80 to 150 rows. The median tooth is slightly wider than it is high with one prominent medial cusp bordered by a smaller cusp on either side. An internal dumb-bell-shaped bract extending across the base of the tooth stains more densely in Chlorozol-black than the remainder of the tooth and bears a pair of small denticles, one in each lower corner. A prominent semicircular bract, which does not take up the stain, projects downward from the base of the medial tooth. This latter element appears to be the structure Kay (1960a) calls the "subtending bract."

The lateral tooth ("admedian" of Kay) is slightly higher than it is wide. It possesses a prominent medial cusp which is large and pointed, while the lateral cusps are relatively small. A densely staining internal bract also occurs in this tooth. Large denticles are present on the lower corners of the tooth, the one on the inner corner being particularly prominent and projecting toward the median tooth. The inner marginal tooth is similar to the lateral but is narrower with a more prominent central cusp and does not possess basal denticles. The outer marginal is still narrower, its lateral cusps are very reduced, no internal bract is visible, and there are no basal denticles.

The shape and proportions of the median tooth and the inner marginal tooth vary slightly. In South Australian and Esperance specimens, the outer cusp on the inner marginal tooth forms a distinct shoulder. This is present but less distinct in Geographe Bay and Sorrento samples. The specimens from Cockburn Sound (plate 334, fig. b) are exceptional in that the inner marginal tooth is relatively narrow and there is no shoulder at the outer lateral cusp. This is consistent in specimens from this locality but appears to be a local feature of that small population, not a regional characteristic. (Cockburn Sound is only about twenty miles from Sorrento

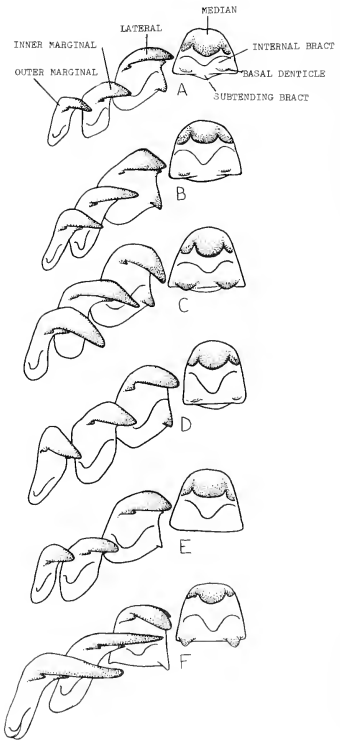

Plate 334. Radulae in the subgenus *Zoila:* **a,** *marginata;* **b,** *friendii;* **c,** *venusta* (from Sorrento); **d,** *decipiens;* **e,** *rosselli;* and the subgenus *Siphocypraea:* **f,** *nuus.*

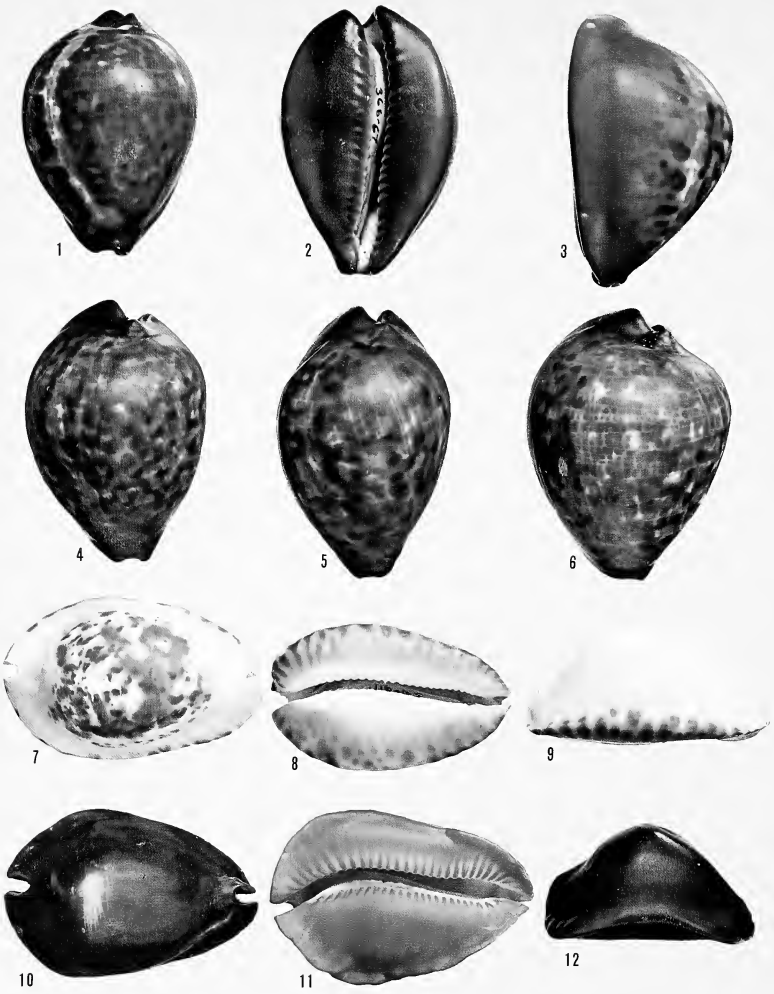

Plate 335

Figs. **1-6.** *Cypraea (Zoila) decipiens* E. A. Smith. **1-3,** Port Hedland, Western Australia; **4-6,** northern Western Australia (ANSP). (p. 10 - 482.)

Figs. **7-9.** *Cypraea (Zoila) marginata* Sowerby. **7,** Abrolhos Islands, Western Australia (Delaware Natural History Museum); **8,** "The Flats," south of the Abrolhos Islands, W.A.; **9,** 28-30 fms., off Jurien Bay, W.A. (p. 10 - 483.)

Figs. **10-12.** *Cypraea (Zoila) rosselli* (Cotton). **10,** Leighton Beach, Western Australia (part of type lot from Rossell); **11,** off Rottnest Island, W.A. (Delaware Natural History Museum); **12,** 30-40 fms., west of Dirk Hartogs Island, W.A. In Western Australian Museum. (p. 10 - 485.) (All natural size.)

where animals occur with normal second lateral teeth.)

The radulae of *venusta, decipiens* and *marginata* resemble that of *friendii* in general; all have a subtending bract, basal denticles and an internal bract on the median tooth. However, diagnostic differences in shape and relative size of the parts exist. These differences are given as diagnostic characters in the descriptions of the species and are evident in plate 334.

The radula of *rosselli* is significantly distinctive in that there is no subtending bract on the median tooth. The basal denticles on the median and lateral teeth are very small, and the marginal teeth are stout with short medial cusps. The median tooth of *mus* also lacks a subtending bract, but in that species the basal denticles on the median and first lateral teeth are prominent and the outer laterals are particularly long and sickle-shaped (plate 334, fig. f).

List of recognized taxa

The fossil species are not considered in this paper. For a review of them, consult F. A. Schilder, 1935, Proc. Mal. Soc. London, vol. 21, pt. 6, pp. 336-339 and in Archiv für Molluskenkunde, 1941, vol. 73, p. 81.

Genus Cypraea Linné, 1758
Subgenus Zoila Jousseaume, 1884

Recent: *friendii* Gray, 1831. **Type** subsp. *thersites* Gaskoin, 1849
marginata Gaskoin, 1849
venusta Sowerby, 1846
decipiens E. A. Smith, 1880
rosselli (Cotton, 1948)

Fossil: †*gigas* McCoy, 1867
†*mulderi* Tate, 1892
†*dorsata* Tate, 1890
†*gabrieli* Chapman, 1912
†*platypyga* McCoy, 1876
†*consobrina* McCoy, 1877
†*toxorhyncha* Tate, 1890
†*gendinganensis* Martin, 1899
†*schilderi* (Dey, 1962)
†*simplicior* (Schilder, 1935)

Affinity between the five living species of *Zoila*

The living species of *Zoila* have many distinctive morphological characters in common, although some of the characters common to *friendii, marginata, venusta* and *decipiens* are not shared by *rosselli*. Females of the former four species possess a large bursa copulatrix and a glandular seminal receptacle (although this is not confirmed for *marginata*); in males the prostate gland is small (relative to that of *C. caputserpentis*); the ampulla abuts directly onto the anterior end of the testis (not confirmed for *marginata*); the median tooth of the radula bears a subtending bract, an internal bract and basal denticles and the first lateral tooth bears a prominent basal denticle on the inner side; margins of the siphons are entire and the mantle is thin and may be quite smooth (*venusta, marginata*) or bear very small, simple papillae (*friendii* and possibly *decipiens*). In shells of all four species the aperture dentition is weak compared to that of many other cowries, especially on the columellar side; the fossula is quite deep, but the anterior columellar teeth do not extend up onto it; the terminal ridge is obsolete, the right side of the anterior channel (ventrally) being a flat or sloping surface with a simple cornered inner edge.

The spire is elevated in *friendii* and *marginata*, but only slightly elevated in *venusta* and almost depressed in *decipiens*. Thus this characteristic, often used as a diagnostic feature of *Zoila*, has only limited application.

In addition to these morphological characters it has been observed that *friendii, venusta* and *decipiens* feed on sponges and commonly may be found perched on the sponges in the open; none show any tendency to bury themselves within the sponges. There is evidence that *marginata* may behave and feed in the same way. As far as we are aware this kind of feeding and behavior is unique among cypraeids. No other cypraeid is known to have such a direct association with sponges. Most cowries are secretive and hide under stones, among corals or in crevices (at least during daytime). Some, like *C. tigris*, may be found in the open in coral pools, but are more often hidden.

This aggregate of anatomical, behavioural and shell characters suggests a close evolutionary affinity between *friendii, venusta, marginata* and *decipiens*.

Therefore we propose to retain the name *Zoila* as a distinct taxon. However, we do not believe that the distinctive characters of the taxon are sufficient to justify generic rank. We rank *Zoila* as a subgenus of *Cypraea*.

Whether *rosselli* should be included in *Zoila* is uncertain. In common with the other species the siphonal margins are smooth, the animal probably lives and feeds on sponges, and the anterior columellar teeth of the shell do not extend onto the fossula. However, *rosselli* differs from the other species by the presence of small but distinct papillae on the mantle; the absence of a subtending bract and basal denticles on the median tooth of the radula; the small size of the basal denticle on the inner side of the first lateral radula tooth; and by the more strongly denticulated shell.

There is doubt whether females of *rosselli* possess a bursa copulatrix. If, when well-preserved animals of *rosselli* become available for study, a bursa copulatrix is shown to be present, then it may be concluded that a relationship with the other four living species of *Zoila* probably does exist, even though *rosselli* is the most outstanding of the group. If the females of *rosselli* do not possess a bursa copulatrix, retention of this species within the same subgenus would be difficult to justify.

Relationships of the subgenus *Zoila*

While a close affinity between the living species of *Zoila* is strongly indicated by the data (*rosselli* being a possible exception), the relationship of this species group to other cowries is yet to be determined. Information on the anatomy and behaviour of many living cowries is still wanted.

One interesting result of this study has been the discovery that the living species of *Zoila* do not conform to either of the two categories recognised on anatomical ground by Kay (1960a). Kay recognised four radula types (R1 to R4) among the species she studied. Those species in which the females possessed a bursa copulatrix and a glandular receptaculum seminis invariably had radula types R2, R3, or R4; those species without a bursa and with a saccate receptaculum seminis had radula type R1; this is the dichotomy shown by Kay to cross previous conchological classifications. Evidence presented in this paper demonstrates that, with the exception of *rosselli*, females of *Zoila* species possess a bursa, a glandular receptaculum seminis, and a radula resembling Kay's type R1 (i.e. with a subtending bract and an internal bract on the median tooth).

This contradiction indicates that a simple two-way split of the Cypracidae on the basis of the female genital system and radula type cannot be maintained as a taxonomic division of the family. However, the fact that four of the five species of *Zoila* differ in the same ways from the fifty-two species studied by Kay, is additional evidence supporting the phyletic distinctness of *Zoila*.

The subgenus *Zoila* has generally been considered closely related to *Bernaya* Jousseaume, 1884 (Upper Jurassic to Recent) and more distantly to *Siphocypraea* Heilprin, 1887 (Miocene to Recent). The taxonomic arrangement of these groups and other fossil relatives has varied (see Schilder and Schilder, 1939; Wenz, 1941; Schilder, 1941). Recently Schilder (1965) ranked *Zoila*, *Bernaya* and *Siphocypraea* as equal genera within the subfamily Cypraeorbinae. We propose to treat these groups as subgenera of *Cypraea*.

The anatomy of *Siphocypraea mus* does not indicate a very close affinity with *Zoila*. The mantle bears numerous, simple papillae and the margins of the siphons are filamented. The female has a large bursa copulatrix but this does not adhere along its whole length to the wall of the mantle cavity as in *Zoila*. In *mus* the median tooth of the radula has an internal dumb-bell-shaped *bract*, but no subtending bract and the basal denticles are prominent and pointed (pl. 334, fig. f). The lateral tooth bears a prominent basal denticle on the inner corner similar to *Zoila* but the marginals are very long and sickle-shaped.

Comparative anatomical data on the two living species of *Bernaya* (i.e. *fultoni* Sowerby, 1903 and *tenleri* Cazenavette, 1846) would be most useful, but these species are seldom collected, and living or preserved specimens are not available for study.

The diagnostic shell characters separating *Zoila* from *Bernaya* are poorly defined in the literature. The descriptions given by Wenz (1941, pp. 969 and 971) for the two genera contain only a few rather subjective differences. In *Bernaya* the sides are said to be rounded, the ventral surface convex, concave at the front, the spire short, the teeth somewhat protracted, the outer lip sloping concavely at the front and the fossula broad, concave, smooth. In *Zoila* the sides are said to be angular, the base flat, the spire "usually visible," the teeth coarser, the outer lip less sloping and the fossula fairly shallow but distinct.

In these circumstances, Schilder's (1963a, p. 127) proposal to attribute the unique Abrolhos Island shell he named *catei* to the genus *Bernaya* is full of interest. He adopted this procedure because ". . . the symmetrical profile in lateral view, the less angular margins, the straight aperture, the more primitive outlets, the well developed columellar teeth sloping inward, etc., seem to point rather to

the genus *Bernaya* than to *Zoila* (Schilder, 1941, pp. 80-81)."

We consider the specimen to which Schilder referred to be an aberrant form of *venusta* and synonymize it as such. It would be possible to take exception to all the definitive characters listed by Schilder as diagnostic of *Bernaya*, on the grounds that they occur inconsistently among living and fossil *Zoila* as well. Nevertheless the point is made that the species of *Zoila* and the species of *Bernaya* overlap with regard to many shell characters. In fact, Schilder (1963a, p. 128) concludes that "The recently discovered *Bernaya catei* seems to represent another link connecting *Bernaya* with *Zoila*, so that one should consider degrading *Zoila* to a subgenus of *Bernaya*." In this paper *Zoila* and *Bernaya* are each considered to be subgenera of *Cypraea* so that such a procedure could not be implemented without eliminating *Zoila* altogether (*Bernaya* has priority). While appreciating the probable close affinity of these two groups we feel that no nomenclatural step of this nature should be made at present, because the diagnostic shell characters remain too ambiguous and poorly defined. A thorough and critical review of the fossil species of both subgenera, and data on the anatomy of living *Bernaya* are needed.

Better understanding of the relationships between fossil and living species of these subgenera would be particularly interesting from the palaeogeographic point of view. *Bernaya* is known from the Upper Jurassic to the Recent ("Subgenus" *Protocypraea*, see Schilder, 1963a, p. 127) and species of *Zoila* are known from Australian specimens as old as the Miocene and from the Upper Miocene to Pleistocene of India and the Indo-Malay Archipelago. Schilder (1963a, p. 128) notes that the upper Tertiary and Pleistocene species of *Zoila* in these tropical Asian regions connect the Australasian *Zoila* with the Tethyan *Bernaya*. Whether the two subgenera are considered to be distinct or synonymous, a close relationship seems highly probable and the living Australian species of *Zoila* may be regarded as surviving relics of a once-flourishing group of Tethyan-Australasian cowries. Links of this kind between the early Tertiary molluscan fauna of the Tethyan region and the Tertiary and Recent fauna of southern Australasia have been demonstrated in a number of molluscan groups (see Fleming, 1957; Ludbrook, 1954). Additional documentation of such links may greatly improve our understanding of the origin and high degree of endemism in the southern Australian and New Zealand marine faunas.

Gigantocypraea Schilder, 1927, has been treated as a subgenus of *Zoila*. We cannot follow this procedure, because we treat *Zoila* itself as a subgenus of *Cypraea*. The status of *Gigantocypraea* must remain in doubt until the fossil species are revised. It may eventually be placed into synonymy with *Zoila* or accepted as a subgenus of equal rank with *Zoila*, *Bernaya* and *Siphocypraea*.

Acknowledgments

This study began in 1963 at the University of Western Australia as a class exercise in applied morphology. The exercise was supervised by Dr. E. P. Hodgkin and to him and senior zoology students of the 1963 class, we extend our thanks for their interest and help. The scope of the investigation has since been considerably extended by the authors. Most of the nomenclatural and literature research was done by the senior author while Research Fellow in Malacology at the Museum of Comparative Zoölogy, Harvard University. We are grateful to Dr. W. J. Clench and Dr. R. D. Turner for advice and assistance in these matters. Mr. C. N. Cate and Mr. Ray Summers also contributed helpful suggestions.

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The abbreviation WAM in this paper refers to the Western Australian Museum, Perth.

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Subgenus Zoila Jousseaume, 1884

Type: *Cypraca friendii* Gray, 1831

This subgenus is represented by five living species on the continental shelf of Western Australia and South Australia. The centre of distribution is the central coast of Western Australia, although two species are known to extend into South Australian waters and one species is apparently restricted to the warm waters of the far northwestern part of Western Australia. Fossil species have been described from the Upper Miocene to the Recent age in southeastern Australia, and from the Upper Miocene to the Pleistocene of India and the Indo-Malay archipelago.

The shell characters diagnostic of *Zoila* are the elevated or at least visible spire, the weak columellar teeth which may extend only part of the way along the columellar side of the aperture, and the concave, smooth, rather shallow but distinct fossula. Wenz (1941, pp. 969 and 971) separates *Zoila* from *Bernaya* by the more angular sides, flatter base, coarser teeth, and less sloping outer lip. These differences need further study in view of the intermediate shell characteristics of *venusta* (see Schilder, 1963a, p. 127).

A number of anatomical features separate *Zoila* from other living cowries. In females there is a large bursa copulatrix; in males the ampulla abuts directly onto the anterior end of the testis; there are subtending internal bracts and basal denticles on the median tooth of the radula; the mantle is smooth and bears only very small papillae, if any; the siphonal margins are smooth and entire. Little is known about the anatomy of *rosselli*, but observations on the mantle and radula of that species place its position in *Zoila* in doubt.

Synonymy —

1883 *Zoila* Jousseaume, Le Naturaliste, Paris, 1st series, vol. 2, 6th year, no. 52, p. 414 (Feb. 15, 1883). No type given; 1883 (April?), Bull. Soc. Zool. France, vol. 9, p. 89. **Type** by original designation: *Cypraca scottii* Brod.

Key to the living species of *Zoila* based on shell characters

a. Sides spotted ..... b
a. Sides unspotted c
b. Medial columellar teeth well-developed .. *marginata* Gaskoin
b. Medial columellar teeth absent or obsolete ..... d
c. Margins and siphonal canals sharp ..... *rosselli* Cotton
c. Margins and siphonal canals rounded .. *decipiens* E. A. Smith
d. Siphonal canals elevated and sharp ..... *friendii* Gray
d. Siphonal canals low and rounded ..... *venusta* Sowerby

Cypraea friendii *subspecies* friendii Gray, 1831

(Pls. 332 and 333)

Range – Western Australia, from Dorre Island to the western part of the Great Australian Bight.

Remarks – The variation of the *friendii* complex has been studied and described by Wilson and Summers (1966) who concluded that this is a highly variable polytypic species with two allopatric populations worthy of recognition as subspecies. The Western Australian population *(friendii friendii)* occurs across the whole width of the continental shelf. Shells from the outer parts of the shelf tend to be much wider than shells from more shallow adjacent water, and there is also a geographic (clinal) increase in width from north to south. This results in a complex situation where the width of the shells of any given population will be determined by both the geographic position and the depth. It was suggested that the causal factor may be water temperature, i.e. the lower the environmental mean water temperature the more swollen the last shell whorl becomes. In addition, beyond 70 fathoms or so, the shells lose their color and may be entirely white, or white with brown or orange spots. At the northern end of the range, shells tend to have faint crenulations or teeth along the columellar side of the aperture and are more pyriform than southern shells. Other characters such as shell size, elevation of the spire, width of the aperture and the degree of elevation of the anterior and posterior channels vary either clinally or at random between local populations and thus have no taxonomic value.

Schilder (1966b) referred to a "unique" specimen from off False Entrance, recorded by Wilson and Summers (1966), apparently overlooking the fact that ten further specimens from off Dorre Island (Shark Bay) were recorded in an addendum of the same paper. Schilder suggested that these northern end-of-cline variants may deserve a new racial name. We oppose this suggestion.

In view of the complex variation of so many shell characters within the Western Australian population as a whole, there is little to be gained from sub-dividing it into subspecies.

The extreme variability of *friendii* makes it difficult to give an adequate description. Nevertheless, other species possess sufficient diagnostic characters so that confusion of any of them with *friendii* is unlikely.

Habitat – The full width of the continental shelf from depths of a few feet to at least 100 fathoms. The animal feeds on sponges and they are commonly taken from sponges growing on rocks, jetty pilings or on weed flats. They do not hide within the sponges, but are found on top or on the sides of the sponges, or sometimes crawling on sand or among weeds on the ocean floor.

Description – Shell ovate (southern end of range and deeper water) to elongately ovate-pyriform (in shallow water near northern end of range). Dorsal hump relatively low (except in extreme deep-water south-coast populations) and behind the centre of the shell. Margins more or less rounded and marginated only at the extremities (more strongly marginated in wider shells); right posterior margins sometimes irregularly indented. Sides of the anterior and posterior channels sharp and usually greatly elevated. Spire elevated and often produced beyond the posterior channel lips; the spire may project into the posterior channel or lie to the left side of it. Aperture narrow, slightly curved posteriorly (more strongly so in wider south-coast shells), and dilated anteriorly.

Aperture dentition of shell – Labial teeth number from 14 to 30 depending on shell size; usually rounded but short; bifid labial teeth are not uncommon, especially in the Esperance population. Columellar teeth greatly reduced; only 4 to 8 columellar teeth present anteriorly, although in shells from the northern end of the range there are usually additional faint crenulations or teeth all along the columellar side of the aperture; anterior columellar teeth short and do not extend up onto the deep and concave fossula. Anterior terminal ridge obsolete.

Color of shell – Extremely variable. Dorsally, shallow-water shells have a white ground color with four radial bands of pale ash-blue blocks overlain by varying degrees of large, irregular and unusually confluent chocolate-brown blotches. Sides bear large, more or less round and discrete spots on a uniform dark chocolate-brown ground color. Base uniformly dark chocolate-brown. In shells from depths greater than 70 fathoms the brown markings become greatly reduced in number and color intensity; usually only a few pale brown spots or flecks remain on the dorsum and the base and sides

are pale brown; some shells are entirely off-white, without markings.

Measurements of shell — Individual size varies greatly between populations. The population with the smallest known individuals is in very shallow water at Quindalup in Geographe Bay (mean length 50.8 mm.; range 48.4 mm. to 52.9 mm.) and the largest individuals have been found at Sorrento about 20 miles north of Fremantle (mean length 91 mm.; range 85 mm. to 99 mm.). Relative width is a clinal character, increasing both horizontally from north to south and east, and vertically with increasing depth.

For details of shell dimensions and their variations see Wilson and Summers (1966).

Soft parts — Mantle, anterior and posterior siphons, foot, head and eye-tentacles are all black; a transverse groove across the truncated anterior end of the foot is yellow and a yellow streak may extend a short distance posteriorly down the antero-ventral edges of the foot. The radula and reproductive anatomy of this species are described in detail in a preceding section (p. 458). See plates 330 and 331.

Synonymy —

1831 *Cypraea friendii* Gray, Zool. Miscell., p. 35. New Holland, near Swan River [type locality here restricted to Cockburn Sound and Owen Anchorage between Garden and Carnac Islands and the mainland]. Lectotype, selected by S. P. Dance, Brit. Mus. (Nat. Hist.), no. 1964777.

1831 [July, 1832] *Cypraea scottii* Broderip, Zool. Jour., vol. 5, p. 330 (Strait of Sunda, near Angia, Java). Sowerby, 1837, corrected the locality to Garden Island, Swan River. Type not located.

1912 *Cypraea thersites* Gaskoin, Verco, Trans. Roy. Soc. So. Australia, vol. 36, pp. 209-210 (in part, i.e., three specimens dredged from 78-100 fms. west of Eucla, Great Australian Bight).

1918 *Cypraea friendii friendii* Gray, Verco, Trans. Roy. Soc. So. Australia, vol. 42, pp. 144-145.

1930 *Zoila friendii vercoi* Schilder, Zool. Anzeiger, Leipzig, vol. 92, p. 74 ("westliche Südküste von Australien; Typus: das mittelgrosse [South Aust. Mus. no. D14124], von Verco 1918, Trans. Roy. Soc. So. Australia, vol. 42, p. 147, erwähnte Stück von Esperance).

1935 *Zoila thersites contraria* Iredale, Australian Zool., vol. 8, p. 107 (72-100 fms. west of Eucla, Great Australian Bight). The types are the specimens collected by Verco (Verco, 1912). Lectotype, here selected, Australian Mus. Sydney no. C35580; also two paralectotypes Australian Mus. no. E3848 and E3839.

1938 *Zoila friendii friendii* Gray, Schilder and Schilder, Proc. Malac. Soc. Lond., vol. 23, p. 174.

1938 *Zoila friendii contraria* Iredale, Schilder and Schilder, Proc. Malac. Soc. Lond., vol. 23, p. 174.

1962 *Cypraea contraria* Iredale, Griffiths, The Cowry, vol. 1, pp. 36-38.

Types and type localities — Gray gave as type locality "New Holland near Swan River [Swan River Colony, not the Swan River itself]." This has been further restricted by Wilson and Summers (1966) to Cockburn Sound between Owen Anchorage and Garden Island, where a large population of *C.* (*Z.*) *friendii friendii* exists. The lectotype, identified by S. P. Dance, British Museum (Nat. Hist.) has no. 1964777.

The type of Schilder's southern race, *Z. friendii vercoi*, is one of the specimens described by Verco (1918) and is now in the South Australian Museum, no. D14124, type locality Esperance.

The type locality for *scottii* was given as Angia, Java. Is., but this is evidently an error.

Three specimens in the Australian Museum represent the type series of Iredale's subspecies *Z. thersites contraria;* lectotype no. C35580; type locality 72 to 100 fathoms west of Eucla, Great Australian Bight.

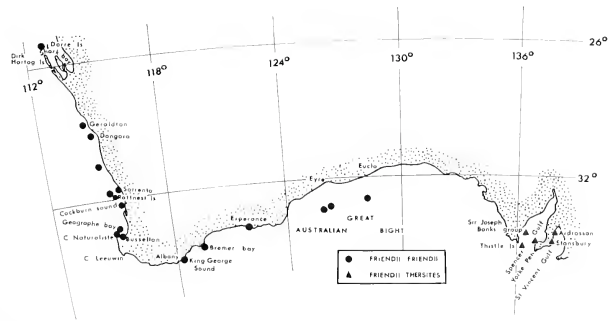

Plate 336. Geographical distribution of *Cypraea (Zoila) friendii friendii* (solid dots) and *C.* (*Z.*) *friendii thersites* in southwest Australia.

Nomenclature – In older texts this species appears under the name *C. scottii* Broderip, 1832, but Gray's name has priority by a few months and is now generally used. Schilder (1930) proposed the subspecies name Z. *friendii vercoi* for specimens from Esperance on the south coast of Western Australia, described by Verco (1918). Wilson and Summers (1966) have rejected this name after an analysis of the diagnostic characters on which it was based. The white or pale form from the outer edge of the continental shelf in the western part of the Great Australian Bight was given the subspecies name Z. *thersites contraria* by Iredale, 1935. However, Wilson and Summers (1966) have shown that these pale shells are deep-water ecotypes of the south-coast *friendii* and that similarly pale shells (but not as wide) occur in similar depths off the west coast of Western Australia. For these reasons deep-water pale forms can have no taxonomic recognition and the name *contraria* must be rejected.

Specimens dissected – Fifteen animals from Parmelia Bank, Cockburn Sound. The radulae of twenty specimens were examined from the same sample; other radulae were examined from specimens from Sorrento, Geographe Bay and Esperance.

Records – WESTERN AUSTRALIA: W. of Dorre Id. (trawled, 60 fms., Poole Bros. on L.F.B. "Bluefin," see Wilson and Summers, 1966); off Geraldton (craypot, 20-25 fms.); off Dongara (craypot, 32 fms.); between Fremantle and Geraldton (pale form, trawled "Endeavour," 1912, 80-100 fms.); 20 mi. N.W. of Rottnest Id. (pale form, pieces only, dredged B. R. Wilson on L.F.B. "Bluefin," 85-110 fms.); 1 mi. N. Bathurst Light, Rottnest Id. (17 fms.); off Sorrento Beach (2-3 fms., on sponge, B. R. Wilson and R. W. George); Parmelia Bank, Cockburn Sound (1-4 fms., on sponge, jetty pilings and among sea-grass, B. R. Wilson, leg); Quindalup, Geographe Bay (small form, 0-1 fm., B. R. Wilson); off Quindalup, Geographe Bay (2-8 fms., B. R. Wilson); Busselton, Geographe Bay (jetty piles, 1-3 fms., B. R. Wilson); King George Sound; Bremer Bay; Esperance (jetty piles, 1-4 fms., B. R. Wilson) (all West. Aust. Mus.); 60 mi. W. of Eucla [probably S.W.], Great Australian Bight (pale form, trawled 72-100 fms., Aust. Mus.); 75 mi. S. of Eyre, Lat. 33°15′0″ S., Long. 126°22′15″ E., Great Australian Bight (pale form, trawled 93 fms., S.S. "Bonthorpe," see Serventy, 1937, p. 77, pl. 4); S. of Eyre, Lat. 33°20′ S., Long. 126° E., Great Australian Bight (pale form, trawled, Ray Summers collection). A complete list of specimens examined is given by Wilson and Summers (1966).

Cypraea friendii *subspecies* thersites Gaskoin, 1849

(Pl. 333, figs. 4-6)

Range – Streaky Bay, eastward to Beachport in South Australia.

Remarks – South Australian populations seem to be isolated from those of southern Western Australia, although insufficient collecting has been done along the shores of the Great Australian Bight to be sure of this. South Australian shells are very similar to shallow-water Esperance shells in dorsal color, but are wider. On the ventral surface they differ in having a white patch along each side of the aperture and usually in having two to four weak posterior columellar teeth. No specimens are recorded from the outer edge of the continental shelf in South Australian waters. No differences were observed in the soft parts of typical *friendii* and its eastern subspecies, *thersites*.

Habitat – Mr. Paul Trenberth (1962 and personal communication) reports that the habitat is much the same as that described above for *friendii friendii*. The deepest South Australian record is 40 fathoms.

Description – Shell ovate. Roundly humped, with the maximum height behind the centre. Base flattened; margins slightly angular at the extremities. Sides of the anterior and posterior channels sharp but only slightly elevated (like deep-water specimens from the south coast of Western Australia). Spire evident but only slightly projecting and usually lying within the posterior channel. Aperture curved and dilated anteriorly. *Aperture dentition* – same as *friendii friendii*, except that two, three, or four weak columellar teeth are often present at the posterior end. *Color of shell* – same as shallow-water *friendii friendii*, except that very dark shells are rather more common and the base has a white patch along each side of the aperture.

Measurements of shell – Average length 73.3 mm.; range 63.6 to 86 mm. For detailed analysis of dimensions, see Wilson and Summers (1966).

Synonymy –

1849 *Cypraea thersites* Gaskoin, Proc. Zool. Soc. London, for 1848, vol. 16, p. 90. Hab. ? [Roberts, 1885 (in) Tryon, Man. of Conch. gives South Australia]. Lectotype, selected by S. P. Dance, Brit. Mus. (Nat. Hist.), no. 18465151, bears no locality.

1918 *Cypraea friendii thersites* Gaskoin, Vereo, Trans. Roy. Soc. So. Australia, vol. 42, pp. 144-148.

1935 *Zoila thersites thersites* Gaskoin, Iredale, Australian Zool, vol. 8, p. 107.

1938 *Zoila friendii thersites* Gaskoin, Schilder and Schilder, Proc. Malac. Soc. London, vol. 23, p. 174.

1961 *Zoila thersites* Gaskoin, Schilder, The Veliger, vol. 4, p. 110.

Types and localities – Gaskoin (1849) gave no locality, but Roberts, 1885, gave South Australia. The lectotype selected by S. P. Dance, British Museum (Nat. Hist.) no 1846.5.15.1 bears no locality.

Nomenclature – Several authors (Verco 1918; Schilder and Schilder 1939) regarded South Australian populations as a subspecies of the western *friendii*, but in recent years others have regarded them as a distinct species. The reasons for this were considered to be the much greater relative width of the shells, the lower spire, less upturned sides of the siphonal channels and the white base. Wilson and Summers (1966) reverted to the earlier procedure and recognised only subspecific rank for the South Australian populations. They showed that relative width is not a suitable diagnostic character because of the two-dimensional clinal variation it exhibits throughout the range of the species complex. Most other shell characters are either inconsistent or are determined by shell width. Only the white patch on the base and the frequent presence of posterior columellar teeth are useful diagnostic characters.

Specimens dissected – One male and two female specimens from Sir Joseph Banks Group, Spencer Gulf, South Australia.

Records – SOUTH AUSTRALIA: Lusby Rocks, Sir Joseph Banks Group, Spencer Gulf, South Australia (P. Trenberth, leg; WAM); Thistle Id., Spencer Gulf (Nat. Mus. Vict.); Corny Pt., Yorke Peninsula, Spencer Gulf (NMV); Stansbury, Gulf St. Vincent (WAM); Ardrossan, Gulf St. Vincent (WAM).

Cypraea venusta Sowerby, 1846

(Pls. 333, 337-340)

Range – Abrolhos Islands to the western part of the Great Australian Bight, Western Australia.

Remarks – This is a variable species, once considered among the world's rarest cowries. From the beginning there has been controversy and confusion about the identity of the species and its distribution, because two apparently distinct color forms occur: one has a pale-yellow or fleshy-pink shell with yellow or pale-brown spots, and the other has a darker shell with dark-brown or tan markings.

The holotype of *venusta* and the British Museum (Natural History) paratype of *thatcheri* have been compared by Dr. Anna Bidder of Cambridge University (personal communication) who pronounced them very similar in all respects. From previous illustrations, they and the holotype of *thatcheri* in the Dautzenberg collection, typify the pale form, which Schilder (1963a, 1966a) regards as the "typical" form of *venusta*. The specimen described and figured by Cox, 1889, and later made the type of *episema* by Iredale, 1939, typifies the dark form.

The dark form is known from localities between Hamelin Bay (just north of Cape Leeuwin) to the Abrolhos Islands. The pale form has been collected at several localities within this range and also in the western part of the Great Australian Bight. Thus, they are sympatric, but it is not yet known whether they ever occur in close proximity. Very little is known about the habitat of the pale form although it is known that it ranges from 5 fathoms (recently collected shell at Cervantes Id.) to 100 fathoms

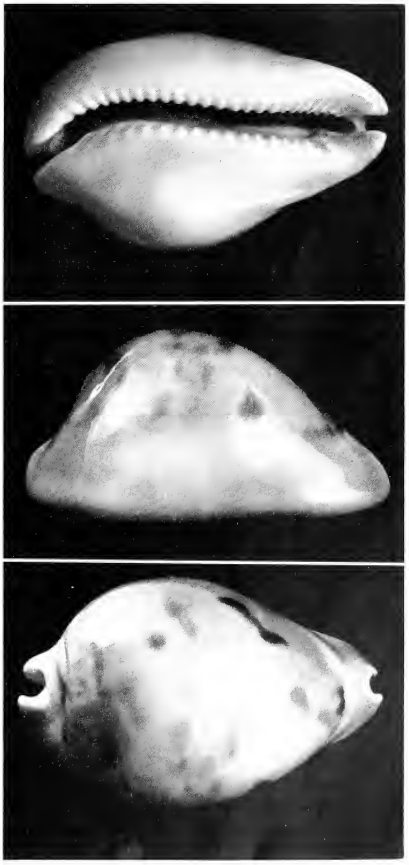

Plate 337. *Cypraea venusta* Sowerby. Paratype of *C. thatcheri* Cox in the British Museum (Natural History). Length: 78 mm. Courtesy of Norman Tebble.

(Great Australian Bight). Therefore, the pale form cannot be regarded as a deep-water variant (cf. pale, deep-water *friendii*).

Schilder (1966a) has concluded that these two forms are color morphs of the one species because they conform in all shell characters except color. We agree with Schilder's conclusion (but not with the taxonomic procedures derived from it — see nomenclatural section). A less likely alternative is that the two forms are distinct sympatric species differing only in shell color (a notoriously bad character for separating species). Pale shells may have strong columellar teeth more often than dark shells, but this needs confirmation. Live specimens of the pale form are needed for comparison with the soft parts and radula of the better known dark form.

The shells of the dark form might be mistaken for *friendii thersites* (see Iredale, 1939) but they are more pyriform, the extremities are more rounded and the whole base is white, pale-tan or pale-pink. In shape the shell of *venusta* resembles *decipiens* but is more swollen and less acutely humped than the latter species. The dark chocolate base and sides of the shell of *decipiens* at once distinguish that species from *venusta*.

Habitat — The depth range is from 2 to about 100 fathoms. At Sorrento Beach living animals are found on yellow-sponge-encrusted limestone rocks, and on the walls and ceilings of underwater caverns at depths of 2 to 5 fathoms (sometimes found in the company of the large *friendii* described by Wilson and Summers, 1966). Two live specimens collected by the senior author at Cape Naturaliste and Yallingup, at depths of 6 to 12 fathoms, were found on sponge- and weed-covered rocks.

At Sorrento during the early summer months (November to February), females may occasionally be found on egg clutches. These consist of several hundred egg capsules embedded in a gelatinous matrix and are laid in upturned, dead limpet, fissurellid or haliotid shells, or in suitably shaped depressions in sponge.

It is certain that the animals feed on sponges. Frequently an animal may be found in a depression in the smooth encrusting sponge which is clearly a result of its own browsing activity. Sponge spicules form a large proportion of the gut contents.

Description — Shell subpyriform; maximum height posterior to the centre; base flattened; lateral margins tend to be angular, especially at the anterior end where marginal wings are produced; sides of posterior and anterior channels rounded and not elevated; spire evident but depressed and not projecting (compared to *friendii* and *marginata*); aperture anteriorly dilated and usually curved posteriorly; anterior siphon canal usually oblique.

Aperture dentition of shell — Labial teeth short and strong. In our Sorrento sample, mean number of labial teeth is 21, range 18 to 23; number of labial teeth in larger shells from other localities varies from 19 to 27. Anterior columellar teeth distinct and extend into the aperture but not on to the fossula; posterior columellar teeth relatively short although distinct, but the medial teeth on the columella are frequently absent, and when present they are obsolete or weak. In the Sorrento sample most shells have no visible medial columellar teeth, but some have faint medial crenulations and a small percentage have a full set of 13 or 14 teeth on that side. One specimen from Yallingup, Cape Naturaliste (WAM 2/1966), a specimen from the Abrolhos Islands (J. Seabrook collection) and the types of *venusta thatcheri* and *catei*, all possess a full set of 15 to 16 columellar teeth, although the medial ones are weak. It is possible that a full set of columellar teeth may be more common in the pale form, but not enough specimens are known to confirm this.

Color of shell is polymorphic; a pale and a dark morph occur. In both morphs the base is pale (pale-tan, white or pale-pink), but there may be light stripes corresponding to the position of the teeth, especially the anterior labial teeth. The sides have a characteristic greyish granular texture, which tends to become darker toward the ends and extends dorsally over the anterior and posterior channels, usually covering the lower part of the spire in adult specimens, and thus encircles the shell. The dorsal background color is white, yellow or pale-tan with varying degrees of irregular darker blotches. The fossula is white but the darker tint of juvenile shells may sometimes be seen within the aperture.

The dorsum of the pale morph may be white, pale-yellow or pale-pink and may bear no blotches (e.g., the type of *bakeri* which is white with two pale distinct bands), or bear a few pale, orange-brown blotches or spots. The sides (i.e., overlaying the pale-grey granular texture) have only a few indistinct, pale orange-brown spots or none at all. The base is white, pale-yellow or pale-pink.

The dorsum of the dark form is usually pale-tan with darker tan or chocolate-brown blotches which may be confluent or more or less discrete and may be sparse or so dense that they cover almost the

whole dorsum. The sides usually, but not always, have large brown spots overlaying the marginal granular texture which is darker than in the pale morph and is often more blue than grey. Some specimens may have a mantle line, e.g., the type of *catei*, see Cate, 1962, pl. 1, a specimen from Yallingup (WAM 2-62) and specimens from Sorrento (WAM).

Measurements of shell – There is considerable variation in shell size between local populations. Shells from relatively deep water (3 to 20 fms.) in the Cape Naturaliste–Geographe Bay area and the Abrolhos Islands area are consistently larger than shells from the small shallow-water population around the reefs off Sorrento Beach. Mean length of our Sorrento sample is 58.3 mm.; range 52.0 to 65.2 mm. Mr. J. Seabrook's specimen from the Abrolhos Islands is 79.7 mm. long. Specimens from Geographe Bay are usually longer than 70 mm.

Several large shells have been taken by divers in 17 to 20 fathoms off Rottnest Island (unfortunately none are yet available for measurement) and one specimen from shallow reefs off Garden Island is small (60.5 mm.), like Sorrento shells. For measurements of additional specimens see Cate, 1962, table 1.

Soft parts – This description is for the dark form only, as we have not yet seen soft parts of pale specimens. The mantle is grey, thin, and the dorsal shell markings are just visible through it; it has a velvety texture and there are no papillae. Eye tentacles and the smooth edges of the anterior and posterior siphons are black. The rest of the head and the sides of the foot are fleshy-grey.

Radula – This description is for the dark form only. Radula dentition of this species is distinctive. The basal denticles on the median tooth are much larger than in any other *Zoila* and may project below or level with the base of the subtending bract (plate 334, fig. c). The central cusps of the lateral teeth are very long and curved compared to other species. Radulae of 33 specimens from the Sorrento population were examined and showed surprisingly little variation. The radula of one specimen from Yallingup, Cape Naturaliste (WAM 2-1965) was examined and was indistinguishable from those of Sorrento specimens. One aberrant Sorrento specimen was noticed with rows containing four lateral teeth on one side; the extra tooth was intermediate in shape between the 2nd and 3rd lateral teeth of normal specimens.

Nomenclature – The exact origin of the very early specimens is still subject to doubt. The first positive record was made by Iredale (1939), who described a shell from Cape Naturaliste, Southwestern Australia, as a western relative of *Zoila thersites* (Gaskoin, 1849), giving it the name *Z. t. episema*. Schilder (1960) separated *episema* from *thersites* and later (1961) allied it with *venusta*. Subsequently, specimens have been collected at other localities and the species has been treated taxonomically in several different ways (Cate, 1962, 1964; Schilder, 1963a, 1966a).

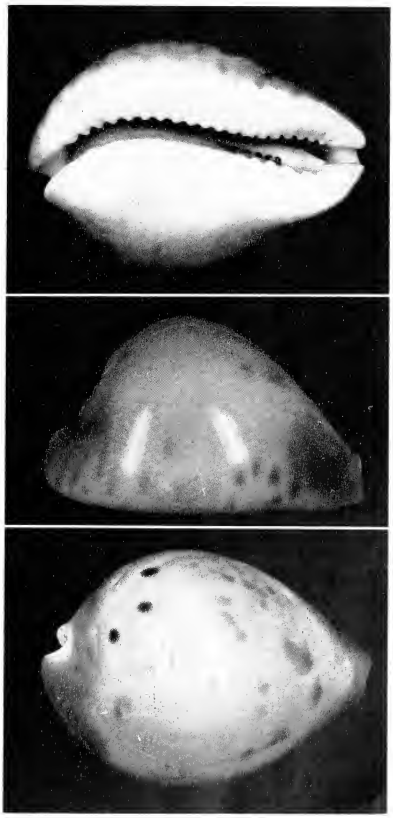

Plate 338. *Cypraea venusta* Sowerby. Eastern part of the Great Australian Bight. B. Bardwell, coll., National Museum of Victoria, Melbourne. Length: 71 mm.

Cate (1962) argued that *venusta* and *episema* are distinct species, although he has since changed that view (personal communication; see also Cate, 1964, p. 22). The stimulus for his 1962 paper was the discovery of the West Wallabi Island, Abrolhos, shell (later nominated type of *eatei* by Schilder) which Cate then believed to represent the typical, pale form of *venusta*. He argued that this shell and the types of *venusta* and *thatcheri* were conspecific but that they were a different species from dark *episema* as represented by his specimens from Geographe Bay and Sorrento. He drew evidence for this argument from the fact that his sample from Sorrento consisted of glossy dark shells like those from Geographe Bay, but unlike his "pale" specimen from the Abrolhos. Cate also pointed out that the type of *thateheri* and his Abrolhos specimen each had a full set of columellar teeth while his samples from Geographe Bay and Sorrento did not include any specimens with this characteristic. This evidence it not substantiated by our data and appears to be the result of a too small sample.

Some shells from all localities may possess a full set of columellar teeth. Although Cape Naturaliste and Geographe Bay shells are characteristically dark, the Sorrento population is highly variable in this respect. We observed that, at Sorrento, specimens found in the underwater caverns are usually dark and glossy while specimens found on sponges in the open shallow water are frequently damaged, deformed and lighter in color. It is likely that Cate's sample from this population was biased toward the "better quality" darker shells by the collectors who sent him his specimens. Cate's specimen from the Abrolhos Islands is not unlike many light tan shells from Sorrento (albeit other differences) but it is not a truly pale shell like the types of *venusta* and *thatcheri*.

Schilder (1963a) recognized the conspecificity of the Geographe Bay and Sorrento populations with the types of *venusta* and *thateheri*. However, he recognised three geographic subspecies within the species. For the "southern" subspecies (Geographe Bay) he retained the name *episema*. For the Sorrento population he introduced the new subspecies name *sorrentoensis*, supposing this to be a "western" subspecies. The typical subspecies *venusta* he supposed to be the "northern" representative on the basis of the type locality which he "preferred" to restrict to the Dampier Archipelago.

Schilder (1963a, p. 126) states: "The differences of geographically restricted races concern size and color only, but there is no constant difference in shape and in the structural features of the dorsum, extremities, margins, base, aperture, dentition and fossula; the posterior columellar teeth possibly are more developed in *Zoila venusta venusta* than in the other two races."

Because of the very restricted area and shallow conditions occupied by the Sorrento populations and the occurrence of similarly small shells in similar habitats (Garden Island) and large shells in adjacent deep water (off Rottnest Island), we regard size as a purely local ecotypic variant having no taxonomic relevance. Color is variable and there are no discrete differences in dorsal ground color and spotting between Geographe Bay and Sorrento populations as indicated by Schilder (1963a, table 2). The western subspecies ("dwarf race") *sorrentoensis*, therefore is not here substantiated, particularly since it occurs within the range of the larger specimens.

Furthermore, in proposing *venusta* as a pale "northern (probably Dampier Archipelago)" race, Schilder (1963a, p. 125) committed a circular argument. The only grounds he had for his "preference" for retaining Dampier Archipelago as the type locality for *venusta*, in spite of Brazier's (1871) evidence to the contrary, is that "Cervantes Island is too close to the area inhabited by Z. *episema*." This very doubtful argument cannot then be used to support the separation of these taxa. It seems unlikely that this species occurs in northern Western Australia at all and the corrected type locality (Cervantes Island) is much more in conformity with the known distribution of the species.

Subsequently, Schilder (1966a) appears to have changed his view because he records a "typical" pale *venusta* from Geographe Bay, i.e., within the range of his southern subspecies *venusta episema*. The new arrangement of the taxa within the species implied by Schilder (1966a) is totally unacceptable in terms of modern taxonomy. The "dwarf race" *sorrentoensis* is apparently still accepted as a subspecies of *episema* but *episema* itself is stated to be a "morph of subspecific rank," presumably of *venusta* with which it is sympatric. Sympatric subspecies is a contradiction of terms.

It is proposed here that subspecific division of *venusta* be discontinued and that the characters on which subdivision was based should be considered as inconsistent or variables dependent upon ecological conditions.

The procedure adopted here of including *Bernaya eatei* Schilder as a synonym of *venusta* is a tentative one. The type of this species is the unique

specimen from the Wallibi Group, Abrolhos Islands, described and figured by Cate (1962) as *venusta*. Schilder (1963a) correctly pointed out that the shell differs just as much from the types of *thatcheri* and *venusta* as it does from Sorrento and Geographe Bay shells (e.g., Cate, 1962, pl. 4 and text-fig. 2). The most significant differences are the globular shape with the maximum height central, the straight aperture with relatively well developed inward sloping teeth and the presence of a dorsal line. Because of these characters Schilder placed the specimen in the genus *Bernaya* rather than *Zoila* and gave it a new species name.

The senior author had the privilege of examining this shell before it left Australia (by courtesy Mr. Max Cramer), and concluded then that it was an interesting aberrant form of *venusta*. Aberrant shells of similar form (although not identical) are quite common at Sorrento. Other large shells, more typical of *venusta*, have since been collected at the Abrolhos Islands. Presence of a dorsal line is not confined to *Bernaya*, as supposed by Schilder. A dorsal line is common in *friendii friendii*, *friendii thersites* and also occasionally occurs in *decipiens* and *rosselli*, as well as in *venusta*. We do not consider the presence of a dorsal line in the type of *catei* to be of anything more than passing interest.

Synonymy –

1846 *Cypraea venusta* Sowerby, Proc. Linn. Soc. London, vol. 1, p. 314.

1869 *Cypraea thatcheri* Cox, Proc. Zool. Soc. London, [for 1869], p. 358, pl. 26, figs. 1, 1a.

1888 *Cypraea roseopunctata* Sby., Melvill, Mem. Proc. Manchester Lit. Soc., ser. 4, vol. 1, no. 5, p. 239 (nomen nudum).

1916 *Cypraea venusta bakeri* Gatliff, Victorian Nat., Melbourne, vol. 32, p. 147, figs. 1-2.

1939 *Zoila thersites episema* Iredale, Aust. Zool., vol. 9, no. 3, pp. 300-301, pl. 27, figs. 3-4.

1963 *Zoila venusta sorrentoensis* Schilder, Veliger, vol. 5, no. 4, p. 126.

1963 *Bernaya catei* Schilder, Veliger, vol. 5, no. 4, p. 127.

Types and localities – Type localities of *venusta* and its synonyms are as follows:

venusta Sowerby: no locality given, but Cate (1962) restricted the type locality to Cervantes Island [approx. 65 miles north of Perth], Western Australia; holotype in the Saul collection, Cambridge University, England; not figured.

thatcheri Cox: the original description and the labels with the types give the locality as Dampier Archipelago, west coast of Australia, but that was subsequently corrected to "Cervantes Id." by Brazier (1871), see Gatliff (1916), Cate (1962, 1964); holotype in Dautzenberg collection, Inst. Roy. Sci. Nat. de Belgique, Brussels, figured by Cox, 1869, pl. 26, figs. 1, 1a (copied by Roberts, 1885, pl. 10, figs. 44, 45, and Cate, 1962, pl. 4); paratype in British Museum (Natural History), no. 19042147, figured by Sowerby, 1869 (copied by Weinkauff, 1881); Allan, 1956, pl. 13, figs. 12-13; and our plate 337.

bakeri Gatliff: "Western Australia"; holotype in National Museum of Victoria, Melbourne, no. F616,

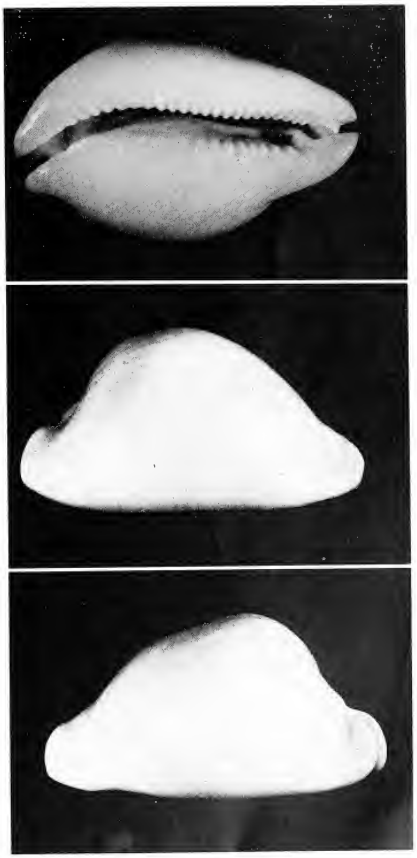

Plate 339. White form of *Cypraca venusta* Sowerby. Holotype of *C. bakeri* Gatliff in the National Museum of Victoria, Melbourne.

figured by Gatliff, 1916, p. 148, figs. 1-2. See our plate 339.

episema Iredale: "Cape Naturaliste, south-western Australia"; holotype in South Australian Museum, Adelaide, no. D3980, figured by Cox, 1889, pl. 15, figs. 1-2, Iredale, 1939, pl. 27, figs. 3-4 (copied by Cate, 1962, pl. 3, figs. 1a, 1b).

sorrentoensis Schilder: "Sorrento Beach near Fremantle [Western Australia]" leg. B. R. Wilson, Jan. 7, 1962; holotype in Schilder collection, no. 13344, not figured; paratypes are the "hypotypes" numbers 3, 4 and 8 to 13 listed by Cate, 1962, p. 7 (numbers 3 and 4 figured, pl. 3, figs. 2a, 2b, 3a, 3b).

catei Schilder: "West Wallaby I., Abrolhos Is. [Western Australia]" leg. Max Cramer; holotype in C. M. Cate collection, no. 563, figured by Cate, 1962, pl. 1 and pl. 2, figs. 1a, 1b, and text-fig. 2a.

Specimens dissected – Fifteen specimens from Sorrento Beach dissected and radulae mounted. Observations made on external anatomy and radula of one live-collected specimen from Eagle Bay, Cape Naturaliste (WAM 115-65) and one from Canal Rocks, Yallingup (WAM 2-62).

Records – West Wallabi Id., Abrolhos Is. (dark form, beach shell, see Cate, 1962); Rat Id., Abrolhos (dark form, J. Seabrook coll., Perth); Cervantes Id. (pale form, see Brazier, 1871, and Cate, 1962); Cervantes Id. (pale form, another specimen, 6 fms., craypot, N. Harold coll., Perth); Sorrento Beach, Perth metropolitan area (small dark form, 2 to 5 fms., sponge covered rocks and walls of underwater limestone caves, leg. B. R. Wilson and R. W. George, WAM, see also Cate, 1962, 1964 and Schilder, 1963); west side Garden Id. (6 fms., craypot, R. Swan, WAM); off Binningup Beach, approx. 15 mi. north of Bunbury (pale form, 65 ft., see Cate, 1964); Busselton, Geographe Bay (pale form, see Schilder, 1966a); off Dunsborough, Geographe Bay (dark form, 9 fms., limestone reef, leg. B. R. Wilson, WAM); Eagle Bay, Cape Naturaliste (dark form, 6 fms., gneissic reef, leg. B. R. Wilson, WAM); Canal Rocks,, Yallingup (dark form, 12 fms., gneissic reef, leg. B. R. Wilson, WAM); west part Great Australian Bight (pale form, trawled 80-100 fms., T. W. Marwick coll., Perth).

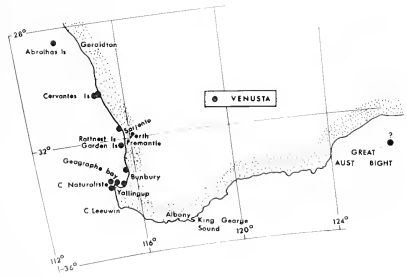

Plate 340. Geographical distribution of *Cypraea (Zoila) venusta* in Western Australia.

Cypraea decipiens E. A. Smith

(Pl. 335, figs. 1-6)

Range – North-west Cape to Buccaneer Archipelago, Western Australia. The geographic range of this species is difficult to determine exactly. It is not always possible to obtain reliable locality data because of the circumstances in which most specimens are obtained. At one time pearl divers brought specimens into Broome, Port Hedland, Port Walcott (old port for Roebourne) and Onslow, but the pearling luggers ranged some distance from these ports. However, there appear to be no records from the Northern Territory or from south of North-west Cape.

Remarks – *C. (Z.) decipiens* is a well-known and distinctive species from the northwestern coast of Western Australia. Apparently it is not encountered on intertidal reefs and is chiefly brought in by pearl divers from the pearling grounds. The unusually humped shell, rounded margins and extremities, and the unspotted chocolate-brown base and sides at once distinguish *decipiens* from other species.

Habitat – Mrs. Phyllis McDaniel, part owner of pearling luggers at Broome, writes (personal communication) that the pearl divers take living specimens from branching sponges in 10 to 40 fathoms. Judging from the numbers brought in on request, the species must be abundant, although occurring in restricted areas and habitats.

Description – Shell proportionately short and subpyriform. Dorsal hump high and steep; maximum height just behind centre. Base flattened with lateral margins only slightly angular, even at the anterior end (i.e., there are no expanded anterior marginal wings as in *venusta*). Sides of anterior and posterior channels rounded and low. Spire evident and slightly projecting with the apex dorsal to the posterior channel (but rarely projecting into the channel). Suture of body whorl slightly impressed. Aperture rather straight and only slightly dilated at the extreme anterior end. *Dentition of shell* – inside edge of labial lip thickened in such a way that the labial teeth are unusually deep (vertically), although they do not extend laterally across the base (except at the anterior end where they tend to be declivous). Weak but relatively (to other *Zoila*) long teeth along the whole length of the columella; anterior columellar teeth only slightly stronger than the midde and posterior teeth and do not extend up onto the fossula or across the base.

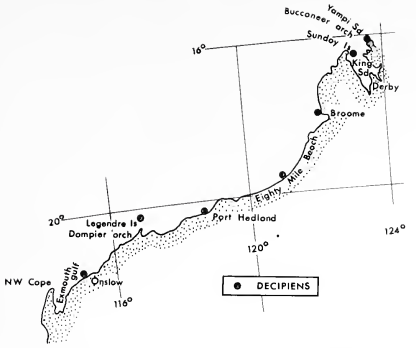

Plate 341. Geographical distribution of *Cypraea (Zoila) decipiens* in Western Australia.

Color of shell – Base and sides evenly colored deep chocolate-brown (no basal or lateral spots); basal coloring extends between the teeth on both sides of the aperture and covers the ventral ends of the teeth, the remainder of which are white. There is usually a patch of brown on the fossula. Dorsum has a unique pattern of numerous fine, white revolving and longitudinal lines (slightly raised) with small rectangular facets between (slightly depressed); each facet contains a more or less crescent-shaped blotch of brown, the overall appearance being a texture like that of a coarsely woven cloth (but smooth to touch). Overlaying this basic pattern there are varying amounts of darker, larger and confluent brown blotches extending upwards from the sides. Interior white, rarely with any coloration on that part of the body whorl visible within the aperture.

Measurements of shell – Average length 57 mm.; range 48 to 70 mm. Average ratio of width: length 0.67; range 0.5 to 0.75.

Soft parts – Mantle thin and orange with black flecks which are most dense near the margins. Smooth margins of siphons black. Eye tentacles and dorsal rim of the mouth black, head otherwise orange. Foot orange with black lateral margins and orange-yellow transverse anterior groove.

Radula – Median tooth rectangular and higher than it is wide (H:W ratio approx. 6:5). A narrow subtending bract is present but the basal denticles are small and ill-defined. Lateral tooth relatively higher than that in *friendii*. See plate 334, fig. d.

Synonymy –

1880 *Cypraea decipiens* E. A. Smith, Proc. Zool. Soc. London [for 1880], p. 482, pl. 48, figs. 8, 8a.

Types and localities – Smith gave only "North Australia" as the type locality for *decipiens*. The types are in the British Museum (Natural History), no. 18805272.

Specimens dissected – Twelve animals collected by pearl divers off Broome (courtesy Mrs. Phyllis McDaniel); fixed, and preserved in methyl alcohol. Six radulae examined.

Records – WESTERN AUSTRALIA: Yampi Sound, Buccaneer Archipelago (Geo. Robinson, leg.); Sunday Id., King Sound (W. H. Matthews, leg.); Broome; Eighty Mile Beach (V. Proudfoot, leg.); Port Hedland; off Legendre Id., Dampier Archipelago (dredged 22 fms., "Hawaiian-W.A. Exp. 1960"); Onslow (Rossell Coll.). All West. Aust. Mus.

Cypraea marginata Gaskoin, 1848

(Pl. 335, figs. 7-9; pl. 342)

Range – Dorre Island, Western Australia, to Cape Jervis, South Australia.

Remarks – Until a few years ago *marginata* was known only from a unique and unlocated specimen

Plate 342. *Cypraea marginata* Gaskoin. Holotype from the British Museum (Natural History). Length: 57 mm.

in the British Museum (Natural History), thought by some (e.g., Allan, 1956) to be a juvenile of *thersites* Gaskoin, 1849. In recent years a number of specimens, including some alive, have been collected and the range of the species established as Western and South Australia (Laws, 1966).

Cypraea marginata seems to be the closest living relative of *friendii*. The radulae of the two species differ only in very minor ways and from the dorsal view some dark specimens of *marginata* might be easily mistaken for *friendii*. However, the pale base with brown impressed spots toward the margins is characteristic of *marginata*. When live animals are compared, the two species may be easily distinguished by differences in animal color. The mantle, eye-tentacles, head and foot are black in *friendii*, but only the eye-tentacles are black in *marginata*, the rest of the body being white or without pigments.

Habitat – The depth range is known to be at least from 6 fathoms to 80 fathoms. The majority of the live specimens collected have come from pots ("craypots") set to catch the commercial crayfish or spiny lobster of Western Australia on rocky (limestone) bottom at depths of 15 to 40 fathoms. A number of live specimens have been collected by skindivers recently. Mr. Kevin Morgan of Perth collected one (J. E. Norton collection) on a sponge-covered rock at about 6 fathoms off Carnac Islands, Western Australia. Dr. H. Laws (1966) records three specimens recently collected by skindivers in South Australia at depths of 7 to 13 fathoms. The species is also reported from South Australia, by Stokes, 1966.

Description – **Shell** ovate. Dorsal hump steep posteriorly; maximum height just behind centre. Base broad and flattened with strongly marginated sides which are characteristically irregularly indented, especially near the posterior end; marginal indentations correspond with irregular impressions on the base. Sides of anterior and posterior channels sharp and elevated, although not as high as in *friendii*. Spire elevated and usually projecting on left side of the posterior channel, sometimes even beyond the extremities. Aperture narrow and only slightly curved.

Relative width and height are clinal variants in this species (cf. *friendii*, Wilson and Summers, 1966). The few specimens from the south coast of Australia are significantly wider and higher relative to shell length than specimens from the mid-west coast of Western Australia (see illustrations by Cate, 1961; Stokes, 1966, and Laws, 1966).

Aperture dentition of shell – Teeth present along whole length of both sides of the aperture. Labial teeth well developed but rather small and sharp and extend about a quarter of the way across the outer lip. Columellar teeth small, short and do not extend up on to the fossula. Number of labial teeth 24 to 29; columellar teeth 16 to 23.

Color of shell variable. Dorsum may be entirely white, or, over a white ground color, bear scattered spots and flecks of brown or occasionally large semi-confluent blotches of brown as in *friendii*. Teeth, fossula and sides of the aperture white; the rest of the base spotted and colored with brown in varying degrees, the larger brown spots usually occupying irregular depressions on the base of the shell. Basal spots extend to the lateral margins.

Measurements – Average length 60 mm.; range 46.0 mm. to 62.4 mm. Range of the ratio width : length 0.62 to 0.65. For additional data see Schilder, 1966c.

Soft parts – Mantle and siphons very thin, smooth, colorless and transparent. The shell markings and

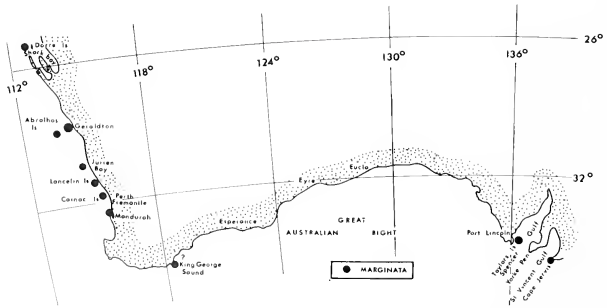

Plate 343. Geographical distribution of *Cypraea (Zoila) marginata* in southwest Australia.

teeth are easily visible beneath the extended mantle. The foot and head are translucent-white; eye-tentacles black. (Data from color photograph courtesy Max Cramer of Geraldton.)

Radula – The radula teeth are similar to those of *friendii* but there is a curious indentation in the top of the median tooth, and the central cusp of the median tooth is more projecting and pointed. The subtending bract also tends to be pointed rather than rounded as in *friendii*. See plate 334, fig. a.

Synonymy –

1849 *Cypraea marginata* Gaskoin, Proc. Zool. Soc. London [for 1848], p. 91.

1964 *Zoila marginata* (Gaskoin, 1849), C. N. Cate, The Veliger, vol. 7, no. 1, p. 23; 1967, Schilder, Hawaiian Shell News, new series, no. 88, April, p. 5 (radula illus.); 1967, *ibid.*, no. 92, Aug., p. 4.

Types and localities – Gaskoin gave no data with the original type specimen which is now located in the collection of the British Museum (Nat. Hist.), no. 42777. Cate (1961, pp. 76-78) purchased the second known specimen from the late Lloyd Berry collection and restricted the type locality on the basis of data on the label with the specimen to "Albany Bay, Western Australia (34° 57′ South Lat., 117° 58′ East Long.)" giving the depth as approximately 80 fathoms. There is no "Albany Bay" (Albany is a small city at the head of King George Sound) and Cate apparently intended the locality to be King George Sound, although the depth "within the perimeter" of the Sound nowhere exceeds 40 fathoms.

As Cate points out in a subsequent paper (1964, p. 23) the locality itself is questionable. Mr. Angelo was not a fisherman, as concluded by Cate, but an amateur shell collector who bought this and specimens of other deep water cowries from trawlers operating from Albany (personal communication from the late Senator T. W. Marwick who accompanied Mr. Angelo). The trawlers were working at depths of 80 to 100 fathoms in the western part of the Great Australian Bight between Eucla and Esperance some 400 miles to the east of Albany, and there is every reason to believe the specimen was trawled in that area.

Cate (1964, p. 23) "corrected" the type locality of *marginata* to "Pelsart Is., Houtman Abrolhos Group" (which lie off the mid-west coast of Western Australia) on the basis of another specimen in his collection from that locality.

Although doubt remains about the exact locality from which the type specimen came, the identity and range of the species is now well established and there is little point in arbitrarily restricting the type locality.

Specimens dissected (cursory examination only) – Bodies of one male and one female from off Jurien Bay (courtesy T. Sutcliffe) and one male from off Geraldton (courtesy Max Cramer). Radulae were examined from all three specimens. See plate 334, fig. a.

Records – WESTERN AUSTRALIA: W. of Dorre Id. (trawled 60 fms., Poole Bros. on "Bluefin"); 12 mi. off Geraldton (craypot, 20 fms., T. Merindino, leg.); S. of Southern Group, Abrolhos Ids. (craypot, 35 fms., K. Gustafsson, leg.); off Jurien Bay (craypot, 25-30 fms., K. Gustafsson) (all West. Aust. Mus.); Garden Id., near Fremantle, 30 ft. depth (Schilder, 1967, Hawaiian Shell News, new series, no. 88, p. 5); Lancelin Id. (see Cate, 1964); off Carnac Id. (diver, 6 fms., K. Morgan, on sponge-covered wall of limestone reef, J. E. Norton coll.); Robert Point, Mandurah (see Cate, 1964); "Albany Bay" [King George Sound], Lat. 34°57′ S., Long. 117°58′ E. [almost certainly erroneous—probably trawled on fishing grounds south of Eyre] (trawled 80 fms., see Cate, 1961, Veliger, vol. 3, no. 3, pp. 76-78, pl. 14). SOUTH AUSTRALIA: near Taylor's Id., 20 mi. from Port Lincoln, 40 ft. (see Stokes, 1966, and Laws, 1966); Cape Jervis, 70-80 ft. (see Laws, 1966).

Cypraea rosselli (Cotton, 1948)

(Pl. 335, figs. 10-12)

Range – Central coast of Western Australia from Binningup Beach north of Bunbury to Dirk Hartogs Island.

Remarks – Superficially, *rosselli* resembles *marginata*, especially in size, dentition and the marginated sides, although, as Schilder (1960) suggests, this is probably due to parallel evolution, not necessarily indicating close genetic relationship. The papillae on the mantle, the lack of a subtending bract and basal denticles on the medial radula tooth, the relatively small size of the inner basal denticle of the first lateral tooth, the relatively well developed aperture dentition and low spire indicate that *rosselli* is probably only distantly related, if at all, to other species of *Zoila*. This relationship will need to be re-evaluated when it becomes possible to examine well-preserved female specimens.

This species was discovered relatively recently and is still a rare shell in collections. The first specimens were collected on the beach at Leighton near North Wharf, Fremantle, by the late Mr. Harold Rossell of Subiaco (a suburb of Perth) in the 1920's, but it was not until 1947 that his specimens came to the attention of Mr. B. C. Cotton of the South Australian Museum, who described them in 1948. Rossell sent four shells to Mr. W. R. Steadman who presented one of them (the holotype) to the South Australian Museum. Rossell himself presented three other specimens to the Western Australian Museum in May 1947 (apparently unknown to Cotton) and retained several in his own collection, which was disposed of by his widow some years after his death. Unfortunately, Rossell dipped all his specimens in hydrochloric acid, so removing all trace of color from their dorsal surfaces and giving them an unnatural white finish.

Rossell (see Cotton, 1948, pp. 30-31) suggested that the shells may all have come from dredgings taken in Fremantle Harbour and dumped just off the beach between North Wharf and Leighton. However, at least one additional dead specimen has since been taken at Cottesloe Beach a few miles farther north (1955, WAM no. N874) and fragments have been dredged in 20 fathoms north of Rottnest Island. It seems at least as likely that the type series came from a living population somewhere off the mainland or north of Rottnest Island.

Mr. E. Nicholls of Mandurah picked up a dead shell on Binningup Beach, about 15 miles north of Bunbury (Hawaiian Shell News, vol. 10, no. 2, p. 7, December 1961). The first live specimen was a juvenile collected by Mr. Max Shaw at Perth while SCUBA diving in 35 fathoms west of Rottnest Island. Shaw and Mr. Kevin Morgan had dived to this great depth and found a beautiful reef with many sponges and other growths. Shaw found the young *rosselli,* which did not have its mantle extended, nestling in a crevice of a large fan-shaped sponge. The shell, sponges and other interesting objects were stuffed into a sack. On reaching the surface Shaw complained of severe cramps and was rushed back to Fremantle and to hospital where his difficulty was diagnosed as divers' paralysis or the "bends." He was placed in a recompression chamber and later recovered. The following day the contents of the sack were examined and out rolled the young live *rosselli.* It was several days before the specimen was brought to the senior author and by that time the animal was in an advanced state of decomposition, but some anatomical information was obtained from it.

As a result of publicity given to this story in the local press, the Western Australian Museum was inundated with cowry shells to be identified and within a few weeks two more fully adult and live-collected shells came to light. Both these specimens were taken from "craypots" set in 20 to 40 fathoms off the Western Australian coast. Since then several other specimens have been collected alive, one by Mr. Max Cramer under the wharf in Geraldton Harbour.

Undoubtedly this beautiful and most unusual species is rare only in collections because of its habitat in relatively deep water.

Habitat — Continental shelf from 3 fathoms to at least 40 fathoms. The specimen collected by Mr. M. Shaw off Rottnest Id. was found on a large fan-shaped sponge (not on fan-coral as stated by Cate, 1964, p. 23).

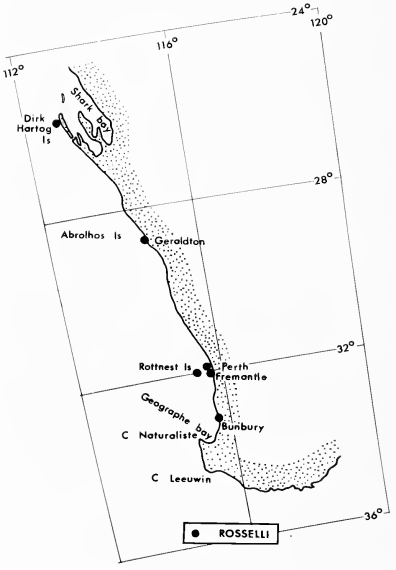

Plate 344. Geographical distribution of *Cypraea (Zoila) rosselli* in Western Australia.

Description – **Shell** ovate-pyriform. Dorsal hump high and rather steep posteriorly, maximum height just behind centre. Base broad and flattened, with sharply angulated margins. At the anterior end the outer lip slopes inward steeply, thereby increasing the angularity of the right extreme anterior margin, so forming a sharp edge; the left anterior and the right posterior margin are flanged and almost as sharp, but the sharpness of the left posterior margin is variable depending on the degree of indentation of the shell beneath the sides of the posterior channel. Anterior channels often almost vertical. Margins on both sides are curiously elevated in the centre, especially on the left side, and often irregularly indented, especially posteriorly on the right side. Sides of the anterior and posterior channels sharp and only slightly elevated. Spire low (compared to other species of the subgenus *Zoila*) and not usually visible in adult shells, being covered by depositions of shell. Aperture strongly curved, but only slightly dilated anteriorly.

Aperture dentition of shell – Teeth are present along both sides of the aperture. Labial teeth number 25 to 31; columellar teeth 18 to 26. Labial teeth short but quite strong; columellar teeth shorter and weaker; anterior columellar teeth only slightly longer than those on the medial region and do not extend up on to the deep fossula. Columellar terminal ridge obsolete.

Color – Dorsal ground color cream, sometimes with a faint pale-tan band anteriorly; ground color usually obliterated, except for a cream-colored patch on the dorsal hump, by dark chocolate-brown extending up from the sides. Base similarly brown, and there are no basal, lateral or dorsal spots. In one specimen (WAM no. 114-65) all that remains visible of the dorsal ground color is a pale longitudinal mantle line which divides to form a Y at both ends; the remainder of the shell is evenly colored dark chocolate-brown. Teeth brown; interstices white. Aperture and fossula white but color sometimes visible on the body whorl posteriorly.

Measurements (mm.) – Shell length varies from 42 to 57 mm. (maximum size *teste* Mr. Max Cramer, Geraldton). Range of the ratio width : length is 0.61 to 0.66.

Soft parts – The bodies of only two specimens have been examined, both in a condition from which little conclusive information could be obtained. Mantle relatively thick and black, bearing a few widely spaced papillae (too contracted to determine whether they were simple or branched); sides of foot black, head and eye tentacles pale-orange in the juvenile specimen and white in the adult (but because the black pigment had partly sloughed off the mantle and foot of both specimens due to the poor preservation, it is possible that lack of pigmentation of the head and eye tentacles may be an artificial consequence of the state of preservation).

Radula – The radula was successfully extracted from only one specimen (juvenile Rottnest Id. specimen). The following is given therefore as a tentative description of the radula of this species.

The lateral and marginal teeth resemble those of other species of *Zoila*, but are rather wider and the medial cusps shorter; the inner basal denticle of the lateral tooth is very much smaller than any other species. The medial tooth is rather high, bears no subtending bract and no basal denticles are evident. The internal dumb-bell-shaped bract of the medial tooth is high and prominent.

Synonymy –

1948 *Zoila rosselli* Cotton, Trans. Roy. Soc. So. Australia, vol. 72(1), p. 30, pl. 1, figs. 1-6.

Specimens dissected (cursory examination only) – One juvenile animal, collected by Max Shaw off Rottnest; soft-parts decomposed; radula mounted. One adult animal, collected by Max Cramer at Geraldton (shell not seen by us); soft-parts damaged during extraction from the shell.

Records – WESTERN AUSTRALIA: W. of Dirk Hartogs Id. (craypot, 30-40 fms., V. Lombardo, WAM); Geralton harbour (diving 2 fms., Max Cramer, see Cate, 1964); 5 mi. N.E. of Rottnest Id. (dredged 20 fms., Mariel King, "Hawaiian–W.A. Exp.," 1960, broken pieces, WAM); W. of Rottnest Id. (on sponge, 35 fms., Max Shaw, WAM); between North Wharf, Fremantle and Leighton Beach (beach specimens, H. Rossell, So. Aust. Mus., WAM and private collections); Mudarup Rocks, Cottesloe (beach collected, D. Wignall, WAM); Binningup Beach, 15 mi. N. of Bunbury (beach collected, E. Nickel, see Hawaiian Shell News, 1961, vol. 10, no. 2, p. 7).

INDEX TO **ZOILA** NAMES IN VOL. 1, NO. 8

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INDEX TO VOLUME 1, NUMBERS 1-8

Several indices have already been issued (Strombus, Turrinae, Pinnidae and Tridacnidae). They are not repeated here, except for the listings of all generic and subgeneric names. All **new names** proposed in volume 1 are listed in this index and are in **boldface** type. A list of issues and contributing authors appears in vol. 1, no. 8, p. 489 (p. 00-007).

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List of Issues	00-005
Guide to Contents	00-100
Phasianellidae	04-000
Strombidae	09-650
Cassidae	12-400
Vasidae	20-400
Turridae	22-500
Pinnidae	53-500
Tridacnidae	62-000
Replaced Pages	95-000

List of Issues

Volume 1	*Subject*	*Author*	*Date of Publication*	*no. pp.*	*First page of looseleaf*
no. 1, pp. 1- 14	Introduction	Editors	Mar. 31, 1959	14	00-003
15- 32	Vasidae	R. T. Abbott	"	18	20-403
2, 33-146	Strombus	R. T. Abbott	Nov. 23, 1960	114	09-831
3, 147-174	Lambis	R. T. Abbott	Sept. 28, 1961	38	10-051
4, 175-226	Pinnidae	J. Rosewater	"	52	53-501
5, 227-346	Turrinae	A. W. B. Powell	Mar. 31, 1964	120	22-661
6, 347-396	Tridacnidae	J. Rosewater	Apr. 30, 1965	50	62-003
397-398	Strombus oldi	W. K. Emerson	"	2	09-881
399-400	Strombus listeri	T. Okutani	"	2	10-001
401-402	Miocene Indian Strombus	R. T. Abbott	"	2	09-945
403-406	Turrinae (replacement)	A. W. B. Powell	"	4	22-947
407-408	Issues and Changes	Editors	"	2	00-005
7, 409-444	Turrinae (concluded)	A. W. B. Powell	May 15, 1967	36	23-101
445-454	Terebellum	Jung and Abbott	"	10	09-801
455-456	Strombus wilsoni	R. T. Abbott	"	2	09-919
8, 457-484	Cypraea (Zoila)	Wilson and McComb	Dec. 8, 1967	28	10-457
485-488	Index to vol. 1	Editors	"	4	91-001
489-490	Issues and Changes	Editors	"	2	00-007

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INTRODUCTION

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