INDO-PACIFIC MOLLUSCA

Monographs of the Marine Mollusks of the Tropical Western Pacific and Indian Oceans

EDITED BY

R. TUCKER ABBOTT

VOLUME I

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THE DEPARTMENT OF MOLLUSKS
Academy of Natural Sciences of Philadelphia
Philadelphia, Pennsylvania, U.S.A.

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INTRODUCTION

INDO-PACIFIC MOLLUSCA is a journal devoted to the taxonomic revision of the marine mollusks of the tropical Western Pacific and Indian Oceans. For two hundred years many thousands of Indo-Pacific mollusks have been described in numerous and widely scattered publications with little or no correlation with previous reports nor in relation to species described from other nearby islands and provinces of this rather uniform region. This has resulted in many synonyms, the unwarranted treatment of some forms as full species, wide variation in nomenclature, and, in some cases, considerable duplication of research and effort.

Purpose of the Journal

Although taxonomic malacology, particularly of the Indo-Pacific, is to a great extent still in the descriptive and cataloging stages, with many new species yet to be described, it has seemed advisable to begin this series of taxonomic monographs, so that all the available information can be drawn together and a careful evaluation made of the known species. While the monographs in this journal may be considered to be "up to date", experience tells us that no scientific effort is either perfect or complete. Newly collected material, a re-examination of characters, differences of opinion, or necessary revisions in nomenclature all contribute towards changes, a better understanding and an improved classification of species.

Method of Publication

To help reduce the confusion caused by additions and changes which inevitably arise when a new monograph stimulates further research, this journal is published in a form which permits it to be either bound in the normal manner or kept in looseleaf fashion. While most of our efforts will be directed towards genera and families that are still in need of revision, there will be some effort to keep previously published monographs "up to date" by adding newly discovered species, important changes in nomenclature or new information concerning habitats, geographical records and anatomy. These supplements will be issued at the close of each volume in the form of a Review Number, and those subscribers maintaining their journal in looseleaf form need only slip the additional pages in the appropriate places. Monographs will be undertaken in groups where sufficient material and competent specialists are available. Numbers will be published at irregular intervals, as research is completed, but it is hoped that a yearly minimum of a hundred pages will be maintained.

Regional Scope of the Journal

This journal attempts to cover the species which are mainly confined to the extensive tropical marine region known as the Indo-Pacific. This is a fairly uniform province embracing the Indian and tropical West Pacific Oceans. It extends from the east coast of Africa across the Indian Ocean (to the north half of Australia and the south half of Japan) and eastward through the Hawaiian Chain and Polynesia to Easter and Clipperton Islands. In malacological terms, the Indo-Pacific may be generalized as that region coinciding with the distribution of such common species as *Cypraea caput-serpentis* Linné, *Conus ebraeus* Linné, *Nerita albicilla* Linné and *Antigona reticulata* (Linné). Within this region there are several provinces which contain endemic species or exclude certain otherwise widely distributed species.

In cases where a genus or family is predominantly Indo-Pacific, the few additional species which occur in other regions of the world will also be included. Pelagic groups, such as *Janthina*, *Recluzia*, the Pteropods, and certain cephalopods will be treated from a worldwide standpoint because of their universal distribution.

Scientific Names

The scientific names employed by the authors of these monographs are those which are considered to be the most acceptable under the present rules and recommendations set down by the International Commission on Zoological Nomenclature. When personal opinion is involved, the name most widely used has been accepted.

Synonymies

The first reference under the species heading is to the original citation, and all subsequent references are to known or supposed synonyms. Other references may be included to demonstrate previous general placement or lead to additional information, such as anatomy, habits, new localities, etc. The geographical name appearing in parentheses refers to the original locality as cited by the author.

Measurements

Measurements of specimens are made in millimeters (25.37 mm. = 1 inch). Except where extensive measurements may be necessary, we generally list only an example of a *large* (the largest we have

seen), *average* (a specimen that appears typical in size for the species and not the average of a long series of measurements), and *small* specimen (given only when a small specimen can be determined as adult).

Common Name

The usage of common names is a very hazardous one because of the wide variation in local names. However, in most cases we have given the name which appears to be most generally in use. In other cases we have coined suitable names for those species which have never received a vernacular name.

Range

The range is a general statement of the geographical distribution of a species, and is based mainly upon specimens we have examined, although some purportedly reliable records from the literature are used. Because of the great need for collections from many areas in the Indo-Pacific, these ranges are not necessarily final. It should also be realized that the special habitat preferences of the various species, such as for mangroves, reefs, rocky shores or sandy bays, may result in the species being absent in certain large areas not offering a suitable environment.

Locality Records

All records are based upon specimens examined by the author of a monograph. Only in rare instances have we used records from the literature, and in these cases have indicated the identifier. Because of the vast area covered and the numerous localities involved, we have omitted those which are very close to each other, and in other cases abbreviated the information to read, for example, "present on 13 of the 26 islets of Bikini Atoll." After each record the name of the museum or private collector is included in parentheses. The following abbreviations refer to the major natural history museums containing large collections of Indo-Pacific mollusks:

ANSP—Academy of Natural Sciences of Philadelphia
Auck. Mus.—Auckland Institute and Museum, N.Z.
Aust. Mus.—Australian Museum, Sydney
BPBM—Bernice P. Bishop Museum, Honolulu
BM—British Museum (Natural History), London
Domin. Mus.—Dominion Museum, Wellington, N.Z.
MCZ—Museum Comparative Zoölogy, Cambridge, Mass.
Nat. Mus. Vict.—National Museum of Victoria, Melbourne
NSF—Natural Science Foundation Expedition, deposited in the ANSP.
So. Aust. Mus.—South Australian Museum, Adelaide
USNM—United States National Museum, Wash., D. C.

Order of Listing Locality Records

Our locality records are listed in a general west to east order (Africa to Galapagos), and secondarily from north to south. The following list of localities is a general outline, and does not mention every island. This is also the sequence in which many museums keep their collections of a single species when there are numerous lots in a drawer.

AFRICA
Natal to Somalia (including the islands of Socotra, Pemba, Zanzibar, Mafia)
Red Sea and Gulf of Aden
Persian and Oman Gulfs

INDIAN OCEAN ISLANDS
Madagascar (and Comores, Aldabra)
Seychelles, Mauritius, Reunion, Rodriquez, Maldives, Laccadives, Chagos

SOUTH ASIA
West Pakistan, India, to the Ganges
Ceylon
Bay of Bengal Islands (Andamans and Nicobars)
Burma and Malay Peninsula

SOUTHEAST ASIA
Korea to southern China; Hainan
Japan, Ryukyus, Taiwan
Philippines
East Indies (Indonesia), Cocos Keeling

AUSTRALIA

MELANESIA
New Guinea, Admiralty, Solomons, to New Caledonia, Lord Howe and Kermadecs

MICRONESIA
Bonins, Marianas, Palaus, Helen Reef, Carolines, Wake, Marshall and Gilberts

POLYNESIA
Hawaiian Chain
Line Islands, Johnston, Ellice, Samoa, Tonga, the Cooks, Society, Marquesas and the Tuamotus

EASTERN PACIFIC
Easter, Clipperton and Galapagos

Ecology

Under this section all ecological data have been included, although it is surprising how little information is available even for the common species. There is also some limitation to the value of some of the published habitat records, since we have no way of knowing if the identifications of the mollusks in question are correct or not. Collectors in the Indo-Pacific area can add much valuable information by recording simple observations on the relative abundance, habitat, habits and living animals of the species collected. A sample of the

species studied should be sent to one of the several museums specializing in mollusks, so that taxonomists will be able to correlate the ecological information with the correct species. The following outline suggests the type of data most needed.

Species number or name

Geographical locality

Date and collector

Relative abundance

Habitat

- Above tide line
- Intertidal
- Offshore depth

Substrate

- Rock, sand, mud, coral, algae or other

Relation to substrate

- Atop, buried, attached to, or rock burrower
- Other

Type of water

- Motion
- Temperature
- Turbidity
- Other

Living habits

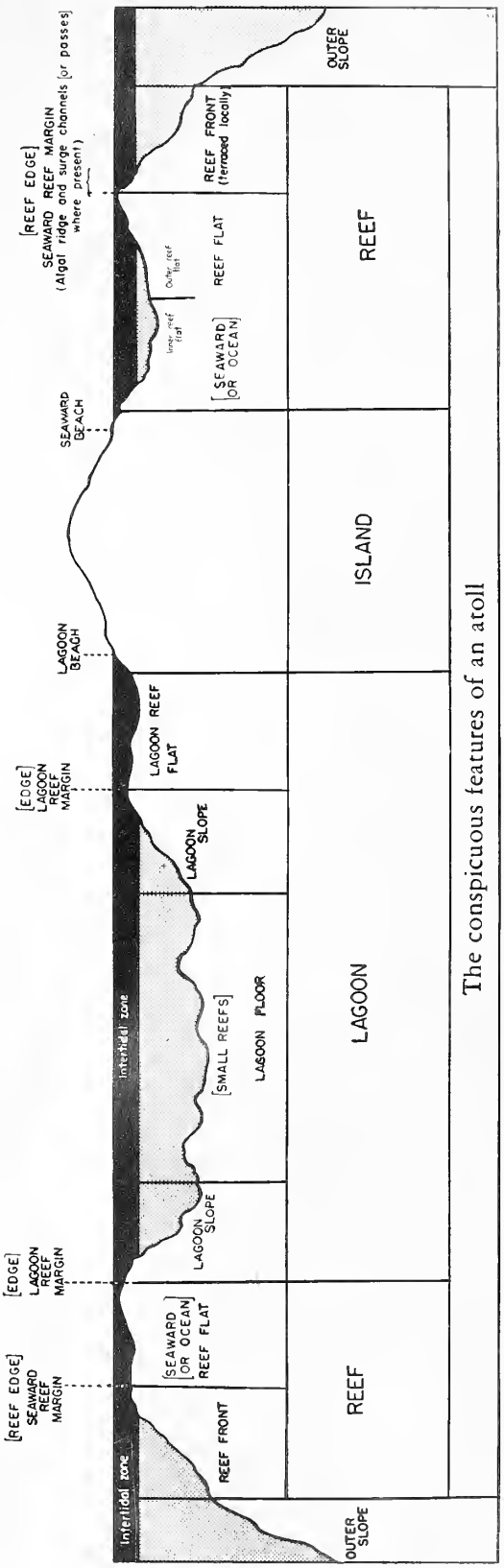
- Solitary or gregarious
- Nocturnal or diurnal
- Special behavior
- Method of feeding
- Food
- Method of locomotion
- Associations with other organisms
- Breeding and eggs

Enemies

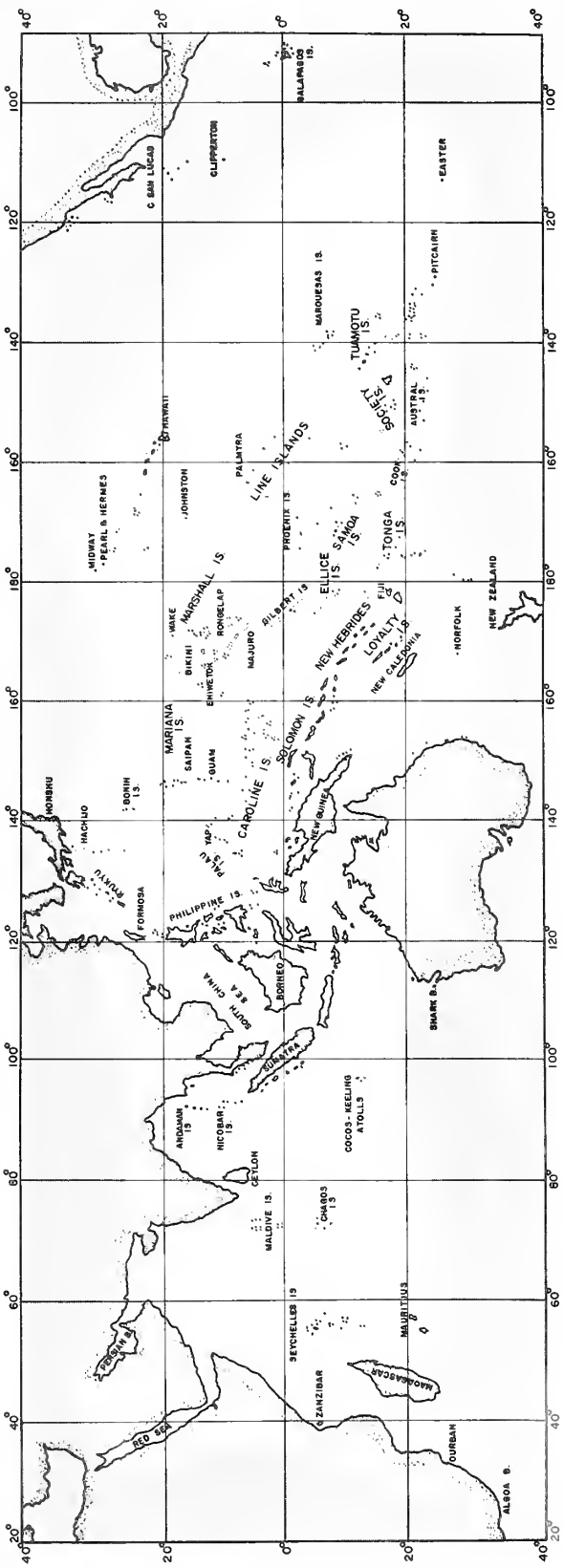
The living mollusk

- Shape
- Color

For those interested in recording detailed information on mollusks collected on coral reefs and atolls, we recommend the reef terminology employed by Joan Demond (Micronesian Reef-associated Gastropods, Pacific Science, vol. II, no. 3, pp. 275-341, July 1957). A similar terminology appeared in mimeographed form in the Atoll Research Bulletin, Washington, D. C., no. 46, 3 pp., 2 figs. 1955 (Tracey, Emery and Cloud).



Cross section of a coral atoll showing reef terminology. (Modified from J. Demond, 1957).



←⋘ Generalized map of the approximate limits of the Indo-Pacific region upon which the monographs in this journal are based. In cases where a genus or family is predominantly Indo-Pacific, the few additional species which occur in other regions of the world are also included in the monographs.

GUIDE TO CONTENTS

The classification of the Phylum Mollusca outlined below by families is largely taken from J. Thiele's Handbuch der Systematischen Weichtierkunde, Jena, vols. 1 and 2, 1929-1935, and from W. Wenz's Handbuch der Paläozoologie, Berlin, vol. 6, 1639 pp., 1938-1944. This list contains all of the recent marine groups. Names in square brackets refer to land and fresh-water groups which are not covered in this journal.

The page numbers refer to the looseleaf pagination found at the bottom of each sheet.

INDO-PACIFIC MOLLUSCA

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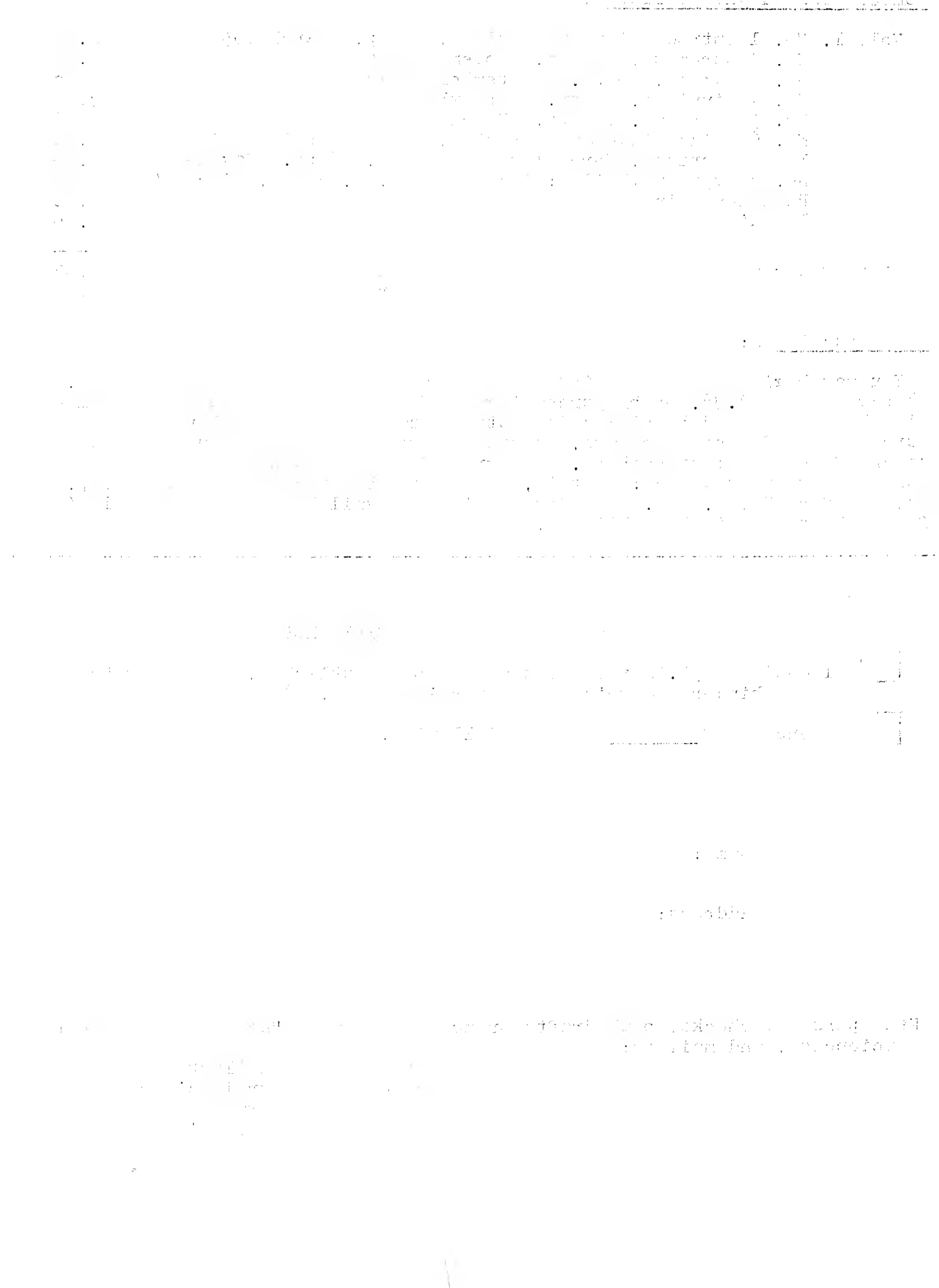


THE FAMILY VASIDAE IN THE INDO-PACIFIC

by R. Tucker Abbott
Pilsbry Chair of Malacology
Academy of Natural Sciences of Philadelphia

The family Vasidae, a worldwide and warm water group of marine gastropods, belongs to the superfamily Volutacea. Because of radula and columellar plicae differences, the family is divided into two major parts—the subfamily Vasinae which includes the Vase shells and the subfamily Xancinae which contains the large Chank shells.

Subfamily Vasinae

Shells usually large, heavy, usually prominently sculptured, and with 2 to 6 irregularly-sized columellar plicae on the lower half of the inner parietal wall. Periostracum thin to heavy. Operculum horny, brown, unguiculate and curved. Radula rachiglossate, with 3 strong teeth, the central bearing 3 strong cusps, the lateral with two cusps. (In the Xancinae, the columellar plicae are located much higher up on the inner parietal wall, and the lateral radular tooth has only one large cusp).

Here, we are dealing with all the known Recent species of the subfamily Vasinae, except those found in the Western Atlantic (see Abbott 1950, Johnsonia, vol. 2, no. 28). Of the twenty known species, five are Western Atlantic, twelve Indo-Pacific, one South Australian, one Panamic and one South African. Most of these species live in the intertidal zone or in very shallow water, although the South Australian species has been dredged at a depth of 120 fathoms. Some prefer reef flat habitats, while others are found on sandy and/or grassy bottoms. Little is known about their biology, except that they feed on clams (and possibly marine worms). The sexes are separate.

The genera now assigned to the subfamily are *Eovasum* Douvillé 1920 (Eocene of Africa and South America), *Vasum* Röding 1798 (Recent, worldwide), *Tudicla* Röding 1798 (Recent, Indian Ocean) and *Tudicula* H. and A. Adams 1863 (Recent, Indo-Pacific). Wenz (1943, p. 1306) also places the genera *Afer* Conrad 1858, *Metzgeria* Norman 1879, *Ptychatractus* Stimpson 1865 and *Piestochilus* Meek 1864 in this subfamily, but further research is evidently needed before accepting these placements.

Genus Vasum Röding

1798 *Vasum* Röding, Museum Boltenianum (2), p. 56. **Type** by subsequent designation (see Abbott 1950, p. 208): *V. turbinellus* Röding 1798 = *Murex turbinellus* Linné, 1758.

1810 *Volutella* Perry, Arcana or the Museum of Natural History, signature B 1, pl. 2. **Type** by monotypy: *V. divergens* Perry 1810 = *V. muricatum* Born, 1778.

1817 *Cynodonta* Schumacher, Essai Nouveau Système Habit. Vers Test., p. 73. **Type** by monotypy: *Voluta ceramica* Linné. (*Cynodona* on p. 241 is a spelling error.)

1835 *Scolymus* Swainson, Elements of Modern Conchology, p. 21; 1840, Treatise Malacology, p. 304. **Type** by subsequent designation (Abbott 1950, p. 208): *S. cornigerus* Chemnitz = *turbinellus* Linné, 1758.

The subgenera employed in the genus *Vasum* are rather nebulous in character, and it is possible that as other species are discovered, especially among the fossils, the differences will become less recognizable. At first glance, there seems little conchological similarity between *Vasum (Altivasum) flindersi* of South Australia and *Vasum (Globivasum) globulus* of the West Indies, yet a more or less gradual transition of generic shell characters may be seen between them in such species as *horridum* Heilprin (Pliocene of Florida), *ceramicum* Linné (Indo-Pacific) and *capitellum* Linné (West Indies). The subgenera of *Vasum* are:

Subgenus *Vasum* Röding, 1798. Type: *turbinellus* Linné, 1758.

Subgenus *Altivasum* Hedley, 1914. Type: *flindersi* Verco, 1914.

Subgenus *Siphovasum* Rehder and Abbott, 1951. Type: *latiriforme* Rehder and Abbott, 1951 (Caribbean).

Subgenus *Globivasum* Abbott 1950. Type: *globulus nuttingi* Henderson, 1919 (Caribbean).

Subgenus Vasum Röding 1798

(for synonymy see under the genus *Vasum*. The type is *Vasum turbinellus* Linné, 1758.)

The shells in this subgenus are fairly large (2 to 5 inches in length), heavy, with slightly to moderately produced spines, and with 3 to 5 columellar plicae. The spire is moderately high, and the siphonal canal short.

Only two of the Indo-Pacific *Vasum* are widely distributed, these being the coral reef species *turbinellus* and *ceramicum* which extend over most

of the Indian and Western Pacific Oceans. The other five species are rather limited in their range, such as *V. tubiferum* which is only found in the Cuyo-Palawan section of the Philippines and *V. rhinoceros* which is known only from British East Africa.

Key to the Indo-Pacific *Vasum* *sensu stricto*

a	Shell nodulated, without spines	*truncatum*
a	Shell with blunt or sharp spines	b
b	Inside of outer lip with black spots	c
b	Inside of outer lip without black spots	d
c	Lower third of columella without black	*armatum*
c	Lower third of columella and lower part of outer lip with black	e
d	Columellar plicae 3; parietal wall yellow-brown	*rhinoceros*
d	Columellar plicae 5; parietal wall purple-brown	*tubiferum*
e	Spire high; 3 columellar plicae strong	*ceramicum*
e	Spire low; 4 to 5 columellar plicae unequal	*turbinellus*

(*Vasum crosseanum* Souverbie is known from a single specimen which we have not seen nor included in this key.)

Plate 1, fig. 1, *Vasum ceramicum* (Linné), Philippines; fig. 2, *Vasum turbinellus* (Linné), New Guinea; fig. 3, *Vasum turbinellus* form *cornigerum* (Lamarck), Red Sea; fig. 4, *Vasum armatum* (broderip), Tuamotu Islands. All natural size.

Vasum (Vasum) turbinellus (Linné, 1758)

(Pl. 1, figs. 2, 3; pl. 2, fig. C)

Range—East Africa to western Polynesia.

Remarks—This is the commonest *Vasum* in the Indo-Pacific and is generally abundant wherever it occurs. It is distinguished by its relatively low spire, by the 3 strong columellar plicae between which are two additional smaller ones, and by the black, slightly raised teeth on the inner edge of the outer lip which are not bifid or in pairs as in *Vasum ceramicum*. *V. armatum* which has a pure-white columella and whose two peripheral rows of spines are almost equal in size replaces *turbinellus* in the central and eastern portions of Polynesia. Since *Vasum* is a neuter noun, adjectival names of species have a neuter ending; however, the name "turbinellus" is a substantive noun, meaning a "top" or "little whirlwind", and should not be changed to *turbinellum*.

The length of the spines on the shoulder of the shell of *turbinellus* varies considerably, and throughout the range of the species, particularly in the Red Sea, they may be very long and curled upward. These specimens may be referred to as **form** *cornigerum* Lamarck, 1822 (Pl. 1, fig. 3).

Habitat—*V. turbinellus* lives in shallow water from the low tide mark to a depth of about 30 feet. In some areas, it is fairly common on the reef flats where, during the day, it takes shelter under dead coral rocks. In other areas, it may be found on a bottom of sand, coral rubble and sparse eelgrass.

Description—Adult shell 30 to 80 mm. in length (1 to 3 inches), solid, heavy, turbinate and strongly spined. Spire moderately elevated. Whorls 7 to 9, the body whorl bearing at the shoulder 8 to 9 stout, blunt, upwardly pointing spines which are slightly open at their ends; immediately below is a similar row of much smaller spines. The middle of the whorl bears 2, rarely 3, spiral cords which may each bear 8 to 15 small knobs. At the base of the shell there are three rows of 7 to 8 bluntly conical spines. Suture indistinct and wavy. Parietal wall glazed, yellowish white with black-brown mottlings. Columella with three large plicae between which may be 2 additional, smaller ones. Outer lip slightly thickened, somewhat crenulated, creamy-white with 4 to 6 squarish black spots over the slightly raised, short teeth on the outer lip. Lower third of columella usually with a brownish stain. Umbilicus absent or rarely a small indentation. Color of outer shell grayish with sparse or heavy blackish brown mottlings. Periostracum thin, weakly foliaceous, and grayish yellow or gray-brown in color. Operculum fills most of the inner aperture, corneous, blackish and unguiculate.

Measurements (mm.) (including spines)—

length	width	no. whorls	
85	73	6	(large; Duteh New Guinea)
50	48	6	(average; Palau Islands)
44	35	6	(small; Marshall Islands)

Synonymy—

1758 *Murex turbinellus* Linné, Systema Naturae, ed. 10, p. 750, no. 466 (in O. Asiatieo ad Nussaanan); refers to Rumphius Mus., pl. 24, fig. B, and others.

1767 *Voluta turbinellus* Linné, Systema Naturae, ed. 12, p. 1195, no. 430; 1955, Dodge, Bull. Amer. Mus. Nat. Hist., vol. 107, art. 1, pp. 127-129.

1811 *Volutella nigra* Perry, Conchology, London, pl. 26, fig. 1 (Afriean Seas).

1822 *Turbinella cornigera* Lamarek, Anim. sans Vert., vol. 7, p. 105, no. 7 (Moluques); 1840, Kiener, Coquilles Vivantes, vol. 6, Turbinelle, pl. 1

1822 *Turbinella variolaris* Lamarek, Anim. sans Vert., vol. 7, p. 110 (loeality not given); 1840, Kiener, Coquilles Vivantes, vol. 6; Turbinelle, pl. 21, fig. 1 (a young, worn speeimen).

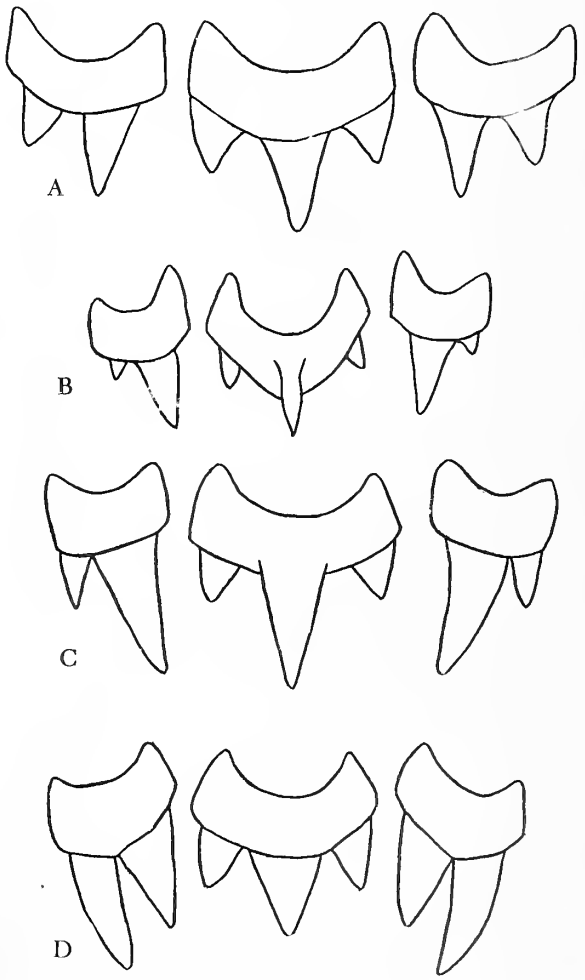


Plate 2. Single rows of radulae from adult *Vasum* (greatly enlarged). Fig. A, *Vasum rhinoceros* (Gmelin), Zanzibar; B, *Vasum armatum* (Broderip), Toau Atoll; C, *Vasum turbinellus* (Linné), Philippines; D, *Vasum ceramicum* (Linné), Philippines.

Types—Linné's type locality is "ad Nussaanan," a place quoted from Rumphius and probably referring to the small islet of Nusa Laut, to the east of Ambon near Saparoea and Haroekoe (formerly Ona) Islands, Indonesia. Possible cotypes of *turbinellus* are in the Linnaean Society collection in London (Dodge, 1955, p. 128).

Locality records — See accompanying map, p. [20-406] solid dots: specimens examined; open circles: from the literature. *Selected records:* SOUTH AFRICA: Natal (Natal Mus.). EGYPT: Berenice, Foul Bay (ANSP) SAUDI ARABIA: Jedda (C. Aslakson, ANSP). KENYA COLONY: Mombasa (B. Verdcourt; ANSP). RYUKYU IDS.: Okinawa (W. A. McCarty, ANSP). POLYNESIA: Vailele Bay, Upolu Id.; Samoan Ids. (N.S.F.); Johnston Id. (D. Thaanum); Howland Id. (Ted Dranga, ANSP).

Vasum (Vasum) armatum (Broderip, 1833)

(Pl. 1, fig. 4; pl. 2, fig. B)

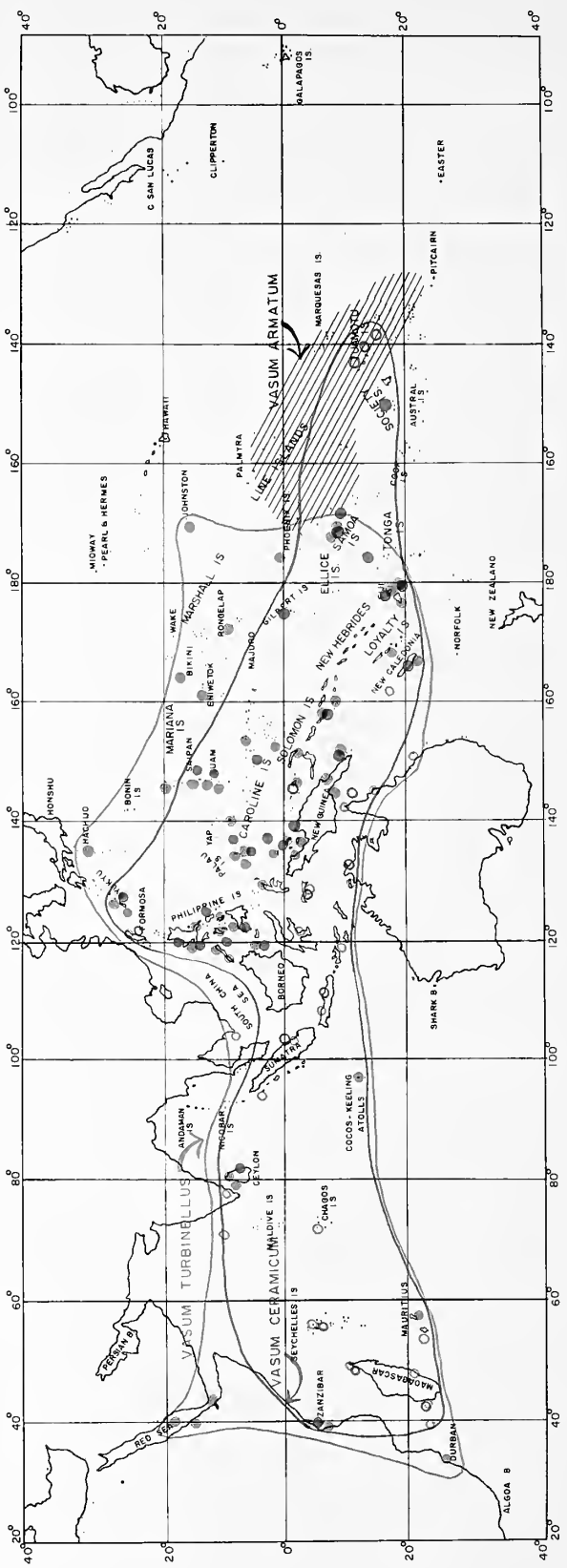
Range—Eastern Polynesia from the Phoenix Islands to the Tuamotu Islands (not Hawaiian Islands).

Remarks—The fusiform shape, white lower columella, and the two rows of equal-sized, conic spines at the shoulder distinguish this Polynesian species from *turbinellus*. Tryon (1882, Manual of Conchology, vol. 4, p. 72) considered this species as a synonym of *ceramicum*. This species appears to be limited to low coral islands and atolls of eastern Polynesia.

"Animal above pale flesh-colour, finely mottled with purplish; siphon and locomotive disk salmon-coloured; eyes on a bulbous expansion near tip of tentacles. Operculum yellowish" (Couthouy's notes in Gould 1852).

Habitat—This appears to be a moderately common to abundant species in pockets of sand on the reef flats facing the open ocean in the intertidal zone.

Description—Adult shell 23 to 70 mm. in length (usually about 52 mm.) (1 to 2¾ inches). Solid, heavy, somewhat fusiform, and moderately heavily spined. Spire elevated. Whorls 6 to 7, the body whorl bearing at the shoulder two rows of 7 to 8 almost equal-sized, conic spines which are slit along their anterior faces. The middle of the whorl bears 3 or 4 small, rough, spiral cords, below which is first a single row of small, well-developed spines, and then, at the base, 1 or 2 rows of weak nodules. Suture indistinct and wavy. The entire outer shell has numerous, coarse, raised, wavy threads. Parietal wall glazed, enamel-white, and rarely with brown markings at the top. Columella white, usually with



4 equal-sized, slanting plicae, rarely with a weak fifth. Inside of body whorl with about 8 small, raised spiral cords. Outer lip thickened and with 4 or 5 pairs of black, rounded teeth. Umbilicus absent. Color of outer shell bluish gray to grayish white with diffused mottlings of bluish brown which are usually more concentrated in a band just below the suture and on the middle of the last whorl. Periostracum thin, translucent, weakly foliaceous. Operculum corneous, claw-shape, light yellowish brown in color, and with its outer surface with very coarse, uneven lines of growth which give it a gnarled appearance.

Measurements (mm.) —

length	width	no. whorls	
74	57	7+	(large; Henderson Atoll)
36	30	7	(average; Henderson Atoll)
26	18	7	(small; Henderson Atoll)

Synonymy —

1833 *Turbinella armata* Broderip, Proc. Zool. Soc. London, vol. 1, p. 7 (ad Insulam Elizabethae); 1847, Reeve, Conch, Icon., vol. 4, Turbinella, pl. 5, fig. 29; 1876, Kobelt, Syst. Conchyl. Cab., vol. 3, no. 3, pl. 16, fig 2 (good).

1852 *Turbinella armata* Broderip, Gould, U.S. Exploring Exped., vol. 12, p. 238, pl. 17, figs. 290, 290a, 291 (animal).

1933 *Vasum ceramicum* var. *armata* Broderip, Dautzenberg and Bouge, Journ. de Conchyl., vol. 77, p. 206. (Anaa Atoll).

Type Locality—On coral reef, Elizabeth Island [Henderson Id., Tuamotu Islands] Hugh Cuming, collector. The types are in the British Museum. Possible cotypes are in ANSP 35230.

Locality records—TUAMOTU ISLANDS: Puka-puka Id. (Honden Id., Gould 1852, p. 238); Toau Atoll (H. A. Pilsbry); Takaroa Atoll (H. A. Pilsbry); Fakarava Id., Makemo Id., Tikahau Atoll, Raroia Atoll (all USNM). Henderson Id., near Pitcairn (Cuming). Flint Island (USNM). Fanning Island (B. P. Bishop Museum). PHOENIX ISLANDS: Hull Id. (USNM). EASTERN SAMOA: Rose Atoll (USNM). See accompanying map, p. [20-406].

Vasum (Vasum) ceramicum (Linné, 1758)

(Pl. 1, fig. 1; pl. 2, fig. D)

Range—British East Africa to eastern Polynesia.

Remarks—The Ceram Vase is the largest member of this genus in the Tropical Indo-Pacific province, being exceeded in size only by *Vasum (Altivasum) flindersi* Verco of South Australia. It is distinguished from the smaller and commoner *V. turbinellus* by its high spire, three strong, slanting columellar plicae (rarely with one or two additional weak plicae), and the small *paired* teeth on the inside of the outer lip. It differs from *armatum* of eastern Polynesia in having a blackish brown patch on the lower end of the columella. Tryon (1882, Manual of Conchology, vol. 4, p. 72) erroneously considered *Latirus vexillulum* (Reeve) a synonym.

Habitat—Moderately common in surging waters off the front edge of coral reefs, usually in depths of 3 to 30 feet.

Description—Adult shell 80 to 140 mm. in length (3 to 5½ in.). Solid, heavy fusiform, and rather strongly spined. Spire elevated. Whorls 9 to 11, the body whorl bearing at the shoulder 7 to 10 strong, somewhat triangular, outwardly projecting spines which are slit open on their anterior faces; immediately below are two similar rows of much smaller spines. Below this are 2 to 4 small, rough spiral cords. The base of the shell bears 1 or 2 rows of small spines. Suture indistinct and wavy; below it on the upper part of the shoulder there are 4 to 6 distinct, raised, spiral threads. Parietal wall glazed, all white or sparsely mottled with black-brown. Columella with 3 very strong, slightly slanting, squarish plicae between which are rarely 1 or 2 more very weak plicae. There are a dozen or so weak, white, spiral cords within the aperture on the inside wall of the body whorl. Outer lip slightly thickened, crenulated and bearing 5 or 6 pairs of small, black, raised teeth. Lower fourth of the columella usually with a brownish black stain. Umbilicus chink-like and shallow. Color of outer shell whitish with heavy mottlings of black or black-brown. Periostracum thin, varnish-like, translucent brown, somewhat foliaceous. Operculum fills most of the inner aperture, is corneous, claw-shaped, blackish, and with a muscle scar of a little more than ⅔ the area of the inner side. Odontophone ¼ the length of the shell, and with 150 rows of radular teeth (see pl. 2, fig. D).

Measurements (mm.) (including spines)—

length	width	no. whorls	
148	94	9+	(large; Guam Id.)
125	81	9+	(average; Zanzibar)
81	56	7+	(small; Guadalcanal Id.)

Synonymy —

1758 *Murex ceramicus* Linné, Systema Naturae, ed. 10, p. 751, no. 470 (O. Asiae ad Ceram). Refers to Rumphius, pl. 24, fig. A, pl. 49, fig. L; Bonanni, pl. 286; and others.

1767 *Voluta ceramica* Linné, Systema Naturae, ed. 12, p. 1195, no. 432; 1955, Dodge, Bull Amer. Mus. Nat. Hist., vol. 107 art. 1, p. 130-132.

1807 *Turbinellus spinosus* G. Fischer (von Waldheim), Museum Demidoff, Moscow, p. 205 (Tranquebar et Nicobar). Refers to Gualtier, pl. 55, fig. D; Lister, pl. 829-51; Chemnitz Conchyl.-Cab., vol. 11, figs. 1725, 1726, the latter being *turbinellus* Linné.

Types—The type locality is Ceram Island, Indonesia. The possible type is in the Zoological Museum of the University of Uppsala, Sweden (Dodge, 1955, p. 131).

Locality records—(see accompanying map). *Selected records*: ZANZIBAR: Chango Id.; Pange Id.; Chumbe Id. CEYLON: Hikkaduwa (G. F. Kline, ANSP). NEW GUINEA: Wombrisau, Biak Id. (NSF). SOLOMON ISLANDS: Lunga, Guadalcanal (ANSP). CAROLINES: Ifaluk Atoll (USNM); Round Rock, Helen Reef (NSF); PALAU ISLANDS: Babelthuap Id. (NSF); Koror Id. (NSF). GILBERTS: Apamama (USNM). RYUKYU ISLANDS: Okinawa Id. (W. A. McCarthy, ANSP). FIJI ISLANDS: Makuluva Id., and Suva, Viti Levu Id. (USNM); Bega Id. (ANSP). NIUAFOU ISLAND (USNM). SAMOA: Fagalii Bay, Upolu Id. (NSF). SOCIETY ISLANDS: Moorea Id. (USNM).

Vasum (Vasum) tubiferum (Anton, 1839)

(Pl. 4, fig. 1; pl. 3)

Range — Cuyo Islands, west central Philippines (also Mindanao Island ?).

Remarks—The Imperial Vase is a very distinctive and highly localized species known, so far, only from one area in the Philippines. It resembles *V. turbinellus*, but differs in having a deep and funnel-shaped umbilicus, purple to lavender splotches on the parietal wall, a "furry" brown periostracum and lacking black spots on the inside of the outer lip. Conchologically, this species most resembles *V. rhinoceros* from East Africa. Melvill and Standen (1895, Jour. Conch., vol. 8, p. 104) report this species from Lifu Island, Loyalty Islands, but I suspect these may be *turbinellus*. I am indebted to Dr. Ramon Lim of Cuyo City, Palawan, for sending preserved specimens for study.

Habitat—A Philippine shell collector told us that this is a moderately common species found in very shallow water in quiet bays where there is a sand and eelgrass bottom.

Description—Adult shell 60 to 116 mm. in length (about 2½ to 4½ inches). Solid, heavy, turbinate and strongly spined. Spire rather well elevated. Whorls about 7, the body whorl bearing at the shoulder 8 long, upwardly curving spines which are flaringly open at their ends. Below are 4 or 5 spiral, coarse cords of decreasing size which may bear raised nodules or very small open-faced spines. Base of the shell with a row of well-developed, open-faced spines, below which are two much weaker rows of low, scale-like spines. Suture indistinct. Parietal wall well-developed, slightly raised, glazed and colored a light tan with large splotches of chestnut- or purple-brown. Columella bears 5 plicae, the upper, lower and middle ones being the largest. Interior of aperture white and smooth. Outer lip thickened, slightly reflected, coarsely crenulated, and tan or whitish in color. Lower third of columella white. Umbilicus funnel-shaped and deep. Color of outer shell orange-brown to yellowish. Periostracum thick, brown, and strongly foliaceous. Operculum corneous, dark-brown, unguiculate, and its exterior with fine, irregular growth lines.

Measurements (mm.) (including spines)—

length	width	no. whorls	
116	90	7	(large; Cuyo Id.)
88	70	7	(average: Cuyo Id.)
74	60	8	(small; Cuyo Id.)

Synonymy —

1839 *Turbinella tubifera* Anton, Verzeichniss der Conchyl., Halle, p. 70 (no locality); 1876, Kobelt, Syst. Conchyl. Cab., vol. 3, no. 3, p. 155, pl. 9, fig. 3.

1842 *Turbinellus imperialis* Reeve, Conch. Systematica, vol. 2, p. 181, pl. 229, fig. 4 (no locality); 1843, Reeve, Proc. Zool. Soc. London, vol. 10, p. 198 (no locality); 1847, Reeve, Conch. Iconica, vol. 4, Turbinella, pl. 5, fig. 28 (Cagayan, Island of Mindanao, Philippines).

Types—Anton gave no locality; nor did Reeve in 1842 and 1843 for his *imperiale*. In 1847, Reeve states that Hugh Cuming collected it at Cagayan, Island of Mindanao, Philippines. I have looked for this species at Cagayan and elsewhere on Mindanao without success, and it is possible that Cuming meant Cauayan Island in the Cuyo—Palawan group where this species is known to exist. Reeve's type in the British Museum is 78 mm. in length, and the purple-brown on the parietal wall has faded to brown.

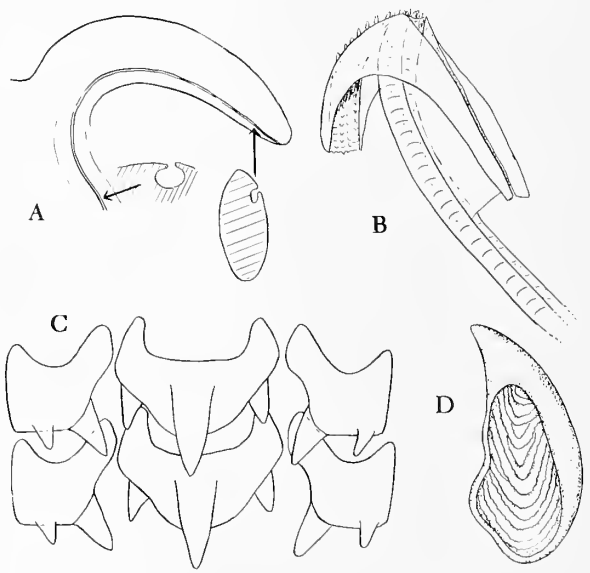


Plate 3. *Vasum tubiferum* (Anton), Cuyo Id., Philippines. Figs. A, external verge, showing cross-section; B, three-quarter view of odontophore; C, two rows of radular teeth; D, attachment side of operculum.

Records—Hugh Cuming is supposed to have collected this species at Cagayan, Misamis Prov., Mindanao Id., Philippines, although there is some doubt about this. A Philippine shell collector brought us two dozen specimens during the 1958 du Pont—Academy Expedition which he had collected on Cuyo Island, Palawan Province, Philippines.

Vasum (Vasum) rhinoceros (Gmelin, 1791)

(Pl. 4, figs. 3, 4)

Range—Kenya Colony and Zanzibar, British East Africa.

Remarks—The Rhinoceros Vase is common, but only found, in Kenya and Zanzibar. It is distinguished by its three single columellar plicae, massive nodules on the shoulder, brown-splotched parietal wall and by the absence of black markings on the outer lip. An unusual color form occurs in some colonies in Zanzibar in which the brown maculations on the outer shell are absent and in which the parietal wall is a pure light-yellow.

Habitat—This species occurs in fairly large colonies in shallow water on a rock, sand and weedy bottom just inside fringing coral reefs. Rarely, it is dredged on a sand and rubble bottom to a depth of 48 feet.

Description—Adult shell 45 to 85 mm. (1¾ to 3½ inches) in length. Solid, heavy, varying in shape from turbinate to sub-fusiform, and with blunt or sharp spines. Whorls 7 to 8, the body whorl bearing at the shoulder one or two rows of 5 to 8 spines which may be large and blunt, open or closed at their ends, or rather pointed and somewhat triangular. The middle of the body whorl bears 6 to

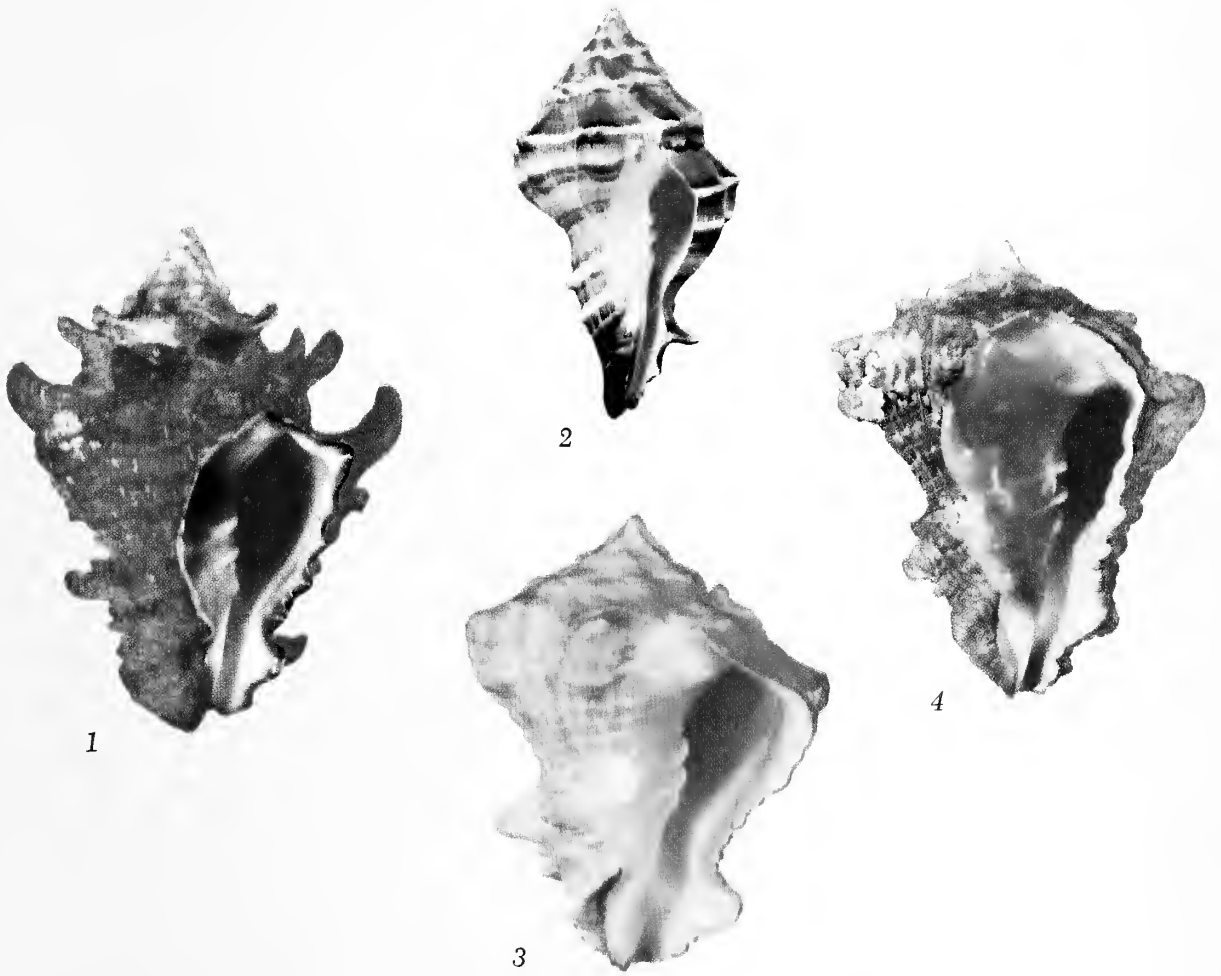


Plate 4, fig. 1, *Vasum tubiferum* (Anton), Cuyo, Philippines; fig. 2, *Tudicula rasilistoma* new species (young shell), Queensland.

Figs. 3 and 4, *Vasum rhinoceros* (Gmelin), Zanzibar; fig. 3 is the yellow form; fig. 4 is normal. All natural size.

10 small, indistinct, unevenly-sized spiral cords. Base of shell with a single row of fairly prominent, open-ended spines, below which are 3 or 4 indistinct, sometimes spined, cords. Nuclear whorl rather large, bulbous, chalky white, followed by numerous, small axial riblets. Axial sculpture of fine foliaceous growth lines which may develop into fine scales. Parietal wall thick, raised, glazed, and colored either chocolate-brown with tan mottling or a pure light-yellow. Columella with 3 distantly-spaced, rather strong, slightly slanting, purplish white plicae, the lowest being the smallest. Aperture elongate, tapering below, and within it is whitish with a large, diffused, mauve-brown splotch and with about 24 fine, spiral ridges. Outer lip thickened, slightly reflected, crudely crenulate, and glossy tan. Umbilicus partially open, narrow, sometimes deep, sometimes sealed. Color of outer shell cream with light-brown mottlings and specks; rarely all yellowish. Periostracum thin, translucent brownish, and slightly foliaceous. Operculum corneous, unguiculate, light-brown, and its outer surface with several weak longitudinal striations. For radula, see pl. 2, fig. A, p. [20-405].

Measurements (mm.) (including spines)—

length	width	no. whorls	
92	76	8+	(large; Zanzibar)
73	58	8	(average; Zanzibar)
57	40	7	(small; Kenya)

Synonymy —

1791 *Voluta rhinoceros* Gmelin, Systema Naturae, ed. 13, p. 3458, no. 128 (ad Novae Guineae); refers to Chemnitz, Conchyl.-Cab., vol. 10, figs. 1407, 1408.

1822 *Turbinella rhinoceros* Gmelin, Lamarck, Anim. sans Vert., vol. 7, p. 105 (Nouvelle-Guinée); 1847, Reeve, Conch. Icon., vol. 4, Turbinelle, sp. 33 (Zanzibar); 1876, Kobelt, Syst. Conchyl. Cab., vol. 3, no. 3, pl. 16, fig. 1 (good), pl. 6, figs. 2, 3 (poor).

Types—Gmelin's type locality of "New Guinea" was evidently erroneous, and it was not until 1847 that the proper locality of Zanzibar was recorded by Reeve. Gmelin did not have a type specimen.

Locality records—KENYA: Malindi; Kilifi; Vipingo; Mombasa (all Coryndon Mem. Mus.); Diani Beach (Abbott, USNM). ZANZIBAR: Chumbe Id. (4-6 fms.); Mangapwani (intertidal); Ras Nungwe (1 fm.); Fumba (intertidal); Mnemba Id. (intertidal); Paje; Mnemba Id. (intertidal); Kiwengwa; Chwaka; Chango Id.; Chukwani; Chumbe Id.; off Kisiki Id. (9 fms.). (all Ostheimer, Orr and Thorington, 1957, ANSP).

Vasum (Vasum) truncatum (Sowerby, 1892)

(Plate 5)

Range—Eastern Cape of Good Hope and southern Natal, South Africa.

Remarks—The South African Vase is evidently a rare species, and, although specimens have been found dead on the beach, Quekett (E. A. Smith, 1903, p. 370) reports it from "deep water". It is readily recognized by its white shell, almost conic shape and its low, weak nodules.

Description—Adult shell 65 to 72 mm. (about 2 to 3 inches) in length, solid whitish, subtriangular and nodulated. Spire flattish, except for the two raised, smooth, papillate nuclear whorls. Whorls 8, the shoulder somewhat carinate and bearing 9 to 11 low but distinct and slightly pointed nodules. Sides of last whorl slightly concave and bearing 5 indistinct rows of very weak, rounded nodules. Suture distinct and very wavy. Aperture white within. Columella and thickened outer lip blotched with brown. Upper end of parietal wall bears a whitish, swollen callus. Columellar plicae 4, the uppermost the largest. In young specimens, umbilicus present and chink-like. Periostracum rather thick, deciduous, matted, and light-brown in color.

Measurements (mm.) –

length	width	no. whorls	
65	50	8	(from Sowerby, 1892)
71	52	–	(from E. A. Smith, 1903)
50	35	7	(immature, Pondoland)

Synonymy –

1892 *Turbinella truncata* Sowerby, Marine Shells of South Africa, London, p. 17, pl. 4, fig. 85 (Port Elizabeth).

1902 *Turbinella triangularis* E. A. Smith, Jour. Conchology, vol. 10, p. 249, pl. 4, fig. 6; 1903, Proc Mal. Soc. London, vol. 5, p. 370, pl. 15, fig. 3 (off Durban and Port Shepstone).

1915 *Xancus truncatus* Sowerby, Bartsch, Bull. 91, U.S. Nat. Mus., p. 42 (Port Alfred).

Types—Port Elizabeth is the type locality. Sowerby states that the type collected by S. D. Bairstow was deposited in the Oxford University Museum, England. The type of *triangularis* is in the British Museum (Natural History), London.

Locality records—SOUTH AFRICA: Port Elizabeth; Port Alfred; Fossil head, Pondoland, (Natal Museum, 3869), all Cape of Good Hope; Port Shepstone; Off Durban, both Natal.

Vasum (Vasum) crosseanum (Souverbie, 1875)

(Plate 6)

Range—Presumably Madagascar.

Remarks—There has been no further information on this evidently rare species since it was first described by Souverbie in 1875. Tryon (Manual of Conchology, vol. 4, p. 71, 1882) erroneously con-

Plate 5. *Vasum truncatum* (Sowerby), Union South Africa (natural size; from the Proc. Mal. Soc. London, vol. 5, pl. 15, fig. 3).

Plate 6. *Vasum crosseanum* (Souverbie). Madagascar? (natural size; from the Journ. de Conchyl., vol. 24, pl. 13, fig. 1).

sidered this a worn and abnormal specimen of *Vasum muricatum* (Linné) from the West Indies, but I feel certain that it is a good species awaiting re-discovery. It appears to be characterized by 5 well-developed columellar plicae, bulbous apex, rounded body whorl, yellowish white mouth, and slight umbilicus. This species is provisionally placed in the subgenus *Vasum.*

Description—Shell 95 mm. (3¾ in.) in length, solid, pyriform, very deeply and narrowly umbilicate and whitish in color with subdued bands of yellowish rose. Whorls 8, the first 4 mammillate and with numerous axial costae. Suture wavy, impressed and with fine fimbriations. Spiral sculpture of numerous uneven, raised, rough threads. Axial sculpture of moderately developed, somewhat pointed nodules on the shoulder of the whorls. Aperture elongate-oval, with a thickened, slightly reflected outer lip and with a strong, raised, yellowish white, glossy parietal shield. Columella bears 6 spiral plicae, the 2nd, 4th and 6th being strong, and the 1st, 3rd and the 5th being weak. Siphonal canal short and open along its entire length. Umbilicus narrow and very deep. Operculum and soft parts unknown.

Measurements (mm.) —

Length 95, width 65, length of aperture 80, width of aperture 32.

Synonymy —

1875 *Turbinella crosseana* Souverbie, Jour. de Conchyl., vol. 23, p. 297; 1876, *ibid*, vol. 24, p. 382, pl. 13, fig. 1 (Mauritius or Madagascar ?)

Types—The type is in the National Museum of Natural History in Paris, France.

Records—Unknown, except for Souverbie's surmise that it comes from Madagascar or Mauritius.

Subgenus Altivasum Hedley 1914

This subgenus includes those *Vasum* species which have evolved in the direction of delicate spinosity, elevated spire, and rather shortened anterior siphonal canal. Evidently the only Indo-Pacific representative is the subgenotype, *flindersi*. In the Western Atlantic region, it is represented by the Recent *V. capitellum* Linné and by two Miocene species *(subcapitellum)* Heilprin and *horridum* Heilprin. *Vasum (Vasum) ceramicum* Linné of the Indo-Pacific bears a superficial resemblance to members of this subgenus by its possession of an elevated spire, but is excluded by its 5 columella plicae, fewer and stouter spines, and lack of an umbilicus.

Description—Shell moderately large, rather heavy and solid, with a well-elevated spire, and bearing several to many spiral rows of long, scale-like spines. Columella with 3 slanting plicae. Umbilicus funnel-shaped and usually deep. Siphonal canal moderately to greatly shortened. Periostracum, thin, coriaceous, brownish yellow in color. Operculum horny, unguiculate, and with a terminal nucleus.

Synonymy —

1914 *Altivasum* Hedley, Biological Results . . . F. I. S. "Endeavour" 1909-1914, vol. 2, pt. 2, p. 68, pl. 9. **Type** by monotypy, *Latirus aurantiacus* Verco 1895, non Montfort 1810 = *Altivasum flindersi* Verco, 1914); 1914, Hedley, Trans. and Proc. Royal Soc. South Australia, vol. 38, p. 484.

1950 *Vasum (Altivasum)* Hedley, Abbott, Johnsonia, vol. 2, no. 28, p. 213.

Vasum (Altivasum) flindersi Verco, 1914

(Pl. 7, figs. 1, 2)

Range—From the Gulf of St. Vincent, South Australia, to Nurina, Western Australia, from 18 to 120 fathoms.

Remarks—This is the largest and most attractive of the Indo-Pacific Vasidae. It is considered a rare shell, at least in collections, probably because of the infrequency at which it is dredged by commercial fishermen off the southern coast of Australia. This species is readily distinguished from *Vasum ceramicum* Linné by its numerous, open spines, wide and deep umbilicus, proportionately high spire and salmon-chalk color. Young specimens lack spines and have a narrower umbilicus, thus giving them the appearance of a *Latirus*.

Habitat—Dredged in 18 to 120 fathoms.

Description—Shell large, 130 to 160 mm. (5 to 6 inches) in length, solid, strongly spinose, and whitish orange to pure white in color. Whorls about 12, the early ones bearing 9 to 11 blunt, axial nodules which in the last 3 or 4 whorls develop into long, slightly recurved, anteriorly open, tubular spines. Nuclear whorls 1½, slightly swollen, round and smoothish. Spiral sculpture on post-nuclear whorls of 5 to 6 raised threads. Suture wavy, indented and bordered below by a raised thread which becomes well fimbriated in the last 3 whorls. Shoulder of the last whorl bears the largest spines, and below this row are 7 to 8 crowded spiral rows of smaller spines. Aperture ovate, white within. Columella bears 3 small, spiral, slightly slanting plicae. Umbilicus rather large, funnel-shaped and very deep. Periostracum thin, translucent-brown and coriaceous.

Measurements (mm.) —

length	width	no. whorls	
160	98	11	(adult, ANSP)
130	65	—	(fide Hedley, 1914)
95	52	8	(immature, ANSP)

Synonymy —

1895 *Latirus aurantiacus Verco*, Trans. Royal Soc. South Australia, vol. 19, p. 89 [79], pl. 2, figs. 1, 1a (Backstairs Passage, South Australia, 18.5 fms.)

1914 *Altivasum flindersi* Verco, Trans. and Proc. Royal Soc. South Australia, vol. 38, p. 484. New name for *L. aurantiacus* Verco 1895, *non* Montfort 1810.

Types—The type locality is Backstairs Passage, South Australia, Australia, in 18.5 fathoms. The holotype, an immature specimen 46 mm. in length, is in the South Australian Museum in Adelaide.

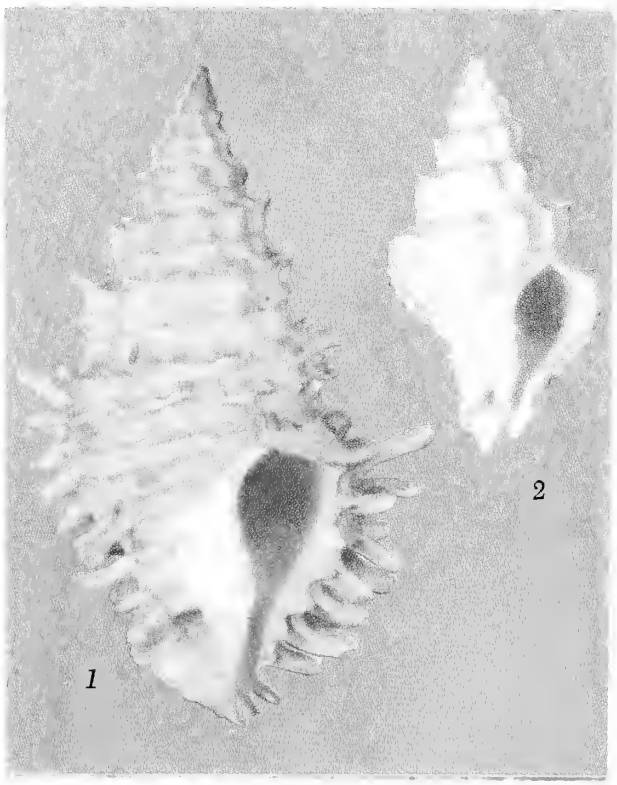


Plate 7. *Vasum (Altivasum) flindersi* Verco, Great Australian Bight. Fig. 1, adult; fig. 2, young. (Both half natural size).

Locality records—SOUTH AUSTRALIA: Backstairs Passage, 18.5 fms. (Verco, 1895); off Newland Head, 20 fms. (Verco, 1914); Gulf of St. Vincent (Hedley, 1914); Great Australian Bight (ANSP). WESTERN AUSTRALIA: Great Australian Bight from 126° to 129° East Long., 120 fms. (Hedley, 1914).

Genus Tudicula H. and A. Adams 1863

Recent species of this genus of Vasidae are known only from the Indian Ocean and the northern half of Australia, although some probably exist in the East Indies. On the whole, they may be considered uncommon or rare, perhaps because of the difficulty in dredging for them at depths ranging from 4 to 20 fathoms. One species, *armigera,* is occasionally found living in the intertidal zone. Members of this genus are undoubtedly carnivorous, and, so far as we know, live on sand and rocky bottom. There are five known Recent species. A number of fossil species have been described under both *Tudicla* and *Tudicula,* but only *sinotecta* Ludbrook, 1941 from the Pliocene of South Australia (Trans. Royal Soc. South Australia, vol. 65, p. 97, pl. 5, fig. 14) seems to belong to true *Tudicula.*

Synonymy –

1863 *Tudicula* H. and A. Adams, Proc. Zool. Soc. London for 1863, p. 429 (as a subgenus of *Tudicla*). **Type** by subsequent designation (W. Wenz, 1943, p. 1303): *T. armigera* A. Adams.

Description—Shells medium in size, 30 to 70 mm. in length, moderately solid, usually pyriform or fusiform, sometimes spinose, and with a long, narrow, anterior siphonal canal. Whorls 4 to 7, usually spinose, rarely smoothish, but always with fine spiral threads. Nuclear whorls rather large and slightly mammillate. Parietal shield usually well-developed. Lower third of columella with 3 or rarely 4, moderately developed, slanting plicae. Operculum corneous, unguiculate, brown, and with a terminal nucleus. Radula rachiglossate, the central tooth with 3 cusps, the lateral teeth with two cusps. Body and penis similar to those in *Vasum.*

Key to the Indo-Pacific *Tudicula*

a Spire angle less than 85° ..... b
a Spire angle greater than 85° c

b With 7 shoulder knobs per whorl ..... *rasilistoma*
b With 10 to 12 shoulder spines per whorl ..... *armigera*

c Aperture oval-round; white ..... d
c Aperture oval-elongate; orange ..... *zanzibarica*

d Shoulder with 12 to 14 spines ..... *spinosa*
d Shoulder without spines ..... *inermis*

Tudicula (Tudicula) armigera (A. Adams, 1855)

(Pl. 9, figs. 9, 10)

Range—Queensland, Australia.

Remarks—This handsome *Tudicula* is moderately common in some parts of Queensland. It is characterized by the single row of well-developed shoulder spines, and the two rows of spines on the rather slender siphonal canal, and by its white parietal wall. The length of spines in adult shells is variable, some being 5 mm. in length, others as long as 14 mm. The color of the shell may vary from yellowish white to reddish brown. This is the type of the genus *Tudicula* H. and A. Adams.

Habitat—This species lives on sand and rubble bottom from low tide mark to a depth of 20 fathoms.

Description—Adult shell 55 to 72 mm. (2¼ to 2¾ inches) in length, solid, pyriform with a long, thin anterior siphonal canal, and spinose. Color white to yellowish cream, with or without light-brown to purplish brown flecks or small maculations. Nuclear whorls 1½, proportionately large, rounded, smooth,

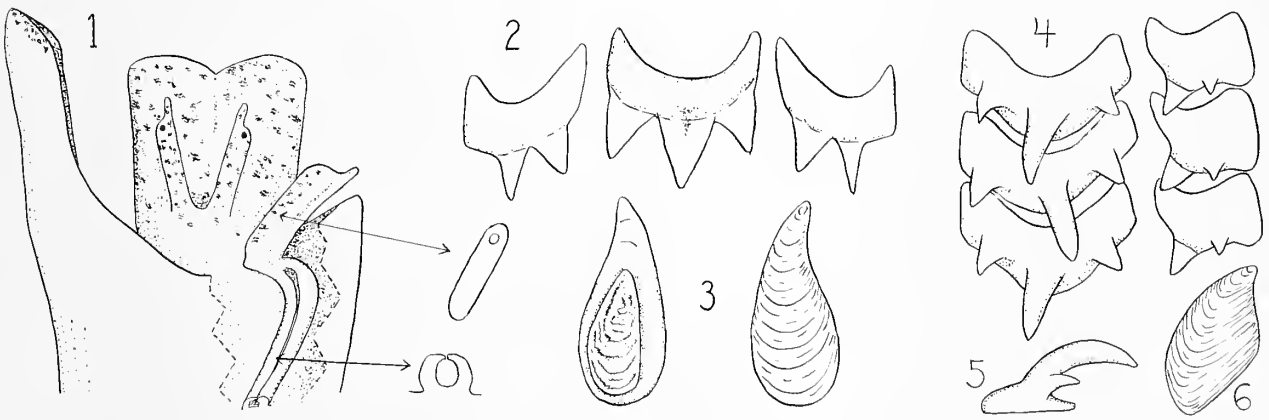


Plate 8. Figs. 1-3, *Tudicula zanzibarica* Abbott, paratype. 1, dorsal view of animal with cross-section of verge; 2, radulae; 3, operculum.

Figs. 4-6, *Tudicula inermis* Angas, off Broome, Western Australia. 4, radulae; 5, side view of central tooth; 6, operculum.

semi-glossy, and white to purple-brown. First postnuclear whorl weakly cancellate; the next 5 whorls bearing 6 to 7 raised, finely fimbriated, spiral threads; the lowest thread, located just above the wavy, well-indented suture, bears increasingly longer, open-faced spines (10 to 12 per whorl). The long siphonal canal bears 2 spiral rows of long, delicate spines. The numerous spiral threads on the body whorl may bear numerous, very small spines. Axial sculpture of 10 to 12 low, rounded folds. Aperture ovate. Outer lip slightly reflected, thickened, glazed and weakly crenulate. Parietal shield well-developed, raised, glossy white to cream. Lower third of columella with 3 (rarely with a weak 4th), slightly slanting plicae, the lowermost being the broadest. Operculum corneous, chestnut-brown, unguiculate, and with a terminal nucleus.

Measurements (mm.) (including spines)—

length	width	no. whorls	
71.4	31.0	6	(large; off Bundaberg)
65.1	30.8	6	(average; Palm Isle)
56.5	28.0	5	(small; Pancake Creek)

Synonymy —

1855 *Tudicla armigera* A. Adams, Proc. Zool. Soc. London for 1854, p. 221 (Moreton Bay).

1884 *Turbinella (Tudicula) armigera* A. Adams, E. A. Smith, Report Zool. Collections H. M. S. "Alert", London, p. 53, pl. 5, fig. G.

Types — The type locality is Moreton Bay, Queensland, Australia. The type is in the British Museum (Natural History), London.

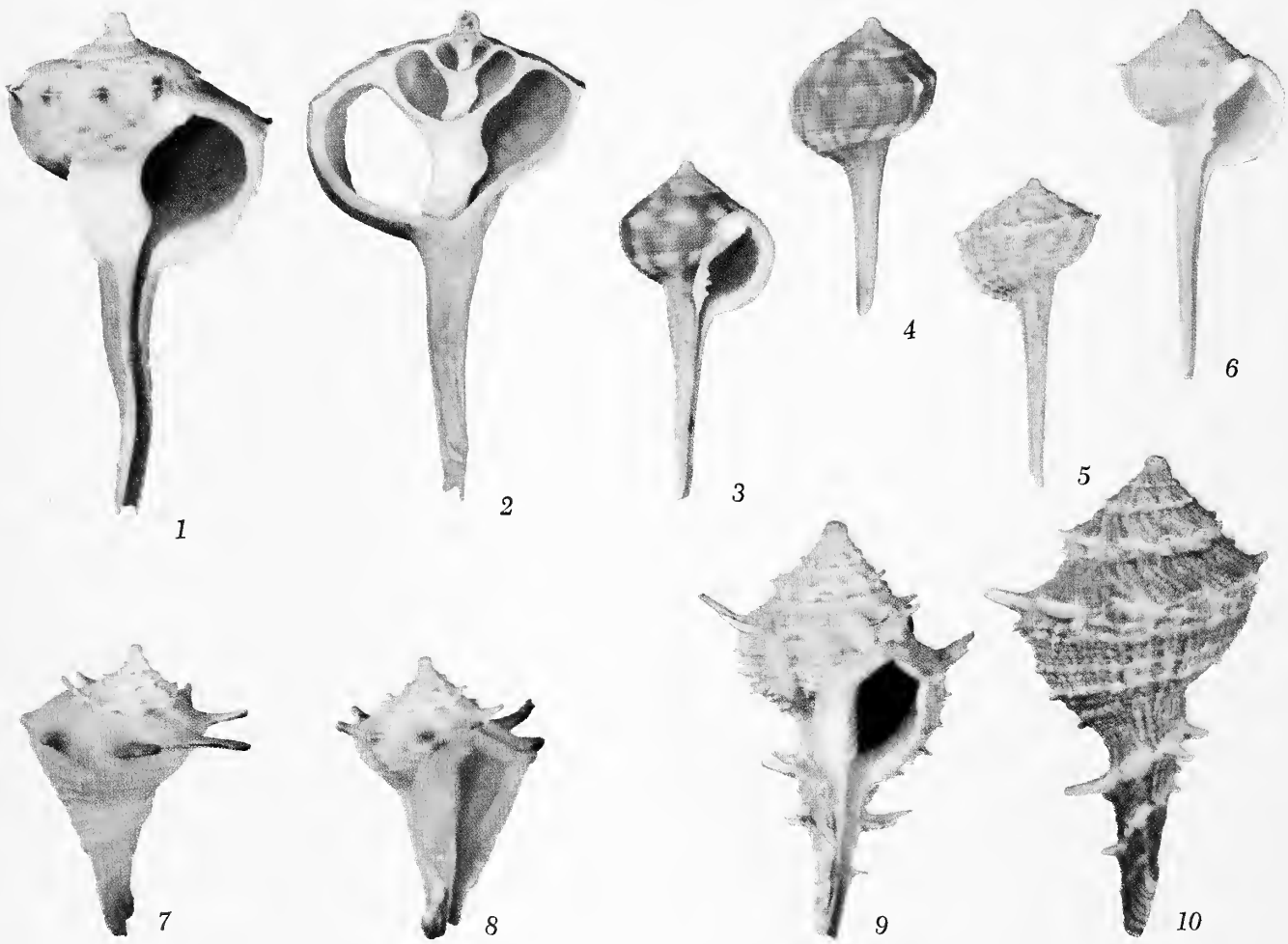


Plate 9. Figs. 1 and 2, *Tudicla spirillus* Linné, east coast of India. Figs. 3 and 4, *Tudicula inermis* Angas; 3, from Exmouth Gulf, West Australia; 4, holotype (Cornell Univ. Paleo. Mus. 19232). Figs. 5 and 6, *Tudicula spinosa* H. and A. Adams; 5, off Darwin, West Australia (A. R. Cahn collection at ANSP); 6, Torres Straits, Queensland (Mrs. W. Barker collection). Figs. 7 and 8, *Tudicula zanzibarica* Abbott, off Zanzibar; 7, paratype (ANSP); 8, holotype (ANSP). Figs. 9 and 10, *Tudicula armigera* A. Adams; 9, Pancake Creek, Queensland (ANSP); 10, off Bundaberg, Queensland (MCZ). All natural size.

Locality records—QUEENSLAND: Palm Isle in 18 fms. (ex J. Brazier, ANSP); Pancake Creek, Bustard Head (ANSP); off Bundaberg in 20 fms. (MCZ); Moreton Bay, Port Curtis, 0 to 11 fms., and Port Molle in 14 fms. (E. A. Smith, 1884, p. 53).

Tudicula (Tudicula) rasilistoma *new species*

(Pl. 4, fig. 2, p. [20-409])
(Pl. 10, figs. A-C)

Range—Known only from northern New South Wales and southern Queensland, Australia.

Remarks—The recently discovered "Polished-mouthed" Tudicula from northeast Australia is evidently related to *T. armigera*, but differs in having two brown spots on the parietal wall, in having a shorter, stouter and brown-tipped siphonal canal, and in having 7 to 8 weakly spined or smooth nodules per whorl (instead of 10 to 12 strong spines per whorl). The apex of most adult shells is eroded away. Young specimens have a delicate pink to rose aperture and lack the parietal shield.

Habitat—Nothing is known about the habitat or habits of this species, except that it occurs in 30 fathoms of water (according to shrimp fishermen).

Description—Adult shell 56 to 72 mm. (2½ to 3 inches) in length, solid, fusiform, weakly spinose, and with a moderately short, stout siphonal canal. Color chalky pinkish cream to whitish and overlaid with irregular bands of various shades of brown. Nuclear whorls 1½, smooth, rounded and opaque-white. Body whorl with two closely set, peripheral rows of 7 (rarely 8) blunt nodules. The midpoint of the stout anterior siphonal canal bears a row of 5 or 6 fairly long, slender, open-faced spines, below which may be a second row of obsolete spines. Lower third of siphonal canal an almost solid, dark chocolate-brown. Umbilicus chink-like, shallow or absent. Parietal wall well-developed, raised, glossy cream to pinkish and with a brown blotch on the left center and at the posterior or upper end. Columellar plicae 3, the middle one being the largest and most distinct. Outer lip slightly reflected, sharp, strong, but finely and unevenly crenulate. Inner wall, behind the outer lip, with weakly developed, raised, spiral lirae. Periostracum grayish brown, translucent, thin, and microscopically fimbriated. Operculum corneous, unguiculate and dark-brown in color.

Measurements (mm.)—

length	width	no. whorls	
72.0	39.0	8	(holotype)
59.0	34.5	7	(Tin Can Bay, Queensland)
58.0	33.0	5?	(paratype, ANSP)

Synonymy—

I am indebted to Miss J. Hope Macpherson of Victoria who suggested the name and asked that I describe this species.

Types—The type locality is off Tweed Heads, northern New South Wales, dredged in 30 fathoms. Holotype (F18189) and paratypes in the Nat. Mus. Victoria. One paratype from Brisbane in ANSP no. 227669.

Locality records—QUEENSLAND: Caloundra (Mrs. L. Brown Coll'n.); off Brisbane (Nat. Mus. Victoria and ANSP); dredged in Tin Can Bay (ANSP). NEW SOUTH WALES: 30 fathoms, off Tweed Heads (Nat. Mus. Victoria).

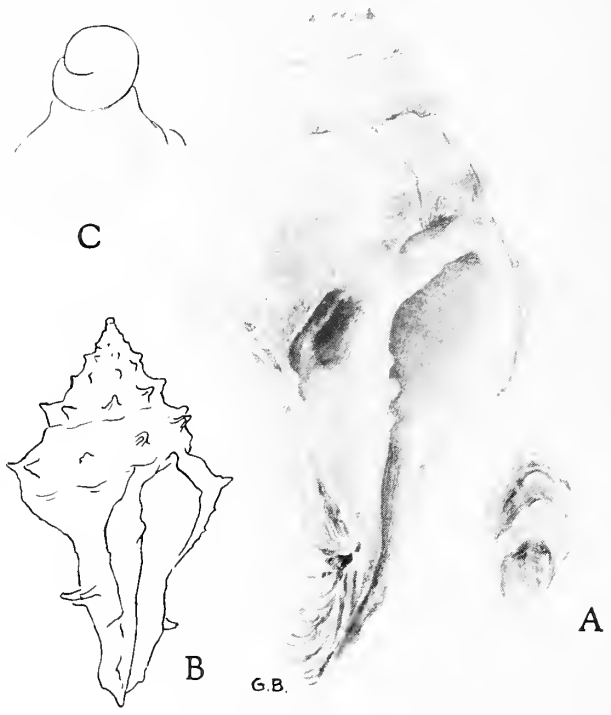


Plate 10. *Tudicula (Tudicula) rasilistoma* new species, holotype from New South Wales. Immature paratype: A, operculum; B, shell; C, nuclear whorls enlarged. (Courtesy of J. Hope Macpherson).

Tudicula (Tudicula) spinosa H. and A. Adams, 1863

(Pl. 9, figs. 5, 6, p. [20-444])

Range—Northern Territory to Queensland, Australia.

Remarks—This small and attractive species is found in a few fathoms of water along the Queensland coast and westward to the Darwin area. It is rather rare in collections, but, to judge from the number of specimens sent to us from the Arafura Sea by Colonel A. R. Cahn, it is not uncommon in its habitat. The species is recognized by the single series of small sharp spines on the periphery of the shoulder. Most specimens are cream in color with small and numerous reddish brown flecks, although some may be pure white or with a wide, broken, subdued band of brownish on the body whorl.

Habitat—Unknown, except for the fact that it has been dredged in 9 fathoms of water.

Description—Adult shell 40 to 50 mm. (2 inches) in length, turnip-shaped, finely spinose, with a long aspinose siphonal canal, and white with yellowish brown flecks. Nuclear whorls 1, glossy, opaque-cream to tan and slightly mammillate. First postnuclear whorl with fine, axial riblets which are soon crossed by 2, then 3, fine spiral threads. Spire flattish, its angle about 100°, and each whorl with 8 to 10 small, irregular, spiral threads. Suture wavy and marked by broken, former shoulder spines. Shoulder of body whorl carinate and with 12 to 15 short, sharp, flattened spines which are open on their anterior faces. Below each spine, a low axial fold runs to the base of the whorl and is crossed by small, distinct, raised, wavy cords. Aperture oval-round, white. Parietal shield raised, white; base of columella bears 3 well-developed plicae which are set at almost right angle to the axis of the shell. Interior of outer wall with 9 to 11 sharp, fine spiral cords running back into the aperture. Siphonal canal about ¾ the length of the entire shell. Periostracum very thin, light-tan, and somewhat deciduous.

Measurements (mm.) (including spines; all from off Darwin)—

length	width	length of siphon	no. whorls
50.0	22.5	31.5	5
42.5	19.5	26.0	5
41.2	19.0	24.3	5

Synonymy—

1863 *Tudicla (Tudicula) spinosa* H. and A Adams, Proc. Zool. Soc. London for 1863, p. 429 (Port Curtis).
1884 *Turbinella (Tudicula) spinosa* H. and A. Adams, E. A. Smith, Report Zool. Collections H. M. S. "Alert", London, p. 54, pl. 5, fig. H.
1932 *Tudicla inermis* Angas, Kuroda, Venus, vol. 3, p. 117, fig. 3 on p. 114 (northern Australia).

Types—The type locality is Port Curtis, Queensland, Australia. The type in the British Museum (Natural History) is 38 mm. in length and entirely white in color.

Locality records—QUEENSLAND: Port Curtis (Hugh Cuming); Prince of Wales Channel, Torres Straits in 9 fms. (E. A. Smith, 1884, p. 54). NORTHERN TERRITORY: off Darwin (ex A. R. Cahn, ANSP).

Tudicula (Tudicula) inermis Angas, 1878

(Pl. 9, figs. 3, 4, p. [20-444])

Range—Western Australia and Northern Territory, Australia.

Remarks—This rare species differs from *spinosa* in lacking the small spines on the shoulder of the body whorl. Most specimens we have seen are rather heavily pigmented with light-brown. We have two specimens from off Darwin which have undulations at the shoulder and weak axial folds on the sides of the body whorl, characters which are approaching those found in *spinosa*. *T. inermis* may subsequently be found to be a western subspecies of *spinosa*. The radula figured is from a specimen loaned by the Australian Museum (no. C. 57363) from Exmouth Gulf. See pl. 8, p. [20-443].

Habitat—Unknown, except for the fact that it occurs at a depth of 5 to 11 fathoms.

Description—Adult shell 40 to 47 mm. (1¾ inches) in length, turnip-shaped, smoothish, with a relatively long siphonal canal; color cream to whitish with light-brown mottlings and flecks. Nuclear whorls 1, glossy, opaque-tan to pinkish brown and slightly mammillate. First two postnuclear whorls with 3 or 4 slightly nodulated spiral threads. Spire flattish, its angle about 100°, and with 8 to 13 irregularly-sized spiral threads. Shoulder of body whorl slightly carinate and with or without weak undulations. In some specimens there may be a very weak axial fold below each of the undulations. Base of last whorl with numerous, fine spiral threads. Aperture oval-round, white. Parietal shield raised, white; the base of the columella bears 3 well-developed plicae which are set almost at right angle to the axis of the shell. Posterior end of the parietal wall with a small, swollen, white callus. Interior of outer wall with 9 to 11 sharp, fine spiral cords running back into the aperture. Siphonal canal about ¾ the length of the entire shell, with brownish flecks, rarely with pink. Periostracum thin, grayish, axially fimbriated and deciduous. Operculum corneous, translucent yellowish brown, unguiculate, with fine growth lines and with a terminal nucleus. The head, foot and tentacles are very similar to those in *Vasum*. In a shell 44 mm. in length, the odontophore is 5.0 mm. in length and bears about 103 rows of teeth.

Measurements (mm.)—

length	width	no. whorls	
41.0	21.0	5.5	(holotype)
44.5	20.0	5.6	(off Broome)
46.5	21.5	6.0	(Exmouth Gulf)

Synonymy—

1878 *Tudicula inermis* Angas, Proc. Zool. Soc. London for 1878, p. 610, 2 figs. (from a dealer at Singapore); 1887, E. A. Smith, Annals and Mag. Nat. Hist., series 5, vol. 19, p. 465 (Exmouth Gulf).

Types—The type locality given by Angas was Singapore. This is evidently erroneous. The holotype is in the Paleontological Museum, Cornell University, Ithaca, New York, no. 19232, from the Newcomb collection.

Locality records — WESTERN AUSTRALIA: Exmouth Gulf, T. H. Hayes (B.M. and ANSP); between Cape Bossut and Broome, 5 fms., A. A. Livingston (Aust. Mus.); Pearl bank, 42 mi. W.S.W. of Cape Jaubert in 42 to 66 ft. (Odhner, 1919). NORTHERN TERRITORY: off Darwin, T. Ino (ANSP).

Tudicula (Tudicula) zanzibarica Abbott, 1958

(Pl. 9, figs. 7, 8, p. [20-444])
(Pl. 8, figs. 1-3, p. [20-443])

Range—Zanzibar, British East Africa.

Remarks—The Zanzibar Tudicula is characterized by its elongate, apricote-colored aperture and the 7 to 8 delicate, somewhat triangular, purple-brown spines on the last whorl. The close relationship between *Tudicula* and *Vasum* is demonstrated in the characters of this species in which the aperture and nucleus are *Vasum*-like, but the general shape of the shell, the spines and the radula are more *Tudicula*-like.

Habitat—Dredged in 8 fathoms on a bottom of sand, broken shell and wiry grass.

Description—Adult shell 28 to 40 mm. (1 to 1½ inches) in length, subtriangular, solid, and spinose. Color chalky-white with a flush of light-orange, and with dark purple-brown on the ends of the shoulder spines and the siphonal canal. Spire moderately elevated, its angle about 90°, its length about ¼ that of the entire shell. Whorls 6, strongly shouldered near the top where there is a peripheral row of 7 to 8 large, flattened, somewhat triangular, purple-brown spines which may be narrowly extended. Sides of whorls flat to slightly concave. Nuclear whorls 1, rather large, bulbous, elevated, smooth and yellowish white. First postnuclear whorl rudely cancellated by 4 coarse, unequal, spiral cords and about 8 axial, poorly-developed ridges. Lower third of the last whorl, in the central region of the siphonal canal, bears 2 spiral rows of about 6 elongate spines which may become obsolete in the last whorl. Microsculpture consists of numerous, small, spiral cords of varying size and of numerous, very fine, axial threads and fimbriations of light-tan periostracum. Aperture long, wide above, gradually becoming constricted below. Outer lip thickened, glossy, weakly crenulate, and pale peach in color. Parietal shield well-developed and raised. Columella bears 3 weak, whitish, spiral plicae. Interior wall of last whorl with about 9 very weak, small, spiral ridges. Operculum corneous, rather thick, unguiculate, brown, and with its muscle scar being about ½ the area of the entire operculum.

Animal's soft parts similar to those of *Vasum*, with a short, squarish foot; head small, bearing two, short stubby tentacles with the eyes near the ends. Gills with about 400 lamellae. Osphradium well-developed, bi-laminate and about half the length of the gills. Color of preserved soft parts cream with maculations of purple-brown. Odontophore long (6 mm. in the 40 mm.-long shell of the holotype), narrow, and with about 145 transverse rows of rachiglossate teeth (see pl. 8, figs. 1-3).

Measurements (mm.) (not including spines)—

length	width	no. whorls	
40.0	25.2	6.0	(holotype)
36.5	20.5	5.5	(paratype)
28.0	15.0	5.0	(paratype)

Synonymy—

1958 *Tudicula zanzibarica* Abbott, Notulae Naturae (Philadelphia), no. 305, pp. 1-4, figs. 1-7 (Zanzibar).

Types—The type locality is 1½ miles W.S.W. of Ras Nungwi, north end of Zanzibar Island. Natural Science Foundation station no. 651, March 4, 1957 (Ostheimer and V. Orr). Holotype in ANSP no. 225261; paratypes in the Coryndon Mem. Mus., B.M., and ANSP.

Locality records—Known only from the type locality.

Genus Tudicla Röding 1798

This genus is apparently limited in Recent times to the Bay of Bengal in the Indian Ocean where it is represented by a single species, *Tudicla spirillus* (Linné). The anatomy is unknown, so that the genus is placed, at present, in the Vasidae solely on conchological grounds. The genus has had several fossil subgenera and six or seven Recent species assigned to it by several authors, but we believe that none of these properly belongs to this genus. Among the possibly related fossil genera are: *Tudiclana* Finlay and Marwick 1937 (Cretaceous, New Zealand), *Pyropsis* Conrad 1860 (probably a Buccinidae from the Upper Cretaceous of southeast United States), and others listed by W. Wenz, 1943, vol. 6, p. 1304.

The genus *Afer* Conrad 1858, represented by two Recent West African species (*afer* Gmelin and *porphyrostoma* Adams and Reeve) has been traditionally placed in the Vasidae next to *Tudicla*, but the shells appear to be more like those of *Latirus* in the family Fasciolariidae. Its anatomy is unknown.

True *Tudicla* appears first in the Cretaceous of East Africa (*krenkeli* Cox, 1925) and Madagascar

(*hourcqi* Collignon, 1951), then the Eocene of Egypt (*rames* and *thebaica* Cuvillier, 1933), the Miocene of Europe (*rusticulus* Bastérot, 1825), the Pliocene of Australia (*angulata*, *costata* and *turbinata* Angas, 1888), and the Pliocene of Karikal, India (*spirillus* Linné). See also Cossmann, 1901, Essais de Paleoconch. Comp., pt. 4, pp. 68-72.

We have not seen specimens of "*Fusus*" *couderti* Petit 1853 or *Tudicla fusoides* A. Adams 1854, both from China, but they do not appear to belong to true *Tudicla* as Tryon (1881) and Küster (1876) believed. Other Recent species, such as *armigera* A. Adams and *spinosa* H. and A. Adams, were once assigned to *Tudicla*, but are actually members of the genus *Tudicula* and much more closely related to the genus *Vasum*.

Fischer in 1884 (Manual de Conch., p. 619) included *Spirillus* Sowerby 1842 as a generic synonym of *Tudicla*. However, Sowerby (Conch. Manual, 2nd ed., p. 306) did not propose this as a new generic name, but was merely capitalizing Linné's specific name of *spirillus*.

Description—Shell medium in size, moderately solid, pyriform, with a swollen, slightly bicarinate body whorl, flattish spire, and a long, narrow siphonal canal. Without an umbilicus. Parietal shield raised, with a sharp edge, and glazed. Columella roundly arched and bearing at its base a single, raised spiral cord. Region of the posterior canal with a swollen, button-like callus. Nucleus mammillate, high and with 1½ round, swollen, glossy whorls. Operculum corneous, narrowly oval with an apical nucleus, according to H. Adams, 1874.

Synonymy —

1798 *Tudicla* Röding, Museum Boltenianum, Hamburg, pt. 2, p. 145. **Type** (by subsequent designation, P. Fischer, 1884, p. 619): *T. carinata* Röding = *Murex spirillus* Linné, 1767.

1835 *Pyrella* Swainson, Elements of Conchology, London, p. 21. **Type** (by monotypy): *P. spirilla* L. = *Murex spirillus* Linné, 1767.

1838 *Spirillus* Schlüter, Kurzgefasstes Verzeichniss Conchyl., Halle, p. 21. **Type** (by monotypy): *S. rostratus* Schlüter = *Murex spirillus* Linné, 1767.

1857 *Pyrenella* J. E. Gray, Guide Syst. Distrib. Mollusca Brit. Mus., pt. 1, p. 11. **Type** (by monotypy): *P. spirilla* = *Murex spirillus* Linné, 1767.

Tudicla (Tudicla) spirillus (Linné, 1767)

(Pl. 9, figs. 1, 2, p. [20-444])

Range—Southeast India and northern Ceylon.

Remarks—This is the only known living species in this genus, and it is easily recognized by its turnip shape, bicarinate body whorl, the single fold on the lower part of the columella, and by its mammillate nuclear whorls.

Habitat—Unknown, except that it probably lives on a sandy bottom in several fathoms of water.

Description—Adult shell 66 to 82 mm. (2½ to 3¼ inches) in length, moderately solid but strong, pyriform, and with a long, sinuous, smooth siphonal canal. Color of shell shiny cream to pinkish gray with sparse flecks of light-brown which form small squarish spots on the upper carina of the body whorl. Nuclear whorls mammillate, projecting, and of 1½ round, swollen, pinkish or yellowish, glossy whorls. Spire flattish, its angle about 140°. Postnuclear whorls 3½. Spiral sculpture of numerous, raised threads which are squarish and broad on the base of the whorls. Body whorl with a squarish periphery, bounded above by a sharp, wavy keel and below by a series of 6 to 8 round, low nodules. Aperture ovate-round, glossy, pinkish to purple within, and bounded on the outer side by a sharp lip. Inside of outer wall with numerous, fine, raised, spiral ridges. Parietal shield well-developed, smooth and glossy white. Posterior canal region with a swollen, button-like, white callus. Base of columella with a single, strong, spiral plica. Siphonal canal open along its length, long and slightly sinuous. Operculum corneous, elongate-oval, and with an apical nucleus. Radula unknown.

Measurements —

length	width	
66.0	36.5	(small; Ceylon)
70.5	41.0	(average; Ceylon)
78.0	43.0	(large; Ceylon)

Synonymy —

1767 *Murex spirillus* Linné, Sysyema Naturae, ed. 12, p. 1221, no. 554 (in Tranquebar); 1957, Dodge, Bull. Amer. Mus. Nat. Hist., vol. 113, art. 2, p. 156.

1798 *Tudicla carinata* Röding, Museum Boltenianum, Hamburg, pt. 2, p. 145 (refers to Knoor, vol. 6, pl. 24, fig. 3). No locality.

1811 *Monoplex capitatus* Perry, Conchology, London, pl. 3, fig. 4 (locality unknown).

1838 *Spirillus rostratus* Schlüter, Kurzgefasstes Verzeichniss Conchyl., Halle, p. 21 (refers to "*Pyrula spirillus* Lam.").

Types—The type locality given by Linné was Tranquebar, a section of the southeast coast of India. The type is in the British Museum (Natural History), London.

Locality records—Known only from the Tranquebar coast in southeast India and the northern part of Ceylon. Gravely, F. H. (1942, p. 66) reports that this species is occasionally washed ashore on the beaches near Madras, southeast India.

THE GENUS STROMBUS IN THE INDO-PACIFIC

by R. Tucker Abbott

Pilsbry Chair of Malacology
Academy of Natural Sciences of Philadelphia

The genus *Strombus* is a world-wide, tropical group of mesogastropods belonging, with other Recent genera such as *Lambis, Terebellum, Tibia,* and *Rimella,* to the family Strombidae. The genus originated during the early Miocene or possibly the Eocene, and became established throughout the warm seas of the world. It flourished during the Pliocene and the early Pleistocene in the area of southeast Asia, but has since had a gradual diminution in species, until none now survive in the Mediterranean, only one in West Africa, seven in the Caribbean region and four in the Panamic region on the Pacific side of Central America. Sixty living races occur in the Indo-Pacific of which thirty eight may be considered to be full species.

Members of the genus *Strombus* are for the most part shallow water inhabitants. In all known cases they are herbivorous or detritus-feeders. The vast majority live from the low tide line to a depth of about 20 feet, although about one fourth of the species occur more commonly from 15 to 30 feet, and two at depths from 6 to 66 fathoms. Few *Strombus* have been found in water too cold to support the production of coral reefs, and the vast majority of species are found within the limits of the 70° F restricted isotherm (water always above 70° F).

Strombus are outstanding for their agility of locomotion. The foot is narrow, very muscular, and with the flat, creeping sole limited to the anterior third of the foot. The operculum is long, sharp, strong and somewhat sickle-shaped, serving not only as a lever in moving the animal forward, but also as a defensive weapon against predatory crabs and fish. The eye peduncles are long and muscular, and near the distal end give rise to a small, short tentacle. The eyes are large and usually adorned with circular rings of orange, yellow or red color.

The animals are dioecious with the adult males bearing a long, open-grooved prong-like penis on the right side of the "back". The animals generally congregate in large colonies in shallower water during the warmer months of the year to spawn. The egg masses consist of a long, jelly-like tube to which sand grains become attached. The coiling tube becomes entwined into a sponge-like mass. The length of unravelled tube may vary from 43 to 74 feet and contain an estimated 185,000 to 460,000 individual eggs. The eggs develop into free-swimming veligers within 80 to 100 hours after first being laid. An account of the spawn and veligers of three Western Atlantic *Strombus* and an excellent bibliography is given by R. Robertson (1959, Proc. Mal. Soc. London, vol. 33, pt. 4, pp. 164-171, 1 pl.).

A slight degree of sexual dimorphism is evident in the shells of most *Strombus*, those of males usually being slightly smaller (see remarks under *S. gibberulus gibbosus*).

The shells of *Strombus* are characterized by the development in the adult of a large, flaring, generally thickened, outer lip and the presence of a U-shaped notch on the edge of the lip near the anterior end. This feature is referred to as the "stromboid notch," and it generally serves as a "peep hole" for the protruding right eye. It is probably the convenience of this notch that has led to a reduction in length of the right eye peduncle, so common a feature in most *Strombus*. Another char-

Plate 11. Living *Strombus pipus* (Röding) emerging from its shell. From left to right: the brown, sickle-shaped operculum, underside of foot, yellowish brown proboscis and brownish mauve-spotted eye peduncles. Zanzibar specimen natural size. Photo by Virginia Orr.

acteristic is the production of slightly thickened, rounded varices in the postnuclear whorls of the spire. These adolescent varices may serve to strengthen the rather fragile young shell. Some species produce wide adolescent varices, such as those found in the subgenus *Gibberulus*, while others produce narrow ones, or on rare occasions none at all.

In shell size, adults vary from the 13-inch *Strombus (Tricornis) goliath* Schröter of Brazil to a dwarf *S. (Canarium) maculatus* Sowerby only ⅝ inch (8 mm.) in length.

Strombus quite commonly differ in shell size from colony to colony due probably to a combination of genetic and ecologic conditions. Examples are discussed under the remarks on *S. canarium* and *S. gibberulus gibbosus*. Some unjustified races have been based upon these local dwarfs or giants. Old adults commonly thicken the shell, especially the outer lip, and may lay down an aluminum-like glaze, features which also have been the basis for unjustified subspecies.

The internal anatomy of several Indo-Pacific species has been treated in detail by B. Haller (1893, Morphologisches Jahrbuch, Leipzig, vol. 19, pp. 577-588, pls. 18-20) and by R. Bergh (1895, Zoologische Jahrbücher, Anat. und Ontog., Jena, vol. 8, pp. 342-378, pls. 22-23).

Subgenera of Strombus

There is always difficulty in defining limits for genera and subgenera that will be satisfactory to all workers. *Strombus* presents no exception. Our evaluation is based upon shell, radular, penial, and opercular characters, as well as the fossil history. Among the shell characters employed are sculpture of apical whorls, production of axial and spiral sculpture in later whorls, development of the outer lip, general shape and texture of shell, the coloration and sculpturing of the columella and of the inside of the outer body wall, and the development of the siphonal canal. Unfortunately, the expression of these characters arises in varying combinations throughout obviously different stocks, so that some shell characters become misleading. The modifications of the penis have served usefully in some cases, some being simple prongs (as in the subgenus *Canarium*), others being strongly bilobed (as in the subgenera *Dolomena, Euprotomus*, and *Lentigo*).

The radula throughout the genus *Strombus* shows little diversity, and, again, sufficient inter- and intra-specific variations occur to reduce this character to secondary importance. The lateral cusps of some species have made possible the rather convenient acceptance of the subgenera *Strombus* sensu stricto and *Doxander*. In other groups, such as *Gibberulus*, the absence of the tiny, but distinct peg at the inner base of the lateral has been helpful. Curiously, some of the radular characteristics are correlated with the marine provinces, rather than with assumed phylogenetic relationships.

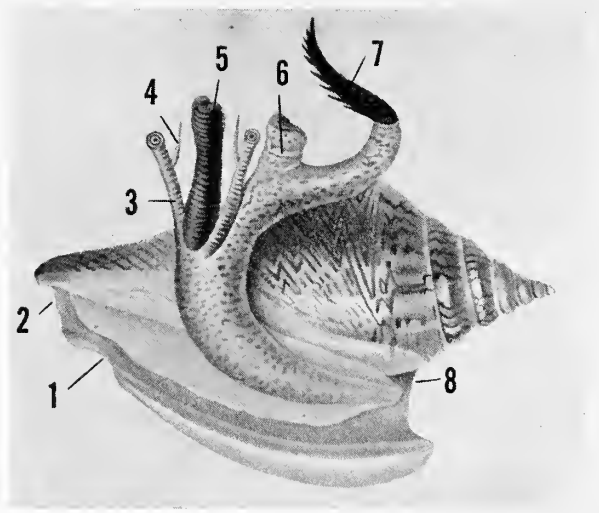


Plate 12. Living animal of *Strombus canarium* Linné. 1, the "stromboid notch". 2, anterior siphonal canal. 3, eye pedunele. 4, tentacle. 5, proboseis and mouth. 6, anterior end of foot. 7, operculum. 8, posterior canal.

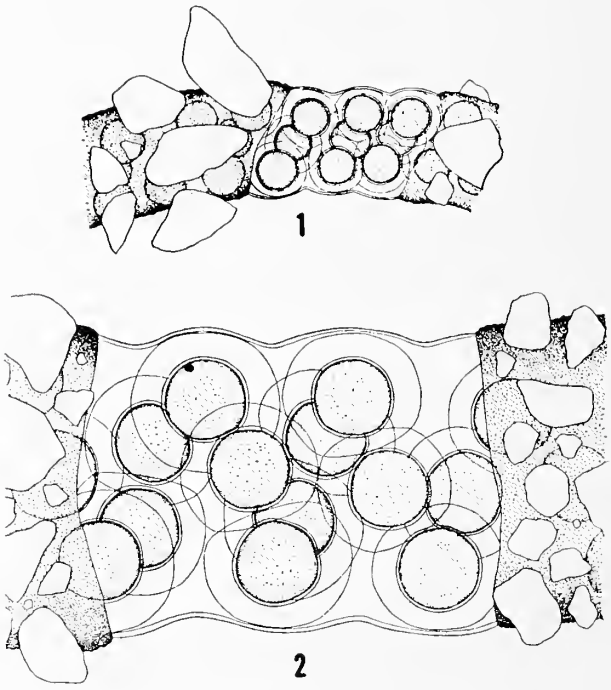


Plate 13. Portion of egg masses of *Strombus* with some sand grains removed to show internal coils of eggs. Fig. 1, *S. raninus* Gmelin, Bahamas. Fig. 2, *S. costatus* Gmelin, Bahamas. Both about × 40. (From R. Robertson, 1959, p. 167).

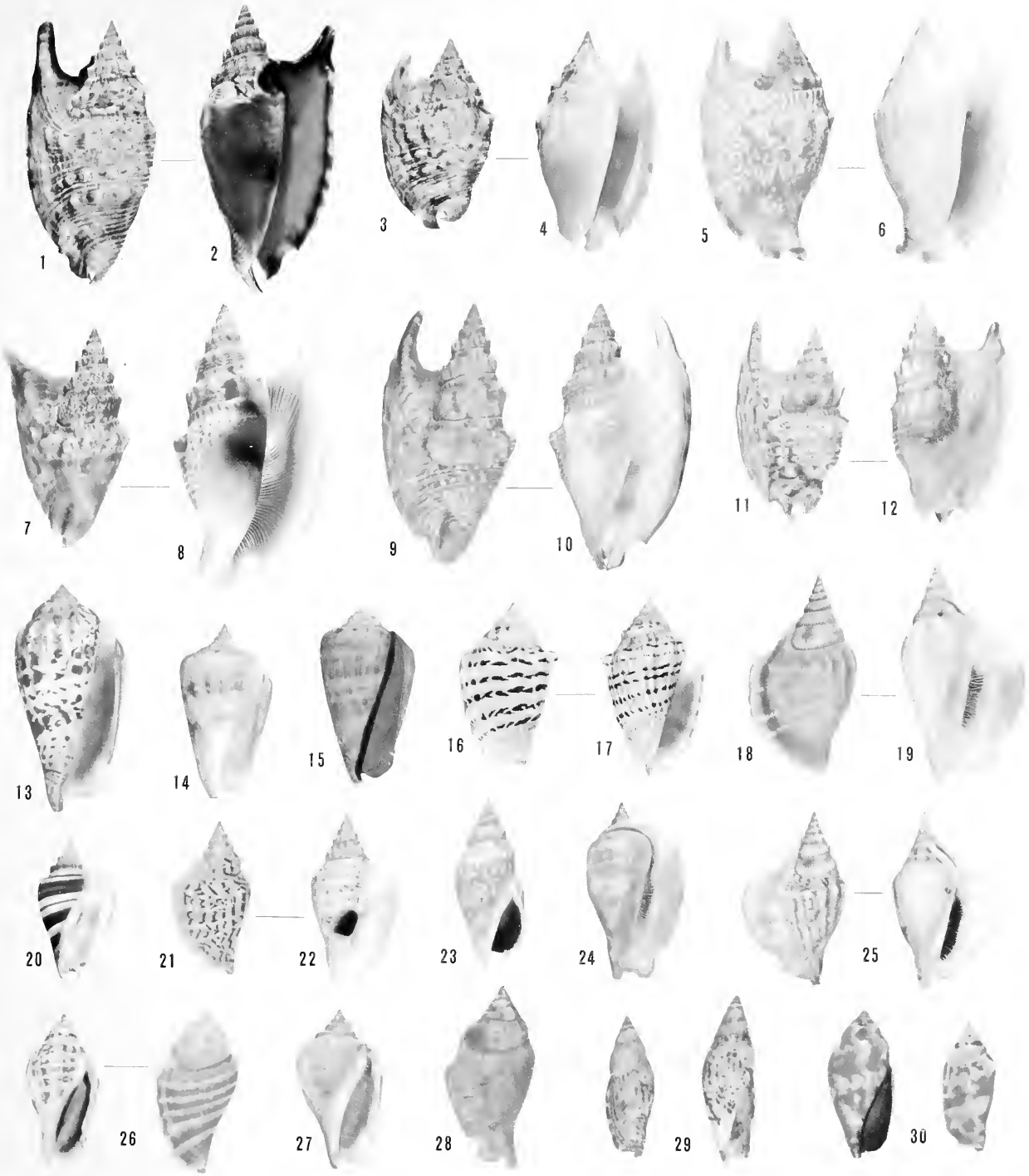


Plate 14

Figs. 1, 2 *Strombus aurisdianae aratrum* (Röding). Cairns.
3, 4 *Strombus aurisdianae* Linné. Balabac Id.
5, 6 *Strombus bulla* (Röding). Cebu Id.
7, 8 *Strombus vomer vomer* (Röding). New Caledonia.
9, 10 *Strombus vomer lawaiensis* Pilsbry. Hawaii.
11, 12 *Strombus vomer iredalei* Abbott. Western Australia.
13 *Strombus decorus decorus* (Röding). Mozambique.
14 *Strombus decorus persicus* Swainson. Arabia.
15 *Strombus luhuanus* Linné. Dutch New Guinea.
16, 17 *Strombus fasciatus* Born. Red Sea.
18, 19 *Strombus dilatatus swainsoni* Reeve. Pacific.
20 *Strombus variabilis* Swainson (color form). Palau.
21, 22 *Strombus variabilis* Swainson. Balabac Id.
23 *Strombus dentatus* Linné. Okinawa Id.
24 *Strombus dilatatus* form *orosminus* Duclos. Cebu.
25 *Strombus dilatatus dilatatus* Swainson. Mindanao.
26 *Strombus gibberulus gibbosus* (Röding). Cebu Id.
27 *Strombus gibberulus albus* Mörch. Red Sea.
28 *Strombus gibberulus gibberulus* Linné. Zanzibar.
29 *Strombus terebellatus* Sowerby. Pacific Ocean.
30 *Strombus fragilis* (Röding). Western Pacific Ocean.
(all approximately ½ natural size)

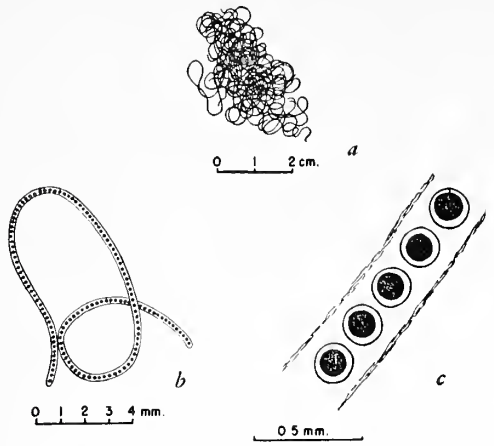


Plate 15. Egg mass (fig. a), egg strand (fig. b), and enlarged section showing single row of eggs (fig. c) of *Strombus maculatus* Sowerby. (from Ostergaard, 1950, p. 95, fig. 17).

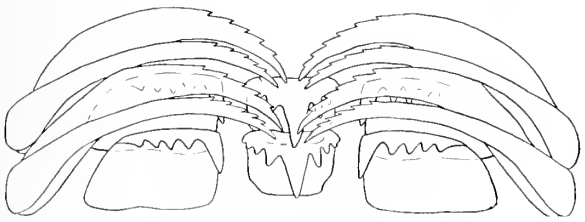


Plate 16. Two of forty transverse rows of radular teeth of *Strombus gibberulus gibbosus* (Röding) from a New Caledonian specimen. ×70.

Little is known about the species characters in the egg masses and veligers, but preliminary observations suggest that these may be additionally useful.

Our subgenera are not of equal rank, as would be expected when attempting to put arbitrary limits on nature's gradual and many-faceted avenues of evolution. The subgenera *Doxander*, *Labiostroubus* (in our restricted sense), *Gibberulus* and *Conomurex* seem to be well defined and sufficiently separated from their morphological neighbors. Within *Canarium* and *Tricornis* are several groups of species which are obviously closely related, but other species have a mixture of these group characters. We have refrained from creating a new series of monotypic subgenera or genera, feeling that this would obscure the relationships. Over-zealous neontologists would do well to consult the fossil record, and paleontologists should not be tempted to recognize some higher categories simply on the basis of long stretches of time.

Below we are listing the accepted subgenera and species of *Strombus*. Those in [brackets] are from other oceans, and those preceded by a dagger † are fossil. Abbreviations: W.A. is Western Atlantic; E.P. is Eastern Tropical Pacific or Panamic region. The list contains 89 fossil and living Indo-Pacific species and subspecies, of which 60 are living. We recognize 38 full species for the Recent Indo-Pacific and a world total of 50 Recent full species.

List of Recognized Taxa

Genus *Strombus* Linné, 1758
- *Strombus s.s.* Linné, 1758
  - [*pugilis* Linné, 1758] **Type** W.A.
  - [*alatus* Gmelin, 1791] W.A.
  - [*gracilior* Sowerby, 1825] E.P.
- *Laevistrombus* Kira, 1955
  - *canarium* Linné, 1758. **Type**
  - †*varinginensis* Martin, 1899
    - subsp. †*martini* Oostingh, 1935
  - †*overbecki* Cox, 1948
  - †*karikalensis* Cossmann, 1903
  - †*glaber* Martin, 1879
- *Tricornis* Jousseaume, 1886
  - *tricornis* Humphrey, 1786. **Type**
  - *thersites* Swainson, 1823
  - †*maximus* Martin, 1883
  - *latissimus* Linné, 1758
  - *taurus* Reeve, 1857
  - *sinuatus* Humphrey, 1786
  - †*junghuhni* Martin, 1879
  - †*mekranicus* Vredenburg, 1928
  - †*inflatus* Martin, 1879
  - †*tjilonganensis* Martin, 1899
  - [*raninus* Gmelin, 1791] W.A.
  - [*peruvianus* Swainson, 1823] E.P.
  - [*gallus* Linné, 1758] W.A.
  - [*costatus* Gmelin, 1791] W.A.
  - [*galeatus* Swainson, 1823] E.P.
  - [*goliath* Schröter, 1805] Brazil
  - [*gigas* Linné, 1758] W.A.
- *Dilatilabrum* Cossmann, 1904
  - [†*fortisi Brongniart*, 1823] **Type.** Eocene
- *Canarium* Schumacher, 1817
  - *urceus* Linné, 1758. **Type**
    - subsp. *orrae* Abbott, 1960
  - *labiatus* (Röding, 1798)
    - subsp. *olydius* Duclos, 1844
    - subsp. †*gendinganensis* Martin, 1879
  - *klineorum* Abbott, 1960
  - *microureeus* (Kira, 1959)
  - *mutabilis* Swainson, 1821
    - subsp. *ochroglottis* Abbott, 1960
    - subsp. †*ostergaardi* Pilsbry, 1921

maculatus Sowerby, 1842
†*unifasciatus* Martin, 1884
†*spolongensis* Martin, 1916
fusiformis Sowerby, 1842
erythrinus Dillwyn, 1817
subsp. *rugosus* Sowerby, 1825
haemastoma Sowerby, 1842
scalariformis Duclos, 1833
helli Kiener, 1843
dentatus Linné, 1758
fragilis (Röding, 1798)
terebellatus Sowerby, 1842
subsp. *afrobellatus* Abbott, 1960
Dolomena Iredale, 1931
plicatus (Röding, 1798)
subsp. *columba* Lamarck, 1822
subsp. *sibbaldi* Sowerby, 1842
subsp. *pulchellus* Reeve, 1851. **Type**
†*palabuanensis* Martin, 1899
†*deperditus* J. de C. Sowerby, 1839
dilatatus Swainson, 1821
subsp. *swainsoni* Reeve, 1850
subsp. †*taiwanicus* Nomura, 1935
subsp. †*fennemai* Martin, 1899
†*rembangensis* Martin, 1899
labiosus Wood, 1828
subsp. †*teschi* Cox, 1948
†*rutteni* Altena, 1942
marginatus Linné, 1758
subsp. *succinctus* Linné, 1767
subsp. *robustus* Sowerby, 1874
subsp. *septimus* Duclos, 1844
†*togopiensis* Cox, 1948
†*sedanensis* Martin, 1899
†*javanus* Martin, 1879
variabilis Swainson, 1820
subsp. *athenius* Duclos, 1844
minimus Linné, 1771
Labiostrombus Oostingh, 1925
epidromis Linné, 1758. **Type**
†*denti* Cox, 1948
†*kemedjingensis* Martin, 1916
Doxander Iredale, 1931
vittatus Linné, 1758. **Type**
subsp. *japonicus* Reeve, 1851
subsp. †*wadiumensis* Martin, 1899
subsp. †*deningeri* P. J. Fischer, 1921
subsp. *campbelli* Griffith and Pidgeon, 1834
†*triangulatus* Martin, 1879
listeri T. Gray, 1852
Lentigo Jousseaume, 1886
lentiginosus Linné, 1758. **Type**
pipus (Röding, 1798)
fasciatus Born, 1778
[*latus* Gmelin, 1791] West Africa
†*preoccupatus* Finlay, 1927
[*granulatus* Swainson, 1822] E.P.
Euprotomus Gill, 1870
aurisdianae Linné, 1758. **Type**
subsp. *aratrum* (Röding, 1798)
bulla (Röding, 1798)
vomer (Röding, 1798)
subsp. *hawaiensis* Pilsbry, 1917
subsp. *iredalei* Abbott, 1960
Conomurex P. Fischer, 1884
luhuanus Linné, 1758. **Type**
decorus (Röding, 1798)
subsp. *persicus* Swainson, 1821
Gibberulus Jousseaume, 1888
gibberulus Linné, 1758. **Type**
subsp. *gibbosus* (Röding, 1798)
subsp. *albus* Mörch, 1850
†*Oostrombus* Sacco, 1893
†*problematicus* Michelotti, 1861. **Type.** Eocene

Distribution of Strombus

A comparison of the distribution and speciation of the genus *Strombus* with that of another mesogastropod group is possible in the case of the Cypracidae because of the recent monograph by Schilder and Schilder (1938, Proc. Mal. Soc. London, vol. 23, pp. 119-231). Allowances should be made for the excessive generic and racial splitting by those authors. Many of their races are not accepted today, nor do some of their marine subregions have much to support their continued recognition (Sulu Sea region, Sumatran region, Bermudian region). Nevertheless, some interesting comparisons are possible.

The living, world-wide Strombidae (*Strombus*, *Lambis*, *Terebellum*, *Tibia*, and *Rimella*) contains about 75 full species (if strong subspecies are added, 100). The genus *Strombus* contains 50 full species. There are about 165 full species in the genus *Cypraea* (Cypraeidae of Schilder and Schilder, 1938, but see Kay, 1960). This ratio of about one *Strombus* species to 3 *Cypraea* species does not maintain itself throughout the various parts of the world tropical seas. One obvious reason for a higher proportion of *Cypraea* in such places as South Australia, South Africa, and the Mediterranean is that the Strombidae are more tropical in habitat preference. About 20 species of *Cypraea* live in waters presumably too cold for *Strombus*. Compared to the world ratio, there are proportionately more *Strombus* than *Cypraea* in the Panamic and Caribbean regions. The slightly cooled waters of the

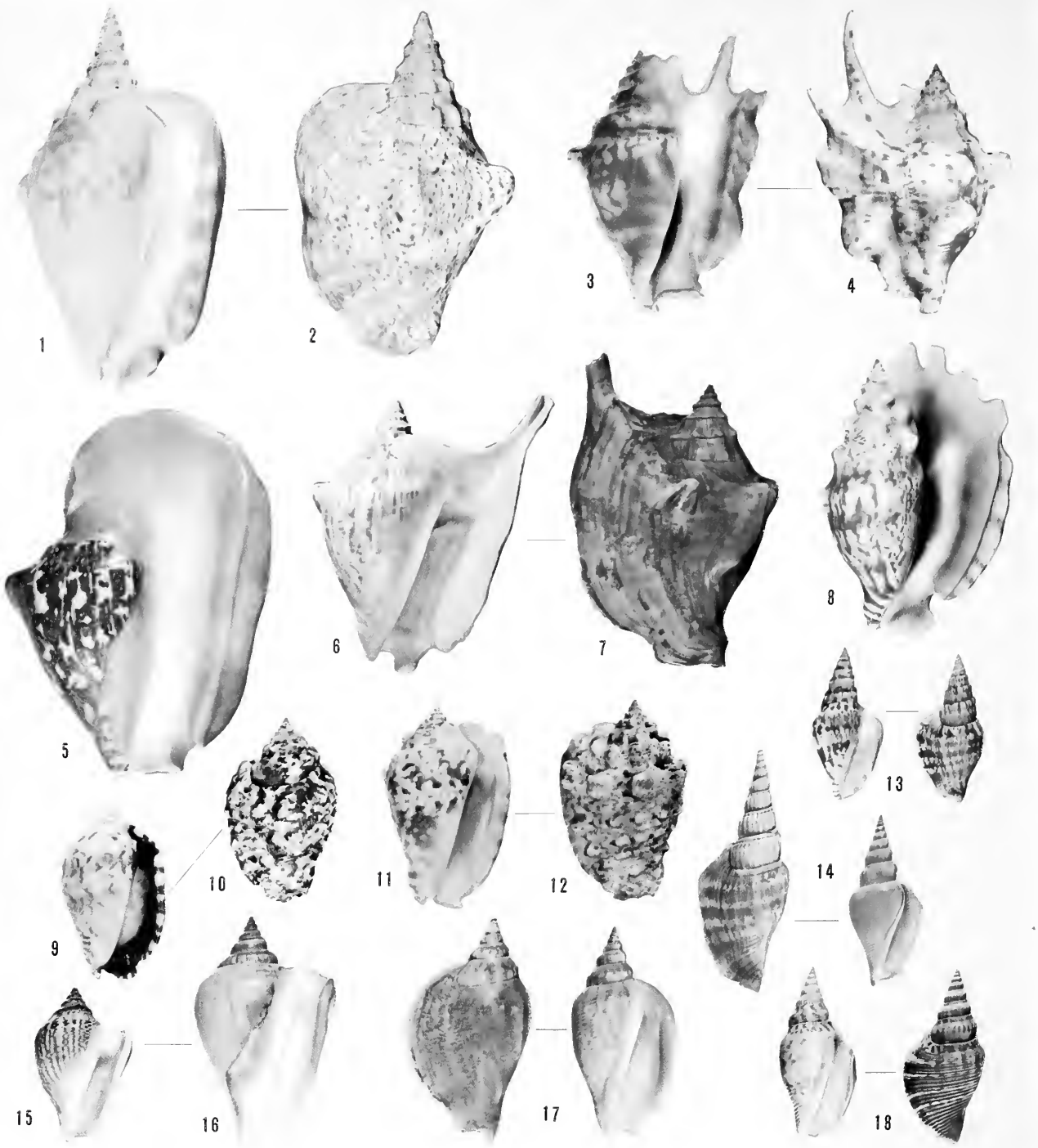


Plate 17

Figs. 1, 2 *Strombus thersites* Swainson. Okinawa Id.
3, 4 *Strombus taurus* Reeve. Rongelap Atoll.
5 *Strombus latissinus* Linné. Mindanao Id.
6, 7 *Strombus tricornis* Humphrey. Red Sea.
8 *Strombus sinuatus* Humphrey. Okinawa Id.
9, 10 *Strombus pipus* (Röding). Mindanao Id.
11, 12 *Strombus lentiginosus* Linné. Schouten Ids.
13 *Strombus vittatus campbelli* Griff. and Pidg. Queensland.
14 *Strombus vittatus vittatus* L. Cebu Id. (left, form *australis* Schröter; right, typical).
15 *Strombus canarium* Linné (typical form). New Caledonia.
16 *Strombus canarium* L. (form *turturellus* Röding)). Samar Id.
17 *Strombus epidromis* Linné. Mindanao Id.
18 *Strombus vittatus japonicus* Reeve. Ise, Japan.
(all approximately ½ natural size)

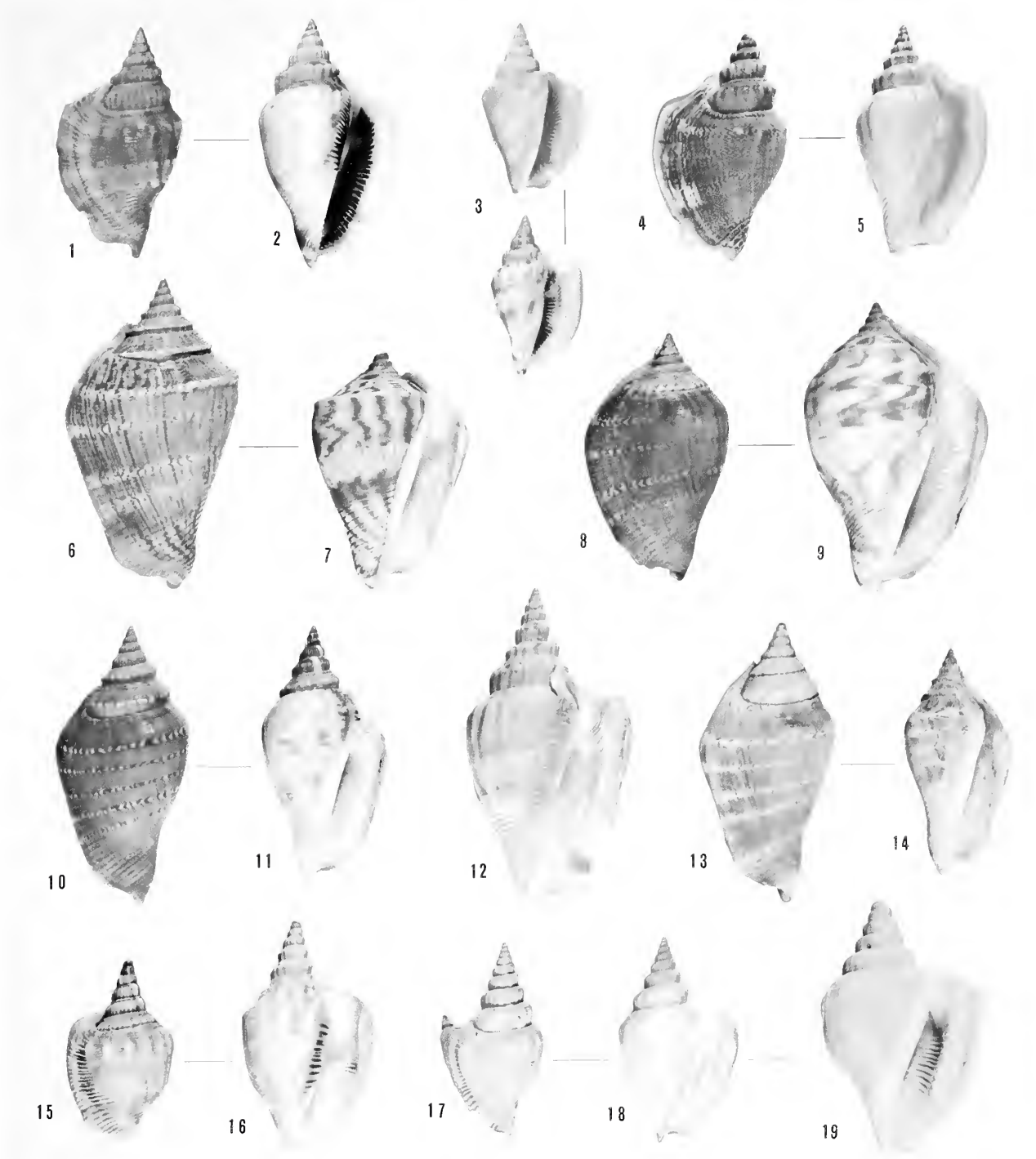
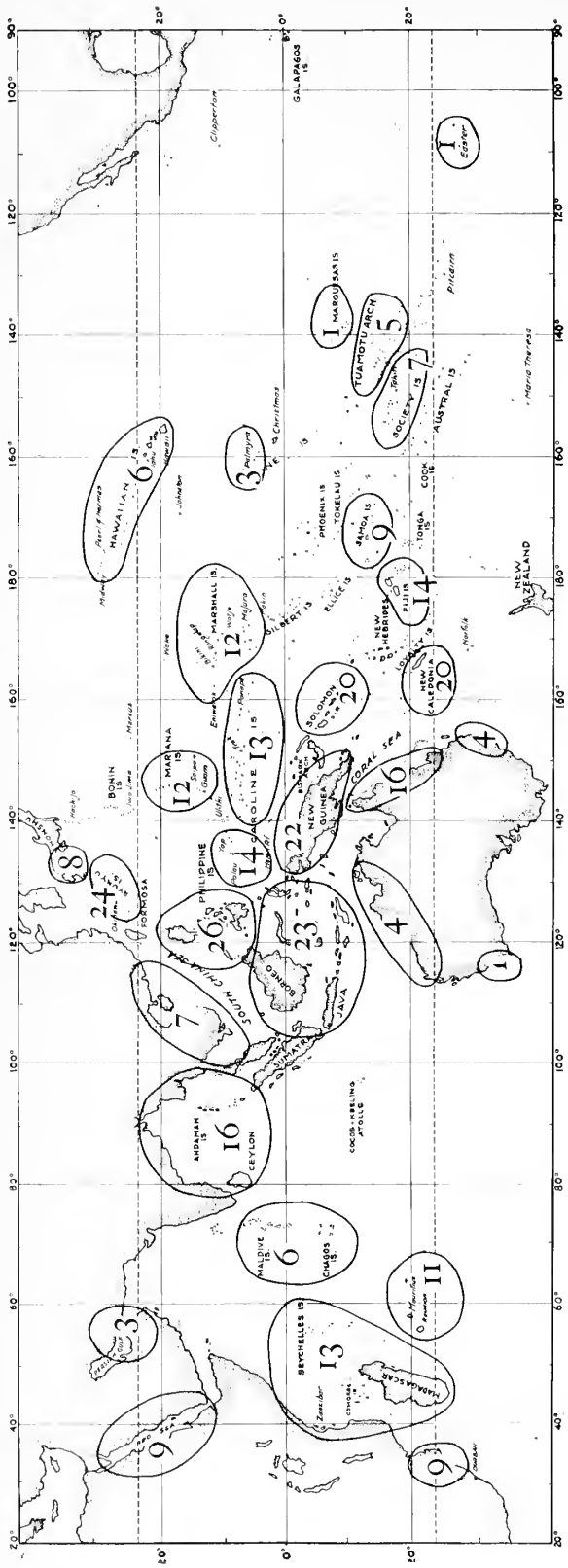


Plate 18

Figs. 1, 2 *Strombus plicatus columba* Lamarck. Zanzibar.
3 *Strombus plicatus pulchellus* Reeve. Luzon Id.
4, 5 *Strombus minimus* Linné. Cebu Id.
6, 7 *Strombus marginatus marginatus* Linné. Bay of Bengal.
8, 9 *Strombus marginatus robustus* Sowerby. Japan.
10, 11 *Strombus marginatus septimus* Duclos. (left, Solomons; right, Luzon Id.)
12 *Strombus plicatus plicatus* (Röding). Gulf of Suez.
13, 14 *Strombus marginatus succinctus* Linné. Ceylon.
15, 16 *Strombus plicatus* form *sibbaldi* Sowerby.
17, 18, 19 *Strombus labiosus* Wood. Philippines.
(all natural size)



Mediterranean and West Africa support 10 *Cypraea* but only one *Strombus* in West Africa. On the other hand, the Indo-Paeific is proportionately rieher in *Cypraea* than in *Strombus*.

A eloser comparison of the distribution within the Indo-Paeifie permits several generalizations. The *Cypraea* are not only more numerous in species for each small geographie area, but also are more evenly distributed. The rich areas (the Western Pacifie Are, the Bay of Bengal and eentral East Afriea) are the same for each genus, but much more pronounced for *Strombus*. The areas of high endemicity (i.e. Red Sea, Bay of Bengal, northern Australia, Hawaii and Polynesia) are about the same for each genus. The reduetion in the number of speeies eastward from the Western Pacific Are into Mieronesia and Polynesia is very pronouneed in *Strombus*, much less so in *Cypraea*. Both genera have but one speeies in Easter Island. There are no close relatives of the Indo-Paeifie *Strombus* in the Panamie provinee, but one *Cypraea* (*isabella* [or *controversa*] subspeeies *mexicana* Stearns, 1893) has made the migration.

The Western Pacific Arc

Our patterns of Indo-Paeifie distribution of *Strombus* speeies are similar to those outlined for *Cypraea* by Schilder and Schilder (1938), with one major differenee, in that those authors have failed to recognize the importanee and nature of the Western Paeifie Arc. This is a zoogeographie area running from the northern Ryukyu Islands south through Taiwan, the Philippines, Indonesia and southeastward through New Guinea, to New Caledonia and Fiji. The center of speeies oeeurrenee is in the eentral and southern Philippines where 26 raees of *Strombus* are present. The Western Pacific Are has a representation of 46 per eent of the Indo-Paeifie and 72 per cent of the Pacifie races of *Strombus* (in contrast to 10 and 15 per eent respectively in the ease of the Hawaiian fauna, and 11 and 18 per eent respeetively in the ease of the Soeiety Islands).

The following species or raees of *Strombus* are endemie to the Western Pacific Arc:

⟵ Plate 19. Number of species and races of *Strombus* in each area of the Indo-Pacific region. Insufficiently collected areas have been omitted, and some of the present censuses will increase by about 10 percent when additional records are found. Total races: 60; Indian Ocean 22; Pacific Ocean: 39.

(Tricornis) latissimus *(Dolomena) minimus*
(Dolomena) dilatatus *(Labiostrombus) epidromis*
(Dolomena) septimus *(Euprotomus) bulla*
(Euprotomus) vomer s.s.

Other species of *Strombus* occurring mainly in the Western Pacific Arc have advanced (or have not retrenched their former more widespread distributions) in several directions. Fifteen species maintain themselves in Queensland, Australia. Some of these may represent Pliocene or even Miocene invasions from the north, but others may be Quaternary migrations along westward flowing currents from the New Caledonia and Brampton Reef areas. The color patterns of *Strombus canarium* support the latter possibility for some species.

Only three species of the Western Pacific Arc occur to the west. Two of these, *canarium* and *labiatus*, are present in the Bay of Bengal and are also capable of sustaining themselves in the slightly cooler waters of Honshu Island, Japan. These species are always associated with large islands or continental shores where nitrogenous-rich waters prevail. The third species, *aurisdianae*, which occurs abundantly throughout the middle of the Indian Ocean from East Africa to Sumatra, may be a case of a recent advancement from Africa into the Western Pacific Arc as far as Okinawa and the Solomons. It occurs relatively abundantly in African fossil beds, but not in Indonesian beds. Furthermore, it is the only species in the Western Pacific Arc which stops at the Solomons. Curiously, the two advancing "horns", one in northern Queensland, the other in the Ryukyus have specimens which show a tendency towards melanism. The Queensland populations are so drastic in this and other characters, that we recognize them as the subspecies *aratrum*. The Indian Ocean populations show great instability in shell characters, and we believe represent potential isolation and a development of an Indian Ocean species or subspecies for the geologic future.

A more advanced case of the *aurisdianae*-like spread, is seen in *Strombus luhuanus*. Its fossil record is also better in Africa, and, in the Recent Indian Ocean, is represented by the distinct species *decorus*. The latter's instability has resulted in a northwestern Indian Ocean subspecies, *persicus*. *S. luhuanus* has spread beyond the Western Pacific Arc as far north as Honshu Island, Japan, as far south as Sydney, Australia, and as far east as Palmyra Island. All three extremities are noted for shells which tend towards either a stunted condition or a reduction of the typical, bright watermelon red in the aperture. If the central Western Pacific Arc populations were to become extinct, there might well develop a situation similar to that which occurs in the peripheral distribution of *S. vomer* and its subspecies (see below).

Other Western Pacific Arc species which exist to the eastward in varying distances are: *fragilis*, *gibberulus gibbosus*, *microureeus*, *pipus*, *sinuatus*, *terebellatus terebellatus*, and *variabilis*. We believe that *pipus* is in a period of shrinkage, since it occurs in small numbers in an isolated pocket in Tahiti, but mainly extends only from the Ryukyus to the Solomons. *S. pipus* is common only in the Sulu Sea. On the other hand, *gibberulus gibbosus*, a Pacific subspecies, is maintaining itself as an abundant species throughout the vast central Pacific, and has died out only in the Hawaiian Chain since the Pliocene. The stunted, smaller, less colorful specimens living in the atolls of the central Pacific suggest that *gibberulus gibbosus* is destined to extinction in the geologic future.

Two striking cases of discontinuous distribution exist in the Western Pacific Arc. One of these appears to be of relatively recent origin, the other of more ancient origin. The large, colorful and handsome *Strombus thersites* has been found on numerous occasions in the waters of New Caledonia and Okinawa, Ryukyu Islands. Despite many years of collecting in the intervening areas where many rare shells, such as *Conus glorianaris*, *Vasum tubiferum*, *Cypraea guttata*, etc., have been found, this large shell has not turned up in the Philippines, Indonesia or New Guinea. It is fairly safe to say that it does not occur, or at least is extremely rare, in these intervening areas. This is also true of *S. vomer vomer* which is moderately common in the Ryukyus and New Caledonia. Both of these species, or very close relatives of them, occur in the Pliocene of Indonesia, Taiwan, and the Lau Islands of Fiji. It appears that both of these species were widely spread throughout the Western Pacific in previous geologic times. Each, today, has been reduced in distribution.

In the case of *vomer*, three recent isolated genetic pools appear to have survived from the once widespread Pliocene range. Probably the oldest of these is the living subspecies *iredalei* which is limited to the Dampierian province from Western Australia to the Gulf of Carpentaria in northwest Queensland. A second subspecies, *hawaiensis*, is now limited to the Hawaiian Chain from Midway to Hawaii. It is closer morphologically to the Western Pacific Arc *vomer vomer* and the Pliocene Taiwan fossil than to *iredalei*. The third subspecies is

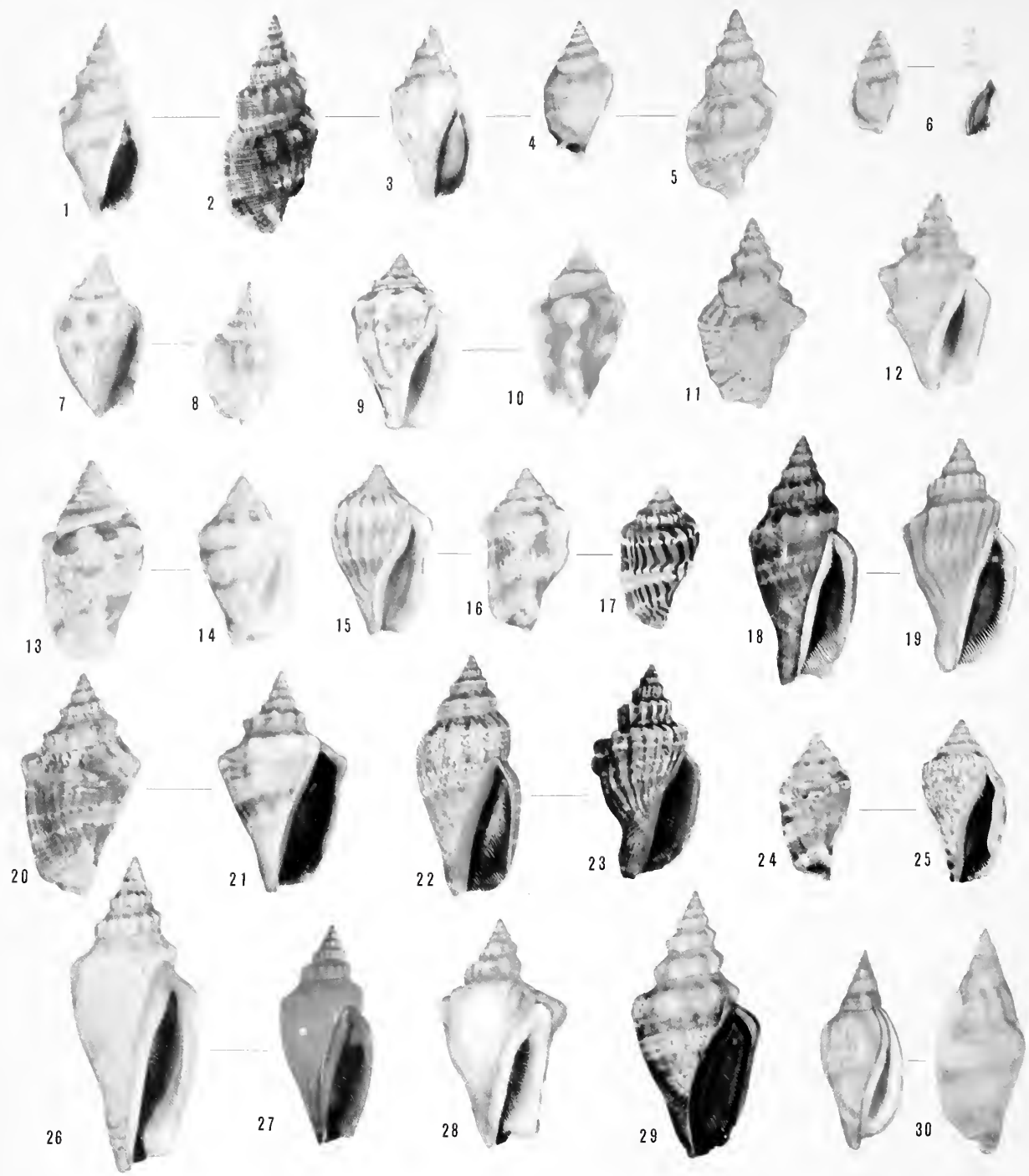


Plate 20

Figs. 1, 2 *Strombus erythrinus elegans* Sowerby. Noumea.
3 *Strombus erythrinus erythrinus* Dillwyn. Red Sea.
4 *Strombus erythrinus* (dwarf **form**). New Guinea.
5 *Strombus erythrinus erythrinus* Dillwyn. Mauritius.
6 *Strombus haemastoma* Sowerby. Wotho Atoll.
7, 8 *Strombus helli* Kiener. Oahu Id., Hawaii.
9, 10 *Strombus mutabilis ochroglottis* Abbott. Mauritius.
11, 12 *Strombus erythrinus rugosus* Sowerby. Polynesia.
13, 14 *Strombus maculatus* Sowerby. Hawaiian Ids.
15, 16 *Strombus mutabilis* Swainson. Cebu Id.
17 *Strombus mutabilis* **form** *zebriolatus* A. and L.
18, 19 *Strombus labiatus olydius* Duclos. Indian Ocean.
20, 21 *Strombus klincorum* Abbott. Ceylon. Holotype.
22 *Strombus labiatus* (Röding) (smooth **form**). Cebu.
23 *Strombus labiatus* (Röding) (ribbed **form**). Samar.
24, 25 *Strombus microurceus* (Kira). Okinawa.
26, 27 *Strombus urceus* Linné. Cebu Id.
28 *Strombus urceus orrae* Abbott. Western Australia.
29 *Strombus urceus* **form** *ustulatus* Sehum. China.
30 *Strombus fusiformis* Sowerby. Zanzibar.

the typical *vomer vomer* which is now, in Recent times, beginning to die out and separate into two remotely isolated populations. Given time, they too may become subspecifically separated.

In the above two cases and in S. *pipus*, we see actual or potential examples of differentiation occurring at the extremities of a range after extinction has occurred in the center of distribution. There are, however, suggestive examples of new subspecies occurring while the parent species is still abundant and in a widespread and continuous range. Examples are *variabilis athenius*, *erythrinus rugosus*, *aurisdianae aratrum*, *gibberulus albus*, the *marginatus* complex and *mutabilis ochroglottis*. These subspecies are by no means equal in strength. The morphological gap is stronger perhaps due more to genetic differences in some cases, while in other cases the differences are subtle and possibly brought about in part by special geographical ecologic conditions.

In some cases, it would appear that a species has developed on the edges of the Western Pacific Arc and then re-invaded the East Indies. Such may be the case of the more easterly located *bulla* which now overlaps the range of its very close relative *aurisdianae*. Some of the shell specimens in the Philippines show a possible hybridization. These two species are normally kept apart by their respective bathymetric ranges, one living in shallow, intertidal waters, the other from about 10 to 40 feet of water.

In general, we have noted that individuals of one species are usually in shallower water in the Philippine area than they are in Micronesia and Polynesia. This is especially pronounced in the case of certain Wake Island and Hawaiian *Strombus*, *Cypraea* and *Terebra*. The possible development of a deeper-water physiological race in the central Pacific would make possible a return invasion into the Western Pacific Arc without genetic swamping by the original parent stock. The converse or opposite direction is also possible.

Discontinuous distributions in which one small center occurs in the Zanzibar-Mauritius-Seychelles triangle of the western Indian Ocean and in which a second, larger center occurs in the western Pacific are noted in the case of *Strombus pipus*, S. *haemastoma*, S. *dentatus*, *Strombus plicatus columba* (Indian Ocean) and S. *plicatus pulchellus* (Western Pacific Arc). A comparable case exists in the distribution of S. *terebellatus* which has its typical race in the Western Pacific Arc and its Indian Ocean subspecies from Mozambique, Zanzibar, northern Madagascar and the Red Sea. Schilder and Schilder (1938, vol. 23, p. 178) found this same Indian-Pacific Ocean discontinuity in *Cypraea* (*Callistocypraea*) *testudinaria* Linné. [his typical *testudinaria* and *testudinosa* should be combined]. The distribution of the Pacific populations of *C. testudinaria* is the same as that of S. *gibberulus gibbosus*. This cowrie and the latter *Strombus* do not have the same bathymetric range, although all are associated with coral reef or coral sand habitats.

Continental and Oceanic Species

It is well-known that each species has its own ecological requirements, and that the distribution of such environmental factors as temperature, substrate, water conditions and, in the case of herbivores, the plant life, will all determine the geographical range of the species. Although little is known about the exact ecological preferences of *Strombus*, we have been struck by the existence of two basic types of species that occur not only in the Strombidae but also throughout most of the marine families of mollusks and some other invertebrates. A large proportion of the Indo-Pacific and the Western Atlantic *Strombus* fall into one or the other of these two groups:

1. Species limited to the rich, nitrogenous shores of continents or well-vegetated volcanic islands (*Strombus*):

(Pacific)	*minimus*
canarium	*urceus*
dilatatus	*vittatus*
epidromis	(Caribbean)
labiatus	*alatus*
latissimus	*pugilis*
marginatus	*goliath*

2. Species mainly living in clear, oceanic waters surrounding small coral islands, submerged banks or in similar oceanic conditions bordering large islands and continents (*Strombus*):

(Pacific)	*maculatus*
dentatus	*microurceus*
erythrinus	*mutabilis*
fragilis	*sinuatus*
gibberulus	*taurus*
lentiginosus	(Caribbean)
luhuanus	*gigas*
decorus	*costatus*

On the whole, the species in the second group are more widely distributed. More cases of endemicity are developed in the first group; and some other families are almost exclusively continental or

large-island-dwellers, such as the Melongenidae and most of the Donacidae and Solenidae. Neither phylogenetic relationship, method of reproduction, size of the animal, relative abundance nor bathymetric range seem to be correlated with the type of distribution. Several *Strombus* and about one fourth of the two hundred species in other families whose distributions we have studied seem either to be intermediate in their habitat preference or are insufficiently understood.

Origin of the Recent Indo-Pacific Fauna

The genus *Strombus* first appeared in the early Miocene in the ancient Tethys Sea. It appears in the fossil beds of the Caribbean, southern Europe and the Indo-Pacific. It does not appear in any fossil beds which are considered by most paleontologists to represent a cooler water fauna. Although the fossil record does not seem to be as full or as complete as the Recent one, it would appear that the Pliocene saw the first great development of *Strombus*, not only in the development of new subgenera, but also in the geographical spread of the various species. Some time during the Pleistocene, there was an almost universal shrinkage in the ranges, particularly in the eastern and central sections of the Pacific Ocean. A few typically Indonesian Pliocene species remained trapped in isolated pockets, such as *Cyrtulus serotinus* Hinds, *Lambis robustus* Swainson (formerly *pseudoscorpio* Lamarck) in the Societies, and such as *Strombus vomer hawaiensis* in Hawaii.

In the main, however, the amount of speciation and the extent of distribution of these species of *Strombus* have remained the same from the Pliocene to Recent times. Continental species closely resembling *canarium* and *epidromis* have remained in the southeast area of Asia. No fossils have turned up, even in the latest drill cores in the Marshalls, which would suggest that any great degree of new speciation had developed in the Central Pacific area during the Neogene. Ladd (1960, Amer. Journ. Sci., vol. 258-A, p. 137) has speculated to the contrary and suggests that the predominance of species in our Western Pacific Arc is the result of a gradual "piling up" of species as they were drifted westward by ocean currents. We support the opposite view that the parent stocks and the majority, although not all, of late Pliocene and Pleistocene races originated in the Western Pacific Arc. A few undoubtedly originated in the Indian Ocean, while others may have started on the eastern edge of the arc. But even such endemic Micronesian and Polynesian species as *Strombus maculatus* have their extremely close relatives in the Miocene of Indonesia.

If Ladd's over-emphasis of the importance of the transportation powers of the equatorial currents and winds were to be applied to the Western Pacific Arc, we should certainly find a greater concentration of Micronesian-like species in the Ryukyu Islands and perhaps even the Marianas. In considering the migration of marine species, two factors must not be overlooked—the many millions of years involved, and the work of the counter currents. How else would several hundreds of Indo-Pacific species have found their way from either the central Pacific or the Western Pacific Arc all the way to the Tuamotu, Society and Marquesas Islands? Nor are there many malacologists ready to suggest that the few obviously Indo-Pacific elements in the Panamic Province (*Conus dalli*, *Cypraea isabella mexicana*, *Conus sponsalis nux*, etc.) are the "seeds" of the Indo-Pacific fauna. In the Caribbean, the concentration of the number of species certainly does not correspond with the activities of the Gulf Stream or other major currents. In fact, many formerly widespread Miocene species have retreated southeasterly against the currents and exist today only in the area of northwestern Venezuela (*Cypraea mus* Linné, *Strombina pumilio* Reeve, etc.).

In view of the presently known fossil record, recent distributions, and the migratory history of marine species in the Indo-Pacific and other oceans, we believe that the central part of the Western Pacific Arc (i.e. the Philippines or Indonesia) is the center of origin of most of the Pacific races and of some of the Indian Ocean races. The paucity in number of species in such areas as eastern Polynesia, the central atolls of the Indian Ocean, the Bahamas and such small coral islands as Grand Cayman Island (West Indies), Easter Island (eastern Polynesia) and Cocos-Keeling (Indian Ocean) are probably due to poor ecological conditions and not to the fact that they are isolated from migrant-carrying currents.

Doubtful species of Strombus

Faustino (1928, Monograph 25, Bureau of Science, Manila, pp. 211-214) lists 30 species of *Strombus* from the Philippines. He erroneously listed *Strombus hebraeus* Linné and *Strombus textile* Linné, doubtlessly meaning Linné's two well-known species of *Conus*. Some early authors prior to 1842 employed the genus *Strombus* to such modern genera as *Turris*, *Rissoina*, *Thiara*, *Faunus* and *Morum*.

Strombus elatus Anton, 1839

Range—Indo-Pacific?

Remarks—It would appear from Anton's description that this species is related to *vittatus* Linné or *labiosus* Wood. It was not figured. Anton lists *Strombus turritus* Lamarck, so it is not that form of *vittatus*.

Synonymy—

1839 *Strombus clatus* Anton, Verzeichniss der Conchylien, Halle, p. 85, no. 2799 (no locality).

Strombus sulcatus Anton, 1839

Range—Mexico [?].

Remarks—If from Mexico, this species may be a synonym of *Strombus gracilior* Sowerby or *S. pugilis* Linné. It was not figured and its description could apply to several species. Non *sulcatus* Holten, 1802.

Synonymy—

1839 *Strombus sulcatus* Anton, *loc. cit.*, p. 85, no. 2798 (Mexico).

Strombus tuberculatus Anton, 1839

Range—Unknown; Indo-Pacific?

Remarks—This species was not illustrated and it's description meagre, although it is quite possible that it is a synonym of the dwarf, knobbed form of *Strombus decorus* (Röding) from East Africa.

Synonymy—

1839 *Strombus tuberculatus* Anton, *loc. cit.*, p. 86, no. 2813 (no locality).

Strombus parvulus Krumbeck, 1906

Range—Tertiary (weisser Versteinerungskalk) Tripoli.

Remarks—This is such a poorly preserved fossil that it is very doubtful that it is a *Strombus*.

Synonymy—

1906 *Strombus parvulus* Krumbeck, Palaeontographica, Stuttgart, vol. 53, p. 118 (Djebel Tar, Tripoli).

Strombus labrosus Menke, 1829

Range—Unknown.

Remarks—This is an unfigured dubious species which Mörch says is a variety of *luhuanus* Linné.

Synonymy—

1829 *Strombus labrosus* Menke, Verz. Conch.-Samml. Malsburg, p. 59, no. 1209; 1871, Mörch, Malak. Blätt., vol. 18, p. 127.

Strombus glabratus Sowerby, 1842

Range—West Africa from Angola to French Guinea.

Remarks—This species evidently belongs in the family Nassariidae and is the type of the genus *Naytia* H. and A. Adams, 1853. It is a synonym of *Naytia obliqua* (Kiener, 1841). However, Sowerby's name must continue in use, since Kiener's *Buccinum obliquum* is a homonym of *obliquum* Gmelin, 1791.

Synonymy—

1842 *Strombus glabratus* Sowerby, Thesaurus Conchyliorum, vol. 1, p. 32, pl. 8, figs. 66, 67 (no locality).

Strombus moisei Cuvillier, 1930

Range—Upper Eocene, Bartonian of Egypt.

Remarks—I doubt if this is a Strombidae, and, if I interpret the four columellar plicae correctly, it should be placed in the family Vasidae.

Synonymy—

1930 *Strombus moisei* Cuvillier, Mémoires l'Institut d'Egypte, vol. 16, pp. 253 and 323, pl. 20, figs. 15 and 16 (Aïn Mouça, Bartonian of Egypt).

Strombus altispirus King, 1953

Range—Miocene of Zululand, South Africa.

Remarks—Not demonstrated, in my opinion, to be a *Strombus*.

Synonymy—

1953 *Strombus altispirus* King, Trans. and Proc. Geol. Soc. South Africa, vol. 56, p. 77, fig. 9, pl. 12, fig. 32 (Sapolwana, Zululand, Miocene).

Strombus mimasakensis Yokoyama, 1929

Range—Miocene or Pliocene of Japan.

Remarks—Based upon a single large broken shell which could be a *Melongena*, or possibly a *Strombus* resembling the fossil *S. maximum* Martin from Java.

Synonymy—

1929 *Strombus mimasakensis* Yokoyama, Journ. Faculty Sci. Imp. Univ. Tokyo, sect. 2, vol. 2, pt. 8, p. 366 (Mimasaka, Chugoku, Japan).

Strombus martapurensis K. Martin, 1889

Range—Tertiary of Indonesia.

Remarks—This does not appear to be a *Strombus*, and possibly not even a member of the family.

Synonymy—

1889 *Strombus martapurensis* K. Martin, Jaarboek Mijnwegen in Nederland. Oost-Indie, Amsterdam, vol. 18, p. 66, pl. 20, fig. 13; 1889, Samml. Geol. Reichs-Mus. Leiden, 1st series, vol. 4, p. 189, pl. 20, fig. 13.

Strombus bivaricosus Nomura, 1935

Range—Pliocene of Taiwan.

Remarks—Nomura likened this possible juvenile form to *S. sondeianus* Martin. It may also be the young of *S. taiwanicus* Yabe and Hatai, 1941.

Synonymy—

1935 *Strombus bivaricosus* Nomura, Science Reports Tohoku Imperial Univ. Sendai, 2nd ser., vol. 18, no. 2, p. 178, pl. 8, figs. 14 a, 14 b (Byoritu Beds, Pliocene, 1000 meters S.E. of Hakusyaton, Taiwan).

Strombus sondeianus Martin, 1906

Range—Pliocene of Java, Indonesia.

Remarks—This is possibly the young of *Strombus fennemai* Martin.

Synonymy—

1906 *Strombus sondeianus* K. Martin, Samml. Geol. Reichs-Mus. Leiden, n. Folge, vol. 1, pt. 9, p. 319, pl. 45, figs. 739, 740 (Sonde, Java, Pliocene).

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The majority of the bibliographic references to *Strombus* appear in the synonymies under the various species. Some of the references, listed by author, date and pagination, which appear in the sections on locality records may be located in the Zoological Record. The standard iconographs which dealt with *Strombus* during the nineteenth century are listed in the synonymies (Sowerby, 1842; Kiener, 1843; Duclos in Chenu, 1844; Reeve, 1850-51, and Tryon, 1885). A useful bibliography of fossil Indonesian species is found in van der Vlerk, 1931 (see below).

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van der Vlerk, I. M. 1931. Caenozoic Amphineura, Gastropoda, Lamellibranchiata, Scaphopoda. Leidsche Geologische Mededeelingen, Leiden, deel 5, pp. 206-296. [*Strombus* on pp. 246-248.]

Subgenus Strombus Linné, 1758

Type: *Strombus pugilis* Linné, 1758

The typical subgenus of *Strombus* is not, in our opinion, represented in the Recent Indo-Pacific. It exists in tropical American waters—*pugilis* Linné 1758, and *alatus* Gmelin, 1791, of the Caribbean and Florida, respectively; and *gracilior* Sowerby, 1825, of the tropical Eastern Pacific. This stock has been in the Caribbean for a long time in the form of such Miocene species as *Strombus proximus* Sowerby, 1850, *bifrons* Sowerby, 1850, and *pugiloides* Guppy, 1873.

There appears to be some close conchological kinship between the above species and the Indonesian Miocene species *Strombus varingineusis* Martin. From this stock, it appears that *Strombus canarium* of the Recent Indo-Pacific could have arisen, especially when the sculpture and color patterns of the Caribbean Miocene *proximus* and *canarium* are compared. However, I find no very close relationships between the radulae and soft parts of *pugilis* and *canarium*, and, hence, have arbitrarily accepted *Laevistrombus* as a valid subgenus for *canarium*.

Strombus sensu stricto is characterized by solid, medium-sized shells with a broadly fusiform shape, a single row of shoulder spines and a smooth columella. The operculum is strongly serrated. The accessory pad of the penis bears a peculiar prong. The central tooth of the radula is quadrate; the lateral very stout, conic and without smaller cusps; and the two marginals thin, narrow and with 5 to 8 denticles.

The Western Atlantic species were treated by Clench and Abbott in Johnsonia, vol. 1, no. 1, pp. 1-16, 1941. I would modify that treatment by accepting *alatus* Gmelin, 1791, as a full species, and by considering *nicaraguensis* Fluck, 1905, as merely a form of *pugilis*.

Synonymy—

1758 *Strombus* Linné, Systema Naturae, ed. 10, p. 742, no. 289. Type by subsequent designation (Montfort, 1810): *Strombus pugilis* Linné; also possibly Lamarck 1799, p. 72 who listed only *pugilis* Linné.

1838 *Strombella* F. Schlüter, Kurzg. Syst. Verz. Conch., p. 22. Type by monotypy: *S. pugilis* Linné.

Subgenus Laevistrombus Kira, 1955

Type: *Strombus canarium* Linné, 1758

This subgenus appears to be limited to the Indo-Pacific, and contains only one living species—*canarium* Linné. Six fossil species, described from the Miocene and Pliocene of Indonesia and India, appear to belong to this group.

The shells are thick, generally rotund and inclined to be smoothish. The columella is smooth, the outer lip thick. The operculum bear 7 to 8 small serrations. The penis is a simple prong, usually dark-maroon or brown in color. The central radular tooth is ovoid; the lateral with a basal peg, and the marginals thin and with only 2 or 3 cusps.

The group does not seem to have survived in, or

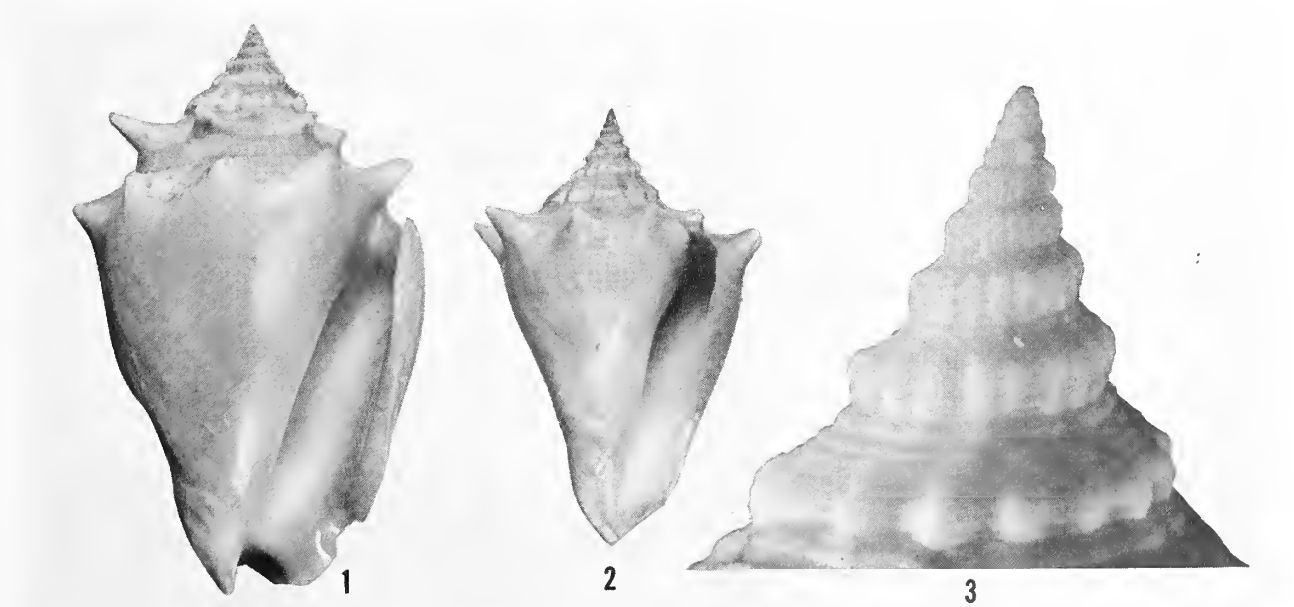


Plate 21. *Strombus pugilis* Linné, type of the genus *Strombus* Linné, 1758. Santo Domingo, West Indies. 1, adult. 2, immature. 3, enlargement of apex. 1 and 2, slightly reduced.

possibly ever reached, East Africa or the Red Sea. Odhner, 1919, probably erroneously reported *canarium* from Madagascar.

Synonymy—

1955 *Laevistrombus* Kira, Coloured Illust. of the Shells of Japan, Osaka, ed. 1, p. 31; 1959, *ibid.*, ed. 2, p. 36. Type hereby designated: *Strombus canarium* Linné.

Strombus canarium Linné, 1758

(Pl. 17, figs. 15, 16; pls. 12, 22, 23, 24)

Range—Southern India to Australia and Melanesia, and north to Japan.

Remarks—This well-known species is usually abundant wherever it occurs. It is not a coral-water species, but rather is associated with larger islands and continental shores where sandy mud exists. Its heavy, smooth brownish shell, its white smooth aperture and its thick, winged outer lip are the distinguishing characters.

This species is very often variable in size, shape and color pattern. The length of adult shells in some colonies (Japen Id., Dutch New Guinea) may not exceed 40 mm., while on nearby Soepiori Id., Schouten Id., Dutch New Guinea, the median adult length is 86 mm. Some colonies exhibit a wide range in size (Tabaco, Albay Prov., Luzon Id., Philippines) from 42 to 98 mm. There are two color forms which may occur in the same individual at different stages of growth, one of a network of light or dark-brown streaks, the other of a unicolor wash of light (or rarely dark) yellow-brown. The latter color form is more common in larger specimens. The netted form is the typical *canarium;* the plain color phase is the form *turturella* (Röding) and *isabella* Lamarck. The spires of the shells may also vary, some being high and with more angular peripheries, others being short and more flat-sided. Although some authors have considered the above forms as separate species, I can find many intergrades, combining characters, and no geographical pattern. Shells from New Caledonia and Queensland are commonly (although not all) very darkly colored. The aluminum-like glaze on the apertural lip is a sign of maturity or old age which is probably also correlated with diet or water conditions.

Habitat—Lives in large colonies on sandy mud and algae bottoms from low tide mark to a depth of about 20 feet. Risbec (1935, vol. 60, p. 409) describes the egg mass as a long, entangled, single, gelatinous tube with a single row of ova.

Description—Adult shell 31 to 97 mm. (1¼ to 3¾ inches) in length, solid, heavy, globose, smooth, light-brown and with a flaring lip. Nuclear whorls 3, smooth, translucent whitish, yellow or tan, and rounded. Postnuclear whorls brown, moderately rounded, and with either 7 to 9 spiral cords or wide, incised lines. Numerous axial riblets may be present to form a gross reticulate pattern. By the second or third whorl, only incised spiral lines are present, and the remaining whorls are sculptureless, except for 6 to 15 weak spiral threads or incised lines at the base of the shell. Apex with 4 to 16 swollen, whitish, rounded, former varices, the early ones being spirally incised or corded, the later ones inclined to be smoothish. Penultimate whorl flattish, rounded, or barely angular. Last whorl roundly

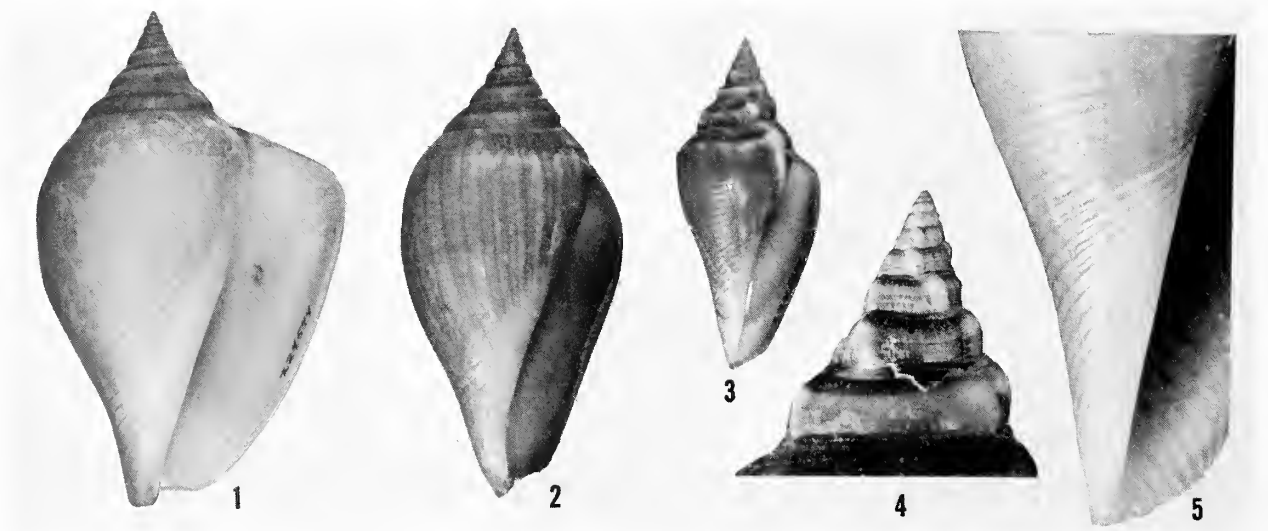


Plate 22. Figs. 1-5, *Strombus canarium* Linné, Gubat, Luzon Id., Philippines. Fig. 1, almost mature, remaining figures represent immature specimens. All natural size.

swollen at the shoulder. Color of shell variable; either a uniform light yellow-brown or chestnut, or densely covered with a fine, zigzag network of darker brown. Columella straight, swollen, glazed, smooth and enamel-white. Outer lip thick, rounded, and its upper end projecting slightly upward. It and the parietal wall may have a brown or gray, aluminum-like glaze. Siphonal canal short. Stromboid notch very shallow. Periostraeum rather thick, reticulated, yellow-brown and fimbriated at the sutures. Operculum stromboid, dark-brown, one third the length of the shell, slightly arching and with 7 to 8 weak serrations.

Radula ribbon 4 mm. in length, with 40 to 45 rows of teeth, and amber to wine-red in color. Formula: 3-1-3; 1-5 to 1-9 (plus peg); 3; 2. Verge simple and with a broad swollen distal end; dark-maroon in color. Posterior mantle filament small.

Measurements (mm.)—

length	width	no. whorls	
97.0	62.1	9+	(giant; Luzon Id.)
90.1	51.0	9+	(large; Schouten Ids.)
67.5	40.0	10	(average; Luzon Id.)
31.0	22.2	6+	(small; New Guinea)

Synonymy—

1758 *Strombus canarium* Linné, Systema Naturae, ed. 10, p. 745, no. 438 (In O. Asiae); 1767, ed. 12, p. 1211, no. 507; 1956, Dodge, Bull. Amer. Mus. Nat. Hist., vol. 111, art. 3, pp. 275-276.

1798 *Lambis turturella* Röding, Museum Boltenianum, Hamburg, pt. 2, p. 65, no. 833. Refers to Conchyl.-Cab., vol. 3, fig. 817.

1822 *Strombus isabella* Lamarck, Anim. sans Vert., vol. 7, p. 207 (Crandes Indes). Refers to Conchyl.-Cab., vol. 3, fig. 817.

1834 *Strombus vanikorensis* Quoy and Caimard, d'Urville's Voy. L'Astrolabe, Zoologie, vol. 3, p. 73, pl. 51, figs. 7-9 (Vanikoro).

1834 *Strombus taeniatus* Quoy and Caimard, *ibid.*, p. 75, pl. 51, figs. 14-15 (Amboine).

1876 *Strombus gibbus* "Martini" Issel and T.-Canefri, Annali Mus. Civico Storia Nat. Genova, vol. 8, p. 344; 1895, R. Bergh, Zoologischer Jahrbücher, Jena, vol. 8, pp. 359-362, pl. 23, figs. 50-53 (anatomy).

1885 *Strombus vanicorensis* Quoy, Tryon, Manual of Conch., Phila., vol. 7, p. 110.

Types—"The type specimen of *canarium*, marked by Linnaeus, is found in the Linnaean collection in London at the Linnaean Society of London" (Dodge, 1956, p. 276). We hereby designate Amboina, Indonesia, as the type locality, since Linnaeus merely gave "In O. Asiae".

Nomenclature—Under our remarks we discussed our reasons for considering *isabella* Lamarck as merely a form of *canarium*. Even if accepted as a subspecies, Lamarck's *isabella* would have to take the earlier name of *turturella* (Röding, 1798).

Selected records (see accompanying map, pl. 23). Solid dots: specimens examined; open circles: literature records)—INDIA: Goa (J. E. Bridwell, USNM); Pamban and Tuticorn, Gulf of Manaar (E. Thurston, 1895, p. 125). CEYLON: Karaitivu Id., and Trincomalee (George and Mary Kline, NSF). ANDAMANS: Port Blair (W. N. Carpenter, USNM). SINGAPORE: muddy sand, algae, intertidal at Tanak Merah Besar (R. D. Purchon, ANSP). THAILAND: Gulf of Siam: Sutamarat; Taluei Id.; Bangbert Bay; Koh Samui; Koh Samit; Lem Sing (all USNM). CHINA: Cheefoo (Yentai) (Ping and Yen, 1932, p. 48 [accurate?]). HONG KONG: S.W. of Urn Id., Rocky Harbour (A. J. Staple, ANSP). JAPAN: Shirahama, Wakayama Pref., Honshu Id. (T. Habe, ANSP). PHILIPPINES: common on most of the islands: Luzon; Leyte; Samar; Catanduanes; Negros; Basilan; Panay; Palawan; Balabac; Polillo; Busuanga; Mindoro; Mindanao; Guyo (ANSP and USNM). INDONESIA: (see Oostingh, 1923, p. 82 for many records). Sarawak, Borneo (MCZ). AUSTRALIA: Queensland: Port Douglas (Tony Marsh, ANSP); Bedford Beach, Cooktown (MCZ); Hayman Id., Gumberland Group (MCZ). NEW CALEDONIA: Touho Bay; Baie des Prunes; Baie de l'Orphelinat (all G. and M. Kline, 1958, NSF). NEW HEBRIDES: Lamap, Mallicolo Id. (G. Massoulard, ANSP). [Records, such as Odhner, 1919, p. 35, for the western part of the Indian Ocean are probably based on mixtures or misidentifications.]

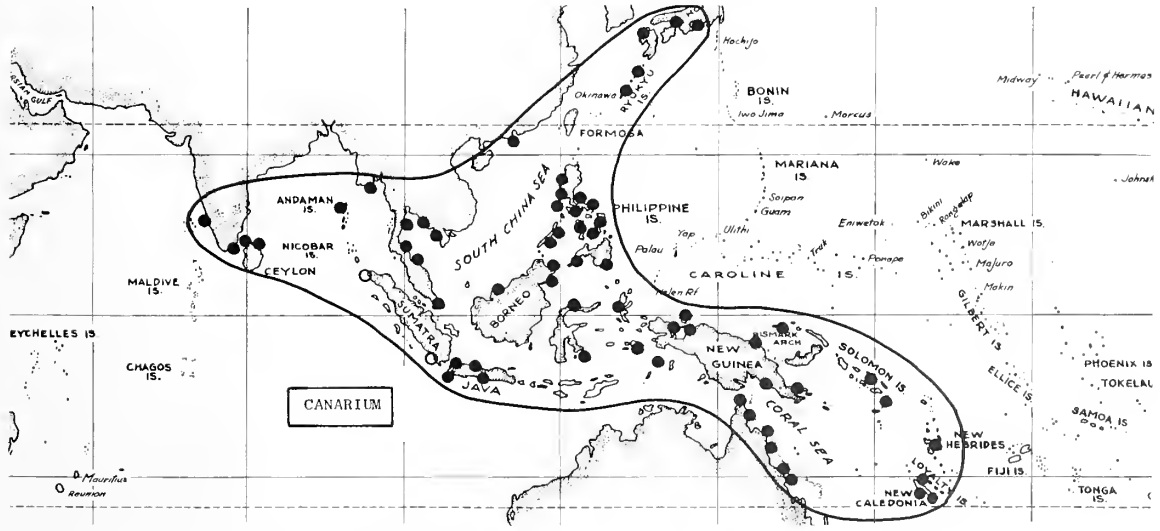


Plate 23. Geographical distribution of *Strombus canarium* Linné.

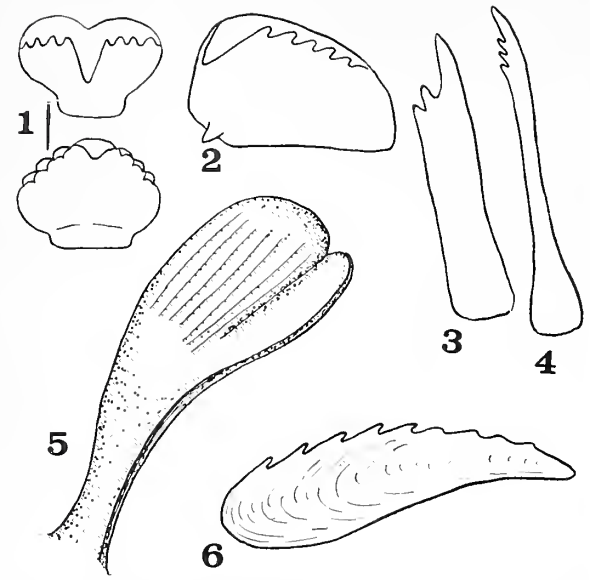


Plate 24. *Strombus canarium* Linné, New Caledonia. Fig. 1, central radular tooth (two views). 2, lateral, showing basal peg. 3, inner marginal. 4, outer marginal. 5, verge. 6, operculum.

Fossil records—Schepman (1907, p. 185) reports this species from the Posttertiary of the Celebes. Altena (1942, vol. 22, pp. 47-49) reports *canarium* from the Pliocene of New Guinea, Indonesia and the Philippines, but certainly some of these are *varinginensis*. Dickerson's Vigo Group, Luzon Id. specimens are probably *varinginensis*. True *canarium* occurs in the upper Pliocene of Niki-Niki, Timor, Indonesia (Tesch, 1920, p. 48, pl. 129, fig. 165). Tesch also claims that it occurs at Nias Island (off west Sumatra); Sondé, Java; Corontalo, Celebes; Fialarang, Timor; and Cheribon, Java, although I have not seen these specimens nor figures of them. Beets (1948, Basteria, vol. 12, p. 8) records five Quaternary specimens from Goenoeng Mendong, eastern Borneo. Abrard (1946, p. 59, pl. 4, fig. 23) records this species as *isabella* from the Nua River Pliocene on Malekula Id., New Hebrides.

Strombus varinginensis Martin, 1899

Range—Pliocene of Java and Borneo, Indonesia, and Luzon Island, Philippines.

Remarks—This and the following fossil species are related to the Recent *Strombus canarium* Linné or possibly *vittatus* Linné.

Synonymy—

1899 *Strombus (Strombus) varinginensis* K. Martin, Samml. geol. Reichs-Mus. Leiden, n. Folge, vol. 1, pt. 1, p. 184, pl. 30, figs. 426-429 (Tji Djadjar, Cheribon Residence, Java, here designated as the type locality).

1922 *Strombus canarium* L., Dickerson, Philippine Journal of Science, vol. 20, p. 202, pl. 5, fig. 3 (Vigo Group, Upper Miocene, Luzon Id.).

1935 *Strombus (Labiostrombus) varinginensis varinginensis* K. Martin, Oostingh, Wetenschappelijke Mededeel., no. 26 (Dienst van den Mijnbouw in Nederl.-Indie), p. 56; 1948, Cox, Schweizerische Palaeontologische Abhandl., vol. 66, p. 25, pl. 2, figs. 3, a, b (Dent Peninsula, Borneo).

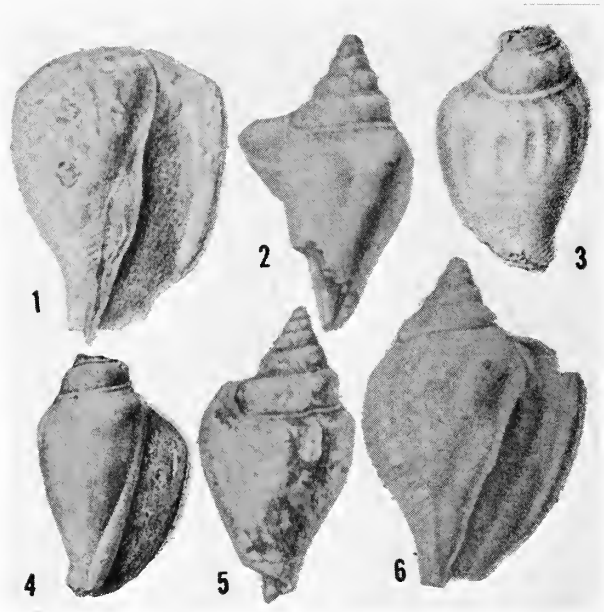


Plate 25. Figs. 1 and 5, *Strombus varinginensis* Martin. Types from the Pliocene of Java. (from K. Martin, 1899, pl. 30, figs. 427, 428). Figs. 2 and 6, *S. varinginensis martini* Oostingh (type of *S. isabella* var. *thersites* Martin, non Swainson; from K. Martin, 1899, pl. 30, figs. 423, 424; Pliocene of Java). Figs. 3 and 4, *Strombus glaber* Martin. Types from the Upper Miocene of Java. (from K. Martin, 1879, pl. 9, fig. 6). All natural size.

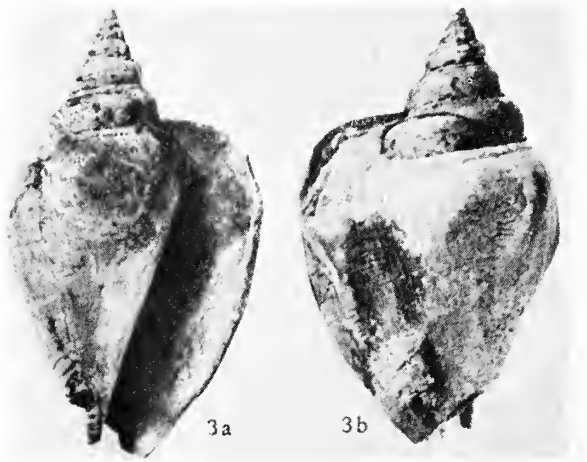


Plate 26. *Strombus varinginensis* Martin. Dent Haven, British North Borneo. Pliocene. (from Cox, 1948, pl. 2, figs. 3a, 3b). ×2.

Strombus varinginensis *subspecies* martini Oostingh, 1935

Range—Pliocene of Java, Sumatra, Borneo and Quarternary of New Guinea.

Remarks—This was originally named *thersites* Martin, 1899 (non Swainson, 1823). Oostingh considered it a subspecies of *varinginensis;* Cox raised it to specific rank despite the presence of the two, only slightly differing, in the same fossil bed in Borneo. It is probably only a form.

Synonymy—

1899 *Strombus isabella* Lam. var. *thersites* K. Martin, Samml. geol. Reichs-Mus. Leiden, n. Folge, vol. 1, pt. 1, p. 184, pl. 30, figs. 423-425 (Java, Pliocene). Non Swainson, 1823.

1935 *Strombus (Labiostrombus) varinginensis martini* Oostingh, Wetenschappelijke Mededeelingen, no. 26 (Dienst van den Mijnbouw in Nederlandsch-Indie), p. 57 (new name); 1942, Oostingh, Leidsche Geologische Mededeel., vol. 22, p. 49.

1948 *Strombus (Labiostrombus) martini* Oostingh, Cox, Schweizerisch Palaeontologische Abhandl., vol. 66, p. 24, pl. 2, figs. 9a, b (Borneo, Pliocene).

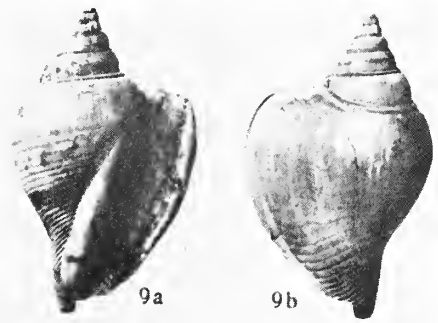


Plate 27. *Strombus martini* Oostingh. Dent Haven, British North Borneo. Pliocene. (from Cox, 1948, pl. 2, figs. 9a, 9b). Natural size.

Strombus overbecki Cox, 1948

Range—Pliocene of Borneo.

Remarks—Quite possibly a malformed specimen of *varinginensis* Martin.

Synonymy—

1948 *Strombus (Labiostrombus) overbecki* Cox, Schweizerisch Palaeontologische Abhandl., vol. 66, p. 26, pl. 2, fig. 7 (7 km. inland from Dent Haven, Dent Peninsula, Borneo).

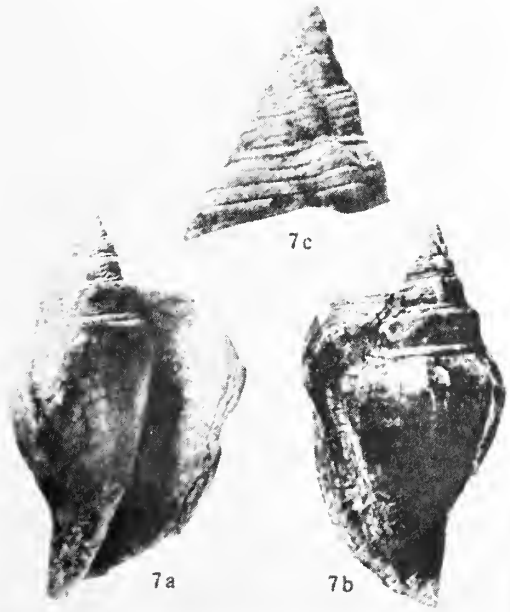


Plate 28. *Strombus overbecki* Cox. Dent Haven, British North Borneo. Pliocene. Adult, holotype. (from Cox, 1948, pl. 2, figs. 7, a, b, c). Natural size.

Strombus glaber Martin, 1879

Range—Upper Miocene of Java, Indonesia.

Remarks—Allied to *S. varinginensis* Martin. From the Tjilanang beds, Upper Miocene of Java (van der Vlerk, 1931, p. 246).

Synonymy—

1879 *Strombus glaber* K. Martin, Die Tertiärschichten auf Java, Leiden, p. 49, pl. 9, fig. 6 (Java); 1905, *ibid.*, n. Folge, vol. 1, pt. 9, p. 319, pl. 45, fig. 738 (Palabuan-ratu, Java, Pliocene).

Strombus karikalensis Cossmann, 1903

Range—Fossil (Pliocene) of southeast India.

Remarks—Allied to *Strombus varinginensis martini* Oostingh. Other than its smoothish spire, this shell resembles the Recent *S. vittatus vittatus* Linné.

Synonymy—

1903 *Strombus karikalensis* Cossmann, Journ. de Conchyl., vol. 51, p. 164, pl. 6, figs. 12, 13 (Karikal, French India).

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

Subgenus Tricornis Jousseaume, 1886

Type: *Strombus tricornis* Humphrey, 1786

Members of this subgenus, whose type is *tricornis* Humphrey, are variable in size, shape of the outer lip, and details of the apical sculpturing. The subgenus has within it several species-groups, but, because so many of the so-called generic characters appear in random combination within almost any one species, it would be impossible to recognize additional subgenera without erecting one for each species. In general, the subgenus *Tricornis* is characterized by large, heavy shells which have prominent axial knobs, a smooth columella, and a fairly thick, usually deciduous periostracum. The operculum is proportionately broad and its edge smooth or with very weak, almost obsolete, serrations. The radular teeth are strong; the central with a large middle cusp, flanked on either side by 1, 2 or 3 smaller cusps. The lateral lacks a distinct, basal peg, and the two marginals are relatively broad with 4 to 6 large cusps.

The tropical Western Atlantic contains *costatus* Gmelin, 1791, *raninus* Gmelin, 1791, *goliath* Schröter, 1805 (= Dillwyn, 1823, Sowerby, 1842), *gallus* Linné, 1758, and *gigas* Linné, 1758. The tropical Eastern Pacific contains *peruvianus* Swainson, 1823, and *galeatus* Swainson, 1823 (allied to *goliath*, Recent, Brasil). The Indo-Pacific contains *tricornis* Humphrey, 1786 (from the Red Sea), *thersites* Swainson, 1823, *taurus* Reeve, 1857 and *sinuatus* Humphrey, 1786.

The earliest fossil recorded is *inflatus* Martin, 1879, from the Lower Miocene of Java. It, *herklotsi* Martin, 1880, and *tjilongaucusis* Martin, 1899 from the Miocene of Java, and *trigonus* Grateloup from the European Dax Lower Miocene are probably forerunners of *tricornis* and *costatus*. Also related are *Strombus haitensis* Sowerby, 1849, (Miocene, Santo Domingo), *galliforuis* Pilsbry and Johnson, 1917 (Miocene, Santo Domingo), *dominator* Pilsbry and Johnson, 1917 (Miocene, Santo Domingo), *chipolanus* Dall, 1900 (Florida, Pliocene), and *leidyi* Heilprin, 1887, (Pliocene of Caloosahatchee, Florida). The latter is represented by a recent form or subspecies in Bermuda's isolated, cooler water.

Strombus fortisi var. *valdetuberculatus* Innocenti (Boll. Soc. Geol. Ital., vol. 47, p. 60, pl. 2, fig. 6) reported from the Eocene of Ronca, Italy, is based upon a poor and almost unidentifiable specimen. *Strombus bravardi* Borchert, 1901, from Brazil is not a *Strombus*.

Synonymy—

1886 *Tricornis* Jousseaume, Le Naturaliste, Paris, 1st series, vol. 3, 8th year, no. 28, p. 220. Type by monotypy: *Tricornis tricornis* Lamarck = *tricornis* Humphrey, 1786; 1888 Jousseaume, Mém. Soc. Zool. de France, vol. 1, p. 174.

1921 *Lobatus* "Swainson" Iredale, 1921, Proc. Mal. Soc. London, vol. 14, p. 208. Type by monotypy: *Strombus bituberculatus* Lamarck = *raninus* Gmelin, 1791.

1929 *Aliger* Thiele, Handbuch Systemat. Weichtierkunde, Jena, vol. 1, pt. 1, p. 254. Type by monotypy: *Strombus gallus* Linné.

1940 *Eustrombus* (subgenus of *Strombus*) Wenz, Handbuch der Paläozoologie, lief. 6, band 6, p. 945. Type by original designation: *Strombus gigas* Linné.

Nomenclature—Iredale stumbled into *Lobatus* and first validated it in 1921 when he erroneously assumed that the name had appeared as a genus in 1837, presumably belonging to Swainson. In the anonymous "Catalogue of the Foreign Shells in the Possession of the Manchester Natural History Society (Manchester ?, 1837) there appears on page 75 the line "[Strombus] *bituberculatus* (*Lobatus*, Swainson)." S. *lobatus* Swainson, 1822 is known to be a synonym of *bituberculatus* Lamarck, and the name in parentheses probably refers to this species, since on page 76 another synonym is listed with a capital letter: "[Strombus] *exustus* (*Papilio*) Lamarck," and not meant as a genus name.

Strombus tricornis Humphrey, 1786

(Pl. 17, figs. 6, 7; pl. 29, figs. 1, 2)

Range—Red Sea and Gulf of Aden.

Remarks—The rather heavy, strongly knobbed shell with its single spine protruding from the upper and outer corner of the outer lip is distinct for this moderately common species from the Red Sea area. The elongate, axially pinched knob on the center of the dorsum is always the largest. The color of the aperture and outer shell is quite variable, the former ranging from white to tan to weak rosy tan, and the latter from white to strongly flecked and suffused with soft browns. Old specimens are apt to have a brownish aluminum-like glaze around the aperture. Adults vary greatly in size.

We have been unable to verify records in the old literature of this species occuring in Réunion, Mauritius, the Seychelles and the West Indies. It is interesting to note that a figure was published of this species over 400 years ago.

Habitat—Little is known about its habitat, except that it occurs in shallow water just below the low tide line.

Plate 29. Figs. 1 and 2, *Strombus tricornis* Humphrey, immatures, Port Sudan, Red Sea. Both natural size.

Description—Adult shell 64 to 125 mm. (2½ to 5 inches) in length, solid, moderately heavy, with large blunt spines on the body whorl, and with a long, triangular projection on the upper and outer end of the outer lip. Color of shell whitish with varying degrees of black-brown to light brown flecks, maculations or axial streaks. Rarely albinistic. Whorls 10. Nuclear whorls 2, smooth, translucent white. Postnuclear whorls carinate, bearing numerous axial riblets which become small knobs (12 to 16 per whorl) just above the minutely indented suture in later whorls. Early whorls with 15 to 20 microscopic threads which become obsolete in the last whorl. Spire rarely with 2 or 3 small, whitish former varices. Shoulder of body whorl with 3 to 4 rather large, pyramidal knobs, the last one usually small, and the second to last one being the largest, slanting and axially pinched. Parietal wall glazed. Columella smooth, white or tinged with tan, rose or lavender. Interior of aperture, smooth enamel-white, rarely tan, orangish or pinkish, and having at the top of the body whorl a sunken, spiral depression or trough. Outer lip thick, somewhat wavy and with its upper and outer end produced into a long triangular to elongate spine which is longer than the spire. Siphonal canal short. Stromboid notch broadly U-shaped. Periostracum moderately thin, somewhat rough, and apt to flake off when dry. Operculum and soft parts unknown.

Measurements (mm.)—(excluding spine)

length	width	no. whorls	
63.9	46.0	9	(small; Red Sea)
101.5	82.1	9+	(average; Red Sea)
125.0	96.2	8+	(large; Red Sea)

Synonymy—

1558 *Murex lacteus* Rondelet, De Natura Aquatilium Carmen . . . Lugduni, p. 37 (non-binomial).

1786 *Strombus tricornis* Humphrey, Portland Catalogue, London, p. 5, no. 50 (no locality); refers to Chemnitz Conchyl.-Cab., vol. 3, figs. 843-845 and Lister, fig. 873.

1807 *Strombus tricornis* G. Fischer, Museum Demidoff, Moscow, p. 188 (Jamaique); refers to Davila, p. 183, and Chemnitz Conchyl.-Cab., vol. 3, figs. 843-845.

1816 *Strombus tricornis* Lamarck, Le Liste, p. 3; pl. 408, fig. 1 of Encyclopéd. Méthod. (no locality); 1954, P.-H. Fischer, Jour. de Conchyl., vol. 94, no. 4, pp. 152-153.

1844 *Strombus orientalis* "Jonston", Duclos, in Chenu, Illus. Conchyl., vol. 4, *Strombus*, p. 15, pl. 18, figs. 5 and 6, pl. 21, figs. 1 and 2 (Les Antilles).

1844 *Strombus pertinax* Duclos, in Chenu, Illus. Conchyl., vol. 4, p. 15, pl. 29, figs. 1, 2 (no locality given).

Types—Humphrey's type was sold at public auction in 1786, and its whereabouts is unknown to us. No locality was given, so we hereby designate the Red Sea as the type locality. G. Fischer's type may be in the zoological museum of the University of Moscow. He referred to a figure in Chemnitz of our *tricornis*, but his locality of "Jamaique" suggests an error in datum or that he had *Strombus gallus* Linné from the West Indies.

Nomenclature—The author of *tricornis* is sometimes listed as Solander, sometimes as Humphrey. We prefer the latter, since we believe he wrote the Portland Catalogue and merely consulted Solander's manuscript card file for names.

Records—RED SEA: Aqaba, Israel (Fischer, 1870, p. 162). Ras Domeirah, Assab Bay, Dahlac Archipelago (Issel and T.-Canefri, 1876, p. 340). Port Sudan (ANSP). 20 miles north of Jidda, Saudi Arabia (C. Aslakson, ANSP). Ras Banas, Egypt (USNM). Massara, Eritrea (MCZ). GULF OF ADEN: Djibouti (MCZ); Berbera (USNM). [Records for the Seychelles, Amirantes, Réunion, Andamans, Philippines and West Indies are unverified and the latter two certainly erroneous.]

Fossil records—SUDAN: raised coral reefs, Port Sudan. Pleistocene (Hall and Standen, 1907, p. 67). EGYPT: Pleistocene, beach 80 ft. alt., Wadi Gueh (R. B. Newton, 1900, p. 508). FRENCH SOMALIA: Pleistocene, Loyada; Doumeira; Ras Doumeira (Abrard, 1942, vol. 18, p. 63, pl. 6, fig. 35).

Strombus thersites Swainson, 1823

(Pl. 17, figs. 1, 2)

Range—Ryukyu Islands, New Caledonia (and Soeiety Islands?)

Remarks—This is one of the rarest of the large *Strombus* of the Indo-Pacifie. It is heavy and massive like *latissimus*, but has a less developed outer lip, is lighter in eolor, and its angle of spire is about 45, rather than 70 to 75, degrees. The knobs on the spire are fewer, more pronounced and more or less evenly developed throughout the entire spire. The two Soeiety Island reeords are open to question. It may oeeur in the areas between the Ryukyu Islands and New Caledonia. It oeeurred in Fiji during the Pliocene.

Habitat—Kira (1959, p. 37) reports that it occurs at a depth from 5 to 10 fathoms.

Description—Shell 110 to 146 mm. (4 to 6 inehes) in length, massive, with a heavy outer lip, its spire with small knobs, and its body whorl with one large and 2 small knobs. Color of shell whitish with sparse, somewhat zigzag, light yellow-brown streaks. Aperture and columella enamel white, rarely with an aluminum-like glaze. Whorls about 11; spire angle about 45 degrees. Nuclear whorls not observed. First few postnuclear whorls with numerous axial riblets. The last 4 whorls (but not the body whorl) each bear just above the wavy suture 9 to 11 prominent, smoothish, rounded knobs which gradually increase in size. Spiral seulpture absent or extremely weak. A few former varices may be present in the apex. Last whorl with one large, longitudinally pinched knob on the left side of the shoulder. The dorsum bears one to three slightly raised, weak nodules. Columella, aperture, and outer lip smooth and with a white enamel glaze. Top of outer lip moderately produeed. Middle of outer lip thick, glazed and with 5 to 7 light brown color bars. Stromboid noteh deep and well-developed. Periostraeum very thin, smooth and translueent tan. Operculum and soft parts unknown.

Measurements (mm.)—

length	width	no. whorls	
145	90	8?	(from Wilkins; lectotype)
146	86	9	(large; Okinawa)
142	94	9	(large; New Caledonia)
134	78	9	(average; Okinawa)
110	78	8	(small; Okinawa)

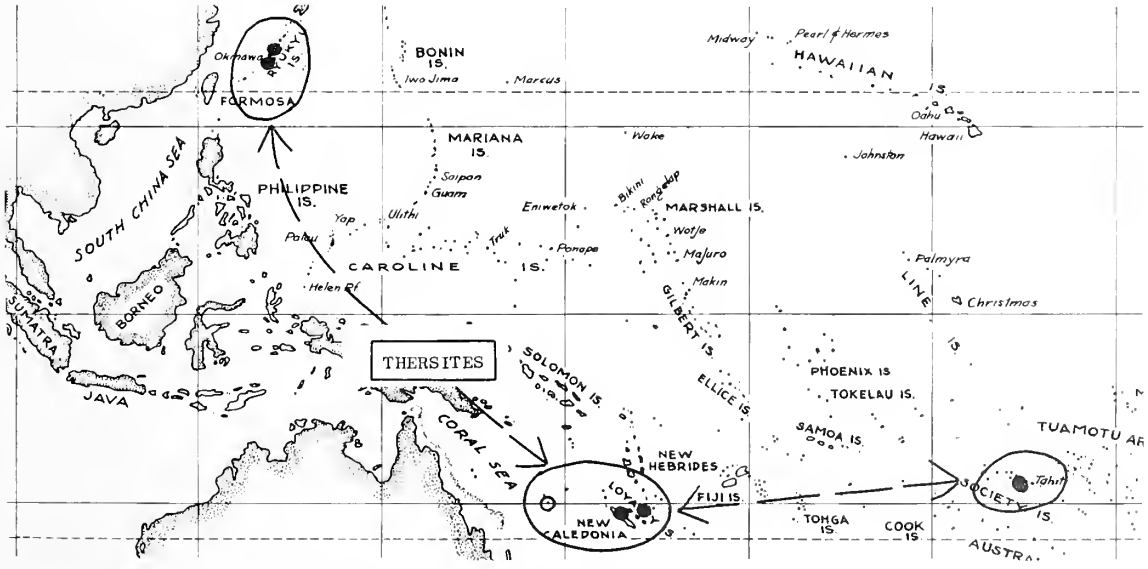


Plate 30. Geographical distribution of *Strombus thersites* Swainson. There are also two literature records for Queensland, Australia.

Synonymy—

1823 *Strombus thersites* Swainson, The Philosophical Magazine, vol. 62, p. 401 (New Caledonia); 1951, Wilkins, Proc. Mal. Soc. London, vol. 28, pt. 6, p. 238, pl. 29.

1828 *Strombus thersites* Wood, Index Testaceol. Suppl., London, p. 14, pl. 4, fig. 17 (locality unknown).

1842 *Strombus thersites* Cray, Reeve, Conchologia Systematica, vol. 2, pl. 249, fig. 1, p. 206.

1842 *Strombus ponderosus* Plulippi, Abbild. Beschr. Conchyl., vol. 1, pt. 1, p. 7, pls. 2 and 3 (Oceanus Pacificus).

1885 *Strombus (Euprotomus) ponderosus* Phil., Tryon., Manual of Conchology, vol. 7, p. 111.

Types—New Caledonia is the type locality. Wilkins, 1951, designated and illustrated the lectotype (Cracherode collection, 1799) now in the British Museum (no. 1950. 11. 15. 1).

Locality records (see accompanying map, pl. 30)—RYUKYU ISLANDS: Amami Id. (Kira, 1959, p. 37); Okinawa Id. (A. A. Scott and A. R. Calin, ANSP). NEW CALEDONIA: (ANSP; BM; MCZ); Touho (D. Cetz). Brampton Reef, 19° 51′ S; 158° 20′ E, (J. Brazier, 1871, p. 585). LOYALTY ISLANDS: Chepcnehe, Lifu (D. Cetz). SOCIETY ISLANDS: Island of Oheteroa, H. Cuming (Wilkins, 1951, p. 239); (also Schmeltz in Mus. Godefroy, 1874, cat. 5). AUSTRALIA: Ribbon Reef, Qld. (T. Hartley, *in litt.*).

Fossil records—Ladd and Hoffmeister, 1945, p. 361 report a fossil which is closely allied to *thersites* from Lakemba Id., Lau Croup (Fiji) in the Futuna limestone (Miocene or Pliocenc). They erroneously likened it to the Red Sea *S. tricornis*.

Plate 31. *Strombus maximus* Martin. Java, Indonesia. Miocene. (from K. Martin, 1883, pl. 9, fig. 1). ×½.

Strombus maximus Martin, 1883

Range—Upper Miocene of Java, Indonesia.

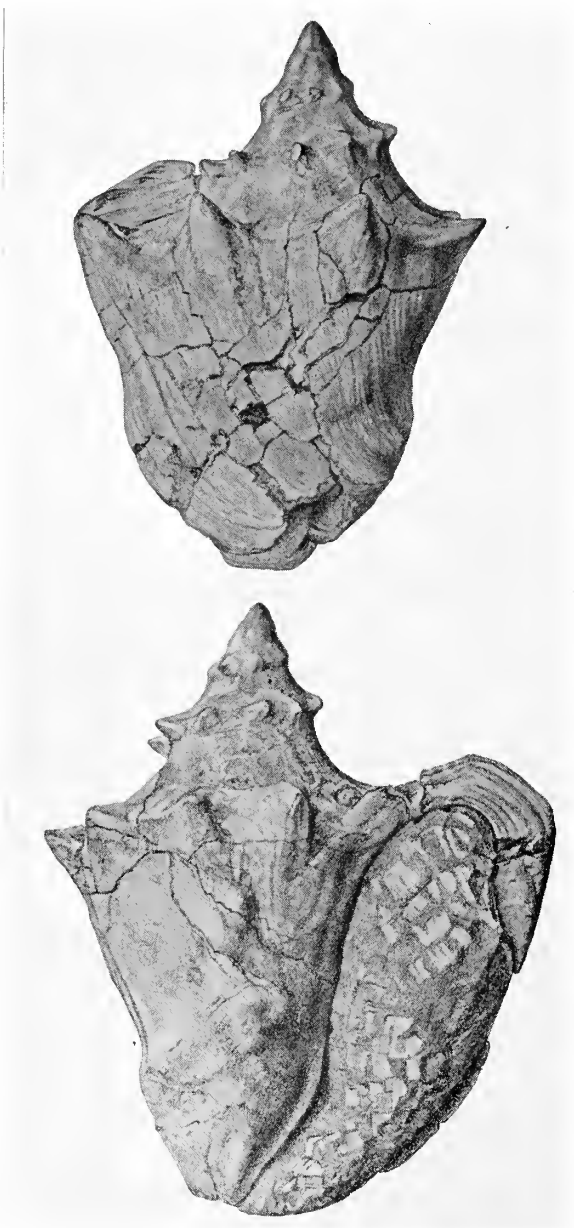


Plate 32. *Strombus maximus* Martin. Upper Mioeene of Java, Indoncsia. (from K. Martin, 1899, pl. 28, fig. 407). ×½.

Remarks—This massive, foot-long (270 mm.) *Strombus* is possibly the progenitor of the Recent *Strombus thersites*. The apex is very similar to that of *thersites*, but is unlike that of *Strombus gigas* Linné of the West Indies as Martin had suggested. The dorsal side of the body whorl bears 3 or 4 large, pyramidal tubercles or spines, a feature absent in *thersites*. Upper Miocene of Java (Tjilanang beds) according to van der Vlerk, 1931, p. 247.

Synonymy—

1883 *Strombus maximus* K. Martin, Samml. geol. Reichs-Mus. Leiden, 1st ser., vol. 1, p. 195, pl. 9, fig. 1 (Tertiary of Java: Gunung Sela and Tjidamar; Batavia); 1899, Martin, *ibid.*, n. Folge, vol. 1, pt. 1, p. 175, pls. 28, 29, figs. 407, 407a (Solo, Java).

Strombus latissimus Linné, 1758

(Pl. 17, fig. 5; pl. 33, fig. 1)

Range—Ryukyu Islands to the Philippines and to Fiji.

Remarks—This is the largest and heaviest of the Indo-Pacific *Strombus*, although it is smaller than either S. *goliath* Schröter, 1805 (Archiv. Zool. Zoot., vol. 4, p. 139) of Brazil or *galeatus* Swainson, 1823 from the Eastern Pacific. S. *latissimus* is considered uncommon, perhaps because it lives well below the low tide line. It is readily recognized by its heaviness, by its broad, thick outer lip which sweeps up beyond the spire, and by its brownish outer coloring. It might be confused with S. *thersites* but the latter has a shorter lip, and its spire angle is about 45 degrees (instead of 70 to 75 degrees as in *latissimus*).

Habitat—Little is known of the habitat, although Philippine collectors have informed me that they must dive in 12 to 24 feet of water to collect it. Kira (1959, p. 37) reports that it lives from 5 to 10 fathoms in the Ryukyu Islands.

Description—Adult shell from 120 to 204 mm. (5 to 8 inches) in length, massive, heavy, rotund, with a broad, thick, flaring lip, yellow-brown to chocolate-brown in color, and with a smooth, tan and whitish aperture. Whorls 11. Nuclear whorls unknown. Angle of spire about 70 to 75 degree. Early whorls pinkish, strongly carinate and with numerous small knobs (22 to 17) on the periphery just above the indented suture. Spiral threads 8 to 12, but absent in later whorls. In the penultimate whorl these knobs become larger, rounded and fewer, rarely absent. Body whorl with one very large, but low, rounded knob at the shoulder on the left side of the whorl not far from the slightly glazed parietal wall. Dorsum roundly swollen. Outer side of lip

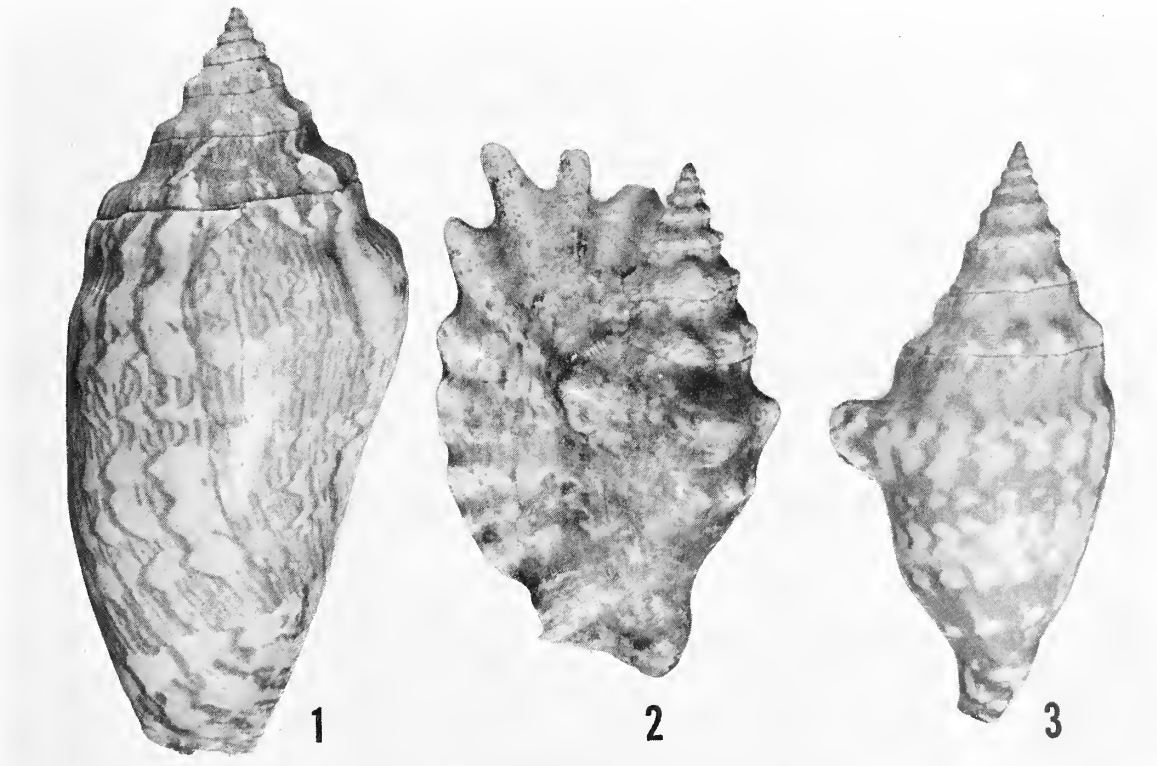


Plate 33. Fig. 1, immature *Strombus latissimus* Linné, Philippines. Fig. 2, *Strombus sinuatus* Humphrey, Okinawa Id., Ryukyu Islands. Fig. 3, immature *Strombus taurus* Reeve, Rongelap Atoll, Marshall Islands. All slightly reduced.

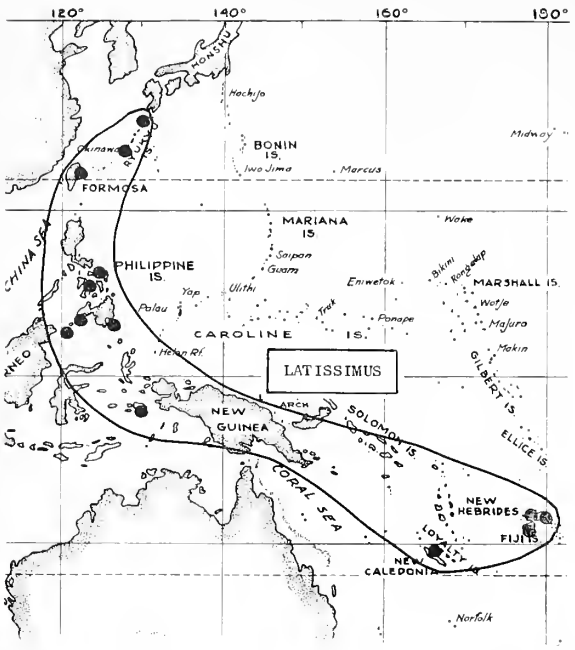


Plate 34. Geographical distribution of *Strombus latissimus* Linné.

with about 20 indistinct, whitish spiral ridges. Outer lip massive, spreading upward beyond the spire and partially obscuring the apex. Edge of lip thick and turned inward. Stromboid notch deep and pronounced. Columella thickened with a tan glaze and smooth. Aperture white and smooth within, becoming tan to smoky brown at the edges. Color of shell cream with dense mottlings of dark- or light-brown. In the penultimate whorl the dark-brown is arranged in irregular, crowded, axial streaks. Periostracum moderately thick, smoothish, translucent tan and flakes off when dry. Operculum and soft parts unknown.

Measurements (mm.)—

length	width	no. whorls	
200.0	147.2	8+	(large; Philippines)
160.2	110.0	11	(average; Okinawa)
111.1	91.0	8+	(small; Jolo Id., P. I.)

Synonymy—

1758 *Strombus latissimus* Linné, Systema Naturae, ed. 10, p. 745, no. 436 (In O. Asiae); 1767, ed. 12, p. 1211, no. 505; 1956, Dodge, Bull. Amer. Mus. Nat. Hist., vol. 111, art. 3, pp. 272-273; 1843, Kiener, Coq. Vivantes, vol. 4, Strombus, pl. 4, fig. 2.

1798 *Lambis latissimus* Linné, Röding, Museum Boltenianum, Hamburg, pt. 2, p. 65, no. 827. Refers to Conchyl.-Cab., vol. 3, figs. 832 and 835.

1798 *Lambis picta* Röding, *loc. cit.*, p. 62, no. 793. Refers to Conchyl.-Cab., vol. 3, fig. 874 (an immature specimen).

1817 *Pterocera alata* Schumacher, Essai Nouv. Syst. Hab. Vers Testacés, Copenhagen, p. 221. Refers to Conchyl.-Cab., vol. 3, figs. 832 and 835. Not *Strombus alatus* Gmelin, 1791.

Types—Evidently Linnaeus did not possess a specimen when he first described the species. A young specimen, possibly to be considered a type, is in the Linnaean collection in Uppsala, Sweden. Since the description was based in part upon the figure given by Rumphius (pl. 36, fig. L), we hereby select Amboina, Indonesia, as the type locality.

Records (see accompanying map, pl. 34)—RYUKYU ISLANDS: Amami Id. (Kira, 1959, p. 37); Okinawa Id. (Mrs. A. A. Scott, ANSP). TAIWAN: Kasyo-to (Kuroda, 1941, p. 97). PHILIPPINES: Borongan village, east side of Samar Id. (ANSP); near Cebu City, Cebu Id. (MCZ); Lubang Id., Mindoro (P. de Mesa, MCZ); Zamboanga, Mindanao Id. (ANSP); Davao Bay, Mindanao; Cuyo Id., Palawan (du Pont-Academy Exped., 1958, ANSP); Jolo Id., Sulu Archipelago (ANSP). INDONESIA: Amboina (Rumphius, 1741, p. 110). NEW CALEDONIA: Touho Bay (M. Leveque, ANSP). FIJI: reefs off Levuka, Ovalau Id. (MCZ); Kamba Point, Viti Levu Id. (H. S. Ladd, USNM).

Fossil records—None reported.

Strombus taurus Reeve, 1857

(Pl. 17, figs. 3, 4; pl. 33, fig. 3)

Range—Known only from the Marshall and Marianas Islands (and possibly the Admiralty Islands).

Remarks—For nearly a hundred years this species was known from only two or three specimens. It is now known to be not uncommon in the Marshall Islands thanks to the keen observations and careful collecting being done by such men as Richard C. Willis and John Roberts, Jr. It probably occurs in the Admiralty Islands and other nearby areas.

Strombus taurus is closely related to the *thersites-latissimus-sinuatus* complex. It has a four-inch-long, heavy shell which is characterized by one long and one short spine at the top of the thickened, wavy outer lip and by the lavender-purple blotch deep within the tan and white aperture.

The young of *taurus* are distinguished by a narrow, bright lavender or rose band just below the suture.

Habitat—Willis and Roberts have kindly supplied the following interesting account: "It occurs in fairly large numbers at Eniaro and Gogon Islands, Rongelap Atoll, at a depth from 4 to 15 feet on a bottom of broken rubble of coral, fine sand and brown furry algae. Specimens were always found in pairs and where the tidal currents form terraces on the north and northeast islands of the atoll. Nearby there were usually other species of *Strombus* (*lentiginosus*) and *Lambis* (*truncata* and *chiragra*), although the *taurus* seem to congregate together. The majority of several dozen specimens collected were pockmarked by erosion, lime de-

posits, and tube worm [*Vermetus* snails] growths. H. T. Ward (1960, p. 1) collected a live pair in 80 feet of water in Guam, Marianas, on a hard rock and algae bottom and in company with *Lambis truncata*.

Description—Shell, excluding spine, 80 to 102 mm. (3 to 4 inches) in length. Spine on outer lip adds another 5 to 25 mm. Heavy, massive, rudely knobbed, with one long and one short spine at the top of the outer lip, and a brownish purple splotch deep within the white and tan aperture. Outer shell creamy white with yellow-brown maculations. In the young there are two spiral bands of alternating brown and white, irregular spots near the mid-portion of the base of the shell, and a narrow, white-speckled band of bright violet or lavender just below the finely indented suture. Whorls 10 to 11, the apex usually eroded away. Nuclear whorls 2, smooth and translucent whitish or pinkish. First two postnuclear whorls with numerous, crowded axial riblets crossed by about a dozen fine spiral threads. The latter persist weakly to the penultimate whorl. By the third whorl small knobs appear just above the suture (10 to 15 per whorl) and continue to the last whorl. Dorsum of body whorl at the shoulder bears two large, pyramidal knobs and anteriorly a swollen ridge. Below the smaller knob and on the middle of the dorsum is a peculiar, large, elongate, irregularly formed and obliquely placed knob. Parietal shield glazed, very swollen below, and colored yellow-brown. Columella whitish above, lavender-tan below with 1 to 3 weak spiral white teeth at the base. In old specimens, the parietal shield runs up on to the spire and is edged above with 1 or 2 short finger-like blades. Aperture constricted, brownish purple to lavender deep within, white further out, and finally soft brown to tan on the outer lip. Deep within the aperture on the upper end and on the body wall is a thickened, rounded, spiral ridge. Outer lip thick, very wavy, glazed with light-brown to creamy tan. Above are two well-developed spines pointing upward, the innermost being twice as long as the outer one. Siphonal canal moderately short, purplish within, and slightly recurved, but not twisted. Stromboid notch very deep and well-developed; below it is a thick, protruding, glazed flange which may have 2 or 3 weakly developed, whitish teeth. Periostracum thin, smoothish, translucent tan, but usually worn away in adults. Operculum stromboid, light-brown, arching, with no or badly worn serrations.

Radula ribbon reddish brown, 10 mm. in length, with about 45 to 50 rows of teeth. Formula: 2-1-2; 1-3 (no peg); 6; 7. Verge simple, red-brown with cream maculations. Tentacles brown with white flecks (preserved specimen).

Measurements (mm.)—(length excludes spines)

length	width	no. whorls	
80.0	76.2	6+	(small; Rongelap Atoll)
89.0	70.1	10	(average; Rongelap Atoll)
101.0	77.1	7+	(large; Rongelap Atoll)

Synonymy—

1857 *Strombus taurus* Reeve, Proc. Zool. Soc. London, for 1857, p. 207, pl. 37, fig. 3 (in color) ("Amirante Islands, a group of the Seychelles"); 1885, Tryon, Manual Conch., Philadelphia, vol. 7, p. 111 (Admiralty Islands); 1960, Ward, Hawaiian Shell News, vol. 8, no. 4, p. 1 (Guam Id.).

Types—The type which was in Sir David Barclay's collection was sold in 1891 and is probably in private hands. It has not been found in the British Museum. The type locality is "Amirante Islands" in the western Indian Ocean. This may be an error and I suspect the original label read "Admiralty Islands" which are close to the known range of this Micronesian species. Tryon who corresponded with Sir David Barclay changed the locality in the Manual of Conchology to "Admiralty Islands". Unfortunately, I have been unable to find any reference to this in Barclay's letters, but I suspect the change was made with cause.

Records—MARIANAS: Asan Point, Guam Id. (Mrs. D. L. Hiatt, in litt.); north side of breakwater, Pier Area, S.W. Tinian Id. (A. B. Bronson, MCZ). MARSHALL ISLANDS: Rongelap Atoll: Eniaro Id. (Willis and Roberts); Kabelle Id., 20 feet (Dick Willis, ANSP); Gogon Id. (Dick Willis); Kieshiechi Id., Arbar Id., and Eniaetok Id. (USNM). Bikini Atoll: ½ mi. S.W. of S.E. Point, Bikini Id.; 4 miles south, Bikini Id., 25 fathoms, dead; Chicerete Id. (all J. P. E. Morrison, USNM). ADMIRALTY ISLANDS: (Tryon, 1885, p. 111). [Amirante Islands, Indian Ocean (Reeve, 1857) may be erroneous.]

Fossil records—None reported.

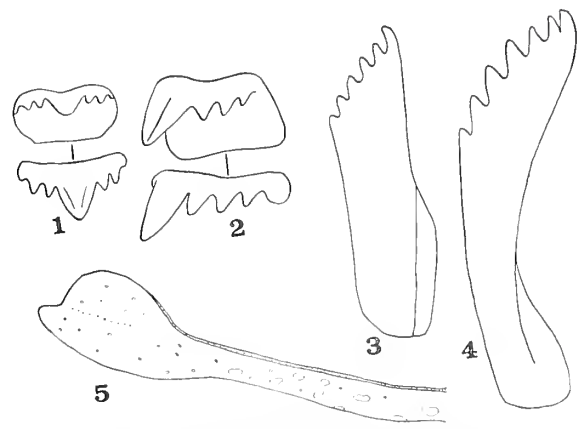


Plate 35. *Strombus taurus* Reeve, Marshall Islands. Fig. 1, central radular tooth. 2, lateral. 3, inner marginal. 4, outer marginal. 5, verge.

Strombus sinuatus Humphrey, 1786

(Pl. 17, fig. 8; pl. 33, fig. 2)

Range—Ryukyu Islands to Australia, Micronesia and Melanesia.

Remarks—This handsome species is readily recognized by its brownish purple aperture and the 3 or 4 thin, finger-like blades at the top of the outer lip. It is uncommon to moderately common throughout its range. In the Bohol-Cebu area of the Philippines it appears in shallow water from April to May in large numbers, some several thousand specimens having been collected commercially in 1957. This species, despite its peculiar *Lambis*-like lip, shows close affinities to *latissimus*, *thersites* and *taurus*.

Habitat—This species lives on coral sand and algae bottoms from low tide mark to a depth of 10 fathoms. In the Marshalls it occurs both in the lagoons and outside. Mr. Richard C. Willis and Mr. John Roberts, Jr. have very kindly supplied the following notes on the occurrence of *sinuatus* on Enieatok Island, Rongelap Atoll, Marshall Islands. "(In September, 1959) shells not plentiful with one or two every 200 feet. Water 4 to 20 feet in depth, clear to slightly murky, temperature 85° F. Bottom of loose broken coral and algae, the latter also growing on the shells. In fresh specimens, the aperture is a delicate lavender, overlaid with radiating streaks of orange in young specimens."

Description—Shell 82 to 113 mm. (3½ to 4½ inches) in length, solid, moderately heavy, with a brownish purple aperture and 3 or 4 finger-like blades at the top of the outer lip. Color of outer shell whitish with heavy mottlings of yellow-brown, and usually with 3 to 5 narrow spiral bands of alternating white and brown flecks on the body whorl. Whorls 10 to 11. Nuclear whorls 2, smooth, translucent tan to pinkish. First 2 postnuclear whorls with numerous, crowded axial riblets running from suture to suture and crossed by 15 to 20 fine, but strongly raised, spiral threads. The latter persist in strength to the penultimate whorl and cross the knobs and 15 to 20 swollen whitish, former varices on the spire. The remaining whorls are well shouldered with neat, rounded, spirally threaded knobs (about 9 to 11 per whorl). Above this row of knobs the whorl is concave. The last whorl has an indistinct, low, long knob on the left side, thus giving the parietal wall a flattish appearance. Anteriorly, are 2 small knobs, followed by a large pyramidal one on the dorsum, and finally by a last and smaller one. Below this series of large shoulder knobs, are 2 spiral rows of 2 to 4 small, round, beads. Parietal wall slightly glazed. Columella moderately thickened, smooth and brownish-tan. Deep interior of aperture brownish purple to deep purple, blending into soft-brown towards the smooth edge of the outer lip. Middle section of outer lip incurved, glossy, and with brownish color bands. Upper end of lip adnate to the spire and having 3 to 5 (usually 4) thin, whitish, tongue-like blades. Siphonal canal short, but twisted to the right. Stromboid notch deep and flaring. The flange below it may have 4 to 5 small white teeth. Periostracum moderately thin, semi-glossy, translucent yellowish and apt to flake off when dry. Operculum stromboid, strongly arched and with weak serrations. Soft parts unknown.

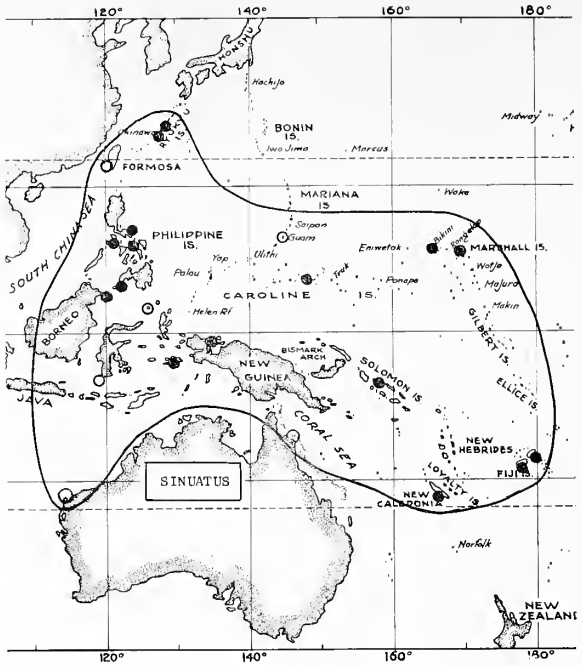


Plate 36. Geographical distribution of *Strombus sinuatus* Humphrey. Open circles indicate literature records; solid dots, specimens examined.

Measurements (mm.)—

length	width	no. whorls	
113.5	69.9	10+	(large; Cebu Id.)
88.8	55.4	10	(average; Bohol Id.)
82.5	53.8	7+	(small; Solomon Ids.)

Synonymy—

1786 *Strombus sinuatus* Humphrey, Portland Catalogue, London, p. 189, no. 4022 (no locality); refers to Seba, vol. 3, pl. 62, fig. 3 and Argenville [Favanne], pl. 22, fig. A2.

1798 *Lambis lobata* Röding, Museum Boltenianum, Hamburg, pt. 2, p. 65, no. 826. Refers to Conchyl.-Cab., vol. 10, figs. 1506, 1507. Not *lobata* Röding, *loc. cit.*, p. 68, no. 872.

1807 *Pterocera palmata* G. Fischer, Museum Demidoff, Moscow, p. 191 (no locality).

1817 *Strombus laciniatus* "Chemnitz" Dillwyn, Descr. Cat. Recent Shells, London, vol. 2, p. 663 (East Indian Seas). Refers to Conchyl.-Cab., vol. 10, figs. 1506, 1507; 1850, Reeve, Conch. Icon., vol. 6, Strombus, pl. 11, fig. and sp. 25.

1822 *Strombus cristatus* Lamarck, Anim. sans Vert., vol. 7, p. 202 (no locality). Refers to Seba and Favanne (*loc. cit.*), and Conchyl.-Cab., vol. 10, figs. 1506, 1507; 1843, Kiener, Coquilles Vivantes, vol. 4, Strombus, pl. 11.

Types—The whereabouts of Humphrey's type of *sinuatus* is unknown to us. It was sold at the auction of the shell collection of the Duchess of Portland in London in 1786. No locality was given. We designate Cebu City, Cebu Island, Philippines as the type locality. The type of *Pteroceras palmata* G. Fischer, if not destroyed by fire, may be in the zoological museum of the University of Moscow (see K. V. W. Palmer, Nautilus, vol. 70, no. 1, 1956).

Nomenclature—The author of *sinuatus* is given as Humphrey by some workers, and as Solander by others. Either refers to the Portland Catalogue.

Records (see accompanying map, pl. 36)—RYUKYU ISLANDS: Tanegashima Id. (Kuroda in MSS); Yaeyama Id. (A. R. Cahn Coll'n., ANSP); Okinawa Id. (Mrs. A. A. Scott, ANSP). TAIWAN: Karenko (Kuroda, 1941, p. 98). PHILIPPINES: near Cebu City, Cebu Id. (A. B. Franco, ANSP); Badang, Sorsogon Prov., Luzon Id. (du Pont-Academy Exped., 1958, ANSP); Panglao Id., northern Bohol Id. (E. Zambo, ANSP); Surigao Id. (Elera, 1896, p. 249); Siasi, Sulu Archipelago (W. E. Old, Jr., coll'n.). INDONESIA: Amboina, Moluccas (MCZ); Sailus Ketjil, Pasternoster Ids., off Sumbawa Id. (Schepman, 1909, p. 148). AUSTRALIA: reefs off Townsville Queensland (*fide* Tony Marsh *in litt.*); Northwest Cape, on reef, Western Australia (A. Whitworth, coll.). NEW GUINEA: Mios Woendi Atoll, Padaido Ids. (NSF, 1956). SOLOMONS: Choiseul Id. (W. J. Eyerdam, ANSP). NEW CALEDONIA: (USNM); Touho (*fide* D. Getz, *in litt.*). FIJI: reefs off Levuka, Ovalau Id. (MCZ); Kamba Point, Viti Levu Id. (H. S. Ladd, USNM). MARIANAS: Guam Ld. (*fide* T. Montgomery, *in litt.*). CAROLINES: Hall Ids., near Truk Id. (Mrs. R. T. Gallemore). MARSHALLS: lagoon, Aomaen Id., and Namu Id., and Bokororyuru Id., all Bikini (J. P. E. Morrison, USNM); Eniaetok, Rongelap Atoll (USNM). [No authenticated Hawaiian records, as yet.]

Fossil records—None reported.

Strombus junghuhni Martin, 1879

Range—Mioeene of Java, Indonesia.

Remarks—This speeies was based upon a single and broken speeimen. From the illustration of the type, it would appear that this is the elosest representative of *Strombus sinuatus* that has been found in the Tertiary. The absenee of details of the outer lip, however, leaves this relationship still in doubt, although the eharaeters of the spire are fairly elose. This is Mioeene aeeording to van der Vlerk, 1931, p. 246.

Synonymy—

1879 *Strombus junghuhni* K. Martin, Die Tertiärschichten auf Java, Leiden. p. 47, pl. 9, fig. 1 (Java, Tertiary).

Strombus mekranieus Vredenburg, 1928

Range—Lower Mioeene of West Pakistan.

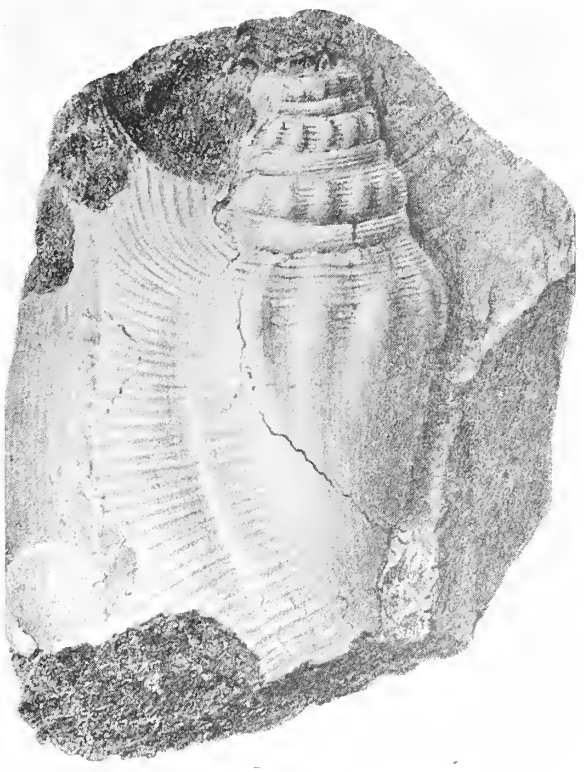


Plate 37. *Strombus junghuhni* Martin. Miocene of Java, Indonesia. Type. (from K. Martin, 1879, pl. 9, fig. 1). Natural size.

Remarks—I eoneur with Vredenburg's remarks that this speeies "is not very elosely related to any living or fossil speeies, though it belongs to the same group that ineludes sueh forms as the reeent *Strombus bubonius* Lamk. [= *latus* Gmelin] and *Strombus tricornis* Lamk. [Humphrey]." It is based upon very poorly preserved speeimens.

Synonymy—

1928 *Strombus mekranicus* Vredenburg, Memoirs Geol. Survey of India, vol. 50, pt. 1, p. 315, pl. 3, figs. 13, 14, pl. 4, fig. 1 (Mekran beds: north of Talar Gorge, on the road from Kej to Gwadar, base of the sandstones constituting the Talar Mountains [West Pakistan].

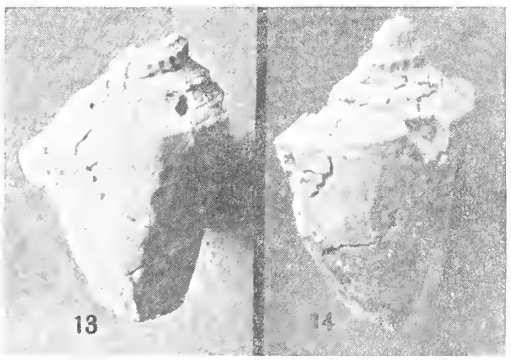


Plate 38. *Strombus mekranicus* Vredenburg. Mekran, Talar, Pakistan. Miocene. (from Vredenburg, 1928, pl. 3, figs. 13, 14). Natural size.

Strombus inflatus Martin, 1879

Range—Lower Miocene and Upper Miocene of Java, Indonesia.

Remarks—*Strombus herklotsi* Martin 1880 and *tuberosa* Martin 1883 from the same locality in Java are possibly synonyms. I know of no Recent Indo-Pacific species resembling it, although *Strombus costatus* Gmelin, 1791 of the West Indies is somewhat similar.

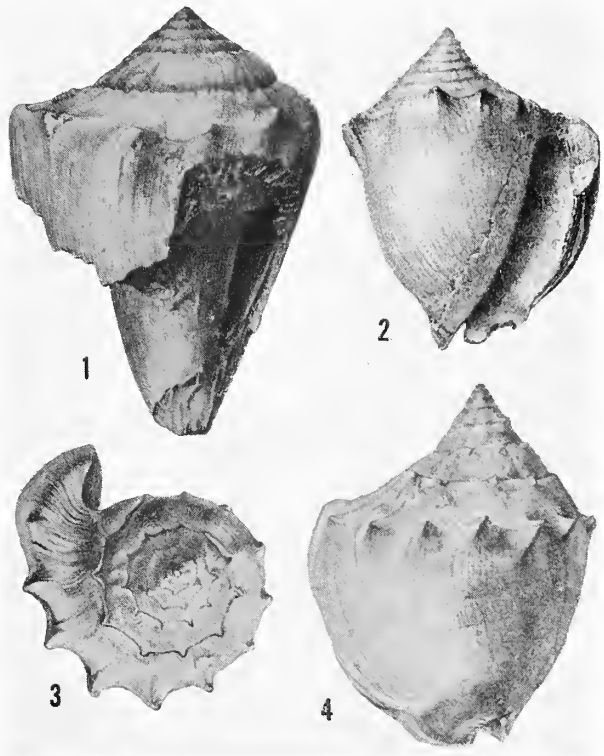


Plate 39. Figs. 1 and 2, *Strombus inflatus* Martin. Tji Longan, Java, Indonesia. Miocene. (from K. Martin, 1883, pl. 9, fig. 3). Figs. 3 and 4, *S. tjilonganensis* K. Martin. Java, Miocene. (from Martin, 1899, pl. 28, figs. 410, 410a, type). All natural size.

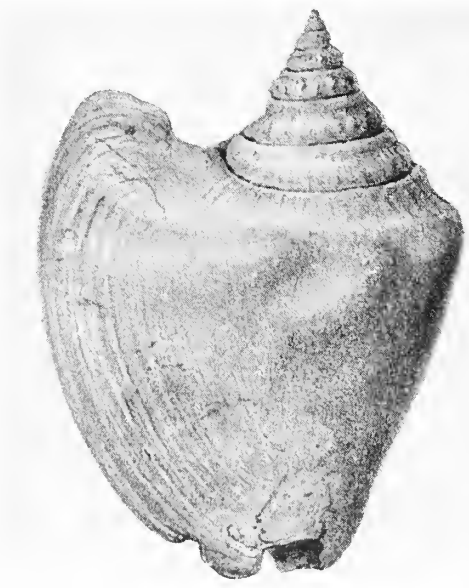


Plate 40. *Strombus tuberosus* Martin. Tji Longan, Java, Indonesia. Miocene. (from K. Martin, 1883, pl. 9, fig. 2). Natural size.

Synonymy—

1879 *Strombus inflatus* K. Martin, Die Tertiärschichten auf Java, Leiden, p. 48, pl. 9, fig. 3 (Java, Tertiary); 1883, Martin, Samml. geol. Reichs-Mus. Leiden, 1st series, vol. 1, p. 197, pl. 9, fig. 3.

1883 *Strombus tuberosus* K. Martin, Samml. geol. Reichs-Mus. Leiden, 1st ser., vol. 1, p. 196, pl. 9, fig. 2 (Tji Longan near Selatjau, Java, Tertiary); 1921, K. Martin, *loc. cit.*, n. Folge, vol. 1, pt. 2, p. 468, pl. 60, figs. 57, 58 (Tji Talahab and Tji Angsana, Java, Pliocene). [Lower Miocene: Njalindoeng beds and upper Miocene: Tjilanang beds, *fide* van der Vlerk, 1931, p. 247.]

1899 *Strombus (s. str.) herklotsi* K. Martin, Samml. geol. Reichs-Mus. Leiden, n. Folge, vol. 1, pt. 1, p. 178, pl. 29, figs. 413, 414 (Java).

Strombus tjilonganensis Martin, 1899

Range—Upper Miocene of Java, Indonesia.

Remarks—Allied to *inflatus* Martin, above, and possibly a form of it.

Synonymy—

1899 *Strombus (s. str.) tjilonganensis* K. Martin, Samml. geol. Reichs-Mus. Leiden, n. Folge, vol. 1, pt. 1, p. 177, pl. 28, figs. 410, 411, pl. 29, fig. 412 (Selatjau, Java, Pliocene).

Subgenus Dilatilabrum Cossmann, 1904

Type: *Strombus fortisi* Brongniart, 1823

Remarks—To our knowledge, this subgenus does not occur in the recent or fossil record of the Indo-Pacific. The subgenus contains two or three species known only from the Italian Eocene of Europe. The shells are large, heavy, with a large flaring lip and presumably with a poorly developed or obsolete stromboid notch. The shells closely resemble some members of the subgenus *Tricornis*, and Cossmann himself felt it might not be worth recognizing. We have not seen specimens of this subgenus, and can give no opinion as to its relationships or its age. If a *Strombus*, it is the earliest known record for the genus.

Synonymy—

1876 *Oncoma* Mayer-Eymar, Beitr. geol. Karte Schweiz, no. 14 (2b), p. 57. Non Fieber, 1861. [Not seen.]

1904 *Dilatilabrum* Cossmann, Essais de Paléoconchologie Comparée, Paris, 6th book, p. 12. Type: *Strombus fortisi* Brongn. of the Eocene of Europe. New name for *Oncoma* Mayer-Eymar, non Fieber, 1861.

Subgenus Canarium Schumacher, 1817

Type: *Strombus urceus* Linné, 1758

The 18 living subspecies and species in this subgenus are limited to the Indo-Pacific. Several, like *mutabilis* Swainson, are very widely distributed, while others, like *helli* Kiener and *klineorum* are very restricted in range. Although some of the species appear to fall into more or less natural groups on mere conchological grounds, such as into the *ureeus-labiatus-erythrinus* group or the *mutabilis-mieroureeus-maculatus* group, we are combining a rather wide selection of species because of conchological intergrades and very similar anatomical features. Despite the slender and smooth shell of *terebellatus*, we believe it has no close phylogenetic relationship with the genus *Terebellum*. Species like *fragilis* bridge the gap from *terebellatus* to *mutabilis* and, thence, to *ureeus*.

The shells in this subgenus are rather small and without a strongly flaring or winged outer lip. The penis is a simple prong with a slightly swollen distal portion. The radula consists of delicate teeth with the central bearing 5 cusps (the middle one being the largest); the lateral usually has only 3 or 4 (rarely 5) cusps and a small basal peg. The operculum has 5 to 9 well-developed serrations.

A number of fossil species occurs in the Miocene and Pliocene of southeast Asia and the East Indies. The most ancient of these appear to be related to *mutabilis* and *labiatus*. Nothing resembling *dentatus* or *fusiformis* occurs in the Pliocene or earlier. *Strombus liocyelus* Dall, 1915, from the Silex beds of Tampa, Florida [Miocene] quite likely belongs to this subgenus, and is the only recorded Caribbean representative.

Synonymy—

1817 *Canarium* Schumacher, Essai Nouveau Système, Copenhagen, p. 219. Type by monotypy: *Canarium ustulatum* Schumacher = Martini, vol. 3, figs. 803, 805 = *urceus* Linné, 1758.

1840 *Strombidea* Swainson, A Treatise on Malacology, London, pp. 138 and 140. Type by monotypy: *urceus* Linné, 1758.

1888 *Conorium* Jousseaume, Mém. Soc. Zool. de France, vol. 1, p. 174. Type by monotypy: *Conorium mutabilis* Swainson [error for *Canarium*?].

Strombus urceus Linné, 1758

(Pl. 20, figs. 26-29; pl. 41, figs. 1-6)

Range—Southeast Asia and the Ryukyu Islands to Australia and Melanesia.

Remarks—This species is close in appearance to *labiatus* (Röding), but is distinguished from the latter by its more drawn out siphonal canal, which is generally dark blue-black within and without, and by the smooth central portion of the usually white, rarely black, and rarely orange columella. The two species do not live in the same immediate habitat (see under *labiatus*). Our interpretation of what Linnaeus meant by *ureeus* is discussed under Types and Nomenclature below.

S. *urceus* is a very variable species. In addition to size, sculptural and color variations that appear within a single colony, there are other geographical clines and groups of morphological variations

Plate 41. *Strombus urceus* Linné. Figs. 1 and 2, Mindanao Id., Philippines. 3, Geelvinck Bay form, Dutch New Guinea. 4, shouldered form, Aitape, New Guinea. 6, Yap Island form. 5, immature of S. *urceus orrae* Abbott, paratype, Broome, Western Australia. All × 1.5.

limited to certain rather discrete geographical areas. Some of these latter cases may well be considered subspecies; others may be due to environmental conditions common to these circumscribed areas. We have refrained from breaking the species up into numerous subspecies because we feel that many more large samples are needed from many more localities. Experimental work is also sorely needed.

The most distinct of the variations, with a fairly well-defined geographical distribution, is the heavy, high-spired, few-knobbed, square-lipped form so common along the northern and especially northwestern portion of the Australian continent. This we accepted as a valid subspecies and name it *Strombus urceus orrae*.

Dominant in the Singapore area, and decreasingly so northward into the Gulf of Siam to Hong Kong, and sparingly in the Ryukyus and only sporadically in the central Philippines is the form with a black-colored columella and aperture: **form** *ustulatus* Schumacher, 1817 (see pl. 20, fig. 29). This dark-mouthed character is probably an example of a single gene cline, and not due to environmental conditions. In Tabaco Bay, Albay Province, Luzon Island, an area where many species are particularly darkly colored (*Conus eburneus* form *polyglottis* Weinkauff), specimens of *Strombus urceus* do not have darkly pigmented apertures.

The deeper water form (1 to 25 fathoms) of *urceus* intergrades with the larger more robust intertidal form. It ranges in size from 18 to 26 mm. in length, is usually quite elongate, light weight and is sparsely and weakly colored. The blue-black on the siphonal canal may be greatly reduced or absent.

An interesting form is dominant in the northeastern waters of New Guinea which, when substantiated with samples from surrounding areas, may prove to be a distinct subspecies. We refer to this as the "Geelvink" **form.** The lower third of the last whorl is solid blue-black. The body whorl is smooth, rounded at the shoulder and bears only 2 or 3 very weak nodules. The parietal wall is smooth, glistening and appearing to be light-tan, but under a lens is seen to be a beautiful, fine, zigzag, axial pattern of delicate orange-brown. The spire is finely beaded and bluish black. We have also seen the form from the Palaus and Ponape Island in the Carolines (see pl. 41, fig. 3).

An additional and evidently closely related form appears to have received the name *incisus* Wood, 1828. We have this form from the Solomons and from three other localities whose authenticity of data is questionable—Majuro Atoll, Saipan and a large series from "Fiji." It may subsequently be considered a subspecies when more is known about its anatomy and range. In shape, the shell is quadrate, with a broad shoulder bearing 6 to 7 short, strong, axial, slanting ribs and a very swollen, squarish, upper end to the outer lip which is elevated to the height of the suture above. The posterior canal is in the form of a minute channel or "knife-cut" located towards the edge of the outer lip. The flange below the stromboid notch is very broad and large and may extend as far forward as the tip of the siphonal canal. The color of the shell is whitish with the lower fourth of the body whorl blue-black to brownish black and the dorsum with 2 or 3 diffused bands of lead to brownish gray. The spire is minutely beaded, the apex blue-black to brownish. Shell length 19 to 30 mm. (see pl. 41, fig. 4).

Habitat—Occurs in colonies on sand or sandy mud bottom from the low tide mark to 20 fathoms. It is sometimes associated with sparse algal bottoms, and is not found intermingled with *Strombus labiatus* (Röding).

Description—Adult shell 19 to 61 mm. (usually about 50 mm.) in length, solid, smooth to axially nodulated, vari-colored, and with an all white, all black, black-rimmed or rarely yellowish-orange columella which is always smooth, except at the top and bottom fourth. Color of outer shell very variable, ranging from brown, whitish, cream, or with grecnish, yellow-brown maculations, flecks, broken bands and axial streaks to a solid pink, orange or yellow. Siphonal canal almost always tipped with bluish black within and without. Whorls either rounded or, especially in the spire, squarish. Nuclear whorls 3, bulimoid, glossy, smooth translucent tan or bluish black, rarely colorless. First postnuclear whorl with about 8 to 10 microscopic, incised lines. Subsequent whorls become shouldered and with 11 to 17 small axial, usually knobbed or beaded, riblets per whorl. Last whorl with 3 to 8 low knobs at the shoulder, the last 2 or 3 on the dorsum being the largest. Axial plications are almost always absent on the parietal area. Base of shell with 8 to 10 incised lines or low, flat, broad cords, the latter never raised, rounded or strong. Siphonal canal somewhat elongate, slightly reflected upward and moderately twisted. Columella smooth, except for 6 to 15 raised spiral lirae at the top third and 1 to 8 distinct lirae at the lower fourth and set almost at right angle to the axis of the columella.

Interior of body whorl with about 50 to 70 fine, purple-brown spiral lirae which may or may not extend to the edge of the outer lip. Deep interior of aperture yellowish white or pure blackish or blushed with purple-brown. Columella either all white, all black, yellowish or orangish or combinations of these colors. Stromboid notch shallow to deep. Periostracum thin, smoothish, translucent grayish to yellowish, and usually worn away on the body whorl. Operculum stromboid, one third the length of the shell, not arching, brown, and with about 12 fine, sharp serrations.

Radula ribbon 4 mm. in length, with about 38 rows of teeth. Formula: 2-1-2; 1-3 (plus peg) or rarely 1-2 (with peg); 4 or 5; 5 or 6. Verge simple, variegated in color and with white and red embedded granules. Posterior mantle filament 3 mm. Edge of mantle with a series of red lines. Eye with 1 red ring. Body variegated in color giving it a marble-like effect.

Measurements (mm.)—

length	width	no. whorls	
61.5	23.9	10	(giant; Singapore)
56.4	24.1	9+	(large; Balabac Id.)
48.5	21.6	9+	(average; Cebu Id.)
32.3	14.7	10	(small; Luzon Id.)
19.0	17.8	8	(dwarf; deep water)
		form *incisus* Wood	
31.0	17.1	8	(large; Fiji)
22.7	12.0	8	(average; Fiji)
18.0	9.5	8	(small; Fiji)

Synonymy—

1758 *Strombus urceus* Linné, Systema Naturae, ed. 10, p. 745, no. 440 (In O. Asiae); 1767, ed. 12, p. 1212, no. 512; 1956, Dodge, Bull. Amer. Mus. Nat. Hist., vol. 111, art. 3, pp. 284-285; 1842, Sowerby, Thesaurus Conchyl., vol. 1, pl. 7, figs. 34-37, 41, 42; 1843, Kiener, Coquilles Vivantes, vol. 4, pl. 15, fig. 2, pl. 30, figs. 2, 3; 1844, Duclos, in Chenu's Illustr. Conchyl., vol. 4, pl. 5, figs. 8, 9, 13-15, pl. 24, figs. 5-6.

?1807 *Lambis reticulata* Link, Beschr. Natur.-Samml., Univ. Rostok, pt. 2, p. 109. Refers to Conchyl.-Cab., vol. 3, fig. 806.

1817 *Canarium ustulatum* Schumacher, Essai Nouv. Syst., p. 219. Refers to Conchyl.-Cab., vol. 3, figs. 803, 805.

1828 *Strombus incisus* Wood, Index Testaceol. Supplement, London, p. 14, pl. 4, fig. 12 (no locality). [Quadrate form.]

1844 *Strombus anatellus* Duclos, in Chenu's Illustr. Conchyl., vol. 2, pl. 4, figs. 11, 12, pl. 21, figs. 8, 9 (Japan). [Smooth-shouldered form.]

?1839 *Strombus crassilabrum* Anton, Verzeichniss Conchylien, Halle, p. 87, no. 2820 (no locality).

1885 *Strombus (Canarium) muricatus* "Martini", Watson, Report . . . H.M.S. Challenger, vol. 15, p. 417; 1909, Sehepman, in Weber's Siboga-Expeditie, Leiden, vol. 28, pt. 2, p. 151.

1938 *Strombus (Canarium) plicatus* Lamarck, Adam and Leloup, Mém. Mus. Royal d'Hist. Nat. Belgique, special series, vol. 2, fasc. 19, p. 112, pl. 1, figs. 8d and e only (non Lamarck).

1946 *Strombus ustulatus* form *laevis* Dodge, Amer. Mus. Novitates, N. Y., no. 1314, pp. 2 and 7, figs. 1 and 6.

?1946 *Strombus (Canarium) gendinganensis* Martin, Abrard, Annales de Paléontologie, Paris, vol. 32, p. 61, pl. 4, fig. 27 (Pliocene, New Hebrides).

Types and Nomenclature—No species of Linnaeus has undergone more alternating interpretations by various authors than *urceus*. Linnaeus' description could fit any of three species, and his figure references could be either of two species. The specimen, marked for this species in the Linnaean collection, has never been illustrated, although Hanley (1855, p. 275) likened it to Sowerby's Thesaurus Conch., vol. 1, pl. 7, fig. 45 which is what we call *mutabilis* Swainson. I cannot help but believe that this specimen was marked as *urceus* at a later date by someone other than Linnaeus. This was done in the case of other species, according to Dodge, Hanley, and

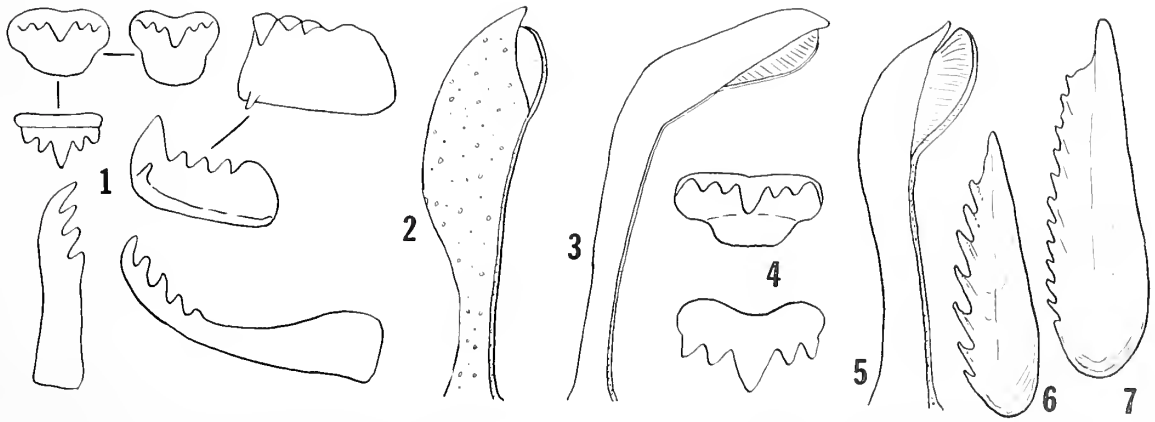


Plate 42. Fig. 1, radula of *Strombus urceus urceus* Linné and, fig. 2, its verge, Palau Islands. 3, verge of *S. erythrinus erythrinus* Dillwyn and, fig. 4, its central radular tooth, New Caledonia. 5, verge of *S. helli* Kiener, Oahu Island. 6, operculum of *S. fragilis* (Röding), Palau Islands. 7, operculum of *S. dentatus* Linné, Zanzibar.

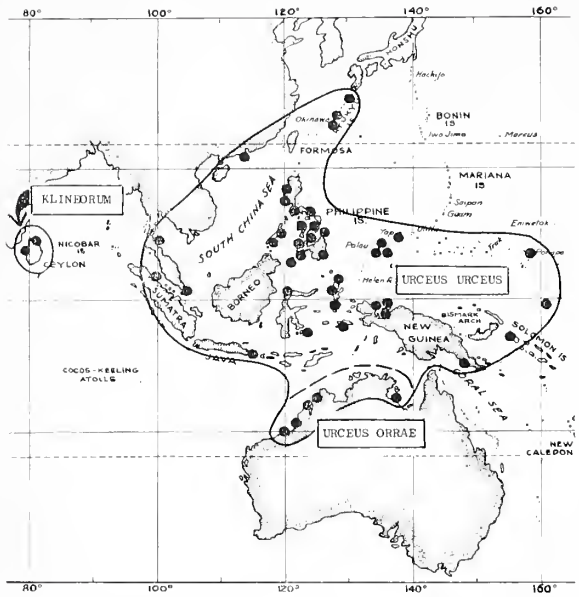


Plate 43. Geographical distribution of *Strombus klineorum* Abbott and *Strombus urceus urceus* Linné and its Australian subspecies, *orrae* Abbott.

others. None of Linnaeus' figure references are to *mutabilis*-like shells, despite the fact that perfectly good pictures of it occur in the works referred to by Linnaeus (Rumphius, pl. 37, fig. W; Seba, pl. 62, figs. 42, 43). However, Linnaeus' figure references (Rumphius, pl. 37, fig. T; Petiver, pl. 98, fig. 19; Gualtieri, pl. 32, fig. G; and in the 12th edition, Seba, pl. 60, figs. 28, 29 and pl. 62, figs. 45, 41, and 47) are all dorsal views and match specimens before us of either of two species which depend upon good apertural views for identification. No amount of arguing is going to settle the point on the basis of the figures. We hereby select shell no. 300 which is illustrated on the microfilm of the Linnaean types in the Museum Ludovicae Ulricae (M. L. U. 288) as the neoholotype or lectotype. This conforms with the *urceus* concept of Lamarck, Deshayes, Sowerby (Thes. Conch., vol. 1, pl. 7, figs. 34-37), Reeve (Conch. Icon., pl. 11, fig. 24b), Tryon and Dodge. Kiener's (1843) best figures are pl. 30, fig. 2, and pl. 31, fig. 1b. We designate Cebu Island, Philippines, as the type locality.

With so much confusion attending the use of the name *urceus*, it is impossible to know in most cases what certain later authors had in mind, unless they illustrated their shells. For this reason we have not used literature information in working out the distribution of *urceus*.

The smooth shouldered form turns up sporadically as probably a minor genetic form in colonies in the Philippines, East Indies, Melanesia and Singapore. It is of no taxonomic significance and has had two names given to it: **form** anatellus Duclos, 1844 and **form** *laevis* Dodge, 1946.

Selected records (see accompanying map, pl. 43. Solid dots: specimens examined; no literature records used)—HONG KONG: Rocky Harbour, Tai She Wan (A. J. Staple, ANSP). THAILAND: Bandon Bight; Koh Chang; Bangbert Bay; Hualpa Id.; Koh Samet; Koh Samui; Koh Tao (all USNM). SINGAPORE: Tanah Merah Besar (R. D. Purchon, ANSP). RYUKYU ISLANDS: Yaka Beach, Ishikawa, Okinawa Id. (USNM). PHILIPPINES: common throughout the islands: Luzon, Mindoro, Lubang, Catanduanes, Negros, Marinduque, Guyo, Cebu, Bohol, Samar, Masbate, Gamiguin, Palawan, Mindanao, Basilan, Tawi Tawi, Jolo, Balabac, Busuanga, Burias, and Sanga Sanga Island (all USNM, ANSP, or MGZ). DUTCH NEW GUINEA: Geelvink Bay: off Rowo Id., Aeori Ids., 1 fm.; Japen Id., Ambai Ids., 8 fms.; (all NSF). PALAUS: South side of Malakal Harbor, 2 fms.; reef, Karamando Bay, Babelthuap Id. (all NSF). CAROLINES: Ponape (V. Wertley, ANSP); Yap Id. (C .O. Kile, ANSP); reef at Mutunlik, Kusaie Id. (USNM). SOLOMONS: Pavuvu Id., Russell Ids. (USNM); Florida Id. (MCZ); Suu, Malaiti Id. (W. J. Eyerdam, ANSP). [Unsubstantiated records: Fiji; Saipan; Majuro Atoll, Marshalls; Tuticorn, India (USNM).]

Fossil records—No bona fide records with the possible exception of Abrard's 1946 Pliocene record from the New Hebrides. The shell figured looks like true *urceus* in shape, and the columella appears to be smooth. If truly an *urceus*, it indicates that the eastern limits of this species have drifted westward since the Pliocene.

Strombus urceus *subspecies* orrae *new subspecies*

(Pl. 20, fig. 28; pl. 41, fig. 5)

Range—Western Australia to the Gulf of Carpentaria, Australia.

Remarks and description—This new subspecies is characterized and distinguished from the southwest Pacific typical *urceus* by its heavier, more quadrate, less colorful shell, its stronger and fewer nodules and its shorter siphonal canal. Its penultimate whorl bears 7 to 11 knobs (instead of as many as 10 to 16 as in typical *urceus*). The top end of the outer lip is square and thickened; the columella always white and the inner aperture yellow with sparse brown lirae. Body whorl with 7 to 9 nodules at the shoulder, the first one or two on the dorsum being large, swollen and prominent. The young show 3 narrow, broken spiral bands of brownish black on the body whorl. Stromboid notch shallow. Nuclear whorls 2½, translucent yellowish and glossy.

I take pleasure in naming this subspecies after Miss Virginia Orr, Assistant, Department of Mollusks at the Academy of Natural Sciences, who collected this subspecies in Australia.

Measurements (mm.)—

length	width	no. whorls	
42.1	20.8	9	(holotype, ANSP)
47.8	21.1	10	(paratype, ANSP)
21.2	9.5	9	(paratype, ANSP)

Habitat—Intertidal on sand flats.

Synonymy—No previously published names or

figures known. Some references to Australian *urceus* Linné may be this subspecies.

Types—Holotype in ANSP no. 247756. The type locality is Augustus Island, Western Australia, Australia. Collected by B. Bardwell. Paratypes in MCZ and ANSP nos. 232673, 233409, 240131, 240137.

Locality records (and other paratypes)—WESTERN AUSTRALIA: Broome (MCZ); Gantheaume Point, Broome; La Grange Bay (both V. Orr, 1958, ANSP); Augustus Id. (ANSP and MCZ). NORTHERN TERRITORY: Cape Leveque (MCZ); Shell Id., and East Point, and Port Darwin, Darwin (all MCZ); Quail Id., 35 mi. west of Darwin (MCZ); Nightcliff Point, Darwin (USNM). Allaru Islet, west of Port Essington, Cobourg Peninsula (MCZ). GULF OF CARPENTARIA: Groot Eylandt and Bickerton Id. (USNM).

Fossil records—None reported.

Strombus labiatus (Röding, 1798)

This well-known species has had a remarkably complicated nomenclatorial history. Various authors have treated it as a form or as a subspecies of *urceus* Linné. Our own studies lead us to conclude that it is a discrete species having two subspecies—the typical *labiatus* from southeast Asia and the southwest Pacific—and the *olydius* Duclos from the western part of the Indian Ocean. The chief differentiating characters of these two subspecies are:

S. labiatus labiatus—columella yellowish- to reddish-orange with fine, slightly raised, spiral lines of darker color. The lirae on the inner wall of the body whorl are usually darkly colored.

S. labiatus olydius—columella light-mauve or whitish violet with rather wide, usually raised, spiral lines of white. The lirae on the mauve inner wall of the body whorl are usually white.

The species appears to be confined to large volcanic islands. Only one specimen of *labiatus labiatus* is known from the Micronesian islands, that being a live specimen taken in 1955 by Mr. Ostheimer on Babelthuap Island, Palau Islands. It is relatively uncommon in New Caledonia and Fiji, but very abundant in the Philippines.

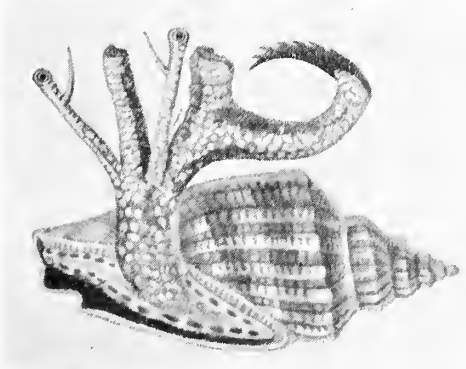


Plate 44. Living animal of female *Strombus labiatus* (Röding). (from Quoy and Gaimard, 1833, pl. 51, fig. 5).

Strombus labiatus *subspecies* labiatus (Röding, 1798)

(Pl. 20, figs. 22, 23; pl. 44, pl. 45, figs. 1-6)

Range—Southeast Asia to Japan, Australia and Melanesia.

Remarks—This is an abundant and well-known species in the central part of its range. It is very variable in size, coloration and sculpture. It may be strongly or weakly ribbed and spirally corded. It is distinguished from *S. urceus* in having an orangish columella which is generally weakly lirate along its entire length (instead of whitish or black-bordered and smooth at the center), in having a more truncate siphonal canal (instead of being drawn out), and in usually having strong, axial plications and sometimes in being spirally corded over the entire outer surface. The geographical range of *urceus* is more restricted than that of *labiatus*.

Habitat—*S. labiatus* is always associated with an algal bottom which is generally intertidal or relatively shallow. *S. urceus* is not as closely associated with algal bottoms, and may be dredged on pure sandy mud to a depth of 20 fathoms. The latter is seldom found on fringing reef flats. Colonies of these two species are never found co-existing, and among about 50 accurately localized collecting stations in the ANSP collection the two species were never taken at the same, immediate station.

Description—Shell 16 to 47 mm. (¾ to 1¾ inches) in length, solid, axially plicate to smoothish, varicolored, and with a yellowish to orange columella which has darker-colored, weak spiral lirae. Color of outer shell very variable, ranging from brown, greenish, gray, or yellowish maculations, flecks, broken bands and axial streaks to a solid light-yellow or orangish. Whorls 8 to 10. Nuclear whorls 3, bulimoid, glossy, smooth, translucent whitish, tan or brown-banded. First postnuclear whorl with about 10 microscopic, spiral incised lines. Next whorl with fewer incised lines, but with a weak subsutural cord and with about 20 weak, rounded axial ribs which in later whorls become noduled at the carinate shoulder. Penultimate whorl with 12 to 16 axial, well-shouldered ribs; whorls rarely rounded and rarely without ribs. Last whorl with 8 to 12 axial plications which are crowded, long and slanting on the rounded parietal wall, but on the dorsum are developed into 2 or 3 shoulder knobs. Last whorl rarely smooth and with a rounded shoulder. Base of whorl with 8 to 10 flat spiral cords, which in some specimens are raised and rounded and extend over the entire surface of the last three whorls. Siphonal canal truncate below.

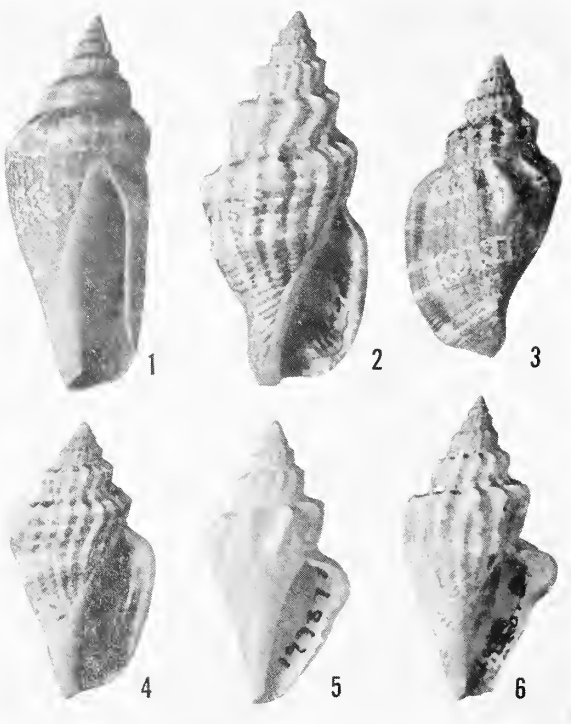


Plate 45. *Strombus labiatus* (Röding). Figs. 1-4, adults, Cebu Island, Philippines. 5 and 6, immatures, Cebu Island, Philippines. All natural size.

Columella narrow, with a sharp left edge, glossy, orange to yellowish orange and with about 30 to 40 spiral stripes of darker brownish orange. On these are raised lirae throughout the length of the columella in some specimens, and raised lirae only at the upper and lower end in other specimens. The upper lirae are usually uneven, broken or intertwining. Interior of body whorl with numerous, crowded, raised brownish purple, spiral lirae. The coloration extends almost out to the edge of the lip. Stromboid notch well or poorly developed. Spire with none or 1 to 11 very small, whitish, axial, swollen, former varices. In young specimens there is usually a brownish or purplish color patch on the upper and inner portion of the parietal or columellar wall. Periostracum thin, smoothish, translucent grayish and flakes off when dry. Operculum stromboid, not arching, light-brown, with 8 to 9 well-developed serrations, and with a longitudinal concave channel on the outer side.

Radular ribbon 4 to 5 mm. in length and with about 38 rows of teeth. Formula: 2-1-2; 1-3 (plus peg) and 1-2 (plug peg); 4; 5. The inner marginal is considerably smaller and broader than the outer marginal. Animal (preserved) mottled with red maculations and with a red ring around the eye. Posterior mantle filament 2 to 2.5 mm. in length.

Measurements (mm.)—

length	width	no. whorls	
47.0	24.2	8+	(giant; Okinawa Id.)
44.0	23.1	8+	(large; Okinawa Id.)
35.1	17.5	10	(average; Luzon Id.)
22.1	12.8	8	(small; Luzon Id.)
17.5	10.0	8	(dwarf; Schouten Ids.)

Synonymy—

1798 *Lambis labiatus* Röding, Museum Boltenianum, Hamburg, pt. 2, p. 63, no. 806 (no locality). Refers to Conchyl.-Cab., vol. 3, figs. 804-805.

?1807 *Lambis reticulata* Link, Beschr. Natur.-Sammlung, Rostock, vol. 2, p. 108. Refers to Conchyl.-Cab., vol. 3, fig. 806.

1816 *Strombus plicatus* Lamarck, Le Liste, Paris, p. 3; Encyclop. Méthod., pl. 408, fig. 2a and b (no locality); 1822, Anim. sans Vert., vol. 7, p. 210 (Moluques); 1843, Kiener, Coquilles Vivantes, vol. 4, pl. 31, fig. 1 (not fig. 1b). Non Röding 1798, non Mühlfeld 1829.

1850 *Strombus dentatus* Linné, Reeve, Conch. Icon., vol. 6, pl. 9, fig. 17. Not Linné, 1758; 1844, Duclos, in Chenu's Illustr. Conchyl., vol. 4, pl. 5, figs. 1-6.

1925 *Strombus (Canarium) plicatus* Lamarck, Oostingh, Mededeel. Landbouwhoogeschool Wageningen, vol. 29, pt. 1, pp. 59-69, form B only.

?1931 *Canarium otiolum* Iredale, Records Australian Mus., vol. 18, no. 4, p. 212, pl. 23, fig. 6 (Sydney Harbour, N.S.W., Australia) [probably an immature].

1946 *Strombus ustulatus* form *plicatus* Lamarck, Dodge, Amer. Mus. Novitates, no. 1314, p. 2, fig. 3.

1959 *Canarium dentatum* Linné, Kira, Coloured Illus. Shells of Japan, Osaka, 2nd ed., p. 35, pl. 15, fig. 6.

Types—Röding's species is based upon figures 804 and 805 of vol. 3 of Martini's Conchylien-Cabinet. Röding gave no type locality. Martini mentioned Amboina, Indonesia, which we hereby designate as the type locality. Figure 806 is probably also *labiatus*, but 803 is an *urceus*, probably from the mainland of southeastern Asia. The former is the type figure for *reticulata* Link. The type of *plicatus* Lamarck is figured in "mirror image" on plate 408, fig. 2, a, b of the Tableau Encyclop. Méthod., pt. 23. It is the common Philippine plicate form.

Nomenclature—Various names have been applied to this species by various authors. *S. plicatus* Lamarck, 1816 is frequently seen in the literature. That name is a homonym of *plicatus* (Röding, 1798). *S. urceus* of authors (not of Linné) and *ustulatus* of authors (not Schumacher) have also been used. See further discussion under the nomenclature of *urceus*.

Selected records (see accompanying map, pl. 46. Solid dots: specimens examined. No literature records used)—ANDAMAN ISLANDS: Port Blair (W. N. Carpenter, USNM). THAILAND: Koh Chang, Gulf of Siam (USNM). JAPAN: Shirahama, Wakayama Pref., Honshu Id. (T. Habe, ANSP). PHILIPPINES: abundant throughout most, if not all, of the islands. INDONESIA: Keledjitan, Bantam, Java (USNM); Amboina, Moluccas (MCZ). AUSTRALIA: Port Douglas, Queensland (Tony Marsh, ANSP). NEW CALEDONIA: Touho Bay and reef at Yate (both G. and M. Kline, 1958, NSF). NEW HEBRIDES: Aore Id. (MCZ).

PALAU ISLANDS: reef, Karamando Bay, Babelthuap Id., rare (NSF, 1955). FIJI: Lambasa, Vanua Levu Id. (ANSP); Buca Bay, Vanua Levu Id. (R. T. Abbott, MCZ). Natakalau, Ovalau Id. (T. Dranga, MCZ). [The USNM has one Guam specimen of doubtful authenticity.]

Fossil records—No authentic fossil records exist, since none of the records for "*plicatus* Lamarck," etc. have been illustrated.

Strombus labiatus *subspecies* olydius Duclos, 1844

(Pl. 20, figs. 18, 19)

Range—Central East Africa to Mauritius and Ceylon.

Remarks and description—This subspecies is limited to the western part of the Indian Ocean. It is uncommon in collections. In external characters, such as sculpture and color, it shows no appreciable difference from the East Indian *labiatus labiatus*. The aperture, however, consistently shows a striking difference both in color and sculpture. The columella is light-mauve to brownish purple with broad, raised, enamel-white spiral lirae. In immature specimens the lirae may be obsolete at the center of the columella and coloration may be limited to only a few brownish purple, fine streaks. Inside of body whorl and outer lip heavily pigmented with mauve over which are numerous, irregular, raised, fine spiral lirae. Operculum stromboid, similar to *labiatus*, and with 9 serrations. Eye in preserved specimens with a narrow red ring, and posterior to this a narrow yellowish one. Radula 4 mm., with 35 rows, and similar to *labiatus* and *urceus*. Formula: 2-1-2; 1-4 (plus peg); 4; 5. The body has a marble-like color pattern similar to that of *urceus*.

Habitat—Found on intertidal, weedy, dead coral reefs.

Measurements (mm.)—

length	width	no. whorls	
47.5	19.5	9	(large; Zanzibar)
38.7	20.8	9+	(average; Zanzibar)
31.5	14.5	8+	(small; Madagascar)

Synonymy—

1844 *Strombus olydius* Duclos, in Chenu's Illustrations Conchyliologiques, Paris, vol. 4, Strombus, p. 4, pl. 5, fig. 7 (no locality).

1929 *Strombus ureeus* Linné, var. *olydius* Duclos, Dautzenberg, Faune des Colonies Françaises, Paris, vol. 3, pt. 4, p. 470.

Types—The type of *olydius* is presumably in the Muséum d'Histoire naturelle de Genève. No locality was given by Duclos. We hereby designate Nossi-bé, northwest Madagascar, as the type locality.

Nomenclature—We know no synonyms of *olydius*. It has been put in the synonymy of *plicatus* Lamarck and *urceus* Linné by most previous authors.

Records—KENYA: Kikambala, 15 mi. north of Mombasa (Coryndon Mus. no. 2582). TANGANYIKA: Mboa Magi (R. T. Abbott, USNM). MOZAMBIQUE: Port Amelia (USNM). ZANZIBAR: Kiwengwa; Mangapwani; Fumba; Mazizini (all NSF, 1957). MADAGASCAR: Nossi-bé (A. Chavane, ANSP; MCZ). MAURITIUS: (N. Pike, MCZ). CEYLON: Hikkaduwa (R. Jonklass, ANSP).

Fossil records—None reported.

Strombus labiatus *subspecies* gendinganensis Martin, 1899

Range—Fossil (Pliocene) of Java, Indonesia, the Philippines and possibly Taiwan.

Remarks—This subspecies differs from the living *labiatus* in usually having the axial riblets and the elongate shoulder and parietal plications greatly re-

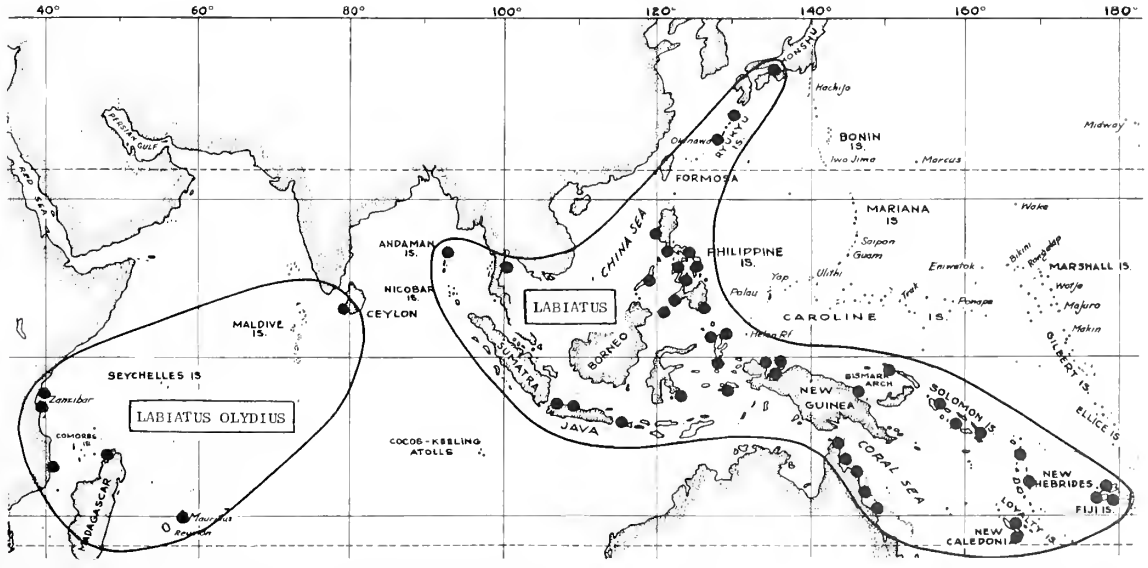


Plate 46. Geographical distribution of *Strombus labiatus labiatus* (Röding) and *Strombus labiatus olydius* Duclos.

duced. Many of the Pliocene literature records of *plicatus* Lamarck in the Indonesian area are probably this subspecies (see Altena's listings, 1942, vol. 12, p. 55-57). From his description (but not illustration), it would appear that *gendinganensis* occurs in the Pliocene, Byoritu Beds of Taiwan (Nomura, 1935, p. 179). Dickerson's *Strombus dentatus sonde* is a slightly more plicate form of this subspecies. For Abrard's 1946 Pliocene New Hebrides record, see under *urceus* Linné.

Synonymy—

1899 *Strombus (Canarium) gendinganensis* K. Martin, Samml. geol. Reichs-Mus. Leiden, n. Folge, vol. 1, pt. 1, p. 187, pl. 30, figs. 432, 432a (typical), 433, 433a (atypical) (Pliocene, Java); 1942, Altena, Leidsche Geologische Mededeelingen, vol. 12, p. 57 (Pliocene, Java); 1922, Dickerson, Philippine Jour. Science, vol. 20, no. 2, p. 225, pl. 5, fig. 4 (Vigo Group, Upper Miocene [? Pliocene], Bondoc Peninsula, Luzon Id., Philippines).

1899 *Strombus dentatus* Linn. var., K. Martin, Samml. geol. Reichs-Mus. Leiden, n. Folge, vol. 1, pt. 1, p. 188, pl. 30, fig. 437 [or is *labiatus* Röding] (Java, Pliocene).

1922 *Strombus dentatus sonde* "Martin" Dickerson, Philippine Jour. Science, vol. 20, no. 2, p. 225, pl. 5, fig. 7 (Vigo Group, Bondoc Peninsula, Luzon Id.).

Strombus klineorum *new species*

(Pl. 20, figs. 20, 21)

Range—Known only from Ceylon.

Remarks—This distinctive new species is so far known only from the area around Ceylon. It closely resembles *labiatus* Röding in morphological characters but appears consistently different in the following characters: parietal wall smooth and somewhat flattened; outer half of columella salmon red to reddish yellow, the inner half being a solid purplish black; penultimate whorl with fewer shoulder knobs; and the shoulder of the outer lip extending to the shoulder above.

Habitat—Found along the shores of Ceylon in 2 to 5 feet of water on a sandy mud and rocky bottom in company with *Conus*, *Cypraea* and *Bursa* (G. and M. Kline). Shallow water within fringing reef, common (R. Jonklass).

Description—Adult shell 17 to 37 mm. (¾ to 1½ inches) in length, smoothish, except for strong knobs at the shoulder, with a brightly colored aperture, and resembling *labiatus*. Whorls 7 to 9. Nuclear whorls 3, glassy, smoothish, translucent tan and moderately rounded. Postnuclear whorls with 7 to 10 fine incised spiral lines which in the third whorl become crossed by 16 to 19 rounded, evenly spaced axial ribs which become increasingly nodulated at the central shoulder. The penultimate whorl has usually 11 (rarely 14) small knobs and the body whorl only 3, of which the last is very large and blunt and located ¼ of a whorl back from the swollen varix. Ventral wall peculiarly flattened and smooth. Suture slightly impressed and bordered below by a weak, small spiral cord only in the first 3 or 4 postnuclear whorls. Color of outer shell olivaceous brown with suffused maculations of light yellow-brown. Center of body whorl with 2 or 3 narrow spiral bands of tiny clusters of opaque-white dots. Aperture squarish at the top, broader below. Upper end of outer lip shouldered by a large swelling. Columella slightly arching, with a strong border on its left. The outer border of the columella and the inner narrow border of the outer lip are bright carmine to yellowish red. The entire inner half of the columella and a broad band inside the outer lip are very dark blackish purple. Deep within the aperture whitish to cream. Columella smooth at the center, but with spiral teeth at the lower and upper fourth. Inside of body whorl with numerous, raised, fine, black or gray spiral lirae. Tip of short, straight siphonal canal without a black stain. Periostracum thin, translucent, and smoothish. Operculum stromboid, slightly less than ⅓ the length of the shell, not arching, light-brown, with about 8 small serrations, and with a weak central rib on the attachment side. Body coloration similar to that of *urceus*.

Measurements (mm.)—(all adults from Ceylon)

length	width	no. whorls	
35	20	8.5	(holotype, ANSP 247621)
36	20	8.5	(paratype, ANSP 211121)
27	15	8.0	(paratype, ANSP 211121)
26	14	7.0	(paratype, ANSP 211173)
19	10	7.0	(paratype, ANSP 211173)

Synonymy—

1844 *Strombus urceus* L., Duelos, in Chenu, Illustr. Conchyl., vol. 2, pl. 5, figs. 10, 11. Non Linné 1758; 1850, Reeve, Conch. Iconica, vol. 6, pl. 11, fig. 24a.

Types—The type locality is Powder Bay, near Trincomalee, Ceylon. Collected by George F. and Mary Kline on January 17, 1957. Holotype is ANSP no. 247621, paratypes in ANSP 211121 and 211173; paratype in MCZ 224889. The species is named with pleasure after the Klines who have been indefatigable collectors for the Department of Mollusks at the Academy.

Locality records (see map, pl. 43)—CEYLON: Kacheri, Powder Bay, and south shore of Fort Frederick, all Trincomalee (NSF). Akurala, S.W. end of island (R. Jonklass, ANSP). [Literature records from Ceylon and southern India of *S. plicatus* Lamarck, *S. urceus* Linné, etc. may be this species.]

Strombus microurceus (Kira, 1959)

(Pl. 20, figs. 24, 25)

Range—Southern Japan to the East Indies, Australia, Melanesia and to Samoa.

Remarks—This small and attractive species has several characters which separate it from closely resembling *mutabilis* and *ureeus*. It is a Southwest Pacific species rather than a widely dispersed one like *mutabilis*. S. *mieroureeus* has a distinctive columella. The outer half is yellowish to whitish orange; the inner half is very dark brownish purple. Across the latter run about 25 to 30, fine, short, spiral lines of yellowish which usually coincide with minutely raised spiral lirae. The latter are usually rather weak or absent near the middle of the columella. Deep within the aperture, the inside of the body whorl is whitish to yellowish, but towards the outer lip there is a broad, well-defined, longitudinal band of dark brownish purple which is crossed by about 50 to 60 whitish, raised, spiral lirae. The exterior of the siphonal canal has a small purplish patch, a feature absent in *mutabilis*. Just behind the outer lip and just below the suture, there is usually a peculiar elongate patch of grayish green or bluish gray.

We have seen one specimen presumably from Zanzibar which closely resembles *mieroureeus* in many respects, except that the columella is smoothish and white in the center, and the shoulder of the last whorl bears several evenly-sized, axially-pinched, short knobs. When more material is at hand, this may prove to be a valid Indian Ocean subspecies of *mieroureeus*.

Habitat—This is a relatively uncommon species, or at least sparse in numbers wherever it occurs. It has been collected on sandy and rocky areas just below low tide and dredged in depths from 1 to 12 fathoms on sand and dead coral bottoms.

Description—Adult shell 14 to 27 mm. (about ½ to 1 inch) in length, solid, smoothish, somewhat quadrate in shape and resembling *mutabilis*. Whorls 7 to 8. Nuclear whorls 3, glassy, smooth, translucent tan and well-rounded. Postnuclear whorl microscopically reticulate. Second, third and fourth postnuclear whorls bear 4 to 5 incised spiral lines, numerous, weak axial nodules and 3 to 5 old, whitish, swollen varices. Body whorl bears 3 to 6 blunt nodules at the shoulder, the last two being the largest and placed well back from the outer lip. Suture moderately indented and bordered below by a single, strong rounded cord which is rarely spirally striate. Color of outer shell variable but usually a cream to white background overlaid with brown and/or yellowish reticulations, maculations, suffused spiral bands and/or minute stripes or bars. Outside of base of shell typically with 2 irregular patches or blue-brown. An all yellow or orange phase occurs rarely. Aperture narrow above, broad below. Columella slightly concave, smooth and yellowish orange along the outer border, but within the aperture it is dark purple-brown. The latter area bears 22 to 32 narrow, spiral flames or streaks of yellowish orange which on the lower and upper part of the columella bear raised, rounded teeth. Inside of outer lip with a wide band of dark purple-brown over which are numerous, irregular, raised spiral lirae or teeth. Deep interior of aperture dirty white to yellowish. Stromboid notch on lower outer lip relatively narrow and well-developed. Base of shell with 11 to 14 strong, rounded, spiral threads.

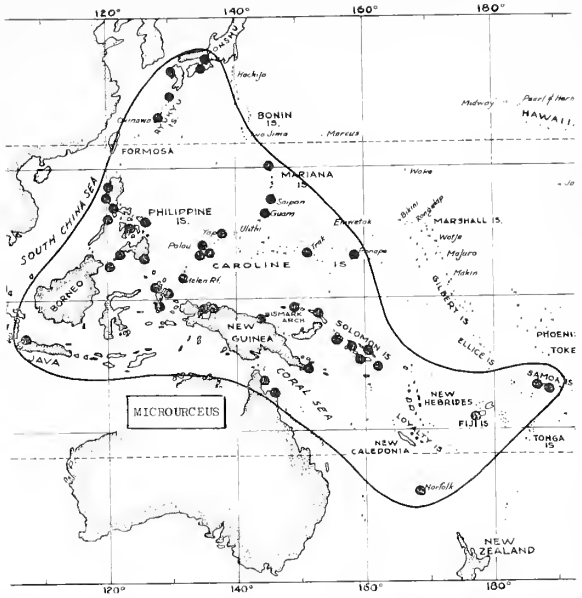


Plate 47. Geographical distribution of *Strombus microurceus* (Kira).

Periostracum very thin (peels off when dry), not smooth and light-tan. Operculum stromboid, one third the length of the shell and with 7 serrations.

Radula ribbon 2 mm. in length, with 29 rows and similar to *mutabilis*. Its formula is: 2-1-2; 1-2 (plus peg); 5; 7. Preserved animals cream with sparse orange spots. Verge half the length of the shell, long, slender, with weak, lemon mottlings and a large lamellated pad at the distal end (Upolu Id., Samoa).

Measurements (mm.)—

length	width	no. whorls	
27.0	14.0	7	(large; Okinawa Id.)
22.0	10.5	7	(average; Palau Ids.)
14.0	7.0	6	(small; Mindanao Id.)

Synonymy—

1955 *Canarium mieroureeum* "Kuroda, MS" Kira, Coloured Illust. Shells Japan, Osaka, ed. 1, pl. 15, fig. 5 (nude name).

1959 *Canarium microurceum* "Kuroda, MS" Kira, Coloured Illust. Shells Japan, Osaka, ed. 2, p. 37, pl. 15, fig. 5 (Honshu southward).

Types—A general geographic range was given by Kira (central Honshu and southward), and we hereby restrict the type locality to Shirahama, Wakayama Pref., Honshu Id., Japan (ANSP no. 234923). The type figured by Kira is presumably in the collection of Mr. Tetuaki Kira of Japan.

Nomenclature—Although Kuroda is given as the author of this species, it was a manuscript name and must now bear Kira as the author.

Selected records (see accompanying map, pl. 47; solid dots: specimens examined; open circles: from the literature) —JAPAN: Shirahama, Wakayama Pref., Honshu (T. Habe, ANSP). PHILIPPINES: shore reefs, Cape Santiago, Batangas Prov., Luzon Id. (Dayrit and Abbott, ANSP); Gigmoto, Catanduanes Id. (ANSP). Also Panay, Mindoro, Mindanao Ids. (USNM). INDONESIA: Keledjitan, Bantam, Java. AUSTRALIA: Green Id., near Cairns, Queensland (MCZ). LORD HOWE ISLAND: (H. L. Clark, MCZ). MARIANAS: Agrighan Id. (Robert R. Hill, ANSP); Agat Bay, Guam Id. (A. J. Ostheimer, NSF). CAROLINES: Ponape Id. (V. Wertley, ANSP); Yap and Elato Atoll (both USNM). FIJI: Suva, Viti Levu Id. (H. S. Ladd, USNM). SAMOA: east side of Vailele Bay, Upolu Id. (A. J. and Ruth Ostheimer, 1955, NSF).

Fossil records—None reported.

Strombus mutabilis Swainson, 1821

(Pl. 20, figs. 15, 16, 17)

Range—The entire tropical Indo-Pacific exclusive of Hawaii, the Line Islands, Marquesas and Easter Island.

Remarks—This is a very widely distributed species which is common on reef flats. It is characterized by its somewhat quadrate shape and rose-tinted aperture. The columella is pink, rose or faint brownish rose over which are 30 to 40 broad, raised, sometimes bifurcating, white, spiral lirae. Where specimens have been heavily covered with algal growths, an abnormal glaze may also cover them (as in some New Caledonia specimens).

S. mutabilis is apt to be confused with *urceus* (which has a longer, purple-tipped siphonal canal), with *maculatus* (which has a flattish spire and a white, smooth columella), with *labiatus* (which has axial riblets on the whorls in the spire) and with *microurceus* (which has the inner half of the columella blackish purple).

Strombus mutabilis, despite its variations in color and size among individuals, is a fairly constant species as a whole throughout its range. We recognize one weak subspecies in the Mauritius area—a golden-throated, white-columella shell, *mutabilis ochroglottis* Abbott. It has not appeared in Madagascan or East African collections, and one old specimen from P. P. Carpenter in the USNM supposedly from Aqaba, Red Sea, we look upon with suspicion.

Abbott (1949, pp. 59-60) has demonstrated the existence of sexual dimorphism in the shell length of *mutabilis*. In the colony of 462 specimens from Agana Bay, Guam Island, Marianas, the mode of the shell length of the entire colony was 23 mm., that of the 210 males was 20.8 mm. and that of the 252 females was 24.1 mm. The range in size of the two sexes, however, was such that the character of the shell length cannot be used as an indication of sex, except for the generalization that the largest specimens are female and the very smallest are males.

The rare color form, *zebriolatus* Adam and Leloup, (see pl. 20, fig. 17) possesses long, dark-brown to chestnut, axial, narrow, zigzag color stripes. It was originally found in Manokwari, Dutch New Guinea, and the Academy collection contains specimens from Catanduanes, Philippines; Okinawa Id., Ryukyus; Babelthuap Id., Palaus; and Ponape Id., Carolines. We have not seen this color form in Indian Ocean specimens.

A pure orange color form occasionally occurs in some colonies. We have seen specimens from Zanzibar, Ryukyu Islands, Luzon Island (Philippines), Choiseul Island (Solomons), Padaido Islands (Dutch New Guinea) and Upolu Island in Western Samoa.

Habitat—Found in colonies from the intertidal zone to a depth of 10 fathoms, although it more

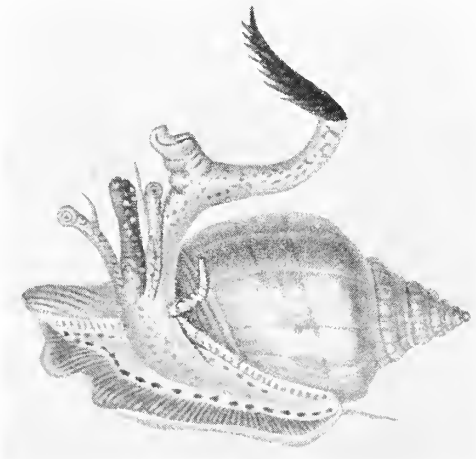


Plate 48. Living animal of male *Strombus mutabilis* Swainson. (from Quoy and Gaimard, 1833, pl. 51, fig. 12).

commonly is found just below the low tide line. Found where there is a mixture of coral sand or sandy mud and algae, whether these conditions are on outer reef flats, lagoons or sheltered shallow bays. The water may be clear or turbid. It is often associated with *Strombus gibberulus*, but not, to my knowledge, found intermingled with *S. maculatus*.

Description—Adult shell 16 to 40 mm. (about ¾ to 1½ inches) in length, solid, smoothish, varicolored, somewhat quadrate in shape, and with a pinkish aperture and striate columella. Whorls 8 to 9. Nuclear whorls 3, glassy, smooth, translucent white and well-rounded. First postnuclear whorl with 5 to 7 microscopic, incised, spiral lines which become obsolete in the penultimate or last whorl. By the second postnuclear whorl, a strong, rounded cord appears just below the indented suture but which may again disappear on the last fourth of the body whorl. Spire with 1 or 2 to as many as 15 swollen, whitish, sometimes broad, former axial varices. Whorls in spire usually shouldered, smoothish or axially ribbed or with small, weak nodules. Last whorl with 3 or 4 ill-formed, swollen, nodules at the shoulder which are located ⅓ to ½ of a whorl back from the swollen outer lip. Base of shell with about a dozen small, spiral threads. Parietal wall evenly rounded and smooth. Columella enameled, pinkish brown to mauve-brown over which are 30 to 40 rather broad, raised, whitish, rarely bifurcating, spiral lirae which are strongest at the base of the columella. Inside of the body whorl usually pink, sometimes whitish or mottled with brownish, and bearing numerous, fine, raised, whitish, spiral lirae which usually run out to the edge of the outer lip. Stromboid notch poorly to well-developed. Upper end of the aperture squarish and bounded on the right by a swollen portion of the outer lip. Siphonal canal short. Color of outer shell variable but usually bright: maculated, flecked, banded and spotted with either browns, yellows, blacks or orange. Rarely unicolor; rarely with long, zigzag axial flames or streaks of chestnut-brown (**form** *zebriolata* Adam and Leloup). Periostracum thin, smoothish and translucent yellowish. Operculum stromboid, barely arching, dark- to light-brown, with 8 to 12 small, sharp serrations, and with a concave, longitudinal channel down the middle of the outer surface.

Radula ribbon delicate, 3 to 4 mm. in length, with 36 to 42 rows of teeth. Formula: 2-1-2; 1-2 (plus peg); 4 or 5; 5 or 6. Verge slender, simple, with an elongate, lamellated, distal pad. Its base is green with white, embedded granules and orange spots. The distal half is mottled in green. Posterior mantle filament green or orange and 2 mm. in length. See plate 49, figs. 1-5.

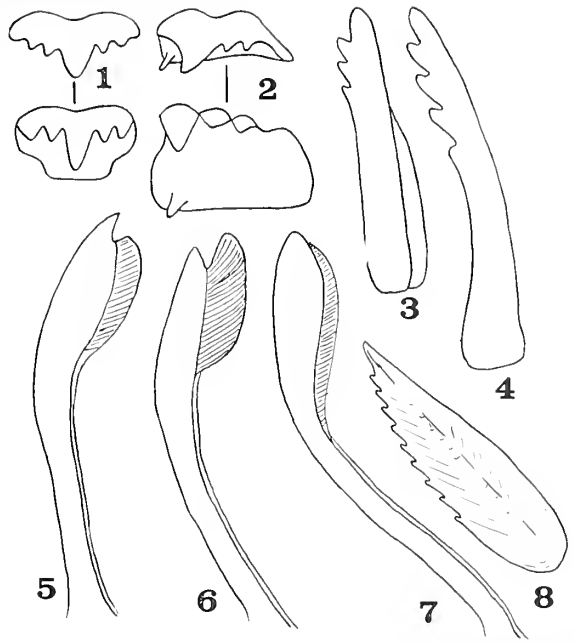


Plate 49. Figs. 1-5, radula and verge of *Strombus mutabilis* Swainson, Luzon Island, Philippines. 6, verge of *S. microurceus* (Kira), Upolu Island, Western Samoa. 7 and 8, verge and operculum of *S. terebellatus afrobellatus* Abbott, Zanzibar.

Measurements (mm.)—

length	width	no. whorls	
40.1	22.9	8	(large; Kenya)
33.5	17.3	8	(average; Samar Id.)
15.8	8.3	7	(small; Samoa)

Synonymy—

1821 *Strombus mutabilis* Swainson, Zoological Illustrations, London, series 1, vol. 2, pl. 71 (East Indies). Also refers to figures of Seba, pl. 61, figs. 26, 27, etc.; Conchyl.-Cab., vol. 3, figs. 799 and 807; Knorr, pt. 2, pl. 14, fig. 3.

1822 *Strombus floridus* Lamarck, Anim. sans Vert., vol. 7, p. 211 (Océan indien et des Moluques). Refers to Conchyl.-Cab., vol. 3, figs. 807-809; Lister, pl. 848, fig. 3; and others.

1840 *Strombidea mutabilis* Swainson, Treatise on Malacology, London, p. 310 (no locality). Refers to Conchyl.-Cab., vol. 3, fig. 807.

1844 *Strombus epimellus* Duclos, in Chenu, Illustr. Conch., vol. 4, p. 3, pl. 16, figs. 11, 12; pl. 22, figs. 5, 6.

1852 *Strombus flosculosus* "Martini" Mörch, Cat. Conchyl. Yoldi, vol. 1, p. 63 (Indies orientalis).

1876 *Strombus flammeus* Link, Issel and T.-Canefri, Annali Mus. Civico Storia Nat. Genova, vol. 8, p. 346. Also of other authors, Mörch, 1852; Iredale, 1931; Abbott, 1949 (Nautilus, vol. 63, no. 2, p. 58), 1950; Dodge, 1946. Not Link, 1807.

1938 *Strombus floridus* Lamarck form *zebriolata* "Dautzenberg" Adam and Leloup, Mém. Mus. Roy. Hist. Nat. Belgique, special series, vol. 2, fasc. 19, p. 117, pl. 1, fig. 7 (Manokwari, Dutch New Guinea).

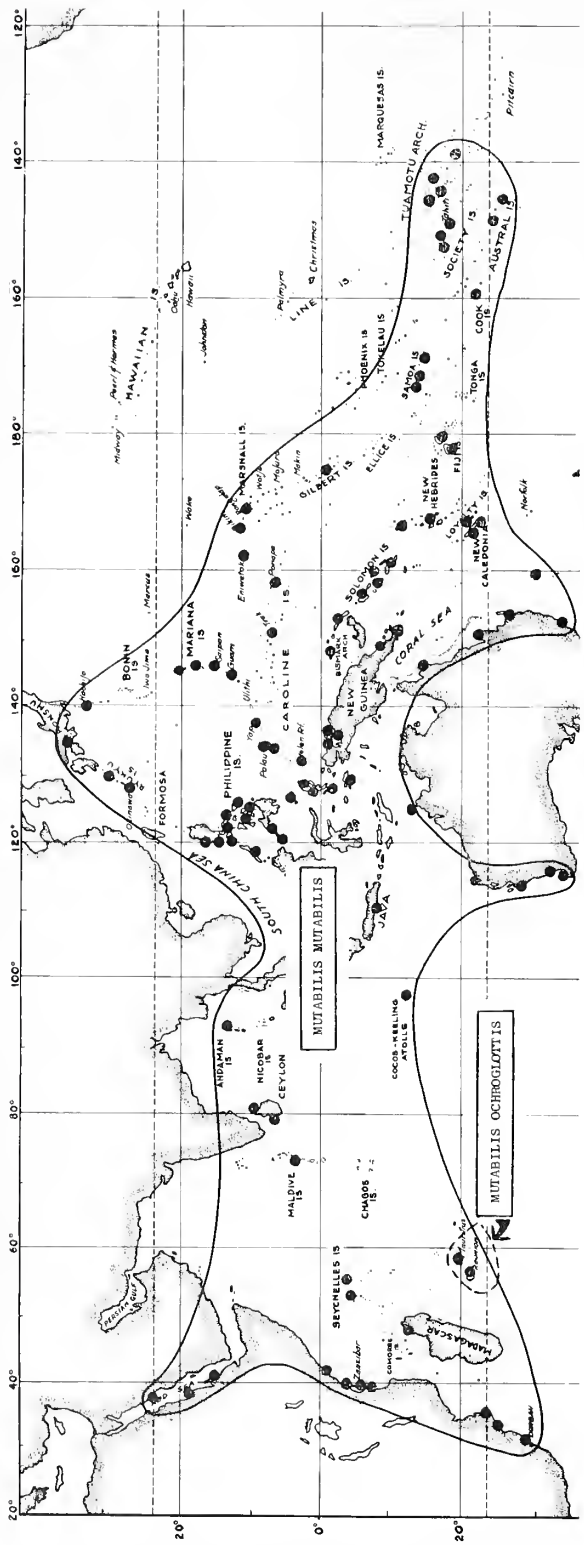


Plate 50. Geographical distribution of *Strombus mutabilis* Swainson, and its subspecies *ochroglottis* Abbott in Mauritius.

Types—The whereabouts of Swainson's type of *mutabilis* is unknown. His type locality was "East Indies" which we further restrict to Cebu City, Cebu Island, Philippines.

Nomenclature—Mörch seems to be the earliest author responsible for associating the name *flammeus* Link, 1807 with the species. We believe this to be entirely unjustified, since Link's name is based upon figure 799, of vol. 3, Conchylien-Cabinet. Martini's description, synonymy and figure are surely the young of *Strombus decorus* Röding of the Indian Ocean. Lamarck's well-known name, *floridus*, has been abandoned for many years because it was published a year later than Swainson's.

Selected records (see accompanying map, pl. 50; solid dots: specimens examined)—NATAL: Durban Bay (USNM). MOZAMBIQUE: Mozambique City (K. Grosch, ANSP). KENYA: Malindi (USNM). RED SEA: Aqaba (MCZ, ANSP); Jidda (USNM); Geb Zebara, Egypt (ANSP). ZANZIBAR: Paje; Chumbe Id.; Ras Nungwe; Fumba; Mangapwani; Chwaka; Mazizini (all NSF, 1957). MADAGAS: CAR: Nossi-bé (A. Chavane, ANSP). SEYCHELLES: Frigate Id.; Beau Vallon, Mahé Id. (both Yale Peabody Mus.) MALDIVES: Hulule Id., N. Male Atoll; Gan Id., Addu Atoll (both Yale Peabody Mus.) CEYLON: Hikkaduwa (G. and M. Kline, 1956, ANSP). COCOS-KEELING ATOLL: (USNM). JAPAN: Shirahama, Wakayama Pref., Honshu Id. (T. Habe, ANSP); Hachijo Id., 275 south of Tokyo (A. R. Cahn, ANSP). RYUKYUS: Oshima, Osumi (MCZ); Okinawa Id. (Mrs. A. A. Scott, ANSP). PHILIPPINES: common throughout the islands: Luzon, Cebu, Samar, Catanduanes, Bohol, Negros, Marinduque, Cuyo, Camiguin, Mindanao, Sulu Archipelago (ANSP, USNM and/or ANSP). INDONESIA: Tjilaoet Eureun, south Java (USNM); Amboina (MCZ). AUSTRALIA: Western Australia: Yallingup Brook; Abrolhos Id., off Geraldton (J. A. Grigg, USNM). Queensland: Green Id., near Cairns (MCZ); Low Isles (Tony Marsh, ANSP); Wilson Id., Capricorn Group (MCZ). New South Wales: The Entrance, and Woolgoolga (both W. E. Old, Jr., ANSP). LORD HOWE ISLAND: (Tomlin, MCZ). CAROLINES: Yap Id. (C. O. Kile, ANSP). MARSHALL ISLANDS: common at Bikini, Eniwetok, Rongelap, and Wotho (USNM). AUSTRAL ISLANDS: Rurutu Id. (Aubert de la Rue, ANSP). Tubuai Id. (H. J. Klein, ANSP). TUAMOTUS: Takume Atoll; Ngarumaoa Id., Raroia Atoll (both J. P. E. Morrison, USNM). [Record for Hawaii in Hawaiian Shell News, vol. 8, no. 7, p. 1, 1960 appears to be *maculatus* Sowerby.]

Fossil records—Fossil *mutabilis* have been reported in the literature from the Pleistocene of Hawaii (J. M. Ostergaard, 1928, p. 27), the Red Sea (R. B. Newton, 1900), Viti Levu Id., Fiji (Ladd, 1934), Somalia (Abrard, 1941, p. 63), Pliocene of New Hebrides (Abrard, 1946, p. 62), and Indonesia, but I have not seen specimens to verify these records. Abrard's 1942 (vol. 18, p. 63, pl. 6, fig. 38) record is good for the Pleistocene of Khor Anghar, French Somalia.

Strombus mutabilis *subspecies* ochroglottis *new subspecies*

(Pl. 20, figs. 9, 10)

Range—Known only from Mauritius, Indian Ocean.

Remarks and description—Colonies of this species from Mauritius are so uniformly different in their apertural coloration and in some sculptural details from colonies elsewhere in the Indo-Pacific that we

have allotted them to a subspecific rank. However, the differences are not always entirely consistent. The new subspecies *ochroglottis* differs in having the greater part of the columella pure white, while deep inside the aperture, both along the columella and the inner part of the body whorl, there is a chrome-yellow taint. In most specimens the columella is smooth along the central portion. Most, but not all, specimens are more coarsely noduled and with a higher spire than most typical *mutabilis*. Also, the weak, small splotches of green found below the suture in the last whorl are absent in Mauritius specimens.

Measurements (mm.)—

length	width	no. whorls	
28.0	16.0	7	(holotype, ANSP)
35.9	20.0	7+	(large, paratype)
27.0	15.0	7	(average, paratype)
16.1	9.0	6	(small, paratype)

Habitat—Unknown; presumably shallow-water or intertidal.

Synonymy—None; nor have we located any pre-Linnaean figures.

Types—The type locality is Mauritius, Indian Ocean. Holotype, ANSP no. 250187; paratypes, ANSP no. 185466; USNM no. 26652a and 465685; and in the MCZ.

Locality records—Known only from Mauritius. [A single Red Sea record in the USNM is probably an erroneous locality].

Strombus mutabilis *subspecies* ostergaardi Pilsbry, 1921

(Plate 51)

Range—Pleistocene of Oahu Island, Hawaii.

Remarks and description—This subspecies is known only from the Pleistocene. It resembles both *mutabilis* and *maculatus*, but I associate it with the former because of the nature of the sculpturing in the spire and on the columella. The shell is somewhat pear-shaped with well-rounded shoulders. The whorls in the spire bear 14 to 18 small, but distinct, shouldered axial riblets or elongate beads which disappear in the penultimate and last whorl. The columella bears about 40 small, but distinct, spiral lirae. The inside of the outer lip bears numerous fine spiral lirae. Stromboid notch moderately developed.

Ostergaard (1960, Hawaiian Shell News, vol. 8, no. 7, p. 3) reports live specimens from Kwajalein Atoll, Okinawa Id., and New Hebrides, but I have not seen these specimens. If verified, this may be considered a full species.

Plate 51. *Strombus mutabilis ostergaardi* Pilsbry. Pleistocene of Oahu Id., Hawaii. Left, holotype; right, paratype. Both × 2.

Measurements (mm.)—

length	width	no. whorls	
24.7	12.2	9	(holotype, Honolulu)
31.2	16.1	7+	(paratype, Honolulu)
21.6	11.9	8	(paratype, Kailua)

Synonymy—

1921 *Strombus ostergaardi* Pilsbry, Proc. Acad. Natural Sciences Philadelphia for 1920, vol. 72, p. 320, pl. 12, figs. 27, 28 (Honolulu Harbor); 1928, Ostergaard, Bull. 51, B. P. Bishop Mus., p. 25, pl. 1, fig. B.

Types—The type locality is "from the dredger dump on the Harbor side of Sand Island, Honolulu Harbor," Oahu Island, Hawaii. J. M. Ostergaard, collector. Holotype in ANSP no. 74549; paratypes in ANSP nos. 247760 and 74550 (Kailua).

Records—Pleistocene: Oahu Island: Honolulu Harbor (ANSP); Wailupe Quarry no. 2, vicinity of Nanakuli Station; Mokapu Point; Kailua Coast (all J. M. Ostergaard, 1928, p. 25).

Strombus maculatus Sowerby, 1842

(Pl. 20, figs. 13, 14)

Range—Hawaiian Chain, Micronesia and eastern Polynesia to Easter Island.

Remarks—This species is abundant throughout the Hawaiian Chain and the Marshall Islands, but becomes progressively uncommon eastward towards Easter Island. Despite intensive collecting and our examining many hundreds of *Strombus* lots from the Marianas, Palaus, Carolines, Solomons and Samoa, we have seen only four specimens from those areas—one live specimen each from Kayangel,

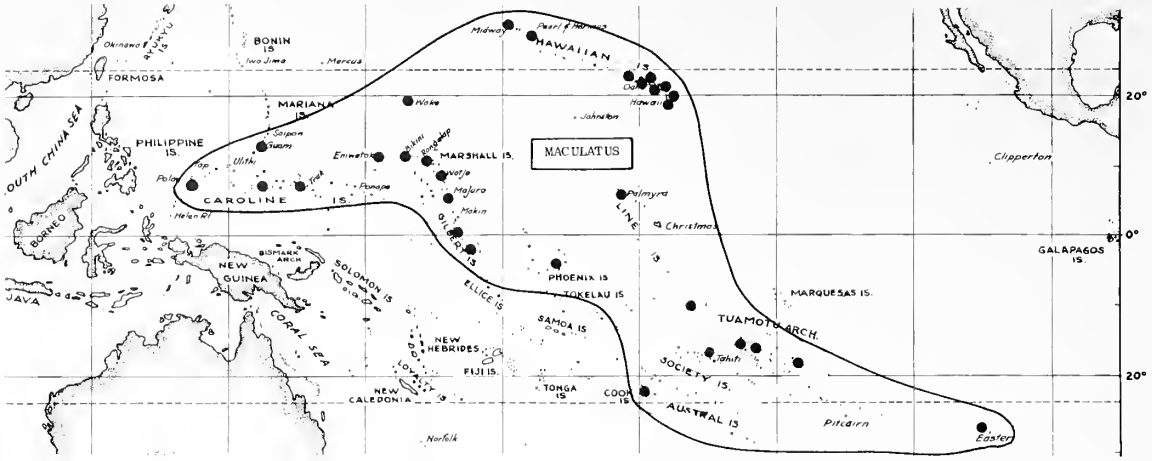


Plate 52. Geographical distribution of *Strombus maculatus* Sowerby. The species is rare in the Caroline and Mariana Islands.

Palaus (NSF station 395, 1955), Elato Atoll and Satawal, Carolines, and Guam, Marianas. I have no reason to doubt the authenticity of these four records which occur a little over 1000 miles to the leeward and west of the densely populated Marshalls. This species also occurs in emerged beaches of presumed Pleistocene age in the Hawaiians. It is possible that Polynesia is the rather recent center of origin of this species and that it is, at this moment, spreading westward. An equally speculative explanation is that *maculatus* once occupied a much larger part of the Indo-Pacific and that *mutabilis* is moving eastward and, in some unknown manner, replacing or "crowding out" *maculatus*. Disease or genetic weakness can also explain the paucity of individuals in certain parts of the range of a species.

Strombus maculatus is characterized by its pale color, relatively heavy shell, smoothish body whorl, rounded shoulder, the flattish whorls in its spire, its white aperture and by the smooth central portion of its glossy-white columella.

Easter Island specimens are very richly colored with axial flames of chestnut-brown over a light-brown and white spotted background. Subsequent collecting of fresh specimens from Easter and the eastern Tuamotu Islands may substantiate the presence of a subspecies of *maculatus*. This odd coloration is reminiscent of the S. *mutabilis* color form *zebriolatus* Adam and Leloup (and incidentally the color pattern of *Conus retifer* Menke). Dautzenberg and Bouge's variety *depauperatus* from Tongareva and the northwest Tuamotus is described as white or yellow with five transverse (axial) bands of small, very bright spots of reddish brown or russet. Should a subspecies exist in this area, this name might be applicable.

Ostergaard (1950, p. 95) describes the egg mass as an entangled, single gelatinous, yellowish tube, 0.25 mm. in diameter, containing a single row of ova, each 0.10 mm. in diameter. They were laid on March 16, 1922.

The smallest adult specimen of any *Strombus* I have seen was the 8-mm.-long *maculatus* collected by Dr. J. P. E. Morrison on the reef on the oceanic side of Enyu Island, Bikini Atoll, Marshall Islands.

Description—Adult shell 8 to 36 mm. (about ¼ to 1½ inches) in length, solid, moderately heavy, with smoothish, rounded, somewhat swollen shoulders, with a smooth central portion to the columella and with an enamel-white aperture. Color of outer shell whitish with weak maculations and fine nettings of light-yellow, light orange-brown or grayish brown. Rarely yellow with a white central band bearing irregular, small brownish spots. Very rarely with axial flames of reddish brown. Whorls 8 to 9. Nuclear whorls 2½, bulimoid, glassy, smooth, translucent whitish. First postnuclear whorl with 10 to 11 very fine but deep incised spiral lines becoming reduced to 8 in the next whorl and gradually disappearing on later whorls. The first two or three postnuclear whorls have a small subsutural cord, but this becomes weak in later whorls. The same whorls may have a spiral row of very small and weak peripheral nodules or beads (12 to 14 per whorl). Other whorls in spire are smoothish and slightly convex. Former varices up to 14 and large. Shoulder of body whorl rounded, smooth, and may bear 1 to 3 very weak swellings. Surface of body whorl with numerous microscopic spiral threads. Base of shell with about a dozen weak spiral cords, either flattish or slightly rounded. Columella enamel-white, smooth at the center and usually with 3 to 7 spiral lirae at the top and 1 to 10 dentations near the base.

Inside of body whorl with 20 to 40 fine, raised spiral lirae. Stromboid notch usually quite shallow and poorly developed. Periostracum moderately thick, smoothish and translucent yellow. Operculum stromboid, light-brown, relatively broad, thin, and with about 10 very small serrations. Soft parts not examined.

Measurements (mm.)—

length	width	no. whorls	
36.1	19.1	9	(large; Hilo, Hawaii)
26.8	14.0	9	(average; Oahu Id.)
12.9	6.3	8	(small; Marshalls)
8.0	4.2	8	(dwarf; Bikini Id.)

Synonymy—

1839 *Strombus maculatus* "Nuttall" Jay, Catalog of Shells, N. Y., ed. 3, p. 82. *Nude name.*

1842 *Strombus maculatus* "Nuttall" Sowerby, Thesaurus Conchyliorum, London, vol. 1, Strombus, p. 30, pl. 7, fig. 53 (Sandwich Islands); 1850, Reeve, Conch. Icon., vol. 6, Strombus, sp. and fig. 23; 1957, Demond, Pacific Science, vol. 11, p. 296.

1933 *Strombus floridus* var. *depauperata* Dautzenberg and Bouge, Jour. de Conchyl., vol. 77, p. 296 (Makatea [here selected as the type locality], Apataki and Motutunga, Tuamotu Ids.).

1950 *Strombus maculatus* Nuttall, Ostergaard, Pacific Science, vol. 4, p. 95, fig. 17 (egg mass).

Types—Sowerby's type of *maculatus* is presumably in the British Museum of Natural History in London. We restrict the original type locality of "Sandwich Islands" to Kawailoa, Oahu Id., Hawaii.

Nomenclature—Although sometimes credited to Nuttall or Jay, this species was first described by Sowerby in 1842.

Records (see accompanying map, pl. 52)—MARIANAS: Guam Id., 1 live specimen (F. J. Flatt, 1948, USNM). PALAUS: north side of Ngariungs Id., Kayangel (NSF station 395, ANSP, 1 live specimen. CAROLINES: Elato Atoll, near Lamotrek; Satawal Atoll (both USNM, but only 1 specimen). WAKE ATOLL: southeast end of Wake Island (du Pont-Academy Exped., 1958, ANSP). MARSHALLS: abundant on reefs on oceanic side throughout Eniwetok, Bikini, Rongelap, Uterik, Rongerik, Taka, Ailuk, Kwajalein and Lae Atolls (all USNM). GILBERTS: Apamama (USNM). PHOENIX IDS: Canton Id.; Hull Id. (both USNM). HAWAIIAN CHAIN: Midway (Phil Spieer, ANSP). Tern Id., French Frigate Shoals (ANSP). Kauai Id. (A. Garrett, MCZ). Maui Id.: Honokowai (USNM). Oahu Id.: Kahaluu; Honolulu Harbor; Kawailoa; Waikiki; Waianae (all H. A. Pilsbry, ANSP). Hawaii Id.: Hilo (A. J. Ostheimer, 3rd, ANSP); Napoopoo (ANSP). LINE ISLANDS: Palmyra Id. (MCZ); Flint Id. (ANSP). COOK IDS.: Aitutake (J. P. E. Morrison, USNM); Rarotonga Id. (USNM). SOCIETY IDS.: outer reef, Moorea Id. (H. A. Rehder, USNM). TUAMOTUS: Reao (Clermont-Tonnere) Id. (Titian R. Peale, 1824, ANSP); Takaroa Id. (A. de la Rue, ANSP); outer reef, Raroia Atoll; outer reef flats, Takume Atoll (both J. P. E. Morrison, USNM); Fakarava Id. (USNM). EASTER ISLAND: (ANSP and USNM). [A. Garrett's record of "Fiji" in ANSP collection open to question.]

Fossil records—HAWAIIAN CHAIN: Kauaiu Stream, Lanai Id.; Lanikai, Oahu Id.; Mokapu Peninsula, Oahu Id. (all USNM, all emerged beach of presumed Pleistocene age). LINE ISLAND: Flint Id. (1 post-Pleistocene fossil, ANSP).

Fossil Relatives of the *urceus-mutabilis-labiatus* Group

It would be unsatisfactory to make any decisions concerning many of the fossil forms in this group without examining good series of specimens which, however, are not available to us at this time. A few are sufficiently illustrated and described to assign them to a position close to either *Strombus urceus*, *mutabilis*, *labiatus*, *microurceus*, *maculatus* or *erythrinus*. The records quoted for *S. labiatus* Röding (as *plicatus* Lamarck) by Altena (1942, vol. 12, p. 55) from the Tertiary of the Indo-Pacific are undoubtedly based upon a wide mixture of these species. *S. gendinganensis* Martin is treated as a subspecies under *labiatus* Röding.

Plate 53. *Strombus* (*Canarium*) *unifasciatus* Martin. Mangkalihat, East Borneo, Indonesia. Lower Miocene. (from Beets, 1941, pl. 3, figs. 119-122). Natural size.

Strombus unifasciatus Martin, 1884

Range—Lower and Upper Miocene of Java, Indonesia.

Remarks—This species is very close to both *mutabilis* Swainson and *maculatus* Sowerby. Its striated columella suggests a closer affinity to the former. Martin's figures 436 and 436a are more like smooth *erythrinus*. The species was first founded upon an immature specimen. The figures given by Beets (1941, p. 65, pl. 3, figs. 119-122 and called *unifasciatus* Martin from the Lower Miocene of East Borneo appear to represent two species, one more similar to the *mutabilis* group, the other (figs. 121, 122) more like *labiatus*.

Synonymy—

1884 *Strombus (Canarium?) unifasciatus* K. Martin, Samml. geol. Reichs-Mus. Leiden, vol. 3, p. 143, pl. 8, fig. 142;*ibid.*, 1899, n. Folge, vol. 1, pt. 1, p. 187, pl. 30, figs. 434, 434a, 435 (Tjilintung, Java); 1884, K. Martin, Jaarbock Mijnwegen in Nederland. Oost-Indië, Amsterdam, vol. 13, p. 176, pl. 8, fig. 142.

Strombus spolongensis Martin, 1916

Range—Lower Miocene (West-Progo beds), Java, Indonesia.

Remarks—This is closely related to *Strombus uni-*

fasciatus Martin, but without examining specimens I would hesitate to suggest its closest affinities, except to say that it resembles the Recent *maculatus-mutabilis-microurceus* group.

Synonymy—

1916 *Strombus (Canarium) spolongensis* K. Martin, Samml. *geol. Reichs-Mus.* Leiden, n. Folge, vol. 2, pt. 6, p. 245, pl. 2, fig. 46 (Gunung Spolong, Java, Upper Miocene).

Strombus fusiformis Sowerby, 1842

(Pl. 20, fig. 30)

Range—Red Sea and the western Indian Ocean.

Remarks—Although rarely seen in collections, this solid, fusiform *Strombus* is locally common in many parts of its range. It is readily recognized by its rather heavy, fusiform shell, by its relatively long posterior siphonal canal, and by the two "humps" on the shoulder of the last whorl. It differs from the similarly shaped *terebellatus* in having a thick body wall and strong spiral lirae within the aperature. Although the shell has a superficial resemblance to the *vittatus-campbelli* group, the radula indicates that it is probably not related.

Habitat—Occurs on sandy coral bottoms from 1 to 34 fathoms. It is rarely found in very shallow water, but has been occasionally washed ashore. The intestine contains white coral sand and foraminifera.

Description—Shell 26 to 45 mm. (1 to 1¾ inches) in length, solid, heavy, fusiform, smoothish and with yellow-brown maculations. Whorls 9 to 10. Angle of spire 40°. Nuclear whorls 3½, bulimoid, rapidly increasing in size, glossy, smooth, transparent and slightly rounded. Postnuclear whorls smooth, except for a single small cord below the suture which may persist to the last whorl. The spire has about 14 irregularly-spaced, low, rounded, small, whitish, former varices. Shoulder of body whorl with 2 (rarely 3) rounded, low knobs, the anterior one being smaller. Base of shell with about a dozen small, squarish, spiral cords which may also be present in the apertural varix. Aperture elongate, the posterior siphonal canal narrow, and extending straight up to or a little beyond the first suture. Inside of outer lip with 18 to 20 small but strong spiral lirae. Columella well-defined, straight, glossy, white to brownish pink, and with weak spiral lirae which, however, may be obsolete in the center portion. Stromboid notch usually poorly developed. Color of shell whitish cream, the early postnuclear whorls sometimes rose, the remainder of the shell mottled and speckled with light to dark yellowish brown. There may be 4 or 5 very narrow, spiral, brown-dotted bands of white on the last few whorls. Columella and aperture white, rarely flushed with weak brownish pink. Periostracum very thin, smooth and translucent tan. Operculum ¼ to ⅓ the length of the shell, stromboid, light-brown, one edge with 9 sharp, small dentitions, the other edge straight, and with a strong central rib on the attachment side.

Radular ribbon very delicate, 3 mm. long (from 33 mm. Zanzibar female shell), and with 40 rows of teeth. Formula: 2-1-2; 1-4 (plus peg) or rarely 1-3 (plus peg); 6; 8. Preserved animal cream with dark-green cobwebs and specklings on the foot, proboscis and body. Eye peduncles and tentacles yellow-chrome with white spots. Edge of mantle with a row of yellow squares. Posterior mantle filament short (3 mm.). Verge short, 10 mm. in length, simple with a rather large lamellated pad at the distal end.

Measurements (mm.)—

length	width	no. whorls	
44.5	18.1	9	(large; Zanzibar)
36.5	15.0	9	(average; Zanzibar)
26.5	12.0	9	(small; Madagascar)

Synonymy—

1842 *Strombus fusiformis* Sowerby, Thesaurus Conchyliorum, London, vol. 1, p. 31, pl. 9, figs. 91, 92 (no locality); 1843, Kiener, Coquilles Vivantes, Paris, vol. 4, Strombus, pl. 28, fig. 2; 1850, Reeve, Conch. Icon., vol. 6, Strombus, pl. 5, sp. 7.

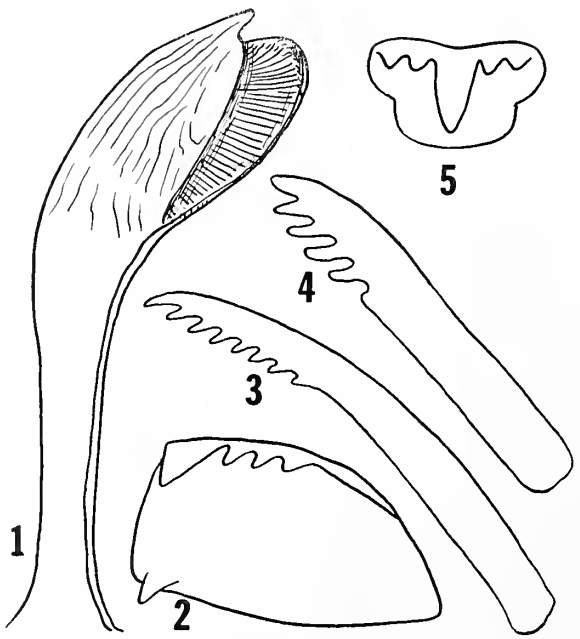


Plate 54. *Strombus fusiformis* Sowerby, Zanzibar. Fig. 1, verge. 2, lateral tooth. 3, outer marginal. 4, inner marginal. 5, central.

Types—The holotype is in the British Museum of Natural History in London. We hereby designate Chumbi Island, west Zanzibar, as the type locality.

Records (see accompanying map, pl. 55)—RED SEA: (ANSP); Gulf of Aqaba; Jubal Id. (Issel and Canefri, 1876, p. 354). SAUDI ARABIA: Shaikh Shuaib Id., Persian Gulf, 7-10 fms. (D. Thaanum Coll'n no. 4899); near Muscat in 15 fms. (Melville and Standen, 1901, p. 380); Aden (E. A. Smith, 1891, p. 419); Berbera, Gulf of Aden (USNM). ZANZIBAR: south side of Pwakuu Id., 11-18 fms. Mnazi Moja, intertidal; 1 mi. W.N.W. of Ras. Mbweni, 7 fms.; Chumbi Id., intertidal; 3 mi. w. of Ras Chukwani, 22 fms.; 2 mi. w. of Chango Id., 15 fms.; ½ mi. w. of Ukombi Id., 6-9 fms. (all NSF, 1957). MOZAMBIQUE: Mozambique City (ANSP). MADAGASCAR: Pointe d'Ankify (Dautzenberg, 1929, p. 467); Nossi-bé (A. Chavane, ANSP). INDIAN OCEAN IDS.: Amirantes, "Sealark" Stations F2, F7, F8, 31-34 fms. (Melvill, 1909, p. 93). AUSTRALIA: Reeve's 1850 record for this continent is probably erroneous.

Fossil records—EGYPT: Pleistocene: beach, 50 ft. alt., Gemsah (R. B. Newton, 1900, p. 508).

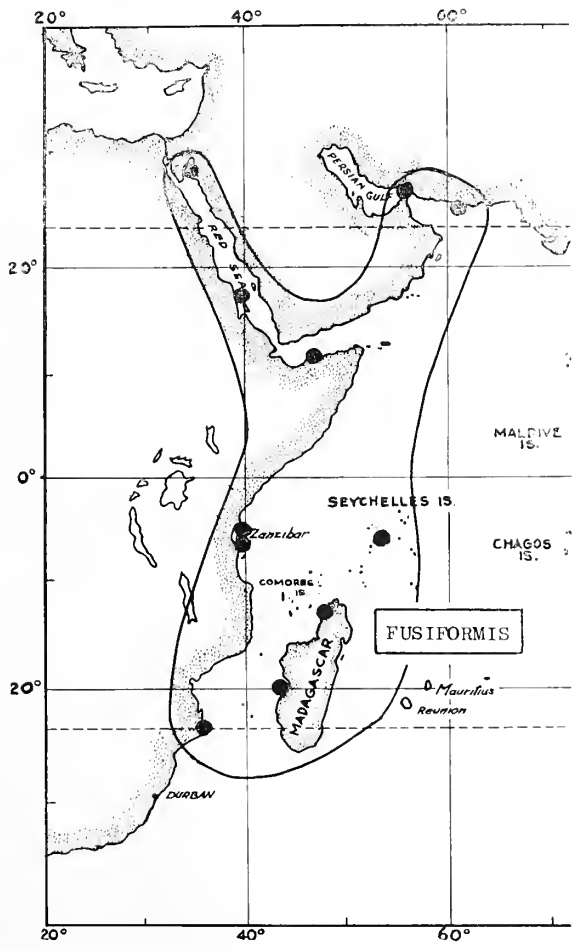


Plate 55. Geographieal distribution of *Strombus fusiformis* Sowerby.

Strombus erythrinus *subspecies* erythrinus Dillwyn, 1817

(Pl. 20, figs. 1-5)

Range—For the species as a whole: Red Sea and East Africa to south Japan and to Hawaii and Ellice Islands. The subspecies *rugosus* Sowerby replaces the typical race in the Fiji and Ellice Islands.

Remarks—This is a wide-spread species of coral waters and is usually uncommon, except in New Caledonia where it is common. It has had a confused synonymy and is not always correctly identified in collections. It is somewhat similar to S. *labiatus* but is immediately distinguished by the purple-brown aperture and a columella which is white or yellowish and smooth on the outer half and purple-brown with weak yellowish teeth on the inner half. The apertural varix is usually crossed by numerous, small, rough, spiral cords.

The subspecies *rugosus* is limited to Fiji and the Ellice Islands, but it may occur further eastward into Polynesia. It differs from *erythrinus* in having a shorter spire, in having 3 or 4 very large knobs on the shoulder of the dorsum, a second spiral row of much smaller knobs below these, and in having an entirely white columella and aperture. Intergrades occur in the Gilbert Islands.

We cannot see any justification in considering *ruppelli* Reeve as a subspecies. We have Red Sea specimens before us that are inseparable from Pacific Ocean specimens.

Dwarf and less colorful specimens have been dredged in the Philippines, Palau Islands and Hawaii. In the Palaus, the dwarf form may have a lavender or whitish nucleus and yellowish patches on the body whorl. In New Caledonia, the shells are large and darkly banded. This species is evidently in a state of flux. Until large series are obtained from many localities, it will be imperfectly understood.

Habitat—This species has been dredged from 2 to 30 fathoms. In some areas, such as New Caledonia, it occurs in silty sand and algae areas just below low-water mark. In the Central Pacific it occurs either in the lagoons or outside the atolls in sparse numbers from 10 to 30 fathoms, and has been recorded from outer reefs.

Description—(of typical *erythrinus*). Shell 12 to 48 (usually about 32) mm. (½ to ¾ inches) in length, solid, elongate, somewhat rugose, with a purplish brown aperture and inner columella, and its exterior either whitish or marbled and banded with various shades of brown. Nuclear whorls 3,

the first one very small, all smooth, translucent, usually whitish, sometimes tan or brown and rarely lavender. Postnuclear whorls moderately rounded, usually with 5 to 10 incised spiral lines which may become small, rough spiral cords in later whorls; rarely smooth. After the first two postnuclear whorls, axial riblets become dominant (12 to 17 per whorl) and may form small rounded knobs at the slightly angular mid-sutural periphery. Spire with 4 to 10 whitish, rounded, axial, former varices. Last whorl with numerous, fine, crowded, rough spiral cords or threads. There is usually a weak, rounded, weakly beaded subsutural thread present. Shoulder of last whorl rounded and bearing about 9 to 11 small, axially lengthened knobs, those on the parietal wall being smallest and longest, followed by 5 or 6 rather large ones, and the two nearest the apertural varix being again small. Apertural varix swollen, rust-brown, banded or whitish, and bearing numerous spiral threads. Below the row of shoulder knobs and above the base of the shell, there may be a very weak suggestion of a secondary spiral row. Color of shell very variable. Usually cream with light or dark suffusions of brown; sometimes whitish; sometimes with two narrow chocolate bands on the middle of the body whorl. Columella with about 24 indistinct spiral lirae or teeth which are usually very weak or absent in the middle portion. Base of columella usually brown. Inner half of columella brown or purple-brown and may have yellow spiral streaks. Outer half of columella glossy, raised, narrow, whitish or yellowish. Deep inside the aperture, the body wall is whitish to purple-brown, the latter becoming darker towards the edge of the outer lip and into the stromboid notch. There may be a white band along the inner edge of the outer lip. 20-28 fine spiral, yellowish brown, spiral threads are on the inside of the body whorl. Periostracum moderately thin, opaque, light-tan and moderately smooth. Operculum stromboid, light-brown, not arching, about ⅓ the length of the shell, with a weak central rib on the attachment side, and with 7 to 9 well-developed, sharp dentitions on one edge.

Radular ribbon delicate, similar to that of *labiatus*, 3 mm. in length, amber-brown and with about 34 rows. Formula in New Caledonia specimens: 2-1-2 (rarely 3-1-3); 1-3 (plus peg); 5; 6. Preserved animal whitish with orange cobwebs and maculations on foot and body. Eye with one orange ring. Mantle edge with a line of tiny orange dots. Tentacles short and arising near the end of the eye peduncle. Verge 20 mm. in length in male shell 29 mm., long, slender, simple.

Measurements (mm.)—

length	width	no. whorls	
12.0	5.5	7.0	(dwarf; Palau Ids.)
23.1	10.5	8.0	(small; Palau Ids.)
29.3	13.9	9.0	(average; Gilbert Ids.)
42.8	17.3	10.0	(large; New Caledonia)
48.5	19.5	10.0	(giant; New Caledonia)

Synonymy—

1795 *Strombus erythrinus* Chemnitz, Conchyl.-Cab., vol. 11, pp. 146-147, figs. 1874-1875 (Red Sea). Non-binomial.

1817 *Strombus erythrinus* "Chemnitz" Dillwyn, Descriptive Cat. Recent Shells, London, vol. 2, p. 673; 1818, Wood, Index Testac., p. 118; 1844, Duclos, Illustr. Conchyl., vol. 4, Strombus, pl. 5, figs. 16-19 [*erytrhinus*, errore typ.].

1842 *Strombus elegans* Sowerby, Thesaurus Conchyl., vol. 1, p. 30, pl. 7, figs. 43, 48 (no locality).

1844 *Strombus radians* Duclos, in Chenu's Illustr. Conchyl., vol. 4, Strombus, p. 5, pl. 4, figs. 15, 16 (les mers du Japon).

1850 *Strombus ruppelli* Reeve, Conch. Iconica, vol. 6, Strombus, pl. 8, figs. 13a, b (Red Sea).

1888 *Strombidea erythrinus* Dill., Jousseaume, Mém. Soc. Zool. France pour 1888, vol. 1, p. 174, no. 26.

1900 *Canarium dentatum* L., var. *erythrynum* Chemnitz, B. Newton, Geol. Magazine, London, new series, decade 4, vol. 7, pp. 508-509.

1912 *Rostellaria rubicunda* Perry, Matthews and Iredale, Victorian Naturalist, vol. 29, p. 10. Non Perry, 1810.

1925 *Strombus (Canarium) plicatus* Lamarck, Oostingh, Mededeel. Landbouw. Wageningen, vol. 29, pt. 1, pp. 59-69 (in part).

?1932 *Strombus rugosus* Sow., Risbec, Bull. Soc. Zool. France, vol. 57, p. 359, figs. (egg mass).

?1946 *Strombus (Canarium) haemastoma* Sowerby, Abrard, Ann. de Paléontologie, Paris, vol. 32, p. 62, pl. 4, fig. 29 (Pliocene, Malakula, New Hebrides).

1953 *Strombus rugosus* Sowerby, Dietrich and Morris, Nautilus, vol. 67, no. 1, pl. 4, fig. 24 (Kwajalein). Non Sowerby.

Types—Dillwyn's *erythrinus* is based upon figures 1874 and 1875, vol. 11 of the Conchylien-Cabinet. The specimen is from the Red Sea which we designate as the type locality. Sowerby's types of *elegans* are in the British Museum in London. One small specimen with a lavender nucleus and smoother surface resembles our specimens from the Palaus. A large cotype, more rugose and less colorful, resembles our specimens from New Caledonia.

Nomenclature—This species has appeared in the literature most frequently as *elegans* Sowerby which, however, is ante-dated by Dillwyn's validation of the name *erythrinus* in 1817. Matthews and Iredale in 1912 suggested that *Rostellaria rubicunda* Perry 1810 (Arcana, London, vol. 1, pl. 2, Conchology, fig. 2 from Amboyna) was this species, but the extremely poor figure probably represents some sort of buccinid.

Records (see accompanying map, pl. 56)—ZANZIBAR: off Pwakuu Id., 11-18 fms., sand, coral and sponge (NSF, 1957). SOMALIA: Djibouti (ANSP). RED SEA: Port

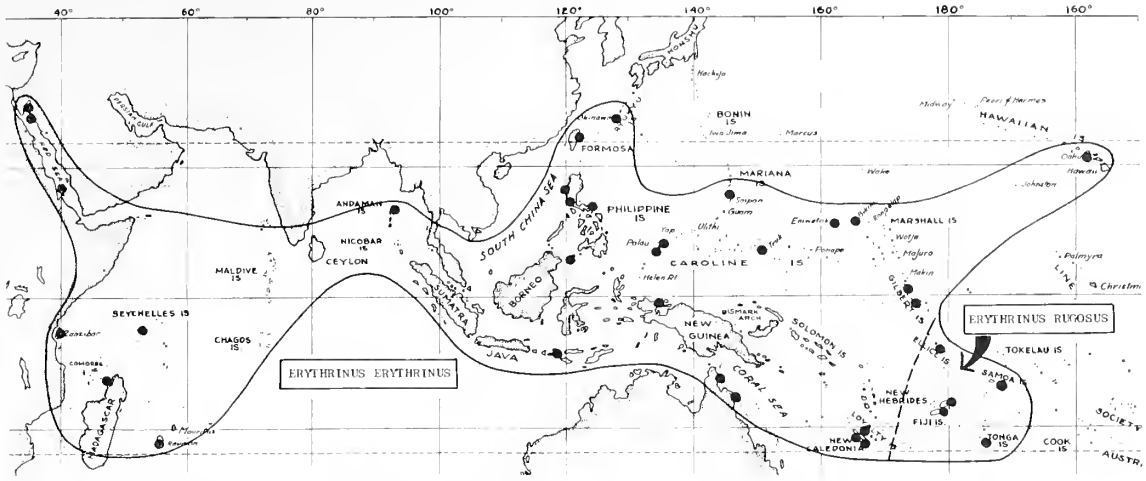


Plate 56. Geographical distribution of *Strombus erythrinus erythrinus* Dillwyn and its eastern subspecies, *rugosus* Sowerby.

Sudan (ANSP, MCZ). Aqaba, Israel (MCZ); Eilat, Gulf of Aqaba (A. Hadar, USNM). MADAGASCAR: Nossi-Fali near Nossi-bé (Oostingh, 1925, p. 67). MAURITIUS: Barkley Id. (ANSP). SEYCHELLES: (Oostingh, 1925, p. 67). ANDAMANS: Port Blair (W. N. Carpenter, USNM). RYUKYU ISLANDS: (Kuroda in MSS). TAIWAN: Kurun (Kuroda, 1941, p. 97). PHILIPPINES: off Tawi Tawi, 18 fms.; off Tinakta Id., Sulu Arch., 10 fms. (both USNM). Sisiman Cove, Bataan, 8 fms., and off Corregidor Id.; Tabaco, Luzon Id., 6-10 fms.; (all du Pont-Academy Exped., 1958, ANSP). Calapan, Mindoro Id. (Yale Peabody Mus.). INDONESIA: Rotti Id. (Schepman, 1909, Siboga, p. 151, no. 16). AUSTRALIA: Queensland: Hinchinbrook Id. (H. A. Pilsbry, ANSP); Green Id., near Cairns (MCZ). DUTCH NEW GUINEA: off Roemwakon, Aoeri Ids., Geelvink Bay, 20-25 fms. (NSF, 1956). NEW CALEDONIA: Noumea Harbor, 1-2 fms.; Magenta, near Noumea, 4 ft.; Plage de Poe, Bourail, 1 fm.; Baie de l'Orphelinat, near Noumea; Baie de Citron, 1 fm. (all G. and M. Kline, 1958, NSF). Charron Id. (ANSP). MARIANAS: Saipan Id. (USNM). PALAU ISLANDS: Kossol Passage, 15-20 fms.; Babelthuap Id.; Yoo Passage, Eil Malk (all NSF, 1955). CAROLINES: Mog Mog, Ulithi; lagoon, Ifaluk (both USNM). MARSHALLS: Bikini lagoon, 25-30 fms.; Eniwetok; Rongerik, outer reefs; Kwajelein; 2 mi. west of Rongelap Atoll, 20 fms. (all USNM). Ebon (MCZ). GILBERTS: Apaiang (A. Garrett, 1859, MCZ); Apamama (USNM). HAWAIIAN CHAIN: off Pokoi Bay, Oahu Id., 20 fms., coral and rubble bottom (C. M. Burgess, coll'n.).

Fossil records—EGYPT: Pleistocene: beach, 20 ft. alt., Gharib Lighthouse; beach, 50 ft. alt., Gemsah (both R. B. Newton, 1900, p. 508). FRENCH SOMALIA: Pleistocene: d'Obock and d'Hacoulta (Abrard, 1942, vol. 18, p. 63, pl. 6, fig. 37). Abrard's (1946, p. 62) record of *haemastoma* Sowerby from the Pliocene of New Hebrides may be a small specimen of this species.

Strombus erythrinus *subspecies* rugosus Sowerby, 1825

(Pl. 20, figs. 11, 12)

Range—Known only from Fiji, the Ellice, Samoan and Tonga Islands.

Remarks and description—We have seen specimens only from Fiji and "Polynesia." Hedley reported it to be abundant alive in the Funafuti lagoon in the Ellice Islands, and if Schmeltz's identifications are correct, it occurs in Samoa and Tonga. This subspecies differs from the typical race in having a stouter shell, with a lower spire, in being proportionally broader, with an entirely white columella and aperture, in having its 4 or 5 shoulder knobs on the body whorl much larger and more pointed, and in having a fairly well-pronounced second spiral row of beads around the middle of the last whorl. The outer lip is more squarely shouldered at the top. Color of shell whitish to mottled in brown, rarely banded. The spiral threads on the outer shell are well-developed. Columella usually smooth at the center.

The locality of "Korea" given by Adams and Reeve in 1848 is probably erroneous.

Measurements (mm.)—

length	width	no. whorls	
23.5	12.5	9	(small; Polynesia)
30.5	15.0	9	(average; Fiji)
43.0	20.1	7+	(large; Fiji)

Synonymy—

1825 *Strombus rugosus* Sowerby, Catalogue Shells Tankerville, London, appendix, p. 20, no. 1791 (East Indies); 1842, Thesaurus Conchyl., vol. 1, p. 30, pl. 7, figs. 58, 60.

1828 *Strombus jugosus* Wood, Index Testaceol., Suppl., London, p. 13, pl. 4, fig. 4 (Indian Ocean).

1848 *Strombus corrugatus* A. Adams and Reeve, Zoology Voyage H.M.S. *Samarang*, London, Mollusca, p. 35, pl. 10, fig. 19 (Korea).

1899 *Strombus dentatus*, var. *rugosus* Sowerby, Hedley, Mem. Australian Mus., vol. 3, pt. 7, p. 428.

Habitat—Unknown, except that Hedley reports it from the lagoon at Funafuti.

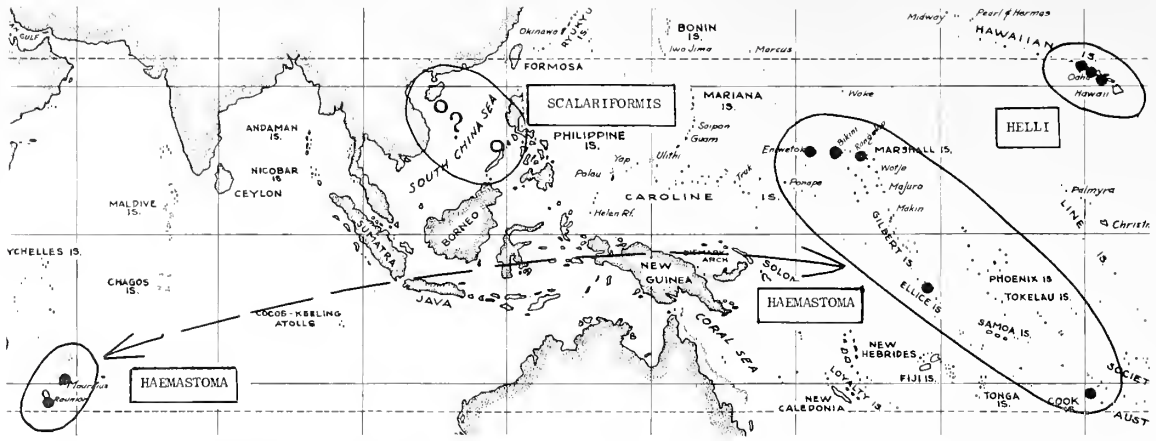


Plate 57. Geographical distribution of *Strombus haemastoma* Sowerby and *Strombus helli* Kiener. *Strombus scalariformis* Duclos is known only from two literature records.

Types—The type of *rugosus* may be in the British Museum of Natural History in London, or sold at auction before reaching there. The locality of "East Indies" is probably erroneous.

Records (see map, pl. 56)—ELLICE ISLANDS: Funafuti (Hedley, 1899, p. 428). FIJI ISLANDS: (A. Garrett, MCZ, ANSP); Yasawa Islands, off Viti Levu (Major Raven-Hart, USNM). SAMOA and TONGA: (Schmeltz, 1874, Mus Godeffroy, cat. 5, p. 142). [Philippine records by Cuming are probably erroneous.]

Fossil records—None reported.

Strombus haemastoma Sowerby, 1842

(Pl. 20, figs. 6)

Range—Western Indian Ocean and Micronesia.

Remarks—This is a rather rare species, which may account for the very incomplete record of its distribution. There are six records from several purportedly reliable sources from the Indian Ocean in the collections of the ANSP, MCZ and USNM. The Marshall and Palau Island records are undisputed. S. *haemastoma* is very similar to *helli*, but differs in being more slender, in having its spire equal or greater than the length of the aperture, in having a columella which is less swollen, narrower, and with only 15 to 18 (instead of about 24) weaker spiral lirae, in having a brownish purple aperture (instead of violet), and (in Marshall Island specimens) in having a purplish apex. It is possible that S. *scalariformis* Duclos, 1833, is a malformed specimen of this species.

Habitat—Unknown. It has been collected dead on reefs and beaches.

Description—Shell 16 to 21 mm. (½ to ¾ inches) in length, solid, ovate-elongate, rugose, whitish with yellow maculations, and brownish to reddish violet around the aperture. Whorls 7 to 8. Nuclear whorls 3, smooth, glassy and translucent violet to whitish. Postnuclear whorls with 8 to 11 fine spiral threads which later ride over the numerous, small axial riblets (about 20 to 25 per whorl). Spire with 12 to 14 small, axial, swollen, rounded, whitish former varices, the last 3 or 4 occurring in the penultimate whorl. Subsutural thread weak or absent. Spiral threads on last whorl strong and 24 to 26 in number. Shoulder of whorls slightly angular. Last third of body whorl bearing 4 or 5 prominent, axially pinched knobs at the shoulder below which is a second spiral row of 4 to 6 much smaller knobs. Parietal wall with 8 to 10 neat axial ribs. Varix behind outer lip strongly swollen and with spiral threads. Columella relatively narrow, thickened red- to pink-brown, slightly concave and with 14 to 16 small spiral, lighter-colored lirae which are weakest at the center of the columella. Depths of aperture smooth and white. Inside of outer lip and siphonal canal with 14 to 16 strong, short spiral lirae and a band of purplish brown which is strongest on the shallow stromboid notch. Posterior anal canal is a short V-shaped channel. Periostracum, operculum and soft parts unknown.

Measurements (mm.)—

length	width	no. whorls	
21.0	11.0	8	(large; Wotho Atoll)
16.0	8.0	7	(small; Mauritius)

Synonymy—

1842 *Strombus haemastoma* Sowerby, Thesaurus Conchyliorum, London, vol. 1, Strombus, p. 31, no. 26, pl. 7, fig. 51 (no locality); 1850, Reeve, Conch. Icon., vol. 6, Strombus, pl. 5, figs. 5a, b; 1844, Duclos, in Chenu's Illustr. Conchyl., vol. 4, pl. 4, figs. 17, 18.

Types—The type is presumably in the British Museum of Natural History, London. Until examined and compared with better specimens from both the Indian and Pacific Oceans, it is best that a type locality not be designated.

Records (see map, pl. 57)—INDIAN OCEAN ISLANDS: Mauritius (ANSP, purchased from Sowerby post 1850; USNM, ex N. Pike and Quadras Collection; MCZ from C.

Decort). Réunion (Deshayes, 1863, p. 114, no. 378). AUSTRALIA: Bird Island (Queensland?) (USNM). ELLICE ISLANDS: Ujae Atoll; Wotho Atoll; Namu Id., Bikini Atoll, 3 mi. west of Jieroru Id., Eniwetok Atoll (all dead, all USNM). COOK ISLANDS: Rarotonga, rare alive (A. Garrett, MCZ).

Fossil records—Abrard's (1946, p. 62) record from the Pliocene of New Hebrides is probably *erythrinus* Dillwyn and not this species.

Strombus scalariformis Duclos, 1833

(Pl. 58, figs. 1, 2)

Range—"China Seas" and Philippines.

Remarks—To our knowledge, this shell has been collected three times, and, on the basis of its characters and the not uncommon occurrence of "scalariform" monstrosities in the family Strombidae, I am inclined to suspect that this species may be a form of *haemastoma*. I have not seen specimens, and only additional specimens would solve the mystery.

Habitat—Unknown.

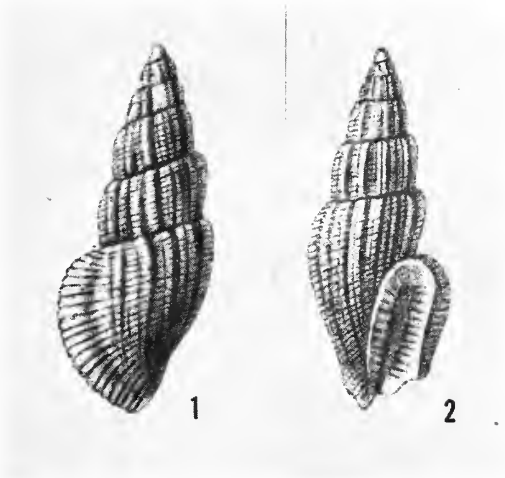


Plate 58. *Strombus scalariformis* Duclos. China Seas. Length 22 mm. (from Kiener, 1843, pl. 14, fig. 3).

Description—(from the literature). Shell 22 mm. in length, solid, somewhat spindle-shaped, rugose, with a high spire, channeled suture and reddish violet aperture. Whorls 7 to 8. Nuclear whorls unknown. Spire tinged with violet. Possibly 8 to 12 whitish, swollen former varices on the spire. Suture well-indented and channeled. Shoulder of apical whorls angular. Spiral threads on body whorl about 24. Axial ribs prominent, possibly 14 on the last whorl. Color of shell yellowish. Columella narrow, raised, bearing fine spiral lirae and reddish violet. Inside of outer lip with stronger, fewer lirae. Stromboid notch well developed. Soft parts unknown.

Synonymy—

1833 *Strombus sealariformis* Duclos, Magasin de Zoologie, Paris, vol. 3, class 5, pl. 28 (les mers de la Chine); 1843, Kiener, Coquilles Vivantes, vol. 4, pl. 14, fig. 3; 1844, Duclos, in Chenu's Illustr. Conchyl., vol. 4, p. 2, pl. 4, figs. 9, 10.

Types—The holotype was in Duclos' collection and is probably in the Muséum d'Histoire naturelle de Genève. Type locality "seas of China."

Records—PHILIPPINES: Cebu Id.; Samar Id. (Elera, 1896, p. 253) [unconfirmed]. The collections at the Santo Thomas University in Manila were destroyed in 1945.

Fossil records—None reported.

Strombus helli Kiener, 1843

(Pl. 20, figs. 7, 8)

Range—Limited to the Hawaiian Chain.

Remarks—This is one of the most attractive and distinctive *Strombus* of the Indo-Pacific. It is rare in most collections but is evidently not uncommon from 10 to 30 fathoms off the Hawaiian Islands. It is the only endemic full species in Hawaii, but is closely related to the rare S. *haemastoma* Sowerby from elsewhere in the Indian and Pacific Oceans. S. *helli* has been present in Hawaii since the Pleistocene. It is characterized by its small size (one inch or less), rotund shape, axially plicate and cancellate sculpture, its swollen, strongly lirate columella and its bright lavender or violet aperture. Adults are quite variable in size.

Specimens in the Museum of Comparative Zoölogy from Rarotonga labelled "*helli*" by Andrew Garrett are *haemastoma*.

Habitat—This species has been dredged alive on coral sand and coral rubble bottom from 6 to 66 fathoms, and in dead condition as deep as 240 fathoms.

Description—Shell 13.5 to 27.0 mm. (½ to 1 inch) in length, solid, rotund, ovate, cancellate and with a rugose, violet or lavender aperture. Whorls 9 to 10. Nuclear whorls 4, bulimoid, rounded, glossy, translucent white. First postnuclear whorl weakly malleated, the remainder bearing small, crowded axial riblets (about 25 to 30 per whorl) between which is a series of weak spiral threads. These become small cords in later whorls and number 25 to 30 on the last whorl. The axial riblets persist over the length of the parietal wall, and on the shoulder of the last third of the body whorl they form 4 or 5 moderately large, axially pinched knobs. The apex bears about 15 smoothish, white, small, swollen former varices, some of which are lined up one under the other. Suture minutely indented and bounded below by a strong, weakly beaded cord. Color of apical whorls tan with a broad spiral band of suffused brownish purple. Outer shell variable in color; usually whitish with heavy mottlings of

various shades of brown; rarely yellow-spotted. Rarely with an indistinct white band below the periphery. The outer portion of the outer lip may show violet streaks. Columella well-calloused, compressed, lavender, and bearing about two dozen, lighter-colored, slightly wavy, raised, rather strong, rarely bifurcating, spiral lirae. The upper 5 or 6 lirae extend into the aperture over a flattened to concave shelf. Posterior anal canal a narrow, vertical slit. Outer lip thin but strong, serrated. Stromboid notch well formed and flanked above by a small and below by a large and flaring tongue-like flange or tooth. Inside of outer lip constricted and bearing about two dozen strong lirae which may be broken into numerous, raised, small beads and bars. Depths of aperture white. Inside of outer lip with violet and with a brown and white border. Periostracum thin, translucent tan, flaking off when dry. Operculum stromboid, with small serrations, and light yellow-brown. Animal whitish (preserved). In a shell 22 mm. long, the simple verge was 6 mm., the radula 3 mm. with 36 rows and a formula of 3-1-3; 1-3 (plus peg); 6; 7.

Measurements (mm.)—

length	width	no. whorls	
27.0	16.3	9+	(large; off Oahu Id.)
21.5	12.0	11	(average; off Oahu Id.)
13.2	0.7	8	(small; off Oahu Id.)

Synonymy—

1843 *Strombus hellii* "Rousseau" Kiener, Coquilles Vivantes, Paris, vol. 4, Strombus, p. 59, pl. 13, fig. 2 (mer des Indies, les cotes de l'île Zanzibar).

1860 *Strombus cancellatus* Pease, Proc. Zool. Soc. London, for 1860, p. 398 (Sandwich Islands = Hawaiian Islands). Non Lamarck, 1816.

Nomenclature—To our knowledge Rousseau did not publish a description of this species, and the first author is Kiener.

Types—The holotype is presumably in the Muséum d'Histoire naturelle de Genève. The type locality of Zanzibar is probably erroneous. There is a probable cotype of *S. cancellatus* Pease in ANSP no. 247097.

Records (see map, pl. 57) (all Hawaiian Chain)—FRENCH FRIGATE SHOALS: Tern Id. (ANSP). NIIHAU ISLAND: (D. Thaanum, ANSP). MAUI: off Olowalu, 6-9 fms. (D. Thaanum, BPBM, USNM); off Mt. Lihau, 4-12 fms.; off Malu Bay, 4-12 fms. (both Albatross, USNM). MOLOKAI: off south coast, 43-66 fms. (Albatross Sta. 3850, USNM). OAHU: entrance to Honolulu Harbor, 6-8 fms. (D. B. Langford, BPBM); off Waikiki, 20-30 fms. (D. Thaanum, BPBM); off Waikiki, 25-50 fms. (D. B. Kuhns, ANSP). Waianai Bay, 18 fms. (C. S. Weaver coll'n, Pele Exped.); Keehe Lagoon, 30 fms. (C. S. Weaver, ANSP). HAWAII: off Rani Id., 235-240 fms., dead, Albatross Sta. 3982 (USNM).

Fossil records—Probably Pleistocene, Kauain Stream, Lanai Id., Hawaiian Ids., 550 ft. altitude (USNM).

Strombus dentatus Linné, 1758

(Pl. 14, fig. 23)

Range—East Africa to Polynesia.

Remarks—This is one of the most widely distributed and most attractive species in the Indo-Pacific, although it is never abundant and, in some areas, is considered uncommon or even rare. Its shell is highly glossed, axially plicate, rather heavy for its 1½ inch size, and characterized by its fore-shortened outer lip which bears 3 or 4 tooth-like, white spines at the base. The columella is thick and white; the inner wall of the last whorl purplish brown with fine, white lirae; and the apex is usually lavender. It is quite variable in color, size and ribbing, and we can see no evidence of geographical subspeciation.

Habitat—This is a shallow-water, coral sand-dwelling species found from the low tide mark to a depth of 20 fathoms. It is usually found near or on coral reefs, but not on the sandy-mud shores of large islands. It has been dredged dead down to 50 fathoms.

Description—Shell 26 to 56 mm. (1 to 2 inches) in length, very solid, glossy, axially plicate, maculated with browns and white and with 3 or 4 white tooth-like projections at the base of the outer lip. Whorls 8 to 10; nuclear whorls 3, translucent lavender (rarely purplish tan), glossy, smooth, well-rounded. First postnuclear whorl (and rarely the second) with 6 to 8 neatly incised, spiral lines. Remaining whorls without spiral lines, but with microscopic, crowded, axial scratches. The last 3 or 4 whorls bear 6 to 14, slanting, rounded, smooth, short axial folds or ribs on the upper third of each whorl. Each of the first 3 or 4 postnuclear whorls bear 3 whitish, rounded, small, but distinct, axial, former varices which may or may not be lined up one under the other. Color of outer shell cream with irregular cloudings, maculations and flecks of chestnut- or yellow-brown and white. Base of siphonal canal with a diffused splotch of bluish brown. Columella thick, glossy, smooth, except for 3 or 4 white lirae at the top and 3 or 4 brown lirae on the inner, lower end. Interior of aperture yellow or rose; inner wall of last whorl with a broad band of purple-brown over which are about 30 to 40 small, distinct, even, raised, white spiral lirae. Outer lip thickened, bearing below 3 or 4 distinct, tooth-like, white projections. Stromboid notch obscured by these projections. Base of shell with about a dozen very weak spiral threads. Periostracum very thin and usually worn off most of the shiny shell. Operculum strom-

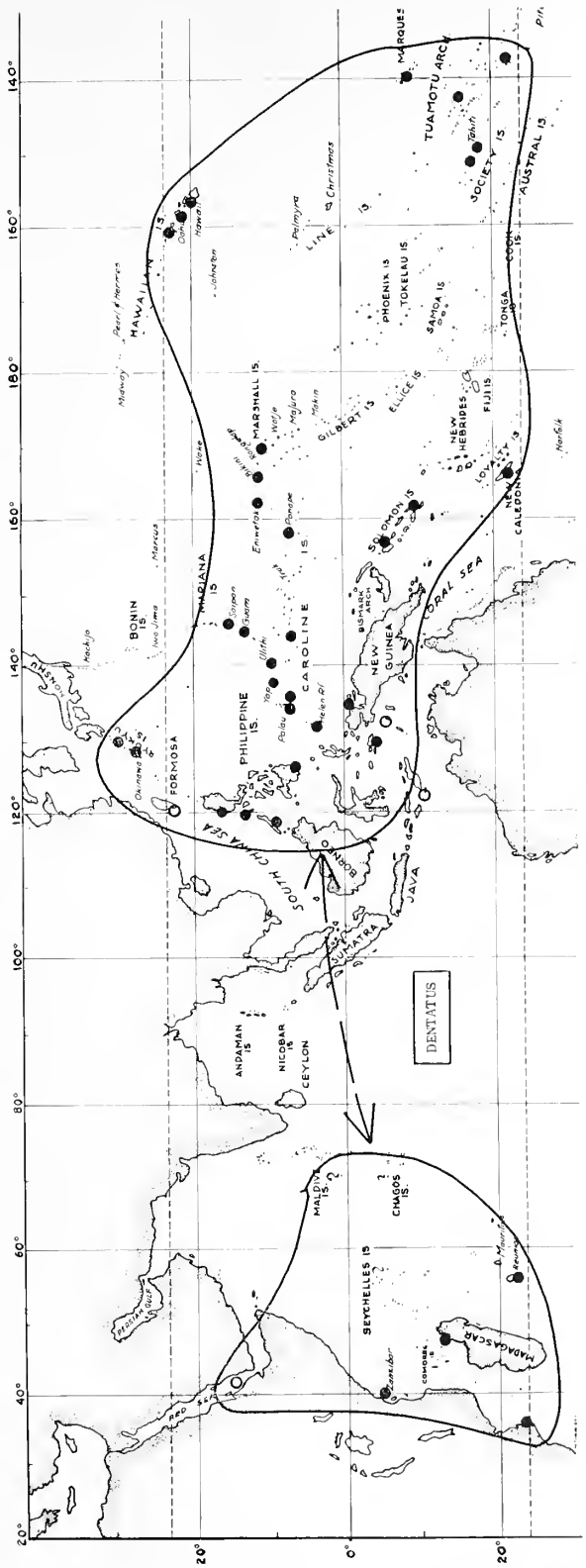


Plate 59. Geographieal distribution of *Strombus dentatus* Linné.

boid, light-brown, not arching, and with about 12 small serrations. Animal and verge similar to those of *urceus*. Radula ribbon amber and rose, 5 mm. in length, and with about 46 rows. Formula of Zanzibar specimen: 2-1-2; 1-3 (plus peg); 6; 6. Posterior mantle filament long.

Measurements (mm.)—

length	width	no. whorls	
56.5	23.1	10	(large; Palau Ids.)
43.3	17.5	10	(average; Okinawa Id.)
26.0	11.5	8	(small; Mindoro Id.)

Synonymy—

1758 *Strombus dentatus* Linné, Systema Naturae, ed. 10, p. 745, no. 0 (no loeality); 1767, ed. 12, p. 1213, no. 513; 1956, Dodge, Bull. Amer. Mus. Nat. Hist., vol. 111, art. 3, pp. 285-288.

1791 *Strombus tridentatus* Gmelin, Systema Naturae, ed. 13, p. 3519, no. 30 (mari indico). Refers to Lister, pl. 858, fig. 14; Conehyl.-Cab., vol. 3, figs. 810-814; 1843, Kiener, Coq. Viv., vol. 4, pl. 26, fig. 2.

1798 *Lambis dentata* Röding, Museum Boltenianum, Hamburg, pt. 2, p. 62, no. 790. Refers to Conchyl.-Cab., vol. 10, figs. 1501-02.

1817 *Strombus samar* "Chemnitz" Dillwyn, Descript. Catalog Reeent Shells, vol. 2, p. 674 (Amboina); 1823. Dillwyn, Index to Hist. Conchyl. Lister, ed. 3, p. 39. Refers to Lister, pl. 858, fig. 14.

1851 *Strombus samarensis* Reeve, Conch. Iconica, London, vol. 6, pl. 19, sp. and fig. 53a, b (Philippine Islands).

Types—According to Dodge, 1956, p. 288, there was no Linnaean type. Nor was a type locality given.

Nomenclaturc—We are following Hanley, 1855, p. 276, Issel and T.-Canefri, 1876, p. 352, Dodge (*loc. cit.*) and most subsequent authors in applying the name *dcntatus* Linné to this species. Recent Japanese authors (Kira, Kuroda, ete.) have used *tridentatus* Gmelin for this speeies, and, erroneously we believe, applied the name *dentatus* to the plicate form of *labiatns* Röding. Literature reeords of *dentatus* Linné arc too confused to be reliable, unless the shell was illustrated or mention was made in whose sense the name was employed.

Selected records (see accompanying map, pl. 59; solid dots: specimens examined; open circles: literature records)— MOZAMBIQUE: Mozambique City (K. Grosch, ANSP). ZANZIBAR: Chumbe Id., 6 ft. (NSF, 1957). RED SEA: ?Baia di Annesley (Issel and T.-Canefri, 1876, p. 353). MADAGASCAR: Nossi-bé (A. Chavane, ANSP). MAURITIUS: (MCZ). CEYLON: ?(Yale Peabody Mus.). JAPAN: Osumi Ids.; Kyushu (MCZ). RYUKYU IDS.: Okinawa Id. (Mrs. A. A. Scott, ANSP). PHILIPPINES: Luzon Id.; Mindoro Id. (ANSP); Mindanao Id.; Balabae (both USNM). INDONESIA: Banda and Rotti Ids. (Schepman, 1909, p. 153); Amboina (MCZ). CAROLINES: Yap Id. (C. O. Kile, ANSP); Truk Id. (Mrs. R. T. Gallemore, ANSP); Ponape (MCZ); Ifaluk (USNM). MARIANAS: Laulau Bahia, Saipan Id. (R. Sutcliffe, ANSP). MARSHALL IDS.: Bikini; Eniwetok; Rongerik; Kwajalein; Wotho; Lae; Ujae (all USNM). HAWAII: off Waikiki, Oahu Id., 35-50 fms.; off Luniupoko Camp, Maui Id.; Keaukaha, Hilo, Hawaii Id. (all D. Thaanum, USNM); off Honolulu Harbor, Oahu Id. (D. Thaanum, ANSP). SOCIETY IDS.: Tahiti Id.: Puna-

auia and Atiue (R. Robertson, 1952, ANSP). TUAMOTU ID.: Tekatikati Id.; Raroia Atoll (USNM); Marutea (Lord Hood Id.) (Dautzenberg and Bouge, 1932, p. 295).

Fossil records—ZANZIBAR: L. R. Cox (1927, p. 86) reports and figures (pl. 18, fig. 5) this species from the Azanian limestone from the base of a well near Makunduchi of Pleistocene age. It occurs in probable Pleistocene deposits, 550 feet altitude, Kawaiu Stream, Lanai Id., Hawaii (USNM). KENYA: Pleistocene: Mombasa Harbour (L. R. Cox, 1930, p. 138).

Strombus fragilis (Röding, 1798)

(Pl. 14, figs. 30)

Range—Southwest Pacific: Ryukyus and Indonesia to Hawaii and Samoa.

Remarks—This species is not uncommon in the central Pacific, but moderately rare to the west. It is characterized by its rather thin, but strong, elongate, smooth shell, and by its smooth, chocolate to red-brown columella. The dorsum of the body whorl rarely has one or two weak axial folds at the shoulder. Under a very high magnification, the surface of the outer shell may appear "silky" due to microscopic spiral and axial scratches.

Habitat—It lives on a bottom of sand, broken coral, weed, and sponge from 2 to 25 fathoms both in lagoons and offshore ocean waters.

Description—Shell 24 to 49 mm. (1 to 2 inches) in length, oval-elongate, without ribs, smoothish, and moderately thin-shelled. Spire slightly concave and with smooth, well-rounded whorls. Whorls 9. Nuclear whorls 3, bulimoid, well-rounded, glossy, smooth and transparent tan. First half postnuclear whorl with 7 to 8 microscopic, spiral, incised lines, disappearing in later whorls. A small subsutural thread persists to the penultimate whorl. Surface of whorls in fresh specimens has a "silky" appearance due to microscopic axial and spiral scratches. Upper part of spire with 5 to 11 very small, rounded, whitish former varices. Color of shell whitish to cream with large, irregular patches of dark- to orange-brown. Spire rarely tinged with light-lavender or rose. Columella solid-brown, smooth, except for 4 or 5 very weak spiral lirae at the base and rarely at the very top. Aperture light-brown within, with a dark, axial brown band near the outer lip, and with numerous, crowded, low, irregular, fine, brown spiral lirae. Stromboid notch weak. Base of shell with about 20 fine, incised spiral lines. Periostracum moderately thick, translucent-brown and with a microscopically sculptured surface. Operculum stromboid, brown, broadly ovate at one end, sharply pointed at the other, not arching, with 7 well-developed dentitions, and with a well-developed central rib on the attachment side.

Radular ribbon 4 mm. in length, with 38 to 43 rows, brown-tinted or clear, and resembling the

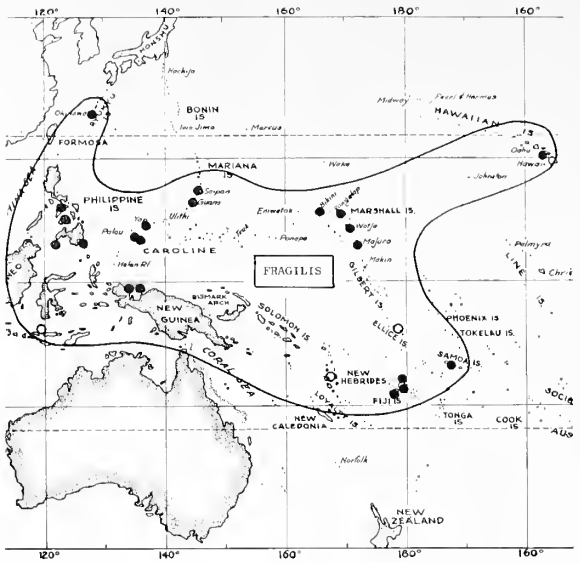


Plate 60. Geographical distribution of *Strombus fragilis* (Röding).

urceus and *labiatus* radulae. Formula from Guam and Palau Islands: 2-1-2; 1-3 (plus peg); 5; 5. Body, foot and verge cream with yellow maculations and spots. Proboscis tipped with brown in Palau specimen. Posterior mantle filament long or short. Verge long and slender, simple, 8 to 16 mm. in length.

Measurements (mm.)—

length	width	no. whorls	
49.0	21.6	9	(large; Fiji)
38.0	15.5	9	(average; Mindanao Id.)
24.5	10.0	7+	(small; Dutch New Guinea)

Synonymy—

1798 *Lambis fragilis* Röding, Museum Boltenianum, Hamburg, pt. 2, p. 62 (no locality). Refers to Conchyl.-Cab., vol. 10, fig. 1503.

1817 *Strombus samar* "Chemnitz" Dillwyn, Descript. Catalog Recent Shells, London, vol. 2, p. 674 (**in part** by reference to Conchyl.-Cab., vol. 10, fig. 1503). See under our *dentatus* synonymy.

?1823 *Strombus dubius* Swainson, Philosophical Magazine, vol. 61, no. 301, p. 377 (no locality). Non Sowerby 1842.

1842 *Strombus bulbulus* Sowerby, Thesaurus Conch., vol. 1, p. 32, pl. 9, figs. 81-83.

1946 *Strombus bullatus* Sowerby, Dodge, Amer. Mus. Novitates, N. Y., no. 1314, p. 5 (error for *bulbulus* Sowerby, 1842).

1946 *Strombus (Canarium) terebellatus* Sowerby, Abrard, Annales de Paleontologie, Paris, vol. 32, p. 64, pl. 4, fig. 32 (Malekula Id., New Hebrides, Pliocene).

Types—Röding's name is based upon the Martini and Chemnitz, vol. 10, fig. 1503. The latter is based upon a specimen from the "East Indies". We restrict the type locality to Zamboanga, Mindanao Id., Philippines. There are three cotypes of *bulbulus* Sowerby in the British Museum of Natural History,

London. ANSP no. 39851 from the Philippines was purchased from Sowerby about 1850 and may be a cotype. I do not know the whereabouts of the type of *dubius* Swainson (non Sowerby).

Nomenclature—This species until a few years ago was known as *bulbulus* Sowerby, but must be known by its earlier name, *fragilis* (Röding).

Records (see map, pl. 60)—RYUKYU IDS.: Okinawa Id. (uncommon, Mrs. A. A. Scott, ANSP). PHILIPPINES: Mindanao Id.: Zamboanga (ANSP), Samal Id., Davao Bay (MCZ); Basilan Id. (ANSP); Looc, Siburan, Negros Id. (USNM). INDONESIA: Pulo Kawassang, Paternoster Ids., n. of Sumbawa Id. (Schepman, 1909, p. 152). NEW GUINEA: off Sowek Id., Soepiori Ids.; 25-30 fms., 1 mi. east of Dauwi Id., E. Padaido Ids.; 20-25 fms., 1 mi. N.E. of Roemwakon, Aoeri Id., Geelvink Bay (all NSF, 1956). FIJI: Bega Id. (T. Dranga, ANSP); Suva Pt., Viti Levu (H. S. Ladd, USNM). MARIANAS: Piti Bay, Guam Id. (A. B. Bronson, ANSP); Managaha Id., Saipan (USNM); Apra Harbor, Guam Id. (R. T. Abbott, USNM). PALAUS: Korak Id., Babelthuap; Gamudoko Id. (both NSF, 1955). CAROLINES: Yap Id. (USNM); Kwajalein Atoll (ANSP, USNM, Yale Peabody Mus., common); Ebon Id. (MCZ). ELLICE IDS.: Funafuti (Hedley, 1899, p. 429). SAMOA: Pago Pago, Tutuila Id. (USNM). HAWAIIAN CHAIN: Honaunau, Hawaii Id., dead (ex J. Q. Burch, ANSP).

Fossil records—Abrard, 1946, p. 64 reports two specimens (as *terebellatus* Sowerby) from the Pliocene from the banks of the Nua river, Malekula Id., central New Hebrides. Schepman (1907, p. 186) makes an unsubstantiated record of this (as *bulbulus* Sby.) in the post-Tertiary of the Celebes. A specimen closely resembling Recent *fragilis* was obtained by H. S. Ladd at Bikini Id., Bikini Atoll, Marshall Ids., drill hole 2A, 925-935.5 ft. (Pleistocene?) (USNM).

Strombus terebellatus Sowerby, 1842

(Pl. 14, figs. 29; pl. 61, fig. 1)

Range—East coast of Africa (subspecies *afrobellatus*) to the Ryukyu Islands and to Fiji (subspecies *terebellatus*).

Remarks—This thin-shelled, smooth species is uncommon on the east coast of Africa, evidently rare or absent in the central Indian Ocean and East Indies, but not uncommon in the Western Pacific. It has not been recorded from the Marshalls, Hawaii or eastern Polynesia. Only further collecting will show whether or not this is a case of discontinuous distribution. The species is readily recognized by its smooth, slender, rather fragile shell, weak or absent columella callus and very shallow stromboid notch. It is likely to be confused with *fragilis*, but the latter is heavier, not as slender, with a darkly colored columella, and with fine spiral striae within the outer lip.

The species may be divided into two geographical races—the typical *terebellatus terebellatus* from the western Pacific whose last whorl descends considerably to produce a spire almost equal to half the entire length of the shell—and *terebellatus afrobellatus* from the east coast of Africa whose spire is only one third the length of the entire shell.

Habitat—Little is known of its habits. It probably lives in sand just off shore.

Description—(terebellatus terebellatus). Shell 28 to 49 mm. (1 to 2 inches) in length, rather fragile, elongate, shiny-smooth, and mottled with browns. Whorls 9, smooth and slightly rounded. Nuclear whorls 3, smooth, glossy and translucent tan. First postnuclear whorl with 5 to 9 microscopic incised lines. Succeeding whorls smooth. There may be one or two very weak former, axial varices on the third and fourth whorls. Spire high; almost one half the length of the entire shell. Color of shell whitish to cream with heavy or weak, irregular mottlings of dark- or light-brown. In most specimens there are fine, irregular spiral lines of brown inside the aperture on the body whorl. Apical whorls sometimes suffused with purplish brown. Columella white with brownish flecks. Base of shell with about a dozen weak spiral incised lines. Outer lip thin, with a weak smooth varix, and a very shallow stromboid notch. Lirae absent within the aperture. Operculum and soft parts unknown.

Measurements (mm.)—

total length	spire length	width	no. whorls
49.2	23.0	18.0	10
45.0	20.2	16.3	9
39.6	17.5	13.5	9
36.5	14.0	13.0	8

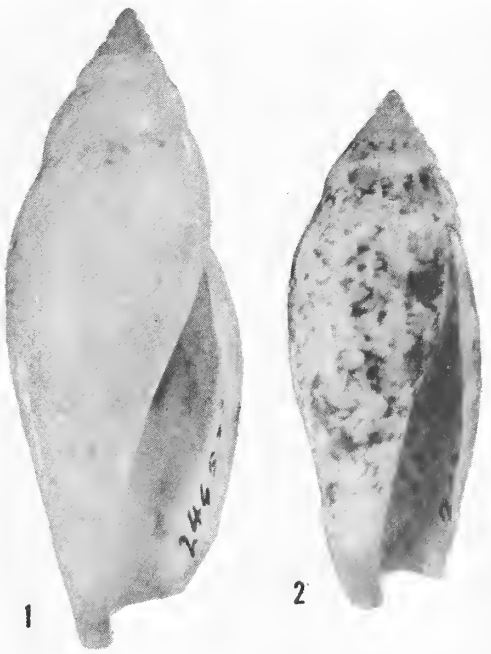


Plate 61. Fig. 1, *Strombus terebellatus terebellatus* Sowerby, Mindanao Id., Philippines. Fig. 2, subspecies *afrobellatus* Abbott, holotype from Pange Id., Zanzibar. Both ×2.

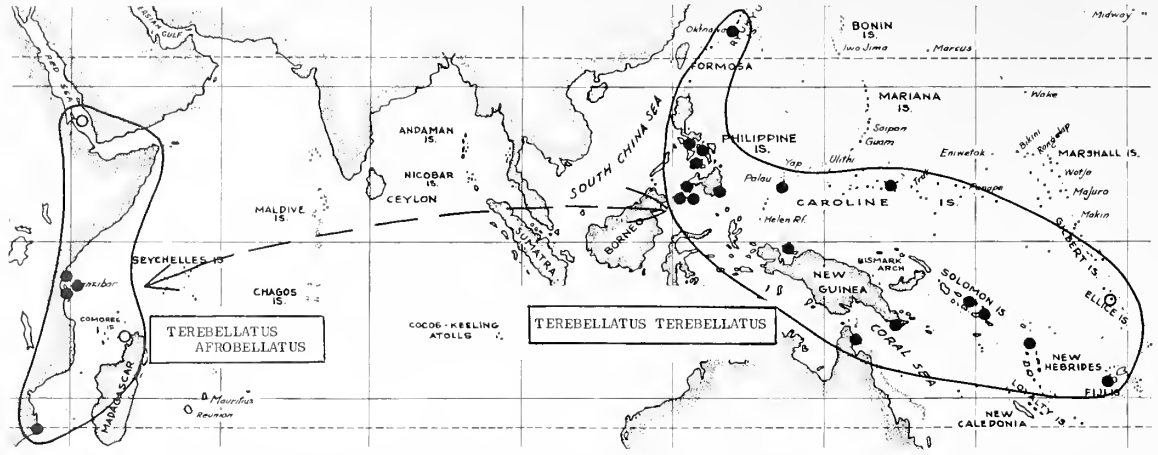


Plate 62. Geographical distribution of the Pacific Ocean *Strombus terebellatus terebellatus* Sowerby and its African subspecies, *afrobellatus* Abbott.

Synonymy—

1842 *Strombus terebellatus* Sowerby, Thesaurus Conchyl., London, vol. 1, Strombus, p. 31, no. 30, pl. 9, figs. 84, 85 (no locality); 1843, Kiener, Coquilles Vivantes, vol. 4, Strombus, p. 66, pl. 18, fig. 2, and errata p. 68 (mer des Indies). Also refers to Conchyl.-Cab., vol. 3, fig. 810.

1843 *Strombus dentatus* Wood, Kiener, *loc. cit.*, pl. 18 explanation only. Non Linné 1758.

Types—Sowerby's cotypes are in the British Museum of Natural History, London. We restrict the type locality to Viti Levu Island, Fiji.

Records (see map, pl. 62) (for *terebellatus terebellatus*)—RYUKYU ISLANDS: Okinawa Id. (Mrs. A. A. Scott coll'n). PHILIPPINES: Basilan Id. (A. R. Cahn coll'n, ANSP); Lubang Id. (P. de Mesa, MCZ); Batangas, Luzon Id. (ANSP); Davao Bay, Mindanao Id. (MCZ, ANSP, USNM); Zamboanga, Mindanao Id. (ANSP); Mambajas, Camiguin Id. (M. C. Quisumbing, ANSP); Lalay, Marinduque Id.; Cebu Id.; Jolo and Siasi Ids., Sulu Archipelago (all USNM). AUSTRALIA: Green Id., Queensland (Tony Marsh, ANSP). NEW GUINEA: Milne Bay (USNM). SOLOMONS: Treasury Id. (USNM, ANSP). NEW HEBRIDES: Espiritu Santo (C. M. Dumbauld, USNM). FIJI: (A. Garrett, ANSP). PALAU ISLANDS: Urukthapel Id. (NSF). CAROLINES: Truk Id. (Mrs. R. T. Gallemore, ANSP). ELLICE ISLANDS: Funafuti, alive but uncommon (Hedley, 1899, p. 428).

Fossil records—R. Abrard's 1946, p. 64, pl. 4, fig. 2 record of this species from the New Hebrides' Neogene is erroneous (see under S. *fragilis*). Schepman (1907, p. 186) makes an unsubstantiated report of it in the post-Tertiary of the Celebes.

Strombus terebellatus *subspecies* afrobellatus, *new subspecies*

(Pl. 61, fig. 2)

Range—Western part of the Indian Ocean.

Remarks—This subspecies differs from the typical western Pacific form in having a much shorter spire which is about one third the length of the entire shell and in lacking the weak, spiral lines of pale-brown within the aperture on the inside of the body whorl.

Habitat—It has been collected on an intertidal reef in sand on Pange Island, on the west side of Zanzibar, East Africa.

Description—Shell 29 to 39 mm. (1 to 1½ inches) in length, rather fragile, smooth, glossy and colored cream with a heavy suffusion of light to dark brown mottlings and flecks. Similar to the typical *terebellatus* (see above) but the apertural wall of the body whorl lacks the small, spiral brown color streaks, although the colors of the outer shell may show through. Columella slightly concave in the middle, slightly convex above. Stromboid notch very weak. Spire only one third the length of the entire shell. Periostracum very thin and smooth, and usually remaining only on the lower third of the shell.

Operculum stromboid, slightly arching, light-brown, with 5 well-developed, sharp serrations. Animal orange-yellow with white spots (preserved). Verge very long (18 mm.), narrow and simple. Radula ribbon 4 mm., delicate, and with a formula of 2-1-2; 1-3 (plus peg); 5; 5.

Measurements (mm.)—

total length	spire length	width	no. whorls	
30.0	8.0	11.0	9	(holotype, ANSP)
29.0	8.0	11.0	7+	(paratype, ANSP)
30.8	9.0	12.0	9	(paratype, Coryndon Mus.)
38.5	14.0	–	–	(paratype, USNM 604529)

Types—The holotype is in ANSP no. 214295. The type locality is Pange Id., west side of Zanzibar, East Africa. Collected by Ostheimer, Orr and Thorington, NSF station 601, in sand on intertidal reef, Jan. 20, 1957. Paratypes listed below.

Records—MOZAMBIQUE: Mozambique City (K. Grotsch, ANSP 211423). TANGANYIKA: Mboa Magi, south of Dares-Salaam (R. T. Abbott, USNM). ZANZIBAR: Pange Id. (NSF, ANSP.) KENYA: Diani Beach (H. Copley, Coryndon Mus. no. 1611). RED SEA: Jubal Id. (Issel and T.-Canefri, 1876, p. 354 [probably this subspecies]). [R. Abrard, 1946, p. 64, reports what is probably this subspecies as coming from Nossi-bé, Madagascar.]

Fossil records—None recorded.

Subgenus Dolomena Iredale, 1931

Type: *Strombus plicatus pulchellus* Reeve, 1851

Living species of this subgenus are limited to the Indo-Pacific, although fossil representatives are numerous in the Pliocene and Miocene of southeast Asia, and one species occurs in the Miocene of the Caribbean (*Strombus bifrons* Sowerby, 1850; Wooding, 1928, p. 324, pl. 24, fig. 1, not pl. 23, figs. 3, 4). Members of the subgenus are absent in Hawaii and Polynesia.

The shells are usually small, with an expanded lip which has a slight posterior sinus, as well as a strong anterior stromboid notch. In many species the upper part of the lip forms a posterior canal which may be long, arching and attached to the spire. Most species have spiral lirae on the inner side of the outer lip, and some have a small amount of purple staining either on the columella or deep within the aperture. The penis has a "heel" or prong on the distal blade; the operculum is strongly serrated; the lateral radular tooth has a basal peg; and the inner marginal is usually much smaller than the outer marginal.

Synonymy—

1931 *Dolomena* Iredale, Records Australian Mus., vol. 18, no. 4, p. 212. Type by monotypy: *pulchella* Reeve [= *Strombus plicatus pulchellus* Reeve].

Strombus plicatus *subspecies* plicatus (Röding, 1798)

(Pl. 18, fig. 12)

Range—Red Sea.

Remarks—The typical form is an uncommon species limited to the Red Sea, so far as we know. It is characterized by the full, rounded body whorl which bears 12 to 16 well-developed axial plications over most of its length, by a few of the spiral plications on the columella being light-brown in color, by the absence of any color within the aperture or outer lip, and by the relatively large (2 inches) size of the shell.

S. *plicatus* Röding appears to have four subspecies: 1) the nomenclatorially typical Red Sea subspecies. 2) the more common, widely distributed, Indian Ocean subspecies *columba* Lamarck. 3) the swollen, stunted subspecies (or possibly a form) *sibbaldi* Sowerby which ranges from the Gulf of Aden to Ceylon. 4) the small western Pacific subspecies *pulchellus* Reeve.

Habitat—Unknown, but presumably in fairly shallow water.

Description—Adult shell 50 to 62 mm. (2 to 2½ inches) in length, relatively thin, but strong, semiglossy, axially plicate, and light-cream to brown-speckled in color. Spire elevated, rather acute, having an angle of about 50°. Whorls strongly shouldered, each bearing 17 to 20 small, but distinct, axial ribs between which are about a dozen microscopic, spiral threads. Suture minutely indented, minutely waved and with a low, broad spiral cord just below. Color of shell whitish to cream with indistinct, broad spiral bands of yellow-brown flecks. The center of the last whorl may have a broad white band. Last whorl with 12 to 15 long, smooth, rounded axial ribs which are swollen at the shoulder and which become obsolescent near the outer lip. Spiral sculpture of fine, irregular threads which become larger and rounded on the base of the shell. Aperture white within. Outer body wall with about 40 spiral lirae which extend out almost to the edge of the outer lip. Columella almost straight, white, with irregular spiral, brown-colored lirae. Base of columella with strong white lirae, and not extending much more than the lower part of the outer lip. Posterior siphonal canal short, deep, and extending up on to the next to the last whorl. Stromboid notch moderately developed. Periostracum thin, varnish-like, translucent. Operculum typical for the genus, ⅕ the length of the shell, light-brown, with about 10 saw-like teeth, and with a deep, narrow longitudinal trough on the outer surface. Animal and radula unknown.

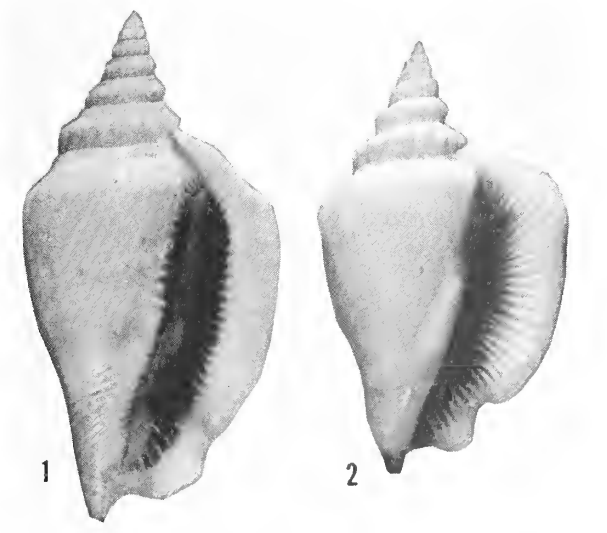


Plate 63. Fig. 1, *Strombus plicatus columba* Lamarck, Zanzibar. 2, *S. plicatus pulchellus* Reeve, Okinawa Island, Ryukyu Islands. Both × 1.6.

Measurements (mm.)—

length	width	no. whorls	
64.0	34.5	11	(large; Gulf of Suez)
57.0	31.0	10	(average; Gulf of Suez)
52.0	28.0	7+	(small; Red Sea)

Synonymy—

1798 *Lambis plicata* Röding, Museum Boltenianum, Hamburg, pt. 2, p. 65, no. 835 (no locality). Refers to Conchyl.-Cab., vol. 10, fig. 1496 (from the Red Sea). Not *Strombus plicatus* Lamarck, 1822.

1834 *Strombus deformis* "Gray" Griffith and Pidgeon, The Animal Kingdom—Cuvier, vol. 12, pl. 25 (facing p. 82), p. 600 (name and figure only); 1851, Reeve, Conch. Icon., vol. 6, Strombus, pl. 19, figs. 55, a, b; 1876, Issel and Canefri, Ann. Mus. Givico Storia Nat. Genova, vol. 8, p. 345.

1843 *Strombus sibbaldi* Sowerby, Kiener, Coquilles Vivantes, vol. 4, Strombus, p. 56, pl. 12, fig. 2. (Not Sowerby, 1842.)

1908 *Strombus plicatus* Bolten, Hedley, Proc. Linn. Soc. New South Wales, vol. 33, pt. 3, p. 460.

Types—Röding's name is based upon figure 1496, vol. 10, of the Conchylien-Cabinet. Röding gave no type locality, so we designate the Red Sea from whence the Conchylien-Cabinet specimen came.

Nomenclature—The name *deformis* has been generally used for this species. Issel and Canefri (1876, p. 346) point out that this Red Sea species was first figured by Chemnitz, but they failed to use Röding's name. Records of *deformis* from Hong Kong and from Australia are evidently based upon misidentifications. Records of *plicatus* Röding from Australia probably were the subspecies *pulchellus* (see below). The *plicatus* Röding has nothing to do with *plicatus* Lamarck which was in general use a few years ago. Kiener (1843) evidently had *deformis* and *sibbaldi* interchanged.

Records (see map, pl. 65)—EGYPT: Zafaran, 50 mi. south of Suez (USNM). Geb Zebara (S. Vatakiotis, ANSP). Jubal Island (Issel and Ganefri, 1876, p. 345).

Fossil records—Abrard (1942, vol. 18, p. 63, pl. 6, fig. 36) records a very young "*deformis* Gray" from the Pleistocene of French Somalia. It may be the young of *Strombus erythrinus* Dillwyn.

Strombus plicatus *subspecies* columba Lamarck, 1822

(Pl. 18, figs. 1, 2; pl. 63, fig. 1)

Range—Western half of the Indian Ocean.

Remarks and Description—This is a moderately common subspecies along the East African coast, rare in Madagascar, but according to Melvill (1909, p. 93) is "one of the most abundant Gastropods in the regions traversed by the "Sealark" [Amirantes and Seychelles]. It has not been authentically reported from Mauritius. The shell is brightly colored and nearly always between 1 and 1½ inches in length. It differs from true *plicatus* in having a purple-brown blotch on the upper part of the columella and an elongate, irregularly-sized blotch on the inside of the outer lip, in having the siphonal canal extend beyond the lowest part of the outer lip, and in lacking axial plications on the ventral side of the body whorl. The subspecies *columba* is apt to be confused with the ¾- to 1-inch-long subspecies *pulchellus* from the western Pacific. However, in the latter there is always a tiny mauve blotch on the base of the columella (instead of pure white), the first 4 or 5 apical whorls lack spiral sculpturing, and the spiral lirae within the outer lip are coarser and almost always run out to the very edge of the outer lip. The apertural color blotches in *columba* are usually dark purple-brown (or even lavender in some Seychelles specimens), while in *pulchellus* they are frequently more diffused and more orange-brown. It is possible that this species will also turn up in the eastern Indian Ocean. In a 42 mm. Zanzibar specimen: operculum stromboid, one fourth the length of the shell, blackish brown, not arching, with 7 to 8 well-developed serrations, and with a strong, median rib on the attachment side. Radula ribbon 3.5 mm., with 44 rows. The peg of the lateral is very small. Formula: 2-1-2; 1-4 (plus peg) or rarely 1-3 (plus peg); 5; 8. Body gray; tentacles and proboscis cream. Posterior mantle filament 3.5 mm. Verge 10 mm. in length, its distal blade with a well-developed "heel".

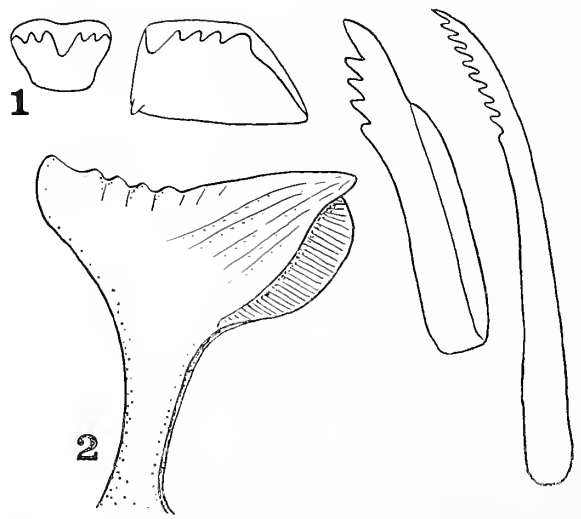


Plate 64. Fig. 1, radula of *Strombus plicatus columba* Lamarck, Zanzibar. 2, verge.

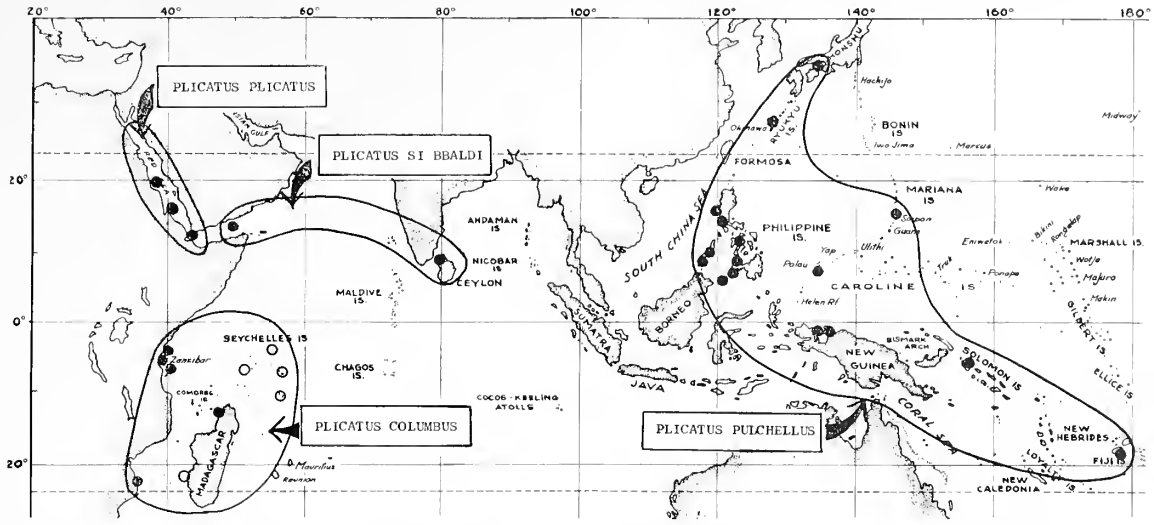


Plate 65. Geographical distribution of the subspecies of *Strombus plicatus–plicatus* (Röding), *columba* Lamarck, *sibbaldi* Sowerby and *pulchellus* Reeve.

Habitat—Occurs in colonies on coral sand, grassy, broken shell and sponge bottom at a depth ranging from 3 to 44 fathoms. The "Scalark" (E. A. Smith, 1909, p. 93) obtained it on the Saya de Malha Banks at 123 fathoms, as well as at 21 to 44 fathoms.

Measurements (mm.)—

length	width	no. whorls	
47.0	24.0	10	(large; Zanzibar)
41.5	23.5	10	(average; Zanzibar)
33.0	19.0	9	(small; Zanzibar)

Synonymy—

1822 *Strombus columba* Lamarck, Anim. sans Vert., Paris, vol. 7, p. 208 (Indes?); 1844, Duclos, in Chenu, Illust. Conchyl., vol. 4, Strombus, pl. 12, figs. 7, 8.

1823 *Strombus tankervillii* Swainson, Philosophical Magazine and Journal, London, vol. 61, no. 301, p. 377 (no locality).

Types—Lamarck's type is presumably in the Muséum d'Histoire naturelle de Genève. His type locality was "Indies?", which we now restrict to Ras Mungwe, Zanzibar. The whereabouts of Swainson's *tankervillii* is unknown, and he gave no type locality.

Nomenclature—The name *columba* is a Latin feminine substantive noun meaning "dove", and should not be changed to *columbus* while in the genus *Strombus*.

Records (see map, pl. 65)—MOZAMBIQUE: Bazaruto Bay (MCZ). ZANZIBAR: 1 mi. and 1½ mi. W.S.W. of Ras Mungwe, 3-7 fms.; 2 mi. W. of Chango Id., 15 fms.; 2 mi. W. of Bawi Id., 15 fms.; 1 mi. N.N.E. of Pange Id., 7 fms.; 1 mi. S.W. of Nguruwe Id., 5-11 fms. (all NSF, 1957). MADACASCAR: Nossi-bé (A. Chavane, ANSP); Ankify and Ambatoloaka (Dautzenberg, 1929, p. 467). INDIAN OCEAN ISLANDS: Mahé, Seychelles (USNM); Amirantes, 32, 28, 33, 34 and 30 fms.; Saya de Malha Banks, 123 and 47 fms.; Cargados Carajos, 30-32, 30 and 16-30 fms. (all Melvill, 1909, p. 93). [SUMATRA: Tjalang (reported by Oostingh, 1929, no. 39, p. 2, but this may be *pulchellus*). This is also possible of Hedley's 1908, p. 460, record from Darnley Island, Australia.]

Fossil records—The vaguely similar *Strombus deperditus* J. de C. Sowerby, 1839 from the Miocene of India was reported under the name of *columba* Lamarck by Vredenburg (1928, p. 317) from the Upper Mioecne of the Gaj of West Pakistan. I doubt if *columba* existed in the Mioecne.

Strombus plicatus *subspecies* sibbaldi Sowerby, 1842

(Pl. 18, figs. 15, 16)

Range—Gulf of Aden to Ceylon.

Remarks and Description—This is a rare form of subspecies of plicatus. Much more material is needed to verify the suspicion that this is a malformation which sporadically appears in any colony. The shells resemble true *plicatus* in having a pure white interior to the apertune, but otherwise differ in having the last whorl more globose and less descending, thus giving the shell a stunted appearance and the spire a concave outline. The axial ribs are absent on the parietal portion of the last whorl, and in this respect resemble the subspecies *columba*. The spiral lirae on the columella are brownish purple in the three specimens we have seen, and not violet-purple as shown in Sowerby's original illustration. American Museum of Natural History specimen no. 49426 from Ceylon is midway in character between *plicatus* and *sibbaldi*, but ANSP no. 39862 from Ceylon and purchased from Sowerby is of the typical *sibbaldi* shape.

Measurements (mm.)–

length	width	no. whorls	
38.5	21.0	7+	(large; Ceylon, AMNH)
30.0	19.0	7+	(average; Ceylon, ANSP)

Synonymy–

1842 *Strombus sibbaldii* Sowerby, Thesaurus Conchyl., London, vol. 1, p. 28, pl. 6, figs. 10, 11 (Ceylon).

1876 *Strombus kieneri* Issel and T.-Canefri, Ann. Mus. Civico Storia Nat. Cenova, vol. 8, p. 346. New name for *deformis* Kiener, 1843, pl. 32, fig. 2, non Gray [Griffith and Pidgeon, 1834].

1891 *Strombus yerburyi* E. A. Smith, Proc. Zool. Soc. London for 1891, p. 419, pl. 33, fig. 5 (Aden).

1843 *Strombus deformis* Gray, Kiener, Coquilles Vivantes, vol. 4, Strombus, pl. 32, fig. 2. Non Gray [Griffith and Pidgeon, 1834]; 1844, Duclos, Illustr. Conchyl., vol. 4, pl. 23, figs. 5-8.

Types–The holotypes of *sibbaldi* and *yerburyi* are presumably in the British Museum in London. The type of *kieneri* would be the specimen which Kiener called *deformis* Gray and figured on his plate 32, fig. 2, and is presumably in the Muséum d'Histoire naturelle de Genève. The type locality for *sibbaldi* is "Ceylon".

Records (see map, pl. 65)–CEYLON: (ex Sowerby, ANSP; AMNH); off south coast, 34 fms. (E. A. Smith, 1904, p. 469). ARABIA: Aden (E. A. Smith, 1891, p. 418). INDIA: off Coromandel coast, 41 fms. (E. A. Smith, 1904, p. 469). I have not verified the record for Warrior Id., Torres Straits, Australia, 5.5 fms. (Melvill and Standen, 1899, p. 165).

Strombus plicatus *subspecies* pulchellus Reeve, 1851

(Pl. 18, figs. 3; pl. 63, fig. 2)

Range–Southern Japan to Micronesia and Melanesia. Also Pliocene of New Hebrides.

Remarks and Description–This small and attractive Western Pacific subspecies is distinguished from typical *plicatus* and the Indian Ocean subspecies, *columba*, by its smaller size (usually 1 inch), absence of spiral sculpture on the first five whorls, smoothness of the central part of the columella, diffused brownish orange coloring inside the aperture, and by the coarser, spiral lirae which usually fan out to the very edge of the outer lip. The spiral cord just below the suture is minute but very distinct. The base of the siphonal canal is tipped with a spot of black-brown. Rarely, the columella may be all brown.

Measurements (mm.)–

length	width	no. whorls	
38.5	19.0	10	(large; Okinawa Id.)
29.0	15.5	9	(average; Luzon Id.)
22.0	11.5	9	(small; Dutch New Guinea)

Habitat–Dredged on coral-sand, sponge and weed bottom in depths from 8 to 50 fathoms.

Synonymy–

1851 *Strombus pulchellus* Reeve, Conchologica Iconica, vol. 6, Strombus, sp. and fig. 52 (Island of Ticao, Philippines).

1946 *Strombus (Gallinula) malekulensis* Abrard, Ann. Paléontol., Paris, vol. 32, p. 59, pl. 4, figs. 24-25 (Pliocene, Malekula, Nua River, New Hebrides).

?1946 *Strombus (Gallinula) minimus* Linné, var. *minor* Abrard, *loc. cit.*, p. 60, pl. 4, fig. 26 (Pliocene, Malekula, Nua River, New Hebrides).

Types–The holotype of *pulchellus* is presumably in the British Museum in London. The type locality is Ticao Island, Philippines.

Records (see map, pl. 65)–JAPAN: off Isshiki, Aichi Pref., Honshu Id., 50 fms. (T. Habe, ANSP). RYUKYU ISLANDS: between Naha and Itoman, Okinawa Id., 40-50 fms. (Langford and Thaanum, ANSP); Motobu, Okinawa Id. (A. A. Scott coll'n). TAIWAN: Taihoku-syu and Takao (Kuroda, 1941, p. 97). PHILIPPINES: east end of Corregidor Id., 6-10 fms.; south side of Corregidor Id., 11 fms.; cove west of Cochinos Point, 9 fms.; and east end of Sisiman Bay, all Luzon Id. (all dupont-Academy Exped., 1958, ANSP); Puerto Princessa, Palawan Id.; Cebu Id.; Sindagan Bay, Mindanao; 17 mi. northeast of Balabac Id., 44 fms., Albatross Station 5355; off Bantayan Id., 32 fms., Albatross Station 5192 (all USNM). Zamboanga, Mindanao Id. (MCZ). NEW GUINEA: 2 mi. north of Matas, Aoeri Ids., 18-20 fms.; 1 mi. east of Dauwi, East Padaido Ids., 25-50 fms.; 1 mi. S.E. of Cape Dgarwawoffi, Japen Id. (all NSF, 1956). PALAU ISLANDS: Eil Malk (NSF, 1955). SOLOMONS: Rabaul, New Britain Id. (USNM). MARIANAS: Pagan Id. (USNM). FIJI: off Rukua, Mbenga Id., 3-12 fms. (Dranga and Thaanum, 1940).

Fossil records–Altena (1942, p. 55) reports a specimen from the Pliocene Upper Kalibeng layers of Java, Indonesia, but I have not seen this specimen. *Strombus palabuanensis* Martin, 1899 (Upper Miocene of Java) may be related to this group. Abrard (see above synonymy) reports the equivalent of *pulchellus* from the Nua River Pliocene on Malekula Id., New Hebrides.

Strombus palabuanensis Martin, 1899

Range–Upper Miocene of Java, Indonesia.

Remarks–Probably allied to the Recent *S. plicatus pulchellus* Reeve. Upper Miocene according to van der Vlerk, 1931, p. 246.

Synonymy–

1899 *Strombus (s. str.) palabuanensis* K. Martin, Samml. geol. Reichs-Mus. Leiden, n. Folge, vol. 1, pt. 1, p. 185, pl. 30, fig. 430 (Kampong Tjiodeng, Palabuan, Java, Pliocene).

Strombus deperditus J. de C. Sowerby, 1839

Range–Miocene of West Pakistan.

Remarks–Although probably related to *Strombus plicatus columba* Lamarck, I do not agree with Vredenburg (1928, p. 317) that *deperditus* is a synonym of *columba*.

Synonymy—

1839 *Strombus deperditus* J. de C. Sowerby, Trans. Geol. Soc. London, 2nd series, vol. 5, pl. 26, fig. 19 (Soomrow, Tertiary, India); 1854, Sowerby, d'Archiac and Haime, Deser. an. foss. gr. numm. Inde, p. 316, pl. 30, fig. 19.

1839 *Strombus nodosus* J. de C. Sowerby, *loc. cit.*, pl. 26, fig. 20 (Soomrow, Cutch India, Tertiary). Non Borson, 1820.

1893 *Strombus exnodosus* Saceo, Molluschi terreni Terziarii Piemonte e Lig., pt. 14, p. 5. New name for *nodosus* Sowerby, non Borson.

1904 *Strombus sowerbyi* Cossmann, Essai de Paléoconchologie Comparée, book 6, p. 7, footnote. New name for *nodosus* Sowerby, non Borson.

Strombus dilatatus *subspecies* dilatatus Swainson, 1821

(Pl. 14, figs. 24, 25; pl. 66, fig. 2)

Range—Singapore to the Solomon Islands; Philippines to Queensland, Australia.

Remarks—This uncommon species is characterized by its flaring, "tongue-like" outer lip, its smooth white columella and by the peculiar purple-brown patch of color within the somewhat constricted throat of the aperture. The spiral lirae within the apertural wall are white and usually bifurcating. The posterior siphonal canal varies in its position, rising directly up on to the spire in the typical form, but curving over far to the left in the form *orosminus* Duclos (fig. 24). Intergrades are not infrequent in Philippine specimens. Old specimens have an aluminum-like glaze on the columella and the thickened outer lip. The color pattern in some specimens is rather like that of dark *epidromis* and lightly pigmented *marginatus septimus*, to which this species is probably closely related.

Habitat—Dredged in few numbers at depths of 4 to 39 fathoms on sandy-mud bottoms. Rarely cast ashore. Not associated with coral atolls.

Description—Adult shell 33 to 58 mm. (1¼ to 2¼ inches) in length, moderately heavy, slightly dorsoventrally compressed, and with a smoothly rounded, flaring, "tongue-shaped" outer lip. Spire elevated, acute and with an angle of about 45°. Whorls 10 to 11, the early ones well-rounded, the last 2 to 3 usually shouldered. Nuclear whorls 3, bulimoid, rapidly increasing in size, glassy-smooth and opaque white. Remaining apical whorls purplish or tan, and finely sculptured with numerous, spiral, incised lines and numerous (about 26 per whorl) axial riblets. Body whorl with 3 to 7 low, axially lengthened knobs at the shoulder. Apex with 6 to 12 swollen, whitish, irregularly-spaced former varices. Suture finely indented, minutely waved and commonly bordered below by one or two small spiral threads. Color of outer shell whitish to tan with sparse to rarely heavy mottlings and speckles of dark-tan to yellowish brown. 4 weakly defined, white spiral bands are sometimes evident on the last whorl. Aperture somewhat constricted within, and bearing numerous, well-developed, sometimes bifurcating, spiral white rugae, and having within an elongate brownish purple patch. Outer lip broadly flaring and "tongue-like", white and smooth along its inner border. Posterior siphonal canal long, narrow, and usually extending up on to 2 or 3 of the whorls of the spire. Occasionally, the posterior siphonal canal is curved over to form a hood-like ledge (form *oros-*

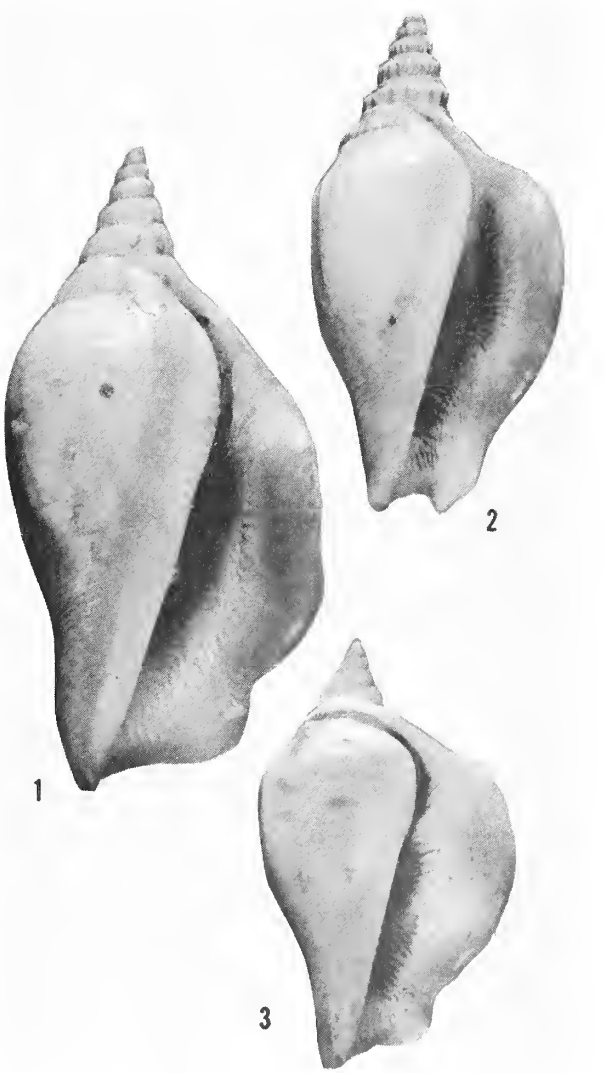


Plate 66. Fig. 1, *Strombus dilatatus swainsoni* Reeve, East Indies. 2, *S. dilatatus dilatatus* Swainson, Loyalty Islands. 3, *S. dilatatus dilatatus* form *orosminus* Duclos, Luzon Id., Philippines. All × 1.5.

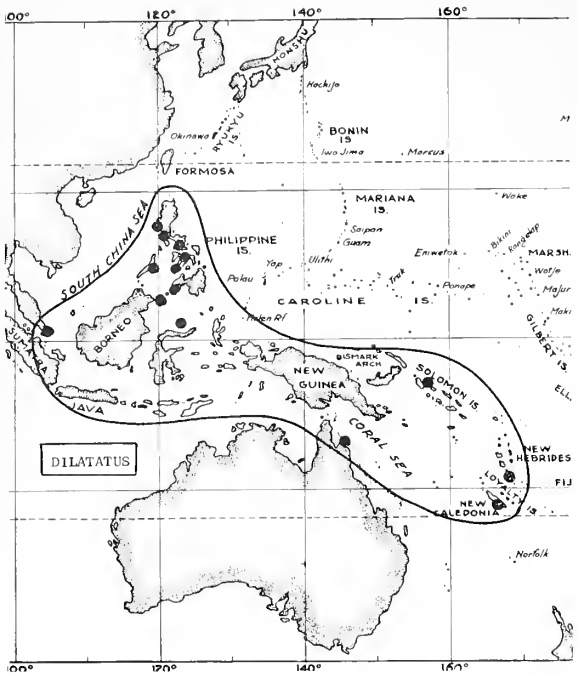


Plate 67. Geographical distribution of *Strombus dilatatus* Swainson.

minus). Columella white, smooth, glossy, and with a swollen callus which runs backward on to the whorls above to border the posterior siphonal canal. Base of columella with 5 to 7 very weak teeth facing the short anterior siphonal canal. Stromboid notch well-developed. Periostracum very thin, varnish-like, smooth and translucent tan. Operculum and radula unknown.

Measurements (mm.)—

length	width	no. whorls	
53.0	31.5	9	(Cebu Id., form *orosminus*)
51.0	29.0	10	(large; Mindanao Id.)
48.5	29.0	10	(average; Mindanao Id.)
35.5	21.0	9	(small; form *orosminus*)

Synonymy—

1821 *Strombus dilatatus* Swainson, Zoological Illustrations, series 1, vol. 2, pl. 71 (no locality). October. Non Lamarck, 1822.

1844 *Strombus orosminus* Duclos, Illustr. Conchyl., vol. 2, p. 6, pl. 10, figs. 10, 11 (locality unknown).

Types—The whereabouts of Swainson's type of *dilatatus* is unknown. We hereby designate Upala Cay, Queensland, Australia, as the type locality. Duclos' type of *orosminus* is presumably in the Mus. d'Hist. Nat. de Genève.

Records (see map, pl. 67)—SINGAPORE: (R. D. Purchon, ANSP). PHILIPPINES: Luzon Id.: San Nicolas Shoals, 7 and 10 fms.; off Corregidor Id., 6-11 fms.; Sisiman Cove, Bataan, 8 fms.; Lusong, on beach (all ANSP). Cebu Id.: near Cebu City (A. B. Franco, ANSP). Mindanao Id.: near Zamboanga (ANSP). Palawan Id. (MCZ). Panay Id.: off N.E. end, Albatross Station 5181, 26 fms. Negros Id.: off S.E. Bantayan Id., Albatross Sta. 5192, 32 fms. Sulu Archipelago: off Tataan Id., Albatross Sta. 5161, 16 fms. (all USNM). INDONESIA: off Taganar Id., Albatross Sta. 5358 (USNM). AUSTRALIA: Upala Cay, near Cairns, Queensland (G. Sax, ANSP); Low Isles, Queensland (Tony Marsh, ANSP). SOLOMON ISLANDS: Rabaul, New Britain Id. (USNM). NEW CALEDONIA: Noumea, 4-12 fms. (G. and M. Kline, ANSP). LOYALTY ISLANDS: Mare Id. (MCZ).

Fossil records—Unknown.

Strombus dilatatus *subspecies* swainsoni Reeve, 1850

(Pl. 14, figs. 18, 19; pl. 66, fig. 1)

Range—Unknown, but probably from Southeast Asia or the western part of Indonesia.

Remarks and Description—We have seen less than a dozen specimens of this distinctive form which we believe will prove to be a good subspecies. It differs from the typical race in having a larger and heavier shell which rarely bears former varices in the spire and whose body whorl is covered with numerous fine, spiral threads or incised lines. Adults vary in length from 54 to 64 mm. The lirae within the aperture are strong.

Habitat—Unknown, but probably in muddy areas at a depth of 10 fathoms.

Measurements (mm.)—

length	width	no. whorls	
64.0	35.0	10	(large; ANSP 39845, fig. 19)
58.0	30.0	10	(average; MCZ, fig. 18)
53.0	25.0	10	(small; ANSP 39845)

Synonymy—

1850 *Strombus swainsoni* Reeve, Conchologia Iconica, London, vol. 6, Strombus, sp. and figs. 28a, b (no locality; Cuming, coll.).

Types—The type is presumably in the British Museum. There is no type locality, and until an authentic record is found one cannot be designated. ANSP 39845 (fig. 19) was purchased from Hugh Cuming about 1860, and may be from the type lot.

Nomenclature—Reeve in 1850 figured this subspecies, thinking that it was the true *dilatatus* Swainson, and, because he erroneously thought that Swainson's name was preoccupied by Lamarck's 1822 *dilatatus*, he intimated that he was proposing the new name *swainsoni*. However, Reeve misidentified Swainson's *dilatatus*, and the name should not have appeared in the synonymy under his valid description and figure of *swainsoni*.

Records—No accurate records exist. One specimen from the Mus. Comp. Zoöl. is labelled "East Indies".

Fossil records—Unknown.

Strombus dilatatus *subspecies* taiwanicus Nomura, 1935

Range—Fossil (Pliocene) of Taiwan (Formosa) and (?) Philippines.

Remarks—This subspecies closely resembles the Recent subspecies *swainsoni* Reeve, and may well be its progenitor. It differs, however, in being narrower, in having a less flaring outer lip and in having fewer and more pronounced spiral incised lines on the body whorl. The tiny axial riblets are stronger and fewer in the early whorls. The length of specimens varies from 51.0 to 28.0 mm. Nomura records it from a number of localities in the Byoritu Beds of Taiwan: Hakusyaton; Wangwa; Rinsuikwa; Bosiho; Keiyukwa; Siko, etc. which he calls Pliocene in origin. The type locality is 1000 meters east of Hakusyaton, station 20, Taiwan. Holotype, Reg. no. 53163, Tohoku Imperial Univ., Sendai.

Dickerson's (1921, Philippine Journal of Science, vol. 18, p. 5; also vol. 20, p. 202, pl. 5, fig. 6) reports what may be this subspecies (as *swainsoni*) from the Miocene [Pliocene?] of Bondoc Peninsula, Tayabas Prov., Luzon Island, Philippines. MacNeil (1960, pl. 12, figs. 14-15, 22-23) records it from the Nakoshi sand, the Naha limestone and Gabusoga, all Tertiary of west Okinawa Id.

Synonymy—

1935 *Strombus taiwanicus* Nomura, Science Reports Tohoku Imperial Univ., Sendai, 2nd ser., vol. 18, no. 2, p. 177, pl. 8, figs. 15a, 15b, 16a, 16b (Byoritu Beds, Taiwain).

1960 *Strombus (Labiostrombus)* cf. *japonicus* Reeve, MacNeil, Tertiary and Quaternary Gastropods of Okinawa. U. S. Geol. Survey Prof. Paper 339, pl. 12, figs. 14, 15, 22, 23 (seen in MSS).

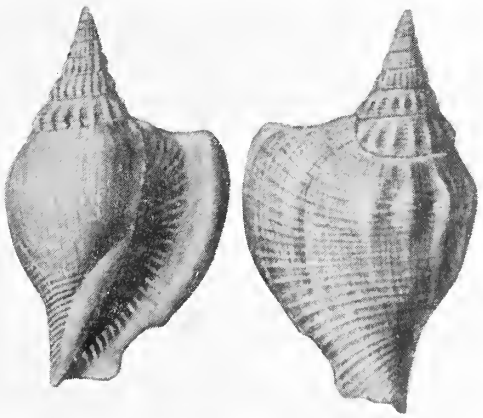


Plate 68. *Strombus fennemai* K. Martin. Pliocene of Ceram Island, Indonesia. (from P. J. Fischer, 1927, pl. 212, figs. 24a, b). Natural size.

Strombus dilatatus *subspecies* fennemai Martin, 1899

Range—Pliocene of Java, Sumatra, and Timor, Indonesia.

Remarks—The figures of the types are almost identical with specimens of *Strombus plicatus columba* Lamarck from the Indian Ocean, and not like the subspecies *pulchellus* Reeve which now lives in southwest Pacific area. *S. fennemai* differs from *columba* in having a slightly more rotund body whorl, in lacking a well-developed, lirated upper third of the columella, and in having a poorer development of axial riblets in the spire.

Synonymy—

1899 *Strombus (s. str.) fennemai* K. Martin, Samml. geol. Reichs-Mus. Leiden, n. Folge, vol. 1, pt. 1, p. 181, pl. 29, figs. 418-420 (Sonde, Padasmalang, Java, Pliocene).

1942 *Strombus (Labiostrombus) fennemai* Martin, Altena, Leidsche Geolog. Mededeel., vol. 12, p. 50 (Semarang, Java; Kendeng Beds, East Java, Pliocene; Atjeh, Sumatra, Pliocene; Poetjangan layers, Bareng beds, Bodjonegoro, Java).

Strombus rembangensis Martin, 1899

Range—Lower Miocene of Java and Borneo.

Remarks—This may be a malformed adult of one of the fossil subspecies of *dilatatus*. We have a similar appearing Recent specimen from New Caledonia whose peculiar shape was caused by shell injury. Until more specimens are available, it would be difficult to assign *rembangensis* to its nearest relative.

Synonymy—

1899 *Strombus (s. str.) rembangensis* K. Martin, Samml. geol. Reichs-Mus. Leiden, n. Folge, vol. 1, pt. 1, p. 180, pl. 29, fig. 417 (Sedan in Rembang, Java).

1947 *Strombus (Labiostrombus) rembangensis* Martin, Beets, Geologie en Mijnbouw, 9th year, no. 3, p. 41 (Lower Miocene, Pulu Balang, East Borneo).

Strombus labiosus Wood, 1828

(Pl. 18, figs. 17, 18)

Range—East Africa to the Ryukyus and the East Indies.

Remarks—This species is rarely collected, except in dredge hauls when it appears to be relatively common. It is readily recognized by its rotund body whorl, by its flaring outer lip which is usually turned upward at the top, by the minutely cancellate early whorls and by the white columella and outer lip. About half of the known specimens have a dozen or so brownish purple spiral lines deep

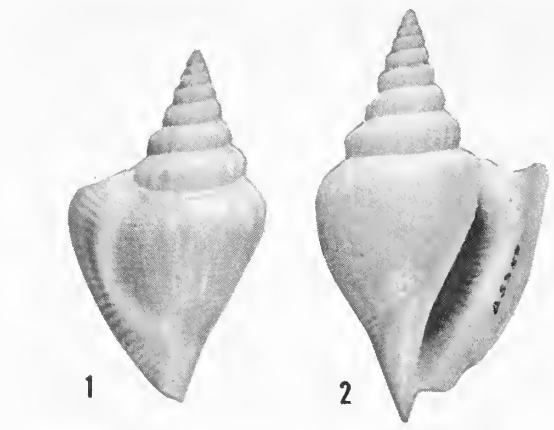


Plate 69. Figs. 1 and 2, *Strombus labiosus* Wood, off Taganak Id., Borneo. Both × 1.5.

within the aperture, while others are colorless.

Habitat—Dredged in 6 to 44 fathoms on muddy or sand and broken shell bottom.

Description—Shell 25 to 51 mm. (1 to 2 inches) in length, solid, obese, with a flaring outer lip, and lead to brownish gray in color. Whorls 10 to 11. Nuclear whorls 2½, small, elevated, rapidly increasing in size, transparent, glossy and smooth. First postnuclear whorl with about 10 microscopic spiral threads which in succeeding whorls cross about 2 dozen very small, rounded axial ribs, thus giving a microscopically cancellate appearance. In remaining whorls the axial ribs become increasingly larger and become knobbed at the periphery in the last whorl. Color of outer shell cream, tan, lead-gray or yellowish, sometimes splotched with a weak purplish brown and usually glistening. Columella and aperture enamel white. In some specimens there is a patch of a dozen or so purple-brown spiral lines deep within the aperture. Spiral sculpture absent on the ventral surface of the body whorl, but consists of numerous coarse threads on the last third of the whorl. Periphery of last whorl with 4 to 7 small rounded knobs. Outer lip wing-like and turned upward at the posterior end. Siphonal notch broadly U-shaped. Posterior siphonal notch short. Interior of outer body wall with numerous, white, spiral lirae which do not run all the way to the edge of the outer lip. Columella slightly concave, callus-like, with numerous spiral, fine lirae which are weak or absent on the middle of the columella. Lower third with about 10 fine spiral teeth. Periostracum very thin, smoothish, translucent tan. Soft parts not available for study.

Measurements (mm.)—

length	width	no. whorls	
50.8	30.0	7+	(large; "Philippines")
34.5	21.0	11	(average; Taganak Id., Borneo)
25.5	15.0	9	(small; Taganak Id., Borneo)

Synonymy—

1828 *Strombus labiosus* Wood, Supplement to Index Testaceologicus, London, p. 54, pl. 4, fig. 3 (name and figure only); 1842, Sowerby, Thes. Conchyl., vol. 1, Strombus, p. 27, pl. 6, figs. 15, 16 (no locality); 1843, Kiener, Coq. Vivantes, vol. 4, pl. 22, fig. 2.

1851 *Strombus labiosus* Gray, Reeve, Conchologica Iconica, London, vol. 6, pl. 18, fig. 50 (Cagayan, Island of Mindanao, Philippines, 25 fms).

1940 *Strombus (Labiostrombus) labiosus* Gray, Beets, Geologie en Mijnbouw, 21 Jaargang, no. 2, pp. 17-25, fig. 1 (bionomics of shell).

1947 *Canarium (Labiostrombus) labiosus* Wood, Wissema, Thesis, Leiden, p. 97 (*fide* Cox, 1948, p. 28, 70). Not seen by us.

Types—The holotype is presumably in the British Museum of Natural History in London. Wood gave

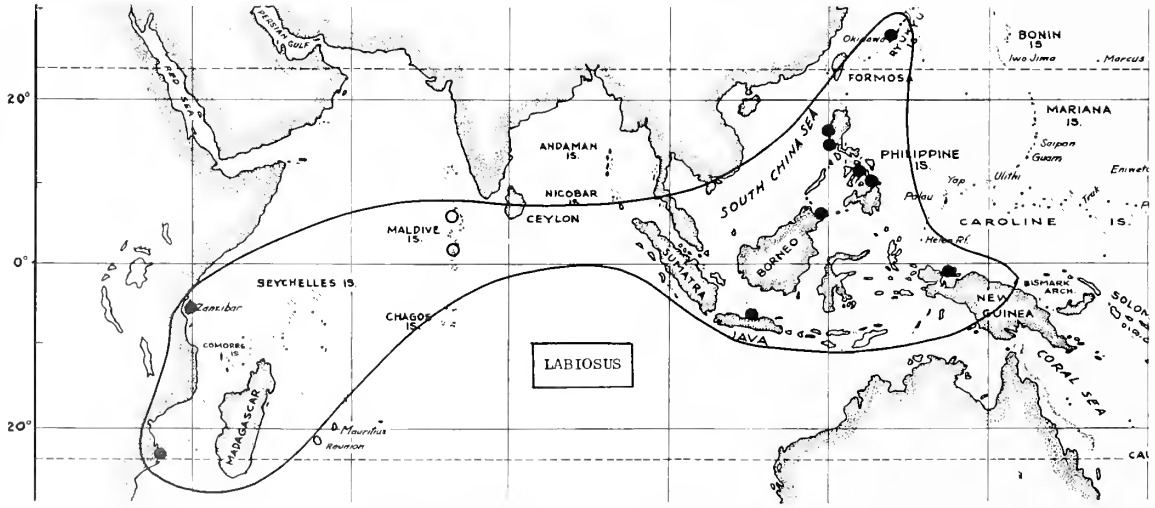


Plate 70. Geographical distribution of *Strombus labiosus* Wood. Open circles indicate literature records; solid dots, specimens examined.

no type locality. We now select Bataan, Luzon Id., Philippines, as the type locality.

Nomenclature—A number of authors have erroneously attributed Gray as the author.

Records (see map, pl. 70)—MOZAMBIQUE: Port Amelia (USNM). ZANZIBAR: 2 mi. west of Chango Id., 15 fms. (NSF). MADAGASCAR: Tamatave (Dautzenberg, 1929, p. 470). INDIAN OCEAN ISLANDS: Mulaku and South Nilandu Atolls, Maldive Islands (E. A. Smith, 1903, vol. 2, p. 612). RYUKYU ISLANDS: beach at Buckner Bay, Okinawa Id. (A. A. Scott, ANSP). PHILIPPINES: Luzon Id.: east end of Corregidor Id., 6-10 fms.; west side of Cochinos Pt., Bataan, 9 fms. (both du Pont-Academy Exped., 1958, ANSP); off Malavatuan Id., 18 fms., Albatross Station 5276. Cebu Id.: near Cebu City (USNM). Leyte Id.: off Tacbuc Pt., 48 fms., Albatross Station 5477; west of Bucas Grande Id., 44 fms., Albatross Station 5235 (both USNM). INDONESIA: Keledjitan, Bantam, Java Id.; off Taganak Id., Borneo Id., 39 fms., Albatross Station 5358 (both USNM). DUTCH NEW GUINEA: 1 mi. S.E. of Cape Dgarwawoffi, Japen Id., 10-16 fms. (NSF, 1956).

Fossil records—Cox (1948, p. 29) quotes Wissema's 1947 thesis as recording typical *labiosus* as occurring in the Plio-Pleistocene of Nias Island (west side of Sumatra), Indonesia. See also C. Beets, 1940, pp. 17-25). Tesch (Palaeontologie von Timor, 1920, pl. 129, fig. 164 a, b) figures this species (as *fennemai* K. Martin) from the Pliocene of Timor.

Plate 71. *Strombus labiosus* Wood. Holotype of var. *teschi* Cox from Dent Haven, British North Borneo. Pliocene. (from Cox, 1948, pl. 2, figs. 8a, b). Natural size.

Strombus labiosus *subspecies* teschi Cox, 1948

Range—Fossil (Pliocene), Java, Timor, Ceram, Philippines.

Remarks—Of the several characters mentioned by Cox as distinguishing this shell from the Recent *labiosus*, only one seems to hold true: there are no tubercles at the shoulder-angle on the dorsal side of the last whorl. The other characters, such as the 48 degree angle of spire, conspicuous striations on the inner side of the wing and of the inner lip, and the details of spiral ornamentation are all represented in living specimens. Wissema (1947, p. 97) notes that typical *labiosus* does exist in the Plio-Pleistocene of Nias Island (west side of Sumatra), Indonesia. Type locality: 7 km. inland from Dent Haven, Dent Peninsula, Borneo (Pliocene).

Synonymy—

1948 *Strombus (Labiostrombus) labiosus* Wood var. *teschi* Cox, Schweizerische Palaeontologische Abhandl., vol. 66, p. 28, pl. 2, figs. 8a, b (Borneo, Pliocene).

Strombus rutteni Altena, 1942

Range—Fossil (Pliocene) from Java, Indonesia.

Remarks—In spire and columella characters this species most closely resembles *Strombus labiosus* Wood but its body whorl is not as rotund, nor the wing of the outer lip as high. The subsutural cord persists to the end of the last whorl, but this feature may also occur in some living specimens of *labiosus*. Length of shell 43 mm., width 25 mm. Type locality: Padasmalang (Sheet 9313), Java: Upper Kalibeng layers, Pliocene. Paratypes from Doekoepengkol, Madioen, Java.

Synonymy—

1942 *Strombus (Labiostrombus) rutteni* Altena, Leidsche Geologische Mededeelingen, vol. 12, p. 53, figs. 15a, 15b (Pliocene, Java).

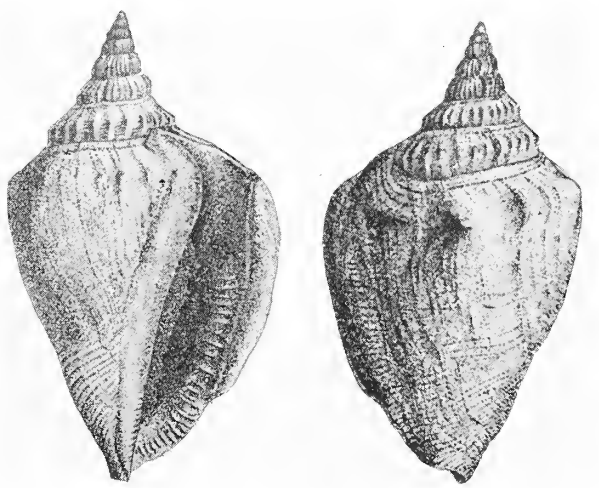


Plate 72. *Strombus rutteni* Altena. Holotype from the Pliocene of Java, Indonesia. (from Altena, 1942, p. 53, figs. 15a, b). × 1.5.

Strombus marginatus Linné, 1758

Until much more material is collected along the shores of Southeast Asia from India to Japan, this species will remain a puzzle with regards to the distribution of its forms and/or subspecies. True *marginatus* of Linné was the earliest name applied to this complex, but unfortunately is the peculiar form bearing a strong, sharp, smooth spiral keel on the shoulder of the last two whorls. This keeled form occurs in the coral-water areas of northern Ceylon, northwest Sumatra and central Burma. A subspecies, or possibly only an ecologic form, occurs in the non-coralline areas of the mainland of

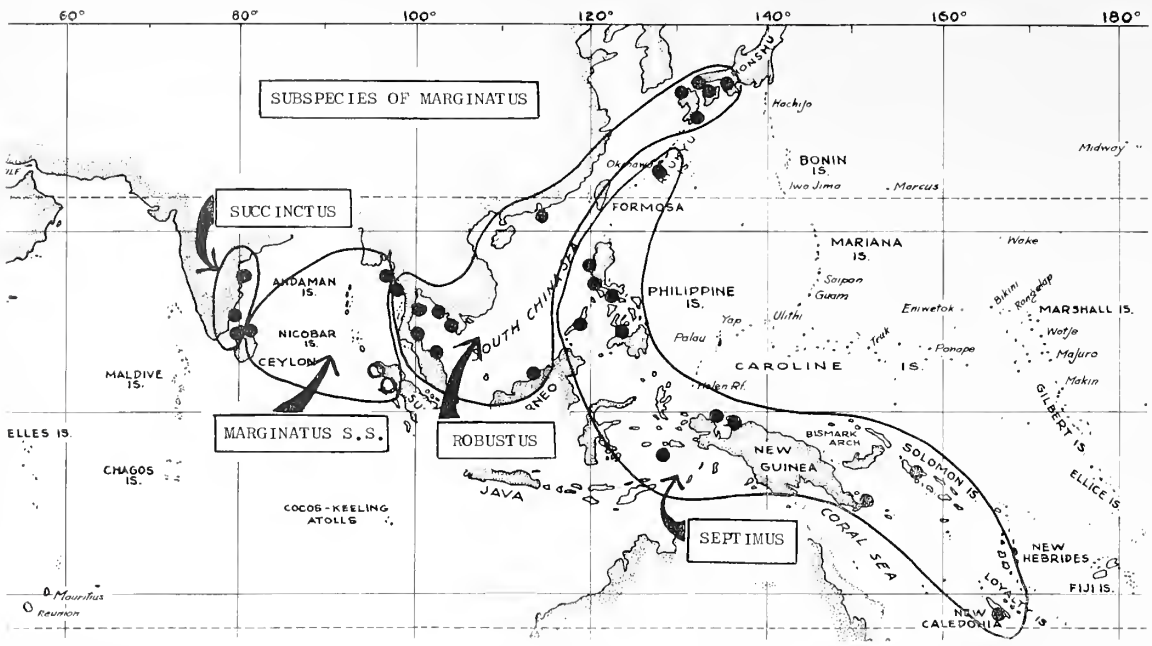


Plate 73. Geographical distribution of the races of *Strombus marginatus* Linné.

Ceylon. This is the elongate, glossy form, lacking a peripheral keel and having a single rather well-developed nodule on the dorsum near the shoulder. Linnaeus named this *succinctus* in 1767. Ranging northward from the Gulf of Siam to at least Hong Kong, and reappearing in Japan proper, is the subspecies *robustus* Sowerby which is a heavier, more rotund shell with a tendency towards short plications or several nodules on the shoulder.

A third subspecies seems quite recognizable in the warm waters of the great Southwest Pacific Island arc running from the southern Ryukyus, the Philippines and New Guinea to New Caledonia. This is the small, somewhat laterally compressed, darkly-colored subspecies *septimus* Duelos.

We have kept the synonymies and treatment of these forms or subspecies separate, until more is understood of this species.

Strombus marginatus *subspecies* marginatus Linné, 1758

(Pl. 18, figs. 6, 7; pl. 74, fig. 1)

Range—Known only from the areas surrounding the Bay of Bengal.

Remarks—This shell is characterized by the sharp, narrow, spiral carina or keel on the shoulder of the last 2 or 3 whorls. In most specimens the keel disappears in the area behind the outer lip. The body whorl may be smooth or entirely covered with numerous fine, but distinct spiral, incised lines. Intergrades exist in Burma between this form and the unkeeled *robustus*.

Habitat—Found below the low tide line in sandy silt and green algal bottoms not far from coral reefs. Von Martens (1887, p. 189) reports it on mud banks at low tide and at four fathoms in the Mergui Archipelago, off Burma.

Description—Adult shell 39 to 57 mm. (1½ to 2¼ inches) in length, solid, rotund, with its narrowing posterior canal arching up on to the spire, and with a strong, angular, sharp spiral keel on the shoulder of the last two whorls. Color of shell whitish with broad and narrow, broken, spiral bands of light- to dark-brown. Nuclear whorls 3, small, elevated, smooth and translucent-tan. Next 3 or 4 postnuclear whorls flat to slightly convex, with numerous, long, crowded, axial riblets (27 to 31 per whorl). In the last 2 or 3 whorls these riblets disappear or are reduced to tiny beads set on the shoulder keel just above the suture. In the last whorl the keel becomes smooth. Spiral sculpture in the spire of 8 to 15 fine threads. Spire with 0 to 8 small, swollen, whitish, former varices. Base of shell with about a dozen sharply incised lines which may also be present over the entire body whorl. Columella white, nearly straight, slightly swollen, and smooth, except for about a dozen weak, broken, wavy, raised lirae at the top and 4 to 10 tiny dentitions at the base. Outer lip thin, incurled, sinuous in side view, and arching up and over to the left on to the spire

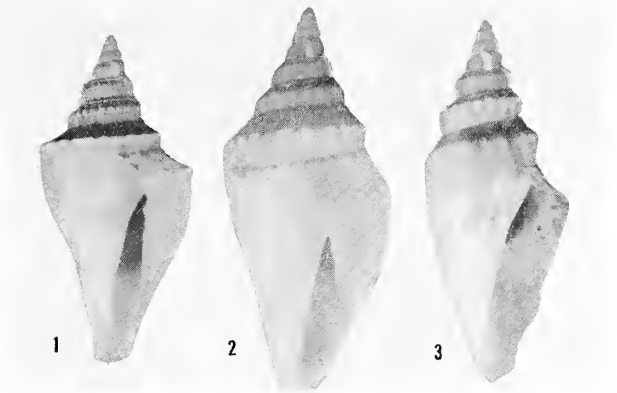


Plate 74. Immature shells of *Strombus*. Fig. 1, S. *marginatus marginatus* Linné, Ceylon. Fig. 2, S. *marginatus septimus* Duclos, Philippines. Fig. 3, S. *minimus* Linné, Philippines. All × 2.

where it ends at the first (rarely the second) suture above. Stromboid notch very shallow, sometimes only an undulation. Inside of outer lip with about 3 dozen fine, irregular or broken, raised white lirae. Periostracum thin, smoothish and translucent yellowish. Operculum stromboid.

Radular ribbon 4 mm. in length, wine-red, with 35 rows of rather delicate teeth. Formula of a Ceylon specimen: 2-1-2; 1-3 (plus peg); 5; 6. Proboscis and eye peduncles brownish maroon with white spots. Sides of foot weakly suffused with brown. Tentaeles rather short. Verge 20 mm., stout, with a broad, "heeled" distal blade; its stem dusted with brownish orange and small white spots. Posterior mantle filament short (2 mm.).

Measurements (mm.)–

length	width	no. whorls	
57.0	29.9	10	(large; Northern Ceylon)
45.2	27.5	9	(average, Gulf of Manaar)
39.0	26.0	7+	(small; "East Indies")

Synonymy–

1758 *Strombus marginatus* Linné, Systema Naturae, ed. 10, p. 744, no. 430 (no locality); 1767, ed. 12, p. 1209, no. 499; 1956, Dodge, Bull. Amer. Mus. Nat. Hist., vol. 111, art. 3, pp. 262-264; 1842, Sowerby, Thesaurus Conch., vol. 1, pl. 6, fig. 17; 1843, Kiener, Coquilles Vivantes, vol. 4, pl. 16, fig. 2; 1851, Reeve, Conch. Icon., vol. 6, Strombus, pl. 18, fig. 49.

1798 *Lambis carinata* Röding, Museum Boltenianum, Hamburg, pt. 2, p. 62, no. 779. Refers to Conchyl.-Cab., vol. 10, figs. 1489, 1490 and vol. 3, fig. 816.

Type–It is agreed by most workers (see Dodge, 1956, pp. 262-264) that Linnaeus did not have a type specimen, nor could he locate a published figure. Knorr's pt. 3, pl. 13, fig. 4 could be either *marginatus* or *succinctus*. The earliest of the recognizable figures is what Schröter called *marginatus* Linné (Einleit. Conchylien. Linné, vol. 1, p. 431, pl. 2, fig. 10; 1783). Subsequent workers have agreed

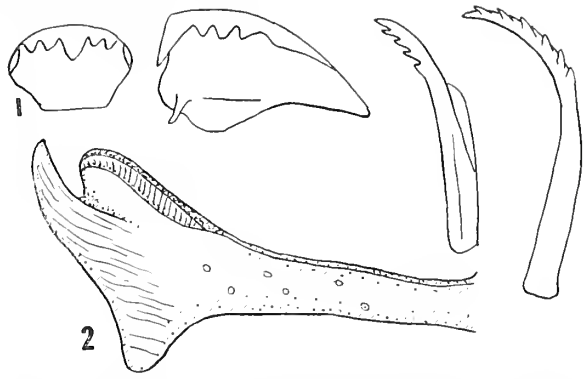


Plate 75. Fig. 1, radula of *Strombus marginatus marginatus* Linné, Ceylon. 2, verge.

that Linné's brief description does point to this species. No locality was given. The shell borrowed by Linné was probably from Ceylon, an island we now designate as the type locality.

Records–INDIA: Pamban, Gulf of Manaar (E. Thurston, 1895, p. 125). CEYLON: Pearl Bank, Gulf of Manaar (Kline, ANSP); north tip of Eluvativu Id. (Kline, ANSP). BURMA: Maungmagon, north of Tavoy (MCZ). SUMATRA: Oedjoeng Batee Kapal; Lam Baro, Atjeh Head (Oostingh, 1929, no. 39, p. 2). [Philippine records are unconfirmed.]

Fossil records–None reported.

Strombus marginatus *subspecies* succinctus Linné, 1767

(Pl. 18, figs. 13, 14)

Range–Ceylon to Madras, India.

Remarks–This is a distinct shell limited to the non-coralline waters of Ceylon and the southeast end of India. Insufficient material is at hand to decide for certain whether this represents a very localized subspecies or an ecologic form. The shell is more elongate and paler in color, and is characterized by a single, rounded, distinct knob on the dorsum of the body whorl at the shoulder. The pale brownish yellow body whorl has 4 or 5 narrow white bands which are delicately flecked with brown.

Habitat–Below low water mark in muddy sand in a sheltered bay (G. and M. Kline in Ceylon); dredge in muddy sand off Madras in several feet of water (Crichton, 1940, p. 203).

Description–Shell 40 to 53 mm. (1½ to 2 inches) in length, smoothish, moderately elongate, and weakly patterned with soft yellow-brown and white. Whorls 10 to 12. Nuclear whorls 2½, small, elevated, glossy, translucent-white. Apical whorls with numerous (about 30) axial riblets which are crossed by about a dozen microscopic, spiral

threads. The first 3 or 4 postnuclear whorls bear a total of 4 to 8 swollen, whitish, rounded, former varices. Suture minutely indented; in the early whorls it is bordered below by a distinct spiral, striated cord; in the third-to-last whorl the suture is commonly bordered above by small beads or nodules. Body whorl usually smooth, except for a few weak spiral threads at the top and about a dozen incised lines at the base. Ventral side of body whorl smooth and flattened; dorsal side, near the shoulder, with one small, but prominent, rounded, low nodule. Color of outer shell a light yellow-brown consisting of very fine reticulated and arrow-shaped lines. Body whorl bears 4 (occasionally a 5th at the base) spiral white bands which are sparsely overlaid with weak arrow-shaped brown lines. Aperture elongate, white and spirally striated within. Parietal callus white, slightly swollen and weakly wrinkled at the top. Outer lip sinuate, sharp, its edge curling inward slightly; posterior canal long, adhering to 2 or 3 whorls in the spire, and extending straight up. "Stromboid notch" weak. Periostracum thin, varnish-like and transparent. Operculum and soft parts not known.

Measurements (mm.)—

length	width	no. whorls	
55.2	22.0	10	(large; "Indian Ocean")
47.1	20.8	10	(average; Nilaveli, Ceylon)
38.3	18.1	9	(small; Trincomalee, Ceylon)

Synonymy—

1767 *Strombus succinctus* Linné, Systema Naturae, ed. 12, p. 1212, no. 509 (In India); 1855, Hanley, Ipsa Linnaei Conchylia, London, p. 274; 1956, Dodge, Bull. Amer. Mus. Nat. Hist., vol. 111, art. 3, pp. 278-280.

1767 *Strombus accinctus* Linné, Systema Naturae, "13th ed." in Vienna (reform. Holmiensen), p. 1212; 1958, Iredale, Proc. Royal Zool. Soc. New South Wales, for 1956-57, p. 61; 1778, Born, Index Rerum Nat. Mus. Caes. Vindob., pt. 1, p. 280.

1768 *Strombus succinctus* Linné, Systema Naturae, ed. 12, vol. 3, "Errata". (for *uccinctus*).

1777 *Strombus succinctus* Linné, Martini, Conchyl.-Cab., Nurnberg, vol. 3, p. 104, pl. 79, fig. 815 (but not 816); 1843, Kiener, Coquilles Vivantes, vol. 4, Strombus, pl. 10, fig. 2 (excellent); 1842, Sowerby, Thesaurus Conchyl., vol. 1, pl. 6, fig. 20.

Types—The type locality is "In India" which we further restrict to Madras, India. Hanley (1855, p. 274) states that the type is in the Linnaean collection and implies that it is figured in Sowerby (1842, vol. 1, pl. 6, fig. 20). None of Linné's figure references refer to this subspecies, all of them being *septimus* Duclos, except for Seba, pl. 62, fig. 20 which is *vittatus* Linné.

Records (see map, pl. 73)—INDIA: Madras (Crichton, 1940, p. 203). CEYLON: Kachcheri Bay, Trincomalee, Ceylon (G. and M. Kline, NSF); 12 miles north of Trincomalee (W. E. Old, Jr., ANSP); Ara Pt., Nilaveli (H. G. Deignan, USNM); Pearl banks, Gulf of Manaar (R. Jonklass, ANSP).

Strombus marginatus *subspecies* robustus Sowerby, 1874

(Pl. 18, figs. 8, 9; pl. 76)

Range—South China Sea to southern half of Japan.

Remarks—This is a quite variable shell, not only within a single colony, but also in certain characters which show a geographical cline. It is perhaps best characterized by its rotund shape (not elongate as in *succinctus*, and not laterally compressed, as in *septimus*), and varying number (1 to 12) of short plications or elongate nodules on the shoulder of the last whorl. In almost every specimen the plication bordering the left side of the parietal wall is the largest and longest. The upper part of the aperture extends up over two sutures at least, sometimes straight up towards the apex, and rarely may arch over to the left. The apex may be pink, purplish or whitish. In Japan the species is abundant and the shell attaining its maximum size of 67 mm. It is also abundant in the Gulf of Siam where the length of the shell ranges from 26 to 50 mm. The MCZ contains two specimens from Sarawak, Borneo, which we refer to as the "*rotund form*." This shell (see pl. 76) is pyriform, smoothly

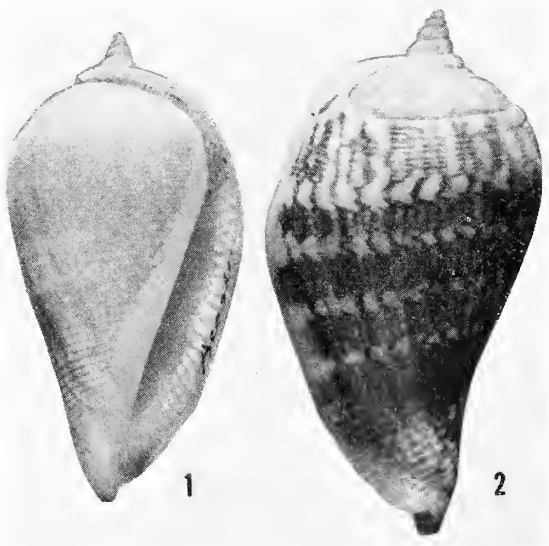


Plate 76. Figs. 1 and 2, *Strombus marginatus robustus* Sowerby, bulbous form from Sarawak, Borneo. Both × 1.5.

rounded at the shoulder, with one weak plication bordering the left side of the parietal wall; finely and microscopically spirally striate and with its posterior canal arching far over to the left. This might prove someday to be a valid subspecies.

Habitat—On sandy to sandy mud bottoms from 1 to 25 fathoms near shore. In Kyushu Island, Japan, it is abundant.

Description—Shell 29 to 67 mm. (1 to 4½ inches) in length, rotund and broadly elongate. Color yellow-brown with irregular white marking. Similar to *marginatus succinctus* and *marginatus septimus*, but the body whorl is more rotund; the shell generally larger; commonly (although not always) with spiral threads over the entire last whorl; and with the long posterior siphonal canal arching up over 1 to 3 sutures. The left border of the ventral (parietal) side of the body whorl characteristically has a peculiar axial swelling. The shoulder on the dorsal side may have one small node and on the ventral side may rarely have a series of short, small axial plications. In some Japanese specimens the interior may be weakly flushed with light-violet. Periostracum thin, translucent yellowish and smoothish. Operculum and soft parts not available for study.

Measurements (mm.)—

length	width	no. whorls	
67.1	37.2	8+	(large; Kyushu Id., Japan)
44.1	24.7	10	(average; Hong Kong)
29.0	16.0	9	(small; Koh Chang, Thailand)

Synonymy—

1874 *Strombus robustus* Sowerby, Proc. Zool. Soc. London for 1874, p. 599, pl. 72, figs. 5, 5a (Hong Kong).

1899 *Strombus septimus* Duclos, Crosse and Fischer, Journ. de Conchyl., vol. 37, p. 287 (Annam). Not *septimus* Duclos.

1959 *Labiostrombus succinctus* Linné, Kira, Coloured Illustr. Shells of Japan, Osaka, 2nd ed., p. 36, pl. 15, fig. 14.

Types—Sowerby's holotype of *robustus* is in the British Museum of Natural History in London. The type locality is Hong Kong.

Nomenclature—Workers on the Japanese fauna have in the past considered *robustus* Sowerby a synonym of *succinctus* Linné. We consider the latter to be an Indian Ocean subspecies of *marginatus* Linné, and *robustus* an eastern Asian subspecies of *marginatus*.

Records (see map, pl. 73)—BURMA: Sandoway (MCZ). THAILAND: Koh Chang; Koh Samet; Khan Nu Paknam (all Gulf of Siam, USNM); Ban Ao Moo, Bang Ko Chai, Chantaburi Prov. (G. Moore, MCZ). HONG KONG: south of Lema Id., 25 fms. (A. J. Staple, ANSP). BORNEO: Sarawak (**rotund form** MCZ). JAPAN: Honshu Island: Sagami Bay, Kanagawa Pref. (A. R. Cahn, ANSP); Kii, Wakayama Pref. (MCZ). Shikoku Island: Tosa Bay, Kochi Pref. (ANSP). Kyushu Island: Moeshima, Kagoshima Bay (T. Habe, ANSP); Miyazaki Pref. (T. Kuroda, 1935, p. 47, no. 142).

Fossil records—Schepman (1907, p. 186) reports this subspecies from the post-Tertiary of the Celebes.

Strombus marginatus *subspecies* septimus Duclos, 1844

(Pl. 18, figs. 10, 11; pl. 74, fig. 2)

Range—Ryukyu Islands southward through the Philippines, East Indies and New Guinea to New Caledonia.

Remarks—The shells of this subspecies are more brightly colored and with a more flaring lip, which gives the shell a slightly flattened or dorso-ventral compression. The color is generally dark-brown with 4 to 6 narrow, white spiral bands which bear numerous arrow-shaped spots of dark-brown. The upper end of the outer lip, or posterior canal, usually ascends only to the first suture above, and not up to the second or third suture, as in *robustus*. The dorsal hump, so prominent in *succinctus*, is reduced or absent in *septimus*.

Habitat—This subspecies has been collected on coral sand and rubble bottom in 4 to 16 fathoms of water. It is commonly washed ashore after storms. We have not found it on coral reefs nor in pure mud areas. Abundant in the Philippines and the Solomons, but rare in the Ryukyus and southern Indonesia.

Description—Shell 26 to 48 mm. (1¼ to 2 inches) in length, broadly elongate and colored with dark-chestnut to rich yellow-brown. Similar to *marginatus succinctus*, but is not as elongate; its lip is broader and more flaring; the posterior siphonal canal extends up to only the first suture; the shoulder of the body whorl lacks the single node but may have one to several very small nodules or beads. Color of shell dark-chestnut to light-brown with 5 to 7 narrower white spiral bands which are crossed by darker, more numerous, arrow-shaped bars of brown. Apex with 9 to 11 whitish former varices. Periostracum moderately thin, translucent-brown. Operculum stromboid, with 5 to 6 serrations. Verge maroon-brown with white dots and a "heel" on the distal blade. Radula 2 to 3 mm., with 37 to 42 rows of teeth. Formula variable: 2-1-2 (also 3-1-3); 1-3 (plus peg), also 1-5 (plus peg); 5 to 7; 6 to 9. Animal like *marginatus*.

Measurements (mm.)—

length	width	no. whorls	
48.5	25.0	10+	(large; Dutch New Guinea)
42.6	23.4	10	(average; Solomon Islands)
30.2	15.0	10	(small; Luzon Id.)

Synonymy—

1844 *Strombus septimus* Duclos, Illustr. Conchyl., vol. 4, p. 7, pl. 13, figs. 9, 10, pl. 15, fig. 11, pl. 26, fig. 2 (locality unknown).

1885 *Strombus succinctus* var. *septimus* Duclos, Tryon, Manual of Conchology, vol. 7, p. 117.

Types—Duclos' type is presumed to be in the Muséum d'Histoire naturelle de Genève. No locality was given, and we hereby designate Lusong, Bataan Peninsula, Luzon Island, Philippines, as the type locality.

Nomenclature—Tryon (1885, p. 117) considered *septimus* as a variety of *succinctus*. Most other workers have considered it to be merely a form and synonym, but with a series of accurately localized material we consider it to be of subspecific rank. The pre-Linnaean figures are mostly of this subspecies: Rumphius, pl. 37, fig. x; Gualtieri pl. 33, fig. B; Seba, pl. 61, fig. 15 (but not 20).

Records (see map, pl. 73)—RYUKYU ISLANDS: Buckner Bay, Okinawa Id., rare (Mrs. A. A. Scott, ANSP). PHILIPPINES: Luzon Id.: Sisiman Cove; Lusong; Bataan; east end of Corregidor Id.; San Nicolas Shoals Light, Manila Bay (all du Pont-ANSP expedition, 1958). Masbate Id. (ANSP). Basilan Id.; Dupolog, Mindanao Id.; Puerto Princessa, Palawan Id. (USNM). INDONESIA: Amboina Id. (MCZ). NEW GUINEA: Oro Bay (ANSP); off Cape Dgarwawoffi, and off Samberbaba, both Japen Id. (NSF). SOLOMONS: Kieta, Bougainville Id. (W. J. Eyerdam, ANSP). NEW CALEDONIA: Bourail (Mme. Revercé, ANSP).

Fossil records—None reported.

Fossil Relatives of *marginatus*

A number of Tertiary species have been described from the East Indies which are undoubtedly closely related to and the possible progenitors of either *septimus* and/or *robustus*. I have not had the opportunity to examine sufficient fossil material to hazard a scheme of relationships. One species from northeast Borneo (Pliocene) could probably be considered as rather closely resembling the subspecies, *septimus*, i.e. *togopiensis* Cox, 1948. These fossil species, subspecies or forms are:

Strombus togopiensis Cox, 1948

Range—Pliocene of northeast Borneo, Indonesia.

Remarks—Probably closely related to *S. marginatus septimus* Duclos.

Synonymy—

1948 *Strombus (Labiostrombus) togopiensis* Cox, Schweizerische Palaontologische Abhandl., vol. 66, p. 27, pl. 2, figs. 10a, b (Dent Peninsula, Borneo, Pliocene).

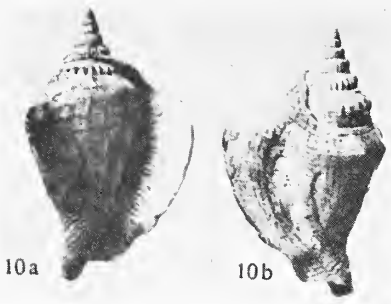


Plate 77. *Strombus togopiensis* Cox. Holotype from Dent Haven, British North Borneo. Pliocene. (from Cox, 1948, pl. 2, figs. 10a, 10b). Natural size.

Strombus sedanensis Martin, 1899

Range—Lower Miocene of Java, Indonesia, and Lower Miocene of West Pakistan.

Remarks—The characters of the spire and the carination of the shoulder in the area of the parietal wall suggest an affinity with the Recent *marginatus* group. However, the rather thick, rounded outer lip and the strong tubercles on the shoulder of the body whorl are particularly curious. I would be inclined to accept this as a full species. I. van der Vlerk, 1931, p. 247 calls the Rembang beds Lower Miocene.

Synonymy—

1899 *Strombus (s. str.) sedanensis* K. Martin, Samml. geol. Reichs-Mus. Leiden, n. Folge, vol. 1, pt. 1, p. 180, pl. 29, figs. 416, 416a (Sedan in Rembang, Java); 1928, Vredenburg, Mem. Geol. Survey India, Calcutta, vol. 50, pt. 1, p. 313 (Gaj beds, near Karachi).

Strombus javanus Martin, 1879

Range—Miocene of Java, Indonesia.

Remarks—This species was based upon an incompletely preserved specimen, but from the characters of the outside of the outer lip and its size, it could be somewhat likened to the Recent *Strombus marginatus septimus* Duclos. Miocene according to van der Vlerk, 1931, p. 246. Smith's *semperi* is possibly a synonym.

Synonymy—

1879 *Strombus javanus* K. Martin, Die Tertiärschichten auf Java, Leiden, p. 47, pl. 9, fig. 2 (Java, Tertiary). Prior to Dec. 1879.

1879 *Strombus sumatranus* H. Woodward, Geol. Mag., London, new series, decade 2, vol. 6, p. 543, pl. 14, fig. 19 (Tertiary Clay-marl, West Coast of Sumatra). Dec. 1879.

1900 *Strombus javanus* var. *semperi* W. D. Smith, Philippine Jour. Science, vol. 1, pl. 3, fig. 3, p. 629 (Upper Miocene, Loboo River, Batangas Prov., Luzon Id., Philippines).

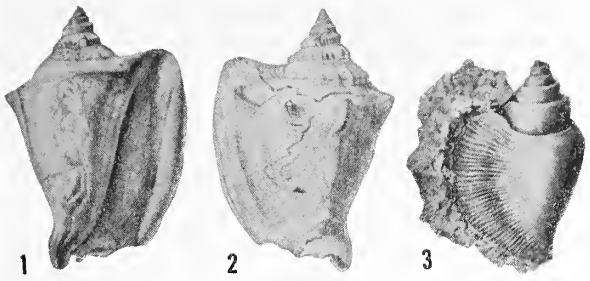


Plate 78. Figs. 1 and 2, *Strombus sedanensis* Martin. Lower Miocene of Java. (from K. Martin, 1899, pl. 29, figs. 416, 416a). Fig. 3, *Strombus javanus* Martin. Type from the Miocene of Java (from K. Martin, 1879, pl. 9, fig. 2). All natural size.

Strombus variabilis *subspecies* variabilis Swainson, 1820

(Pl. 14, figs. 21, 22)

Range—Sumatra and Thailand, eastward through Micronesia, Melanesia, northern Australia to Samoa.

Remarks—This species is rather variable in size, shape and color pattern. Insufficient material is available to establish any clear-cut subspeciation, but we would point out the presence of three forms. Typical *variabilis* from the western part of the range is the largest (usually about 2 inches in length), generally has a brown spot on the columella, has numerous, short, dark-brown, zigzag axial lines on the outer shell, and has well-shouldered apical whorls. At the east end of the range the supposed subspecies *athenius* is smaller (usually about 1¼ inches in length), is lighter-colored, with a more rounded spire, much heavier shell, and rarely has a brown patch on the columella. A dark-banded color form (pl. 14, fig. 20) occurs sporadically in the middle of the range.

Habitat—Just below the low tide mark in weedy, sandy mud to 25 fathoms in weed and coral sand.

Description—(of the typical form) Shell 33 to 60 mm. (1¼ to 2½ inches) in length, solid, moderately light, with a well-knobbed, shouldered spire, and winged outer lip. Color of shell enamel-white to cream with a heavy flecking and suffusion of dark- to yellow-brown, mainly consisting of numerous, crowded, short, zigzag lines. The last whorl has 5 narrow, indistinct, spiral, white bands. Columella and aperture smooth and milky white. Most specimens have a distinct, dark-brown, oblong color patch on the center of the columella. Whorls 9 to 10. Nuclear whorls 3, the first being minute and elevated, the remaining being rounded, glossy, smooth, and translucent-tan. First three postnuclear whorls with 10 to 12 microscopic, squarish spiral threads. The fourth and later whorls bear 13 to 16 evenly-sized and evenly-distributed rounded knobs midway between the suture, this giving the periphery of the whorl an angular or shouldered appearance. Ventral side of body whorl smooth, slightly keeled above; dorsal side with 3 or 4 knobs, the next to last being largest, and the earlier ones being axially elongated. There are 8 to 9 whitish, rounded, swollen former varices in the first 4 postnuclear whorls. Base of shell with about 18 indistinct spiral threads. Columella smooth, rarely with a few very weak plications at the base. Inner lip usually smooth, but rarely with a few lirae near the base and stromboid notch. Upper end of outer lip with a short posterior siphonal groove and a shallow notch. Periostracum rather thin, translucent-tan, usually worn away. Operculum stromboid, strongly arching, light-brown, about one third the length of the shell, and with 7 strong serrations.

Radula ribbon 4 mm., light-tan and with about 42 rows of teeth. Formula 2-1-2; 1-2 (plus peg); 4; 4. Verge with a prominent thumb-like appendage on the broad, distal blade.

Measurements (mm.)—

length	width	no. whorls	
60.0	30.0	9+	(large; Cebu Id.)
49.0	25.0	10	(average; Balabac Id.)
33.0	18.5	9	(small; Balabac Id.)

Synonymy—

1820 *Strombus variabilis* Swainson, Zoological Illustrations, series 1, vol. 1, pl. 10 (South Seas) (spotted variety from India); 1843, Kiener, Coquilles Vivantes, vol. 4, pl. 21, fig. 2; 1844, Duclos, in Chenu's Illustr. Conchyl., vol. 4, pl. 11, figs. 9, 10; 1850, Reeve, Conch. Icon., vol. 6, Strombus, pl. 10, fig. 21c and d.

1829 *Strombus lituratus* Menke, Verzeichniss Conchyl.-Samml. Malsburg, Pyrmont, p. 58, no. 1205 (no locality); 1871, Morch, Malakozool. Blätter, vol. 18, p. 127.

Types—Swainson's type is probably lost. He evidently had a mixture between the typical *variabilis* and the smaller *athenius*. The fact that he speaks of "numerous undulated short lines of darker colour" and a shell "two inches and a quarter long" leads us to believe he meant the Philippine form which we have figured on plate 14, fig. 21 and 22. For similar figures, see those mentioned in the above synonymies. We restrict the type locality to Cebu Island, Philippines.

Plate 79. Figs. 1 and 2, immature and adult *Strombus variabilis variabilis* Swainson, Luzon Id., Philippines. 3 and 4, adult and immature S. *variabilis athenius* Duclos, Dutch New Guinea. All × 1.5.

Records (see map, pl. 80)—THAILAND: Koh Samet; Koh Chang (USNM); Ban Pe, Rayong Prov. (MCZ). INDONESIA: Poelo We, Atjeh, w. Sumatra Id. (Oostingh, 1929, no. 39, p. 2); Bouro Id., Moluccas (MCZ); Woda Id., Halmahera (MCZ). MALAYA: Singapore (USNM). PHILIPPINES: Mindoro: San Jose; Tilic Bay, Lubang Id. (both MCZ); Luzon: Tabaco, Albay Prov. (du Pont-Academy Exped., 1958); Legaspi Bay (ANSP); Palawan: Balabac and Cuyo Id. (ANSP); Cebu: Bantayan (ANSP); near Cebu City (A. B. Franco, ANSP); Bohol: off Jagoliao Id., 2 fms. (E. Zambo, ANSP); Mindanao: Zamboanga (ANSP); Sulu Archipelago: Sanga Sanga Id. (John Root, ANSP). CAROLINES: Peleliu Id., Palau Ids. (NSF, 1955). ADMIRALTY ISLANDS: 16-25 fms. (R. B. Watson, 1886, "Challenger," p. 420). SOLOMONS: Buin, Bougainville Id. (MCZ; ANSP). AUSTRALIA: Yirrkala, Arnhemland; Croote Eylandt, Culf of Carpenteria (both USNM); Swecrs Id., Culf of Carpenteria (MCZ); Queensland: Creen Id., Batt Reef, and Low Id. (MCZ; ANSP). [Melvill and Sykes, 1899, p. 44, record "Andamans", but this needs verification.]

Fossil records—Pliocene: Nias Id., off Sumatra, Indonesia (Icke and Martin, 1907, pp. 214, 239, pl. 15, figs. 23, 23a (this is based upon a young specimen which only resembles an immature *variabilis*). Pliocene: Upper Kalibeng layers, Java, Indonesia, according to Altena (1942, pp. 54, 55). Quaternary of East Borneo: Pocloe Boenjoe (Beets, 1950, vol. 15, p. 244).

Strombus variabilis *subspecies* athenius Duclos, 1844

(Pl. 14, fig. 20; pl. 79, figs. 3, 4)

Range—Northern New Guinea, Marshalls to Samoa and New Caledonia.

Remarks—Insufficient material is available for a more complete understanding of this subspecies. It is possible that it represents a stunted ecological form. It is characterized by its much heavier shell, more rounded apex, absence of numerous, small, axial lines of dark-brown, its lighter color (which is all-white in Samoa and the Gilberts), and by the more weakly shouldered apical whorls. Its body whorl usually has 5 very broad light orange-brown bands. 10 of 57 specimens examined have the small dark patch on the columella, while in the typical *variabilis* from the Philippines 90 per cent of several dozen specimens have the brown columellar patch. Its length is between 26 and 43 mm. Animal similar to that of *variabilis*. Verge with a less developed thumb-like appendage. Radula formula: 2-1-2; 1-3 (plus peg), rarely 1-2 (plus peg); 4 or 5; 4, 5, or 6.

A third kind which appears to be a color form (our plate 14, fig. 20, p. [09-833]) has turned up in the Palau Islands, the Solomons, New Caledonia and northeast Australia. It is characterized by 5 or 6 very dark, even, chocolate-brown spiral bands. Reeve (1850) figures it in his pl. 10, fig. 21a from Darnley's Island, Australia. The sculpturing and the shape of the shell is more like true *variabilis*, but in color pattern it is more like *athenius*.

Measurements (mm.)—

length	width	no. whorls	
43.0	24.0	8+	(large; Dutch New Cuinea)
36.5	20.0	9	(average; Dutch New Cuinea)
27.0	15.5	9	(small; Dutch New Cuinea)

Synonymy—

1843 *Strombus variabilis* Swainson, Kiener, Coquilles Vivantes, Paris, vol. 4, pl. 21, fig. 2a (not fig. 2); 1850, Reeve, Conch. Icon., vol. 6, pl. 10, fig. 21b (not others).

1844 *Strombus athenius* Duclos, in Chenu's Illustr. Conchyl., vol. 4, p. 7, pl. 11, fig. 2 (probably not fig. 1). Locality unknown.

Types—We hereby designate as the lectoholotype the specimen figured on plate 11, fig. 2 in Duclos' *Strombus* monograph of 1844. We restrict the type locality to Biak Island, Dutch New Guinea.

Nomenclature—Duclos described this species on the basis of several good characters, as mentioned above. However, he was not aware that some specimens may have a brown columellar patch, a feature which he erroneously attributed solely to

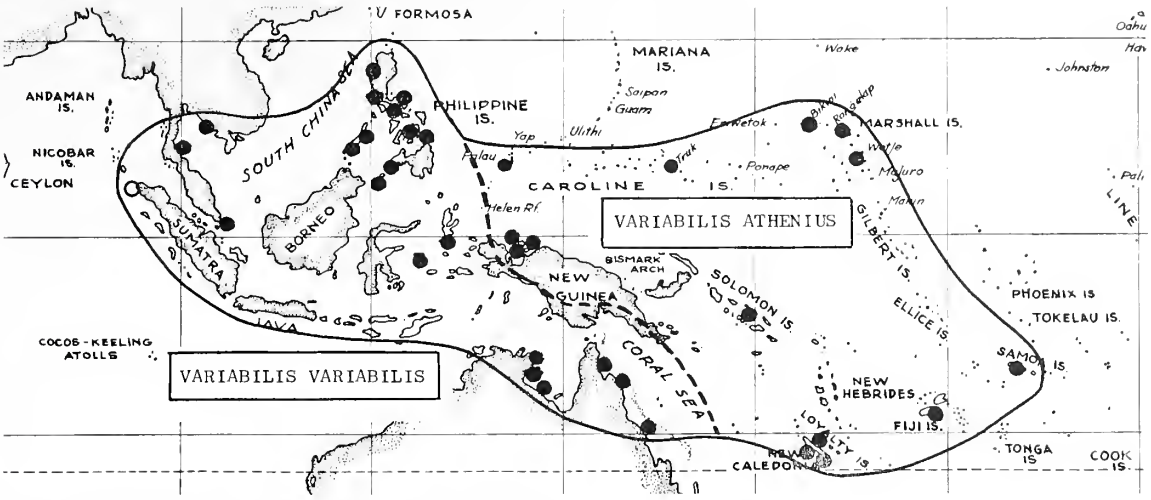


Plate 80. Geographical distribution of *Strombus variabilis variabilis* Swainson and its eastern subspecies, *athenius* Duclos.

variabilis. It is possible that his figure 2 is a true *variabilis*.

Records (see map, pl. 80)—DUTCH NEW GUINEA: off Rani Island, Schouten Ids., 1-3 fms.; off Rouw Id., Aoeri Ids., 1 fm.; Matas Id., Aoeri Ids., intertidal; off Mios Woendi, Padaido Ids., 3-8 fms.; 2 mi. west of Korido, Soepiori Id., reef flat (all NSF, 1956). NEW CALEDONIA: Dge (Cockerell, ANSP); Laregnere Reef, E. of Noumea, 2 fms.; Noumea, 4-12 fms.; barrier reef, Touho Bay (all G. and M. Kline, NSF, 1959). FIJI: Suva (ANSP). MARSHALL ISLANDS: Bikini; Rongelap; Majuro; Arno lagoon (all USNM); Kwajalein (Yale Peabody Mus.). GILBERTS: Apiang (MCZ). SAMOA: Tutuila Id. (ANSP). CAROLINES: Truk Id. (Mrs. R. T. Gallemore).

Fossil records—None recorded.

Strombus minimus Linné, 1771

(Pl. 18, figs. 4, 5; pl. 74, fig. 3)

Range—Ryuku Islands to Indonesia and eastward through Melanesia to Fiji.

Remarks—This species is locally abundant in the middle of its range, but rather uncommon to the north and to the east. It is evidently absent from small islands or coral waters. It is readily recognized by its small, thick, heavy shell, chrome-yellow aperture, and by the swollen columella and thick posterior siphonal canal. No subspecies have been recognized, except Abrard's Pliocene *minor* which we believe is *pulchellus* Reeve.

Habitat—Lives in large colonies from the low tide mark down to 12 fathoms, sometimes on coral sand and weed bottom, at other times in muddy, dirty, shallow water. Its sparsity in the Ryukyu Islands, Fiji and New Caledonia probably means that it does not live in very shallow water in those areas. They are cast up on many Philippine beaches after storms.

Description—Shell 14 to 40 mm. (usually about 30) in length (about 1 inch), very heavy and solid for its size, with a swollen columella, with the edges of its posterior siphonal canal swollen, and with a chrome-yellow aperture. Color of outer shell dark- to light- brown with minute flecks of cream. Last whorl with one, rarely two, spiral rows of white squares. Parietal wall usually cream to whitish. Whorls 9; nuclear whorls 3, the first very small and elevated, the remainder rounded, glossy, smooth and translucent brown to tan. Next 4 postnuclear whorls with about 15 microscopic, squarish, spiral threads which cross over the 9 small, rounded, whitish former varices. Axial sculpture begins in the 5th whorl in the form of about 17 elongated, shouldered knobs. The smooth ventral wall of the body whorl is swollen on its left by an elongate axial ridge, and followed anteriorly by 2 or 3 small shoulder knobs. Posterior siphonal canal slightly S-shaped, extending up over 2 sutures, and with 2 very thickened, flattened edges. Columella very swollen, white, smooth, but rarely with 2 to 4 weak lirae at the base. Outer lip smooth within, except for a dozen very weak, short lirae at the base. Interior of aperture chrome-yellow. Base of shell with about 10 weak spiral threads. Stromboid notch very shallow. Periostracum moderately developed, translucent-tan. Operculum stromboid, slightly less than one third the length of the shell, and with 8 well-developed, sharp serrations.

Radula ribbon delicate, translucent-tan, 2 mm. in length (shell 29 mm.), and with about 33 rows. Formula for one Luzon specimen: 3-1-3; 1-4 (plus peg); 5; 7. Another Luzon specimen: 2-1-2; 1-3 (plus peg); 5; 6. Tentacles and posterior mantle filament long. Animal with red-brown maculations and dustings of black. Verge unknown.

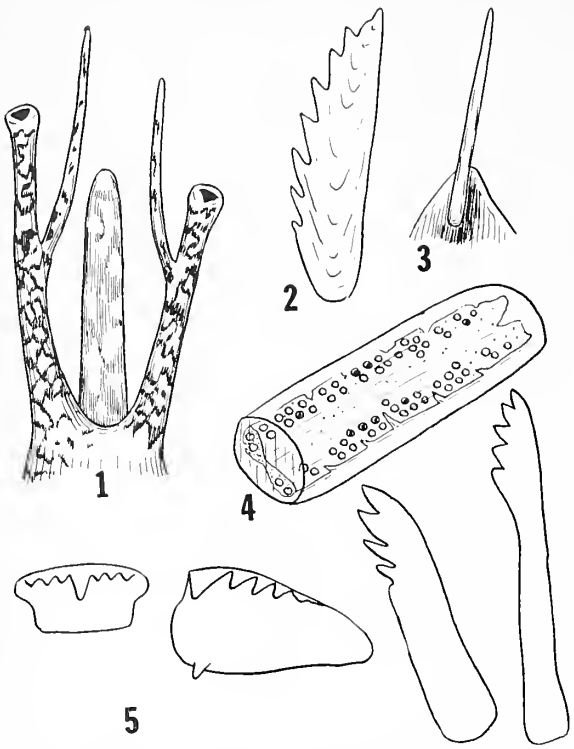


Plate 81. *Strombus minimus* Linné, Luzon Island, Philippines. Fig. 1, dorsal view of head, showing eye peduncles and proboscis. 2, operculum. 3, posterior corner of mantle margin, showing 2 mm.-long, fleshy appendage. 4, 3-mm. terminal part of gelatinous egg mass removed from preserved female. 5, radular teeth.

Measurements (mm.)—

length	width	no. whorls	
14.0	9.0	5+	(small; Luzon Id.)
41.0	21.5	10	(large; Cebu Id.)
31.5	18.0	10	(average; Luzon Id.)

Synonymy—

1771 *Strombus minimus* Linné, Mantissa plantarum—regni anim. appendix, p. 549 (In India orientali); 1956, Dodge, Bull. Amer. Mus. Nat. Hist., vol. 111, art. 3, p. 298-299; 1851, Reeve, Conch. Icon., vol. 6, pl. 18, fig. 47.

1798 *Lambis minimus* Gmelin, Röding, Museum Boltenianum, Hamburg, pt. 2, p. 65, no. 836. Refers to Conchyl.-Cab., vol. 10, figs. 1491, 1492.

1822 *Strombus troglodytes* Lamarck, Anim. sans Vert., vol. 7, p. 209 (Grandes Indes). Refers to S. *minimus* Linné; Conchyl.-Cab., vol. 10, figs. 1491 and 1492; and others.

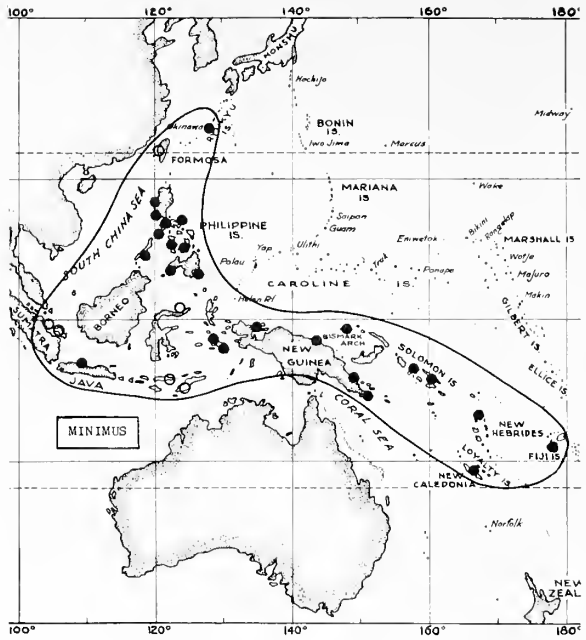


Plate 82. Geographical distribution of *Strombus minimus* Linné.

1843 *Strombus troglodites* Lam., Kiener, Coquilles Vivantes, vol. 4, pl. 31, fig. 2.

Types—According to Dodge (1956, p. 298), Linnaeus' type is not in existence. We hereby restrict the type locality to Cebu City, Cebu Island, Philippines, from whence our figures 4 and 5 specimens come.

Records (see map, pl. 82)—RYUKYU ISLANDS: Buchner Bay (A. A. Scott, ANSP). TAIWAN: Taihoku-syu (Kuroda, 1941, p. 97). PHILIPPINES: abundant throughout the archipelago: Luzon; Mindanao; Cebu; Panay; Palawan; Mindoro; Negros; Camaguin; and Marinduque Ids. (ANSP; USNM; MCZ). INDONESIA: Amboina (MCZ); Isle of Dol, N. Loloda Ids. (MCZ); Riouw Ids.; Banka Id.; Celebes; Flores; Timor (all Oostingh, 1923, p. 83). NEW GUINEA: Dauwi Id., E. Padaido Ids. (NSF, 1956); Finschhafen (MCZ); Samarai and Oro Bay (ANSP); Seleo Id., Aitape Id. (USNM). SOLOMONS: Rabaul, New Britain Id. (USNM); Guadalcanal Id. (MCZ). NEW HEBRIDES: Espiritu Santo Id. (MCZ). NEW CALEDONIA: Touho Bay (G. and M. Kline, NSF, 1959). FIJI: off Rukua, Bega Id., 3-12 fms. (D. Thaanum); Suva Pt., Viti Levu Id. (H. S Ladd, USNM).

Fossil records—INDONESIA: Pliocene of Sondc, Java (K. Martin, 1899, p. 182, pl. 29, fig. 421). Abrard's 1946, p. 60 record for the Pliocenc of New Hebrides is probably *pulchellus* Reeve.

Subgenus Labiostrombus Oostingh, 1925

Type: *Strombus epidromis* Linné, 1758

Because of anatomical and shell characters, we are considering *Labiostrombus*, with its sole living species, *epidromis* Linné, as a subgenus distinct from the many-species subgenus *Dolomena* Iredale. *Labiostrombus*, in the past, has been applied to species which we now consider to be members of *Dolomena* (*minimus*, *marginatus*, *pulchellus*, etc.).

Three fossil species of *Labiostrombus* are known: *Strombus leurus* Wooding, 1928, from the Miocene of Jamaica, West Indies; *denti* Cox, 1948 from the Pliocene of Borneo; and *kemedjingensis* Martin, 1916, from the Lower Miocene of Java.

Conchologically, the shells are characterized by having the upper part of the outer lip rising evenly, without a posterior sinus, on to the whorl above. The shell is rather light-weight and thin, the columella smooth and axial sculpture usually poorly developed. The main cusps in the central and the elongate lateral sometimes have very tiny sub-denticles. The marginals are long and slender; the lateral has a small basal peg. In general, the radular teeth are very delicate and loosely attached to the odontophore. The very long prong-like penis has three peculiar divisions at the distal end. The eye stalks and tentacles are long, and the operculum has many small serrations.

Synonymy—

1847 *Gallinula* "Klein" Herrmannsen, Indicis Generum Malacozoorum Primordia, vol. 1, p. 461. Not validly proposed (name only). Non Brisson, 1760.

1852 *Gallinula* "Klein" Mörch, Cat. Conch. de Yoldi, p. 61. Type hereby selected: *Strombus epidromis* Linné, 1758.

1854 *Gallinula* "Klein" H. and A. Adams, Genera of Recent Mollusca, vol. 1, p. 259. (Invalid type designation by Kobelt, 1878, Illust. Conchyl., p. 105: *s. isabella* Lamarck [not in original list by name]); [Tryon, 1885, vol. 7, p. 101 and Oostingh, 1925, p. 58 both gave the invalid type designation of *suecinctus* Linné].

1868 *Gallinula* H. and A. Adams, American Journal of Conchology, vol. 4, pt. 3, p. 139. Type by listing first species, *campbelli;* invalid designation.

1904 *Gallinula* "Klein" Cossmann, Essai de Paleoconch. Compar., Paris, 6th book, p. 9. First valid designation of type: *Strombus epidromis* Linné.

1925 *Labiostrombus* Oostingh, Mededeelingen van de Landbouwhoogeschool Wageningen, vol. 29, pt. 1, p. 58. New name for *Gallinula* H. and A. Adams, non Brisson, 1760. Type [invalid] by original designation: *suecinctus* Linné. New type designation hereby made: *Strombus epidromis* Linné.

Nomenclature—The first valid introduction of *Gallinula* for mollusks was made by Mörch in 1852. Tryon's type designation of *succinctus* Linné is invalid, since that species is not listed by any previous authors in *Gallinula*. Cossmann's 1904 designation of *epidromis* Linné is the first valid designation. Oostingh's *Labiostrombus*, a new name, will have to take this type also. Herrmannsen's 1847 name is not defined nor contains any species by name. It is also a homonym of the bird genus *Gallinula* Brisson, 1760.

Strombus epidromis Linné, 1758

(Pl. 17, figs. 17; pl. 83, figs. 1, 2)

Range—Ryukyu Islands and Singapore to Queensland and New Caledonia.

Remarks—This handsome species is sparsely distributed throughout its moderately restricted range, but evidently occurs in large colonies in certain very localized areas. For its three-inch size, the shell is rather light, has a large, rounded, flaring outer lip, and is characterized by a smooth, enamel-white aperture and columella. Older specimens may have an aluminum-like glaze on the lips. The upper part of the outer lip may either just reach to the first suture above or extend up to the second suture. The radula and the verge are both very unusual (see under description).

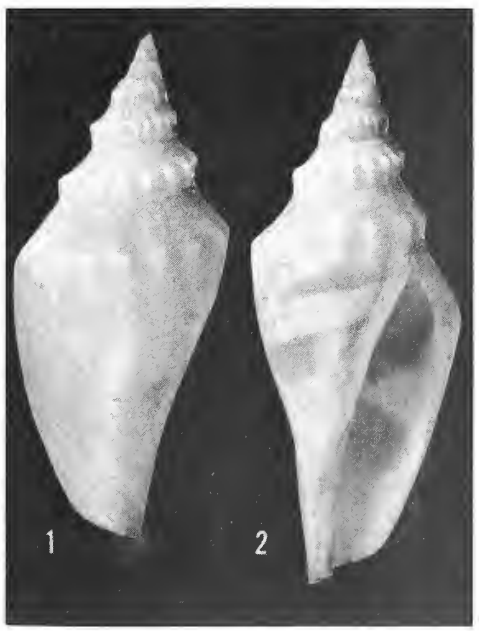


Plate 83. Figs. 1 and 2, *Strombus epidromis* Linné (immature), Dutch New Guinea. Both × 2.

Although no fossil specimens have been found, closely related species are recorded from the Pliocene and Upper Miocene of Indonesia.

Habitat—Lives in muddy to sandy bottoms from 1 to 16 fathoms. Fine coral sand and foraminifera have been found in the intestine. The species has not been found on small coral atolls, but rather is associated with larger islands.

Description—Shell 53 to 90 mm. (2 to 3½ inches) in length, relatively thin-shelled but strong, with a smoothish last whorl, with a large, flaring, rounded outer lip, and with a smooth, white aperture. Whorls 10 to 11, rounded to shouldered in the apex and only slightly convex in the last. Angle of spire about 50° and with a dozen whitish former varices. Nuclear whorls 2, rounded, elevated, glossy, smooth, translucent and either whitish or lavender. First 4 postnuclear whorls with about 10 squarish, minute, spiral cords which cross about 20 small, crowded, rounded axial riblets. The spiral cords disappear on the lower whorls, and the axial riblets are reduced to a spiral series of small, even, knobs on the now squarish shoulder of the whorl. Last whorl glossy, smooth, except for 3 or 4 long, weak, axial plications. One or two of the latter usually have a small, low, rounded knob. Suture even, minutely indented, and, in the apex, bounded below by a weak spiral cord. Aperture ample, smooth and enamel-white within. Columellar callus weak, smooth and white. Posterior siphonal canal short; stromboid notch broadly U-shaped. Base of shell with about a dozen, weak spiral threads. Outer shell whitish to cream with weak mottlings, speckles and rarely with flames of yellow-brown. Spire rarely lavender. Periostracum rather thin, rather smooth and grayish to translucent-tan. Operculum stromboid, chestnut to black-brown, arching about ¼ the length of the shell; attachment side with a strong, central rib; convex edge with 12 to 14 small, narrow, curved serrations.

Radular ribbon proportionately small (5.5 to 6.0 mm. in length and 1.5 mm. in width), with weakly attached, tan to amber teeth in 55 to 60 rows. Central ovoid to quadrate with a simple or tricuspid central cusp flanked on each side by 2 or rarely 3 smaller cusps. Lateral thin, quadrate, with a small basal peg, with its largest cusps usually bearing 1 or 2 tiny dentitions. Outer marginal long and bent. Formula: 2-1-2 or 3-1-3; 1-4 (plus peg); 5; 6 (New Caledonia and Dutch New Guinea specimens examined).

Body stromboid; eye peduncles with purplish brown background and white spots; proboscis with dark, narrow, transverse color lines. Tentacles long. Verge long and narrow (30 mm. in length; shell of male, 68 mm.). Terminal end three-pronged.

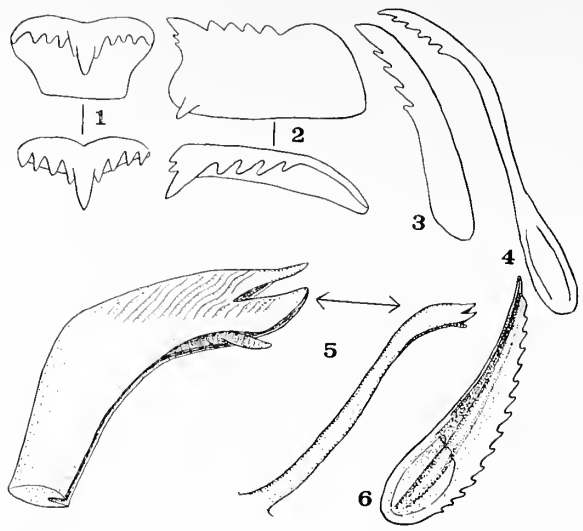


Plate 84. *Strombus epidromis* Linné, Dutch New Guinea. Fig. 1, central. 2, lateral tooth. 3, inner marginal. 4, outer marginal. 5, verge, showing enlargement of distal end. 6, operculum.

Measurements (mm.)—

length	width	no. whorls	
89.0	49.5	6+	(large; Cebu Id.)
74.0	42.0	10	(average; Dutch New Guinea)
53.5	32.1	9	(small; New Caledonia)

Synonymy—

1758 *Strombus epidromis* Linné, Systema Naturae, ed. 10, p. 745, no. 436 (In O. Asiae); 1767, ed. 12, p. 1211, no. 506; 1956, Dodge, Bull. Amer. Mus. Nat. Hist., vol. 111, art. 3, pp. 273-275.

1798 *Lambis epidromis* Gmelin, Röding, Museum Boltenianum, Hamburg, pt. 2, p. 65, no. 834. Refers to Conchyl.-Cab., vol. 3, fig. 821.

1885 *Strombus expansa* "Martini", Tryon, Manual of Conchology, Phila., vol. 7, p. 138.

Types—"The specimen marked for *epidromis* in the Linnaean collection in [Linnaean Society of London]London is the *epidromis* of all authors and may therefore be accepted as the type specimen." (Dodge, 1956, p. 274). We hereby restrict the type locality to Amboina, Indonesia.

Records (see map, pl. 85)—SINGAPORE: (R. D. Purchon, ANSP). RYUKYU ISLANDS: Buckner Bay, Okinawa Id. (A. A. Scott, ANSP). PHILIPPINES: off Corregidor Id., Luzon Id., 6-10 fms. (du Pont-Academy Exped., 1958). Cebu Id.: Bantayan (E. Zambo, ANSP); near Cebu City (A. B. Franco, ANSP). Bohol Id.: Jagoliao Id., 2 fms. (du Pont-Academy Exped., 1958). Cuyo Id., Palawan Prov. (ANSP). Mindanao Id.: Mindanao (ANSP). Sulu Archipelago: Bongao Channel, Sanga Sanga Id. (John Root, ANSP); Jolo Id. (USNM); Tataan Id., 16 fms., Albatross Station 5161 (USNM). INDONESIA: Amboina (MCZ).

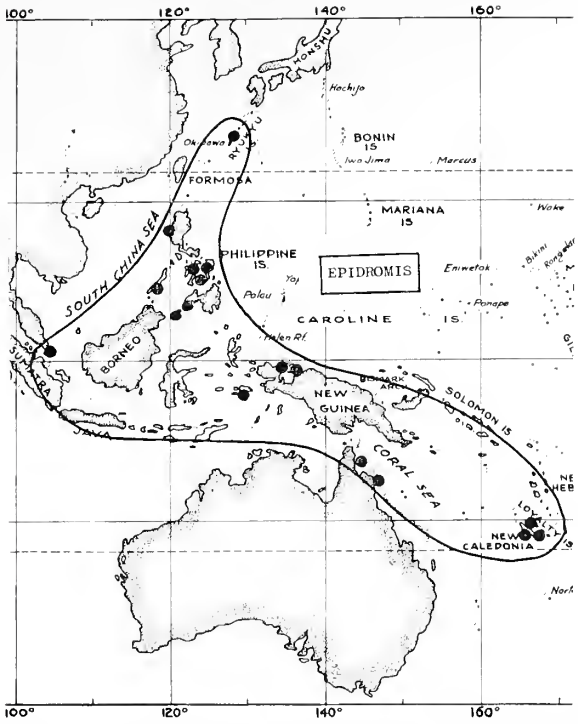


Plate 85. Ceographieal distribution of *Strombus epidromis* Linné.

DUTCH NEW GUINEA: Mios Woendi Isle, Padaido Ids. (NSF, 1956). AUSTRALIA: Queensland: Cooktown (Tony Marsh, ANSP), Bundaberg (W. E. Old, Jr., ANSP). NEW CALEDONIA: Dge (Cockerell, ANSP); Baie de l'Orphelinat, 1 fm., mud; Bourail; Noumea, 4-12 fms. (all G. and M. Kline, NSF, 1959).

Fossil records—None recorded.

Strombus sp. may be the young of *denti* or an *epidromis*-like speeies.

Synonymy—

1948 *Strombus (Labiostrombus) denti* Cox, Schweizerische Palaeontologische Abhandlungen, vol. 66, art. 2, p. 29, pl. 2, figs. 4 a, b, 5 (Pliocene, Borneo).

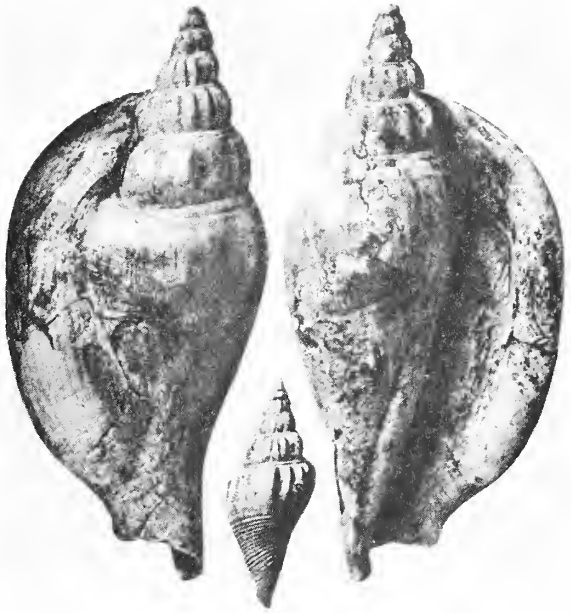


Plate 86. *Strombus* (*Labiostrombus*) *denti* Cox. Dent Haven, British North Borneo. Pliocene. (from Cox, 1948, pl. 2, figs. 4a, b, holotype, fig. 5, immature, paratype). Natural size.

Strombus denti Cox, 1948

Range—Fossil (Pliocene) of northeast Borneo, Indonesia.

Remarks—This speeies appears to be related to *epidromis,* but differs in having long axial riblets in the spire, laeking the angulation of the spire whorls, and in having a less expansive outer lip whieh reaehes up to the seeond suture above. Whorls 12, length of shell 90.5 mm. Type locality: 7 km. inland from Dent Haven, Dent Peninsula, northeast Borneo, Indonesia. Cox points out that *Strombus deningeri* Fiseher, 1921, based upon an immature specimen from the Pliocene of Ceram, is suspiciously akin to young specimens of *denti.* The latter may be a subspecies or synonym of *deningeri* Fischer. Dickerson's (1922, vol. 20, pl. 5, fig. 5)

Strombus kemedjingensis Martin, 1916

Range—Lower Mioeene (West-Progo beds), Java, Indonesia.

Remarks—Based upon a badly broken specimen. Martin likened it to *vittatus* Linné and *isabella* Lam. [= *canariuu* Linné], but I would suggest that it is allied to the *denti* Cox and *epidromis* Linné complex. Lower Miocene according to van der Vlerk, 1931, p. 247.

Synonymy—

1916 *Strombus (Gallinula) kemedjingensis* K. Martin, Samml. Geol. Reichs-Mus. Leiden, n. Folge, vol. 2, pt. 6, p. 246, pl. 2, figs. 47, 48 (Upper Miocene, Kali Kemedjing, Java); 1928, Leidsche Geol. Meded., vol. 3, pt. 2, p. 126.

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

Subgenus Doxander Iredale, 1931

Type: *Strombus vittatus* Linné, 1758

Whether one considers *Strombus vittatus* Linné, *campbelli* Gray, and *japonicus* Reeve as distinct species or subspecies of *vittatus*, the three make a rather small, compact and distinct subgenus which is characterized by shells with a high spire, a verge with a rather large accessory pad, and a radula whose marginals are very thick, roundish in cross-section and with very reduced or absent denticles. There are only 24 to 28 rows of teeth. The operculum is serrated along one edge. The subgenus is represented in the Recent Indo-Pacific only.

There are three fossil species or subspecies in the Upper Miocene and Pliocene of Indonesia which are treated in this account.

Synonymy—

1931 *Doxander* Iredale, Records Australian Mus., vol. 18, no. 4, p. 212. Type by original designation: *vittatus* Gmelin [= *Strombus vittatus* Linné].

Nomenclature—Gabb in 1868 implied, but did not legally select, *campbelli* (a close relative to *vittatus*) as the type of the genus *Gallinula* H. and A. Adams. However, the latter name is a homonym in any event and would not precede *Doxander* (see under synonymy of *Labiostrombus* Oostingh).

Strombus vittatus Linné, 1758

Strombus vittatus is a polytypic and very variable species extending in range from Japan southward through the East Indies and Melanesia to northern Australia. There are three geographically distinct subspecies, probably of late Pliocene or early Pleistocene origin. One of these is the northern *japonicus* Reeve from Japan. The typical subspecies, *vittatus*, occupies the central area from southeastern Asia to Melanesia. The third subspecies, *campbelli*, is evidently confined to the Australian mainland. Workers solely using the morphological concept of species consider these as separate species.

A synopsis of the key characters of the three subspecies is given below:

vittatus—body whorl smoothish, its dorsum with one weak knob; 1 to 4 smooth spiral cords or incised lines just below the suture (rarely a weak channel).

japonicus—body whorl strongly and spirally corded; subsutural threads 1 to 3 and weak.

campbelli—body whorl smoothish, its dorsum always with one fairly strong knob or swelling subsutural band well-beaded, especially in earlier whorls.

Strombus vittatus *subspecies* vittatus Linné, 1758

(Pl. 17, figs. 14)

Range—Southern China to eastern Malaya to Melanesia and northern Australia.

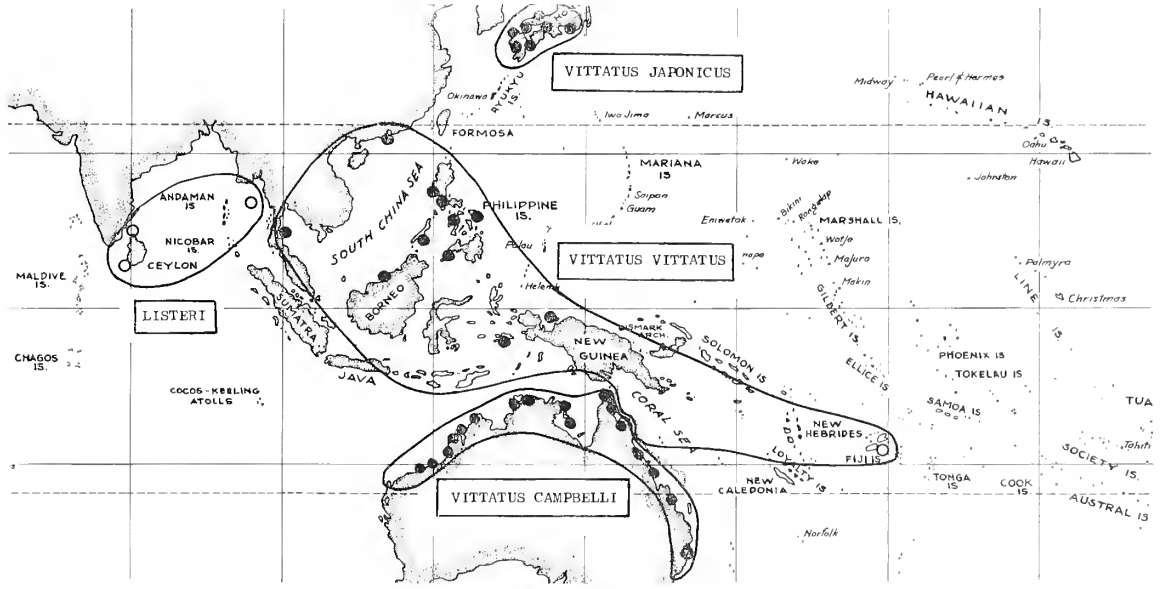


Plate 87. Geographical distribution of *Strombus listeri* T. Gray, and the subspecies of *Strombus vittatus—vittatus* Linné, *japonicus* Reeve and *campbelli* Griffith and Pidgeon.

Plate 88. Radula of *Strombus vittatus vittatus* Linné, Hong Kong. Fig. 1, central. 2, lateral. 3, inner marginal, showing cross-sections. 4, outer marginal.

Remarks—This subspecies is very variable in size, coloration, height of spiral and degree of axial plication. It is moderately common offshore, but infrequently cast up on beaches. Specimens with extremely high spires and strong axial plications persisting to the parietal wall are referred to as *form turritus* Lamarck or *australis* Schröter. Intergrades with the shorter, smoother forms are not uncommon. The small hump or smooth knob on the dorsum of the body whorl (so common in *campbelli*) appears in some specimens. Specimens from Hong Kong have barnacles attached to the "dorsal" surface.

A peculiar specimen from China lacking axial sculpture and having a channeled suture was illustrated by Chemnitz in the Conchyl.-Cab., vol. 11, pl. 195A, figs. 1870 and 1871. It received a valid name in 1802 (*sulcatus* Holten) and in 1817 (*sulcatus* Dillwyn). I have not seen specimens, and am inclined to believe, as have others, that it is a malformed *vittatus*. A similar malformation has been found in S. *gigas* of the West Indies (named *canaliculatus* Burry, 1949).

Description—(of the typical form). Shell 40 to 66 mm. (1½ to 3½ inches) in length, rather thin but strong, with a moderately- to well-produced spire, a winged outer lip, white aperture and with its exterior colored a light yellow-brown to tan which may have 4 to 5 narrow, white and brown flecked spiral bands on the body whorl. Whorls 11 to 12. Nuclear whorls 4, translucent-white or lavender, glossy, and with the first one very small. First postnuclear whorl glistening, first with 1 to 3 spiral incised scratches, then with glossy, crowded, rather neat, axial riblets (15 to 22 per whorl). In later whorls the spiral incised lines are usually limited to 3 to 6 on the lower half of the whorl. The shouldered axial riblets do not invade the area just below the suture where there may be a smooth concave area or a series of 1 to 4 spiral threads. Base of shell with 15 to 20 low, flat-topped, spiral cords. Center of body whorl usually smooth, but may have a single low knob on the dorsum just below the suture. The axial riblet may disappear on the last two whorls. Columella slightly arching, enamel-white, its left side sometimes bordered by a longitudinal chink, smooth in the center, but above with a dozen very weak spiral rugae and at the base sometimes with 2 or 3 very weak lirae. Posterior canal narrow and extending to the suture above. Wing of outer lip tongue-like and curled slightly inward. Interior of body whorl glossy white and with a series of tiny, irregular, low, white, spiral lirae which are dispersed along a band a slight way back from the edge of the outer lip. Stromboid notch usually weakly developed. Anterior siphonal canal short, not recurved nor twisted. Spire angle varying from 30 to 40 degrees, and with or without 4 or 5 small, swollen, whitish former varices in the upper 6 whorls. Periostracum extremely thin and transparent, usually being worn off, but sometimes persisting in the form of axial fimbriations in the concave subsutural channel. Operculum stromboid, light-brown, slightly arching, moderately thin and in our worn specimens showing signs of about 7 weak serrations.

Radula with moderately strong teeth, 9 mm. in length and with only 25 to 26 rows. The marginals are thick and with few denticles and the peg on the lateral is quite reduced. Formula: 3-1-3 (also 2-1-2); 1-2; 2 to 4; 5. Verge simple, with a well-developed laminated pad which is mottled. Posterior mantle filament short.

Measurements (mm.)—

length	width	no. whorls	
86.5	35.0	10+	(large; Hong Kong)
72.3	31.2	10+	(average; Mindanao Id.)
40.0	20.8	8+	(small; Luzon Id.)
36.1	18.1	11	(dwarf; Palawan Id.)

Synonymy—

1758 *Strombus vittatus* Linné, Systema Naturae, ed. 10, p. 745, no. 439 (In O. Asiae); 1767, ed. 12, p. 1211, no. 508; 1956, Dodge, Bull. Amer. Mus. Nat. Hist., vol. 111, art. 3, pp. 276-278.

1798 *Lambis vittatus* Gmelin, Röding, Museum Boltenianum, Hamburg, pt. 2, p. 66, no. 838. Refers to Conchyl.-Cab., vol. 10, figs. 1481, 1482.

?1802 *Strombus sulcatus* Holten, Enumeratio Systematica Conchyl., beat. Chemnitzii, p. 56, no. 735. Refers to Conchyl.-Cab., vol. 11, figs. 1870, 1871; 1823, Dillwyn, An Index to Hist. Conchyl. Lister, ed. 3, p. 38. Not G. Fischer, 1807; not Anton, 1839 which is S. *alatus* Gmelin.

1805 *Strombus australis* Schröter, Wiedermann's Archiv. fur Zool. und Zootomie, Braunschweig, vol. 4, p. 93 (Sudlandern). Refers to Conchyl.-Cab., vol. 10, figs. 1481, 1482. Non Gray, 1826, non Anton, 1839 (The **turreted form.**)

1822 *Strombus turritus* Lamarek, Anim. sans Vert., Paris, vol. 7, p. 212 (no locality). Refers to Conchyl.-Cab., vol. 10, figs. 1481, 1482. Non Link, 1807. (The **turreted form.**)

1950 *Strombus (Doxander) vittatus* Gmelin, Beets, Overdruk Leidse Geol. Mededeelingen, vol. 15, p. 245. (**Turreted form** from Quaternary of East Borneo.)

Types—Linné's type of *vittatus* was present in the Linnaean collection at the Linnaean Soeiety of London (aceording to Hanley, 1855, p. 273). We hereby restrict the type locality to Amboina, Indonesia.

Nomenelature—The higher spired and more strongly plicate form was first named *australis* Schröter in 1805, and has preeedenee over the form name *turritus* Lamarck, 1822. The latter is a seeondary homonym of *Lambis turrita* Röding, 1798 which is a synonym of *gallus* Linné from the Caribbean.

Records (see map, pl. 87) (for typieal *vittatus* and its "turreted" forms)—HONG KONG: south of Aap Li Chaan (A. Staple, ANSP); beaeh at Stanley (Mme. de Breuil, ANSP). THAILAND: all Gulf of Siam: Maikhas Beach, Phuket (G. M. Moore, MCZ); Khan Nu Paknam; Bangbert Bay; Koh Samet; Singora (all USNM). PHILIPPINES: 7-10 fms. at San Nicolas Shoals, Manila Bay, Luzon Id. (du Pont-Aeademy Exped., 1958, ANSP); Cuyo Id., Palawan Prov. (ANSP); 40 fms., Aborlan, Palawan (ANSP, MCZ); Iloilo, Panay Id. (USNM); Cadiz and Santa Cruz, Negros Id. (USNM); north end of Cebu Id. (Dr. Lucerno, ANSP); Catbalogan, Samar Id. (R. T. Abbott, MCZ); Zamboanga, Mindanao Id. (MCZ); off Tawi Tawi, Sulu Archipelago (18 fms., green mud, Albatross Sta. 5164 USNM). INDONESIA: 39 fms., off Taganak Id., Borneo (USNM). Sarawak, Brit. Borneo (MCZ). Keledjitan and Tjiperwagaran, Bantam, Java (both USNM); Amboina, Celebes (MCZ); 1400 meters in the Madura Straits; 27-32 meters in the Maeassar Straits; 13 meters, Pulu Jedan, Aru Ids. (all "Siboga", Sehepman, 1909, p. 148). DUTCH NEW GUINEA: 10-16 fms., off Cape Dgarwawoffi, Japen Id. (NSF, 1956). AUSTRALIA: Queensland: Brampton Reef, Bowen (ANSP); Cape Upstart (ANSP); sand flats at Port Douglas (Tony Marsh, ANSP). FIJI: 12 fms., off Levuka Id. (E. A. Smith, "Challenger", 1886, p. 420).

Fossil records—Reported, but unverified by me, from the Pliocene of Java (see van der Vlerk, 1931, p. 247). Probably based upon other speeies. S. *deningeri* P. J. Fischer, 1921, is the young of a *vittatus vittatus*-like Pliocene *Strombus* from Ceram Island, Indonesia. Beets (1950, vol. 15, p. 245) reports two speeimens of the "turreted" form from the Quaternary of Blitong, Java, and one Quaternary specimen from Poeloe Boenjoe, East Borneo, Indonesia. A Plioeene Java, Indonesia, form (S. *triangulatus* Martin) is extremely close to Reeent speeimens of *vittatus* and might well be eonsidered a subspecies of it.

Strombus vittatus *subspecies* japonicus Reeve, 1851

(Pl. 17, figs. 18)

Range—Southern half of Honshu Island to southern Kyushu Island, Japan.

Remarks and description—This common Japanese subspeeies differs from the southern *vittatus* in being more brightly colored, in having a lower spire (45 to 50 degree angle), and in having small but well-developed, erowded spiral eords over the entire body whorl. There are two or three very weak, sometimes obsolete, spiral threads just below the suture. The outer lip is generally thiek*e*r and the spiral lirae within the aperture are fewer (25 to 30), longer and stronger. The posterior siphonal canal is usually longer, running beyond the above suture, and sometimes being sinuate. The banded pattern on the body whorl is pronouneed in most speeimens, and the brown eoloring is usually dark. We have seen an all-orange speeimen. In some speeimens the shoulder of the body whorl may bear 5 to 8 indistinet, white-blotched rather equal-sized nodules. Periostraeum moderately thiek, yellow-brown, rough and flaking off when dry.

Measurements (mm.)—

length	width	no. whorls	
66.0	32.5	10	(large; Nagasaki)
56.8	27.1	11	(average; Hazu-gun)
47.6	24.0	9+	(small; Hiroshima)

Habitat—Common in colonies on mud or gravel and mud bottoms from 5 to 20 fathoms.

Synonymy—

1851 *Strombus japonicus* Reeve, Conchologiea Iconica, London, vol. 6, Strombus, pl. 17, fig. and sp. 42 (Japan).

1869 *Strombus japonicus* Reeve, Lisehke, Japanisehe Meeres-Conchylien, suppl. 4, vol. 1, p. 30, pl. 5, fig. 7 (Nagasaki).

1959 *Labiostrombus japonicus* Reeve, Kira, Colour. Illus. Shells of Japan, Osaka, 2nd ed., p. 13, pl. 15, fig. 13.

Types—Reeve's type is presumably in the British Museum of Natural History in London. The type loeality is "Japan" which we further restriet to Nagasaki, Kyushu Island.

Records (see map, pl. 87) (all Japan)—HONSHU: Nonai, Mutsu Bay, Aomori Pref. (Nomura and Hatai, 1931, p. 11); Oga Peninsula, Akita Pref. (Nishimura and Watabe, 1943, no. 3, p. 67). Yamagata Pref. (Nomura and Zimbo, 1936, no. 30, p. 28, no. 102). Tateyama, near Tokyo Bay, Chiba Pref. (ANSP); Suruga Bay, Shizuoka Pref. (K. Oyama, 1943, p. 16, no. 146). Shirako, Mie Pref. (T. Habe, ANSP). Ei, Awaji Id., Hyogo Pref. (T. Habe, ANSP). Hiroshima, Hiroshima Pref. (A. R. Calm, ANSP). Isshiki, Hazu-gun, Aichi Pref. (T. Habe, ANSP); Wakasa Bay, Kyoto Pref. (ANSP). SHIKOKU: Tosa Bay (ANSP). KYUSHU: Chikuzen (K. Hatai, ANSP); Tomioka, Amakusa, Kumamoto Pref. (T. Habe, ANSP); Nagasaki, Nagasaki Pref. (H. Loomis, ANSP; USNM). Iwakawa, pt. 2, 1905, p. 86 records this species from Ogasawarajima [Bonin Ids.] but I have not been able to verify this.

Fossil records—RYUKYU ISLANDS: Simaziri Beds, lower Pliocene, Gabusoga, Okinawa Id. (Nomura and Zimbo, 1936, vol. 18, no. 3, p. 259, pl. 11, figs. 27a, b.) JAPAN: Honshu Island: Otake, Shimosa in the Upper Musashino of the Upper Plioeene or later (Yokoyama, 1922, vol. 44, p. 70, pl. 3, fig. 12); the Oti Graben Pleistocene in Noto Peninsula (Y. Otuka, 1935, vol. 13, p. 366, pl. 54, fig. 99).

Strombus vittatus *subspecies* madiunensis Martin, 1899

Range—Pliocene of Java.

Remarks—This species is closest in most characters to *vittatus japonicus*, differing only in having a slightly lower spire and in having slightly more angular whorls in the spire. Altena's Atjeh, Sumatra specimen (*madiunensis* Martin, Altena, 1942, p. 52, figure 14) is probably not this subspecies, but possibly another species which, at least in shape, is more like S. *marginatus succinctus* Linné from the Bay of Bengal. Nomura and Zimbo's *japonicus* (1936, p. 259, pl. 11, fig. 27) from the Lower Pliocene of Okinawa may be this subspecies.

Synonymy—

1899 *Strombus (s. str.) madiunensis* K. Martin, Samml. Geol. Reichs-Mus. Leiden, n. Folge, vol. 1, pt. 1, p. 183, pl. 29, figs. 422, 422a, 422b (Sonde, Gendingan, Madiun Residency, Java, Pliocene).

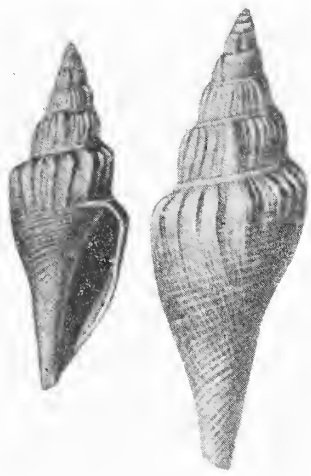


Plate 89. *Strombus vittatus deningeri* P. J. Fischer. Pliocene of Ceram Island, Indonesia. Types. (from Fischer, 1927, pl. 212, figs. 25a, b). ×2.

Strombus vittatus *subspecies* deningeri P. J. Fischer, 1921

Range—Pliocene of Ceram, Indonesia.

Remarks—This species was based upon an immature specimen which closely resembles the young stage of the Recent *vittatus*. It is not allied to *variabilis* or *denti* Cox.

Synonymy—

1921 *Strombus deningeri* P. J. Fischer, Centralblatt für Mineral., Geol. Paläont., vol. 22, p. 244 (Western Seran); 1927, P. J. Fischer, Paläontologie von Timor, Stuttgard, pt. 15, art. 25, p. 56, pl. 212, fig. 25 a, b. (Pliocene, Seran [Ceram Id., Indonesia]).

Strombus vittatus *subspecies* campbelli Griffith and Pidgeon, 1834

(Pl. 17, figs. 13)

Range—The north half of Australia from Western Australia to New South Wales.

Remarks and Description—This is a very distinctive geographical subspecies of *vittatus* and is, by some, considered a separate species. The whorls in the spire are usually flatter and the subsutural cord bears numerous, small, but well-developed, axially elongated beads. The latter may disappear in the last whorl. Nuclear whorls 3½, glossy, translucent white, rarely tinged with lavender. First postnuclear whorl with a fine incised line just below the suture, then joined by numerous axial, glossy riblets. Spire with 1 or 2 to 14 small, swollen, rounded, white, axial former varices. Color of shell whitish cream with irregular mottlings of light- to dark-brown which under the microscope show numerous delicate zigzag streaks, flecks and arrowheads. Columella enamel-white, glossy, with a few weak rugae at the top inner end and rarely with 1 or 2 weak lirae near the base. Spiral lirae within the inside of the outer lip usually very weak. Parietal wall slightly flattened due to an axial swelling to its left. This is followed by 2 or 3 small, rounded axial swellings on the shoulder, and then on the dorsum by a rather pronounced rounded knob. Base of shell with about a dozen spiral incised lines. Periostracum moderately thin, translucent yellow-brown, somewhat rough, and flaking off when dry. Operculum stromboid, about one fourth the length of the shell, and with 7 serrations. Radula 5 mm. and with 27 rows of teeth. Formula: 3-1-3; 1-2 (plus peg) (also 1-3 (plus peg)); 1; 3 to 5. Animal and verge similar to that of *vittatus vittatus*.

Measurements (mm.)—

length	width	no. whorls	
68.4	30.4	9+	(Sandy Cape, Qld.)
50.3	24.0	8+	(Bowen, Queensland)
32.2	15.5	10	(Western Australia)

Synonymy—

1834 *Strombus campbellii* "Gray" Griffith and Pidgeon, The Animal Kingdom—Cuvier, London, vol. 12, p. 600, pl. 25, fig. 6 (no locality); 1842, Sowerby, Thesaurus Conchyl., vol. 1, pl. 6, figs. 22, 23; 1908, Hedley, Proc. Linn. Soc. New South Wales, vol. 33, pt. 3, p. 460.

1886 *Alaba (Styliferina) sulcata* Watson, Voyage of the Challenger, Zoology, vol. 15, p. 570, pl. 42, fig. 7 (Cape York, Queensland); 1905, Hedley, Proc. Linn. Soc. New South Wales, pt. 4, p. 523.

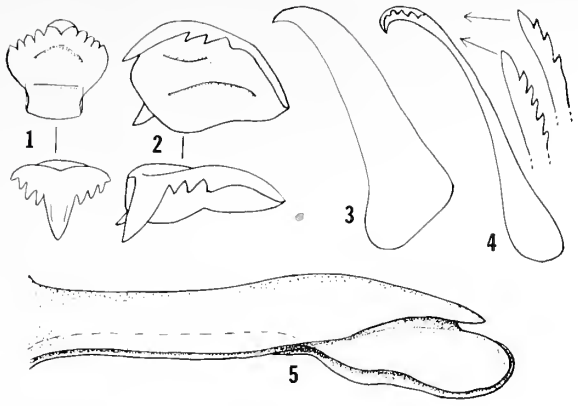


Plate 90. *Strombus vittatus campbelli* Griffith and Pidgeon, Broome, Western Australia. Figs. 1-4, radulae. 5, verge.

Types—The type of Griffith and Pidgeon appears to be lost. No locality was given. The drawing of the type (Pl. 24, fig. 6, *supra cit.*) is a low-spired, well-pigmented specimen such as we have seen from Bowen, Queensland, Australia.

Nomenclature—Gray is usually not considered to be the author of Griffith and Pidgeon's "The Animal Kingdom", and since no adequate descriptions accompany the explanation to the plates the latter two gentlemen are considered the authors of *campbelli.*

Records (see map, pl. 87) (all Australia)—WESTERN AUSTRALIA: Eighty Mile Beach; Cape Bossut; La Grange Bay (all H. L. Clark, MCZ); Ridall's Beach and Black Ledge and sand flat, 2½ miles south of Broome (all V. Orr, ANSP); Cape Leveque (H. L. Clark, MCZ); Augustus Id. (B. Bardwell, ANSP). NORTHERN TERRITORY: East Point, near Darwin (H. L. Clark, ANSP); Van Dieman's Gulf (Calvert's coll'n., ANSP); Yirrkala, Arnhem Land (USNM); Gulf of Carpenteria (ex Roth, Hedley, 1908, p. 460). QUEENSLAND: off Cape York, 3-12 fms., coral mud (R. B. Watson, "Challenger", 1886, p. 418); between Hammond and Wednesday Ids. (Melvill and Standen, 1899, p. 165); Bedford Beach, Cooktown (MCZ); Cairns (MCZ); Dunk Id. (H. A. Pilsbry, ANSP); Magnetic Id., off Townsville (MCZ); Queens Beach, Bowen (P. Coleman, ANSP); Keppel Id. (Tony Marsh, ANSP); Bustard Head (ANSP); Moreton Bay (B. R. Bales, ANSP). NEW SOUTH WALES: Port Stephens (fide Angas, 1877, p. 185). [We have specimens from the Solomon Islands, but feel that the locality data is erroneous.]

Fossil records—None reported.

Strombus triangulatus Martin, 1879

Range—Upper Miocene of Java, Indonesia.

Remarks—This species is allied to the Recent S. *vittatus* Linné. I. van der Vlerk (1931, vol. 5, p. 291) considered this species to be one of the guide fossils for the Miocene of the East Indies, although I believe some Pliocene species could be confused with it. Martin's 1899 figs. 431, 431a are immature and may be the young of *varinginensis* Martin.

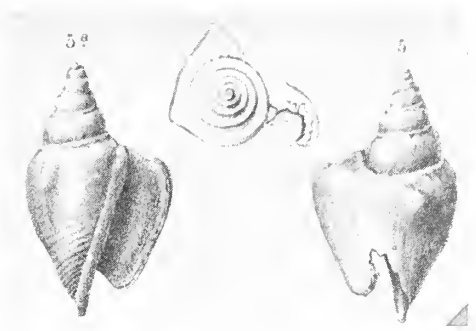


Plate 91. *Strombus triangulatus* Martin. Upper Miocene of Java, Indonesia. Type. (from K. Martin, 1879, pl. 9, figs. 5, 5a). Natural size.

Synonymy—

1879 *Strombus triangulatus* K. Martin, Die Tertiärschichten auf Java, Leiden, vol. 5, p. 49, pl. 9, fig. 5 (Java); 1899, *ibid.*, n. Folge, vol. 1, pt. 1, p. 186, pl. 30, figs. 431, 431a (Java).

Strombus listeri T. Gray, 1852

(Pl. 92)

Range—Known only from the Bay of Bengal from Ceylon to Burma.

Remarks—I am provisionally treating *listeri* as a good species, although it is possible that it is merely a large, gerontic form of *vittatus.* The peculiarly misshapen siphonal canal suggests the latter. To date, we know of only three adult specimens—the holotype in the Hunterian Museum in Glasgow which probably is the shell figured by Lister in 1685 on plate 855, fig. 12a. Its length is 4¾ inches. Sowerby's holotype is a fresh specimen and is 5⅞ inches in length. Langdon (1874, Quart. Jour. Conch., London, vol. 1, p. 74) reports another specimen from Ceylon. The color of the shell is similar to that of *vittatus*—light-brown and whitish overlaid with dark-chestnut axial stripes. There is no spiral incised line below the suture as in most specimens of *vittatus.* E. A. Smith (1904, Ann. Mag. Nat. Hist., ser. 7, vol. 13, p. 469) states that the Steamer "Investigator" obtained two young specimens in the Gulf of Martaban, Burma, in 67 fathoms. If a good species, it is one of the rarest and most desirable of the world's *Strombus.*

Synonymy—

1852 *Strombus listeri* T. Gray, Ann. Mag. Nat. Hist., series 2, vol. 10, p. 429 (no locality).

1870 *Strombus mirabilis* Sowerby, Proc. Zool. Soc. London for 1870, p. 257, pl. 21, fig. 4 (Ceylon).

Fossil records—None reported.

Plate 92. *Strombus listeri* T. Gray. Ceylon. (holotype of *Strombus mirabilis* Sowerby, 1870, pl. 21, fig. 4). Natural size.

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

Subgenus Lentigo Jousseaume, 1886

Type: *Strombus lentiginosus* Linné, 1758

This appears to have been a fairly wide-spread and old group which first occurred in the Lower Miocene of Indonesia (*Strombus preoccupatus* Finlay) and the Miocene of Florida (*Strombus aldrichi* Dall). Today, the living remnants are widely separated geographically and conchologically. In the Indo-Pacific are *lentiginosus* Linné and *pipus* Röding. In the tropical Eastern Pacific is *granulatus* Swainson, 1822. A probable member of the subgenus, *Strombus latus* Gmelin, 1791 (formerly *bubonius* Lamarck), occurs alone in West Africa. *Strombus fasciatus* Born, a rather aberrant form, is limited to the Red Sea area.

The shells are moderately large, somewhat quadrate in shape, and have three or four spiral rows of knobs on the last whorl. The upper row bears large, somewhat equal-sized, blunt spines. The penis in *lentiginosus* and *pipus* has an auxiliary prong, and there is no basal peg on the marginal radular tooth. The operculum is weakly serrated.

Synonymy—

1886 *Lentigo* Jousseaume, Le Naturaliste, Paris, 1st series, vol. 3, 8th year, no. 28, p. 220. Type by monotypy: *L. lentiginosus* Linné. [Lentigo "Klein" Moreh, 1868, Malak. Blatt., vol. 15, p. 21 is a nude name.]

Strombus lentiginosus Linné, 1758

(Pl. 17, figs. 11, 12; pl. 94, fig. 4)

Range—East Africa to the Marshall and Tuamotu Islands.

Remarks—This is a rather widely distributed, shallow-water and coral-water species which is remarkably constant in its sculpture, coloration and size. It is characterized by the cream and light orange aperture which is frequently overlaid by a silvery or aluminum-like glaze, by the 4 or 5 squarish blunt knobs on the shoulder of the body whorl, and by the peculiar, angular lobe at the base of the columella. This species is most likely to be confused with *S. pipus* (Röding). The latter has a purple-brown aperture bearing fine spiral lirae, and its parietal wall has a peculiar "feathery" zigzag pattern of soft browns.

S. lentiginosus is common wherever it has established itself. In Polynesia it occurs in relatively few areas but is moderately common when found.

Habitat—This species occurs in moderate to large numbers from low tide mark to a depth of about 12 feet, usually on a coral sand bottom which may be rocky and with weeds. They occur on barrier, fringing or lagoon reefs, and usually where the water is relatively clear. The outer shell surface may bear green algae, bryozoans, Vermetid and Hipponicid gastropods (*Sabia conica* (Schumacher)).

Description—Shell 55 to 104 mm. (2 to 4 inches) in length, solid, heavy, nodulose, with a pinkish cream aperture and glossy parietal wall. Color of outer shell whitish with heavy specklings and mottlings of greenish gray to grayish brown. Parietal wall cream with gray and brown, irregular mottlings over which is laid a clear to translucent, shiny glaze. The glaze sometimes extends up on to the spire as far as the apex. Interior of aperture smooth, and flushed with light orangish rose. Outer lip tan with 5 to 6 indistinct light-brown bars. Columella smooth and white within, and swollen and projecting near the lower end. Outer lip wavy, the up-

Plate 93. Fig. 1. Living animal of *Strombus pipus* (Röding), female. Fig. 2, *Strombus lentiginosus* Linné, male. (both from Quoy and Gaimard, 1833, pl. 50).

per end with 2 or 3 tongue-like projections. Stromboid notch deep and somewhat W-shaped. Whorls 9 to 10. Nuclear whorls unknown, but appear to be 2 or 3. Postnuclear whorls with 12 to 14 spiral threads, increasing to small cords in later whorls. Suture minutely indented and wavy. Early whorls with numerous fine axial riblets becoming nodulated in later whorls at the shoulder. Last whorl with 7 to 9 large, squarish knobs at the shoulder. Below this are 3, 4 or 5 spiral rows of small rounded knobs. In front of most of these knobs is a chestnut-brown spot. The upper 4 whorls in the spire bear 9 to 12 small, rounded, whitish former varices, sometimes lined up one below the other. Siphonal canal short, thick-walled and twisted to the right and slightly upward. Periostracum very thin, translucent-tan, and flaky when dry. Operculum stromboid, blackish brown, strongly arched, with 2 or 3 worn, indistinct or smoothish serrations, and about ⅓ the length of the shell.

Radula ribbon strong, wine-red to amber, 7 to 8 mm. in length, and with about 45 to 47 rows of teeth. Lateral without a peg. Formula: 2-1-2; 1-3; 6; 7. One Palau specimen with marginal formula of 5; 5 and 6; 6. Verge 24 to 28 mm., with a strong thumb-like appendage on the distal blade. Posterior mantle filament proportionately short (3 to 4 mm.).

Quoy and Gaimard (1833, Atlas of the Voyage de l'Astrolabe, pl. 50) depict the living animal as being mottled with green, with a yellow margined mantle edge, and the yellow eye being bordered with red ring.

Measurements (mm.)—

length	width	no. whorls	
105.0	67.0	8+	(large; "East Indies")
73.0	48.2	9+	(average; Schouten Islands)
54.5	37.0	8+	(small; Palau Islands)

Synonymy—

1758 *Strombus lentiginosus* Linné, Systema Naturae, ed. 10, p. 743, no. 427 (In O. Asiae); 1767, ed. 12, p. 1208, no. 495; 1956, Dodge, Amer. Mus. Nat. Hist., vol. 111, art. 3, p. 253-254; 1842, Sowerby, Thesaurus Conchyl., vol. 1, Strombus, pl. 8, fig. 79; 1843, Kiener, Coq. Vivantes, vol. 4, pl. 18, fig. 1.

1798 *Lambis rana* Röding, Museum Boltenianum, Hamburg, pt. 2, p. 63, no. 802. Substitute name for *lentiginosus* L.

1834 *Strombus rana* Oken, Isis, Leipzig, vol. 27, pt. 4, pl. 6, fig. 3; 1836, *loc. cit.*, vol. 29, pt. 1, p. 43. Refers to Quoy and Gaimard, 1833, Voy. Astrolabe, pl. 50, figs. 3-5.

Types—According to Dodge (1956, p. 254) the type of *lentiginosus* is in the Linnaean collection in the Linnaean Society of London. Linné's local-

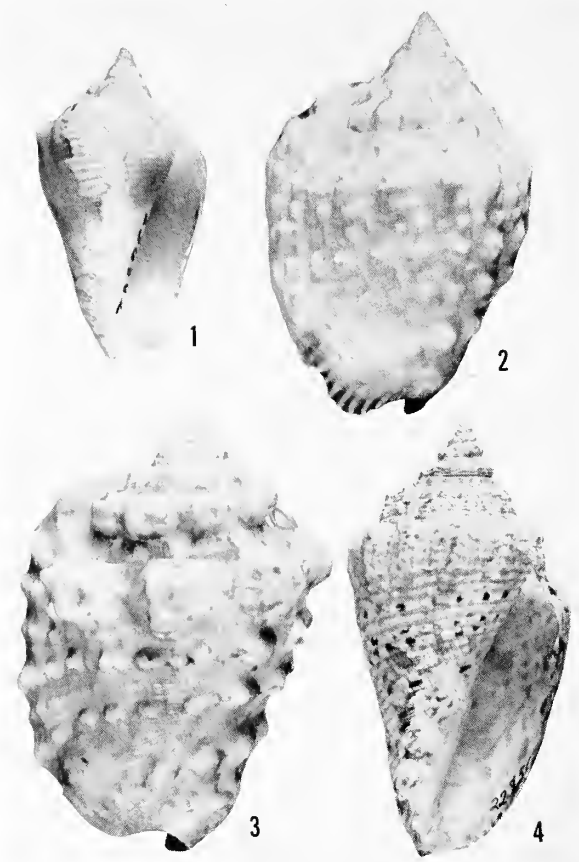


Plate 94. Figs. 1-3, immature and adults of *Strombus pipus* (Röding), Mindanao Id., Philippines. 4, immature S. *lentiginosus* Linné, Philippines. All natural size.

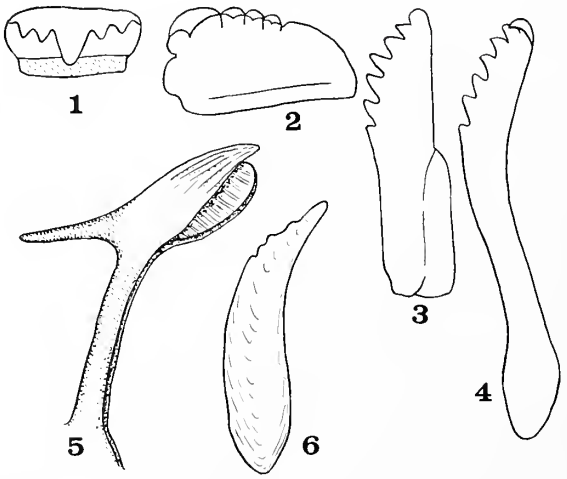


Plate 95. *Strombus lentiginosus* Linné, Palau Islands. Figs. 1-4, radulae. 5, verge. 6, operculum.

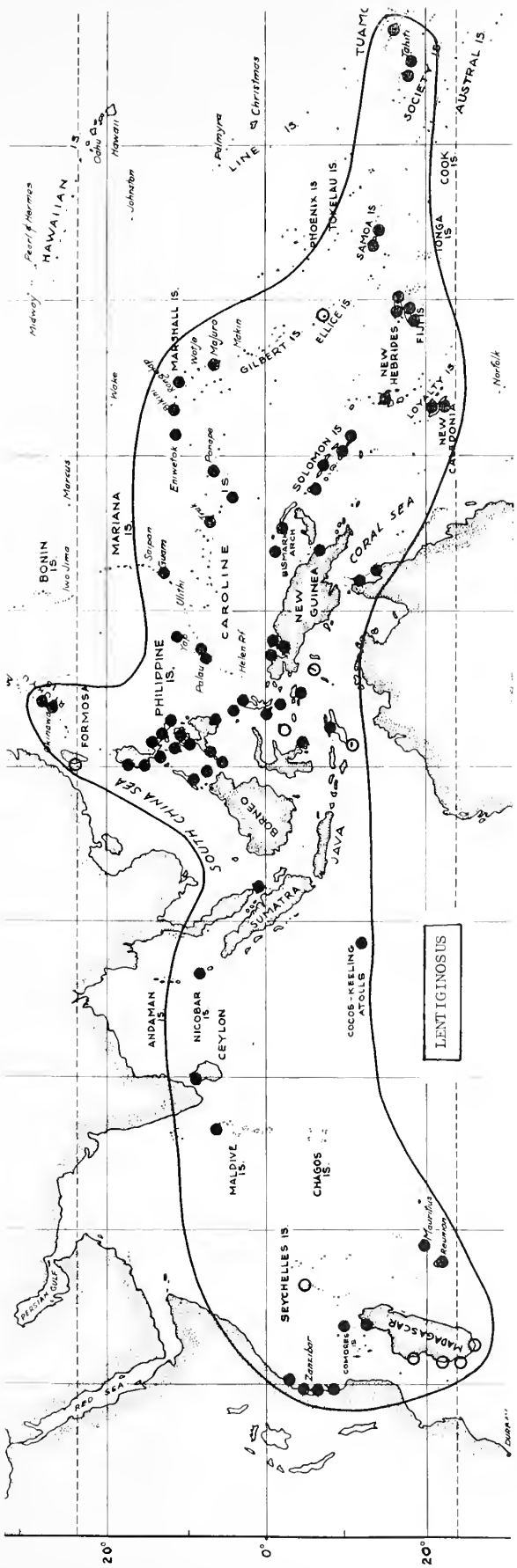


Plate 96. Geographical distribution of *Strombus lentiginosus* Linné.

ity was "O. Asiae" which we further restrict to Amboina, Indonesia.

Selected records (see accompanying map, pl. 96; solid dots: specimens examined; open circles: literature records)—TANGANYIKA: Inner Sinda Id. (R. T. Abbott, USNM). KENYA: Diani Beach and Mombasa (R. T. Abbott, MCZ). ZANZIBAR: Common around the island (NSF). MADAGASCAR: Nossi-bé; Nossi Andrano; Tulear; Saradrana; Sainte Marie (all Dautzenberg, 1929, p. 467). MALDIVES: north Malé Atoll (Yale Seychelles Exped., Peabody Mus.). RYUKYU ISLANDS: Okinawa Id. (Mrs. A. A. Scott, ANSP). TAIWAN: Hoko (Kuroda, 1941, p. 97). INDONESIA: Obi Major; Nusa Laut; Taam; Rotti; Kur Id. (all Schepman, 1909, p. 147). ELLICE ISLANDS: Funafuti (Hedley, 1899, p. 428). CAROLINES: Yap; Eawujlik; Ifalik (all USNM). MARSHALLS: Eniwetok; Bikini; Rongelap; Rongerik (all USNM). SOCIETY ISLANDS: Outer reef, Moorea Id. (H. A. Rehder, USNM). Ative, Punaavia, Tahiti Id. (R. Robertson, ANSP). TUAMOTUS: (Dautzenberg and Bouge, 1933, p. 299).

Fossil records—None reported.

Strombus pipus (Röding, 1798)

(Pl. 17, figs. 9, 10; pl. 94, figs. 1-3)

Range—East Africa to the Society Islands.

Remarks—This attractive, purple-mouthed *Strombus* is rather uncommon, although it has a range as wide as that of its abundant relative, *S. lentiginosus*. In some areas, it is considered a rarity although this may be due to the fact that it lives well off shore. Our records show two areas where it is not uncommon—the western portion of the Indian Ocean and the Philippines. It has not been recorded, as yet, from Micronesia or Hawaii.

S. pipus is characterized by the purple-brown aperture which has a series of fine spiral lirae along the inside of the outer lip, and by the "feathery" mosaic of soft-brown maculations on the glossy parietal wall. The shell is smaller than most *lentiginosus*, and the shoulder knobs on the body whorl vary from 8 or 9 large to 15 very small ones. Intergrades exist in the same colony, and there is no correlation between darkness of aperture and degree of sculpturing. The parietal glaze does not extend up on to the apex, as in *lentiginosus*. The young of *pipus* have a large brown spot on the upper third of the columella, a feature absent in *lentiginosus*.

Habitat—Lives on bottom of coral sand and algae from 8 to 39 fathoms.

Description—Shell 38 to 70 mm. (1½ to 2¾ inches) in length, solid, roughly sculptured, roundly quad-

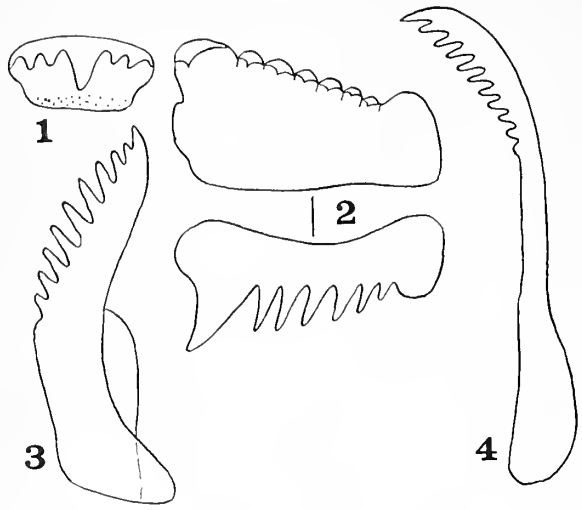


Plate 97. Radula of *Strombus pipus* (Röding). 1, central. 2, lateral. 3, inner marginal. 4, outer marginal.

rate, and with a rugose, purplish-black aperture. Color of outer shell white with light or heavy, diffused light-brown mottlings and numerous, very fine axial lines of brown which give a "feathery" mosaic appearance. Whorls 10 to 11. Nuclear whorls 2½, whitish, smooth, and glossy. First 2 or 3 postnuclear whorls with numerous, small, but strong, smoothish axial riblets (about 24 per whorl) between which are about 10 spiral threads. The latter cross the surface of the riblets after the third whorl. Penultimate whorl with 8 to 14 small knobs. Shoulder of body whorl with 8 or 9 rather large squarish, axially pinched knobs or with 9 to 15 small rounded knobs. Below these are 3 or 4 spiral rows of much smaller, rounded knobs or swollen beads. Apex with 8 to 12 whitish, swollen former varices, the last 2 or 3 sometimes being quite broad and low. Parietal wall glazed with the shell color showing through. Columella thick and with a cream, smooth glaze over the lower two thirds. Upper portion tainted with brown or purplish. Deep interior of aperture whitish lavender becoming dark purple-brown or purple-black and spirally rugose towards the thickened outer lip. Top of outer lip extends slightly upward and with a broad sulcus which has 2 small white, rounded projections. Central portion of lip edge cream with 5 to 6 pairs of brown bands. Stromboid notch U-shaped and sometimes with 3 to 5 small white teeth at the edge. Base of outer lip projecting and with 3 to 5 small white teeth. Interior of siphonal canal purplish brown. Periostracum thin, microscopically striate, translucent-tan. Operculum stromboid, light-brown, rather narrow, arching with about 7 very poorly developed (or badly worn) serrations, and with a strong narrow rib on the attachment side.

Radula ribbon 7 mm. in length, its denticles long. Formula: 2-1-2; 1-5 or 1-6; 9 or 10; 10 or 11. Posterior mantle filament very short.

Quoy and Gaimard (1833, Atlas of the Voyage de l'Astrolabe, pl. 50, fig. 1,2) depict the living animal as being delicately mottled and flecked with light-brown, and with the yellow mantle edge having large spots of brown. The eye rings of white, black, bluish and red. See our plate 11, p. 33.

Measurements (mm.)—

length	width	no. whorls	
70.0	42.5	9+	(large; Mauritius)
38.0	28.0	8+	(small; Philippines)
57.5	36.5	10	(average; Zamboanga)

Synonymy—

1798 *Lambis pipa* Röding, Museum Boltenianum, Hamburg, pt. 2, p. 63 (no locality). Refers to Conehyl.-Cab., vol. 3, figs. 825, 826.

1817 *Strombus papilio* "Chemnitz" Dillwyn, Deser. Cat. Recent Shells, London, vol. 2, p. 661 (East Indian Seas). Refers to Conehyl.-Cab., vol. 10, figs. 1510, 1511; 1818, Wood, Index Test., London, p. 116 East Indies); 1843, Kiener, Coq. Vivantes, vol. 4, pl. 17, figs. 1, 2.

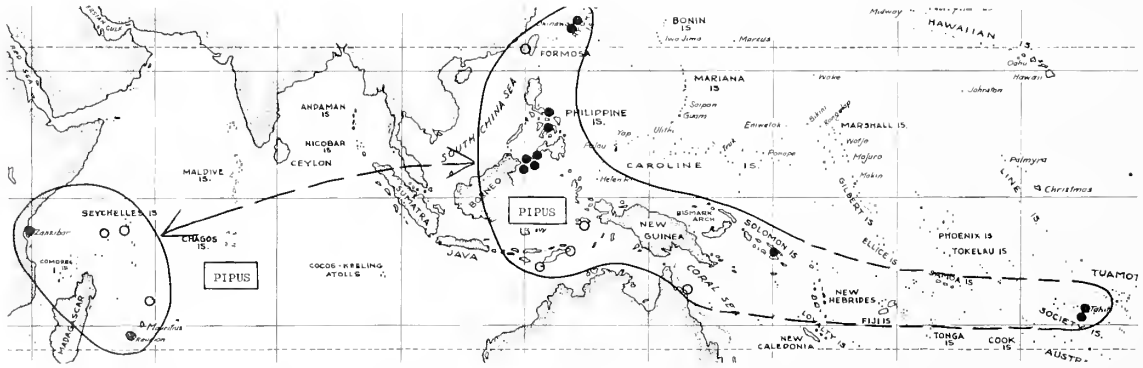


Plate 98. Geographical distribution of *Strombus pipus* (Röding), showing the discontinuity of its range.

1822 *Strombus exustus* Swainson, Zoological Illustrations, London, series 1, vol. 3, pl. 134 (Haynam Id., East Indies); Berge, Conchylienbueh, Stuttgart, p. 231, pl. 38, fig. 4.

1851 *Strombus adustus* "Swainson" Reeve, Conch. Icon., vol. 6, Strombus, pl. 13, sp. 29. Non Gray, 1826.

Type—Röding's *pipus* is based upon figures 825 and 826 of volume 3 of the Conchylien-Cabinet which, in turn, are based upon a specimen in Bolten's collection, according to Martini. That specimen is the type, but is probably lost. We restrict the type locality to Jolo Id., southern Philippines. Swainson's type of *exustus* may be at Cambridge University, England.

Nomenclature—The more familiar name of *papilio* Dillwyn, 1817, has already been replaced by many recent authors with Röding's earlier *pipus*. S. *exustus* Swainson is a synonym based upon a color form, and *adustus* Reeve was a misquote of Swainson's *exustus*.

Records (see map, pl. 98)—ZANZIBAR: 1½ mi. W.S.W. of Ras Mungwe, 8 fms. (NSF, 1957). INDIAN OCEAN ISLANDS: Cargador Carajor, 30 fms.; Amirantes, 30-39 fms.; Praslin Id., Seychelles, 34 fms. (all Melvill, "Sealark", 1909, p. 92). Mauritius (ANSP). RYUKYU ISLANDS: Okinawa Id. (A. A. Scott and A. R. Cahn, ANSP). TAIWAN: Taihokusyu (Kuroda, 1941, p. 97). PHILIPPINES: Cubat, Sorsogon Prov., Luzon Id. (duPont-Academy Exped., 1958); Cebu City and Olango Id., Cebu Id. (A. B. Franco, ANSP); Jolo Id., and Siasi Id., Sulu Archipelago (MCZ); off Simonar Id., 28 fms.; off Lapae Id., Tapul Id., 10 fms., Albatross Sta. 5149 (both USNM). INDONESIA: Banda, Timor and Rotti Ids., 9-45 meters (Schepman, 1909, p. 147). AUSTRALIA: Green Id., Queensland (Tony Marsh, in litt.). SOLOMONS: Florida Id. (USNM). SOCIETY ISLANDS: Punaruu, Punaauia, Tahiti (R. Robertson, 1952, ANSP); Mataiea, Tahiti (J. Jaquenin, USNM).

Fossil records—None reported.

Strombus fasciatus Born, 1778

(Pl. 14, figs. 16, 17)

Range—Limited to the Red Sea.

Remarks—This is one of the most distinctive and most restricted in its range of all the Indo-Pacific *Strombus*. It has no close living relatives, although it shows some features of *decorus* Röding. It is moderately common wherever it lives. The shell is readily recognized by its somewhat conic shape, by its large, somewhat evenly-sized shoulder spines, by the orange-yellow aperture and by the 5 to 7 broken, narrow, spiral bands of black-brown on the body whorl.

Habitat—It is presumably moderately common in shallow water in sand or muddy areas.

Description—Shell 32 to 50 (1¼ to 2 inches) in length, solid, somewhat conic, spined at the angular shoulder, with a yellow-orange aperture, and the body whorl with 5 to 7 broken, narrow, black-brown bands. Whorls 9. Nuclear whorls 3(?), glossy translucent whitish. Postnuclear whorls pinkish or whitish, slightly rounded, may have 3 to 5 small, whitish former varices, and may or may not have a single, spiral incised line below the suture. Knobs develop on the penultimate whorl, and become 8 to 12 smooth, pyramidal spines on the angular shoulder of the last whorl. Central part of last whorl may have 1 or 2 low, rounded, broad spiral cords. Columella straight, weakly calloused, smoothish, except for microscopic spiral striae near the edge in some specimens. Columella whitish to translucent-yellow. Inner aperture smooth, glossy, flushed with yellow-orange. Siphonal canal very short. Stromboid notch U-shaped. Outer shell cream with fine, light-brown flecks over which are 5 to 8 broken, black-brown, narrow, spiral color bands. Periostracum thin, smoothish and translucent-tan. Operculum, radula soft parts not observed.

Measurements (mm.)—

length	width	no. whorls	
50.0	26.0	9	(large; Red Sea)
42.1	24.0	9	(average; Red Sea)
32.1	19.1	7+	(small; Red Sea)

Synonymy—

1778 *Strombus fasciatus* Born, Index Rerum Natur. Mus. Caesarei Vindobonensis, p. 274 (no locality); refers to Chemnitz Conchyl.-Cab., vol. 3, figs. 800-802. Non Gmelin 1791, non Röding 1798.

1788 *Strombus subalata* Herbst, Natur. Abbild. der merkw. Würmer, Berlin, vol. 9, p. 204, no. 15, pl. 48, fig. 3 (Red Sea).

1798 *Lambis elegantissima* Röding, Museum Boltenianum, Hamburg, pt. 2, p. 61, no. 773; 1807, Link, Beschr. Natur.-Samml. Univ. Rostock, pt. 2, p. 108 (no locality).

1817 *Strombus polyfasciatus* Dillwyn, Descriptive Cat. Recent Shells, vol. 2, p. 662 (Red Sea).

1822 *Strombus lineatus* Lamarck, Anim. sans Vert., vol. 7, p. 211, no. 29 (Océan indien?). Refers to Conchyl.-Cab., vol. 3, figs. 800-802; 1843, Kiener, Coquilles Vivantes, vol. 4, pl. 30, figs. 1, 1a.

1828 *Strombus lineolatus* Wood, Index Testaceol., Suppl., p. 13, pl. 24, fig. 11 (no locality).

1844 *Strombus sublatus* Herbst, Duelos, Illustr. Conchyl., vol. 2, p. 7.

1885 *Strombus flavigula* Meuschen, Tryon, Manual Conch., Phila., vol. 7, p. 120.

Types—Born's type is probably in the museum at Vienna. No locality was given, and we hereby designate the Red Sea as the type locality.

Records—RED SEA: Port Sudan, Anglo-Egyptian Sudan (ANSP); Jobal Straits, Egypt (ANSP); Massaua, Eritrea (ANSP); Aqaba, Gulf of Suez (A. Hadar); Jidda Harbor, Saudi Arabia (USNM); Sharm Ubhar, and Genaba Bay, Farasan Kebir, Saudi Arabia (both USNM); 10 km. north of Jidda, Saudi Arabia (C. Aslakson, ANSP).

Fossil records—Port Sudan, raised coral reef, Pleistocene (Hall and Standen, 1907, p. 67). EGYPT: Pleistocene; beach, 50 ft. alt., Gemsah; beach, 80 ft. alt., Wadi Gueh, west of Kosseir (both R. B. Newton, 1900, p. 508).

Strombus latus Gmelin, 1791

(Pl. 99, figs. 1 and 2)

Range—West coast of Africa from Spanish West Africa to Angola, including the Cape Verde Islands.

Remarks—This is not an Indo-Pacific species, but is included here, since it is the only living *Strombus* in the Eastern Atlantic. It is recognized by its somewhat quadrate shape, rather evenly-sized knobs on the shoulder, the peculiar, raised spiral cord or ridge running back from the stromboid notch, and by its light-brown, white-flecked and rose-striped exterior. The periostracum is usually heavy and brownish. In general shape and coloration, it stands midway between *lentiginosus* of the Indo-Pacific and *granulatus* of the Panamic Pacific Province.

Unfortunately, there have been four earlier names applied to this shell which, until Dodge's 1956 revision, had been known as *bubonius* Lamarck. Duclos employed the name *latus* Gmelin in 1844 in his monograph.

Plate 99. Figs. 1 and 2. *Strombus latus* Gmelin (formerly *bubonius* Lamarck), Tropical West Africa. Both natural size.

Description—Adult shell 90 to 156 mm. in length, solid, moderately heavy, somewhat quadrate in shape, well-spired, and maculated with orange-brown, rose and white. Whorls 10. Nuclear whorls not seen. Spire slightly convex, the early whorls somewhat distorted by 2 to 5 raher broad former varices. Spiral sculpture of 8 to 12 fine cords which disappear in the last two whorls. Suture well-indented, wavy because it half-covers the numerous, evenly-sized, rounded knobs in the whorls. 8 to 10 rounded knobs on the shoulder of each whorl. In the last whorl, the last three knobs are the largest. Below these, and midway on the whorl, is a second spiral row of much smaller, rounded knobs. Near the base of the shell, and in line with the stromboid notch is a single, raised, strong cord or ridge. Outer lip slightly expanded, its edge reflected, smooth, glossy and with 3 or 4 broad bands of light-brown. Columella and parietal wall smooth, glossy, creamish tan. Interior of aperture white. Stromboid notch deep. Base of columella constricted. Periostracum moderately thick, light-brown, and flakes off when dry. Operculum and soft parts unknown.

Measurements (mm.)—

length	width	no. whorls	
156.0	102.0	10+	(large; West Africa)
106.0	68.0	10+	(average; Cape Verde Ids.)
88.0	51.0	10+	(small; West Africa)

Types—The whereabouts of the types is unknown. We hereby designate Sierra Leone, West Africa, as the type locality.

Synonymy—

1791 *Strombus latus* Gmelin, Systema Naturae, ed. 13, p. 3520 (no locality). Refers to Seba, pl. 63, figs. 4, 5; 1956, Dodge, Bull. Amer. Mus. Nat. Hist., vol. 111, art. 3, p. 272, footnote 1.

1791 *Strombus fasciatus* Gmelin, Systema Naturae, ed. 13, p. 3510, no. 9 (in Africa); refers to Conchyl.-Cab., vol. 3, figs. 833-834. Non Born 1778.

1795 *Strobus auratus* Spalowsky, Prodromus Systema Historicum Testaceorum, Vienna, pp. 43-44, pl. 6, fig. 9 (as *Strombus*) (India orientalis?).

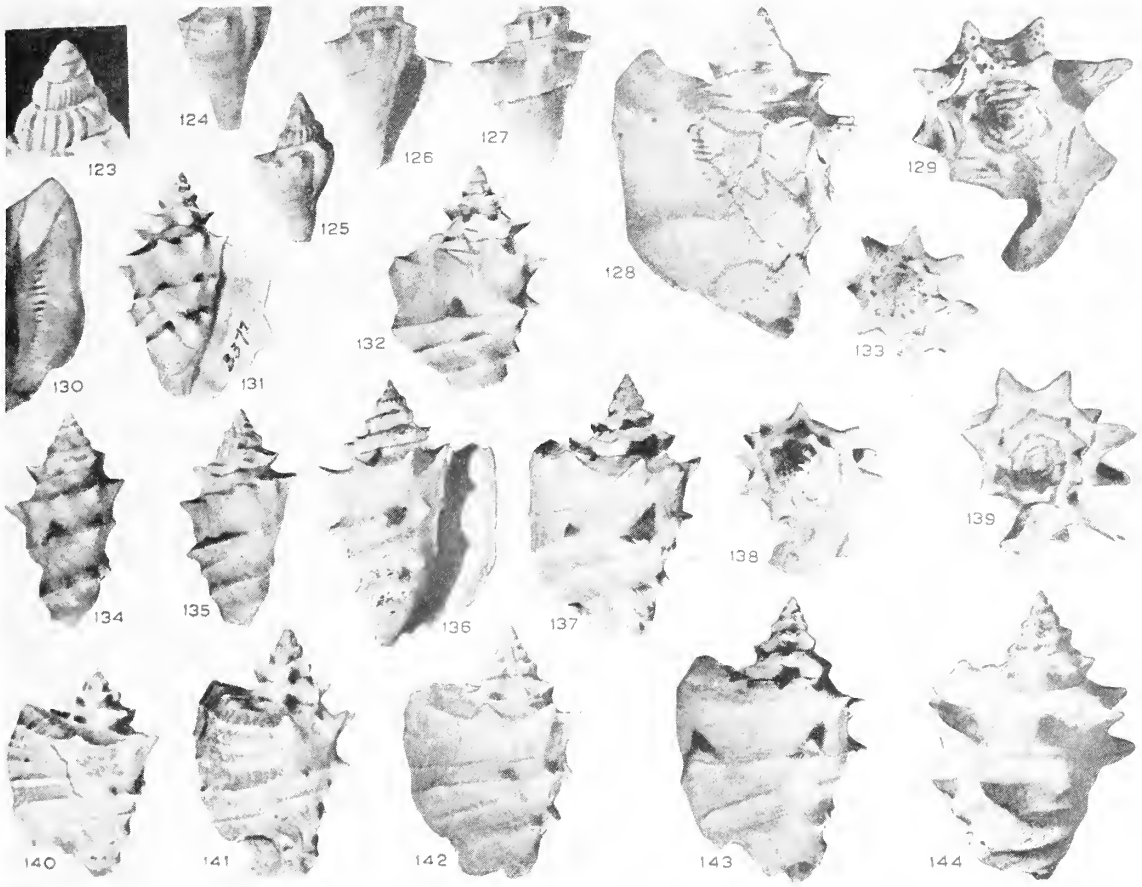


Plate 100. *Strombus (Lentigo) preoccupatus* Finlay. A series of Lower Miocene specimens from Mangkalihat, East Borneo, Indonesia. (from Beets, 1941, pl. 3, figs. 123-144). Natural size.

1798 *Lambis carnea* Röding, Museum Boltenianum, Hamburg, pt. 2, p. 63, no. 808 (no locality); refers to Conchyl.-Cab., vol. 3, figs. 833-834.

1798 *Lambis carnaria* Röding, *loc. cit.*, p. 64, no. 809 (refers to Conchyl.-Cab., vol. 3, fig. 893, a young specimen).

1807 *Lambis fasciatus* Gmelin, Link, Beschr. Natur.-Samml. Univ. Rostock, pt. 2, p. 109.

1822 *Strombus bubonius* Lamarck, Anim. sans Vert., vol. 7, p. 203 (Antilles [erroneous]); 1950, Nicklès, Manuels Ouest-Africains, vol. 2, p. 76, fig. 106.

1822 *Strombus dilatatus* Lamarck, Anim. sans Vert., vol. 7, p. 203, no. 8 (no locality). Refers to Seba, vol. 3, pl. 63, figs. 4 and 5 [which might also be a smooth S. *costatus* Gmelin]; Kiener, 1843, Coquilles Vivantes, vol. 4, pl. 5. Non Swainson 1821.

1827 *Strombus adansoni* Defrance, in Blainville's Dict. Sci. Nat., vol. 51, p. 115. Refers to Adanson, 1757, pl. 9, fig. 30 (L'île Goree).

1833 *Strombus bubo* Lamarck, Deshayes, in Exped. Scientif. de Moree, Mollusques, vol. 3, pt. 1, p. 192. Non Röding, 1798.

1844 *Strombus latus* Gmelin, Duclos, in Chenu, Illust. Conchyl., vol. 4, Strombus, pl. 13, figs. 5-7.

Records—SPANISH WEST AFRICA: Rio de Oro (M. Nicklès, 1950, p. 77. CAPE VERDE ISLANDS: (ANSP, MCZ). SIERRA LEONE: Turtle Island, off Sherbro Islands; off Freetown (both MCZ). SPANISH GUINEA: Adjé, 20 miles south of Benito; Coriseo Island (both MCZ). Prineipe Island (MCZ). San Thomé Island (Hoyle, 1887, p. 340 and MCZ). ANGOLA: (M. Nicklès, 1950, p. 77).

Strombus preoccupatus Finlay, 1927

Range—Lower and Upper Miocene of Java and Borneo, Indonesia.

Remarks—Beets (1941, p. 67, pl. 3) has given an excellent series of figures of this interesting species which has no Recent counterpart in the Indo-Pacific. *S. fasciatus* (Red Sea) may belong to this stock. The Recent S. *granulatus* Swainson from the tropical Eastern Pacific is extremely similar to *preoccupatus*. *Strombus nodosus* (Borson, 1820) from the Italian Tertiary belongs to the same group.

Synonymy—

1881 *Strombus spinosus* K. Martin, Samml. geol. Reichs-Mus., Leiden, 1st ser., vol. 1, p. 122, pl. 7, figs. 3, 4 (Podjok; Djokdjokarta; and Wirosari, Java; non Linné, 1767, p. 1212; 1899, K. Martin, *loc. cit.*, part 45, p. 176, pl. 28, figs. 408-409; 1921, *loc. cit.*, n. Folge, vol. 1, pt. 2, p. 468, pl. 59, fig. 56 (Tji Talahab and Tji Angsana, Java).

1927 *Strombus preoccupatus* Finlay, Trans. and Proc. New Zealand Inst., vol. 57, p. 502 (new name for *spinosus* Martin, non Linné); 1941, Beets, Overdruk Verhand. Geolog. Mijnbowk. Genoot. Nederl. Kolonien, Geol. series, vol. 13, p. 67, pl. 3, figs. 123-144 (East Borneo).

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

Subgenus Euprotomus Gill, 1870

Type: *Strombus aurisdianae* Linné, 1758

This group is limited to the Indo-Paeific, one species extending from Melanesia to East Africa, the other five mainly centered in the Western Paeifie. The fossil reeord goes back only to the Plioeene of the Western Pacific. The shells are medium-sized for the genus and are eharacterized by a high spire, a high prong-like extension of the posterior end of the outer lip, and a smooth eolumella. The inside of the outer lip may be smooth or with strong, spiral lirae. The penis is "keeled", that is bearing an accessory projeetion of the distal blade. The tentaeles are usually short and loeated quite near the end of the eye pedunele. The marginal radular teeth are very broad and bear 4 to 6 large, triangular dentieles. There is no basal peg on the lateral tooth. The operculum bears 6 to 8 small serrations.

Synonymy—

1847 *Monodactylus* "Klein" Herrmannsen, Indices Generum Malacozoorum Primordia, vol. 2, p. 53 [invalid]; 1852, "Klein" Mörch, Cat. Conchyl. de Yoldi, p. 62; 1854, "Klein" H. and A. Adams, The Genera of Recent Mollusca, vol. 1, p. 259; 1868, H. and A. Adams, Gabb, Ameriean Journal of Conchology, vol. 4, pt. 3, p. 138. Type by subsequent designation: *Strombus adustus* = *aurisdianae aratrum* Röding, 1798; 1884, "Klein" P. Fischer, Manuel de Conchyliologie, Paris, pt. 7, p. 670. Type by subsequent designation: *Strombus pacificus* Swainson = *vomer* Röding, 1798; 1904, "Klein" Cossmann, Essai de Paléoeonch. Comparée, Paris, 6th book, p. 7. Type by subsequent designation: *Strombus gallus* Linné [invalid]. Non *Monodactylus* Lacépède, 1800.

1870 *Euprotomus* Gill, American Journal of Conchology, vol. 5, pt. 3, p. 131, footnote. Type by monotypy: *Strombus aurisdianae* Linné.

Strombus aurisdianae *subspecies* aurisdianae Linné, 1758

(Pl. 14, figs. 3, 4; pl. 101, figs. 1-4)

Range—Central East Africa to the Solomon Islands, and the Ryukyu Islands south to Queensland, Australia.

Remarks—This is a well-known and moderately common shallow-water speeies. In some areas in the Philippines it is abundant. Some eonfusion has existed coneerning its elose relatives and various forms. Its nomenelatorial history in relation to the synonym, *lamarcki* Sowerby, 1842, is diseussed below. We consider *bulla* (Röding) to be a separate speeies, but *aratrum* (Röding) from northern Australia to be a subspeeies. Below is a synopsis of the characters of these three taxa:

S. *aurisdianae aurisdianae*—exterior rough and with a dull finish; interior of aperture usually pinkish and with 8 to 12 fine lirae on the upper part of the outer lip; spire glazed over on the ventral side of 3 or 4 whorls above; without brown splotches in the glazed portions; siphonal canal reflected about 90 degrees.

S. *aurisdianae aratrum*—exterior rough and with a dull finish; interior of aperture brownish orange to salmon and with 5 to 9 fine lirae on the upper part of the outer lip; spire glazed over only on the ventral side of 1 or 2 whorls above; with brown splotehes in the glazed portions; siphonal canal reflected about 75 degrees.

S. *bulla*—exterior smoothish (except for single row

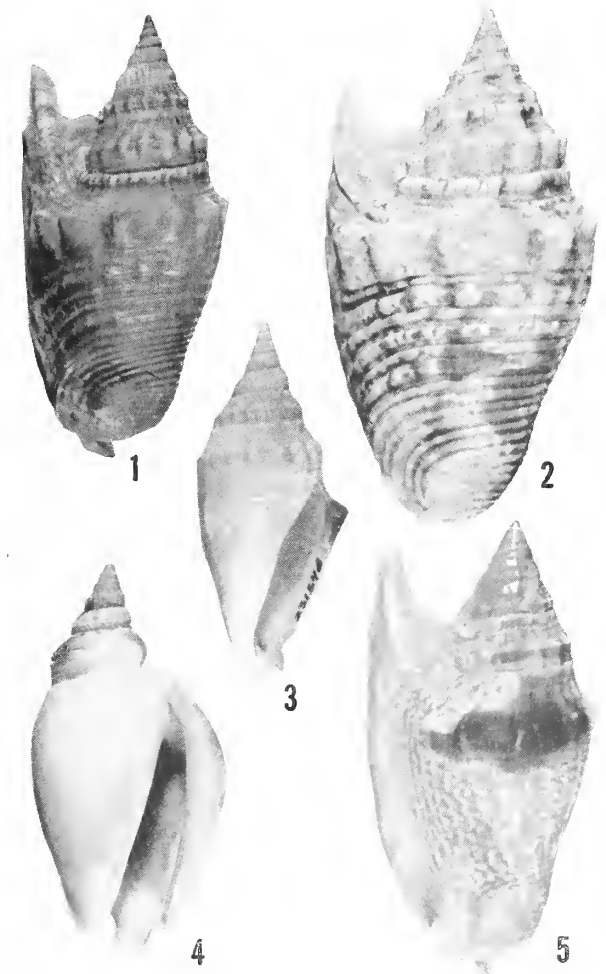


Plate 101. Figs. 1 and 2, *Strombus aurisdianae* Linné, Zanzibar. 3, immature S. *bulla* (Röding) from the Luzon Island. 4, "wingless" abnormality of *aurisdianae* from Cebu Island, Philippines. 5, S. *bulla* (Röding), brown-spotted form from Cebu Island, Philippines. All natural size.

of knobs) and with a glossy finish; interior of aperture reddish orange and with no or rarely 1 or 2 fine lirae on the upper part of the outer lip; spire usually glazed over the entire spire in adults; glaze white in color, sometimes with violet on the spire; siphonal canal reflected 85 to 95 degrees.

Typical *aurisdianae* is characterized by its rough exterior, smoothish brownish to reddish orange aperture, the single wing-like extension at the top of the outer lip, the strongly recurved siphonal canal, and by the 5 to 9 shoulder knobs on the dorsal side of the body whorls. In the Western Pacific it is fairly constant in characters, although Ryukyu Island specimens (**form** *chrysostomus*) may take on the cream-orange apertural coloration of the Australian subspecies, *aratrum*. However, certain Philippine and Indian Ocean specimens may also exhibit this probable dietary form. Certain Zanzibar and Seychelles specimens show a tendency towards stronger rugosity and a uniform orangish exterior. They intergrade with normal Indian Ocean *aurisdianae*, and, at best, might be considered an "incipient subspecies."

We collected an adult malformed specimen in 1958 on Olango Island, Cebu, Philippines, in which the upper part of the outer lip is rounded over and entirely lacking the posterior projection. (Pl. 101, fig. 4.)

Habitat—Occurs in moderate numbers in shallow water from the low tide mark to a depth of about 12 feet, either on grassy sand flats, on dead coral reefs, or on a coral sand and grass bottom.

Description—Shell 46 to 76 mm. (2 to 3 inches) in length, solid, rugose, with a posterior projection on the outer lip, with a strongly recurved siphonal canal and with a smoothish, glossy, cream and orange aperture. Nuclear whorls 3, glossy, translucent, rounded, and either whitish, tan or brown in color. First 3 postnuclear whorls well-rounded, neatly reticulate. Following whorls with numerous axial, knobbed ribs crossed by a dozen uneven spiral threads. There is a large, wavy cord just below the suture. Shoulder of last whorl with 5 to 9 small, short knobs (other knobs are glazed over by the parietal wall). Below are two spiral rows of very obscure nodules. Base of shell with numerous rather smooth spiral, crowded, rounded cords. Parietal glaze cream to whitish and extending up on to 3 to 5 of the whorls in the spire. Columella straight, glossy, tan or light-cream, and smooth except for indistinct lirae and wrinkles at the very top. Inner lip smooth, brownish orange to pinkish, rarely yellowish orange, bordered with a broad band of whitish to tan-cream; aperture smooth, except for a dozen lirae below the deep stromboid notch and 8 to 12 fine, irregular, white lirae on the floor of the posterior canal region. Outer lip moderately sharp; rounded, glazed, smooth posteriorly where there are 5 to 7 grayish brown spiral bars. Posterior projection of outer lip extending half-way to all the way back as far as the apex of the spire. It may extend straight back or curve slightly towards the apex. Siphonal canal recurved about 90 degrees and slightly twisted to the right. Periostracum very thin, translucent yellowish, flaking off when dry, and usually worn away from the shell in life. Operculum stromboid, dark-brown, strongly arched, pointed, and with 6 to 7 serrations.

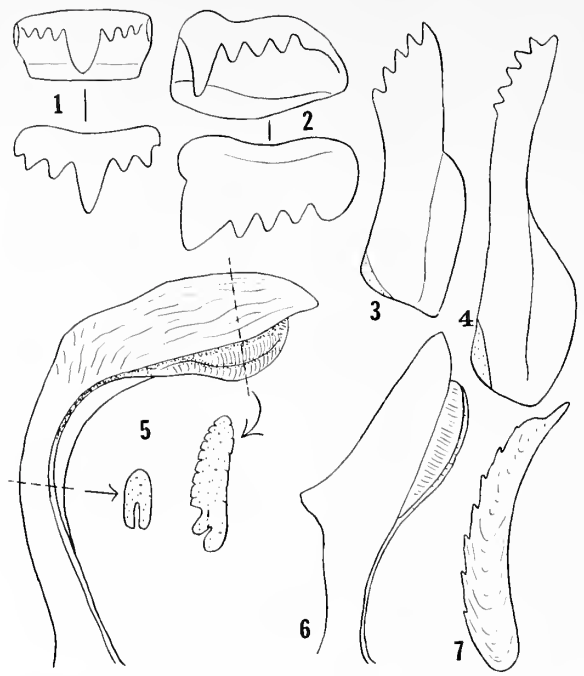


Plate 102. *Strombus aurisdianae* Linné. Figs. 1-5 from Dutch New Guinea. 1, central radular tooth. 2, lateral. 3, inner marginal. 4, outer marginal. 5, verge, showing cross-sections. 6 and 7, verge and operculum from Zanzibar specimen.

Radula ribbon 6 to 8 mm. in length, with about 40 to 50 rows of teeth. Formula for New Guinea: 2-1-2; 1-3 (without peg); 4; 5. Zanzibar: 2-1-2 (also 3-1-3); 1-3 (without peg); 4 or 5; 5 or 6. Verge simple, 16 to 18 mm. in length, with a laminated pad. Posterior mantle filament 4 mm. in length.

Measurements (mm.)—

length	width	no. whorls	
76.5	42.9	9+	(large; Ryukyu Islands)
61.0	34.0	9	(average; Cebu Id.)
46.5	25.7	10	(small; Negros Id.)

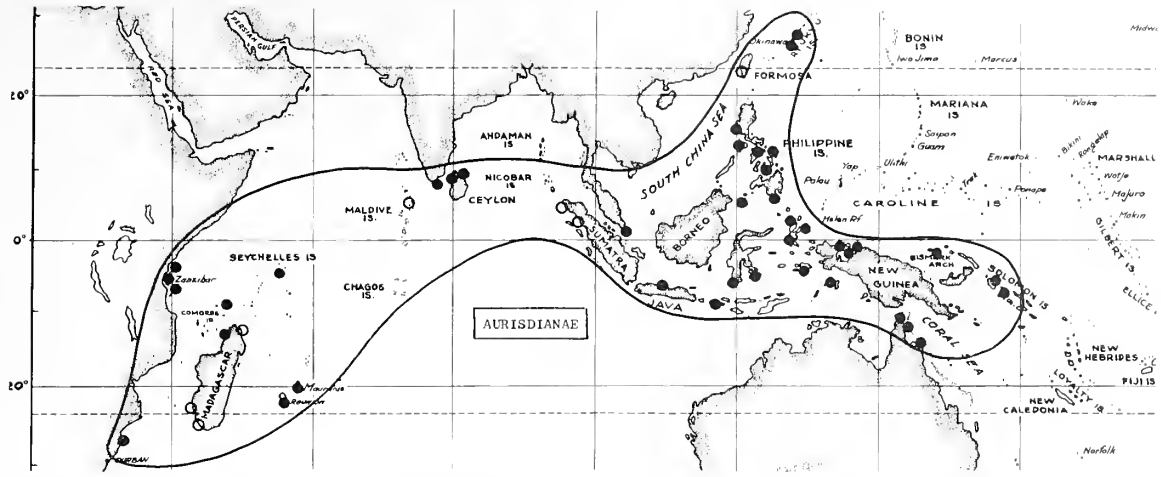


Plate 103. Geographieal distribution of *Strombus aurisdianae* Linné.

Synonymy—

1758 *Strombus auris-dianae* Linné, Systema Naturae, ed. 10, p. 743, no. 429 (In O. Asiae); 1767, ed. 12, p. 1209, no. 497; 1956, Dodge, Bull. Amer. Mus. Nat. Hist., vol. 111, art. 3, pp. 256-258.

1798 *Lambis stiva* Röding, Museum Boltenianum, Hamburg, pt. 2, p. 64, no. 815. Substitute name for *aurisdianae* L.

1798 *Lambis buris* Röding, *ibid.*, p. 64, no. 819.

1842 *Strombus lamarekii* Gray, Sowerby, Thesaurus Conehyl., vol. 1, p. 35, pl. 9, figs. 98, 99. Non Gray, 1826; 1938, Adam and Leloup, Result. Sci. Voy. Indes Orient. Neerl., vol. 2, fase. 19, p. 117. Non Gray, 1826.

1942 *Strombus chrysostomus* Kuroda, Venus, vol. 12, p. 7, figs. 1 and 2 on p. 4 (Okinawa Ids.).

1880 *Strombus striatogranosus* "Mörch," von Martens in Möbius, Beitr. Meeresfauna I. Mauritius Seyehellen, Berlin, p. 277.

Types—Linné's types are in the Linnaean Society of London and are a mixture of two speeies. I hereby designate the first figure reference in Linné's 10th edition synonymy as being the "type figure" or the most representative of the species—Rumphius, pl. 37, fig. R. The original type locality was "O. Asiae". I further restriet it to Amboina, Indonesia.

Nomenclature—The exaet identity of Linné's *aurisdianae* has been a subject of contention at various times, commencing with Hanley (1855, pp. 268-269) and continued by Dodge (1956) who gives a lengthy summary of the matter, but still confuses the problem. It is a fact that Linné had a mixture of specimens and his eited figures represented two species. The ehoiee is between the smooth species (which we call *bulla* Röding) and the rough species referred to by authors as *lanarcki* Sowerby. I prefer to reserve the name of *aurisdianae* for the very common speeies whieh has its "dorso murieato" and is figured in Sowerby's Thesaurus, pl. 9, figs. 98 and 99. The name *lanarcki* was first instituted by Gray (not Sowerby, 1842) in 1826 and applies to the smooth species (*bulla* Röding). On this basis, we disagree with Oostingh (1925, p. 54) that Sowerby 1842 was the first revisor.

Selected records (see accompanying map, pl. 103); solid dots: speeimens examined; open circles: literature records)—MOZAMBIQUE: Port Amelia (MCZ). TANGANYIKA: Mboa Magi (R. T. Abbott, USNM). MADAGASCAR: Majunga; Tulear; Sarodrano (all Dautzenberg, 1929, p. 467). Nossi-bé (A. Chavane, ANSP). Gloriosa and Providence Id. (USNM). SEYCHELLES: Cerf Id. (Yale Peabody Mus.). MALDIVES: Hulule Id. (E. A. Smith, 1903, p. 612, no. 202). CEYLON: Pearl Bank, Gulf of Manaar (G. and M. Kline, NSF, 1956). MALAYA: off Pulau Sudong, Singapore (R. D. Purchon, ANSP). SUMATRA: near Poelo Raja, and Tjalang, west Atjeh (Oostingh, 1929, no. 39, p. 2). RYUKYU ISLANDS: Shioya, Shanawan Bay, Okinawa Id. (USNM). PHILIPPINES: common on the following islands: Luzon; Samar; Cebu; Bohol; Mindoro; Negros; Catanduanes; Balabac; Mindanao; Sanga Sanga, Sulu Archipelago (all ANSP). Lubang; Marinduque, Ramblon; Panay; Camiguin (all USNM). AUSTRALIA: Queensland: Hope Id. (USNM); Danley Id., Torres Straits (MCZ); Low Isles (Tony Marsh, ANSP). SOLOMONS: Bougainville Id. (MCZ).

Fossil records—Altena (1942, p. 58) reports one specimen (as *lamarekii* Sowerby) from the Plioeene Upper Kalibeng layers, Java, Indonesia, but I have not seen this speeimen. Records for the Ryukyu Islands are fossil specimens of *S. vomer hawaiensis* Pilsbry. KENYA: Pliocene, Crag: South Mombasa Id., just west of Mbaraki Creek (J. Weir, Monograph 5, 1938, p. 68, pl. 5, fig. 2). HAWAIIAN CHAIN: Pleistocene: Oahu Island: entire fossil from Honolulu Harbor (J. M. Ostergaard, 1928, p. 27; this may be a *vomer hawaiensis* Pilsbry).

Strombus aurisdianae *subspecies* aratrum (Röding, 1798)

(Pl. 14, figs. 1, 2)

Range—Northeast Queensland, Australia.

Remarks and Description—This subspecies occurs nearer to the mainland and in muddier waters than the typical subspecies which is a coral-water form. *S. aurisdianae aratrum* is somewhat more elongate, with a less reeurved siphonal canal, usually with

smaller and more numerous knobs on the shoulder of the last half of the body whorl, and with a darker more orange-brown aperture. The nuclear whorls are whitish and very similar to those of *aurisdianae*. The upper portion of the parietal wall is poorly glazed and well decorated with numerous, dark blackish brown zigzag stripes. Black-brown staining is generally present around the glossy underside of the shell. An ecologic and life history study would clarify the relationship of these two subspecies.

Measurements (mm.)—

length	width	no. whorls	
90.6	42.3	10	(large; Cairns)
73.8	41.2	9+	(average; Pilot Point)
58.8	30.6	10	(small, Bowen)

Habitat—Moderately common on sand in intertidal areas.

Synonymy—

1798 *Lambis aratrum* Röding, Museum Boltenianum, Hamburg, pt. 2, p. 64, no. 820. Refers to Conchyl.-Cab., vol. 10, figs. 1487-88.

1816 *Strombus aurisdianae* Linné, Lamarck, Le Liste, p. 4. Encycl. Méth., pl. 409, figs. 3a, b.

1817 *Strombus aurisdianae* var. *adusta* "Chemnitz", Dillwyn, Descr. Cat. Recent Shells, London, vol. 2, p. 664.

1822 *Strombus melastomus* Swainson, Appendix to Cat. Shells of Mrs. Bligh, London, p. 8 (Pacific Ocean).

1823 *Strombus aurisasini* Dillwyn, Index Hist. Conchyl. Lister, London, p. 39 (no locality). Refers to Lister pl. 872, fig. 27.

1825 *Strombus melanostomus* Sowerby, Cat. Shells Earl of Tankerville, p. 68. Emendation of *melastomus* Swainson.

1826 *Strombus adusta* Gray, in King Narrative Survey—Australia, London, vol. 2, appendix, p. 490. Refers to Conchyl.-Cab., vol. 10, figs. 1487-88.

1835 *Strombus melanastomus* Swainson, Exotic Conchology, 2nd issue, pt. 6, pl. 47.

Types—Röding's species is based upon figures 1487-88, vol. 10, Conchylien-Cabinet. Chemnitz's locality of East Indies was evidently erroneous. Some old collections bear labels of Java, Mauritius and Amboina, but we believe these are manufactured locality records. We hereby designate Bowen, Queensland, Australia, as the type locality.

Nomenclature—As indicated by our synonymy, the name *aratrum* Röding must take precedence over *melastomus* Swainson and *melanostomus* Sowerby. The name *aratrum* Martyn 1784 (applied to the species *vomer* Röding) is non-binomial and invalid because the figures are entirely hand produced and not printed. Therefore, it does not preoccupy Röding's 1798 name. This species is the "*adustus* Chemnitz" of early authors.

Records—AUSTRALIA: Queensland: Thursday Island (USNM), Cape York (MCZ); Green Island, Cairns (ANSP); Pilot Point, Brampton Reef and Sinclair Bay, all near Bowen (ANSP); Dunk Id. (USNM); Bedford Beach (USNM); Port Douglas, 50 mi. north of Cairns (MCZ and ANSP); Turtle Bay, Cape Grafton, near Cairns (MCZ); Alexandra Reef (MCZ); Bustard Head (ANSP); Whitsunday Id. (USNM).

Strombus bulla (Röding, 1798)

(Pl. 14, figs. 5, 6, pl. 101, fig. 5)

Range—Ryukyu Islands to Melanesia and Samoa.

Remarks—We consider S. *bulla* to be a species separate from *aurisdianae*. Their ranges overlap without signs of interbreeding in the western Pacific. To the east of the Solomons one finds only *bulla* and to the west of the East Indies one evidently only finds *aurisdianae*. S. *bulla* lives in deeper water. The two are closely related. One could hazard a guess that *bulla* originally evolved as a Central Pacific subspecies, and later, as a full species, re-invaded the territory of the parent *aurisdianae*, although the reverse could also have been possible. The key to identifying features of this glossy smooth, lavender-tipped species are listed under the remarks of *aurisdianae*.

Habitat—S. *bulla* occurs sparingly from just below the lowest tide line to a depth of 10 fathoms on clean sand bottoms.

Description—Shell 49 to 72 mm. (2 to 3 inches) in length, solid, with a smoothish, glistening surface, with a posterior projection on the outer lip, with a strongly recurved siphonal canal and with a smooth, glossy, white and rose-orange aperture. Nuclear whorls 3, glossy, translucent, rounded, and

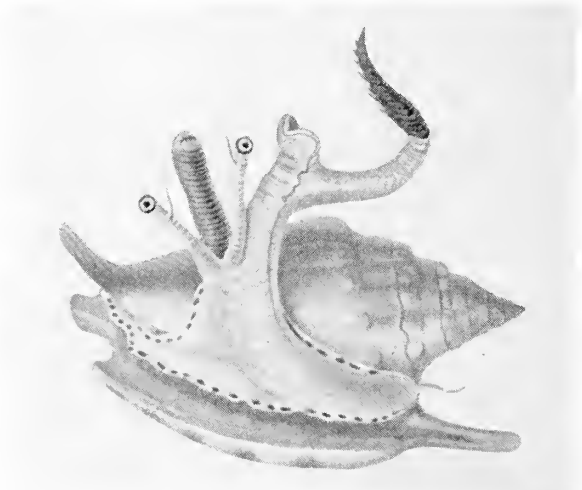


Plate 104. Living animal of female *Strombus bulla* (Röding). (from Quoy and Gaimard, 1833, pl. 51, fig. 1).

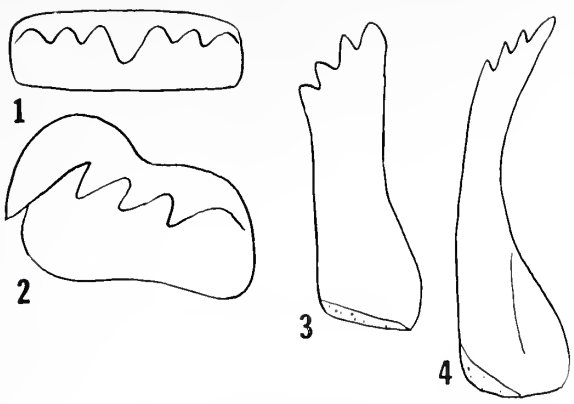


Plate 105. Radula of *Strombus bulla* (Röding), Dutch New Guinea. Fig. 1, central. 2, lateral. 3, inner marginal. 4, outer marginal.

either whitish, tan or purplish in color. First 3 postnuclear whorls well-rounded, and neatly reticulate. Following whorls with numerous axial, knobbed ribs crossed by about a dozen uneven spiral threads. The subsutural cord is very weak and is weakly crinkled. Shoulder of last whorl with 5 to 9 small, short, smoothish knobs (other knobs are glazed over by the parietal wall). There are no spiral rows of smaller knobs below. Base of shell with crowded, weak, spiral cords. Parietal glaze enamel-white, usually quite thick, and extending up nearly to or over the apical whorls. In some instances, the glaze may cover the entire spire. Columella straight, glossy, whitish and entirely smooth. Outer lip enamel-white, except for a lavender stain at the base. Deep interior of aperture reddish to rose-orange and smooth. Posterior projection of the outer lip extending ¾ way back as far as the spire or rarely slightly beyond. In some specimens it leans towards the apex. Siphonal canal recurved from 85 to 95 degrees and slightly twisted to the right. Body whorl with large mottlings of light brown, and small speeklings of white; rarely with mauve undertones. Some Philippine specimens may have an irregular dark chestnut-brown patch on the dorsum of the last whorl. Periostraeum very thin, translucent, and usually worn away even in live specimens. Opereulum stromboid. Animal tan with large white spots. Verge with a "heel" on the distal blade. Radula 6 mm., and with 42 rows of teeth. Formula for New Guinea: 2-1-2; 1-3 (without peg); 4; 5.

Measurements (mm.)—

length	width	no. whorls	
73.0	37.4	11	(large; Cebu Id.)
61.5	33.5	9+	(average; Okinawa Id.)
49.2	28.0	10	(small; Luzon Id.)

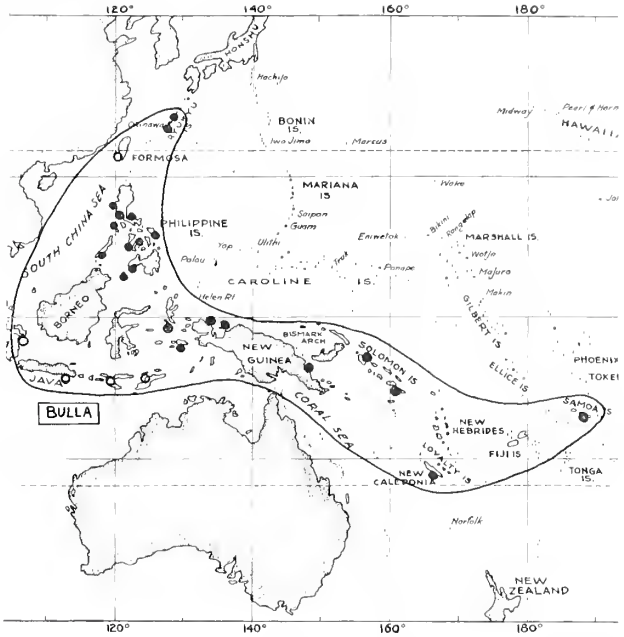


Plate 106. Geographical distribution of *Strombus bulla* (Röding).

Synonymy—

1798 *Lambis bulla* Röding, Museum Boltenianum, Hamburg, pt. 2, p. 64, no. 814 (no locality). Refers to Conchyl.-Cab., vol. 3, fig. 840.

1811 *Strombus laevis* Perry, Conchology, London, pl. 13, fig. 4 (African Seas).

1826 *Strombus lamarckii* Gray, in King, Narrative Survey—Australia, London, vol. 2, appendix, p. 490. Refers to Conchyl.-Cab., vol. 3, fig. 840 and Seba, pl. 61, figs. 1, 2. Non Sowerby, 1842.

1840 *Strombus lamarckii* Swainson, in Lardner's Cabinet Cyclopaedia, Treatise Malacology, London, p. 139. Non Sowerby, 1842.

1842 *Strombus aurisdianae* Linné, Reeve, Conchologia Systematica, vol. 2, p. 206, pl. 251, fig. 4.

1843 *Strombus guttatus* "Martini" Kiener, Coquilles Vivantes, vol. 4, Strombus, p. 24, pl. 15, fig. 1 (Mer des Indes); 1851, Reeve, Conch. Icon., vol. 6, Strombus, pl. 14, fig. 33.

1925 *Strombus (Strombus) aurisdianae* Linné, Oostingh, Mededeel. Landbouw. Wageningen, vol. 29, pt. 1, p. 55.

1938 *Strombus (Euprotomus) aurisdianae* Linné, Adam and Leloup, Result. Sci. Voy. Indes Orient. Neerl., vol. 2, fasc. 19, p. 117.

Types—Röding's *bulla* is based upon figure 840, vol. 3, Conchylien-Cabinet. The latter gave no locality. We hereby designate Cebu City, Cebu Island, Philippines, as the type locality.

Nomenclature—This is the species referred to in the old literature as *Strombus gultatus* Martini, a non-binomial name. This was not validated until 1843 by Kiener, but had two earlier names, *bulla* Röding and *laevis* Perry. Many authors between 1847 and 1938 referred to this species as *aurisdianae* L., but on the basis of Gray's 1826 revision we

have restricted the latter name to the commoner, rough species figured by Rumphius, pl. 37, fig. R. S. *bulla* is S. *lamarcki* of Gray not Sowerby, Hanley, Oostingh and Adam and Leloup.

Records (see map, pl. 106)—RYUKYU ISLANDS: Itoma Jima Id. (MCZ); Okinawa Id. (Mrs. A. A. Scott, ANSP). TAIWAN: Hoko (Kuroda, 1941, p. 97). PHILIPPINES: Luzon: Lusong Cove, Bataan, 7 fms.; off Corregidor Id., 6-10 fms.; San Miguel Id., Tabaco Bay, Albay Prov. (all duPont-Academy Exped., 1958, ANSP). Mindoro: Mansalay Bay (ANSP); Calapan (MCZ); Lubang (MCZ). Cuyo Id., Palawan (ANSP). Cebu City, Cebu Id. (A. B. Franco, ANSP). Sulu Archipelago: Bongao Channel, Sanga Sanga Id. (J. Root, ANSP); Jolo Id. (MCZ). Samar Id. (MCZ). INDONESIA: Amboina and Bouro Ids. (MCZ); Misol, Timor, Savu, Flores, Java and Banka Islands (Oostingh, 1925, p. 56). DUTCH NEW GUINEA: Soepiori Id., Schouten Ids. and Aoerori Id., east Padaido Ids. (both NSF, 1956, ANSP). PAPUA: Finschhafen Bay (MCZ). SOLOMONS: Ugi Id. (ANSP); Kieta, Bougainville Id. (W. J. Eyerdam, ANSP). NEW CALEDONIA: (MCZ). SAMOA: Tutuila Id. (ANSP).

Fossil records—KENYA: Pleistocene: reef-limestone, eastern shore of Mombasa Harbour (L. R. Cox, 1930, Monograph 4, p. 137, not figured). Also an unverified report (see Cox, above) from the Pleistocene of Dar-es-Salaam, Tanganyika, by Koert and Tornau, 1910).

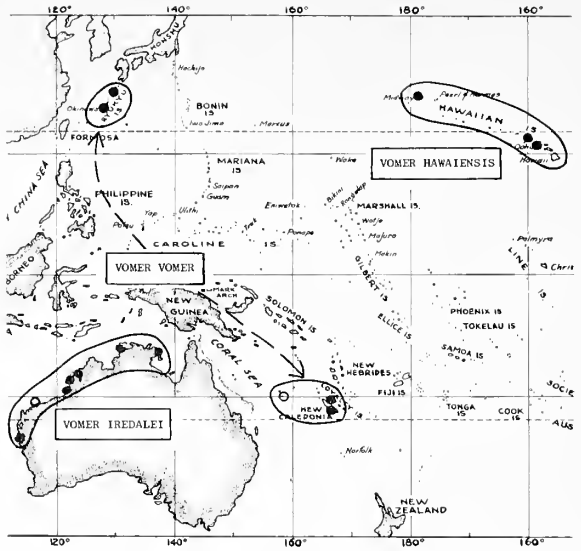


Plate 107. The discontinuous geographical distribution of *Strombus vomer vomer* (Röding) in the Western Pacific Arc, its Australian subspecies, *iredalei* Abbott, and its Hawaiian subspecies, *hawaiensis* Pilsbry.

Strombus vomer *subspecies* vomer (Röding, 1798)

(Pl. 14, figs. 7, 8)

Range—Ryukyu Islands and New Caledonia.

Remarks—To date, this very attractive species has been recorded in fair numbers from only the Ryukyu Islands and New Caledonia. Despite its apparent absence over a stretch of 3000 miles, there is no discernible difference in specimens from these two distant places. It would not be entirely surprising if it were to turn up in the Philippines and Indonesia, although we believe that this species, which was once widespread in the Pliocene, is now shrinking in range and becoming extinct. This shrinkage has left two peripheral subspecies, *iredalei* in northern Australia and *hawaiensis* in the Hawaiian Chain. The two isolated colonies of *vomer vomer* may, in future geological times, produce a further differentiation. This entire *vomer* complex presents an example of the various stages of development of allopatric species, with *iredalei* being the most advanced, and the *vomer vomer* colonies representing potential subspeciation.

Strombus vomer is a polytypic species containing three subspecies —*vomer* (Röding) from the Central Pacific Arc, *iredalei* Abbott from northern Australia and *hawaiensis* Pilsbry from the Hawaiian Chain. Iredale's *donnellyi* is quite likely a slightly malformed or immature specimen of *vomer vomer*. It was obtained dead near Sydney, Australia, from dredged piles of sand from the ship, "Triton", which had been working in New Caledonia under the command of Captian Comtesse. Other New Caledonian, as well as Australian, species occurred in dead condition in these sand piles, and the authenticity of their origins is very questionable.

Typical *vomer* is distinguished from the other members of the subgenus *Euprotomus* by the interior of its orange to lemon-yellow aperture which bears 45 to 50 smooth, rather even-sized, white spiral lirae, by the brown patch on the upper part of the parietal wall, and by the very weak or obsolete rugae on the base of the columella. *Strombus vomer iredalei* and *vomer hawaiensis* have a whitish to light yellowish aperture with numerous, crowded, uneven-sized lirae, and the base of the columella in each usually has moderately developed rugae. The former subspecies, from Australia, has an extra one or two spiral rows of weak, small knobs on the lower part of the body whorl and may or may not have black-brown stains on the parietal wall. Two of the lirae inside the upper part of the aperture are usually larger than the others. The smoothish, glossy exterior of *vomer vomer* and the rough, non-glossy exterior of *iredalei* are similar to the difference between the smooth *Strombus bulla* (Röding) and the rough S. *aurisdianae*.

Habitat—Found by George and Mary Kline in New Caledonia in 4 to 10 feet of water on coral sand and coral rubble on the barrier reef in Touho

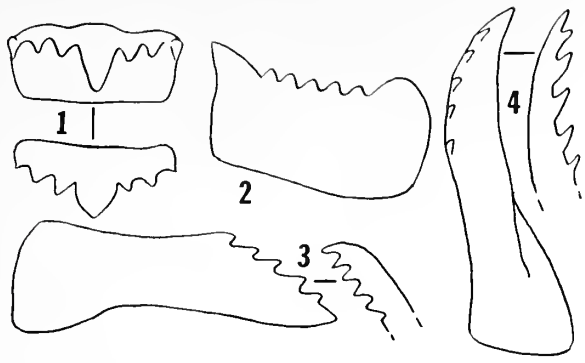


Plate 108. Radula of *Strombus vomer vomer* (Röding), New Caledonia. Fig. 1, central. 2, lateral. 3, inner marginal. 4, outer marginal.

Bay. Mrs. Anita A. Scott says *(in litt.)* it is uncommon in sand at dead low tide on Okinawa Island, Ryukyus.

Description—Shell 55 to 88 mm. (2 to 3½ inches) in length, solid, glistening, knobbed, with a high spire and projecting upper and outer lip, and with an orange inner aperture over which are white, spiral lirae. Whorls 11. Nuclear whorls 2, smooth, translucent lavender and convex. First 4 postnuclear whorls angulate, lavender, and with 10 to 12 spiral threads crossed by fine, axial threads which give the first 2 or 3 postnuclear whorls a microscopically cancellate appearance. At the angular periphery of the whorls, beads appear which become larger and fewer (7 to 9 in the body whorl; 9 to 10 in the penultimate; 11 to 16 in the whorl above this). Except for these knobs and for the 20 to 24 weak spiral cords at the base of the shell, the outer shell is smoothish, glossy, with a whitish background over which are maculations, speckles, tiny bars and arrows and axial streaks of mauve-brown. Outer lip moderately flaring, thickened and with a single, whitish, long or short projection at the top. Upper parietal wall with a glaze of blackish brown (like scorched paper); lower half swollen and cream. Inner columella wall brownish orange and weakly lirate above, smooth in the center, and with 5 or 6 small teeth near the white base. Siphonal canal long and bent back about 90 degrees. To the left of the strong, deep stromboid notch there is a large, cream, glossy, twisted flange. Inside of entire outer lip, including the dorsal projection, smooth and enamel-white. Interior of aperture orange to lemon-orange over which are 45 to 50 distinct, raised, smooth, white spiral lirae. Periostracum thin, smoothish, translucent. Operculum stromboid, dark- to light-brown, slightly arching, and with 7 to 8 very small serrations.

Mantle ridged, its edge smooth. Radula ribbon (shell 83 mm.) 8 mm. long, with 44 rows of teeth. Formula: 2-1-2; 1-4 or 1-5 (without peg); 5; 5 or 6. Verge not observed.

Measurements (mm.)—

length	width	no. whorls	
88.0	50.0	11	(large; locality unknown)
72.5	40.5	10	(average; New Caledonia)
55.1	36.0	10	(small; Ryukyu Ids.)

Synonymy—

1784 *Aratrum*, T. Martyn, Universal Conchologist, London, vol. 1, pl. 1 (Friendly Isles), non-binomial.

1798 *Lambis vomer* Röding, Museum Boltenianum, Hamburg, pt. 2, p. 64, no. 821 (no locality). Refers to Conchyl.-Cab., vol. 10, figs. 1485-6.

1811 *Strombus acutus* Perry, Conchology, London, pl. 12, fig. 2 (Pacific Ocean).

1826 *Strombus zelandiae* Gray, in King, Narrative Survey—Australia, London, vol. 2, appendix, p. 490. Refers to Conchyl.-Cab., vol. 10, figs. 1485-86.

1821 *Strombus pacificus* Swainson, Exotic Conchology, London, pt. 3, pl. 17 (Friendly Isles); 1841, *ibid.*, 2nd ed., p. 10, pl. 17.

1840 *Strombus chemnitzii* Pfeiffer, Kritisches Register Martini Chemnitz Conch.-Kab., Kassel, p. viii, no. 7. Refers also to Conchyl.-Cab., vol. 10, figs. 1485-1486.

1842 *Strombus novae zelandiae* Chemnitz, Reeve, Conchologia Systematica, vol. 2, p. 206, pl. 250, fig. 2; 1844, Duclos, in Chenu, Illust. Conchyl., vol. 4, p. 11, pl. 7, figs. 5, 6; 1851, Reeve, Conch. Icon., vol. 6, sp. and fig. 35.

1869 *Strombus nova-seelandia*, Ch., Paetel, Molluscorum Systema et Catalogus, Dresden, second p. 46.

?1931 *Euprotomus donnellyi* Iredale, Records Australian Museum, vol. 18, no. 4, p. 212, pl. 23, fig. 19 (Sydney Harbour, N. S. W.).

1942 *Strombus hirasei* Kuroda, Venus, vol. 12, p. 8, figs. 3 and 4 on p. 6 (Okinawa Ids.).

1950 *Euprotomus atratum* Allan, Australian Shells, Melbourne, p. 99, pl. 17, fig. 3 [error for *aratrum* Martyn].

Types—Röding's species is based upon figures 1485 and 1486, vol. 10, Conchylien-Cabinet. Chemnitz believed his specimen was from New Zealand, but this is evidently erroneous. Two other localities are mentioned in the early literature, Friendly Isles [Fiji] by Thomas Martyn (1784) and Pulo Condore [120 miles S.E. of Cambodia, China Sea] in the Portland Catalogue (1786, p. 29 and p. 64). The latter two records are unconfirmed. We hereby designate Noumea, New Caledonia, as the type locality. The type of *S. hirasei* Kuroda is presumably in the Kyoto University collection and is from Okinawa. From the description and figures it appears to fit within the limits of *vomer vomer*. The type of *Euprotomus donnellyi* Iredale is presumably in the Australian Museum.

Nomenclature—Thomas Martyn's name *Aratrum* appears without a generic name and is evidently non-binomial. This is generally and rightfully rejected because all of the illustrations and ruled

borders were hand painted and not printed. None of the four paintings I have examined of this species are the same.

Records (see map, pl. 107)—RYUKYU ISLANDS: Yaeyama and Oshima, Amami-Osima Ids. (Y. Hirase, ANSP); Satsuma (MCZ); Okinawa (Mrs. A. A. Scott and A. R. Calm, ANSP). NEW CALEDONIA: Touho Bay (G. and M. Kline, NSF, 1959); Bourail (Mme. Revercé, ANSP). Brampton Reef, 19° 51′ S.; 158° 20′ E. (J. Brazier, 1871, p. 585). Kuroda, 1942, p. 8, questions a Wakayama-Ken, Kii, Honshu Id., Japan, record, since it was probably from an Okinawan fisherman. The Pulo Condore Id., South China Sea, record in the Portland Catalogue (1786, p. 29 and 64) is unconfirmed, but possible.]

Fossil records—None reported.

Strombus vomer *subspecies* hawaiensis Pilsbry, 1917

(Pl. 14, figs. 9, 10; pl. 109)

Range—Hawaiian Chain from Midway to Maui Island.

Remarks and description—Shell 64 to 98 mm. (2½ to 4 inches in length), very similar to *vomer vomer*, but differing in having a white to yellowish tinted aperture; in having finer, more numerous, crowded, uneven-sized spiral lirae (55 to 70 instead of 45 to 50) on the inside of the body whorl which may extend to the edge of the outer lip; in having 10 to 15 weak teeth or spiral lirae at the base of the columella (instead of 5 to 6); in lacking the brown stain on the parietal wall; and in having stronger spiral cords on the lower half of the whorls, of which 2 to 4 show in the bottom half of the whorls in the spire. The length of the projection at the top of the outer lip is variable in adults, and usually has a longitudinal furrow down the middle inner side. Periostracum not seen. Operculum yellowish brown, thick, longitudinally furrowed and with a saw-toothed edge. Soft parts not examined.

I am greatly endebted to several Hawaiian collectors for the gift and loan of specimens of this rare subspecies: Clifton S. Weaver, Dr. Tom H. Richert, Mr. Bobby Lee, Mr. John Duarte, and Mr. Crawford N. Cate. *S. hawaiiensis*, not *hawaiensis*, is a misspelling.

Habitat—Lives on sand and coral rubble bottom from 3 to 21 fathoms. A rare subspecies, and rarely cast on shore.

Measurements (mm.)—

length	width	no. whorls	
75.0	41.0	10	(holotype)
98.3	52.0	10	(large; Maui Id.)
83.5	41.5	11	(average; Kauai Id.)
72.0	41.0	11	(small; Oahu Id.)
64.0	32.5	8+	(small; Oahu Id.)

Plate 109. Figs. 1 and 2, holotype of *Strombus vomer hawaiensis* Pilsbry, Hawaii. Natural size.

Synonymy—

1917 *Strombus hawaiensis* Pilsbry, Proc. Acad. Nat. Sci. Philadelphia, vol. 69, p. 329, pl. 22, figs. 1, 2 (Pearl and Hermes Reef, Hawaiian Chain).

1952 *Strombus hawaiiensis* Pilsbry, Tinker, Pacific Sea Shells, Honolulu, p. 52.

Types—The holotype is in the B. P. Bishop museum, Honolulu. It was collected by Lt. W. H. Munter. One beachworn paratype in ANSP no. 46724. The type locality is Pearl and Hermes Reef, Hawaiian Chain.

Records (see map, pl. 107)—HAWAIIAN CHAIN: Midway Id. (ANSP and MCZ). Pearl and Hermes Reef (BPBM). KAUAI: Haena (W. A. Bryan, ANSP); Milolii (W. A. Bryan); Wailua Bay (John Duarte). MOLOKAI: Moomumi (W. A. Bryan). OAHU: Paumalu (Cliff Weaver); Waianae (W. A. Bryan); Ewa (T. H. Richert and ANSP). MAUI: southwest end (Bobby Lee).

Fossil records—RYUKYU ISLANDS: Gabusoga and Nakosi, Okinawa Id. (lower part of Pliocene) (Nomura and Zimbo, 1936, Science Reports Tohoku Imp. Univ., Sendai, 2nd ser., vol. 18, no. 3, p. 259, pl. 11, figs. 26a, 26b, as *S. aurisdianae* L.). A specimen closely resembling *hawaiensis* was collected by H. S. Ladd (station F 238, in USNM) of probable Miocene age near Nasongo, Viti Levu Id., Fiji.

Strombus vomer *subspecies*
iredalei Abbott *(new name)*

(Pl. 14, figs. 11, 12)

Range—Western Australia to the Gulf of Carpenteria, Australia.

Remarks and description—This subspecies appears to be limited to about 2000 miles of coast along western and northern Australia. It is closer in morphological characters to the geographically distant *hawaiensis* than to the central, typical *vomer vomer*. *S. vomer iredalei* has an exterior which is less shiny and more rugose, with the body whorl bearing 2 to 4 fairly strong spiral rows of coarse beads or poorly developed knobs below the row of small, somewhat even-sized pointed knobs at the shoulder. The spiral cord just below the suture bears numerous, elongate beads. Interior of aperture whitish with numerous spiral, white lirae of unequal size and with 2 or 3 of these at the upper end being much larger than the others. Lower half of parietal wall and columella strongly swollen, cream, tan or rarely brownish orange, and usually with small rugae on the inner, lower end. Parietal wall not glazed over at the center, but may be bordered with brownish markings. The outer lip may be somewhat flaring or turned inward. The nuclear and early whorls are whitish to pinkish but otherwise like those of *hawaiensis*.

Radula similar to that of *vomer vomer*, its formula 2-1-2; 1-4 (also 1-3); 5; 5. Verge not observed.

Habitat—Little is known about its habitat or ecology. A live specimen was collected in shallow water at Broome by Dr. Hubert Lyman Clark of Harvard.

Measurements (mm.)—

length	width	no. whorls	
76.5	42.0	11	(large; west Australia)
64.8	35.2	10	(average; Australia)
55.5	33.5	11	(small; Broome, Australia)
37.0	22.5	6+	(small; Australia)

Synonymy—

1826 *Strombus australis* Gray, in King, Narrative Survey—Australia, London, vol. 2, appendix, p. 489 (Australia). Non Schröter, 1805.

1842 *Strombus australis* Sowerby, Thesaurus Conchyliorum, vol. 1, Strombus, p. 36, no. 53, pl. 9, figs. 96-97 (Australia); 1843, Kiener, Coq. Vivantes, vol. 4, Strombus, pl. 14, fig. 1; 1851, Reeve, Conch. Icon., vol. 6, pl. 14, fig. 34. Non Schröter, 1805.

1854 *Strombus (Monodactylus) australis* Sowerby, H. and A. Adams, Genera of Recent Mollusca, London, vol. 1, p. 259.

1885 *Strombus australis* Gray, Brazier, Proc. Linn. Soc. New South Wales, vol. 10, pt. 1, p. 88.

Types—The type of *Strombus australis* Gray is presumably in the British Museum of Natural History in London. Australia is the type locality which we do not restrict until more is known about this subspecies.

Nomenclature—Gray gave a fairly diagnostic Latin and English description, but somewhat confused the picture with badly punctuated remarks which contained some typographical errors (for "Martini, vii", read "Martini, iii"). Some have felt that Gray referred his new species to Martini, Conchyl.-Cab., vol. 3, figs. 338, 339 and to Seba's pl. 61, fig. 5, 6, but it may be noted under the Latin description that Gray put "Icon.—?" This meant he could not find an illustration of it in any of the iconographs available to him at that time. In view of the description, and subsequent illustrations of this species by Sowerby and Kiener, I am accepting *australis* Gray as described and illustrated in our present monograph.

Strombus australis Gray, 1826, is preoccupied by *Strombus australis* Schröter, 1805 (which is the high-spired, "*turritus*" form of *Strombus vittatus*). I hereby rename *australis* Gray, 1826, and *australis* Sowerby, 1842 as *iredalei* after Tom Iredale of Sydney, Australia.

Records (see map, pl. 107)—WESTERN AUSTRALIA: Rowley Shoals (J. Brazier, 1885, p. 88); Nicol Bay (J. Brazier, 1885, p. 88). Geraldton (MCZ); mouth of False Cape Creek, La Grange Bay, Broome; Ridell's Beach, near Broome; James Price Point, 35 mi. north of Broome (all V. Orr, 1958, ANSP). NORTHERN TERRITORY: off Darwin (A. R. Cahn, ANSP). Yirrkola, Arnhem Land (USNM).

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

Subgenus Conomurex P. Fischer, 1884

Type: *Strombus luhuanus* Linné, 1758

This subgenus is limited to the Indo-Pacific area, and contains two species—the Pacific Ocean *luhuanus* Linné, and the Indian Ocean *decorus* Röding. The latter has a subspecies, *persicus* Swainson, in the northwest section of the Indian Ocean. The subgenus may be a rather recent development, since it has not been recorded in the fossil record earlier than the Upper Pliocene of Indonesia.

The shells are characterized by their somewhat conic shape, depressed spire, and rose to red aperture. The penis is scarlet to rose and has a prong arising from one corner of the distal blade. The operculum has 4 to 6 well-developed serrations. The lateral tooth of the radula has a very large cusp on the inner side and a small, pointed peg at the base.

Synonymy—

1884 *Conomurex* "Bayle" P. Fischer, Manuel de Conchyliologie, fasc. 7, p. 670. Type by monotypy: *Strombus luhuanus* Linné, 1758.

Strombus luhuanus Linné, 1758

(Pl. 14, fig. 15; pl. 110)

Range—Southeast Japan to Indonesia, Australia and east to Palmyra and Fiji.

Remarks—This common, shallow-water, western Pacific species is readily recognized by its black-brown, smooth columella, its blood-red to bright orange-red aperture, and its rather heavy shell. Young or badly beachworn specimens may lack color on the columella and aperture. Specimens at the extreme range of distribution are inclined to be small and lacking the rich watermelon-red of the aperture. Such dwarf, whitish-mouthed ecologic forms have been found in Vaucluse Bay, Sydney, Australia and on Palmyra Island, south of the Hawaiian Chain. I suspect the dwarfed Palmyra Island *luhuanus* is an ecologic form rather than a very localized subspecies. Not all Palmyra specimens have a white aperture and not all have a high, extended spire. The latter character appears to be correlated with the unusually heavy growth of calcareous algae on the spire during the animal's growth, thus forcing an unnaturally rapid descent of the whorls. I call this the "Palmyra" *form*. Records and specimens of this species from the Mauritius and Madagascar area are most likely due to misidentifications or mixed labels. The Indian Ocean counterpart to *luhuanus* is S. *decorus* (Röding). The latter has no black on the columella and its aperture is rose to orange with a white border. There are reports (von Martens, 1887, p. 189) of *luhuanus* in the Bay of Bengal which I have not verified.

Habitat—This species is usually abundant wherever it occurs. Large colonies live in shallow water from the low tide mark to a depth of 30 feet, usually where the bottom consists of coral sand, coral rubble and patches of algae. It is found in Micronesian lagoons and in the bays of large islands, providing there are no muddy conditions. The animals give off great quantities of mucus when disturbed. Many shells from certain localities have live *Sabia conica* (Schumacher) (Hipponicidae) attached to the outer shell. They are more commonly on the spire, but may be found on the body whorl. Their attachment causes a round, deep, irregular scar.

Description—Shell 32 to 70 mm. (1 to 2¾ inches) in length, solid, well-shouldered, conic, with a black columella and orange-red aperture, and with a thick, rough, brown periostracum. Color of outer shell (when brown periostracum is removed) white with 7 to 12 irregularly-sized spiral bands of light-brown which may contain axial, flame-like bars of brown. Aperture orange- to watermelon-red. Columella darkly suffused with black-brown. Whorls 8 or 9. Nuclear whorls 3, bulimoid, glossy, smooth, translucent-tan or translucent-rose. First

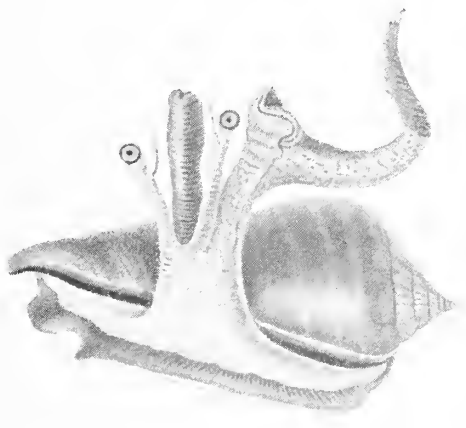


Plate 110. Living animal of female *Strombus luhuanus* Linné. (from Quoy and Gaimard, 1833, pl. 51, fig. 3).

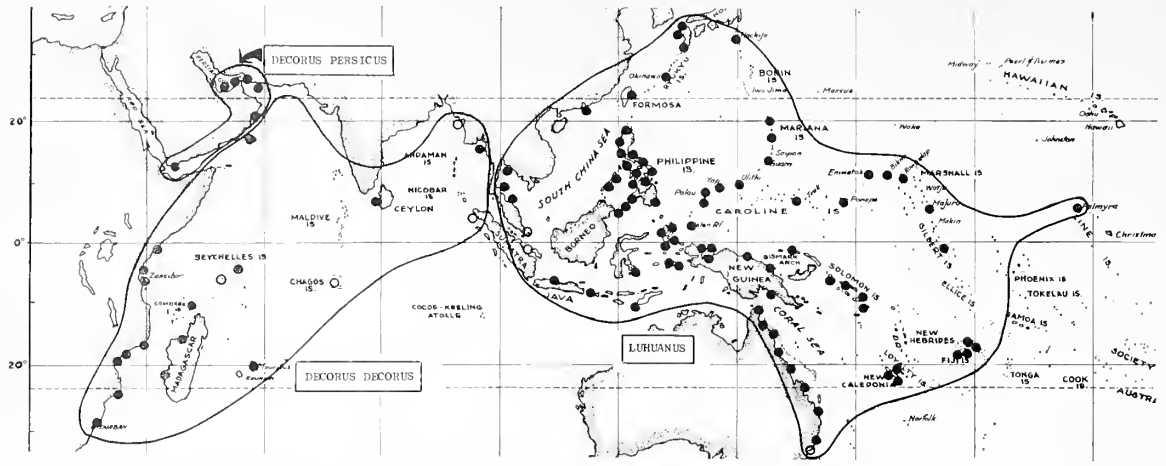


Plate 111. Geographical distribution of *Strombus decorus* (Röding) and its Arabian subspecies, *persicus* Swainson, and of the Pacific Ocean *Strombus luhuanus* Linné.

postnuclear whorl with 15 to 18 microscopic spiral threads which are axially crossed by much smaller scratches. In later whorls, numerous fine, axial riblets develop. Spire with 8 to 10 small, whitish, swollen, former varices. After the fourth postnuclear whorls, the rounded shoulder has about 20 short, even-sized, well-rounded, ribs per whorl. These disappear on the last whorl. Base of shell with about 2 dozen almost obsolete spiral threads. Interior of body whorl with about 100 very fine spiral lirae which do not reach the edge of the sharp outer lip. Stromboid notch usually well-developed. A similar notch occurs at the shoulder, a little below the well-indented, almost channeled, suture. Columella smooth, glossy, black-brown, but poorly developed. Periostracum thick, axially fimbriated, especially below the suture, tan to brown in color. Operculum stromboid, blackish brown, slightly arching, with 3 to 5 large serrations, and slightly less than one third the length of the shell.

Radular ribbon 5 to 8 mm. long, wine-red to brown, with 42 to 46 rows of teeth; main cusps very large. Formula 2-1-2 or 3-1-3; 1-4 or 1-3; 4 to 6; 7 or 8. Eye peduncles usually equal in length. Head and body heavily speckled and mottled with crimson-red (preserved). Eye with a single red ring. Verge with a long, thin, thumb-like appendage. Verge scarlet-red with the laminated, distal pad yellowish.

Measurements (mm.)—

length	width	no. whorls	
69.5	38.0	9	(large; Helen Reef, Carolines)
56.5	30.5	9	(average; Samar Id., Phil. Ids.)
32.2	18.0	6+	(small; Palmyra Id.)

Synonymy—

1758 *Strombus luhuanus* Linné Systema Naturae, ed. 10, p. 744, no. 432 (In O. Asiae); 1767, ed. 12, p. 1209, no. 500; 1956, Dodge, Bull. Amer. Mus. Nat. Hist., vol. 111, art. 3, pp. 264-265.

1788 *Strombus luguanus* Herbst, Natur. Abbild. der merkw. Würmer, vol. 9, p. 203, pl. 48, fig. 2 (no loeality). S. *luthuanus* on plate caption.

1798 *Lambis luhuana* Röding, Museum Boltenianum, Hamburg, pt. 2, p. 61 (refer to Conchyl.-Cab., vol. 3, figs. 789, 790). No locality.

?1839 *Strombus pusillus* Anton, Verzercluiss der Conehylien, Halle, p. 86, no. 2812 (Young of *luhuanus*?).

1884 *Strombus (Conomurex) luhuanus* L., Fischer, Manuel de Conchyliologie, Paris, fasc. 7, p. 670; 1929, Thiele, Handb. Syst. Weichtierkunde, Jena, vol. 1, p. 254.

1931 *Conomurex luhuanus* Linné, Iredale, Records Australian Mus., vol. 18, no. 4, p. 212; 1959, Kira, Coloured Illus. Shells Japan, Osaka, p. 35, pl. 15, fig. 8.

Types—According to Dodge, 1956, p. 265, the Linnaean collection in the Linnaean Society of London, contains two cotypes marked by Linnaeus himself. The original locality was given merely as "in O. Asiae". We are restricting the type locality to Luhu Island, near Amboina and Ceram, Indonesia. This was the locality given by Rumphius on his pl. 37, fig. S and upon which Linnaeus named the species, *luhuanus*.

Selected records (see map on this page for others; solid dots: speeimens examined; open eircles: literature reeords)—HONG KONG: Port Shelter (A. J. Staple, ANSP). THAILAND: all Gulf of Siam: Koh Samit; Koh Tao; Koh Samui; Koh Samet; Maprao Id. (all USNM). SINGAPORE: (Oostingh, 1923, p. 85). JAPAN: Haehijo Id., south of Tokyo; Shirahama, Wakayama Pref., Honshu Id.; Tomioka, Amakusa, Kyushu Id. (all T. Habe, ANSP). RYUKYU ISLANDS: Shioya, Shanawan Bay, Okinawa (USNM). TAIWAN: Taihoku-syu; Kiirun; Suo; Hoku; Tusyo (all Kuroda, 1941, p. 97). PHILIPPINES: common throughout the islands of Luzon; Lubang; Mindoro; Samar; Leyte; Catanduanes; Marinduque; Basilan; Bilan; Santa Cruz; Palawan; Cebu; Panay; Mindanao; Sanga Sanga; Tawi Tawi; Siasi (all ANSP, USNM and MCZ). INDONESIA: Bouro Id., Moluceas; Roti Id., Timor; Wodo Id., Halmahera; Poeloe Boeton, Celebes (all MCZ). AUSTRALIA: Vaucluse Bay,

Sydney, N.S.W.; Green Id., Palm Id., Brook Id., Queensland (all ANSP). MARIANAS: Maug Id. (USNM); Saipan Id. (USNM); Apra Harbor, Guam Id. (A. J. Ostheimer, ANSP). CAROLINES: Yap Id. (C. O. Kile, ANSP); Ponape Id. (V. Wertley, ANSP); lagoon, Ifaluk Atoll; Lukunor Atoll; Ulithi (all USNM). NEW CALEDONIA: Baie de l'Orphelinat, 8 ft. (G. and M. Kline, NSF, 1959). FIJI: Makongai Id. (R. T. Abbott, MCZ). ELLICE ISLANDS: Funafuti (Hedley, 1899, p. 429). LINE ISLANDS: Palmyra Id. (George Vanderbilt, ANSP). [Records from Tahiti, Samoa, Seychelles, Mauritius, Reunion and Amirante Ids. are in our opinion based upon misidentifications or erroneous locality data.]

Fossil records—INDONESIA: Pleistocene of Timor (Oostingh, 1923, p. 85), and Celebes (K. Martin, 1890, p. 278); Pleistocene or Upper Pliocene (Teseh, p. 49, pl. 130, fig. 167). NEW HEBRIDES: Efate Id., Upper Pliocene (Abrard, 1946, p. 64). MARSHALL ISLANDS: Pleistoeene at Bikini, drill hole 2, core 11, core pieee 1, 180 to 185 feet (H. S. Ladd, USNM). MARIANAS: Pleistoeene (?), Guam and Tanapag, Saipan (USNM). TAIWAN: Byoritu Beds (Siko), Pliocene (Nomura, 1935, p. 179, pl. 9, fig. 23).

Strombus decorus *subspecies* decorus (Röding, 1798)

(Pl. 14, fig. 13; pl. 113)

Range—Durban, South Africa, to the Gulf of Bengal.

Remarks—This species (formerly known as *mauritianus* Lamarck) is limited to the Indian Ocean and is evidently closely related to the Pacific Ocean *luhuanus*. Despite their resemblance to each other, I have considered them full allopatric species, since the differences are many and I have seen no intergrades from the Malayan region. *S. decorus* is more variable in size, shape and color pattern, especially in the same colony, than is *luhuanus*, and along its northern distribution in the Arabian Sea it has developed into a rather distinct, smoothish, angular-shouldered form which we identify as the subspecies, *persicus* Swainson (formerly *belutschicnsis* Melvill).

Strombus decorus decorus is distinguished from *luhuanus* by the absence of black on the columella, by the delicate, light-orange to rose interior of the aperture, by the white border of the inside of the outer lip which produces a white interior to the siphonal canal, and by the usual presence of axial knobs on the shoulder on the last whorl. These smaller, more knobbed specimens, occuring sporadically in Zanzibar colonies, are form *coniformis* Sowerby, 1842. Specimens often have circular, sunken scars caused by the attachment of the cap shell, *Sabia conica* (Schumacher).

Habitat—Live in colonies on coral sand, sponge and weed bottom from low water to 18 fathoms. Usually common wherever it occurs.

Description—Shell 34 to 74 mm. (1½ to 3 inches) in length, solid, heavy, somewhat conic in shape, with a white and brown-flecked columella, and a rose-tinted aperture. Color of outer shell variable, with a white to cream background over which are sparse mottlings, or nettings, or zigzag streaks, or

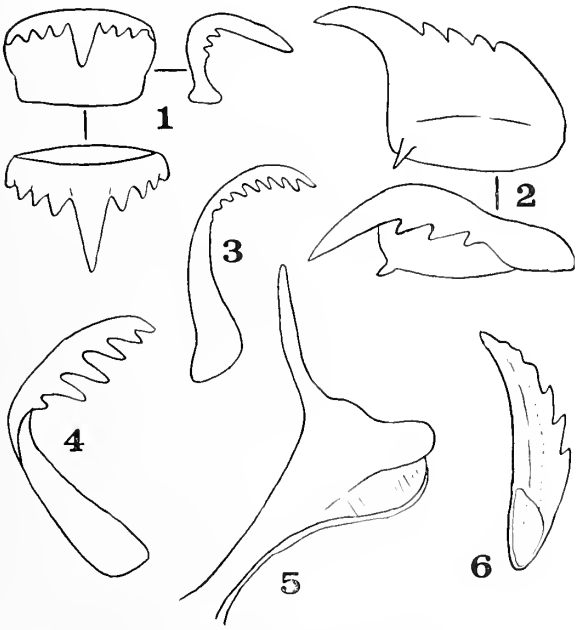


Plate 112. *Strombus luhuanus* Linné, Sanga Sanga Island, Philippines. Fig. 1, central radular tooth (three views). 2, lateral. 3, inner marginal. 4, outer marginal. 5, verge. 6, operculum, showing scar from muscle attachment.

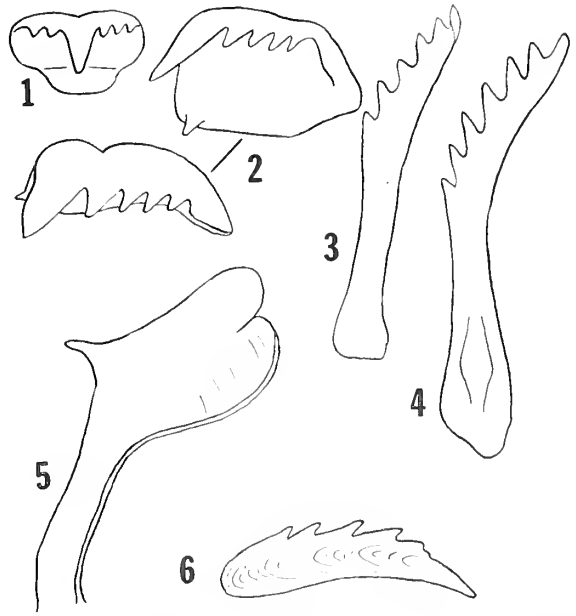


Plate 113. *Strombus decorus decorus* (Röding), Portuguese East Africa. Fig. 1, central radular tooth. 2, lateral. 3, inner marginal. 4, outer marginal. 5, verge. 6, operculum.

indistinct spiral bands of light- or dark-brown or yellowish orange. Whorls 9 to 10. Spire usually moderately raised, rarely high, rarely low. Nuclear whorls 3, glossy, smooth, rounded. First three postnuclear whorls with 7 to 9 microscopic, incised spiral lines crossing numerous, small axial riblets (about 24 per whorl). Top of spire with 6 to 8 small, whitish, rounded, swollen former varices. Whorls rounded in the spire and, in the penultimate whorl, bearing 14 to 16 small, well-rounded axial ribs or knobs. The last whorl may be smoothish at the rounded shoulder or bear 4 to 6 prominent knobs. Base of shell smoothish. Columella callus very thin, white or flecked with brown. Interior of aperture light-orange to rose, with a broad white border. Inner wall of body whorl with exceedingly fine, numerous spiral threads. Stromboid notch moderately deep. Posterior siphonal notch moderately developed and bordered above by a white tongue-like flap which is adherent to the previous whorl. Periostracum thin, smoothish, translucent-tan. Operculum stromboid, light-brown, arching, one third the length of the shell and with 6 or 7 sharp serrations.

Radula formula of Mozambique specimens: 2-1-2 (rarely 3-1-3); 1-3 to 1-5 (plus peg); 4 or 5; 5 or 6. Verge with a rose base and a yellowish distal blade which has a "heel" or slightly developed thumb-like process.

Measurements (mm.)—

length	width	no. whorls	
74.3	40.5	9+	(large; Mozambique)
54.0	27.5	10	(average; Zanzibar)
33.5	18.0	9	(small; Zanzibar)

Synonymy—

1798 *Lambis decora* Röding, Museum Boltenianum, Hamburg, pt. 2, p. 62, no. 777 (no locality). Refers to Conchyl.-Cab., vol. 10, figs. 1499 and 1500.

1807 *Lambis miniata* Link, Beschr. Natur.-Samml., Rostok, p. 108. Refers to Conchyl.-Cab., vol. 10, figs. 1499-1500.

1807 *Lambis flammea* Link, *ibid*, p. 108. Refers to Conchyl.-Cab., vol. 3, fig. 799 (a young specimen).

1821 *Strombus cylindricus* Swainson, Zoological Illustrations, series 1, vol. 1, pl. 53 (no locality); 1855, Berge, Conchylienbuch, Stuttgart, p. 231, pl. 38, fig. 5.

1822 *Strombus mauritianus* Lamarck, Anim. sans Vert., vol. 7, p. 206 (Ile de France [Mauritius]). Refers to Knorr, pt. 6, pl. 15, fig. 3; Lister, pl. 849, fig. 4a; and others.

1823 *Strombus lutruanus* Dillwyn, An Index to Hist. Conchyl. Lister, London, p. 38. Refers to Lister, pl. 849, fig. 4a.

1828 *Strombus laevilabris* Menke, Synopsis Method. Molluscorum, Pyrmonte, p. 41 (no locality). Refers to Conchyl.-Cab., vol. 10, figs. 1499-1500.

1842 *Strombus coniformis* Sowerby, Thesaurus Conchyl., London, vol. 1, p. 29, pl. 7, figs. 55 and 61 [the knobbed form].

Types—Röding's species is based upon figs. 1499 and 1500 in vol. 10 of the Conchylien Cabinet. Chemnitz says that specimen came from Mauritius, which we now designate as the type locality. This is also the type locality for Lamarck's *mauritianus*, the type of which is probably in the Museum d'-Histoire naturelle de Genève. The whereabouts of Swainson's type of *cylindricus* is unknown to us.

Nomenclature—The more familiar name of *mauritianus* Lamarck, 1822, is unfortunately antedated by three other names, the earliest being *decorus* Röding. *Lambris flammea* Link, 1807, is based upon Conchyl.-Cab., vol. 3, fig. 799, and, together with the description, there is little doubt that it is a young specimen of *decorus*. Mörch (1852, p. 63) was the first erroneously to associate Link's name with *floridus* Lamarck (i.e. *mutabilis* Swainson). This error has been continued by many workers.

Records (see map, pl. 111)—UNION SOUTH AFRICA: Durban, Natal (USNM). MOZAMBIQUE: Port Amelia (USNM, MCZ; Bazaruto Id. (MCZ); Inhaca Id., Delagoa Bay (W. Macnea, ANSP); Mozambique City (K. Crosch, ANSP). ZANZIBAR: Chango Id.; Paje; Chumbe Id.; Bawi Id.; Mnemba Id.; Pwakuu Id. (all NSF, 1957). KENYA: Malindi (USNM). SAUDI ARABIA: Muscat (ANSP). MADAGASCAR: Nossi-bé (A. Chavane, ANSP); Nossi Fanihi; Tuléar; Tamatave (all Dautzenberg, 1929, p. 471). INDIAN OCEAN ISLANDS: Diego Garcia lagoon, Chagos Ids. (Melvill, "Sealark", 1909, p. 93). Marie-Louise Id., Amirante Isles (E. A. Smith, "Alert", 1884, p. 502). Malé, Maldives (R. Jonklass, ANSP). Mauritius (ANSP, MCZ, USNM). CEYLON: (USNM). THAILAND: Koh Pipidon, Puket (Bay of Bengal) (USNM). INDONESIA: Poelau Berhala, Sumatra, 3 live specimens on coral reef, fide Tomlin (Oostingh, 1929, no. 39, p. 3); off Deli, Sumatra (Oostingh, 1930, no. 49, p. 4). BURMA: Mergui Archip. (von Martens, 1887, p. 189).

Fossil records—According to L. R. Cox (1930, Monograph 4, p. 137): KENYA: Pleistocene, reef-limestone, eastern shore of Mombasa Harbour. TANCANYIKA: Pleistocene of Dar-es-Salaam.

Strombus decorus *subspecies* persicus Swainson, 1821

(Pl. 14, fig. 14)

Range—Arabian Sea and Persian Gulf.

Remarks—In the northern range of *decorus*, most specimens take on a characteristic flat-sided, conic shape, a reduction of the size of the axial riblets, and a reduction in the rose tint within the aperture. We are accepting this as a subspecies, since intergrades exist. Young specimens closely resemble the genus *Conus*, but are recognized as *Strombus* by the minute varices in the apex.

Habitat—Lives in sandy mud and coral sand from low water line to a depth of 10 fathoms.

Description—Shell 40 to 51 mm. (1½ to 2 inches) in length, solid, conic, smoothish, with angular shoulders and lightly colored with light-brown netting and weak yellow-brown spiral bands. Whorls 9. Spire flat-sided, variable in height, and with about 6 small, swollen, former varices. Nuclear whorls unknown but probably like those in *decorus*. First two or three postnuclear whorls rose or whitish, with about 10 microscopic, spiral threads crossing larger axial riblets (about 22 per whorl). These riblets disappear three whorls from the last. Top of whorls flattish, the shoulder angular. Sides of last whorl flat. Columella glossy white. Interior of aperture usually white, rarely tinted with rose. Stromboid notch weakly to moderately developed. Periostracum moderately to very thin, dull, tan to brownish. Operculum typical, with 6 to 8 serrations.

Measurements (mm.)—

length	width	no. whorls	
37.0	22.1	8+	(small; Liujab, Persian Gulf)
42.0	24.1	8+	(average; Jask, Persian Gulf)
51.1	27.5	9	(large; Dhahran, Persian Gulf)

Synonymy—

1821 *Strombus persicus* Swainson, Zoological Illustrations, series 1, vol. 1, pl. 53 (Persian Gulf). June.

1844 *Strombus ismarius* Duclos, in Chenu's Illustr. Conchyl., vol. 4, Strombus, p. 5, pl. 7, figs. 1 and 2 (Nouvelle-Guinee). (dwarf form).

1898 *Strombus (Conomurex) belutschiensis* Melvill, Mem. and Proc. Manchester Lit. and Philos. Soc., vol. 42, no. 4, p. 37, text fig. (Charbar, Mekran coast of Beluchistan, 7 fms.).

1901 *Strombus (Conomurex) beluchiensis* Melvill, in Melvill and Standen, Proc. Zool. Soc. London for 1901, p. 380, pl. 21, figs. 13, 15 (in color). Emendation for *belutschiensis* Melvill.

Types—The type of *belutschiensis* Melvill is presumably in the British Museum of Natural History in London. Its type locality is Charbar, Mekran Coast of Beluchistan [now Iran or Persia]. The type locality for *persicus* is "Persian Gulf", but we do not know the whereabouts of Swainson's type, unless, by chance, it is at Cambridge University, England. Duclos' type of *isuarius* is probably in the Muséum d'Histore naturelle de Genève.

Nomenclature—This subspecies appears to have received several names and one spelling emendation, as is seen in our synonymy. The earliest valid name, *persicus* Swainson, 1821, is well illustrated and well described. We should like to point out that some argument might arise on whether or not the name *persicus* is a homonym of Humphrey, 1786 (A Catalogue of the Portland Museum, London, p. 3, item no. 15). The line reads: "15 Strombus Fusus, L. *Persicus*, or Persian Spindle, a pair *fine*, *Lister*. 854. 12." This is a *Tibia*, and if the name *Persicus* is to be interpreted as a species name, it would make *Persicus* Swainson a homonym and unavailable. However, in looking through the rest of the Portland Catalogue, we note that no other trivial or generic name is italicized, and that all geographical names *are* italicized. We feel certain that Humphrey was merely giving the latin name for "Persian" and not intending a species name. *S. isuarius* Duclos is undoubtedly this species, and the locality of "Nouvelle-Guinee" is probably erroneous.

Strombus cailliaudi Jay, Tryon (Manual of Conchology, vol. 7, p. 122) is probably not a *Strombus*. I concur with Tomlin (1937, Proc Mal. Soc. London, vol. 22, p. 224) that Jay's species is the long-spired form of *Conus mediterraneus* Hwass. Jay's type of *Conus cailliaudi* appears to have been lost or destroyed by fire.

Records (see map, pl. 111)—PERSIAN GULF: Zaal Id., Tarut Bay; Kuwait (both USNM); Ras Tanura (Mrs. B. J. Grantier, ANSP); Liujab, 3½ fms. (Thaanum Coll'n.). SAUDI ARABIA: Aden (Melvill and Standen, 1901, p. 381); Abu Musa Id. and Dubae, Trucian Oman Coast, 7 fms. (Melvill, 1898, p. 37).

Fossil records—None reported.

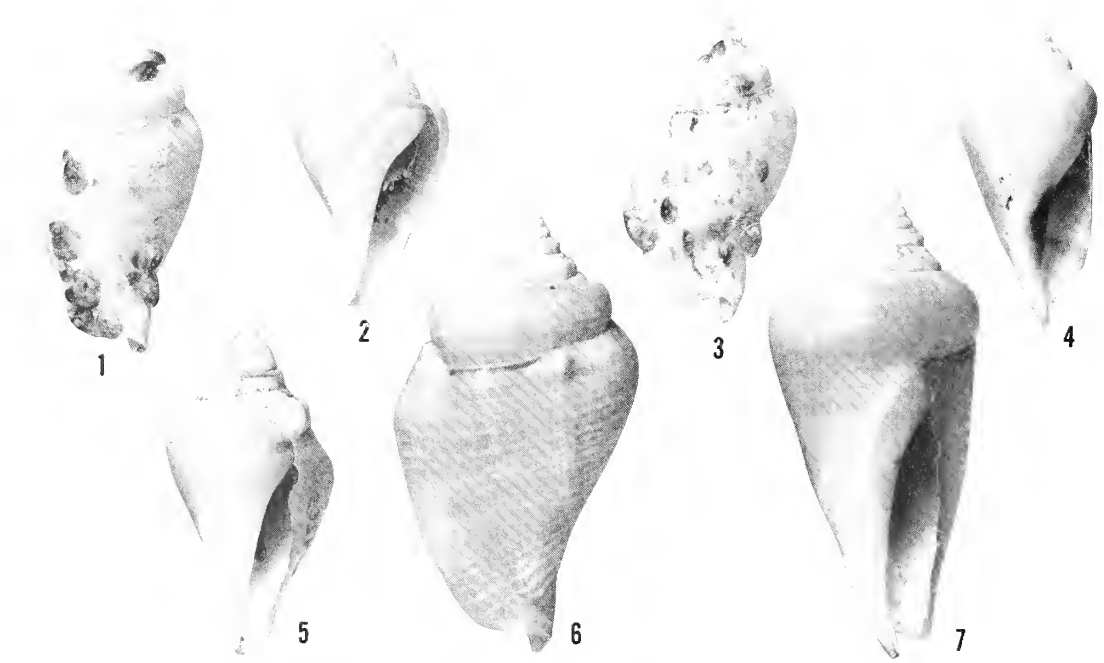


Plate 114. Figs. 1-4, *Strombus gibberulus gibbosus* (Röding), Schouten Ids., Dutch New Guinea. 1 and 3, adults with shells of the snail, "*Capulus*," attached. 2 and 4, immature specimens. Figs. 5-7, *Strombus gibberulus gibberulus* Linné, Zanzibar. 5 and 7, immature. 6, adult. All natural size.

Subgenus Gibberulus Jousseaume, 1888

Type: *Strombus gibberulus* Linné, 1758

This subgenus is limited to the Indo-Paeific area, and eontains only one speeies whieh, however, has broken into three subspeeies—true *gibberulus* Linné from the Indian Oeean, *albus* Möreh of the Red Sea area, and *gibbosus* Röding of the Paeific Ocean. The shells are charaeterized by a peeuliar, abnormal eoiling whieh gives them a distorted appearance The apieal varices are extremely broad. The penis has a "heel" or aeeessory prong on the distal blade. The marginal radular teeth are rather long, delieate and with 5 to 10 dentitions. There is no basal peg on the marginal. The opereulum is proportionately broad and with 6 to 9 large serrations.

The fossil reeords of this group are not numerous, except in the Pleistoeene of the Indo-Paeific. Abrard's *praegibberulus* from the Plioeene of the New Hebrides is possibly *gibberulus gibbosus.*

I have serious reservations as to whether or not *Oostroubus* Saeeo, 1893 (I Molluschi dei Terreni Terziarii del Piemonte e della Liguria, pt. 14, p.13; type by original designation: *Strombus problematicus* Michelotti, 1861) is related to the recent subgenus *Gibberulus.* Cossmann, 1904, p. 16 notes the absenee of *Oostroubus* in the Mioeene. In any event, the name *Gibberulus* Jousseaume has priority. Cossmann (1904, p. 14) and Wenz (1943, part 6, p. 1255) plaee the genus *Thersitea* Coquand, 1862, of the Eoeene in the Faseiolariidae. I agree that it probably does not belong in Strombidae.

Synonymy—

1888 *Gibberulus* Jousseaume, Mémoires Soc. Zool. de France, vol. 1, p. 174. Type by original designation and monotypy: *Gibberulus gibberulus* Gmelin = *gibberulus* Linné, 1758.

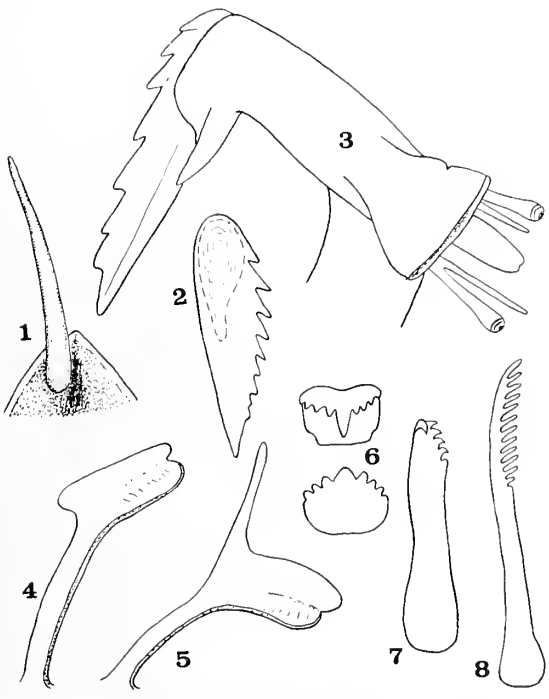


Plate 115. *Strombus gibberulus gibbosus* (Röding), New Caledonia. Fig. 1, posterior corner of mantle margin, showing 4 mm.-long, fleshy appendage. 2, operculum, showing scar from muscle attachment. 3, under view of animal, showing operculum, foot, mucus slit at the anterior edge, egg-laying groove or notch on the right side of the anterior end, and the eye peduncles and proboscis. 4, verge. 6-8, radulae. 5, verge of S. *gibberulus gibberulus* Linné, Zanzibar.

Strombus gibberulus *subspecies* gibberulus Linné, 1758

(Pl. 14, fig. 28; pl. 114, figs. 5-7)

Range—(Entire speeies: East Africa to the Tuamotu Islands). Typieal *gibberulus:* Indian Ocean, exclusive of South Africa, Red Sea and Australia.

Remarks—This is one of the most abundant and widely distributed, shallow-water *Strombus* of the Indo-Paeific region. It is divided into three well-defined geographieal subspeeies: *gibberulus* from the Indian Oeean, *albus* from the Red Sea and *gibbosus* from the Paeifie Oeean. All are charaeterized by the peeuliarly distorted, swollen penultimate whorl and the large size of the swollen, whitish, former variees in the upper whorls.

Typieal *gibberulus* is the largest (usually about 55 mm. in length, but ranging from 30 to 70 mm.); the outer shell is a drab yellowish to grayish tan with numerous fine spiral lines of white; when the columella has eoloration, it is always limited to a faint purple well within the aperture; the spiral raised threads are usually pronouneed on the varix of the last whorl. One out of several hundred speeimens seen from East Afriea had a rose-tinted mouth, others being purple-tinted.

The subspeeies *gibbosus,* confined to the Pacific Oeean, is smaller (usually about 40 mm. in length, but ranging from 28 to 55 mm.); the outer shell is eommonly banded or flecked with bright-yellows and browns; when the columella has eoloration, the purple-brown, elongate splotch is always in full view; the spiral threads over the varix of the last whorl are usually weak or absent.

The subspeeies *albus* from the Red Sea is pro-

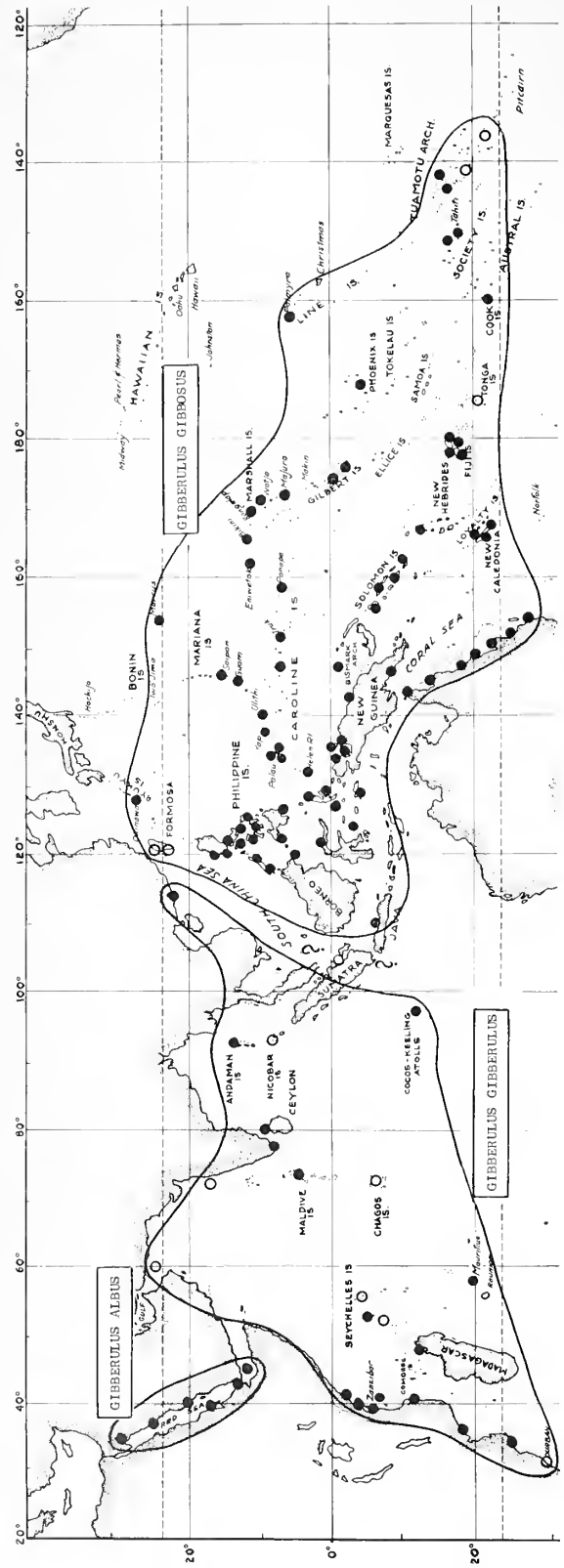


Plate 116. Geographical distribution of the three subspecies of *Strombus gibberulus—gibberulus* Linné of the Indian Ocean, *albus* Mörch of the Red Sea, and *gibbosus* (Röding) of the tropical western Pacific.

portionately wider, has an appearance of being more distorted, is usually milk-white on the outside and the interior of the outer lip is a strong rose.

I have examined several dozen animals from both the Indian and Pacific Oceans and find considerable variation in the radula and the number of dentitions on the opercula, so that no differences are meaningful. However, the verges appear to be separable, although not to a degree that would justify treating the Pacific Ocean subspecies as a full species. In most, if not all, of the Pacific specimens the right eye peduncle and the tentacle are as long or even slightly longer than the left peduncle and the left tentacle, while in the Indian Ocean specimens (and in all other species of *Strombus* we have examined) the left is the longer.

Abbott (1949, pp. 59-61) made a study of the shell length and frequency of the color phases in various colonies of the subspecies *gibbosus*, and concluded that the shells of males are only slightly smaller than those of the females. In three colonies examined, 40% were males, the remainder females. There was no indication of any sex-linking in the dark- or light-phase. Although shell size varies greatly within the subspecies, there is a fair amount of uniformity within each localized population. Some mean shell lengths of large population samples are 33 mm. (north end, Agana Bay, Guam); 30 mm. for males, 31.5 for females (S. W. side, Igurin Island, Eniwetok Atoll); 32 mm. (lagoon, Lae Atoll); 41.5 mm. (Puerto Princessa, Palawan Island); 48.0 mm. (Cebu City, Cebu Island); 34 mm. (Helen Reef, S. W. of Palau Ids.). We have noticed in specimens examined that, generally, smaller shells come from smaller atolls or areas with evidently less nitrogenous matter in the water. Similar ecologic size differences exist in the Indian Ocean *gibberulus gibberulus*.

Habitat—*S. gibberulus* and its subspecies are colonial, shallow-water species living from the intertidal area to a depth of 10 fathoms. While they are more abundant on clear sand and weed bottoms just below the low water mark, they also occur in sandy patches on barrier reef flats, on sandy lagoon bottoms, and also in muddy sand bottoms. In some areas the shells are festooned with algal growths, and in deeper, clearer water they are small and brightly colored. It is quite probable that the colonies migrate in the breeding season from deep to shallow water. This species lives in or near coral waters, and does not exist, as does *S. canarium*, in muddy, continental-like areas.

Description—(of the Indian Ocean *gibberulus gibberulus*). Shell 30 to 70 mm. (1½ to 2¾ inches) in length, solid, somewhat fusiform, and with distorted whorls. Color of outer shell light-tan to whitish with numerous, crowded spiral bands of darker tan. Columella smooth, white or with a faint flush of violet on the portion well within the aperture. Inner edge of outer lip white; within this is a broad violet or dark-purple, axial band crossed by numerous, irregular, whitish, spiral lirae. Deep within the aperture the shell is lightly flushed with violet. Posterior canal, short, deep, narrow, pointing directly upward; bounded on the body wall side by a swollen, white callus. Stromboid notch deep. Spire angle 70°. Whorls 10; nuclear whorls 3, the first very small and slightly elevated, the remainder rounded, glossy, smooth and transparent. The first and second postnuclear whorls have only 5 to 6 incised spiral lines on the upper part of the whorl. Apical whorls with 10 to 11 very broad, swollen, whitish former varices which are crossed by 6 to 8 coarse, spiral threads. Penultimate whorl strongly and roundly shouldered, so that the last third of the body whorl descends rapidly, thus giving a distortion to the entire shell. Last part and base of body whorl with strong, raised threads. Periostracum translucent-tan to light-brown, smooth and usually glistening. Operculum stromboid, slightly arching, broad at the attachment end, light-brown, and with 7 to 8 sharp, rather long serrations, and slightly less than ⅓ the length of the shell.

Radular ribbon 2 to 5 mm. in length, with 32 to 46 rows. Formula 4-1-4 or rarely 3-1-3; 1-4 (no peg); 7; 7. Verge up to 10 mm. in length, with a long thumb-like process.

Measurements (mm.)—

length	width	no. whorls	
70.0	32.5	10	(large; Zanzibar)
55.0	28.5	9	(average; Zanzibar)
30.0	16.0	8	(small; Zanzibar)

Synonymy—

1758 *Strombus gibberulus* Linné, Systema Naturae, ed. 10., p. 744, no. 443 (In. O. Asiae); 1767, Linné, ed. 12, p. 1210, no. 501; 1842, Sowerby, Thesaurus Conchyl., vol. 1, pl. 6, fig. 19 (not 24-26); 1843, Kiener, Coquilles Vivantes, vol. 4, Strombus, pl. 28, fig. 1 (not 1 a).

1811 *Strombus labiatus* Perry, Conchology, London, pl. 12, fig. 3 (no locality). Non Röding, 1798.

Types—Linnaeus' type is in the Linnaean Society of London. Hanley implies that Sowerby's figure 19 is the type, which is the Indian Ocean subspecies. We restrict the type locality to Zanzibar, British East Africa.

Nomenclature—To our knowledge, this is the first time that *gibberulus* has been separated into three subspecies. The Red Sea *albus* has been long recognized. It is difficult to say if Linné included the Pacific Ocean subspecies in his *gibberulus*. The first available name for the Pacific subspecies is *gibbosa* Röding.

Selected records (see accompanying map, pl. 116; solid dots: specimens examined; open circles: from the literature)—MOZAMBIQUE: Inhaca Id., Delagoa Bay (W. MacNae, ANSP). Mozambique City (Kurt Grosch, ANSP). TANGANYIKA: Mboa Maji, intertidal (R. T. Abbott, ANSP). MADAGASCAR: Nossi-bé (A. Chavane, ANSP: MCZ). Gloriosa Id. (UNSM). INDIAN OCEAN ISLANDS: Mahé, Seychelles (USNM). Ile des Roches, Amirante Isles (E. A. Smith), 1884, "Alert", p. 503). Chagos Archip. (Melville, 1909, "Sealark", p. 93. CEYLON: Powder Bay, Trincomalee (G. and M. Kline, NSF). ANDAMAN IDS: (MCZ). COCOS KEELING: (USNM). HONGKONG: Castle Peak Bay (A. J. Staple, ANSP).

Fossil records—Raised Quartenary beaches of the Red Sea region (Nardini, 1934, p. 222). Pleistocene of French Somalia (Nardini, 1933, p. 171). Cox (1930, p. 138) reports *gibberulus* from the Quartenary of Mombasa, Kenja. Perim Island, Quartenary of Tanga, Tanganyika (Koert and Tornan, 1910, p. 10).

Strombus gibberulus *subspecies* gibbosus (Röding, 1798)

(Pl. 14, figs. 26; pl. 114, figs. 1-4)

Range—From the Ryukyu Islands to Indonesia and Australia, and eastward to the Tuamotu Islands (but not the Hawaiian Chain).

Remarks and description—This is the very abundant and widely distributed Pacific subspecies whose differentiating characters are listed in the remarks under the typical *gibberulus*. The first few postnuclear whorls bear 1 to 12 microscopic spiral threads in *gibbosus*, in contrast to the 5 to 6 incised lines only on the upper two-thirds of the whorl in *gibberulus*. The aperture of *gibbosus* may be all-white or tinted with violet, or yellow or brown or orange, while that of *gibberulus* is almost always tinted with purple to violet. Operculum stromboid, slightly arching, about ⅓ to ¼ the length of the shell and with 6 to 7 serrations. Radular ribbon 4 to 8 mm. in length, with 28 to 48 rows. Formula variable: usually 4-1-4 (rarely 3-1-3 or 5-1-5); 1-4 (rarely 1-3) and no peg; usually 6 (rarely 3, 4, 5 or 7 denticles on the inner marginal); usually 7, but rarely 5 to 10 on the outer marginal. Verge with a slightly developed "heel" on the distal blade.

The intestines of some contained coral sand, foraminifera and small, whole gastropod shells. However, the species is undoubtedly herbivorous or omnivorous.

Measurements (mm.)—

length	width	no. whorls	
58.0	25.0	10	(large; Cebu Id.)
40.0	18.2	9	(average; Suva, Fiji)
30.0	15.2	9	(small; New Caledonia)

Synonymy—

1798 *Lambis gibbosa* Röding, Museum Boltenianum, Hamburg, pt. 2, p. 62, no. 786. (no locality). Refers to Conchyl.-Cab., vol. 3, fig. 794.

1842 *Strombus gibberulus* Linné, Sowerby, Thesaurus Conchyl., vol. 1, pl. 6, figs. 24-26; 1843, Kiener, Coquilles Vivantes, vol. 4, pl. 28, fig. 1a (not figs. 1); 1949, Abbott, Nautilus, vol. 63, no. 2, pp. 58-61 (sexual dimorphism). 1957, Demond, Pacific Science, Honolulu, vol. 11, no. 3, p. 295, fig. 14. Not *gibberulus gibberulus* Linné.

?1946 *Strombus (Canarium) praegibberulus* Abrard, Ann. de Paléontologie, vol. 32, p. 63, pl. 4, figs. 30-31 (Pliocene, Malekula, New Hebrides).

Types—To our knowledge no type exists. The species was based upon figure 794 in vol. 3 of Martini and Chemnitz, Conchyl.-Cab., Nurnberg, 1777 which had no locality. We hereby designate Cebu City, Cebu Island, Philippines, as the type locality.

Nomenclature—Heretofore, this subspecies has been referred to as *gibberulus* Linné, but now properly is *gibberulus gibbosus* Röding.

Selected records (see accompanying map, pl. 116, for other records; solid dots: specimens examined; open circles: literature records)—RUYKYU ISLANDS: Okinawa (A. A. Scott, ANSP). TAIWAN: Kurun (Kuroda, 1941. p. 97). PHILIPPINES: common on most islands, Luzon, Cebu, Catanduanes, Samar, Balabac, Palawan (all ANSP), Busuanga, Cuyo, Marinduque, Panay, Sanga Sanga (USNM). INDONESIA: Amboina; Halmahera Id., Batjan and Bouro Id., Molucea; Marissa, Celebes Id. (all MCZ). AUSTRALIA: Low Islands, Queensland (Tony Marsh, ANSP). Helen Reef, N. W. of New Guinea (V. Orr, NSF). CAROLINES: Truk Id. (Mrs. R. T. Gallemore); Ponape (Mrs. V. Wertley, ANSP). PHOENIX ISLANDS: Canton Id. (Frank Witts, ANSP). SAMOA: Toloa Pt., Upolu Id. (NSF). LINE ISLANDS: Palmyra (USNM). SOCIETY ISLANDS: Moorea, Tahiti and Borabora (H. A. Rehder, USNM). TUAMOTU ISLANDS: Raroia, Takume and Tikahau (J. P. E. Morrison, USNM); Marutea (Dautzenberg and Bouge 1933, p. 297).

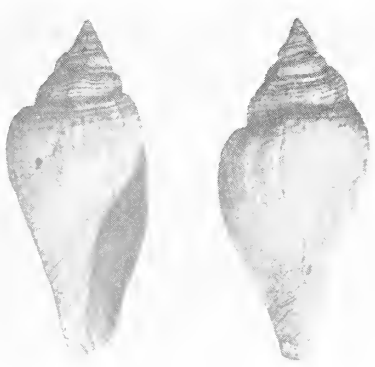


Plate 117. *Strombus praegibberulus* Abrard. Holotype, Pliocene of New Hebrides. (from Abrard, 1946, pl. 4, figs. 30, 31). Natural size.

Fossil records—Pleistocene, Lanai Id., Hawaii (USNM). Pleistocene, Honolulu Harbor, Oahu Id. (J. M. Ostergaard, 1928, p. 27). Pleistocene (?) of Aranit Id., Eniwetok Atoll, Marshall Id., drill hole A-1, 136.5 to 138.0 ft., H. S. Ladd (USNM). INDONESIA: Altena (1942, p. 47) reports *gibberulus* from the Pliocene of Java, Obi and Timor Islands; also the Quarternary of Timor. The only record I have seen illustrated is that of Tesch's from the Pliocene of Timor which may be nearer the subspecies *gibbosa* (Tesch, 1920, p. 49, pl. 130, figs. 166a,b). Tesch also records it from the Quarternary of Koepang, Timor and Macassar, Celebes. Abrard (1946, p. 63) records it from the Pliocene and Quaternary of the New Hebrides.

Strombus gibberulus *subspecies* albus Mörch, 1850

(Pl. 14, fig. 27)

Range—Limited to the Red Sea and Gulf of Aden.

Remarks and description—This rather restricted subspecies differs from the typical Indian Ocean *gibberulus* in being smaller, much paler and usually white on the outside, and in having the inside of the last whorl flushed with rose to carmine-rose. Rarely, the white columella is tinted with rose. There is an inch-long, narrow bar of purplish brown just below the suture on the dorsal side of the body whorl which is rarely, if ever, present in *gibberulus*, and rarely in *gibbosus*. Soft parts not available for study.

Measurements—

length	width	no. whorls	
56.1	28.5	9	(large; Eilat, Israeli)
43.0	25.0	9	(average; Aqaba, Red Sea)
34.0	18.0	8	(small; Port Sudan)

Synonymy—

1850 *Strombus albus* "Mart." Möreh, Cat. Conchyl. C. P. Kierulf, Hafniae, p. 11. no. 264. Refers to Conchyl.-Cab., vol. 3, figs. 797, 798; 1852, Möreh, Yoldi Catalog -, p. 62. (Red Sea).

1869 *Strombus gibberulus* var. *rhodostomus* "Möreh" von Martens, in Decken's Reisen in Ost-Afrika, vol. 3, Mollusken, p. 64 (Sansibar).

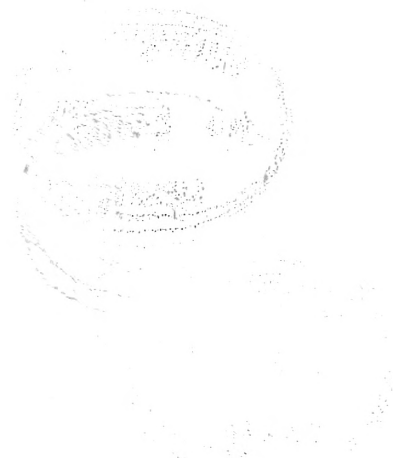
Types—The species is based upon Martini's figures 797, 798, and no type of Mörch's exists. The type locality is "Red Sea".

Records (see map, pl. 116)—ECYPT: Ras Banas (USNM); Ceb Zebara (ANSP); Gulf of Suez (USNM). SAUDI ARABIA: 20 mi. north of Jidda (C. Aslakson, ANSP); SUDAN: Berbera (USNM); Port Sudan (ANSP). ISRAELI: Eilat, Gulf of Aqaba (A. Hadar).

Fossil records—EGYPT: Pleistocene: Wadi Cueh, 80 ft. alt. (R. B. Newton, 1900, p. 508, pl. 20). FRENCH SOMALIA: Pleistocene, Ravin de Baghenda; near d'Oboek; d'haeoulta; Ras Bir; Ras Doumeira; Khor Ambada (Abrard, 1942, vol. 18, p. 64, pl. 6, fig. 39).

INDEX TO STROMBUS NAMES IN VOL. 1, NO. 2

Looseleaf subscribers should place this index at the beginning of the family Strombidae. *Strombus* begins on p. [09-831].



THE GENUS LAMBIS IN THE INDO-PACIFIC

by R. Tucker Abbott

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The nine known species of scorpion or spider conchs of the genus *Lambis* are limited to the tropical Indo-Pacific. Their general anatomy, egg masses and radulae are extremely close to those of *Strombus*, and, from a biological standpoint, some workers might wish to consider them a subgenus of *Strombus*. The main distinguishing characters are the great development of long spines or digitations on the apertural borders of the shell, and the absence or great reduction of the posterior mantle filament. Like members of *Strombus*, the *Lambis* are shallow water, active snails, usually associated with algal-rich coral reefs. C. M. Yonge (1932) gives an excellent account of the herbivorous feeding methods and the nature of the crystalline style. Their diet is evidently largely restricted to the delicate red algae (see under *Lambis lambis* Linné).

The *Strombus* subgenus, *Euprotomus*, has more characters in common with *Lambis* than do any other subgenera. The verge is almost identical and the lateral radular tooth lacks a basal "peg" in both groups. However, the early co-existence of fossil *Lambis crocata* (Link) and *Strombus (Euprotomus) aurisdianae* Linné in the Pliocene of Zanzibar suggests that these two groups had already arisen, perhaps from a common stock, during the early Pliocene or late Miocene. Fossil records are not numerous, except in the Pleistocene where they are not uncommon from the Red Sea to the Hawaiian Islands. Today, they are extinct in Hawaii. H. S. Ladd obtained a *Lambis lambis*-like specimen in the Miocene-Pliocene, tuffaceous limestone of Lakemba, Lau Group, Fiji. Fossil records of *Pterocera* in the nineteenth century European literature refer to members of the family Aporrhaidae. There are no known *Lambis* species restricted to the Tertiary or earlier periods.

Of the nine living species four are polytypic with subspecies of varying degrees of morphological separation, ranging from the distinctly different *chiragra chiragra* and *chiragra arthritica* to the weakly separated *scorpius scorpius* and *scorpius indomaris*. Most abundant and most ubiquitous is *Lambis lambis* which is the largest and dominant gastropod in many shallow-water areas of the Indo-Pacific. Equally widespread from East Africa to Polynesia are *truncata* (moderately common), *digitata* (rare) and *crocata* (uncommon). Three species have rather limited ranges: *violacea* (rare in Mauritius), *robusta* (rare in southeast Polynesia), and *millepeda* (abundant in the central part of the Western Pacific arc).

Lambis, particularly *lambis* and *truncata*, are

Plate 118. Living animal of male *Lambis lambis* (Linné). Between the eyestalks and tentacles is the darkly colored proboscis. Below is the long muscular foot at the end of which is the corneous, sickle-shaped operculum. Arising from the back of the animal is the long, external verge or penis. (natural size; from Quoy and Gaimard, 1833, pl. 50, fig. 11).

used as food, both cooked and raw, in most areas of the Indo-Pacific. The common *lambis* is seen on sale alive in most country fish markets in the Philippines. *Lambis millepeda* is generally not eaten because of its bitter taste. In Ceylon, according to Deraniyagala (1933, Ceylon Journal of Sciences, sect. C, Fisheries, vol. 5, p. 63), *lambis* and *rugosa* [? = *chiragra*] are roasted in the shell and eaten by Tamil fishermen. The flesh of the Mullu Shanku or *Lambis* acts as a mild narcotic. Both bitterness and narcoticness may be associated with the algal diet of the animal.

Accounts of the gross anatomy of *Lambis*, which do not differ materially from those of *Strombus*, have been published by M. F. Woodward (1894), R. Bergh (1895), Jean Risbec (1925) and J. H. Prince (1955). The latter treats with the details of the eyestalks of *Lambis lambis*.

Geographical Distribution of Sexual Dimorphism

It has been pointed out by many workers that in *Strombus*, as well as in other dioecious prosobranchs, the shells of the males are smaller than those of the females. Abbott (1949, p. 59) brought attention to the fact that the sexual difference in shell size varied in *Strombus* from colony to colony, and suggested that there might be a geographical distribution of the degree of difference. Our soft anatomy examinations of *Lambis* were limited to thirty specimens, but, together with measurements of over a hundred shells, suggest the existence of sexual dimorphism in the sculpturing and nature of the spines, as well as the expected difference in shell length.

The most striking example occurs in *Lambis lambis* in the central part of its range in the area of the Philippines, the Palaus, Carolines, New Guinea, Indonesia and northeastern Australia. The males are from 30 to 45 percent smaller than the females, and are further characterized by two small knobs on the shoulder of the last whorl (rather than a welding of these two into a longer and higher knob) and by proportionately smaller spines which hook in the plane of the outer lip in the posterior direction of the apex (rather than long, upwardly curling spines). The differences are much less developed both to the west toward East Africa and to the east into New Caledonia, Fiji and Tonga.

When we examine *chiragra* as a species extending from East Africa to Polynesia, we find that the Indian Ocean subspecies, *arthritica*, shows little sexual dimorphism (males slightly smaller), but

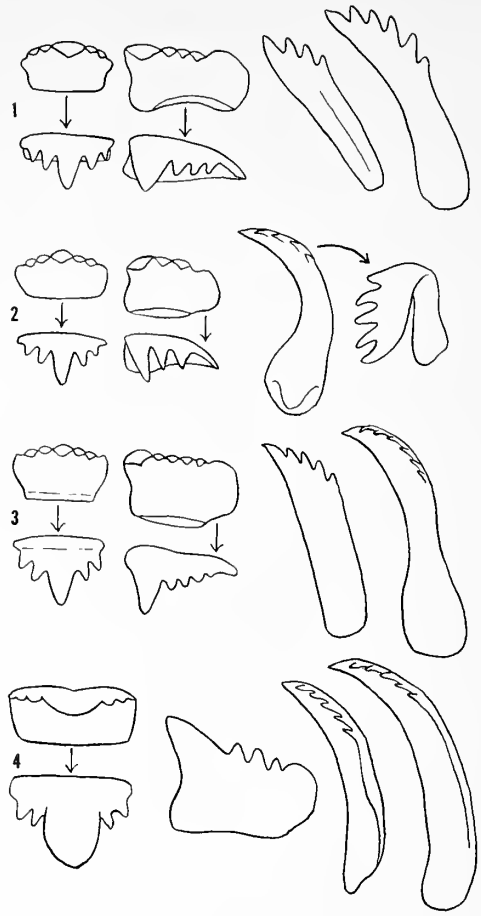

Plate 119. Radulae of *Lambis;* left to right: two views of the central tooth; two views of the lateral; the inner marginal; and the outer marginal. The formula in the text refers to the cusps on each tooth, e.g. for fig. 1: 2-1-2; 1-3; 4; 6. Fig. 1, *Lambis lambis* (Seychelles). 2, *L. crocata* (Zanzibar). 3, *L. chiragra chiragra* (Palau Islands). 4, *L. truncata sebae* (New Caledonia). All × 80.

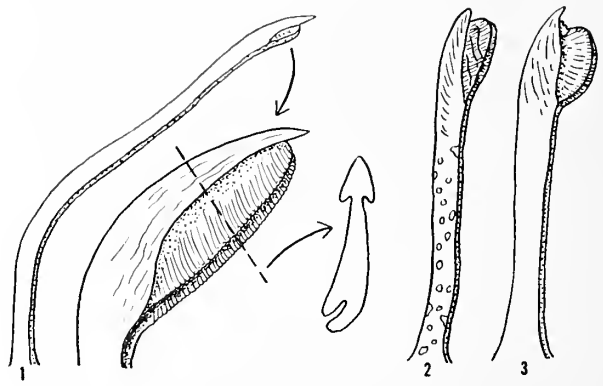

Plate 120. Verges from male *Lambis*. Fig. 1, *Lambis lambis*, showing enlargement of the distal pad and its cross-section (Palau Islands). 2, *L. crocata* (Zanzibar). 3, *L. chiragra arthritica*. All × 2.

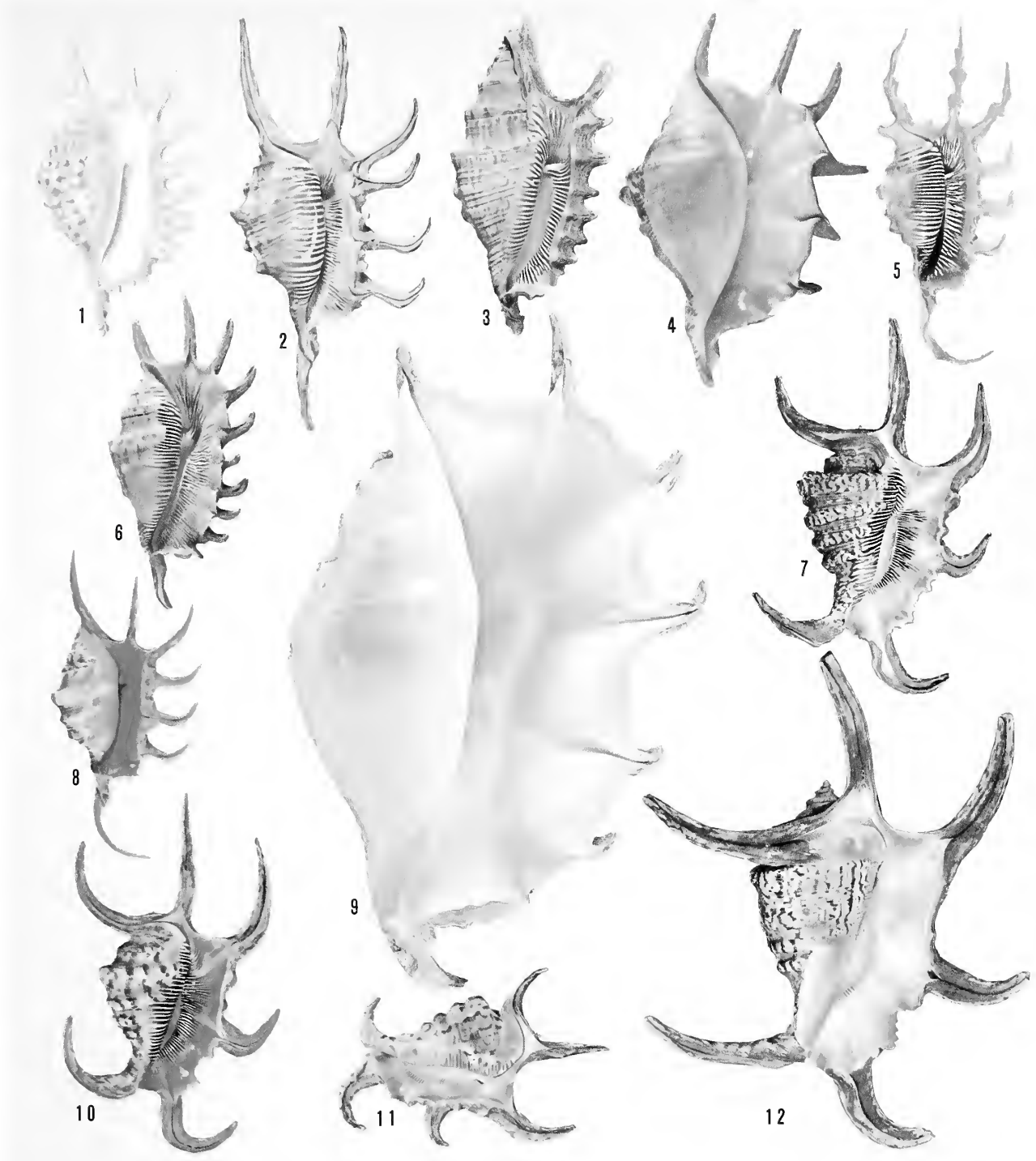

Plate 121

Fig. 1 *Lambis (Millepes) violacea* (Swainson, 1821). Mauritius. Rare.
2 *Lambis (Millepes) robusta* (Swainson, 1821). Society Islands. Rare.
3 *Lambis (Millepes) digitata* (Perry, 1811). Upolu Island, Samoa. Uncommon.
4 *Lambis (Lambis) lambis* (Linné, 1758). A female from Cebu Island, Philippines. Abundant.
5 *Lambis (Millepes) scorpius scorpius* (Linné, 1758). Okinawa Island, Ryukyu Islands. Moderately common from the East Indies to Samoa. Note small flange on left side of base of topmost digitation which is absent in the Indian Ocean subspecies, *indomaris*.
6 *Lambis (Millepes) millepeda* (Linné, 1758). Cebu Island, Philippines. Common in the S. W. Pacific.
7 *Lambis (Harpago) chiragra arthritica* Röding, 1798. Mozambique. Uncommon in the Indian Ocean.
8 *Lambis (Lambis) crocata* (Link, 1807). Zanzibar Island. Moderately common in the Indo-Pacific.
9 *Lambis (Lambis) truncata sebae* (Kiener, 1843). Saipan Island, Marianas. Moderately common in the Red Sea and Western Pacific.
10 *Lambis (Harpago) chiragra chiragra* (Linné, 1758). The uncommon *rugosa* form found in certain males.
11 the same, but a male from the Palau Islands showing very weak columellar sculpturing.
12 *Lambis (Harpago) chiragra chiragra* (Linné, 1758). A female from Luzon Island, Philippines.

(all 2/5 natural size; center shell, fig. 9, is 12 inches in length)

that the subspecies *chiragra* shows in most cases a great size difference, as well as a columellar difference, in the Western Pacific. The male very commonly takes on the so-called *rugosa*-like columella, while the large females have a smooth, rose columella. Curiously, further to the east in the Line, Tuamotu and Society Islands, only the *rugosa* type has so far been found. I have not seen many specimens from there and have had no opportunity to examine soft parts, but I suspect that both males and females have a *rugosa*-like columella. I have not been able to find any significant differences, other than size, in the shells of the males and females of the other species of *Lambis*.

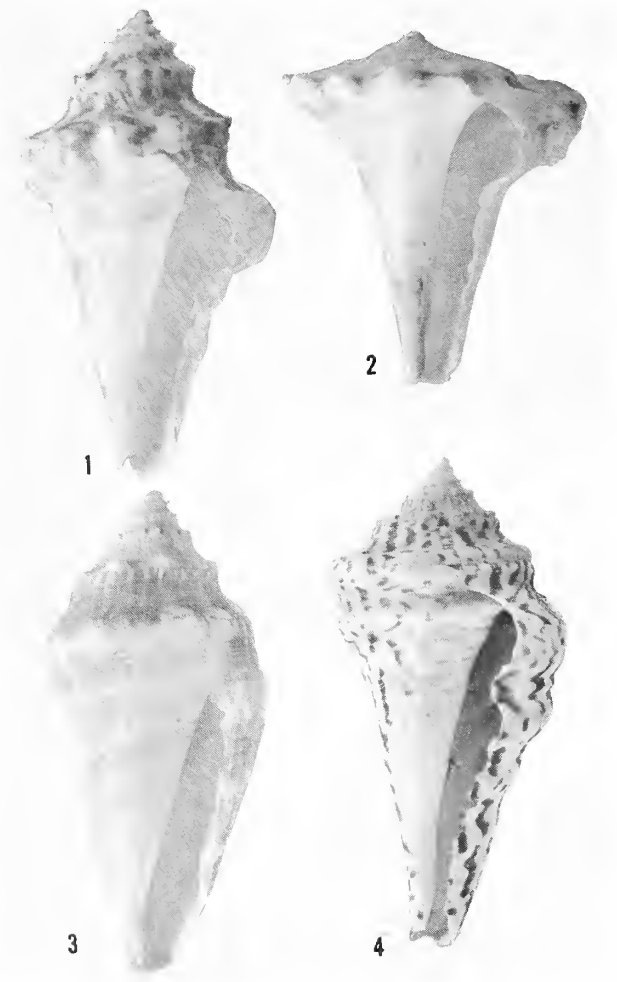

Plate 122. Young shells of *Lambis*. Fig. 1, *L. truncata sebae* (Tahiti). 2, *L. truncata truncata* (Mauritius). 3, *L. lambis* (Saipan Island). 4, *L. chiragra chiragra* (Sanga Sanga Island, Sulu Sea). All natural size.

List of Recognized Taxa

Genus *Lambis* Röding, 1798
- **Subgenus** *Lambis* s.s. Röding, 1798
  - *lambis* (Linné, 1758). Type
  - *truncata* (Humphrey, 1786)
    - subsp. *scbac* (Kiener, 1843)
  - *crocata* (Link, 1807)
    - subsp. *pilsbryi* Abbott, 1961
- **Subgenus** *Millipes* Mörch, 1852
  - *millepeda* (Linné, 1758). Type
  - *digitata* (Perry, 1811)
  - *scorpius* (Linné, 1758)
    - subsp. *indonaris* Abbott, 1961
  - *robusta* (Swainson, 1821)
  - *violacea* (Swainson, 1821)
- **Subgenus** *Harpago* Mörch, 1852
  - *chiragra* (Linné, 1758)
    - subsp. *arthritica* Röding, 1798

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Yonge, C. M. 1932. Notes on Feeding and Digestion in Pteroceras and Vermetus, with a Diseussion on the Occurrence of the Crystalline Style in the Gastropoda. Great Barrier Reef Exped., vol. 1, no. 10, pp. 259-281.

Subgenus Lambis Röding, 1798

Type: *Lambis lambis* (Linné, 1758)

The typical subgenus of *Lambis* contains three species each of which is characterized by a smooth columella and an inner body wall which lacks spiral lirae. There are 7 digitations, 6 of which arise from the edge of the outer lip, and the seventh being an extended anterior siphonal canal. All three species, *lambis, truncata* and *crocata* are moderately common to abundant over a large part of the Indo-Pacific. The latter two are polytypic, one having a subspecies in the Indian Ocean, the other a subspecies in the Marquesas Islands, Polynesia. The earliest fossil records of *Lambis* belong to this subgenus, one of these being *Lambis crocata* (Link) from the Pliocene of Zanzibar.

Synonymy –

1798 *Lambis* Röding, Museum Boltenianum, Hamburg, pt. 2, p. 61 (Type by absolute tautonomy: *Lambis lambis* Gmelin = Linné; p. 66).

1799 *Pterocera* Lamarck, Mémoires Soc. d'Hist. Naturelle Paris, (Vol. 1), p. 72. Type by monotypy: *Strombus lambis* Linné, (and by Children, 1823, p. 127); 1929, Thiele, Handbuch Syst. Weicht., vol. 1, p. 255; 1940, Wenz, Handbuch der Palaont., vol. 6, pt. 4, p. 946.

1807 *Pteroceras* Link, Beschr. Naturalien-Samml., Rostock, part 3, p. 109. (type hereby selected: *Pt. lambis* Linn.).

1810 *Pteroceres* Montfort, Conchyliologie Systématique, Paris, vol. 2, p. 607 (substitute name for *Pterocera* Lamarck, 1799). Invalid type by original designation: *P. scorpius* Linné.

1823 *Digitata* O. Fabricius, Fortegnelse over Fabriciusses efterladte Naturalien, Copenhagen, p. 86. (nude name).

1829 *Pterocerus* Brongniart, Tableau Terrains, p. 410.

1852 *Heptadactylus* "Klein", Mörch, Catalogus Conchyl. . . . Yoldi, Hafniae, p. 60 (type hereby designated: *lambis* L.); 1859, Chenu, Manuel de Conchyl. et Paleont. Conchyl., Paris, vol. 1, p. 259 (type by monotypy: *Pterocera lambis* Linné).

1878 *Heptadactylus* Kobelt, Illustrirtes Conchylienbuch, vol. 1, p. 106 (type hereby designated: *Pterocera lambis* Linné).

Nomenclature – The genus name *Pteroceres* Montfort, 1810, must evidently be interpreted as a substitute name for *Pterocera* Lamarck. Montfort customarily changed the gender of Lamarck's feminine genera to masculine. He refers to Lamarck's genus. A similar case was similarly interpreted in Opinion 120, I.C.Z.N., Smithsonian Misc. Coll., vol. 73, no. 7, p. 29 (The Status of *Achatinus* Montfort, 1810).

Lamarck's once well known name, *Pterocera,* is a junior synonym of *Lambis* and has not been in general use for over twenty years, despite Thiele's and Wenz's usage in 1929 and 1940, respectively.

Lambis lambis (Linné, 1758)

(Pl. 121, fig. 4; pl. 118; pl. 123, figs. 1-3)

Range – East Africa to Micronesia and eastern Melanesia.

Remarks – This is the commonest and one of the most widely distributed species of *Lambis.* It is one of the few marine gastropods to exhibit pronounced sexual dimorphism, other than size, in its shell

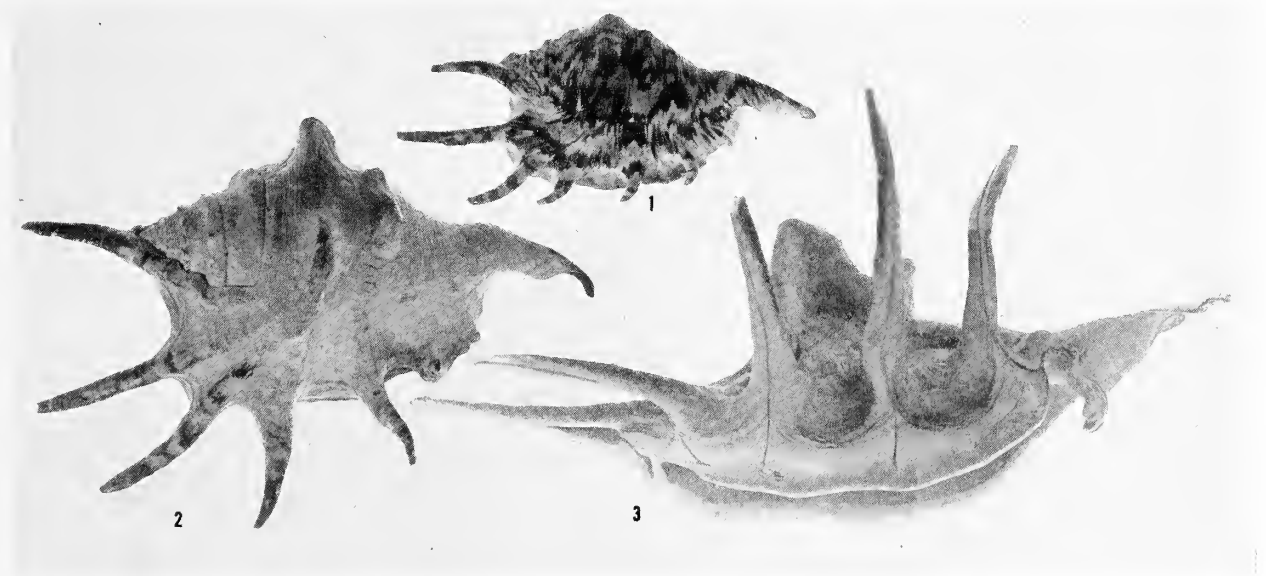

Plate 123. Male and female shells of *Lambis lambis* (Yap Island, Carolines). Fig. 1, male. 2 and 3, dorsal and side view of females. ½ natural size.

characters. The size of the shell of the male is usually about 60 percent that of the shell of the female. The degree of sexual dimorphism varies geographically. It is most pronounced in the Caroline Islands and in most, but not all, areas of the Philippines, Indonesia, Queensland and the Solomons. The differences are less obvious in the Indian Ocean and at the extreme eastern end of the range in New Caledonia, Fiji and Tonga. In extreme examples in the male, the lowest three labial digitations are short and hooked posteriorly, while in the female, they are two or three times as long and are strongly curved upward. The female usually has a very large, pinched, somewhat-bilobed knob on the dorsal part of the shoulder. In the male this is reduced to two small, equal-sized nodules. The two most posterior digitations are usually more widely separated in females than in males.

It is possible that the upturning of the digitations in the females facilitates mating. When *Lambis* is in the position of coition, the right anterior end, or region of the "stromboid notch," of each shell is approximately in juxtaposition. A closer contact would be possible because of the shortness of the digitations of the male and because the female's digitations are curved upward out of the way.

There is considerable geographical variation in the shape and size of the dorsal knobs in females; within a colony there is a uniformity. At Yap and Ponape Islands in the Carolines, the dorsal knob is very large, axially pinched, and bordered below by a smaller, sharp ridge. In Zanzibar, the dorsal knob is not as high as and is more elongate than those in most East Indian and Western Pacific specimens.

In general, there are three color forms which occur throughout the range of the species in either sex — light-cream with sparse paintings of light-brown; a cream background with heavy mottlings of dark purplish brown; and an over all light-brown with flecks of white. Intergrades are not uncommon within any colony. In the young of some, but not all, shells there is a large burnt-brown splotch on the upper section of the inner parietal wall. Couturier's (1907, p. 154) reference to "*Pterocera lambis*" from Mangareva and Tahiti undoubtedly are specimens of *truncata sebae* Kiener. Although *lambis* has been reported from the Red Sea on several occasions, I have not seen authenticated specimens from there.

C. M. Yonge (1932, p. 260) discussed in detail the herbivorous habits of this species, and included a detailed account of the crystalline style. The animal feeds only on the fine red algae and not on the gross brown algae or eelgrass. A powerful cellulase digestive enzyme is present in the stomach. Yonge identified his species as "*Pterocera crocata*," but unquestionably he had *Lambis lambis* (Linné), since he figures the latter species in his 1930 book on "A Year on the Great Barrier Reef" (p. 83, pl. XXV, fig. C). He states (in 1932, p. 260) that his species is abundant and the most characteristic member of the fauna of the reef flat and mangrove areas of Low Isles on the Great Barrier Reef. The length of the shell ranged from 180 to 200 mm. and the aperture was red. All of these features are characteristic of *Lambis lambis* in Queensland and do not apply to the uncommon, smaller, outer reef *crocata* (Link).

I have been unable to verify the literature records for this species in the Red Sea. R. Sturany (1903, p. 46) reported the less common *L. truncata* from ten Red Sea localities, but evidently failed to find *L. lambis*.

Miss Virginia Orr made the following observations on the egg mass being laid by a female *lambis* at Poum, New Caledonia, on January 4, 1961: "the tangled clump was laid under an old slab of coral in 2 feet of water. The clear jelly tube was several feet in length and about 1 mm. in diameter. The orange eggs were about 0.3 mm. in diameter and there were about 30 of them per 10 mm. of tube." Risbec also briefly described the egg mass of *lambis* which he says is most commonly laid in February in New Caledonia (Risbec [in Vayssière], 1927, Ann. Mus. d'Hist. Nat. Marseilles, vol. 21, p. 185).

Habitat — *L. lambis* occurs in colonies on reef flats and on sand or coral-rubble bottom, usually in association with algae, at depths ranging from the zone of low tide to several fathoms. Demond (1957, p. 297) says it "lives in sand on both seaward and lagoon reef flats, and on sandy lagoon floors, ranging from a few feet below low tide line to depths of 10 feet" in the Marshall Island atolls. M. Couturier (1907, p. 154) records it at depths of 3 to 5 fathoms in the Tuamotu Islands, but I believe that he was observing *L. truncata sebae*. Melvill (1909, p. 94) reported a specimen at 30 fathoms at Cargados Carajos, Indian Ocean, but this may have been a dead shell.

Description — Shell, including the digitations, 90 to 200 mm. (about 3½ to 8 inches) in length, with 6 slender, labial digitations which may be either short and bent posteriorly or long and bent upwards towards the dorsum. Siphonal canal moderately long and slightly twisted to the left. Whorls 10 to 11. Nuclear whorls smooth. Postnuclear whorls

slightly concave above the carinate shoulder. The carina may bear numerous small beads or nodules. Spiral sculpture between the indented suture consists of about a dozen, irregular, microscopic threads. Last whorl with strong, blunt nodules on the shoulder. Mid-area of last whorl with a spiral row of 3 or 4 small nodules or rarely a raised, elongate nodule. Aperture and columella smooth, except for 4 to 7 weak lirae at the posterior end of the aperture, just behind the deep, smooth pit. Outer lip crenulated in young specimens, but smooth in old specimens. Color of aperture uniform tan, cream, or rarely orange tan or rose. A black-brown blotch may or may not be present on the upper part of the columellar wall of young specimens. Color of outer shell variable: cream with light- or dark-brown flecks and maculations; or mottled and spotted with purple-tan or blue-black. Periostracum thin, smoothish, translucent-tan. Operculum corneous, brown, clongate, arching, and without serrations. Radula formula: 2-1-2; 1-4 or 1-3; 5 or 6; 5 or 6. Verge as long as the aperture (see pls. 119 and 120).

Measurements (mm.) – (including digitations)

length	width	no. whorls	
200	111	10+	(large; north Ceylon)
180	100	10+	(average; Luzon Id.)
92	43	10	(small; Palau Ids.)

Synonymy –

1758 *Strombus lambis* Linné, Systema naturae, ed. 10, p. 743, no. 425; 1767, ed. 12, p. 1208, no. 493 (O. Asiae); 1956, Dodge, Bull. Amer. Mus. Nat. Hist., vol. 111, art. 3, pp. 250-251.

1798 *Lambis lambis* Gmel., Röding, Museum Boltenianum, Hamburg, pt. 2, p. 66, no. 844. Refers to Conchyl.-Cab., vol. 3, fig. 855, 888.

1798 *Lambis lobata* Röding, loc. cit., p. 68, no. 872. Refers to Conchyl.-Cab., vol. 3, fig. 902. Non *lobata* Röding loc. cit., p. 65, no. 826, which is *Strombus sinuatus* Humphrey.

1798 *Lambis lamboides* Röding, loc. cit., p. 66, no. 845. Substitute name for *lambis* Gmelin, 1791.

1798 *Lambis cerea* Röding, loc. cit., p. 66, no. 846. Substitute name for *lambis* Gmelin, 1791.

1798 *Lambis hermaphrodita* Röding, loc. cit., p. 68, no. 875. Substitute name for *lambis* Gmelin, 1791.

1798 *Lambis laciniata* Röding, loc. cit., p. 68, no. 877. Substitute name for *lambis* Gmelin, 1791.

1798 *Lambis maculata* Röding, loc. cit., p. 67, no. 854. Refers to Conchyl-Gab., vol. 3, figs. 858, 859.

1817 *Strombus lambis* Linné, Dillwyn, Descriptive Catalogue Recent Shells, London, vol. 2, p. 658.

1826 *Strombus camelus* "Chemn." Gray in King, Narrative Survey—Coasts of Australia, London, vol. 2, appendix, p. 490. (refers to Conchyl.-Cabinet, vol. 10, fig. 1478); 1830, Menke, Synopsis Method. Molluscorum, ed. 2, Pyrmonte, p. 72.

1842 *Pteroceras lambis* Lin., Sowerby, Thesaurus Conchyl., vol. 1, Pteroceras, p. 41, pl. 11, figs. 5 and 7 not 6.

1932 *Pterocera crocata*, Yonge, Great Barrier Reef Exped., Scientific Reports, vol. 1, no. 10, pp. 260-267. [feeding and digestion].

Types – Hanley (1855, p. 267) states that a specimen like that figured in Sowerby's Thesaurus Conch., vol. 1, pl. 1, fig. 5 is marked as *lambis* in the Linnaean collection in London. From that figure and from Linné's description it appears that this species was founded upon a male specimen. We restrict the type locality to Amboina, Indonesia.

Nomenclature – Most of the synonyms of *lambis* Linné refer to the male shell. This is true of all of Röding's names listed in our synonymy. Among the early figures of the male are: Schröter, 1782, Musei Gottwaldiani, pl. 21, figs. 142, 142; Rumphius, pls. 36A and 35E; Lister, pl. 866, fig. 21; Argenville, pl. 14, fig. E; Regenfuss, pl. 4, fig. 45 [excellent]; Knorr, pt. 1, pl. 28, fig. 1 [excellent]; and the Conchyl.-Cab., vol. 3, figs. 858, 859, 902, 903. It is also figured in Butot, 1955, pl. 2, fig. 2; Blainville, 1827, pl. 25, figs. 4, 4a [excellent].

The female shell, with its long recurved, lower digitations, has received only one other name: *camelus* Chemnitz, 1788 [non-binomial] which was validated in 1826 by Gray. It has been figured in: Conchyl.-Cab., vol. 10, fig. 1478; also vol. 3, fig. 855; Schröter, 1782, pl. 21, fig. 139a; Rumphius, pl. 35F;

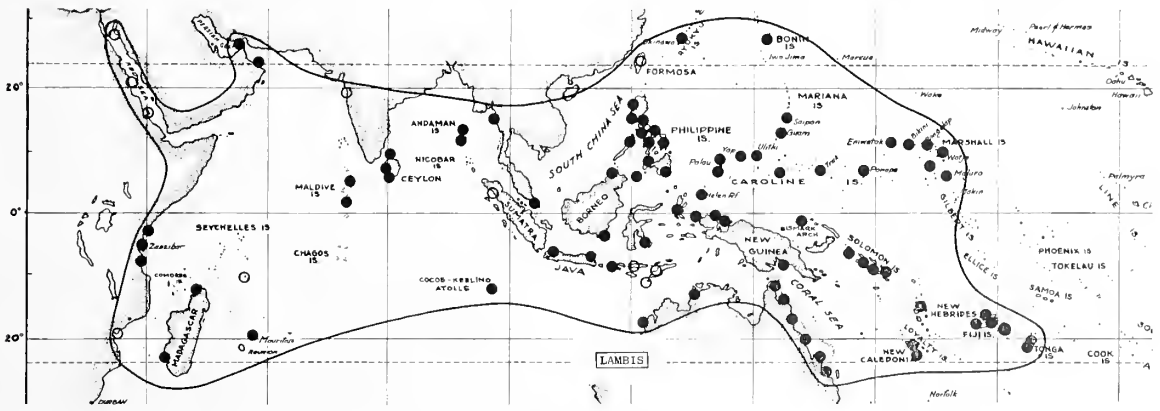

Plate 124. Geographical distribution of *Lambis lambis* (Linné). The Red Sea literature records (open circles) may be based upon specimens of *L. truncata sebae* (Kiener).

Reeve, 1851, pl. 5, fig. 8; Abbott, 1949, p. 324 (Scientific Monthly, vol. 69).

It may be pointed out that the use of the terms "male" and "female" among native collectors, even today, and among early writers, such as Rumphius, refers not to the sex of the animal but to the immature or light-weight ("female") and the older, heavier ("male") specimens.

Selected records (see accompanying map for others; solid dots: specimens examined; open circles: literature records) — SAUDI ARABIA: Muscat, Gulf of Oman (Melvill and Standen, 1901, p. 381). MOZAMBIQUE (von Martens, 1880, p. 279). TANGANYIKA: Inner Sinda Id. (R. T. Abbott, USNM). ZANZIBAR: common around the island; Kiwengwa; Chumbe Id.; Mnazi Moja; Paje; (NSF, 1957). RED SEA: Suakin; Aqaba; Massana (all Issel and T.-Canefri, 1876, p. 357). Persian Gulf (MCZ). MADAGASCAR: Nossi-bé (A. Chavane, ANSP). Cargados Carajos (Melvill, 1909, p. 94). Mauritius (N. Pike, MCZ). MALDIVES: Gan Id., Addu Atoll; North Malé Atoll (both Yale Peabody Mus.). INDIA: Bombay (Hornell, 1951, p. 87). CEYLON: Fort Frederick, Dutch Bay (Yale Peabody Mus.); Weligama Bay; Hikkaduwa; Eluvativa Id. (all G. and M. Kline, NSF, 1957). ANDAMANS: Port Blair; Long Id. (both Brit. Mus.). THAILAND: Phuket, Bay of Bengal (F. N. Crider, ANSP). SINGAPORE: Raffles Light (R. D. Purchon, ANSP). RYUKYU IDS.: Shioya, Shanawan Bay (USNM). TAIWAN: Hoko (Kuroda, 1941, p. 98). PHILIPPINES: common throughout the islands of Luzon, Samar, Cebu, Catanduanes, Mindoro, Bohol, Masbate, Burias, Panay, Basilan, Lubang, Marinduque, Polillo, Palawan, Mindanao, Jolo, Sanga Sanga (all ANSP, USNM and MCZ). INDONESIA: Pulu Pandjang and Biliton Id., west Sumatra; Madura Id. and Bay of Batavia, Java; Obi Id., Moluccas; Lintido, Celebes (all ex Rijksmus. Nat. Hist., Leiden, ANSP) Banka, Kangeang (east of Madura), Flores, Timor, Amboina, Nusa-Laut, Halmahera, Waigen, Kei Islands (all Oostingh, 1923, p. 78). COCOS KEELING ATOLL (A. R. Whitworth, ANSP). AUSTRALIA: Western Australia: Cape Leveque (A. R. Whitworth). Northern Territory: Darwin (A. R. Whitworth, ANSP). Queensland: Rubber Reef, Port Douglas (Tony Marsh, ANSP); Hayman Id., Brook Id., Orpheus Id., Palm Ids. (all H. A. Pilsbry, ANSP); Mossman (ANSP); Black Reef and Lupton Reef, Whitsunday Group (MCZ); Green Id., near Cairns (MCZ). DUTCH NEW GUINEA: Mios Woendi Atoll, Padaido Ids.; Sowek, Soepiori, Schouten Ids.; Aoeri Id. (all NSF, 1956). Port Moresby, Papua (P. Coleman, ANSP). ADMIRALTY IDS.: Koruniat (ANSP). SOLOMONS: Choiseul, Malita, Bougainville, Shortland Ids. (all W. J. Eyerdam, ANSP). NEW HEBRIDES: Mallicolo Id. (G. Massoulard, ANSP). NEW CALEDONIA: Touho Bay; Yaté; Bourail (all G. and M. Kline, NSF, 1959). BONIN IDS.: Chichi Jima (Y. Kondo, USNM). MARIANAS: Saipan (ANSP); Apra Harbor, Guam Id. (A. J. Ostheimer, NSF, 1953). PALAUS: common throughout the islands of Koror, Babelthuap, Kayangel, etc. (NSF, 1955); Yap Id. (C. O. Kile, ANSP); CAROLINES: Ulithi (ANSP); Oneop Id., Lukunor Atoll (MCZ). MARSHALLS: Bikini, Eniwetok, Rongelap and Rongerik Atolls (all USNM). FIJI: Mbau Id. and Suva (H. S. Ladd, USNM); Levuka, Ovalau Id. (R. T. Abbott, MCZ); Ongea Levu, Lau Group (H. S. Ladd, USNM). TONGA: Vlitoa (BPBM no. 68528); Vava'u (ANSP).

Fossil records — KENYA: Pleistocene; reef limestone, Mombasa (L. R. Cox, 1930, p. 139). TANGANYIKA: Pleistocene of Dar-es-Salaam (A. Ortmann, 1892, p. 642). SUDAN: Port Sudan, coral reef, Pleistocene (Hall and Standen, 1907, p. 67). INDONESIA: Post-Tertiary Pleistocene, Billiton [Belitong Id.], Borneo. (K. Martin, 1881, vol. 3, p. 17). Young Quaternary at Goenoeng Medong, east Borneo Id. (Beets, 1948, p. 8). FIJI ISLANDS: Lau Id., Futuna limestone, Pliocene (?), Station L 493 (specimen resembling *L. lambis* seen in USNM). NEW HEBRIDES: Espirito Santo Island, Pliocene (?), H. T. Stearns Station ES–14, alt. 240 ft. (specimen of *L. lambis* seen in USNM).

Lambis truncata (Humphrey, 1786)

This is the largest and one of the most widely distributed members of the genus in the Indo-Pacific. Adults reach a length of 10 to 15 inches. It is distinguished from the smaller *L. lambis* by the large knobs on the spire and by the absence of the strong, raised, axially-pinched knob which is present on the dorsum of female *lambis*. The dark purple-brown maculations found in some *lambis* are absent in *truncata*. This species may be readily separated into two subspecies:

truncata truncata (Humphrey, 1786)—with a flat apex, thus giving the spire a truncate appearance. Limited to the Indian Ocean.

truncata sebae (Kiener, 1843)—with a pointed apex, thus giving the spire an acute angle. With a curious, discontinuous distribution in the Red Sea and the Pacific Ocean as far east as the Tuamotu Islands.

We cannot on the basis of the few authentic specimens we have seen distinguish Red Sea and Western Pacific specimens of *sebae*. The dorsal hump or shoulder knob in Red Sea specimens is much more pronounced than that of Pacific specimens. This is a not uncommon feature of some of the *truncata truncata* from Zanzibar. *L. t. sebae* occurs also in Pleistocene deposits in the Red Sea area. It is possible that the subspecies *truncata* has more recently developed in the Indian Ocean and has now isolated the extreme ends of the parent subspecies, *sebae*.

Some, but not all, specimens from eastern Polynesia take on an elongate shape with the spire angle being less than that of East Indian and Melanesian specimens. The interior of the aperture, at the upper end, may have a few axial folds or creases. This is what Mörch named *sowerbyi* which we are synonymizing with *sebae*. The chocolate coloration of the aperture mentioned by Mörch occurs in only a few specimens, and may be only due to environmental conditions. At best, it is a very weak subspecies.

Lambis truncata *subspecies* truncata (Humphrey, 1786)

(Pl. 122, fig. 2)

Range — Indian Ocean from central East Africa to the Bay of Bengal and Cocos Keeling Atoll.

Remarks — This subspecies is characterized by its truncate, flat apex which is brought about by the first 5 whorls revolving in the same plane. The sixth and subsequent whorls descend at a normal

rate, so that the adult shell takes on a normal *Lambis* shape. The young shell is so strikingly different from the adult that Grateloup described it as a new species of "*Pyrula*" in 1840. There is little difference in the adult shells of *sebae* and *truncata*, except that the latter generally has a rather large, indistinct hump on the dorsum, grows to a slightly larger size and usually has one or two fewer knobs per whorl in the spire. This species is moderately common throughout its Indian Ocean range.

Recently matured specimens have six long, slightly arching labial digitations. Rarely, a small, aberrant seventh may occur between the first and second digitations. Old specimens, usually found in shallow water on reefs and in lagoons, are very heavy and encrusted with calcareous algae, vermetid snails and rarely coral. The digitations and siphonal canal are greatly reduced, the aperture constricted and the parietal wall and outer lip covered with a creamy brown, granular glaze.

Habitat — Occurs near reefs in 12 to 15 feet of water (Issel and T.-Canefri, 1876, p. 356). I have seen natives dive for this species in 20 feet of water off the reefs of Kenya. It is rarely seen on the reefs, mainly, I believe, because the natives remove most of the larger shells for food purposes at each low tide.

Description — Shell massive and, including the digitations, 9 to 15 inches in length, with 6 slightly arching labial digitations. Siphonal canal proportionately short and almost straight. Whorls 9 to 10. Apex with about 4 to 5 flat whorls. Shoulder of whorls in spire with rather large, rounded nodules, usually 10 to 12 per whorl, but becoming obsolete in the last whorl. Dorsum of body whorl with 2 or 3 knob-like swellings, one of which may be large and mound-like. Spiral sculpture of numerous, weak, irregularly-sized threads or cords. Aperture and parietal area with an enamel gloss. The glaze at the upper end of the columella extends over the nodules on the spire and sometimes over the apex. Color of aperture white within and becoming tan or purplish brown near the edges. Outer lip wavy in recently matured specimens, but very thick and smooth in old specimens. Columella straight and smooth. "Stromboid notch" bounded anteriorly by a small, pointed spur. Color of outer shell whitish cream with sparse, light-brown specklings or sometimes with chestnut-brown spiral bands and maculations. Periostracum moderately developed, translucent-tan and flaking off when dry. Operculum chitinous, elongate, very slightly curved, brown, and with smoothish edges. The radulae are proportionately massive and with about 55 transverse rows. The center cusp of the central tooth is broadly rounded. Formula: 2-1-2; 1-3 or 1-4; 5; 6 to 8.

Measurements (mm.) — (including digitations)

length	width	no. whorls	
375	212	10+	(large; Zanzibar)
387	225	8+	(large; Seychelles)
250	150	8+	(small; Zanzibar)

Synonymy —

1786 *Strombus truncatus* Humphrey, Portland Catalogue, p. 133, no. 2967 (East Indies); refers to Davila, vol. 1, pl. 12, fig. 14; ibid., p. 150, no. 3307 (young); ibid., p. 169, no. 3655 (China); 1817, Dillwyn, Descr. Cat., vol. 2, p. 659.

1791 *Strombus bryonia* Gmelin, Systema Naturae, 13th ed., p. 3520, No. 33 (no locality). Refers to Lister, pl. 882, fig. 4 and others; 1825, Wood, Index Testaceologicus, pl. 24, fig. 8.

1798 *Lambis davilae* Röding, Museum Boltenianum, Hamburg, pt. 2, p. 66. Refers to Davila, vol. 1, pl. 14, pl. 13.

1798 *Lambis radix* Röding, loc. cit., p. 67, Refers to Conchyl.-Cab., vol. 10, fig. 1514.

1840 *Pyrula bengalina* Grateloup, Actes Soc. Linn. Bordeaux, vol. 11, pp. 170 and 448, pl. 4, fig. 5 (Bengal).

1852 *Pterocera (Heptadactylus) radix-bryoniae* Ch., Mörch, Catalogus Conchyl. . . . Yoldi, Hafniae, p. 60.

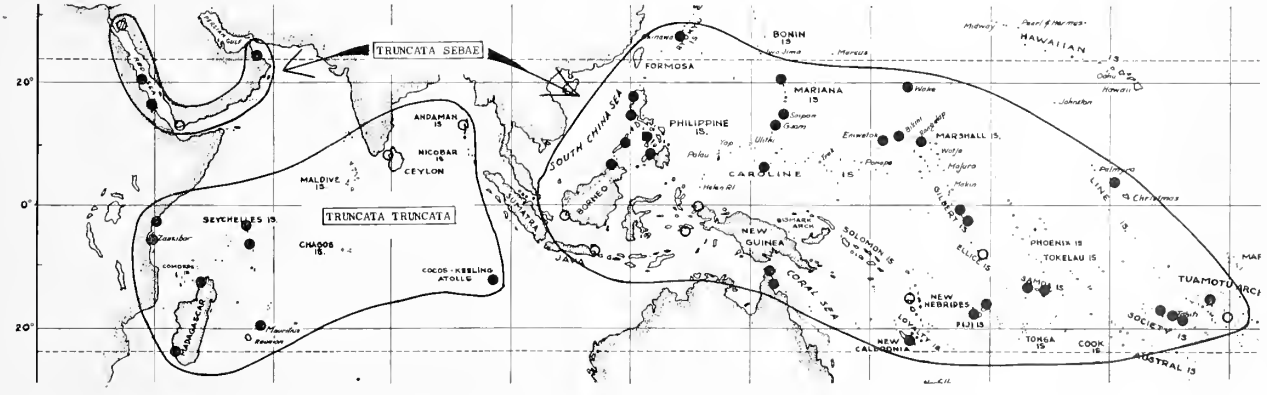

Plate 125. Geographical distribution of *Lambis truncata truncata* (Humphrey) in the Indian Ocean, and of the subspecies *sebae* (Kiener) which has a discontinuous distribution.

1854 *Harpago (Heptadactylus) radix-bryoniae* Cmel., H. and A. Adams, Genera of Recent Mollusca, London, vol. 1, p. 261.

1822 *Pterocera truncata* Lamarck, Anim. sans Vert., vol. 7, p. 195; 1834, Kiener, Coquilles Vivantes, vol. 4, pl. 1, pl. 10, fig. 5.

1872 *Pterocera (Heptadactylus) truncata* Humphrey, Mörch, Jour. de Conchyl., vol. 20, p. 132.

1955 *Lambis (Lambis) truncata* (Humphrey), Butot, Penggemar Alam, vol. 35, p. 76 (in part).

Types — The whereabouts of Humphrey's type is unknown to me. It was probably sold at auction in 1786 in London.

Nomenclature — The eighteenth century figures of *truncata* were a mixture between the flat-topped Indian Ocean and acute-spired Red Sea and Pacific Ocean subspecies. Humphrey's 1786 name of *truncata* refers to Davila, pl. 12, fig. 14, a flat-topped specimen probably from East Africa. The earliest valid name for the acute-spired subspecies appears to be that of *sebae* (Kiener, 1843).

Grateloup's *Pyrula bengalina* is a very young specimen of *truncata truncata*, a fact which was pointed out by Kiener in 1843.

Although Butot (1955, p. 76) seemed to have understood the characters of *L. truncata* which has a truncate spire, he confused the issue by referring his own acute-spired specimen (his plate 2) from Kangean Island, Indonesia, and that of Rumphius ("Cornuta decumana" Rumphius 1705, pl. 35, fig. H) to *truncata*, rather than to *sebae* (Kiener).

Records (also see accompanying map) — KENYA: Diani Beach, south of Mombasa (R. T. Abbott, USNM, MCZ). MADAGASCAR: Nossi Iranja, south side of Nossi-bé (Academy-Madagascar Exped., 1960); Nossi Fanihi; Tulear; Ambodifotatra; Tamatave (all Dautzenberg, 1929, p. 472). SEYCHELLES: Southeast Id., off Mahé Id. (Yale Peabody Mus.). MAURITIUS: Port Louis (MCZ). CEYLON: (Issel and T.-Canefri, 1876, p. 356). ANDAMANS: Port Blair (Issel and T.-Canefri, 1876, p. 356). BENCAL: (Crateloup, 1840, pl. 4). COCOS KEELINC ATOLL: shallow water in lagoon (USNM).

Fossil Records — None recorded.

Lambis truncata *subspecies* sebae (Kiener, 1843)

(Pl. 121, fig. 9; pl. 122, fig. 1)

Range — Red Sea and the tropical Pacific Ocean from the East Indies to eastern Polynesia.

Remarks — This subspecies differs from the typical *truncata truncata* of the Indian Ocean in having a pointed, rather than a truncate, apex. Adults rarely exceed 13 inches in length (including spines), while *truncata* may reach 16 inches. The curious distribution of this subspecies in two distantly separated areas, one in the Red Sea, one in the Pacific, can be explained by at least two possibilities. Either, two morphologically similar forms have evolved independently of one another, or the once continuous distribution has recently been broken by the invasion of a geographically intervening race of flat-topped Indian Ocean specimens. The fossil record is too poorly known to settle this matter.

The flesh of this *Lambis* is commonly eaten by natives. Hedley (1899, p. 429) reports that the Ellice Islanders eat the snail raw or roasted.

Habitat — Lives in colonies on sandy, algal and coral rubble bottoms in the vicinity of coral reefs. "Commonly found at depths of 15 to 30 feet off the edge of seaward reefs . . . and on sandy lagoon shelves among seaweed or on minor reef prominences in 2 to 10 feet of water. Invariably occurs below low tide line [Marshall Islands]" (Demond, 1957, p. 297). Old and worn, but living, specimens occur on gravel flats in the lagoon at Funafuti in waist deep water (Hedley, 1897, p. 429, fig. 18). "It is rare in the central Philippine Islands" (E. Zambo, *in litt.*, 1958).

Description — Shell massive, 9 to 13 inches in length, and differing from the Indian Ocean *truncata truncata* in having the apex of the shell with a spire angle of 80 to 100 degrees, and in rarely exceeding a total length of 12 inches. Young specimens show a predominance of fine axial streaks of light-brown. The radulae are illustrated on plate 119, fig. 4.

Measurements (mm.) — (including digitations)

length	width	no. whorls	
300	200	9+	(large; Samoa)
275	170	8+	(average; Saipan Id.)
225	137	8+	(small; Mindanao Id.)

Synonymy —

1843 *Pterocera sebae* "Valenciennes" Kiener, Coquilles Vivantes, Paris, vol. 4, Ptérocère, p. 4, pl. 2, pl. 4, fig. 2 (la mer Rouge et l'océan Indien).

1872 *Pterocera (Heptadactylus) sebae* Valenciennes, Mörch, Jour. de Conchyl., vol. 20, p. 131.

1872 *Pterocera (Heptadactylus) sowerbyi* Mörch, Jour. de Conchyl., vol. 20, p. 131 (Ins. Taiti).

1935 *Lambis bryonia* Cmelin, Y. Hirase and Pilsbry, 1000 shells in Color (Kai Sen Shu), vol. 4, pl. 73, fig. 368.

1938 *Lambis truncata* (Solander), S. Hirase, A Collection of Japanese Shells, 6th ed., pl. 87, fig. 2.

1955 *Lambis sebae* Valenciennes (Kiener), Butot, Penggemar Alam, vol. 35, p. 76, pl. 1, fig. 2.

1955 *Lambis truncata* (Humphrey, 1786), Butot, loc. cit., pl. 1, fig. 1, 3, pl. 2, fig. 7.

1958 *Lambis (Lambis) truncata* (Humphrey), Oyama, The Molluscan Shells, Tokyo, vol. 2, Lambis (1), figs. 7, 8 (Okinawa).

Types — We hereby restrict the type locality of *sebae* Kiener to the Red Sea. The type is presumably in the Musée d'Histoire Naturelle de Genève.

RED SEA records: Case Arm, Israel (ANSP); Aqaba, Israel (Issel and T.-Canetri, 1876, p. 356). Sherm Sheikh; Shadwan Id.; Ras Abu Somer; Hassani Id., and Jidda (all R. Sturany, 1903, p. 28). Port Berenice, Egypt (ANSP). 10 mi. off Port Sudan (R. C. Spencer, coll'n.). Berbera, Gulf of Aden (USNM).

PACIFIC OCEAN records (also see accompanying map) — RYUKYU ISLANDS: (USNM). PHILIPPINES: Iba, Zambales, Luzon Id. (P. de Mesa, ANSP). Lubang Id., Mindoro Prov. (P. de Mesa, ANSP). Cuyo Id., Palawan Prov.; Zamboanga, Mindanao Id. (both du Pont-Academy Exped., 1958). Sibuyan Id., Romblon Prov. (Alcasid, 1947, p. 180). Sarangani Bay, S. Mindanao Id.; Tara Id. (both USNM). INDONESIA: Amboina (Rumphius, 1705, pl. 35, fig. H). Borneo and Ceram Ids.; Kangean Id., N. E. of Java (all Butot, 1955, p. 76). Waigeu Id., west of Dutch New Guinea (Butot, 1955, p. 76). AUSTRALIA: Torres Straits (ANSP); Keeper Reef, 40 mi. from Townsville, Queensland (Tony Marsh, *in litt.*). NEW HEBRIDES: Erromanga (Hedley, 1899, p. 429). NEW CALEDONIA: barrier reef, Touho Bay; Plage de Poe, Bourail (both G. and M. Kline, NSF, 1959). FIJI ISLANDS: Namuka Id., Kaloka Levu, Viti Levu Id. (R. T. Abbott, MCZ). Suva, Viti Levu Id. (H. S. Ladd, USNM). MARIANAS: barrier reef, Tanapag, Saipan Id. (R. Sutcliffe, ANSP). Tinian Id. (J. L. Chamberlin, MCZ). Cuam Id. (USNM). Maug Id. (USNM). CAROLINES: 4 fms., Main Pass, Ifaluk Atoll (USNM). MARSHALL ISLANDS: Bikini, Eniwetok, Rongelap Atolls (J. P. E. Morrison, USNM). GILBERT ISLANDS: Onotoa Atoll (P. E. Cloud, USNM); Apiang (A. Carrett, MCZ). HAWAIIAN CHAIN: [Evidently absent. Spicer, 1941, p. 2, reports that Guam specimens were taken to and sold on Midway]. LINE ISLANDS: Christmas Id. (Fred Barnett, ANSP). ELLICE ISLANDS: Funafuti (Hedley, 1899, p. 429). SAMOA: Satalo Id., Upolu Id. (NSF, 1955). Fagaitua Bay, Tutuila Id. (MCZ). SOCIETY ISLANDS: District of Anau, Bora Bora; Aua, District of Paea, and Ative, District of Punaauia, Tahiti (all R. Robertson, 1952, ANSP). Nauarei, Moorea Id. (H. A. Rehder. USNM). TUAMOTU ISLANDS: Ship Pass, Raroia (R. Rufon, ANSP). Hao and Oluura [= possibly Takapoto] (Couturier. 1907, p. 154). Maranganai Id., Toau [Elizabeth Atoll] (H. A. Pilsbry, 1929, ANSP).

Fossil records — Pleistocene of Khor Ambado, French Somalia (Abrard, 1942, p. 62, pl. 6, fig. 34, as *Pterocera* cf. *millepeda* Linné). HAWAIIAN CHAIN: "Pleistocene" raised beach, 15 feet altitude, Makua, south coast of Oahu Id. (Children's Museum, Honolulu).

Lambis crocata *subspecies* crocata (Link, 1807)

(Pl. 121, fig. 8, pl. 126)

Range — East Africa to Samoa and the Ryukyu Islands to northern Australia.

Remarks — This moderately common species is readily recognized by its solid-orange, smooth aperture. The outer lip bears 6 slender digitations, and the siphonal digitation is long and gracefully curved. We have divided the species into two races—the typical *crocata* of the Indian and western Pacific Oceans which becomes progressively rare towards the east where it appears to have reached its limits in Samoa—and the giant subspecies *pilsbryi* which appears to be limited to the Marquesas Islands in eastern Polynesia.

The exterior of the shell is usually mottled in creamy-white and soft brownish orange, although a pure-orange color form rarely occurs in colonies

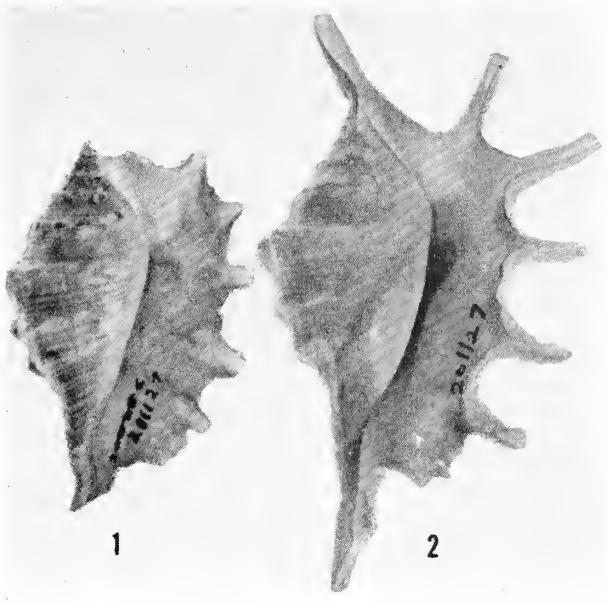

Plate 126. Immature shells of *Lambis crocata* (Kayangel Island, Palau Islands). Fig. 1, with digitations beginning to be formed. 2, with digitations almost completed. Both natural size.

from the Palau Island and the Philippines. A specimen from Chumbe Island, Zanzibar, is malformed and has 9 labial digitations. This species has not been recorded from the Red Sea or the Hawaiian Chain. It was formerly called *aurantia* Lamarck.

Habitat — This species lives on seaward reefs from the low tide mark to a depth of about 10 feet. Melvill (1909, p. 94) reported it at depths of 31 and 34 fathoms in the Seychelles, but did not indicate whether or not these were live specimens. Alan J. Kohn recovered live specimens on the reefs in the Seychelles (Yale Peabody Exped., station 41, 1957).

Description — Shell 100 to 150 mm. (4 to 5½ inches) in length (including the digitations), with 6 labial digitations, and a long, slender, curved siphonal digitation. Aperture a solid, whitish orange and smooth. Nuclear whorls 3, smooth, glossy and light-brown in color. 7 to 8 postnuclear whorls with numerous spiral threads. The shoulder of the whorls in the spire bears a small beaded carina which lies just above the finely indented suture. Last whorl with 3 spiral rows of knobs, the upper row having 2 to 4 widely-separated rather large, rounded knobs and the lower two rows having 4 to 6 smaller knobs. Color of outer shell solid orange-tan or whitish with orange-tan maculations. Lower 3 labial digitations hooked posteriorly at an 80 to 90 degree angle. Aperture elongate, solid orange, smooth, constricted within by a long axial ridge on the inside of the body whorl. Upper end of aperture with

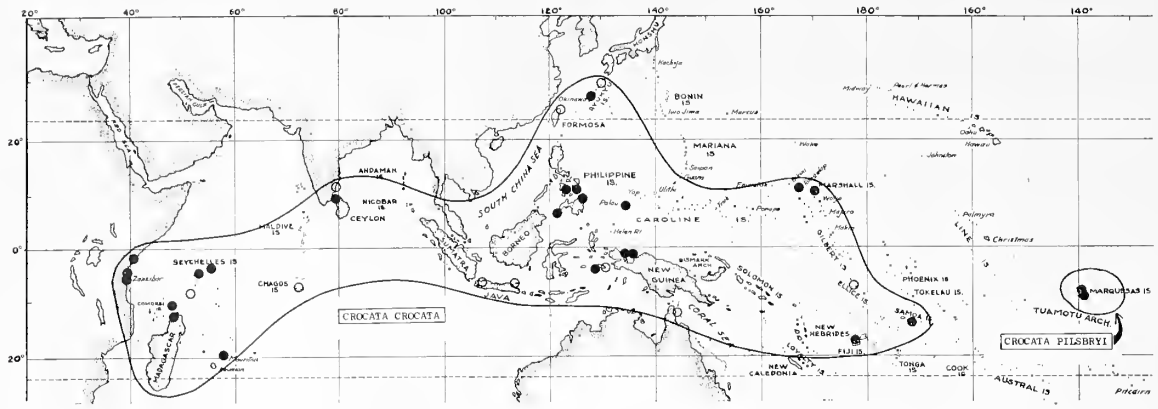

Plate 127. Geographical distribution of *Lambis crocata crocata* (Link) and its Marquesan subspecies *pilsbryi* Abbott.

a deep well which is bounded by a small spiral ridge on the upper end of the columella. Columellar callus enameled, swollen, and with a sinuate line of demarkation on the left side. "Stromboid notch" large and fluted. Periostracum heavy, brown and slightly rough, but usually worn off the body whorl. Operculum slightly curved, brown and its edges smoothish. The verge is slender, with a small distal pad, maculated with cream spots, and about ½ the length of the aperture. The odontophore is about 8 mm. in length with 40 transverse rows of teeth. The radular formula is 2-1-2; 1-2; 5; 5.

Measurements (mm.) — (including digitations)

length	width	no. whorls	
150	73	8+	(large; Tutuila Id., Samoa)
128	55	8+	(average; Cebu Id., Philippines)
103	45	5+	(small; Gulf of Manaar, India)

Synonymy —

1798 *Lambis scorpius* Cmelin, Röding, Museum Boltenianum, Hamburg, pt. 2, p. 67, no. 60. Refers to Conchyl.-Cab., vol. 10, figs. 1508-09. Non Cmelin, 1791; non Linné, 1758.

1807 *Pteroceras crocatus* Link, Beschr. Naturalien-Sammlung, Rostock, pt. 2, pp. 109, 110. Refers to Conchyl.-Cab., vol. 10, figs. 1508-1509.

1811 *Strombus aculeatus* Perry, Conchology, London, pl. 13, fig. 2 (no locality). Perhaps a *nomen dubium*.

1822 *Pterocera aurantia* Lamarck, Anim. sans Vert., vol. 7, p. 198 (Indes orientales). Refers to Conchyl.-Cab., vol. 10, figs. 1508, 1509 and Knorr, pt. 5, pl. 4, fig. 3.

1825 *Strombus lambis* L., Wood, Index Testaceologicus, London, p. 116, pl. 24, fig. 7.

1825 *Pteroceras aurantiacum* Sowerby, Catalogue Shells . . . Tankerville, London, p. 67 (substitute name for *aurantia* Lam.).

1842 *Pteroceras aurantia* Lam., Sowerby, Thesaurus Conchyl., vol. 1, Pteroceras, p. 42, pl. 11, fig. 11.

1941 *Lambis crocata* (Link), Kuroda, Mem. Faculty Sci. Agriculture, Taihoku Imperial Univ., vol. 22, no. 4, p. 98; 1955, Butot, Penggemar Alam, vol. 35, p. 77, pl. 2, fig. 3.

Types — Link's species is based upon figures 1508 and 1509 of the Conchylien-Cabinet, vol. 10. That specimen is said to come from the East Indies. We hereby restrict the type locality to Amboina, Indonesia. Perry's type of *aculeatus* probably fell into private hands, and may still be in existence, but probably without identifying labels.

Locality records — KENYA: Shimoni, Mombasa (Yale Peabody Mus.); Diani Beach (R. T. Abbott, USNM, MCZ). ZANZIBAR: Chumbe Id.; Pange Id.; outer reef, Kiwengwa; Ras Nungwe (NSF, 1957). MADACASCAR: Nossi-bé (A. Chavane, ANSP). INDIAN OCEAN ISLANDS: Gloriosa Id. (USNM); Providence Id., Mascarenes (E. A. Smith, 1884, "Alert", p. 503); Seychelles: Menai Id., Cosmoledo Atoll; Ile Platte (both A. J. Kohn, Yale Peabody Mus.). Chagos Islands: (Lienard, 1877, p. 95). Mauritius (N. Pike, MCZ). CEYLON: Pearl Bank, Gulf of Manaar (C. and M. Kline, ANSP). INDIA: Pamban and Tuticorn (Thurston, 1895, p. 125). RYUKYU ISLANDS: Okinawa Id. (Mrs. A. A. Scott, ANSP). Amami Islands (Kira, 1959, p. 37). TAIWAN: Ryukyo-syo (Kuroda, 1941, p. 98). PHILIPPINES: Olango Id., east Cebu (du Pont-Academy Exped., 1958); Panglao, Bohol Id. (E. Zambo, ANSP); Surigao, Mindanao Id. (ANSP); Jolo Id., Sulu Arch. (ANSP). INDONESIA: Amboina (MCZ); Java Id.; Madura Id.; Ambon Id.; and Ceram Id. (Butot, 1955, p. 77). AUSTRALIA: Undine Reef, Queensland (Tony Marsh, *in litt.*). DUTCH NEW CUINEA: Mios Woendi Atoll, Padaido Ids. (NSF. 1956). PALAUS: Nguarangel (USNM); Kayangel Id. (NSF, 1955). MARSHALLS: Lomuilal Id., Rongelap Atoll: Taka Atoll (both USNM). FIJI ISLANDS: Namuka Id., off Kaloka Levu, Viti Levu Id. (R. T. Abbott, MCZ). SAMOA: Fagaitua Bay, Tutuila Id. (R. T. Abbott, MCZ).

Fossil records — Pliocene, south end of Mombasa Id., Kenya (J. Weir, 1938, p. 69, pl. 5, fig. 3).

Lambis crocata *subspecies* pilsbryi, *new subspecies*

(Pl. 128, figs. 1, 2)

Range — Known only from the Marquesas Islands, Polynesia.

Remarks and Description — This giant, isolated race is presumed to be limited to the Marquesas Islands. I have seen only six specimens. One of these was given to Dr. H. A. Pilsbry by Père Siméon Delmas of the Marquesas. The shells of this subspecies differ from those of *crocata crocata* in being twice as large (7 to 9 inches in length, including digitations), in having the 3rd, 4th and 5th digita-

Plate 128. *Lambis crocata* new subspecies *pilsbryi*. Marquesas Islands. Fig. 1, holotype, ANSP no. 156123. 2, paratype, ANSP 255621. ½ natural size.

tions straight or only slightly curved, and in lacking the fairly prominent edge on the left of the parietal callus. In *pilsbryi*, the dorsal shoulder knob is much larger, the apex of the spire is usually buried by the first digitation, and the small, columellar ridge at the posterior end of the aperture is very weak. In other characters, such as the color of the outer shell and aperture and in the sculpturing of the spire, it is similar to *crocata*. Operculum and soft parts unknown.

Two names have been proposed for *crocata* which might possibly refer to this subspecies, although one of them, *Lambis yoldii* (Mörch, 1852) is inadequately described, and the other, *Lambis aculeata* (Perry, 1811), is based upon a distorted illustration and too brief a description for certain identification. We consider them *nomena dubia*. We name this new subspecies in honor of Dr. Henry A. Pilsbry, former Curator of the Department of Mollusks at the Academy of Natural Sciences of Philadelphia.

Measurements (mm.) — (including digitations)

length	width	no. whorls	
240	113	7+	(paratype, MCZ no. 49694)
212+	95	7+	(holotype, ANSP no. 156123)
182+	90	8	(paratype, ANSP no. 255621)

Synonymy —

1842 *Pteroceras lambis* Lin., Sowerby, (in part), Thesaurus Conchyl., vol. 1, Pteroceras, p. 41, pl. 11, fig. 6 only. Not *lambis* (Linné).

Types and Locality Records — The type locality is Nuku Hiva in the Marquesas Islands. The holotype is in ANSP no. 156123 and was collected by Père Siméon Delmas. Most of Delmas' shells were collected on the coral banks in Tai O Hae Bay. One paratype is in MCZ no. 49694. One paratype in B. P. Bishop Mus. no. 68268 from Uahuka, Marquesas (S. Delmas, 1922). Miss Martha E. Hunt of Baltimore kindly loaned me a specimen which T. Gavaldon collected in the Marquesas in 1959.

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

Subgenus Millepes Mörch, 1852

Type: *Lambis millepeda* Linné

The shells in this group of *Lambis* are characterized by elongate apertures bearing well-developed spiral lirae, by a siphonal canal which is either straight or curved to the right, and by the presence of 6 to 10 labial digitations. There are five species, three of which are quite limited in distribution, the other two being found in both the Indian and Southwest Pacific Oceans. Only one, *Lambis scorpius* Linné, shows any subspeciation.

Below is a synopsis of the differentiating characters of the five living species.

Lambis scorpius scorpius (Linné) – (Southwest Pacific). Six labial digitations nodulose, the lower three strongly hooked. Siphonal canal long, strongly curved to the right. Deep in the throat is a white bar or ridge just below the concavity caused by the dorsal tubercle. An ear-like lobe present at the left side of the base of the first digitation.

Lambis scorpius indomaris Abbott – (Indian Ocean). Differing from the above in lacking a well-developed lobe at the base of the first digitation, and in having stunted, shorter 4th, 5th and 6th digitations.

Lambis robusta (Swainson) – (Southeastern Polynesia). Six axial digitations almost smooth; the 3rd and 4th close together; siphonal canal almost straight. No white ridge deep in throat.

Lambis millepeda (Linné) – (Western Pacific Arc). Nine labial digitations; aperture mauve-brown. Lower parictal callus weakly lirate. Spire low.

Lambis digitata (Perry) – (Indo-Pacific). 8 to 9 labial digitations, the first usually being bifurcate. Spire elongate. Parietal wall callus raised and with prominent, wavy, whitish lirae. Lower 6 digitations very short. Edge of outer lip broad, covered with periostracum.

Lambis violacea (Swainson) – (Indian Ocean). 9 to 11 labial digitations, the first usually being bifurcate, and all being enamel-white and flattish on the underside. Spire relatively short. Aperture whitish with yellowish bars on the outer lip, and the throat violet to lavender. Apertural lirae fine and numerous.

There are no species limited to the Tertiary, but *millepeda* and *scorpius* have been recorded from the Quaternary of Indonesia.

Synonymy –

1852 *Millepes* "Klein", Mörch, Cat. Conchyl. . . . Yoldi, Hafniae, p. 60; 1859, Chenu, Manuel de Conchyl. et Paleont. Conchyl., Paris, vol. 1, p. 259; 1940, Wenz, Handbuch der Paläozool., vol. 6, pt. 4, p. 948 (type by subsequent designation: *millepeda* Linné).

1854 *Millipes* "Klein", H. and A. Adams, Genera of Recent Mollusca, London, p. 261; 1868, Gabb, American Jour. Conch., vol. 4, no. 3, p. 140; Tryon, Manual of Conch., Philadelphia, vol. 7, p. 125; 1878, Kobelt, Illustrirtes Conchlienbuch, vol. 1, p. 106 (type by subsequent designation: *scorpio* Linné).

1870 *Millipes* Mörch, Gill, American Jour. Conch., vol. 5, no. 3, p. 128, 134; 1955, Butot, Penggemar Alam, vol. 35, p. 74.

Lambis millepeda (Linné, 1758)

(Pl. 121, fig. 6; pl. 129, fig. 3)

Range – Southwest Pacific.

Remarks – This species is rather common wherever it occurs, but its distribution is limited to the central portion of the Western Pacific Arc from the Philippines to New Guinea. It is recognized by its 9 labial digitations which arise just behind the edge

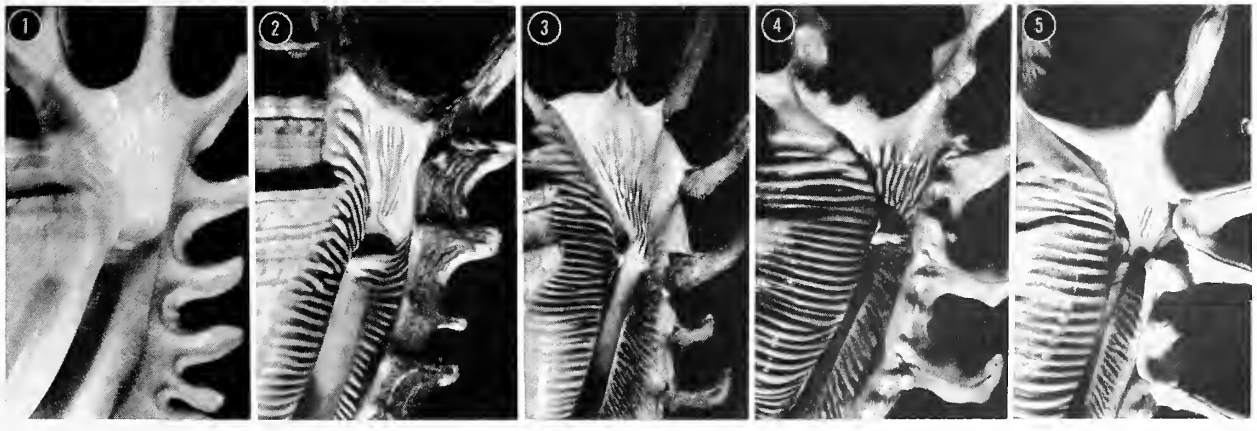

Plate 129. Apertural details of members of the subgenus *Millepes* Mörch. Fig. 1, *Lambis violacea* (Swainson). 2, *L. digitata* (Perry). 3, *L. millepeda* (Linné). 4, *L. scorpius scorpius* (Linné). 5, *L. robusta* (Swainson). All about ½ natural size.

of the outer lip and by the brownish mauve aperture which bears whitish mauve lirae well into the throat of the aperture. The lower 3 or 4 labial digitations are turned or hooked towards the posterior or spire end.

Mr. Evaristo Zambo of Cebu, Philippines, informs me that the flesh of *millepeda* is bitter and generally not eaten by natives. No authentic records of this species are known from the Red Sea or Indian Ocean. An account of the gross anatomy was published by R. Bergh (1895, pp. 364-368, pl. 23).

Habitat — Lives in shallow water down to a depth of 2 fathoms.

Description — Shell 90 to 145 mm. (3½ to 5½ inches) in length including the digitations. Aperture mauve-brown with numerous white lirae. Outer lip with 9 short labial digitations of which the lower 4 or 5 are hooked towards the apex. Siphonal canal rather short and twisted. Nuclear whorls 3, smooth, translucent-tan. Postnuclear whorls 8. Early whorls with a beaded carina; later whorls with 9 to 11 nodules. Last whorl with 3 spiral rows of nodules, the top row with 4 large, somewhat elongate knobs, the lower two rows with 3 or 4 small, round nodules. Color of outer shell cream with a heavy suffusion or network of dark-brown. Edge of outer lip crenate. Aperture mauve-brown with numerous, wavy, weak lirae of a whitish purple color. Throat yellow within and bounded by an axial whitish ridge on the inside of the body wall. Upper end of aperture has a deep, round, yellow depression or well which is bounded above by two facing, tongue-like whitish ridges. Columella swollen below; bears about 40 to 50 irregular, spiral, mauve-white lirae which cross the blackish to chocolate-brown parietal wall. "Stromboid notch" with 2 or 3 short, flat projections at its edge. Periostracum thin, glossy and translucent-brown. Operculum long, dark-brown and with smoothish edges. Bergh's (1895) figures show a radula similar to that of *scorpius* and with a formula of 2-1-2; 1-4; 6; 6.

Measurements (mm.) — (including digitations)

length	width	no. whorls	
145	62	8+	(large; Luzon Id.)
100	53	11	(average; Cebu Id.)
95	48	9+	(small; Schouten Ids.)

Synonymy —

1758 *Strombus millepeda* Linné, Systema naturae, ed. 10, p. 743, no. 426 (In O. Asiae); 1764, Mus. Ludovicae Ulricae, p. 618; 1767; 12 ed., p. 1208, no. 494; 1956, Dodge, Bull. Amer. Mus. Nat. Hist., vol. 111 pt. 3, pp. 251-252; 1801, Bosc, Hist. Nat. des Coquilles, Paris, vol. 4, p. 249.

1798 *Lambis millepeda* Cmelin, Röding, Museum Boltenianum, Hamburg, pt. 2, p. 67, no. 855 (refers to Conchyl.-Cab., vol. 3, figs. 861-862).

1807 *Pteroceras millepeda* Linné, Link, Beschr. Natur.-Samml., Rostock, pt. 2, p. 110 (refers to Conchyl.-Cab., vol. 3, figs. 861-862); 1842, Sowerby, Thesaurus Conchyl., vol. 1, p. 43, pl. 11, fig. 3 (Philippines).

1807 *Pterocera millepeda* Linné, G. Fischer, Muscum-Demidoff, Moscow, vol. 3, p. 191 (refers to Conchyl.-Cab., vol. 3, figs. 861-862); 1839, Anton, Verz. Conchyl., Halle, p. 84; 1843, Kiener, Coquilles Vivantes, Paris, vol. 4, p. 10, pl. 9, figs. 1, 2 (not pl. 10, fig. 1); 1851, Reeve, Conch. Icon., vol. 6, pl. 6, fig. 10.

1870 *Pterocera millipeda* Lam. ex Linn., Cill, American Jour. Conch., vol. 5, no. 3, p. 135.

1955 *Lambis (Millipes) millepeda* (Linné, 1758), Butot, Penggemar Alam, vol. 35, p. 77, pl. 2, fig. 4 (Madura, Indonesia).

Types — "The Linnaean collection in London contains a properly marked specimen of *millepeda* which thus may be accepted as the type of the species." (Dodge, 1956.) We hereby designate Olango Island on the east side of Cebu Island, Philippines, as the type locality.

Nomenclature — Linnaeus, Gmelin (1791), Dillwyn (1817) and Lamarck (1822) considered what was later described as *violacea* (Swainson) and *digitata* (Perry) to be synonyms or varieties of *millepeda* (Linné). Swainson in 1821 was the first to accept them as distinct species. Sowerby (1842) and, later, Deshayes (1843) also separated them but gave names which are now considered synonyms. Curiously, Dodge (1956, pp. 251-252) confused the situation by believing that *elongata* (Swainson) and *digitata* (Perry) were different species, and that the latter was the same as *multipes* of Chemnitz and of Deshayes. Actually, *multipes* is a synonym of *violacea* (Swainson, 1821). *Alata polydactylus* Martini 1777 is a non-binomial synonym of *millepeda* Linné.

Records — (See accompanying map, pl. 130) PHILIPPINES: Calapan, Mindoro (P. de Mesa, MCZ). Luzon Id.: Iba, Zambales (P. de Mesa, ANSP); Tabaco, Albay Prov. (du Pont-Academy Exped., 1958, ANSP). Cebu Id.: Olango (ANSP). Bohol Id.: east side of Jagoliao Id. (both du Pont-Academy Exped., 1958). Mindanao Id.: Davao Bay (MCZ). Masbate Id.; Basilan Id.; Marongas Id., Jolo Ids. (all USNM). Romblon Prov., Sibuyan (Alcasid, 1947, p. 184). INDONESIA: Amboina (MCZ); Batjan Id. (MCZ); Madura Id., Java; Ternate; Ceram; Timor (all Butot, 1955, p. 77). DUTCH NEW GUINEA: Soepiori Id., Schouten Ids.; Japen Id. and Biak Id., and Aoeri Ids. (all NSF, 1956). AUSTRALIA: Cotton (1953, no. 3, second page, fig. 17) reports it from Northern Australia and from Queensland, although J. Allan (1959, p. 102) states this is not so.

Fossil records — INDONESIA: Pleistocene-Pliocene: Koepang, Timor Id. (Tesch, 1920, p. 52, pl. 130, fig. 172). [Abrard's 1942, vol. 18, p. 62, pl. 6, fig. 34 of *millepeda* from the Pleistocene of the Red Sea looks like a *Lambis truncata sebae*]. [R. B. Newton's 1900, p. 509, Pleistocene record for Cemsah, Egypt needs confirmation, and may well be *L. digitata*].

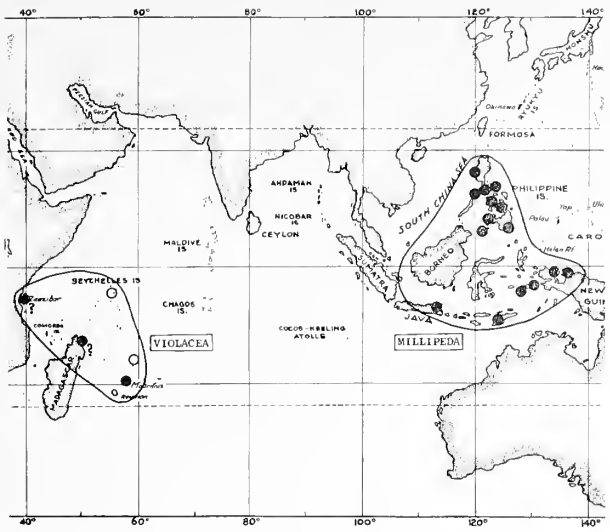

Plate 130. Geographical distribution of *Lambis violacea* (Swainson) and *Lambis millepeda* (Linné).

Lambis digitata (Perry, 1811)

(Pl. 121, fig. 3; pl. 129, fig. 2)

Range — East Africa to Samoa.

Remarks — This is not a common species, but it has a rather wide distribution. It was formerly known as *elongata* (Swainson). It is characterized by a proportionately high spire, by 8 or 9 labial digitations of which the lower 6 or 7 are very small and the first two, at the upper end of the aperture, are longer and widely separated. The first digitation is usually bifurcate. The edge of the outer lip is broad and thickly covered with brown, rough periostracum. The interior of the aperture is similar to that of *millepeda*, but differs in being less constricted and in having a short, spiral, whitish ridge just below the concavity (caused by the last dorsal knob on the outside of the shell). The raised, lirate parietal callus in *digitata* has a sharp, delimiting left edge.

I have seen only two specimens from the Indian Ocean. They have one extra digitation on the outer lip, and other differences, which suggest that there may be an Indian Ocean subspecies, but more specimens are needed to prove this point. Reeve's *crocea* looks like the Indian Ocean form and his name is available for it.

Habitat — Unknown, although it is probably associated with coral reefs at depths from 1 to 3 fathoms.

Description — Shell 98 to 145 mm. (4 to 5½ inches) in length, with 8 (rarely 9) labial digitations of which the anterior or first one is bifurcate and the lower 5 or 6 are very short. Spire very high and with an angle of about 40 degrees. Nuclear whorls unknown. Postnuclear whorls 10. Shoulder of whorls carinate and bearing numerous, small, sharp nodules. Body whorl with 3 rows of nodules, the top row with the 5 largest, and the two rows below bearing 4 to 6 small nodules. Color of outer shell whitish with yellow-brown specklings and mottlings. Outer lip thick. Aperture purplish mauve with numerous whitish spiral lirae. Throat yellowish white within and with a deep depression at the posterior end which is bounded anteriorly by a strong whitish ridge. Columella with a thickened mauve callus which bears about 25 whitish, bifurcating, spiral lirae. This parietal or columellar callus is sharply bordered on its left side. Inside of outer lip purplish with numerous purplish white spiral lirae. "Stromboid notch" well-developed and with the thick outer lip slightly overhanging its upper edge. Siphonal canal rather short and twisted. Periostracum brown and thicker on the edge of the outer lip. Operculum and soft parts unknown.

Measurements (mm.) — (including digitations)

length	width	no. whorls	
140	70	10+	(large; "Pacific Ocean")
132	53	9+	(average; "Indian Ocean")
118	53	10+	(small; "Pacific Ocean")

Synonymy —

1811 *Strombus digitatus* Perry, Conchology, London, pl. 13, fig. 1 (Eastern Ocean).

1816 *Pterocera millepeda* Lamarck, Le Liste, p. 4; pl. 410, fig. 1a and b of Encycloped. Méthod. (no locality); 1839, Anton, Verzeich. Conchyl., Halle, p. 84, no. 2780. Non Linné, 1758.

1821 *Pterocera elongata* Swainson, Exotic Conchology, London, pt. 1, sign. B4, 12th page; 1841, appendix, p. 32 (no locality). Also refers to Conchyl.-Cab., vol. 10, figs. 1479-80.

1842 *Pterocera crocea* Reeve, Conchologia Systematica, vol. 2, p. 204, pl. 248, fig. 2 (no locality); 1842, Sowerby, Thes. Conch., vol. 1, pt. 2, pl. 11, fig. 4. [Indian Ocean?].

1843 *Pterocera novem-dactylis* Deshayes, in Lamarck's ed. 2, Anim. sans Vert., vol. 9, p. 678, no. 9 (no locality); 1845, Küster, Syst. Conchyl.-Cab., second series, vol. 4, pt. 1, p. 86.

1955 *Lambias (Millipes) elongata* (Swainson; 1834), Butot, Penggemar Alam, vol. 35, p. 78, pl. 1, fig. 4. [*Lambis*].

1955 *Lambis violacea* Swainson, Abbott, Nautilus, vol. 68, no. 4, p. 124.

Types — The type of Perry's *digitata* has probably been lost. I hereby restrict Perry's type locality of "Eastern Ocean" to Upolu Island, Western Samoa. Swainson's type of *elongata* may be at Cam-

bridge University, or possibly lost.

Nomenclature — There can be little doubt from Perry's illustration that his *Strombus digitatus* is the species which Swainson later described and named *elongata*.

Records — MOZAMBIQUE: Mozambique City (ANSP); Port Amelia (MCZ). MADAGASCAR: Sarodrano (Dautzenberg, 1929, p. 473). MAURITIUS: (MCZ). PHILIPPINES: Mindoro Id.; Surigao, Mindanao Id. (both Elera, 1896, p. 255). SAMOA: Upolu Id. (Titian R. Peale, 1839, ANSP).

Fossil records — None reported.

Lambis scorpius (Linné, 1758)

This handsome species is rather widely distributed, and, although well known, it is comparatively uncommon. It is characterized by the gnarled or knobbed digitations and the brightly colored aperture which is purple and white-striped within and brownish to reddish orange at the border. In Eastern Polynesia, this species is replaced by the rare *Lambis robusta* (Swainson). The latter has smoother and heavier digitations and has no small, raised, white spiral ridge deep within the upper part of the aperture, a feature characteristic of *scorpius*.

Indian Ocean specimens of *scorpius* show slight, but fairly constant, differences from the typical Pacific race, and for this reason we are recognizing two geographical races. In Pacific specimens, there is a large, flat ear-like lobe on the left side of the base of the first digitation. In the Indian Ocean subspecies *indomaris*, this lobe is greatly reduced or pushed back over the apex of the spire. Digitations 4, 5 and 6 are considerably more stunted and less protruding in *indomaris* than in the typical *scorpius*.

Lambis scorpius *subspecies* scorpius (Linné, 1758)

(Pl. 121, fig. 5; pl. 129, fig. 4)

Range — Indonesia and the Ryukyu Islands to Samoa.

Remarks — The typical subspecies appears to be limited to the western Pacific. Its distinguishing characters are discussed above.

Habitat — This species is found in shallow water at a depth of 1 to 10 feet, usually on coral reef flats where there is some protection from the ocean waves under or among dead coral slabs and boulders. Mrs. Anita Scott reports (*in litt.*) that they are more often, although uncommonly, found in shallow water during the warm summer months in the Ryukyu Islands.

Description — Shell 100 to 165 mm. (4 to 6½ inches) in length, with 6 knobbed labial digitations and a long slender, knobbed siphonal digitation which is strongly curved to the right. Whorls 9 to 11. Nuclear whorls 3, smoothish, opaque-tan, and elevated. Sometimes with a weak spiral band of brown just below the suture. Postnuclear whorls flattish, and bearing numerous small knobs on a strong carina which is located just above the suture. Body whorl with 3 main spiral rows of low knobs, the top one bearing the 4 largest, the middle row bearing 8 to 9 small knobs and the lowest row bearing 5 or 6 knobs of intermediate size. Outer lip bearing 6 digitations, all having 2 or 3 broad knobs, thus giving them a gnarled or jointed appearance. First digitation usually pointed upward in line with the axis of the shell, and bears a large, flat, ear-like lobe at the base on the left side. Digitations 4, 5 and 6 are bent posteriorly, almost at right angles to the axis of the shell. Siphonal canal long, strongly curved to the right, and bearing 4 or 5 weak knobs. Aperture rather narrow, quadrate, and deep within is solid purple. Inside of outer lip with numerous, crowded, white, slightly raised spiral lirae which end before they reach the broad, smoothish yellow-orange edge of the outer lip. Deep within the upper part of the aperture is a strong, white, bar-like, spiral lira. Columella and parietal wall brownish purple and overlaid with about 30 to 40 white to tan-white, raised, spiral lirae which may or may not run parallel with the spiral cords on the body whorl. Columella bounded by a long, narrow, white, axial swelling deep within the aperture. Periostracum thin, translucent-tan, and heaviest on the under surface of the digitations. Operculum long, slightly curved, light-brown and with 10 small serrations. Verge half the length of the aperture and with a small distal pad. Radula with 46 rows and a formula of 2-1-2; 1-3; 4; 5.

Measurements (mm.) — (including digitations)

length	width	no. whorls	
168.0	66.2	8+	(large; Okinawa)
135.0	55.1	10	(average; Truk Id.)
97.2	42.0	8+	(small; Biak Id.)

Synonymy —

1758 *Strombus scorpius* Linné, Systema Naturae, ed. 10, p. 743 (In O. Asiatico); 1767, 12th ed., p. 1208, no. 492; 1956, Dodge, Bull. Amer. Mus. Hist., vol. 111, art. 3, pp. 249-250.

1771 *Strombus scorpio* L., Murray, Fundamenta Test., Amoenitates Academicae, vol. 8, p. 45, pl. 1., fig. 29; 1778, Born, Index Rerum Natur. Mus. Caesarei Vindobon, p. 268.

1798 *Lambis chiragra* Gmelin, Röding, Museum Boltenianum, pt. 2, p. 67, no. 856, (Non Gmelin 1791, non Linné 1758).

1805 *Pterocera scorpius* L., Roissy, Buffon's Hist. Nat. des Moll., vol. 6, p. 91, pl. 58, fig. 5.

1807 *Pterocera scorpius* Lin., G. Fisher, Museum Demidoff, Moscow, vol. 3, p. 191.

1810 *Pteroceres scorpius* L., Montfort, Conchyl. Systemat., Paris, vol. 2, p. 607.

1816 *Pterocera nodosa* Lamarck, in Bruguière's Encyclop. Method., pt. 23, Le Liste, Paris, p. 4, pl. 410, fig. 2; 1821, Swainson, Exotic Conchology, London, appendix, p. 32 (sign, B3, 11th page).

1822 *Pterocera scorpio* Lin., Lamarck, Anim. sans Vert., vol. 7, p. 197.

1842 *Pteroceras scorpio* Linn., Sowerby, Thesaurus Conchyl., vol. 1, pl. 11, fig. 1 (Moluccas).

1843 *Pterocera scorpio* Lam., Kiener, Coquilles Vivantes, vol. 4, pl. 6, (mer des Indes).

1845 *Pterocera scorpio* Murray, Küster, Syst. Conchyl.-Cab., second series, vol. 4, pt. 1, p. 87, pl. 14, fig. 7.

1851 *Pterocera scorpius* Linné, Reeve, Conchologica Icon., vol. 6, Pterocera, pl. 3, fig. 3 (Philippines).

1955 *Lambis (Millipes) scorpius* Linné, Butot, Penggemar Alam, vol. 35, p. 77, pl. 2, fig. 5 (Madura, Java).

Types — We restrict the type locality to Mactan Island, opposite Cebu City, Cebu Island, Philippines. Linnaeus' type is in the Linnaean collection in the Linnaean Society of London, according to Dodge, 1956, p. 249.

Nomenclature — Linnaeus originally used the Latin substantive noun "Scorpius" for this species. Later authors (Murray, 1771, Born, 1778, and Lamarck, 1822) used the more common form, "scorpio." We consider the use of the latter name to be an invalid emendation, and are following Butot (1955) who uses *scorpius*. All of Linné's figure references are to the Pacific Ocean form, as are those in Knorr, pt. 2, pl. 3, fig. 1 and Martini, Conchylien-Cabinet, vol. 3, fig. 860.

Records (see map, pl. 131) — RYUKYU IDS.: Okinawa Id. (A. A. Scott and A. R. Cahn Coll'n., ANSP). TAIWAN: Kasyo-to (Kuroda, 1941, p. 98). PHILIPPINES: Calapan and Lubang Id., Mindoro (P. de Mesa, MCZ); Batang Id., Batanes Group (USNM); Borongan, Samar Id.; Gigmoto, Catanduanes Id.; Marivales, Luzon Id. (all du Pont-Academy Exped., 1958); Jolo Id., Sulu Sea (ANSP); Cebu City, Cebu Id. (A. B. Franco, ANSP). INDONESIA: Sumatra: Atje (Zool. Mus. Amsterdam); Pandjang. Java: Djakarta Bay; Panaitan; Madura; Peutjang. Borneo: Sebuku. Also Roti, Timor, Ambon, Ceram, Ternate, Obi and Waigeu Islands (all Butot, 1955, p. 78). Maumerie, Flores Id. (Rijksmus. Nat. Hist., ANSP). AUSTRALIA: Queensland (Cotton, 1953, no. 3, second page, fig. 16). DUTCH NEW CUINEA: reef at Biak (NSF, 1956). SOLOMONS: Guadalcanar (AMNH). NEW CALEDONIA: barrier reef, Touho Bay (G. and M. Kline, 1959). MARIANAS: Apra Harbor, Cuam Id. (MCZ and ANSP). CAROLINES: Moen Id., Truk (MCZ). FIJI IDS.: Suva, Viti Levu Id. (H. S. Ladd, USNM). SAMOA: Tutuila Id. (ANSP and USNM); Upolu Id. (T. R. Peale, U. S. Explor. Exped., ANSP). [Tahiti records in the literature are probably based upon specimens of *Lambis robusta* (Swainson)].

Fossil records — None reported.

Lambis scorpius *subspecies* indomaris *new subspecies*

Range — Limited to western and central Indian Ocean.

Remarks and Description — The differences exhibited in the shells of this Indian Ocean race and the typical Pacific Ocean race are slight, but constant, and warrant, we believe, subspecific recognition. In *scorpius indomaris*, the lobe on the left side of the first digitation is either very much reduced or bent back around the apex of the shell. Digitations 4, 5 and 6 are considerably more stunted, their basal portions being not as long as the curved, distal portions. The dorsal sides of the terminal halves of the digitations and the siphonal canal are usually, although not always, more darkly pigmented with purple-brown. There appears to be no or little difference in the apertural sculpture or coloring. Operculum with about 10 serrations and the radula indistinguishable from that of *scorpius scorpius*.

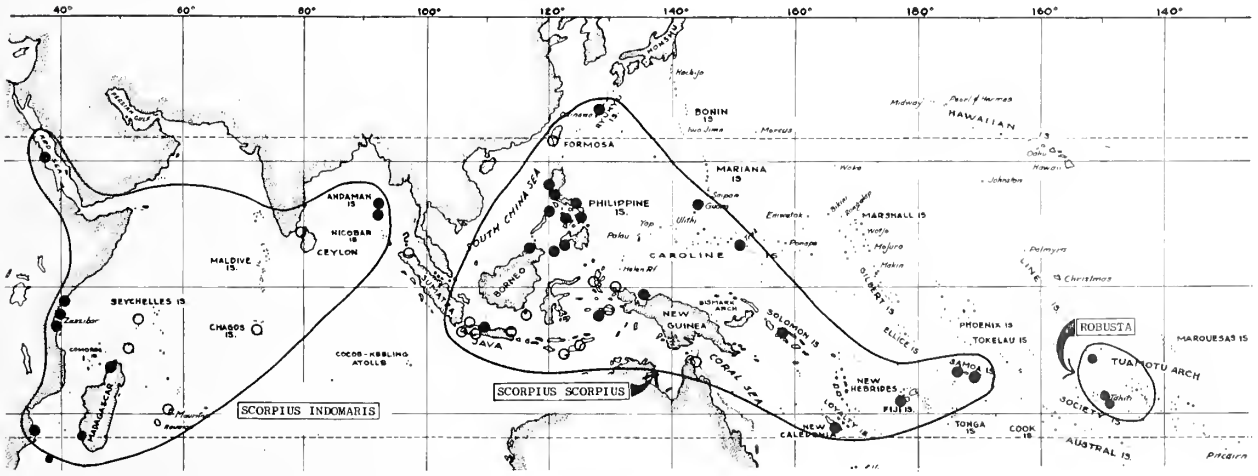

Plate 131. Geographical distribution of *Lambis scorpius scorpius* (Linné) in the central Indo-Pacific, *L. scorpius indomaris* Abbott in the Indian Ocean, and *L. robusta* (Swainson) in eastern Polynesia.

This subspecies was named *sinuatus* Perry, 1811 (non Solander, 1786) which is a homonym. I propose the new name, *indomaris*.

Habitat — This is an uncommon subspecies which lives in shallow water on coral and rock-strewn outer reefs. Also found on coral gravel shallows among beds of algae.

Measurements (mm.) — (including digitations)

length	width	no. whorls	
135.0	50.0	7+	(holotype, ANSP no. 242210)
130.0	53.0	9+	(paratype, ANSP no. 212384)
111.0	45.0	8+	(paratype, ANSP no. 189165)
170.0	75.0	7+	(Tanikely Id., N.W. Madagascar)

Synonymy —

1811 *Strombus sinuatus* Perry, Conchology, London, pl. 13, fig. 3 (American Seas, and at Madeira [both erroneous]). Non Solander (or Humphrey) 1786.

1829 *Pterocera pseudo-scorpio* Lam., Schubert and Wagner, Conchylien-Cabinet, Nurnberg, vol. 12, p. 16, pl. 218, figs. 3040-41 (locality unknown).

Types — The type locality is Nossi-bé, northwest Madagascar. The holotype is in ANSP no. 242210. Paratypes in ANSP are listed below.

Records — (see map, pl. 131). MOZAMBIQUE: Mozambique City (K. Grosch, ANSP no. 247564). ZANZIBAR: outer reef, Kiwengwa (ANSP no. 212384); Pange Id. (ANSP no. 214263); Mangapwani (ANSP no. 212968) (all NSF, 1957). KENYA: Kikambala, 15 n. of Mombasa (Coryndon Mus.). EGYPT: Geb Zebara (ANSP no. 189165). MADAGASCAR: Nossi-bé (A. Chavane, ANSP); Tanikely Id. (Academy-Madagascar Exped., 1960). CEYLON: [presumed to be this subspecies] Condatchey, Gulf of Manaar (le Beck, 1799, Philosophical Magazine, vol. 5, p. 339; and Langdon, 1874, p. 74). Andaman Islands: Port Blair; Long Island (both BM). Lienard (1877, p. 38 and 94) reported *scorpius* [this subspecies?] from Mauritius and Chagos Ids., Indian Ocean. Von Martens (1880, p. 279) reported it from the Seychelles and Amirantes.

Fossil records — None reported.

Lambis robusta (Swainson, 1821)

(Pl. 121, fig. 2; pl. 129, fig. 5)

Range — Southeastern Polynesia.

Remarks — Until recently, exact locality data was not known for this rare and poorly understood species. Such erroneous localities as Zanzibar and the Philippines had been listed by Reeve (1851) and others. A specimen was located in the Museum of Comparative Zoölogy which was collected at Tahiti, Society Islands, by W. H. Pease during the latter part of the Nineteenth Century. Dr. Robert Robertson collected five dead specimens on the same island in 1952.

Although this species closely resembles *scorpius*, it is certainly quite distinct and evidently limited to French Oceania. *L. robusta* differs in having stouter, smoothish digitations of which the third and fourth usually have a common base, in having an almost straight siphonal canal, in lacking a lobe at the base of the first digitation, in lacking the short white bar deep within the upper part of the aperture, and in having, instead, a strong lobe deep inside on the upper portion of the columella. This last feature is difficult to see because it is set so deeply within the aperture. *L. robusta* (Swainson, 1821), was formerly known as *pseudoscorpio* (Lamarck, 1822). This species was characterized by Deshayes (1843) as being larger than *scorpius*, but many adults of *robusta* are smaller than some *scorpius*.

Habitat — Unknown, but suspected to be in fairly deep water off the ocean edge of coral reefs.

Description — Shell 110 to 150 mm. (4½ to 6 inches) in length, with 6 moderately stout, smoothish labial digitations and a moderately long, slightly curved, siphonal digitation. Whorls about 9. Nuclear whorls not observed. Postnuclear whorls flattish, and bearing numerous small knobs on a strong carina which is located just above the finely impressed suture. Top of apical whorls with numerous, microscopic, spiral threads. Body whorl with 3 main spiral rows of low knobs, the top one at the shoulder bearing 5 or 6 large, irregularly-sized knobs, the middle row bearing 7 or 8 and the lowest row 6 or 7 smaller equal-sized, rounded knobs. Outer lip bearing 6 smoothish digitations, the first and uppermost being the stoutest and longest. Digitations 3 and 4 have a common base. Digitations 4, 5 and 6 have the terminal third bent posteriorly (or upwards). Siphonal canal slightly curved to the right, and about the same length as the first digitation. Aperture rather narrow and quadrate, and deep within is yellowish cream, and, at the upper end has a small sunken depression which is not bounded below by spiral bar. Inside of outer lip tan with an irregular flush of brownish violet which is overlaid by numerous, irregular, raised spiral lirae sometimes extending to the outer edge of the lip. Parietal wall brownish to brownish purple with about 30 irregular, raised, spiral lirae. Columella bounded by a long, weak, narrow, cream-colored, axial swelling deep within the aperture. Periostracum moderately thin and light-brown. Operculum and soft parts unknown.

Measurements (mm.) — (including digitations)

length	width	no. whorls	
190.0	. . .	. .	(large, fide Tryon, 1885, p. 125)
153.0	72.0	7+	(U.S.N.M. specimen)
125.0	80.0	7+	(average, Tahiti)
111.0	58.0	7+	(small, Tahiti)

Synonymy —

1821 *Pterocera robusta* Swainson, Exotic Conchology, sign. B 3, 11th page; 1841, appendix, p. 32 (no locality).

1822 *Pterocera pseudo-scorpio* Lamarck, Anim. sans Vert., vol. 7, p. 197 (no locality). Refers to Bonanni, pl. 3, fig. 312 and Lister, pl. 867, fig. 22; 1823, Dillwyn, An Index to Hist. Conchyl. Lister, London, p. 39; 1843, Deshayes, Anim. sans Vert., ed. 2, vol. 9, p. 674; 1870, Cill, Amer. Jour. Conch., Philadelphia, vol. 5, p. 134.

1842 *Pteroceras pseudoscorpio* Lam., Sowerby, Thesaurus Conchyl., vol. 1, p. 43, pl. 11, fig. 2 (no locality); 1851, Reeve, Conch. Icon., vol. 6, Pterocera, pl. 3, fig. 4 (Zanzibar).

1852 *Pterocera (Harpago) pseudoscorpio* Lam., Mörch, Cat. Conchyl. Yoldi, p. 60.

1854 *Harpago (Millipes) pseudoscorpio* Lam., H. and A. Adams, Genera Recent Mollusca, vol. 1, p. 261.

1955 *Lambis (Millipes) pseudoscorpio* Lamarck, Butot, Penggemar Alam, vol. 35, p. 78.

Types — We hereby designate Tahiti Island, Society Islands, as the type locality. The whereabouts of Swainson's type of *robusta* is unknown to me. The type of *pseudoscorpio* Lamarck is presumably in the Muséum d'Histoire Naturelle de Genève. The earliest figure is plate 867 in Lister, 1685.

Records — (see accompanying map, pl. 131). SOCIETY ISLANDS: Tahiti (W. H. Pease, MCZ); Atiue, near Maruapo River; near Punaauia Point (all District of Punaauia, Tahiti, R. Robertson, 1952, ANSP). LINE ISLANDS: Flint Island (C. D. Voy, ANSP). [Records for Zanzibar, Philippines, Australia are probably erroneous].

Fossil records — None reported.

Lambis violacea (Swainson, 1821)

(Pl. 121, fig. 1; pl. 129, fig. 1)

Range — Indian Ocean.

Remarks — This is one of the rarest and most attractive of all the *Lambis*. I would judge that there are no more than a hundred known specimens, and most of these have come from Mauritius. The other localities mentioned in the literature may not be accurate. I am puzzled by Butot's (1955, p. 79) record from Indonesia.

Lambis violacea is readily recognized by its yellowish-white shell, and by its whitish aperture which is tinted with violet or lavender deep within the throat. The spiral lirae on the inside of the outer lip are fine, rather even, numerous and white. The labial digitations may vary in number from 9 to 11.

Habitat — Unknown, although it probably lives on sand and algae bottoms at a depth of 20 to 60 feet.

Description — Shell 73 to 114 mm. (about 3 to 4½ inches) in length, with 10 to 11 thin, blade-like, short labial digitations and a moderately long, slightly twisted, siphonal digitation. Whorls about 9. Nuclear whorls not observed. Post-nuclear whorls slightly concave, and sharply carinate just above the suture. This shoulder carination bears numerous, evenly-sized, nodules which are crossed by 4 to 5 small, but distinct, spiral cords. Above the carination, the whorls are crossed by about a dozen fine spiral threads and by numerous axial threads, thus giving a somewhat reticulated effect. Shoulder of body whorl with a row of 5 or 6 paired knobs, the last one being low and elongate and the next to last one being the highest. Below these, and on the center of the body whorl, are 3 strong beaded cords. Remainder of whorl with numerous, smoothish, smaller, spiral cords. Outer lip with 9 to 11 digitations whose undersurfaces are smoothish, enamel-white and somewhat concave. First digitation obscures the apex of the shell and is bifurcate, the prong to the left being shorter and broader. The other 8 or 9 digitations become progressively smaller towards the anterior end. "Stromboid notch" deep and U-shaped. Below it, the base of the outer lip bears 3 or 4 very small digitations. Siphonal canal is twisted but descends almost straight down. Aperture somewhat quadrate and violet or lavender deep inside, except for a white depression near the top. Outer wall of aperture with about 80 fine, strongly raised, spiral, white lirae. Outer edge of aperture with large, weak, yellowish spots. Parietal wall weakly and unevenly lirate, its lower section strongly swollen, smooth and tan or purplish cream. Outer shell whitish with a few isolated, small, squarish, light-brown spots. Periostracum unknown. Operculum chitinous, elongate, light-brown and with smoothish edges. Radula unknown.

Measurements (mm.) — (including digitations)

length	width	no. whorls	
113.5	55.1	74	(Mauritius, ANSP)
73.0	42.0	8	(Mauritius, MCZ)

Synonymy —

1817 *Strombus millepeda* L., variety C, Dillwyn, Descript. Cat. Recent Shells, London, vol. 2, p. 660 (refers to Conchyl.-Cab., vol. 10, figs. 1494-95).

1821 *Pterocera violacea* Swainson, Exotic Conchology, sign. B4, 12th page; 1834, ibid., appendix, p. 33 (Red Sea); 1841, ibid., ed. 2, p. 33.

1823 *Strombus purpureus* Mawe, Linné's Syst. Conch., London, p. 127 (nude name).

1825 *Pterocera purpurea* Swainson, Dubois, An Epitome of Lamarck's Arrangement of Testacea, London, p. 248; 1837, Swainson [?], Catalogue of the Foreign Shells Manchester Nat. Hist. Soc., p. 74 (both nude names).

1842 *Pteroceras multipes* "Chemn." Sowerby, Thesaurus Conchyl., vol. 1, p. 43, pl. 11, fig. 8; 1842, Reeve, Conchologica Systematica, vol. 2, p. 204, pl. 248, fig. 1.

1842 *Pteroceras purpuraseens* "Swainson" Sowerby, loc. cit., p. 43 (in synonymy).

1843 *Pteroeera multipes* Deshayes, in Lamarck's ed. 2, Anim. sans Vert., vol. 9, p. 677, no. 8 (mers de l'Inde). Also refers to Conchyl.-Cab., vol. 10, figs. 1494-95; 1850, Traité Element. Conchyl., pl. 115, fig. 7.

1843 *Pteroeera millepeda* var., Kiener, Coquilles Vivantes, Paris, vol. 4, Pterocera, p. 11, pl. 10, fig. 1.

1955 *Lambis (Millipes) violacea* (Swainson, 1834), Butot, Penggemar Alam, vol. 35, pp. 78-79, pl. 2, fig. 6 (Madura, Indonesia).

Types — The location of Swainson's type is unknown to me, although it may be at Cambridge University. The type locality is the "Red Sea."

Nomenclature — The earliest valid name appears to be *violacea* Swainson, 1821. Dillwyn in 1817 used the name *multipes* Chemnitz only in synonymy under his *millepeda* L. variety C, and is, therefore, not validly used. The name *purpurea* used by Swainson and Mawe is nude.

Records — (see pl. 130) Mauritius (N. Pike, MCZ; ANSP). Cargados Island (J. Robillard, Nat. Mus. Vict.; Lienard, 1877, p. 109). Zanzibar (MCZ). Seychelles (H. Cuming, Nat. Mus. Vict.). Madagascar (McGill Redpath Mus.). Red Sea (Swainson, 1841, p. 33). INDONESIA: Ambat, east Madura (Butot, 1955, p. 79). [Philippine records have never been confirmed].

Fossil records — None recorded.

Subgenus Harpago Mörch, 1852

Type: *Strombus chiragra* Linné, 1758.

The speeiation problem in this group is very intriguing and not entirely solved to our satisfaetion. Colleeting of live material in Indonesia and Polynesia will doubtlessly settle the matter. There are three shell forms whieh have been variously treated by earlier authors as forms, subspeeies or even separate speeies.

One of these, *arthritica* Röding (see our pl. 121, fig. 7), is a shell of quite eonstant eharaeters and limited to the Indian Oeean. There are no signifieant differenees between the shells of the males and females, other than the slightly smaller size of males. We have been unable to aseertain the eastern limits of this form. Two of Butot's speeimens from Indonesia (his pl. 3, figs. 5 and 6) look like *arthritica*. I have also seen speeimens labelled "Philippines" but this loeality may be in error.

The seeond kind of shell is the typieal and traditionally aeeepted *chiragra* (Linné). This is the large, rose-mouthed form with an almost smooth, lower eolumella, whieh is eommon in the western Paeifie (see our distributional map, pl. 134, and our pl. 121, fig. 12). This is the female shell whieh is further eharaeterized by the welding together of the last two knobs on the shoulder of the body whorl.

The third form we believe is the male shell of *chiragra*. It has two peeuliarities whieh euriously enough resemble eharaeters found in the Indian Oeean *arthritica*. These are a tendeney to develop white spiral lirae on the purplish brown eolumella, and the presenee of equal-sized knobs on the shoulder. The shell as a whole is generally mueh smaller than the female shell. The eolumellar lirae and purple taint vary from a strong development (see our pl. 121, fig. 10) to a weak development (pl. 121, fig. 11). Intermediate shell forms between males and females are not uncommon (see pl. 132, figs. 2-4).

Below, we are presenting our elassifieation and a synopsis of the distinguishing eharaeters. For convenienee, we have retained the form name *rugosa* (Sowerby) for the male, and have listed its synonymy separately.

Lambis chiragra chiragra (Linné).

Typieal or **female form:** 6 to 10 inehes (150 to 250 mm.) in length; aperture whitish rose; lower eolumella smoothish (aperture of Bay of Bengal speeimens with a purplish stain possibly due to environment); upper end of aperture with an elongate, whitish depressed well or shelf; last two knobs of shoulder larger than the others and welded together; the 5th labial digitation produees a rather high ridge on the dorsal part of the base of the last whorl.

Male or *rugosa* (Sowerby) **form:** 4 to 7 inehes (100 to 175 mm.) in length; aperture rose to reddish with slight or strong purplish markings; lower eolumella slightly to strongly lirate; upper end of aperture with an elongate, purple and white, depressed well or shelf; last two knobs of shoulder small and not welded together; 5th labial digitation produees a very

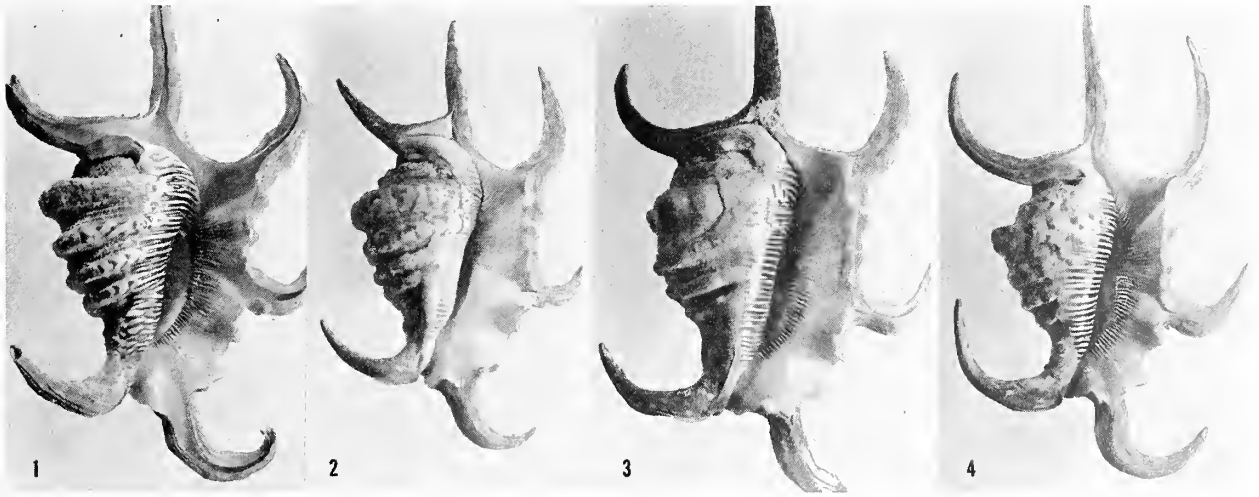

Plate 132. Fig. 1, *Lambis chiragra* subspecies *arthritica* Röding from East Africa. Figs. 2-4, intergrading variations in the columellar coloration and spiral lirae in the form *rugosa* in *L. chiragra chiragra* (Linné). All about ½ natural size.

low ridge on the dorsal side of the base of the last whorl. The columella of some males is the same as that in the females.

Lambis chiragra subspecies *arthritica* Röding

Male and female form: 5 to 6¾ inches (127 to 173 mm.) in length; aperture yellowish white; entire columella purplish brown with strong, white, spiral lirae which parallel the spiral cords (in form *rugosa*, the lirae cross the cords at a slight angle); upper end of aperture without an elongate, deep depression; last two knobs the same size as the others on the shoulder; 5th labial digitation produces a very low ridge on the dorsal side of the base of the last whorl.

It is rather curious that the few records we have seen from eastern Polynesia are the *rugosa* form. This suggests either that only males have been so far collected or that the females also take on the *rugosa*-type characters. If the later be true, we would have an interesting situation in which major sexual dimorphism occurs in the center of distribution while at both ends of the range there is little or no difference in the shells of the two sexes.

Synonymy —

1839 *Pterocera* Lam., Anton, Verzeichniss Conchylien, Halle, p. 84 (type by subsequent designation: *chiragra* Linné).

1852 *Harpago* "Klein", Mörch, Catalogus Conchyliorum . . . Yoldi, Hafniae, p. 60 (type by indirect tautonomy: *Lambis harpago* Bolten = *chiragra* Linné); 1854, H. and A. Adams, Genera of Recent Mollusca, London, vol. 1, p. 261; 1929, Thiele, Handbuch Syst. Weicht., vol. 1, p. 255; 1940, Wenz, Handbuch der Paläont., vol. 6, pt. 4, p. 946 (type by subsequent designation: *chiragra* Linné).

1870 *Harpago* H. and A. Adams, Gill, American Journ. Conch., vol. 5, no. 3, p. 136.

1870 *Pterocera* Lamarck, Kobelt, Illustrirtes Conchylienbuch, vol. 1, p. 105 (type by subsequent designation: *Pterocera chiragra* Linné).

Lambis chiragra *subspecies* chiragra (Linné, 1758)

(Pl. 121, figs. 10-12; pl. 132, figs. 2-4)

Range — Eastern Indian Ocean to eastern Polynesia (but not now living in Hawaii).

Remarks — Comparative notes are given above in the subgeneric discussion. The females have large shells with a whitish rose aperture and a whitish, smooth lower columella. The male shells are usually smaller and sometimes with strong, white, spiral lirae laid over a darkly-stained, purple columella. These lirae cross the spiral cords of the body whorl at a slight angle, whereas in *arthritica* they are parallel to the spiral cords. In the Bay of Bengal and Western Australia, specimens of *chiragra* usually lack the rose coloration in the aperture and, instead, may have a dirty brownish stain which is probably due to environmental conditions. Suites of dwarf specimens sometimes found in museum collections are probably male shells selected out by collectors in the field, and do not represent a dwarf race.

Dautzenberg's (1929, p. 474) records of *chiragra* from Madagascar (which are based upon identifications by Sganzin, von Martens, Thiele and Odhner), undoubtedly are misidentifications of specimens of *Lambis arthritica* Röding. The latter is moderately common in that area, and we have not seen a specimen of typical *chiragra* with reliable locality data from the western part of the Indian Ocean. E. A. Smith (1903, p. 613) reports *chiragra* from the Maldives and Laccadives southwest of India, but these are probably also *arthritica*. Thiele's Handbuch figure (1929, p. 255, fig. 266) of "*chiragra*" is certainly *arthritica*.

We have seen less than a dozen specimens of *chiragra* from eastern Polynesia, and they have all been the male *rugosa* form. Whether or not the female shell exhibits the characters of large size and whitish rose aperture is not known. It is possible that there is less sexual dimorphism in the eastern part of the range. I have seen typical *rugosa* forms from Okinawa, Ryukyu Islands; "Philippines"; Touho Bay and Noumea, New Caledonia (ANSP); Ngarumaoa Id., Raroia Atoll, Tuamotu Ids. (USNM); Hikueru, Tuamotu Ids. (San Diego Soc. Nat. Hist.); Saipan Id., Marianas; the Society Islands; and from the Line Islands (B. P. Bishop Mus.). Dautzenberg and Bouge's (1932, p. 302) records of *Pterocera rugosa* from the Societies and Tuamotus are probably male *chiragra*.

Lambis chiragra has not been found alive in Hawaii, but we have examined several late Pleistocene specimens from Oahu Island (through the kindness of Clifton Weaver, H. M. Baker and Karl Greene).

Habitat — Demond (1957, p. 297) states that this species, in the Marshall Islands, "lives on seaward reef flats, in sand between rocks and coral heads, and in tide pools. Also found among masses of coral *(Heliopora)* in channels between seaward reefs in 8 to 10 feet of water. Invariably found below low tide line." George and Mary Kline collected males and females on the barrier reef in 4 to 10 feet of water at Touho Bay, New Caledonia. In other areas, such as the Philippines and Palau Islands, it is also associated with sand, coral and algal covered reefs where there is surging of oceanic waters.

Description of shell of female – Shell large, 150 to 250 mm. (6 to 10 inches) in length, massive, with 5 large labial digitations and with the siphonal canal turned to the left. Large "stromboid" notch located between the 4th and 5th labial digitations. Whorls 10 to 11. Whorls in spire concave, bordered above and below by two raised, spiral cords, between which runs the finely indented suture. Spiral sculpture of numerous, small threads and, on the body whorl, of 4 or 5 large spiral cords. The upper cord at the shoulder bears 6 to 7 large knobs of which the last two are the largest and are welded together. The lowest fourth cord is the weakest, but it extends on to the dorsal side of the 5th labial digitation and there forms a raised ridge. Color of outer shell whitish to cream with crowded, zigzag streaks of light- or purple-brown. Color of deep interior of aperture is white. Throat of aperture somewhat constricted, flushed with rose and bearing short, white, raised, spiral lirae. Parietal wall slightly glazed, cream with brown, axial streaks. Lower columella area made into a raised shield which is smoothish, cream and tinted with rose. At the upper or posterior end of the throat of the aperture there is an elongate, concave, greatly depressed, whitish lobe attached to the inner parietal wall. Ceylon specimens usually have a brown or purple-brown stain over all of the apertural area. Periostracum moderately thin, brown, axially striate, but usually worn off on the dorsal sides of the digitations and body whorl. Operculum chitinous, dark-brown, fusiform, with about 16 fine serrations on one side (commonly worn away), usually filling the constricted throat of the aperture and with the muscle attachment scar being half the area of the entire operculum.

Description of shell of male (form *rugosa*) – Shell similar to that of the female, but about ½ to ⅓ the size; 100 to 175 mm. (4 to 7 inches) in length. Shoulder with 4 to 6 rather evenly-sized small knobs. Throat and columella pinkish or strongly stained with purple-brown over which run weak to strong, white, raised spiral lirae which cross the spiral cords of the parietal wall at an oblique angle. The inside of the outer lip may be reddish in some specimens. Operculum and periostracum like those in the female.

Radula ribbon with about 46 transverse rows of teeth. Formula: 2-1-2; 1-3 (sometimes 1-4); 5; 7. Verge moderately long, simple and with a laminated pad near the distal end.

Measurements (mm.) – (including digitations)

length	width	no. whorls	
260.0	190.0	9+	(large, female; Ceylon)
246.0	170.0	8+	(large, female; Philippines)
150.0	85.0	9+	(large, male; New Caledonia)
95.0	65.0	8+	(small, male; Palau Ids.)

Synonymy – The names listed below are of *chiragra* (Linné). For convenience and for a clearer understanding of the history of the names applied to the female and male forms, we are listing the synonyms of both forms separately.

Synonymy of female –

1555 *Strombus* ———, Belon, La Nature et Diversite des Poissons, Paris, p. 423, fig. (non-binomial).

1758 *Strombus chiragra* Linné, Systema naturae, ed. 10, p. 742, no. 423 (Ad Bandam Asiae); 1767, ed. 12, p. 1207, no. 491; 1956, Dodge, Bull. Amer. Mus. Nat. Hist., vol. 111, art. 3, pp. 247-249.

1798 *Lambis harpago* Röding, Museum Boltenianum, Hamburg, pt. 2, p. 67, no. 860, Substitute name for *chiragra* Gmelin, 1791.

1798 *Lambis undulata* Röding, loc. cit., p. 68, no. 873 (refers to Conchyl.-Cab., vol. 3, fig. 898, a young of *chiragra*?).

1842 *Pteroceras chiragra* L., Sowerby, Thesaurus Conch., vol. 1, p. 42, pl. 11, fig. 12.

Plate 133. A Pleistocene specimen of *L. chiragra chiragra* (Linné) from a raised beach near Sunset Beach, Oahu Island, Hawaii. (from the Children's Museum of Honolulu). Slightly reduced.

1855 *Pteroccra kochii* Freyer, Sitzungb. Math.-Natur. der Kaiser. Akad. der Wissenschaften Vienna, vol. 15, p. 22 (no locality). Refers to Kiener, 1843, pl. 5.

1938 *Lambis (Harpago) chiragra* (Linné), Hirase, A Collection of Japanese Shells, Tokyo, 6th ed., pl. 88, fig. 2; 1949, Abbott, Scientific Monthly, vol. 69, p. 325, left fig.

1940 *Pteroccra (Harpago) chiragra* (Linné), Wenz, Handbueh der Paläozoologie, Berlin, Lief. 6, band 6, p. 948, fig. 2764.

1950 *Lambis chiragra* Linné, Abbott, Bull. Raffles Mus., Singapore, no. 22, p. 74 (Cocos Keeling Ids.).

Synonymy of male or form *rugosa* –

1823 *Strombus chiragra* L., Mawe, Linnaean Syst. Conch., London, p. 125, pl. 25, fig. 4. Not Linné, 1758.

1842 *Ptcroceras rugosum* Sowerby, Thesaurus Conchyliorum, vol. I, p. 42, pl. 11, fig. 9 (not 10).

1851 *Ptcroccra rugosa* Sowerby, Reeve, Conchologia Iconiea, vol. 6, Pterocera, pl. 4, sp. and fig. 6 (Society Islands). Non Sowerby, 1842; 1936, Robert, Kunstgebilde des Meeeres, Bern, p. 15, pl. 14 (Neu-Kaledonien).

1911 *Ptcroccra (Harpago) rugosa* Sowerby, Dautzenberg, Bull. l'Institut Oceanograph., Monaco, no. 161, p. 3.

1938 *Lambis (Harpago) chiragra rugosa* (Sowerby), S. Hirase, A Collection of Japanese Shells, Tokyo, pl. 88, figs. 3.

1949 *Lambis rugosus*, Platt, National Geographic Magazine, vol. 96, no. 1, p. 68, fig. 1 (in color).

1949 *Lambis arthritica* Röding, Abbott, Scientific Monthly, vol. 69, no. 5, p. 324, fig. upper center.

1953 *Harpago chiragra* Linné, Cotton, Malacol. Section, Royal Soc. South Australia, no. 3, Family Strombidae, fig. 18.

1959 *Lambis chiragra rugosa* (Sowerby), Sakurai in Oyama, The Molluscan Shells, Resources Exploitation Institute, Tokyo, vol. 2, Lambis pl. 3, figs. 2, 3.

Types – Dodge (1956, p. 247) states that "the specimen marked for *chiragra* in the Linnaean collection in London is a typical and perfect specimen of the *chiragra* of all authors." Hanley (1855, p. 366) likened the type to the shell illustrated by Sowerby (Thesaurus Conchyl., vol. 1, pl. 11, fig. 12). That shell is probably a large female and the color form from Ceylon.

Mr. Peter Dance (1960) was unable to locate for us the type of Sowerby's *Pteroceras rugosum*. Sowerby illustrated both *arthritica* Röding (his fig. 10) and the male form of *chiragra* (his fig. 9). He speaks of the two varieties. His reference to the "rose aperture" suggests the Pacific male form. I hereby designate his pl. 11, fig. 9 as representing the holotype.

Records (see accompanying map, pl. 134) – [We believe literature records for Madagascar and East Africa are erroneous]. CEYLON: Hikkaduwa (G. and M. Kline, NSF); reef, Foul Point (W. D. Hartman, Yale Peabody Mus.). ANDAMAN IDS.: Port Blair (W. N. Carpenter, USNM). THAILAND: Phuket, Bay of Bengal (F. N. Crider, ANSP). Siantan Id., Anambas Ids., east of Malaya (ANSP). SOUTH CHINA SEA: Paracel Islands (Saurin, 1960, p. 204). COCOS KEELING: (USNM). RYUKYU ISLANDS: Okinawa Id. (W. A. McCarty, ANSP); Shiyo, Shanawan Bay, Okinawa Id. (USNM). TAIWAN: Kasyo-to; Hukukaku (Kuroda, 1941, p. 98). PHILIPPINES: Tabaco, Albany Prov., Luzon Id.; Cuyo Id. (both du Pont-Academy Exped., 1958); Iba, Zambales Prov., Luzon Id. (P. de Mesa, ANSP); San Pedro Bay, Samar Id.; Mindoro Id.; Surigao, Mindanao Id.; Tataan Id., Tawi Tawi Ids.; Camiguin Id.; Dumaguete, Negros Id.; Batan Id., Batanes Group; Leyte Id.; Busuanga Id. (all USNM); Sanga Sanga Id., Sulu Arch. (ANSP); Jolo Id., Sulu Arch. (E. Gutianjo, ANSP). INDONESIA: Sumatra: Sinabang Bay, Simalur Id. (west coast); Biliton Id. (east coast). Java: Leiden Id., Bay of Batavia; Bali Id.; Timor Id.; Great Obi Id., Moluccas; Gulf of Madjene, Celebes (all ex Rykmus. Nat. Hist., Leiden, ANSP). Moluceas: Bouro Id.; Saparua Id.; Batjan Id. (all MCZ). AUSTRALIA: 14 mi. north of Warroora Sheep Station, 150 mi. north of Carnarvon, West Australia (Areh Whitworth, ANSP). Green Id., Queensland (Tony Marsh, in litt.). DUTCH NEW GUINEA: Mios Woendi Atoll, Padaido Ids.; Maransabadi Id., Aoeri Ids. (both A. J. Ostheimer, NSF). SOLOMON ISLANDS: Tai Lagoon, Malaita Id. (Calif. Acad. Sci.). Roriana Lagoon, South New Georgia Id. (MCZ): Lutee, Choiseul Id. (W. J. Eyerdam, ANSP). NEW HEBRIDES: Lamap, Mallicola Id. (G. Massoulard, ANSP). NEW CALEDONIA: barrier reef, Touho Bay (G. and M. Kline, NSF). MARIANAS: Saipan Id. (MCZ; USNM); Guam Id. (USNM). PALAUS: Kayangel; Babelthuap; Koror; Eil Malk; Gorokottan (all A. J. Ostheimer, NSF). Helen Id., Helen Reef (V. Orr, NSF). CAROLINES: Ulithi; Ponape; Elato; Ifaluk (all USNM). MARSHALLS: Bikini; Rongelap; Eniwetok; Wotho; Ujelang (all USNM); Ebon and Jaliut (MCZ). GILBERTS: Onotoa (USNM). SAMOA: Tutuila Id. (ANSP). SOCIETY IDS.: (San Diego Soc. Nat. Hist. form *rugosa*). WAKE ID.: (A. E. Tara, AMNH). PHOENIX GROUP: Baker's Id.

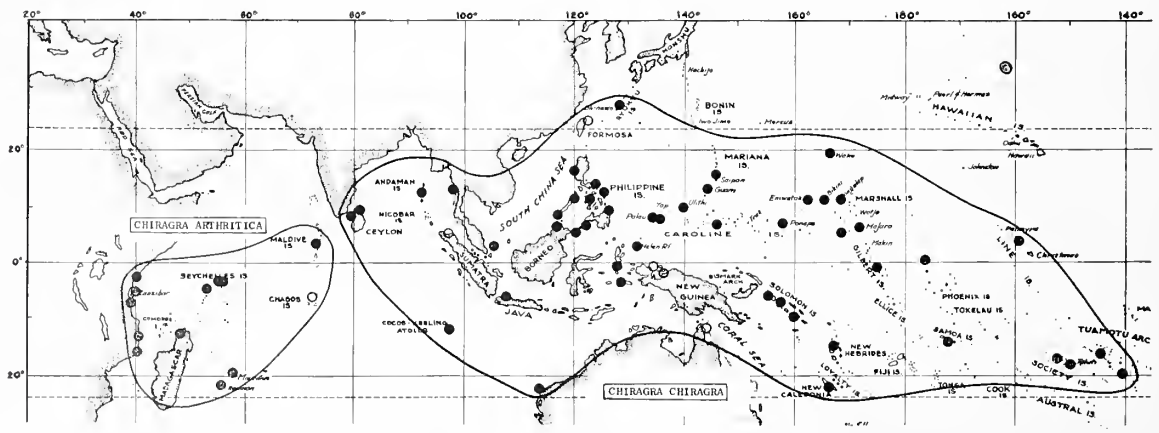

Plate 134. Geographical distribution of *Lambis chiragra* subspecies *arthritica* Röding and *L. chiragra chiragra* (Linné).

(B. P. Bishop Mus.). LINE IDS.: Fanning and Christmas Id. (B. P. Bishop Mus.). TUAMOTU IDS.: Hikueru (San Diego Soc. Nat. Hist.); Ngarumaoa Id., Raroia Atoll (J. P. E. Morrison, USNM); both form *rugosa;* Hao and Otepa (M. Couturier, 1907, p. 153), form *rugosa.* MARQUESAS: (Tony Gavaldon, coll., 1959), form *rugosa.*

Fossil records — HAWAIIAN CHAIN: all Late Pleistocene; Midway (USNM); Sunset Beach, Oahu (Children's Museum); Kapaloma Basin, Oahu (H. M. Baker, coll'n.); side of hill, 15 feet above high tide, Makua, Oahu (Clifton Weaver, coll'n.); lava-coral formation, Waimea Bay, Oahu (H. M. Baker, coll'n.); Kauaiu Stream, 250-290 ft. alt., Lanai Id. (H. Stearns, USNM 496365); Honolulu Harbor and Kupikipikio, Oahu Id. (J. M. Ostergaard, 1928, p. 26).

Lambis chiragra *subspecies* arthritica Röding, 1798

(Pl. 121, fig. 7; pl. 132, fig. 1)

Range — East Africa to the Central Indian Ocean.

Remarks — This distinct subspecies appears to be limited to the western half of the Indian Ocean. Literature reports of it in the East Indies are probably based upon the similar-looking male phase or *rugosa* form of *L. chiragra. L. chiragra arthritica* differs from male *chiragra chiragra* in lacking the deep-set, elongate well or depression at the upper end of the aperture, in having the white spiral lirae on the parietal wall running parallel with the spiral cords (instead of slightly oblique), and in generally having a yellowish rose (rather than a pinkish rose) background color to the aperture.

Both Abbott (1950, p. 74) and Butot (1955, p. 79) seem not to have recognized the problem of subspecific and sexual differences in the *chiragra-arthritica* complex. Although Abbott saw intergrades in columella characters in the Pacific shells and rightfully suspected a close connection between the two forms in *chiragra,* he did not realize that he was working with a sexually dimorphic species. He also failed to recognize the morphological and geographical uniqueness of the western Indian Ocean subspecies *arthritica.* Butot recognized the distinctiveness of *arthritica,* but erroneously considered the Pacific males of *chiragra* (the form *rugosa*) as part of *arthritica.* Thus his records of *arthritica* from the Ryukyu Islands, Funafuti, New Caledonia (Ceylon and Indonesia?) are doubtlessly based upon male *chiragra.*

In the shells of male and female *arthritica* I can find no startling differences, other than the slightly smaller size of males and a very slight indication of larger or more elongate shoulder knobs on the shells of females.

Habitat — The Natural Science Foundation expedition to Zanzibar in 1957 found this subspecies reasonably common just below the low tide mark on flat, offshore reefs which were largely covered with algae and marine grass. They found them in company with *Lambis crocata* (Link), *Vasum rhinoceros* (Gmelin), *Conus, Haliotis* and some live coral. A label written by Mr. Kurt Grotsch (ANSP 192618) reports that in Mozambique they are found rarely at all seasons "just above the low water level on weed-covered, stony reefs where a swift current moves. In 2 to 3 fathoms of water they live among corals and gravel and their shells are eroded."

Description — Shell (including digitations) 120 to 190 mm. (5 to 7 inches) in length with 5 labial digitations and with its siphonal canal turned to the left. Large "stromboid notch" located between the 4th and 5th labial digitations. Similar to *chiragra chiragra,* but instead of having a deep depression at the upper end of the aperture, there is an arching broadly rounded, slightly depressed shelf projecting from the upper part of the parietal wall. The color of the inside of the outer lip is usually yellowish or pinkish yellow with splotches of purplish underlying the white spiral lirae. The columella is brownish purple with strong whitish spiral lirae which tend to parallel the 4 spiral cords on the parietal wall. On the dorsum of the body whorl, the top spiral cord bears 7 to 9 evenly-sized, rounded nodules. Periostracum thin, varnish-like and translucent-yellowish.

Measurements (mm.) — (including digitations)

length	width	no. whorls	
190	93	7+	(large; Mozambique)
140	75	8+	(average; Zanzibar)
125	70	7+	(small; Zanzibar)
120	70	9+	(small, male, Seychelles)

Synonymy —

1798 *Lambis arthritica* Röding, Museum Boltenianum, Hamburg, pt. 2, p. 67, no. 858 (no locality). Refers to Conchyl.-Cab., vol. 3, fig. 857 (which is from Mauritius).

1811 *Strombus divergens* Perry, Arcana, London, vol. 2, pl. 74 (no locality).

1811 *Strombus nigricans* Perry, Arcana, London, vol. 2, pl. 74 (no locality). Additional name for *divergens.*

1842 *Pteroceras rugosum* Sowerby, Thesaurus Conchyliorum, vol. 1, p. 42 (South Sea), pl. 11, figs. 10 (not 9). In part.

1842 *Pterocera rugosa* Sowerby, Reeve, Conchologia Systematica, vol. 2, p. 204, pl. 247, fig. 1.

1855 *Pterocera chiragra* Linné, Freyer, Sitzungb. der Kaiser Akad. des Wissenschaften, Vienna, vol. 15, p. 22. Refers to Lister, pl. 870.

1859 *Pterocera chiragra* Linné, Chenu, Manuel de Conchyl., Paris, vol. 1, p. 258, fig. 1612. Non Linné 1758.

1929 *Pterocera (Harpago) chiragra* (Linné), Thiele, Handbuch der System. Weich., Jena, vol. 1, p. 255, fig. 266.

Types – Röding's *arthritica* is based upon a figure of a specimen from Mauritius which we hereby designate as the type locality.

Records – (see map on pl. 134) MOZAMBIQUE: Mozambique City (K. Grotsch, ANSP); Port Amelia (MCZ; USNM); KENYA: Diani Beach, 20 miles south of Mombasa (R. T. Abbott, MCZ; USNM); Wasin Id., off Shimoni (J. K. Howard, MCZ); Malindi (USNM). ZANZIBAR: rock reef, 5 mi. south of Paje; reef off Ras Nungwe; outer reef at Kiwengwa (all NSF, 1957). MADAGASCAR: Nossibé (A. Chavane, ANSP). SEYCHELLES: Bird Id., Frigate Id.; Beau Vallon, Mahé Id. (all Yale-Peabody Mus., 1957); Anse Boileau, Mahé Id. (Wickworth, Brit. Mus.). MAURITIUS: (N. Pike, MCZ). REUNION ID.: (MCZ). MALDIVES: Kureduls, Fadiffolu Atoll (Yale-Peabody Mus., 1957). CHAGOS IDS.: (Melvill, 1909, p. 94, "Investigator". [the MCZ has records for "Fiji, Singapore and Amboina", but I suspect manufactured data, since they came from old private collections].

Fossil records – None recorded.

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THE FAMILY PINNIDAE IN THE INDO-PACIFIC

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The bivalve family Pinnidae is unique among the anisomyarian clams which have a large posterior adductor and a small or no anterior adductor muscle. Commonly called Pen-, Fan-, Wing-Shells or Spanish Oysters, their shells are large, thin, broad and fragile. There are two layers of limy material: an outer prismatic sheath of very large crystals of calcite produced at a right angle to the long axis of the shell (pl. 135, and pl. 136, fig. 2), and a partial inner, shingled layer of nacreous material of aragonite produced parallel to the long axis of the shell (pl. 136, fig. 2). The periostracum is usually worn away, and hinge teeth are lacking in the Pinnidae. The valves are united along their dorso-anterior margins by a dark, nonelastic primary ligament; and along their dorso-posterior margins by a fusion of the outer prismatic shell layer called the secondary ligament (Yonge, 1953). The anatomy of these animals is even more specialized than their shells, exhibiting several unique organs, including the protrusible pallial organ, the eye-like Organs of Will found along the margin of the mantle, and a pair of elongate, gutter-shaped waste canals which aid in ejecting debris from the mantle cavity (pl. 137). These morphological modifications aid the sessile pen-shells in surviving in their habitat—rooted deeply in sandy mud, where currents and predators are likely to uproot and destroy them.

Little is known of the reproduction and development of the Pinnidae. Species which have been studied were found to be dioecious. Cahn (1951) reported dates of spawning and growth rates of *Atrina japonica* in Japan (= *A. pectinata*). Yoshida (1956) studied the early life history of *pectinata*. However, to date, no work has been done on the embryology of any species. Young pinnas begin their existence as minute equilateral bivalves (pl. 139). Growth proceeds in a posterior direction leaving the equilateral embryonic valves perched on the umbos of the young adult form. The former are usually worn away before the latter reaches much more than a centimeter in length.

At present we know of twenty well-defined species and subspecies of Pinnidae, but when more adequate material is available for study from collections from shallow waters in the tropical and temperate regions of the world this number may be increased to as many as thirty or more. We recognize three distinct Recent genera: *Pinna*, *Atrina* and *Streptopinna*. The latter is known only from the Indo-Pacific, while the other two are found in all warm seas. Turner and Rosewater (1958, Johnsonia, vol. 3, no. 38) dealt with the Western Atlantic species in considerable detail. In this study, nine Recent and several Tertiary species of Indo-Pacific Pinnidae are considered.

Fossil Pinnidae

The Pinnidae first appeared in the geologic record during the Paleozoic Era. Of the Recent genera, *Atrina* Gray appeared during the Carboniferous and *Pinna* Linné later, in the Jurassic. The order of appearance of these genera may indicate a tendency for development through time of more complex shell structure in this family. The genus *Streptopinna* probably developed during the late Tertiary.

Several extinct genera have been described in the Pinnidae. Turner and Rosewater (1958) have discussed these, and Vokes [1951, pp. 40, 116] gave a complete list of the genera. These genera are represented by species apparently having more generalized shells than Recent Pinnidae and show affinities with other closely related bivalve groups such as the Mytilidae, Isognomonidae, Pteriidae and Ostreidae.

There has been a relatively large number of fossil Pinnidae described from strata from widespread geographic areas in both Europe and the Western Hemisphere. Many of these are from the Paleozoic, but Mesozoic and Quaternary fossils are also plentiful. Species described by early workers are almost impossible to identify. The Pinnidae, because of the fragility of their valves, became poor fossils and usually are represented by fragments only. Descrip-

tions are based on supposed shapes of valves projected from the fragments and characteristics of visible sculpture which, even in Recent species, may tend to be convergent. In the present study an attempt has been made to include all of the Indo-Pacific fossil species described from the Tertiary to Recent, and fossil records are given for Recent species.

Economic Importance

The Pinnidae have considerable economic importance in many parts of the world. They produce pearls of moderate value. In the Mediterranean area, material made from the holdfast or byssus of *Pinna nobilis* Linné has been utilized in the manufacture of clothing for many centuries: gloves, shawls, stockings and cloaks. Apparel made from this material has an attractive golden hue and these items were greatly valued by the ancients.

Today, Pinnidae are eaten in Japan, Polynesia, in several other Indo-Pacific island groups, and on the west coast of Mexico. In Polynesia, the valves of *Atrina vexillum* are carved to form decorative articles, and entire valves of larger specimens are sometimes used as plates. Turner and Rosewater (1958) give a more complete discussion of the economic importance of Pinnidae; also see Cahn (1951); Salis von Marschlins (1795); Simmonds (1879); Yates (1843); Gilroy (1845); Haas (1955); Feen (1949), and Reyne (1947).

Commensalism

The Pinnidae serve as hosts to a number of organisms, both internally as commensals and externally as holdfasts for barnacles, sessile bivalves, tube worms, algae and other forms of marine life. Aristotle and Pliny recorded the classic association of the small crab, *Pinnotheres*, which lives in the mantle cavity of *Pinna*. The two were supposed to live together in intimate friendship with the crab warning the bivalve of approaching danger and gaining refuge within the latter's mantle cavity. According to Christensen and McDermott (1958), it is only the crab which receives any benefit from this association.

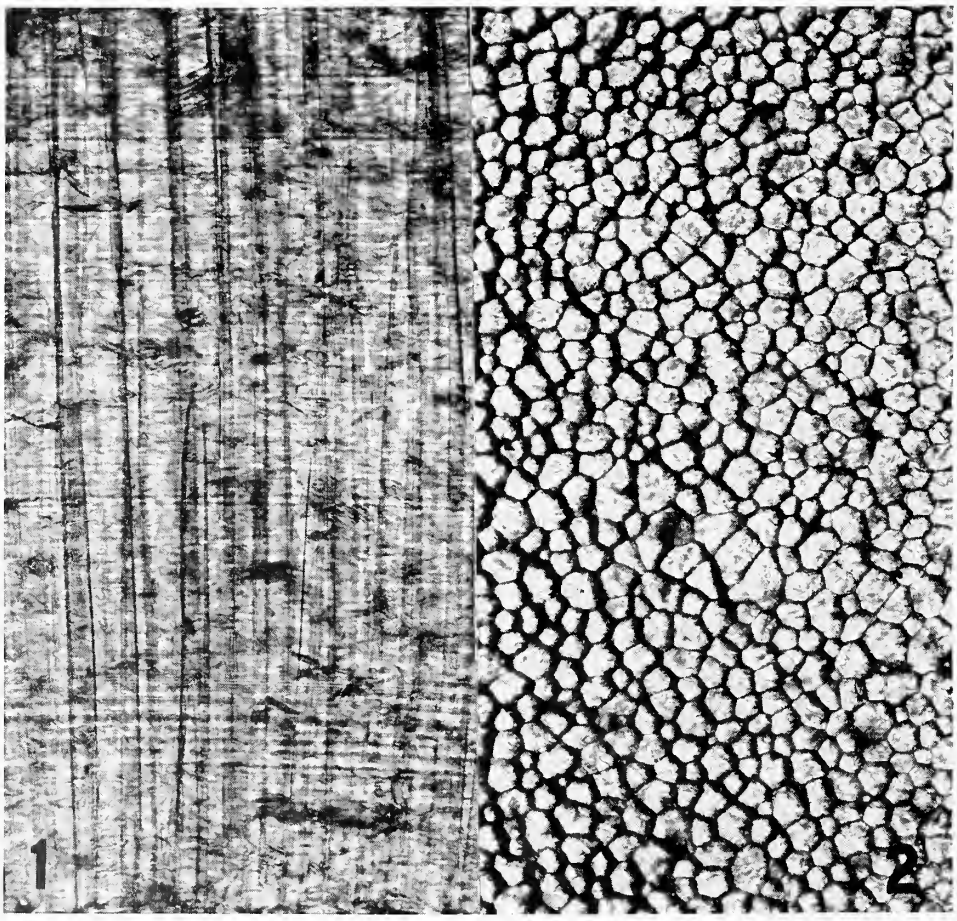


Plate 135. Shell structure of *Pinna carnea* Gmelin (Western Atlantic). Fig. 1. Longitudinal section to show the length of crystals of the prismatic layer. Fig. 2. Cross section to show hexagonal shape; from same area of shell as in Fig. 1 (both × 110; from Johnsonia, vol. 3, no. 38, pl. 151).

Shrimps are also known to live in the mantle cavity of the Pinnidae. Turner and Rosewater (1957, p. 297) reported the observation of a shrimp in *Pinna carnea* from the Western Atlantic. Holthuis (1952) reported several cases of shrimp-pinnid commensalism in the Indo-Pacific and they are mentioned below in the systematic portion of this study under the appropriate species.

Remarks on Anatomy

The usual habitat of Pinnidae is in a substrate of soft, sandy mud with the narrow, umbonal tip of the shell downward. They are sessile animals and, after becoming imbedded, there is probably little horizontal movement carried on, excursions being limited to vertical burrowing. As Yonge (1953) has stated, the Pinnidae are structurally well suited for the life they lead and are further aided in their adjustment by several unique anatomical features (see Plate 137).

The gross anatomy of the Pinnidae is similar in the several genera with minor differences in proportions. The pallial organ is visible atop (posterior and dorsal to) the posterior adductor muscle. It differs somewhat in shape among the genera. In *Atrina*, it has a thickened stalk and a conical to rounded head; in *Pinna* and *Streptopinna*, it is usually thin and the head nearly aciculate-conical, depending on the degree of contraction. The fragile shells of the Pinnidae are easily broken posteriorly and the pallial organ functions in clearing away pieces of broken shell and debris from the mantle cavity. The organ is made turgid with body fluids and is thus able to move posteriorly. Intrinsic muscles cause lateral movements. With obstructions removed the extensible mantle may make necessary repairs to the shell.

The pallial organ has an interesting nomenclatorial history. Poli (1795) called it a "trachea"; Rogers (1908) an osphradium; Grave (1911) the mantle gland; and Yonge (1953) the pallial organ. The last appears to be the best name for this structure as it consists of differentiated parts made up of glandular and muscular tissue which are thought to have been derived from the pallium or mantle.

Another useful and unique structure is the waste canal located ventral to the gills (plate 137). Because of the vertical habit of the Pinnidae, considerable material might enter and accumulate in the mantle cavity were it not for this structure. Its function is the removal of rejected food and debris from the anterior portion of the cavity. The canals consist of two open, ciliated gutters, one on either half of the mantle, which produce a strong current carrying material rapidly to the posterior border where it is caught in the exhalent respiratory-feeding discharge and so expelled.

Another unusual set of structures whose function is not yet well understood is present in the mantle margin of members of the genera *Pinna* and *Streptopinna*. Will (1844) was probably the first to record their presence, calling them eyes. They are located between the middle and inner mantle lobes and occur in greatest numbers posteriorly, becoming widely spaced anteriorly. Rawitz (1890, pp. 64-72, pl. 4, figs. 28, 29) declared they were not eyes but glandular in nature. Sections kindly prepared by C. E. Cutress, Division of Marine Invertebrates, United States National Museum, show what appear to be secretory granules, so that a visual function probably does not exist. The eye-like structures of Will have been noted in the following species of Pinnidae: *P. bicolor*, *P. muricata*, *P. carnea* and *Streptopinna saccata*. Their comparative appearance is commented upon in descriptions of the species studied in this report. None have been seen in any specimens examined of the genus *Atrina*.

The real purpose and function of these structures has not yet been discovered (see Patten, 1886, pp. 606, 607; Braun, 1954). Winckworth (1929, p. 282) called attention to them in S. *saccata*, referring to them as pigment spots. In connection with a possible excretory pigment-secreting ability, it is here tentatively suggested that these glands may produce the colored rays which are found in the shells of certain species in this group (see Comfort, 1951). The relative size and degree of pigmentation of the glands appear to vary in the several species and may be correlated with the degree of shell pigmentation.

List of Recognized Taxa

The following list contains the names of the genera and subgenera of all living and fossil Pinnidae. All living species, which we consider valid, together with the Tertiary fossils from the Indo-Pacific are also included. Brackets [ ] indicate other oceans; daggers † are fossil genera and species; E.A. is Eastern Atlantic; W.A. is Western Atlantic; E.P. is Eastern Pacific.

Genus †*Palaeopinna* Hall, 1870

[†*flabella* Hall, 1884] Type? Devonian

Genus †*Sulcatipinna* Hyatt, 1892

[†*flexicostata* (Mc Coy, 1844)] Type. Carboniferous

Genus †*Laevipinna* Paul, 1941
[†*spatula* (Mc Coy, 1853)] Type. Carboniferous
Genus †*Aviculipinna* Meek, 1864
[†*prisca* (Muenster, 1837)] Type. Permian
Genus †*Stegoconcha* Boehm, 1907
[†*granulata* (Sowerby, 1822)] Type? Jurassic
Genus †*Trichites* Deshayes, 1832
[†*nodosus* (Lycett, 1850)] Type. Jurassic-Cretaceous
Genus †*Pinnigena* Bronn, 1836
[†*ampla* (Sowerby, 1812)] Type? Jurassic-Cretaceous
Genus †*Oxysma* Rafinesque, 1819
[†*bifida* Rafinesque, 1819] Type. Tertiary?
Genus †*Curvulites* Rafinesque, 1831 (New name for *Curvula* Raf., 1819)
[†*striata* Rafinesque, 1831] Type. Tertiary?
Genus *Pinna* Linné, 1758
†*punjabensis* Eames, 1951
†*rembangensis* Martin, 1910
†*asakuraensis* Nagao, 1928
muricata Linné, 1758
†*blanfordi* Boettger, 1880
bicolor Gmelin, 1791
incurva Gmelin, 1791
[*nobilis* Linné, 1758] E.A.
[*rudis* Linné, 1758] Type. E.A., W.A.
[*carnea* Gmelin, 1791] W.A.
[*rugosa* Sowerby, 1835] E.P.
Genus *Atrina* Gray, 1842
Subgenus *Atrina* s.s. Gray, 1842
†*pachyostraca* (Davies, 1923)
vexillum (Born, 1778) Type.
squamifera (Sowerby, 1835) South Africa
[*chautardi* (Nicklés, 1953)] West Africa
[*fragilis* (Pennant, 1777)] E.A.
[*rigida* (Solander, 1786)] W.A.
[*tuberculosa* (Sowerby, 1835)] E.P.
Subgenus *Servatrina* Iredale, 1939
pectinata (Linné, 1767) Type.
subsp. *zelandica* (Gray, 1835) New Zealand
†*cordata* (Pritchard, 1895)
†*janjukiensis* (Crespin, 1950)
†*tateana* (Hedley, 1924)
tasmanica (Tenison-Woods, 1875)
[*seminuda* (Lamarck, 1819)] W.A.
[*serrata* (Sowerby, 1825)] W.A.
[*maura* (Sowerby, 1835)] E.P.
Genus *Streptopinna* von Martens, 1880
?†*reticosa* (Chapman, 1912)
saccata (Linné, 1758)

Taxonomic Characters of the Pinnidae

Early workers depended wholly on external details of the shells to distinguish species in the Pinnidae. Although external shell form is very useful, it is so subject to change by the environment that other details of the soft anatomy and the internal shell must be used for positive identification. In most instances adult specimens must be used. Identification to species is based on a combination of characters which include the general shape and texture of the shell, the comparative numbers of ribs, the development of the spines, the contour and extent of the nacreous layer and, when available, the details of certain parts of the soft anatomy.

As more anatomical information becomes available, it may well become the main basis for precise specific identification. The present methods of preservation of the animals produce a variety of effects

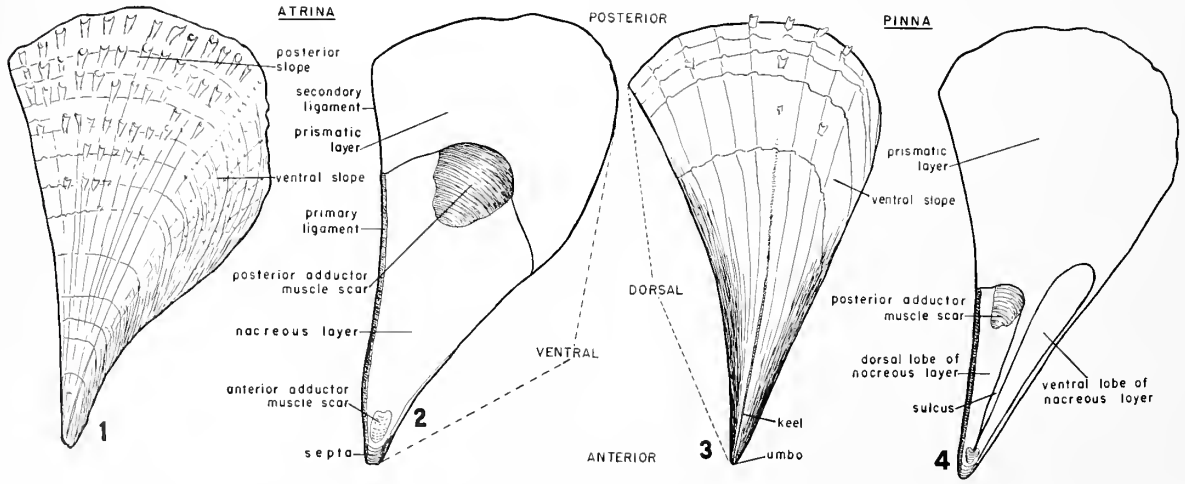
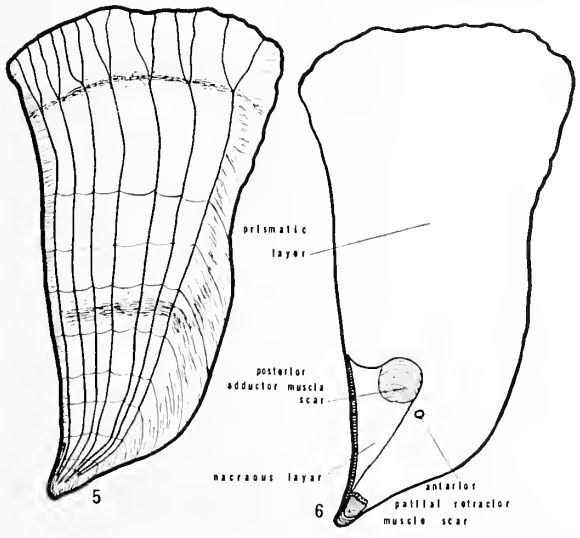


Plate 136. Diagrammatic sketch of the valves of the genera *Atrina*, *Pinna* and *Streptopinna* to show diagnostic characters. Figs. 1-2. External and Internal surfaces of the valves of *Atrina*. Figs. 3-4. The same of the valves of *Pinna*. Figs.

such as shrinkage and hardening so that apparent differences in the proportions and shapes of various organs cannot always be considered reliable. Live animals must be relaxed in some effective way, killed rapidly in a substance which fixes the soft parts in the relaxed state, and then preserved in a standard medium.

An excellent procedure for some bivalves which produces very pliable specimens easily manipulated for study is the following: relax the living animal in Propylene Phenoxetol; fix in buffered formalin; then preserve in Propylene Phenoxetol (Turner, 1960, p. 7). Another method utilizes 10% Nembutal as a relaxant; A.F.A. (Lavandowsky's mixture of alcohol, formalin, and acetic acid) as a fixing medium and 70% alcohol for preservation. The latter also produces fairly well relaxed specimens, although not so pliable as those preserved in Propylene Phenoxetol. (See Van der Schalie, 1953, for instructions on the use of Nembutal as a relaxant.) These methods are relatively simple, easy to learn, and many times increase the taxonomic value of material collected during costly expeditions.

In spite of the difficulty of obtaining well-preserved material, some anatomical work has been done in the Pinnidae which may be of use in taxonomy. Purchon (1957) found the stomachs of *Atrina vexillum* (Born) and *Pinna atropurpurea* [= *P. bicolor* Gmelin] to differ in some details, the latter being more complicated. As no other work has been done on this organ in other species of Pinnidae it is not known whether these differences should be considered of generic or specific value. Various other characters, such as the curvature and position of the waste canal, the shape of the pallial



5-6. The same of the valves of *Streptopinna*. (Figs. 1-4 from Johnsonia, vol. 3, no. 38, pl. 154.)

organ and coloration of internal organs, have served to discriminate species of Pinnidae (see Turner and Rosewater, 1958, p. 300). Color of the organs is of little value unless the specimens can be seen alive, since they tend to fade in preservation. Notes taken on a single species, *Pinna bicolor*, by D. F. McMichael, Australian Museum, are the only data of this type available in the present study. They concern the coloration of the ovary of a female specimen (see description of *bicolor*). Nothing is known of the coloration of the male organ.

Winckworth (1929) expressed confidence in determining species by means of correlating the number of gill filaments per plica with the size of the apical filaments (see plate 138). This character was described by Ridewood (1903) who gives counts for several species of *Pinna* and *Atrina*. Ridewood found that *Pinna pectinata* [= *A. fragilis* (Pen.)] possessed 16-17 filaments per plica. This count was verified by Winckworth. The other species examined by Ridewood (*Pinna nobilis; Pinna nigra* [= *Atrina vexillum*?]; *Pinna zealandica* [error for *Atrina zelandica*] and *Pinna virgata* [= *Pinna muricata*?]) all possessed filament counts from 10 to 13. Differences were noted in the sizes of the apical filaments. In *fragilis*, *nobilis* and *bicolor* the apical filament was found to be much larger than the ordinary filaments, but in *vexillum* it was of about the same size or only slightly larger. In our present study the gills of seven species of Pinnidae have been examined grossly by means of a binocular dissecting microscope (*P. bicolor; P. muricata; P. carnea; A. vexillum; A. pectinata; A. seminuda;* and *S. saccata).* It was noted in all specimens examined that the number of ordinary gill filaments was about 12 (6 on either side of a plica). In addition there is one principal and one apical filament (see plate 138). Differences were noted in the relative sizes of the apical and ordinary filaments and probably in the shapes of the plicae. Unfortunately these specimens were preserved in several different ways, some obviously having undergone violent contraction and shrinkage of the gills. For this reason any attempt to compare the gill anatomy of these species will be deferred until properly relaxed and preserved specimens are available.

In the final analysis a combination of as many taxonomic characters as possible should be utilized in separating species. Unfortunately, however, in the usual museum mollusk collection only shells are found. For this reason, in the following key to species of Indo-Pacific Pinnidae, the characteristics of the shells are stressed (see pl. 136 for orientation in shell morphology).

Key to the Recent Indo-Pacific Pinnidae

1. Internal nacreous layer divided by a longitudinal sulcus ..... *Pinna* (3)
   Internal nacreous layer not divided ..... (2)
2. Nacreous layer occupying entire interior of anterior portion of valves ..... *Atrina* (5)
   Nacreous layer limited to dorsal anterior portion of valves only; shell usually misshapen and contorted ..... *Streptopinna saccata*
3. Posterior shell-margin squarely truncate; posterior adductor scar often extending onto ventral lobe of nacreous layer ..... *Pinna muricata*
   Posterior shell-margin not squarely truncate but arcuate or broadly rounded; posterior adductor scar never extending onto ventral lobe ..... (4)
4. Posterior nacreous borders both sharply oblique, forming a deep medial "V"; posterior extension of dorsal and ventral lobes about equal; shell long and narrow, thin and fragile; color light-horn to light reddish brown ..... *Pinna incurva*
   Posterior nacreous borders not both sharply oblique, not forming deep "V"; the ventral usually oblique, the dorsal truncate; posterior extension of dorsal and ventral lobes subequal, the ventral may be longer or shorter; shell often thickly produced, not long and narrow; light-horn to dark brownish purple, often colorfully patterned .. *Pinna bicolor*
5. Posterior adductor muscle scar protruding beyond posterior border of nacreous layer or contiguous with it ..... *Atrina s.s.* (6)
   Posterior adductor scar not protruding; located well within posterior border of nacreous layer ..... *Servatrina* (7)
6. Shell reaching large size, thick, heavy, black, broadly ham-shaped; early growth showing prickly major ribs which often have 2-3 rows of minor ribs between them. *Atrina (Atrina) vexillum*
   Shell not especially large, thick or heavy, sculptured with large, erect, nearly tubular spines; without minor ribs (South Africa) ..... *Atrina (Atrina) squamifera*
7. Shell olivaceous to black, or with few color stripes; rather thin; with 14-30 rows of prickly to spiny ribs; posterior margin truncate ..... (8)
   Shell reddish brown (olivaceous when young); moderately heavy; ribs usually less than 14; posterior margin rounded (southeastern Australia and northern Tasmania). *Atrina (Servatrina) tasmania*
8. Sculpture reduced to few scattered spines or low uniform imbrications; color olivaceous tan to black (India to Melanesia but not southeastern Australia, Tasmania or New Zealand). *Atrina (Servatrina) pectinata*
   Sculpture not obsolete but rather uniformly spinose; color olivaceous tan, often with vertical bars of brownish purple (New Zealand) ..... *Atrina (Servatrina) zelandica*

Geographic Distribution of Recent Species

World-wide Distribution — The geologic history of the family Pinnidae, which began in the late Paleozoic, is largely unknown because of the poor preservation of specimens. Inferences must be made largely from today's distribution of living forms. The family probably has a history of diverse genera and species which once flourished but have since disappeared without fossil traces. It also seems likely that certain conservative stocks, such as the Carboniferous *Atrina*, have survived to Recent times without appreciable change, much in the same manner as members of the brachiopod genus, *Lingula*, and the eurypterid-like horseshoe crab, *Limulus*.

In the main, the family has remained in shallow seas of a tropical and warm temperate nature, rarely having representatives in cooler waters. Because of the pelagic nature of the larval stages and the ease of transportation of young individuals which have attached themselves to floatable objects, the pen shells have had ample time and occasion to reach

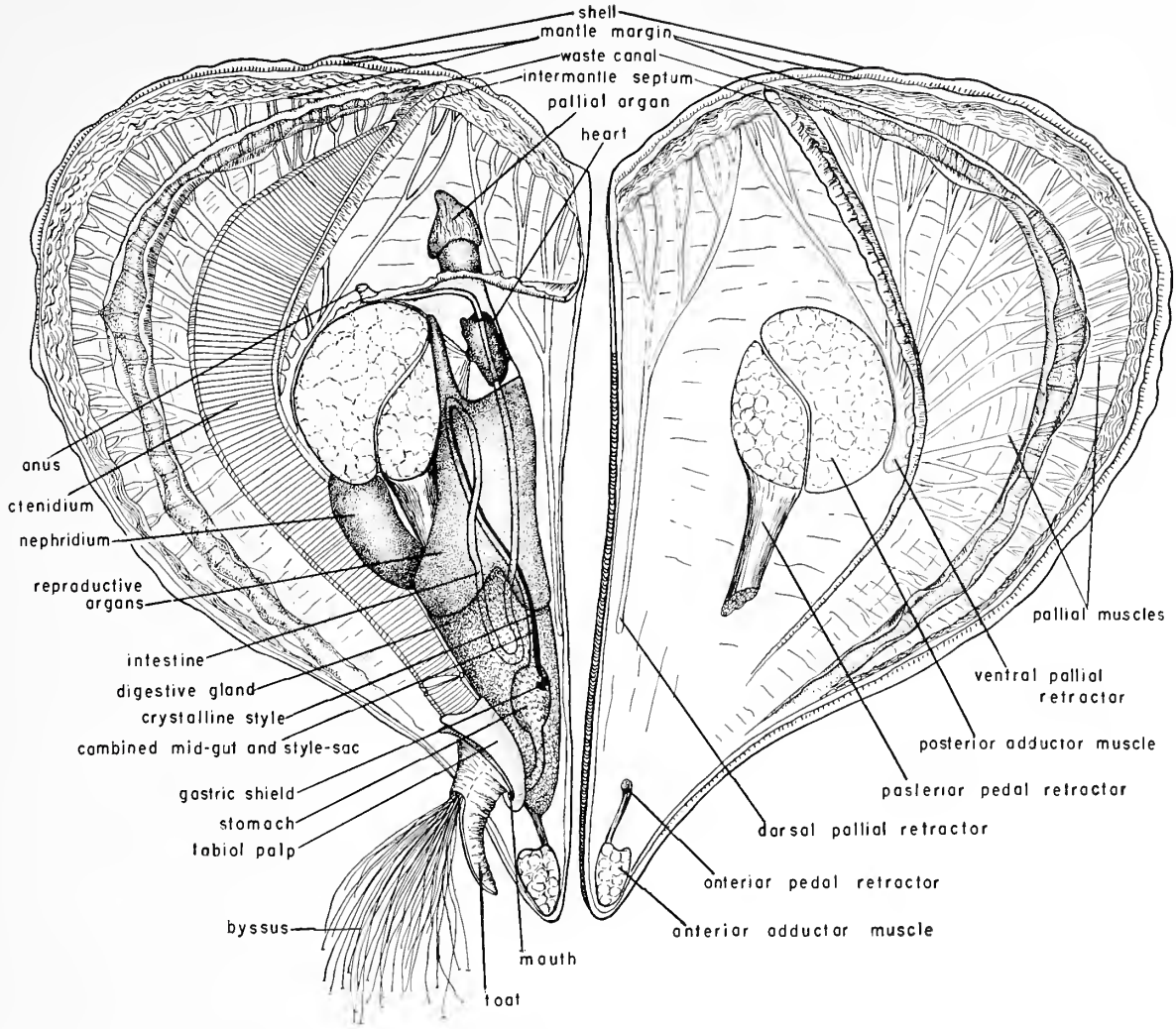


Plate 137. Semidiagrammatic drawing of the anatomy of *Atrina*. The right half shows only the muscles and characteristic features of the mantle (from Johnsonia, vol. 3, no. 38, pl. 152).

all parts of the world's oceans. Today's distributions are a reflection of those of former species, some of which may have had wider, others smaller, ranges.

Despite the world-wide distribution of *Atrina*, *Servatrina* and *Pinna* throughout today's distinct faunal regions, there is a remarkable similarity in the morphological characters among the species of each group. Some of the Recent species probably evolved from forms which had continuous distributions during the Mesozoic or possibly the early Cenozoic. One genus, *Streptopinna*, is limited to the tropical Indo-Pacific and appears to be a more recent development, probably during the late Tertiary. The gastropod genus *Lambis* (Strombidae) and the pelecypod genus *Tridacna*, both known only from the Indo-Pacific, have analogous histories.

Within the genus *Pinna* there are two types of species groups, those which are limited to one province, such as the Indo-Pacific, and those which extend across two or more provinces either as subspecies or very closely related allopatric species. To the former group belong *P. muricata* (widespread in the Indo-Pacific only), *bicolor* (Indian Ocean, Western Pacific and Hawaii), and *incurva* (India to northern Australia). They appear to have no analogues in other Recent seas.

Of the pandemic groups of *Pinna*, species which extend through several faunal provinces, one is *P. rudis* Linné of the tropical Eastern Atlantic and Caribbean and its Eastern Pacific analogue, *P. rugosa* Sowerby. The latter may well be considered by some workers as a geographic subspecies of *rudis*. Another example is the Eastern Atlantic *P. nobilis* Linné and its Western Atlantic analogue, *P. carnea* Gmelin. These two species are certainly

speeifieally distinet but show marked similarities in details of the nacreous pattern.

Members of the subgenus *Servatrina* of the genus *Atrina* in distant parts of the world may closely resemble each other. The shells of *A. seminuda* (Lamarck) and *A. serrata* (Sowerby) of the Western Atlantic are almost inseparable from some specimens of *A. pectinata* (Linné) of the Indo-Pacifie. It is of interest to note that while *seminuda* and *serrata* are easily separable in the Western Atlantie, phenotypes somewhat resembling both Atlantic speeies appear to intergrade in *pectinata* in the Indo-Pacifie. Young specimens of *Atrina maura* (Sowerby) of the Eastern Paeifie also resemble *seminuda*, *serrata* and *pectinata* but become more lamellosely seulptured as adults and quite distinct.

Atrina fragilis Pennant of Europe and *A. chautardi* (Nicklés) of West Afriea are apparently the only members of *Atrina s.s.* present in the Eastern Atlantic. The species are quite convergent and both somewhat resemble *A. squamifera* (Sowerby) of South Afriea. The three may have had a continuous distribution in the past (see Remarks under *A. squamifera*). There is a greater degree of spinosity in *squamifera* and *chautardi* than in *fragilis* but the latter appears to attain a larger size. Speeimens of *chautardi* have not been available for eomparison; however, the nacreous patterns of the other two are similar.

Atrina rigida (Solander) of the Western Atlantie may be eonsidered the analogue of *A. tuberculosa* (Sowerby) of the Eastern Paeific, although the shell of the latter beeomes larger and heavier. Both are elosely related to *A. vexillum* (Born), a widely distributed Indo-Pacific speeies. All three are heavy, with dark pigmentation, either spinose or smooth, and exhibit a similar naereous pattern with very large posteriorly protruding musele sears. Certain features peculiar to each of these speeies, undoubtedly brought about through isolation, serve to distinguish them.

The world distribution of living Pinnidae is summarized in Table 1.

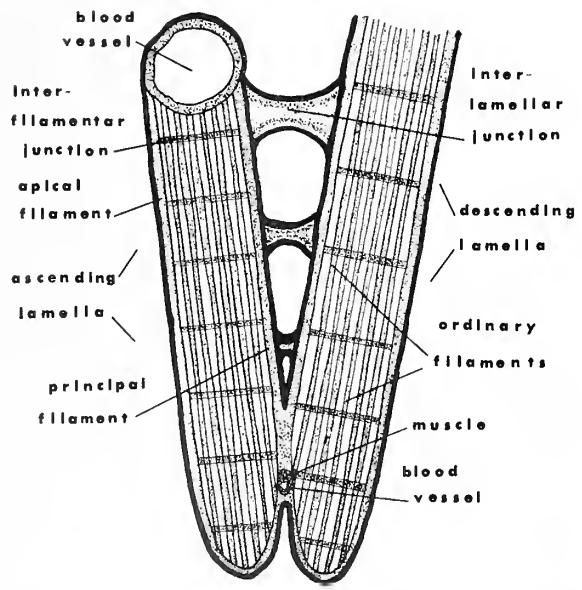


Plate 138. Diagrammatic sketch of gill of *Pinna*. Vertical section of outer demibraneh, one-half plica in thickness (looking down on long axis of gill; after Ridewood, 1903, fig. 17).

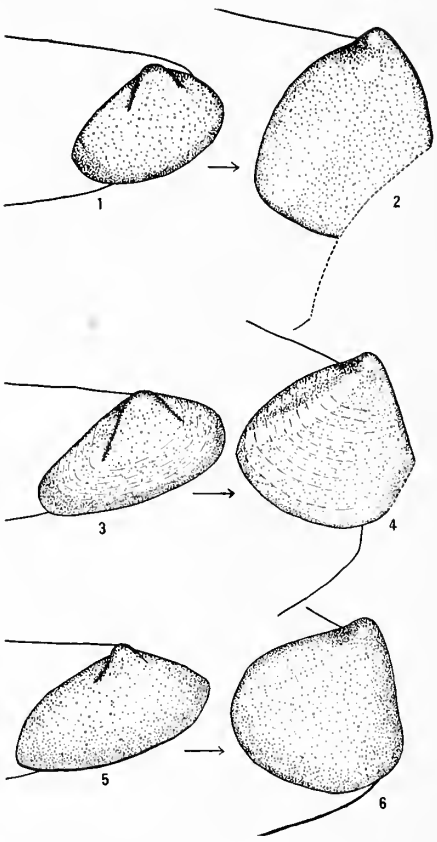


Plate 139. Embryonic valves of Indo-Pacific Pinnidae. Figs. 1-2. *Pinna muricata* Linné from Long Reef, New South Wales, Australia (0.5 mm. in length). Figs. 3-4. *Atrina vexillum* (Born), from Auau Channel, Hawaii (21-28 fathoms) (0.5 mm. in length). Figs. 5-6. *Atrina pectinata* (Linné), from Nagasaki, Japan (107 fathoms) (1.0 mm. in length).

Table 1. *World Distribution of Living Pinnidae*

	Indo-Pacific	East Pacific	West Atlantic	East Atlantic	South Africa
Pinna	*muricata* *bicolor* *incurva*	*rugosa*	*rudis* *carnea*	*rudis* *nobilis*	
Atrina	*vexillum*	*tuberculosa*	*rigida*	*fragilis* *chantardi*	*squamifera*
Servatrina	*pectinata* *zelandica* *tasmanica*	*maura*	*serrata* *seminuda*		
Streptopinna	*saccata*				

Origin and Distribution of Indo-Pacific Pinnidae – It is probably impossible to determine the place of origin of the family Pinnidae because it is an old group whose most ancient ancestors have never been found. On the basis of the distribution of Recent Indo-Pacific species, it would appear that the Western Pacific might have been the place of origin, as it is here that two-thirds of the species are found. However, this information may be misleading. Now, and undoubtedly in the past, the largest number of species in most groups have thrived where their particular ecological requirements are met most efficiently. Given time, any species having a pelagic larva can probably reach any location in the oceans. However, conditions must be ideal for these migrants to become established. This, of course, limits many species which have narrow ecological requirements.

Arguments of Ladd (1960) and Abbott (1960) respectively suggest a nearly mid-Pacific and extreme western Pacific origin for several groups of mollusks. It is probable that, through time, both areas have served this purpose. In recent geologic time the mid-Pacific islands have been nearly inundated, and rich mineral and organic constituents are lacking which could supply the necessary ecological requirements for some species. The western Pacific is a rich area ecologically and probably has been so for a very long time, supplying an abundance of nutrient materials for the food chain. This may explain the accumulation of species in the latter area, as it no doubt attracts and holds species which arrive there. This does not eliminate more easterly islands as places of origin since, in the past, there is evidence that these also supported a large fauna.

In the case of the Pinnidae, those species whose ranges extend from Africa to Polynesia *(P. muricata; A. vexillum;* and *Streptopinna saccata)* probably have sufficiently broad ecological tolerances permitting them to live not only in rich continental seas but also on the shores of coral islands. *Pinna muricata*, however, seems to grow most rapidly and attain a larger size in the western Pacific (Mariveles Bay, Philippines). The rest of the Indo-Pacific Pinnidae are limited to continental areas or the larger islands.

Pinna bicolor Gmelin is limited to the western Pacific and Indian Oceans. It is the only *Pinna* which is found in Victoria and South Australia, no other member of the genus extending any farther south than New South Wales. It inhabits the high islands from southern Japan to New Caledonia but does not inhabit the low coral atolls of the mid-Pacific. It is found westward from the high islands into the Indian Ocean to the east coast of Africa and the Red Sea. It was recently found in Hawaii. Young specimens were, perhaps accidentally, transported there, and it is doubtful whether or not the species will survive in Hawaiian waters.

The scanty locality data for *Pinna incurva* Gmelin, from the literature and specimens examined, indicate that its range is relatively narrow in southeast Asia, extending from India to Queensland, Australia, and north to the Philippines.

Species of *Atrina*, other than the widespread *vexillum*, have more limited ranges. *Atrina pectinata* (Linné) is the most ubiquitous of these remaining species, its range extending from the coast of India to Queensland and north to southern Japan. This species evidently has not invaded the low atolls of the mid-Pacific.

Atrina pectinata zelandica (Gray) is limited in its distribution to New Zealand; *A. tasmanica* (Teni-

son-Woods) to Tasmania, Victoria, South Australia and New South Wales; *A. squamifera* (Sowerby) to South Africa. It is of interest to note that these last three species have extended beyond the warm Indo-Pacific faunal provinces into cooler waters and occupy widely separated geographic positions. Although not properly members of the Indo-Pacific fauna, they are included here to complete the family for the area.

Doubtful Species of Pinnidae

Most of the specific names in the Pinnidae were treated in Winckworth's catalogues (1929, 1936). He cited several nude names but the following were not included.

1931 *Pinna striolata* 'Turton' Sherborn, Index Animalium, section 2, part 25, p. 6204 [nomen nudum]; error for *Anomia striolata* Turton, 1822.

1933 *Pinna italicus* Sherborn, ibid., part 32, p. 842 [nomen nudum].

The doubtful species listed below in some cases provide additional information to that given by Winckworth. Hedley (1924) also listed erroneous species recorded from Australia.

Pinna rotundata Linné, 1758

Range — Mediterranean?

Remarks — Hanley (1855) and Winckworth (1929) considered *rotundata* unrecognizable; Dodge (1952) felt it suggested *Pinna nobilis* Linné of the Mediterranean. Gualtieri's plate 79, fig. C, to which Linné referred is too vague for certain placement of this species. The immature shell figured could be that of any young *Pinna*.

Synonymy —

1758 *Pinna rotundata* Linné, Systema Naturae, ed. 10, p. 707 (O. meridionali); refers to Gualtieri, pl. 79, fig. C.

Pinna digitiformis Linné, 1758

Range — Indo-Pacific?

Remarks — Hanley (1855, p. 153) supposed this to be a pteropod; Winckworth (1929, p. 291) guessed it was a brachiopod. I concur with Dodge (1952, p. 230) that the species is unrecognizable and should be eliminated from further conjecture.

Synonymy —

1758 *Pinna digitiformis* Linné, Systema Naturae, ed. 10, p. 708 (O. Indico).

Pinna lobata Linné, 1758

Range — Indo-Pacific?

Remarks — As in the case of *P. digitiformis* it is doubtful whether *P. lobata* is a bivalve. The species is unrecognizable (see Hanley, 1955; Winckworth, 1929; Dodge, 1952).

Synonymy —

1758 *Pinna lobata* Linné, Systema Naturae, ed. 10, p. 708 (O. Indico).

Pinna pennacea Linné, 1758

Range — Unknown.

Remarks — This is the pen of a cuttlefish (Cephalopoda). It was first described as a *Pinna* with reservations, but removed from this group (Linné, 1767) and placed in *Sepia* (see Hanley, Winckworth and Dodge).

Synonymy —

1758 *Pinna pennacea* Linné, Systema Naturae, ed. 10, p. 708 (no locality); 1767, ibid., ed. 12, p. 1090.

Pinna sanguinea Gmelin, 1791

Range — Unknown.

Remarks — Gmelin himself questioned the validity of this species. Winckworth (1929, p. 295) suggested that *P. sanguinea* might be *P. nobilis* Linné of the Mediterranean. However, I agree with him that Gualtieri's pl. 79, fig. B, which was cited by Gmelin, is a doubtful figure, and I consider *sanguinea* unrecognizable.

Synonymy —

1791 *Pinna sanguinea* Gmelin, Systema Naturae, ed. 13, p. 3367 (no locality given).

Pinna bullata Gmelin, 1791

Range — Unknown.

Remarks — The plate reference given for this species by Gmelin was Gualtieri, pl. 79, fig. C, which was also cited for *P. rotundata* Linné. In agreement with Gmelin ("an distincta a reliquis species?"), Hanley (1855) and Winckworth (1929) considered *P. bullata* as unrecognizable. Reeve's (1858, pl. 9, fig. 16) figure is probably *P. bicolor* from the Moluccas.

Synonymy —

1791 *Pinna bullata* Gmelin, Systema Naturae, ed. 13, p. 3367 (no locality given); refers to Gualtieri, pl. 79, fig. C.

Pinna deflecta Perry, 1811

Range — Unknown; Indo-Pacific?

Remarks — The figure in Perry appears doubtful and could represent more than one Indo-Pacific *Pinna*. The species is unrecognizable.

Synonymy —

1811 *Pinna deflecta* Perry, Conchology, pl. 61, **Pinna**, fig. 2 (no locality given).

Pinna marginata Lamarck, 1819

Range — Unknown.

Remarks — Lamarck had no specimens of *marginata*, but referred to the same plate in Gualtieri (pl. 79, fig. C) cited for *P. rotundata* Linné and *P. bullata* Gmelin. Winckworth (1929) allied *marginata* with *bullata* Gmelin and called the latter a synonym of *rotundata*. *Pinna rotundata* was unidentified at that time and remains so. The species is unrecognizable.

Synonymy —

1819 *Pinna marginata* Lamarck, Histoire Naturelle des Animaux sans Vertèbres, vol. 6, part 1, p. 132 (no locality given); refers to Gualtieri, pl. 79, fig. C, and to *Pinna bullata* Gmelin.

Pinna sanguinolenta Reeve, 1859

Range — Unknown; Indo-Pacific?

Remarks — The outward appearance and red coloration of this species are reminiscent of *P. carnea* Gmelin. A photograph of the valve of the type in the British Museum (N.H.) shows an immature specimen with a nacreous pattern similar to that of *P. bicolor*. Because of the lack of locality data it seems best to leave this species in a doubtful category until proof is available of its identity.

Synonymy —

1859 *Pinna sanguinolenta* Reeve, Conchologia Iconica, vol. 11, **Pinna**, pl. 33, fig. 62 (no locality given).

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Genus Pinna Linné, 1758

Type: *Pinna rudis* Linné, 1758

This genus includes all of the pen-shells which have the internal nacreous layer divided into two portions by a longitudinal sulcus. Its species are world-wide in distribution in tropical and subtropical seas.

Several generic names have been proposed for apparently different morphological and geographical groups of *Pinna*. They are here considered synonyms of *Pinna*. The descriptions of the last three (see synonymy of *Pinna*) were prompted by the great degree of ecologically-caused phenotypic variation shown by the species of this group. *Quantulopinna, Subitopinna* and *Exitopinna*, all Iredale, 1939, are "geographical genera" erected for the Australian forms of widespread Indo-Pacific species. Their types are assignable respectively to an arrested specimen of *P. muricata;* a "normal" *P. bicolor* and an abnormal *P. bicolor* (*"Exitopinna deltodes ultra"* Iredale). *Cyrtopinna* Mörch is monotypic for *Pinna incurva* Gmelin, an attenuate species from southeast Asia and, although this species is quite distinct, it does not warrant treatment in a separate genus with present available information.

Three Recent and four Tertiary species from the Indo-Pacific are considered here.

Description — Shell reaching a large size, up to 700 mm. (about 28 inches) in length in some species; wedge-shaped, generally fragile in structure and sculptured with radiating ribs which may bear spines or imbrications. Nacreous layer divided by a longitudinal sulcus into dorsal and ventral lobes. Posterior adductor muscle scar usually completely enclosed within dorsal lobe.

Synonymy —

1758 *Pinna* Linné, Systema Naturae, ed. 10, p. 707. Type by subsequent selection (Children, 1823; also see Eames, 1951, Phil. Trans. R. Soc., London, vol. 235 (B), p. 339; Turner and Rosewater, 1958, pp. 301-303): *Pinna rudis* Linné, 1758.

1791 *Chimaera* Poli, Testacea Utriusque Siciliae, vol. 1, p. 31. Type by subsequent selection, (Winckworth, 1929): *Pinna nobilis* Linné.

1795 *Chimaeroderma* Poli, Testacea Utriusque Siciliae, vol. 2, p. 259. Type by subsequent selection (Turner and Rosewater, 1958, p. 301): *Pinna nobilis* Linné.

1806 *Pinnarius* Duméril, Zoologie Analytique, pp. 169, 340; Iredale, 1939, Great Barrier Reef Expedition Scientific Reports, vol. 5, p. 309 [new name for *Pinna* Linné].

1815 *Pinnula* Rafinesque, Analyse de la Nature, ou tableau de l'Univers et des Corps Organises, Palerme, p. 147 [a substitute name for *Pinna* Linné].

1853 *Cyrtopinna* Mörch, Catalogus Conchyliorum Comes de Yoldi, part 2, p. 51. Type by monotypy: *Pinna incurvata* Chemnitz [= *P. incurva* Gmelin].

1939 *Quantulopinna* Iredale, Great Barrier Reef Expedition Scientific Reports, vol. 5, **Mollusca,** part 1, p. 310. Type by original designation: *Quantulopinna delsa* Iredale, 1939 [= *Pinna muricata* Linné].

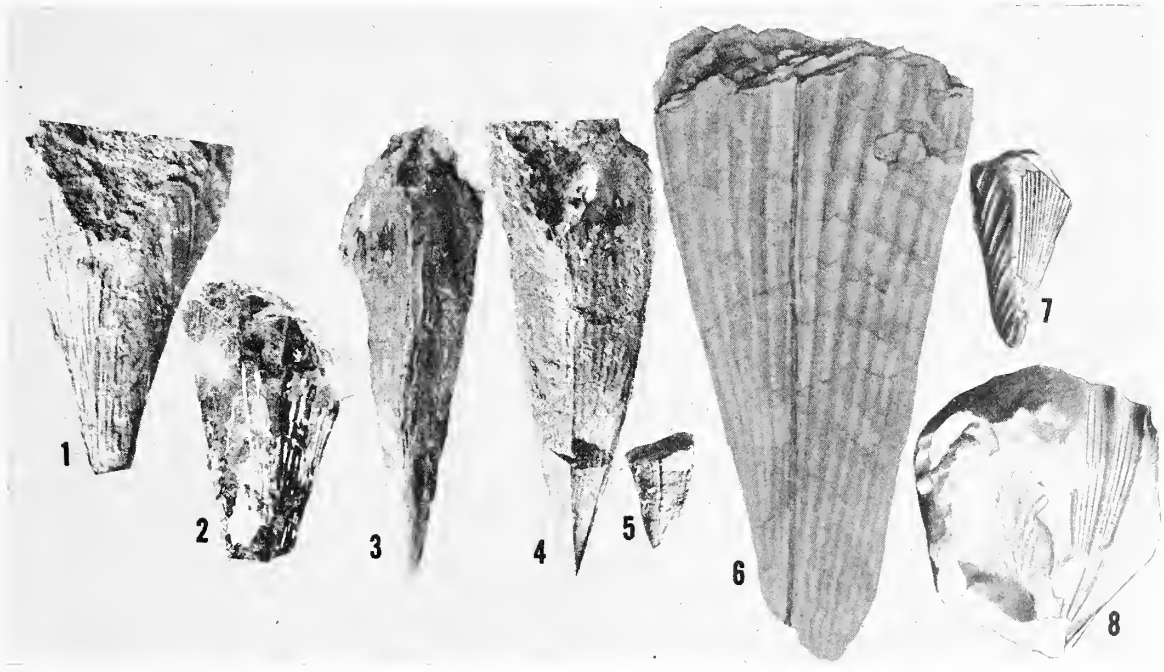

Plate 140. Figs. 1-5. *Pinna asakuraensis* Nagao. Hoshuyama-mura, Asakura-gun, Chikuzen, Kyushu, Japan. Eocene. Fig. 3 is holotype (all reduced ⅔, from Nagao, 1928, pl. 8, figs. 16, 18, 20, 20a, 21). Fig. 6. *Pinna rembangensis* Martin. Rembang, Java. Miocene. (nat. size, from Martin, 1910, pl. 51, fig. 73). Figs. 7-8. *Pinna punjabensis* Eames, Punjab and Kohat, Pakistan. Eocene. · ½. (Fig. 8. is *P. shekhanensis* Eames = *punjabensis;* from Eames, 1951, pl. 11, figs. 39a, 40).

1939 *Subitopinna* Iredale, ibid., p. 312. Type by original designation: *Pinna menkei* Reeve [= *P. bicolor* Gmelin].

1939 *Exitopinna* Iredale, ibid., p. 315. Type by original designation: *Exitopinna deltodes ultra* Iredale [= *P. bicolor* Gmelin].

Pinna asakuraensis Nagao, 1928

(Pl. 140, figs. 1-5)

Range — From the Tertiary of Japan, Lower Eocene, Island of Kyushu.

Remarks — This species is a true *Pinna* and is apparently more closely related to *P. muricata* in sculptural characteristics than to the other Recent species of Pinnidae. As mentioned by Nagao, *P. blanfordi* Boettger is "more slender and differently sculptured" and is here considered closer to *P. bicolor* Gmelin.

Synonymy —

1928 *Pinna asakuraensis* T. Nagao, Science Reports of Tôhoku Imperial University, Sendai, Japan, series 2 (Geology) vol. 12, no. 1, p. 31, pl. 8, figs. 16, 18, 20-22 [21] (Kawamagari Beds; Doshi and Hôshuyama Mines, Hôshuyama-mura, Asakura-gun, province of Chikuzen).

Pinna rembangensis Martin, 1910

(Pl. 140, fig. 6)

Range — Lower Miocene of Rembang, and West-Progo beds, Java, Indonesia (Van der Vlerk, 1931); also, questionably, from the Pliocene of Karikal, India (Cossmann, 1924, p. 93).

Remarks — From the appearance of the partial internal mold figured by Martin, *rembangensis* is closest in relationship to *Pinna muricata* Linné. It is impossible to assign with certainty the fragment figured by Cossman to this species.

Synonymy —

1910 *Pinna rembangensis* K. Martin, Sammlungen Des Geologischen Reichs-Museums In Leiden, Neue Folge, Bd. 1, 2 Abteilung, Heft 2, p. 357, pl. 51, fig. 73 (Rembang [Java]).

?1924 *Pinna* cf. *rembangensis* Martin, Cossmann, Journal de Conchyliologie, vol. 68, p. 92, figs. 21-22 (Pliocene, Karikal).

Pinna punjabensis Eames, 1951

(Pl. 140, figs. 7-8)

Range — From the Eocene of Pakistan.

Remarks — *Pinna punjabensis* has sculptural characteristics similar to *Pinna muricata* Linné and may be ancestral to that species. In spite of the differences pointed out by Eames in his description of *P. shekhanensis*, also from the Pakistan Eocene, it is probably a synonym of *punjabensis*. The figure of the former (Eames, 1951, pl. 11, fig. 40) represents a fossil probably consisting of portions of two valves and when so considered is much like *punjabensis*.

Synonymy —

1951 *Pinna punjabensis* Eames, Philosophical Transactions Royal Society of London, Series B, vol. 235, no. 627, p. 339, pl. 11, fig. 39 a, b (Ghazij Shales; south of Nila Kund, Dera Ghazi Khan District, Punjab (Pakistan)).

1951 *Pinna shekhanensis* Eames, ibid., p. 340, pl. 11, fig. 40 (Kohat area (Shekhan Nala section): Lower Shekhan Limestone (Pakistan)).

Pinna muricata Linné, 1758

(Pls. 139, 141-145)

Range — East Africa to eastern Polynesia.

Remarks — The Prickly Pen Shell owes its common name to the fairly fine, sharp spines which may be present on the radiating ribs on the exterior of the shell. These are a rather poor distinguishing character as they may be absent in this species, and other members of the family may exhibit them similarly. This species may be readily distinguished from other members of the genus in the Indo-Pacific by its exceedingly narrow longitudinal sulcus which brings the dorsal and ventral nacreous lobes into very close proximity. A specific character possibly related to the last is the overlapping of a small portion of the posterior adductor scar onto the ventral lobe of the nacreous area. This condition is unique in the genus *Pinna*, the posterior adductor scar usually being limited entirely to the dorsal nacreous lobe. The movement of the adductor muscle, and thus its scar, onto the ventral lobe appears to be an age-progressive phenomenon. Young specimens of *P. muricata* commonly do not exhibit it, while older ones usually do, even though they may be stunted and small.

The number of radiating ribs, usually 12 to 26, may also be a distinguishing character; *P. bicolor* usually has 8 to 17, except that occasionally the shells of injured specimens of *bicolor* which have regenerated may exhibit a higher number of ribs posteriorly; in *incurva* the ribs are obsolete. The characteristic of alternating smooth and spinose ribs mentioned by some authors in describing *muricata* and its synonyms is present in some specimens and absent in others (see also *Remarks* under *P. bicolor*).

Bruce (in litt., 1960) reported finding specimens of the shrimp *Anchistus custos* (Forskal, 1775) in the mantle cavity of *P. muricata* from Mazizini Bay, Zanzibar.

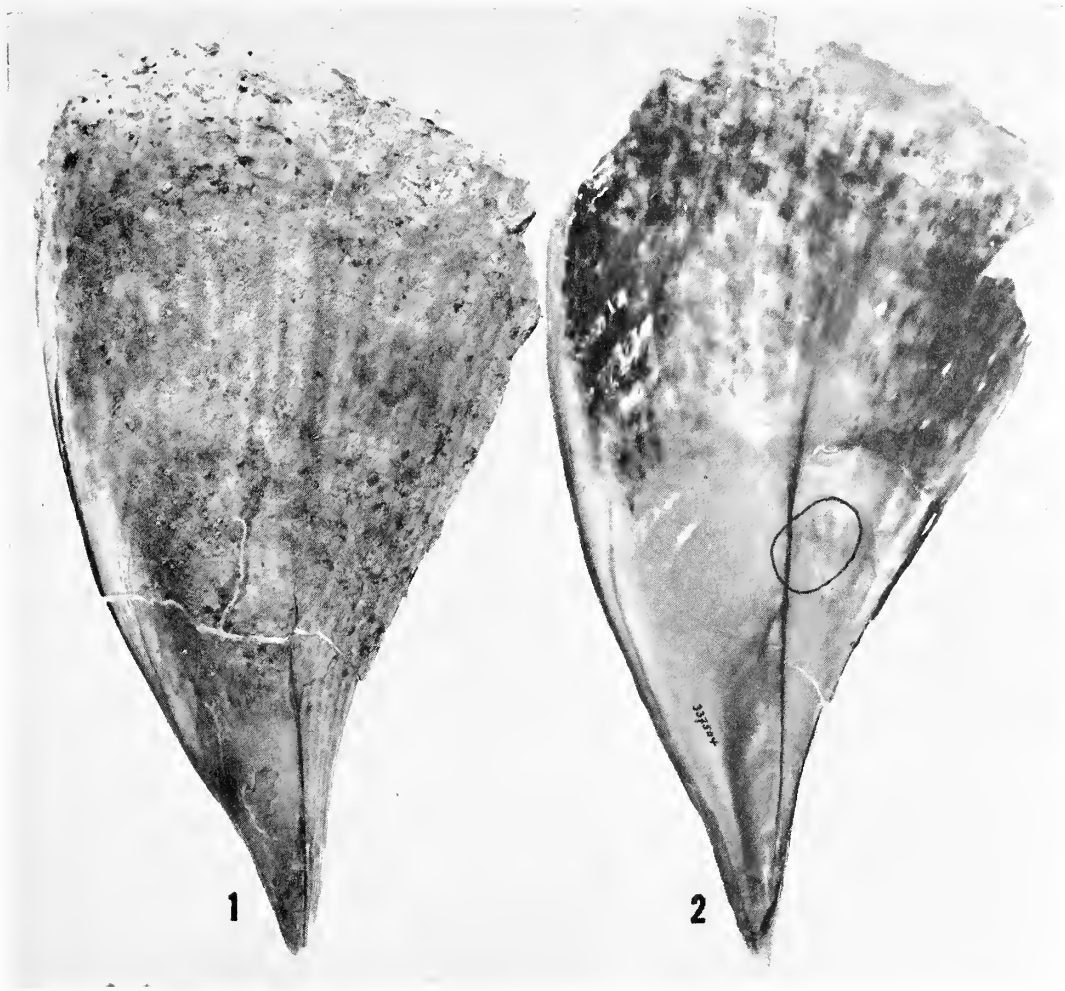

Plate 141. *Pinna muricata* Linné, Hilo, Hawaii. Fig. 1. Exterior of right valve. Fig. 2. Interior of left valve with posterior adductor muscle scar outlined in black. (reduced ½, Smithsonian Institution photo.)

Casts of fossil *Pinna* made available for my inspection by Dr. H. S. Ladd, U. S. Geological Survey, bear a striking resemblance to *P. muricata* Linné. They were found on Guam Island in the Mariana Limestone and are probably Pleistocene in age. Dr. Ladd (personal communication, March, 1960) suggested that the fossils are probably referrable to a present day species. These specimens are very probably *P. muricata*.

Habitat — *Pinna muricata* is most commonly found with only the posterior margin of the shell protruding from sand or silty mud among rocks, in eel grass sand flats, and in sandy patches on coral reefs, in shallow water from a few feet to two fathoms in depth. It has also been dredged alive from depths of 20 to 33 fathoms from sand and mud bottoms. Ecological data indicate that its toleration for fresh water at the mouths of rivers is fairly great.

Description — Shell reaching 311 mm. (about 12¼ inches) in length; attenuately triangular in shape, the posterior margin usually sharply truncate; moderately inflated, a specimen 155 mm. in length is about 25 mm. in thickness at the widest point; with a moderately weak longitudinal keel on the anterior half of the shell. Valves rather thin, appearing fragile and sculptured with radiating ribs. Shells translucent and usually light horn color, but often having few to many narrow, irregular, blotchy, radiating tan to dark reddish brown bands on the posterior half. Surface generally smooth and shining anteriorly where imbedded in substrate, but dull posteriorly where exposed, and sometimes coated with fine sandy mud. Radial sculpture consists of from about 12 to 26 radiating ribs limited to the posterior slope which often bear relatively few upright spines which are open posteriorly; ventral slope smooth or with obsolete ribs. There are often minor ribs occurring between the major spine-bearing ribs, together totaling the mentioned number. Concentric sculpture consists of quite fine

incremental lines which are transverse on the posterior slope, turning rapidly anteriorly on the ventral slope where they may form semilunar ridges of irregular occurrence. Posterior margin showing signs of repeated breakage and repair, usually truncate. Dorsal margin nearly straight to concave. Ventral margin broadly concave to convex and sometimes convex posteriorly and concave anteriorly. Interior of valves light horn color to faint yellowish green and sometimes with tinges of pinkish orange; posterior portion usually with brown to purplish black patches, smooth and glossy. Nacreous layer hardly iridescent, instead with a silvery or whitish veil, occupying the anterior one-half to three-quarters of the shell and divided along most of its length into two lobes by an especially narrow longitudinal sulcus. Dorsal lobe of nacreous layer extending farther posteriorly than ventral lobe. Both lobes rather squarely truncate to bluntly rounded posteriorly. Anterior adductor muscle scar small, subapical, situated a short distance anterior to the end of the longitudinal sulcus. Posterior adductor muscle scar subterminal on dorsal nacreous lobe, usually extending partially onto the ventral lobe. Primary hinge ligament thin, black, extending from the anterior end of the shell to the posterior border of the nacreous layer. Secondary ligament not colored, but evident in intact specimens whose dorsal margins are fused.

Embryonic valve about 0.5 mm. in length, rounded oval, not inflated; the umbos prominent, directed medially and slightly posteriorly (plate 139, figs. 1, 2). Posterior mantle margin grayish black with white markings in preserved specimens; "eyes of Will" darkly pigmented, but not conspicuous, widely spaced and located deep in the fold between the inner and middle mantle lobes (see Introduction: *Remarks on Anatomy*).

Measurements (mm.) —

length	width	
311	149	(large; Mariveles Bay, Philippines)
245	98	(large; Oahu, Hawaii)
215	115	(large; Hilo, Hawaii)
150	92	(average; Cocos-Keeling Atoll)
82	37	(small; Cagayan, Philippines)

Synonymy —

1758 *Pinna muricata* Linné, Systema Naturae, ed. 10, p. 707, (in M. Mediterraneo [Indo-Pacific]); refers to Rumphius Mus., pl. 46, fig. M., and others; not *P. muricata* 'Linné' Holmes, 1860 [= *Atrina serrata* Sowerby, Western Atlantic].

1786 *Pinna nebulosa* Solander, Catalogue of Portland Museum, pp. 16, 71 (nomen nudum); = *P. muricata* Linné, fide Dillwyn (1817) Descriptive Catalogue of Recent Shells, vol. 1, p. 238.

1786 *Pinna tenera* Solander, ibid., p. 61 (nomen nudum); = *P. papyracea* Gmelin [= *P. muricata* Linné] fide Dillwyn, loc. cit., p. 331.

1791 *Pinna papyracea* Gmelin, Systema Naturae, ed. 13, p. 3367 (Oceano indico); refers to Chemnitz, vol. 8, pl. 93, fig. 786.

1837 *Pinna semi-costata* Conrad, Journal Academy of Natural Sciences, Philadelphia, vol. 7, p. 245, pl. 20, fig. 11 (Sandwich Islands).

1843 *Pinna virgata* Menke, Molluscorum Novae Hollandiae Specimen, p. 36, (ad litus occidentale [Western Australia]).

1858 (April) *Pinna rumphii* 'Hanley' Reeve, Conchologia Iconica, vol. 11, **Pinna**, pl. 5, fig. 9 (Moluccas); Hanley [July] 1858, Proceedings Zoological Society of London, p. 136; Clessin, 1891, Conchylien Cabinet, vol. 8, part 1, Malleacea, p. 98, pl. 18, fig. 3.

1858 *Pinna philippinensis* 'Hanley' Reeve, ibid., pl. 11, fig. 20 (Philippine Islands); [attributed to Hanley in error].

1858 *Pinna zebuensis* Reeve, ibid., pl. 14, fig. 26 (Island of Zebu, Philippines).

1858 *Pinna semicostata* Reeve, ibid., pl. 16, fig. 30 (Philippine Islands).

1861 *Pinna trigonalis* Pease, Proceedings Zoological Society of London, p. 242 (Kingsmill [Gilbert] Islands); figured in von Martens and Langkavel (1871) Donum Bismarckianum, p. 64, pl. 4, fig. 7.

1866 *Pinna philippensis* 'Reeve' von Martens, Annals and Magazine of Natural History (3) vol. 17, p. 87 [error for *philippinensis* Reeve].

1866 *Pinna philippinarum* 'Reeve' von Martens, ibid. [error for *philippinensis* Reeve].

1880 *Pinna aequilatera* von Martens, Beiträge zur Meeresfauna der Insel Mauritius und der Seychellen: Mollusken, p. 317, pl. 22, fig. 4 (Mauritius); not *P. aequilatera* Weinkauff, 1867, Die Conchylien des Mittlemeeres, vol. 1, **Mollusca acephala,** p. 236 [= *P. nobilis* Linné].

1896 *Pinna cebuensis* 'Reeve' Elera, Catálogo Sistem. Fauna de Filipinas, vol. 3, p. 800 (Cebu) [error for *zebuensis* Reeve].

1932 *Pinna (Atrina) strangei* 'Reeve' Prashad (part) The Lamellibranchia of the Siboga Expedition, Systematic Part II.: Pelecypoda, p. 136, pl. 4, figs. 11-13 (southern Philippines and East Indies) [Prashad's figures are *P. muricata* Linné]; not *P. strangei* Reeve, 1858 [= *Atrina pectinata* Linné].

1938 *Pinna hawaiensis* Dall, Bartsch and Rehder, Bernice P. Bishop Mus. Bull. no. 153, p. 73, pl. 17, figs. 8-11 (dredged off Kaanapali, Maui, 4-8 fathoms [Hawaii]).

1938 *Pinna exquisita* Dall, Bartsch and Rehder, ibid., p. 75, pl. 17, figs. 1, 2 (Albatross Sta.: 3965, near Laysan Island [Hawaii] in 147-116 fathoms on coral sand bottom).

1939 *Quantulopinna delsa* Iredale, Great Barrier Reef Expedition Scientific Reports, vol. 5: Mollusca, part 1, p. 311, pl. 4, fig. 16 (Low Isles, Queensland).

1939 *Quantulopinna delsa howensis* Iredale, ibid., p. 311 (Lord Howe Island [New South Wales]).

Nomenclature — Linné (1758) listed as the type locality for *Pinna muricata*, "in M. Mediterraneo." Turner and Rosewater (1958, pp. 302-303) considered this problem and referred to pertinent discussions in the literature which show that this species is limited in its distribution to the Indo-Pacific. A possible explanation for Linné's error in assigning *muricata* to the Mediterranean may be traced to the reference under the original description in the

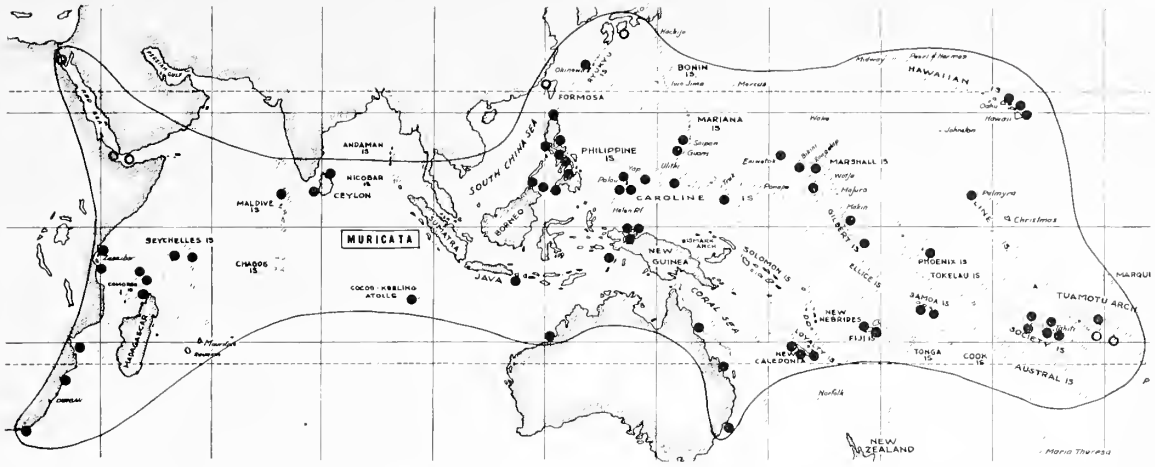

Plate 142. Geographical distribution of *Pinna muricata* Linné.

Systema Naturae to Lister, pl. 370, fig. 215 (1685). On consulting Lister, no such combination of table and figures can be found. Figure 215 (pl. 374) is a representation of *Pinna nobilis* Linné, duly inscribed by Lister: "mar med." Apparently, the figure to which Linné had intended to refer was 210 (pl. 370; the lower specimen, with the words, quoted by Linné, "Pinna tenuis striata muricata") which shows a reasonable likeness of *Pinna muricata* from the Indo-Pacific. The locality, Jamaica, given by Lister, for the figured specimen is also in error. This may account, also, for the several references to *muricata* in the West Indies which appear in the literature.

The holotype of *Pinna exquisita* Dall, Bartsch and Rehder is a unique specimen of this species described from a rather badly worn and partially broken shell dredged in Hawaiian waters. When considered apart from the range of morphological variation of the shell of *P. muricata* it may seem rather distinct. However, it is a young specimen which resembles certain other individuals of *muricata* of the same age. The unusually large number of ribs in this specimen are also present in other young *muricata* examined. The ribs may become indistinct as these individuals increase in size.

With some doubt, Winckworth (1929) considered *Pinna virgata* Menke to be a synonym of *P. atropurpurea* Sowerby (= *P. bicolor* Gmelin). Previously Hedley (1924) had proposed that *virgata* was a valid species and that its range extended to South Australia. Later, Winckworth (1936) appeared to follow this suggestion. Critical reading of Menke's original description reveals certain clues regarding the identity of *virgata*. The species was described as having rusty red, radiating stripes on the valves, having obsolete, radiating ribs which bear transverse series of prickly, short, arched spines; with straight dorsal and ventral margins; the posterior margin being oblique and arcuately truncate. Although this description is not as clear as could be hoped and Menke's types are not extant (Keen, 1958, p. viii), this species is almost certainly *Pinna muricata* Linné, whose range does not extend to South Australia, according to presently available records. The reddish lines, prickly valves and truncate posterior margin represent a combi-

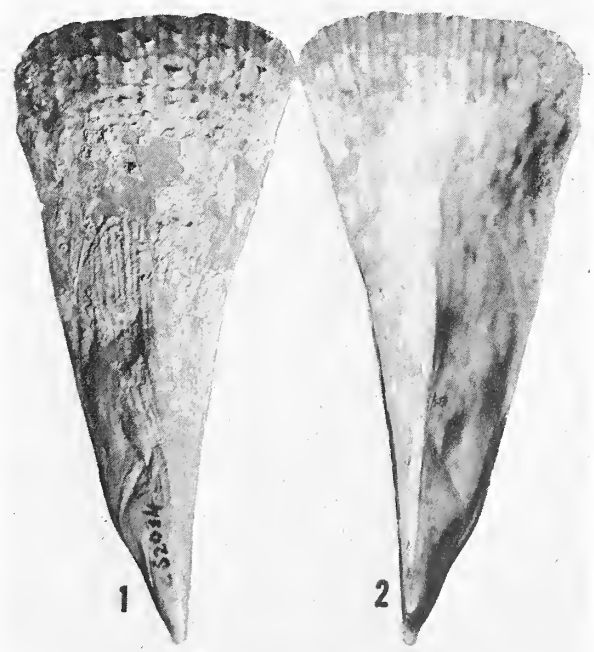

Plate 143. *Pinna muricata* Linné. Holotype of *Quantulopinna delsa* Iredale, Low Isles, Queensland. Fig. 1. Exterior of right valve. Fig. 2. Interior of left valve. (⅔ nat. size, Australian Museum photo.)

nation of characters not present in *P. bicolor*, but commonly found in specimens of *muricata*.

Winckworth (1929, p. 284) included *P. aequilatera* von Martens in the synonymy of *P. atropurpurea* (= *P. bicolor*). The figure (von Martens, 1880, pl. 22, fig. 4) clearly shows an average specimen of *P. muricata*, lacking spines but with characteristic coloration and a concave dorsal shell margin. Von Martens noted that *P. muricata* was similar to his species and gave the reference: Chemnitz, vol. 6 [8], fig. 779, which is also *muricata*.

Similar results were noted upon examination of photographs from the British Museum (N.H.) of the holotypes of *Pinna philippinensis* and *zebuensis* Reeve, i.e., formerly considered synonyms of *atropurpurea* by Winckworth, upon critical study they were found to be synonyms of *P. muricata*.

Pinna rumphii Reeve was considered by Winckworth to be a synonym of the apparently rare *P. incurva* Gmelin. A photograph of the holotype in the British Museum (N.H.) shows *rumphii* to be a young specimen of *P. muricata*.

Types — Since the whereabouts of the type specimen of *Pinna muricata* is apparently unknown, Rumphius pl. 46, fig. M is here selected as the type figure. A discussion of the type locality of *P. muricata* is given above under *Nomenclature* and is also thoroughly discussed by Dodge (1952, pp. 227-228), establishing the latter as an Indo-Pacific species. The type locality is here restricted to Amboina, Moluccas Islands, Indonesia, where the specimen figured by Rumphius was undoubtedly collected. The location of the type of *P. papyracea* Gmelin is not known. Chemnitz, vol. 8, pl. 93, fig. 786 is here selected as the type figure. The type of *P. semicostata* Conrad may be in the Academy of Natural Sciences, Philadelphia, although it could not be found during a recent search there. Types of species described by Reeve are in the British Museum (N.H.). The type of *Pinna virgata* Menke is presumed lost as is the balance of that author's type material (Keen, 1958, p. viii). The type locality of *P. virgata* is here restricted to La Grange Bay, Western Australia, a locality from which specimens are known to have been collected. The type of *P. aequilatera* von Martens is probably in the Berlin Museum. The holotypes of *Pinna hawaiensis* and *P. exquisita* Dall, Bartsch and Rehder are in the United States National Museum. Types of *Quantulopinna delsa* and *Q. delsa howensis* Iredale are in the Australian Museum, Sydney.

Lectotype Selection: Pinna trigonalis Pease was

Plate 144. *Pinna muricata* Linné, an example of the splendid, large phenotype named *philippinensis* by Reeve; Mariveles Bay, Bataan, Philippines. Fig. 1. Exterior of right valve. Fig. 2. Interior of left valve, the posterior adductor muscle scar outlined in black. (⅓ nat. size, Smithsonian Institution photo.)

Plate 145. *Pinna muricata*. Lectotype of *P. trigonalis* Pease, Kingsmill Islands, Gilbert Islands, Micronesia. Fig. 1. Exterior of right valve. Fig. 2. Interior of left valve. (reduced about ½, Smithsonian Institution photo.)

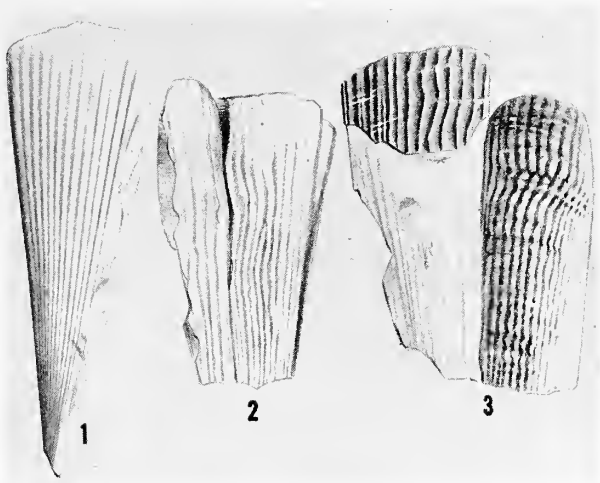

Plate 146. *Pinna blanfordi* Boettger. West Coast of Sumatra, Indonesia. Lower Eocene. (reduced ½, from Boettger, 1880, pl. 3, figs. 4-6; Smithsonian Institution photo.)

described from specimens collected in the Kingsmill [Gilbert] Islands, Micronesia. Although many of the Pease types are in the M.C.Z. the holotype of *trigonalis* is not. A syntype of *trigonalis* in the U.S.N.M. collection, received from Pease from the type locality, is here selected as lectotype; U.S.N.M. Catalogue number 41455; length 225 mm., width 82 mm. (plate 145, figs. 1, 2).

Selected Records (see accompanying map, pl. 142). Solid dots: specimens examined; open circles: literature records – SOUTH AFRICA: Port Alfred (MCZ). MOZAMBIQUE: Inhaca Id., Delagoa Bay (J. K. Howard, MCZ; ANSP). TANGANYIKA: Dar-es-Salaam (MCZ). ZANZIBAR: Chumbe Id. (NSF). RED SEA: Suez. GULF OF ADEN: Djibouti; Aden (all Lamy, 1928, p. 353). MADAGASCAR: Nossi Bé (MCZ). SEYCHELLES: Astove Id.; West North and Menai Islands, Cosmoledo Atoll (all A. J. Kohn, Peabody Mus., Yale Univ.); Mahé Id. (MCZ; A. J. Kohn and W. D. Hartman, Peabody Mus., Yale Univ.); Frigate Id. (Peabody Mus., Yale Univ.). MALDIVE ISLANDS: Donikolu Id., South Malosmadulu Atoll (A. J. Kohn, Peabody Mus., Yale Univ.) CEYLON: Hikkaduwa (G. F. Kline, ANSP; MCZ); Kacheri, Powder Bay, Trincomali (G. F. Kline, ANSP). JAPAN: Shikoku (Habe, 1953a, p. 186). RYUKYU ISLANDS: Naga, Okinawa Id. (MCZ; USNM; ANSP). PHILIPPINES: many localities (see map; ANSP; USNM; MCZ). INDONESIA: Kilsium, off west coast Kei Ids. (MCZ, ex. Siboga Expedition); Koeta Bay, Bali (MCZ). COCOS-KEELING ISLANDS: Cocos-Keeling Atoll (USNM). AUSTRALIA: False Cape Bossuit, La Grange Bay, Western Australia (ANSP); Capricorn Group, Queensland, Long Reef [north of Sydney], New South Wales (both J. Kerslake; USNM). NEW GUINEA: Mios Workbondi Ids., Schouten Ids. (NSF; MCZ). NEW CALEDONIA: Plage de Poe, Bourail (NSF). FIJI: Suva, Viti Levu (USNM). MARIANA ISLANDS: Saipan (USNM); Guam (NSF). PALAU IDS.: Babelthaup Id. (NSF). CAROLINES: Ifaluk Atoll (F. M. Bayer, USNM); Kutu Id. Satawan Atoll (USNM). MARSHALLS: Bikini Atoll and others (see map) (USNM). GILBERTS: Apemama (USNM). HAWAII: Kaneohe Bay, Oahu (C. M. Burgess, USNM). LINE ISLANDS: Palmyra Id. (MCZ; USNM). PHOENIX IDS.: Hull Id. (USNM). SAMOA: Tutuila Id. (USNM). SOCIETY IDS.: west of Mount Tahara, District of Mahina, Tahiti (R. Robertson, ANSP). TUAMOTU IDS.: south end Oneroa Id., Raroia Atoll (J. P. E. Morrison, USNM); Hao and Vahitahi Atolls (both Dautzenberg and Bouge, 1933, p. 434).

Fossil Records – Yokoyama (1923, Japanese Journ. Geol. and Geogr., vol. 2, no. 3, p. 57, pl. 6, fig. 15) reported a "fragment of a beak-portion with several distinct radiating riblets" which is probably referrable to *P. muricata:* Lower Pliocene, coast of Takinai, Kii, Japan. Fossils of this species have also been found on Guam Island in the Mariana Limestone and are of Pleistocene age (see *Remarks*).

Pinna blanfordi Boettger, 1880

(Pl. 146)

Range – Lower Eocene of Sumatra, Indonesia.

Remarks – This species was considered to be distinct from *Atrina vexillum* by Boettger, and it does seem to be a true *Pinna.* It is probably more closely related to *P. bicolor* than to either *muricata* or *incurva.*

Synonymy –

1880 *Pinna blanfordi*, O. Boettger, In Verbeek, R. D. M., O. Boettger und von Fritsch, K., Palaeontographica, Supplement III., Lief. 8-9, Teil 1, p. 48, pl. 3, figs. 4-6 (untereocänen Plattenkalken von Locrah Tambang bei Boekiet Bessi [west coast, Sumatra]).

Pinna bicolor Gmelin, 1791

(Pls. 147-153)

Range – East Africa to Melanesia, including southern Japan, the Philippines and Australia; Hawaii.

Remarks – It may be surprising to find the name *P. atropurpurea* included in the synonymy of *P. bicolor.* However, examination of as large a series of shells as possible from different localities throughout the range of these "species" has convinced me that they merge. The two forms are represented in plates 147 and 148. "Typical" *bicolor* seems to be more prevalent in the western Indian Ocean with the "*atropurpurea*" form becoming more common further east, although mixtures seem to occur. Examination of large series from single localities ("*menkei*" from Australia; "*atropurpurea*" from the Philippines) shows a uniformity of characters in specimens from any one place. This may indicate that the species has a short larval life and opportunities for exchange of genetic material between far flung localities is nearly prohibited. If this is so, it may serve as a partial explanation for the apparent considerable variation between different populations of *Pinna bicolor.*

Due to the effects of the physical environment which subject the shell to breakage, often followed by abnormal regrowth and repair, the substrate upon which the animal settles and the degree to which it is imbedded, a relatively broad or narrow

Plate 147. *Pinna bicolor* Gmelin, northeast end Maroepi Id., Ambai Group, northwest Dutch New Guinea. Specimen is 375 mm. (15 inches) in length. Fig. 1. Exterior of left valve. Fig. 2. Interior of right valve. (Smithsonian Institution photo.)

shell with a variety of sculptural patterns may result. The coloration of the shell is also highly variable sometimes being dark brownish purple but often light horn color or of alternating bands of both colors—possibly reflecting differences in available food, chemical composition of the sea water or minor genetic variation.

A degree of morphological stability is evident in *Pinna bicolor* amid the array of shell variation in this species. The animal within a shell looking much like "*atropurpurea*," from New South Wales, is nearly identical to one from Hong Kong, the latter having a shell more similar to the narrower, light horn form of *bicolor*. Furthermore, both specimens possess large "eyes of Will" protruding from their mantle edges.

Pinna bicolor differs from *muricata* in having a rounded posterior margin, rather than a truncate one; in having the ventral nacreous arca rounded, rather than somewhat truncate; in usually having 8 to 17 radiating ribs, rather than 12 to 26; and in usually being bluish black with radial rays, rather than being light horn to tan. The "eyes of Will" are conspicuous and closely spaced in the mantle of *bicolor*, while in *muricata* they are inconspicuous and widely spaced.

Pinna bicolor may also be distinguished from *P. incurva* Gmelin on the basis of shell characters: shape, sculpture, color, transverse growth lines and the nacreous patches (see descriptions).

Holthuis (1952) from quoted sources noted the

presenee of the palaemonoid shrimps, *Anchistus custos* (Forskal) and *Conchodytes biunguiculatus* (Paulson) in the mantle cavity of *P. bicolor* from the Andaman Islands (see Kemp, 1922). *Anchistus custos* was also noted in *P. madida* Reeve [= *P. bicolor*] from Bowen, Queensland. Bruce (in litt., 1960) found specimens of the shrimp, *Paranchistus ornatus* Holthuis, in the mantle cavity of *Pinna bicolor* from Mazizini Bay, Zanzibar.

For some reason, perhaps related to ecological tolerances, *bicolor* appears to be limited in its distribution to the shores of larger land masses or to the islands in elose proximity to continental areas. In this respect it differs from *muricata* whose distribution includes oeeanie islands. The sporadic appearanee of *P. bicolor* in Hawaii is probably the result of chanee introduction.

Habitat — Imbedded in muddy sand and reef flats, in shallow water of 1 to 2 fathoms in depth.

Description — Shell reaching 495 mm. (about 19 inches) in length; broadly to attenuately triangular in shape, the posterior margin varying from nearly truneate to more or less evenly eonvex-rounded and sometimes dorsally eonvex and sloping ventrally; moderately inflated, a speeimen 255 mm. in length is about 35 mm. in thickness at its widest point; with a moderately strong longitudinal keel on the anterior half of shell. Valves varying from rather heavy and thick in large specimens to rather thin and fragile in smaller individuals, seulptured with radiating ribs. Shells translucent and varying from light horn color to dark purplish brown, often with radiating bands of alternating dark and light color (particularly conspicuous near the posterior border in older speeimens) sometimes interrupted, giving the eolor pattern a eoncentric appearanee. Surface of valves generally smooth and shining anteriorly where imbedded in substrate, but dull posteriorly and often enerusted with eoralline algae, eoral, other organisms and debris. Radial seulpture eonsists of from about 8 to 17 fairly well defined radiating ribs whieh may beeome nearly obsolete and whieh posteriorly may bear a few flat to tubular spines, in some speeimens approaehing a lamellose eondition; spines usually nearly obsolete exeept near the posterior margin. Concentrie seulpture consisting of fine growth lines whieh are bowed posteriorly and then slope anteriorly toward the ventral margin. Posterior margin often showing signs of repeated breakage followed by rough repair presenting a greatly thickened margin; although this may be entirely absent in speeimens whieh apparently grow in sheltered areas; outline as stated above. Dorsal margin usually straight, but may be only slightly convex to moderately eoneave. Ventral margin often duplieating dorsal margin as the arms of an inverted isoseeles triangle, but sometimes convex posteriorly and eoneave anteriorly, almost forming an upright but flattened sigmoid eurve. Interior of valves light smoky horn to dark purplish brown in eolor, often with the radiating bands of alternating dark and light showing through; surfaee smooth and glossy. Naereous area iridescent, roughly oeeupying the anterior half of the shell and is divided along most of its length by a longitudinal suleus. Dorsal and ventral lobes of the nacreous area moderately well separated, the interlobe distanee especially varying posteriorly. Dorsal lobe of naereous area usually extends farther posteriorly than ventral lobe near the sulcus, its posterior margin truncate to slightly oblique. The ventral lobe may extend obliquely farther posteriorly near the ventral margin or is sometimes (aberrantly) unevenly truneate and shorter than the dorsal lobe. Anterior adduetor musele sear small to

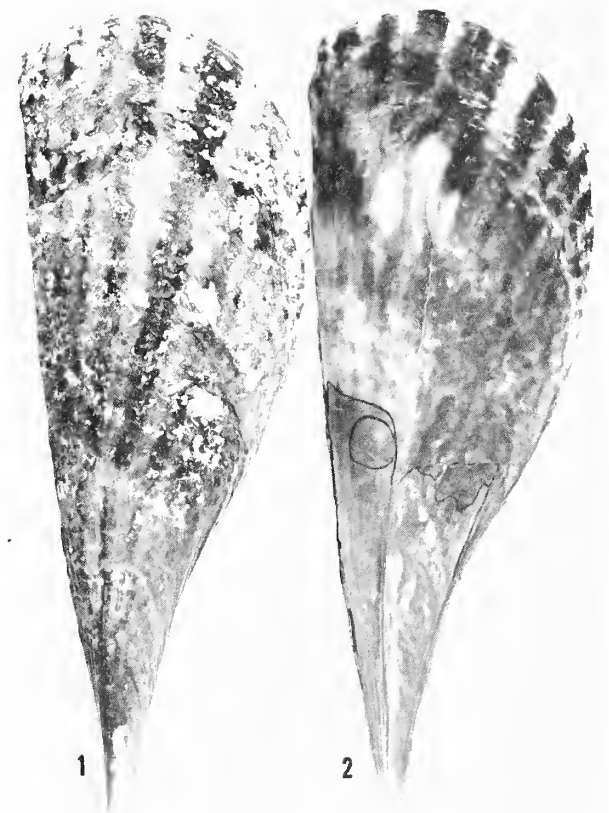

Plate 148. *Pinna bicolor* Gmelin, Ambariotelo, between Nossi Bé and Nossi Komba, Madagascar. Fig. 1. Exterior of left valve. Fig. 2. Interior of right valve; actual posterior border of ventral nacreous lobe outlined by solid black irregular line; broken line indicates probable normal appearance. (⅓ nat. size, Smithsonian Institution photo.)

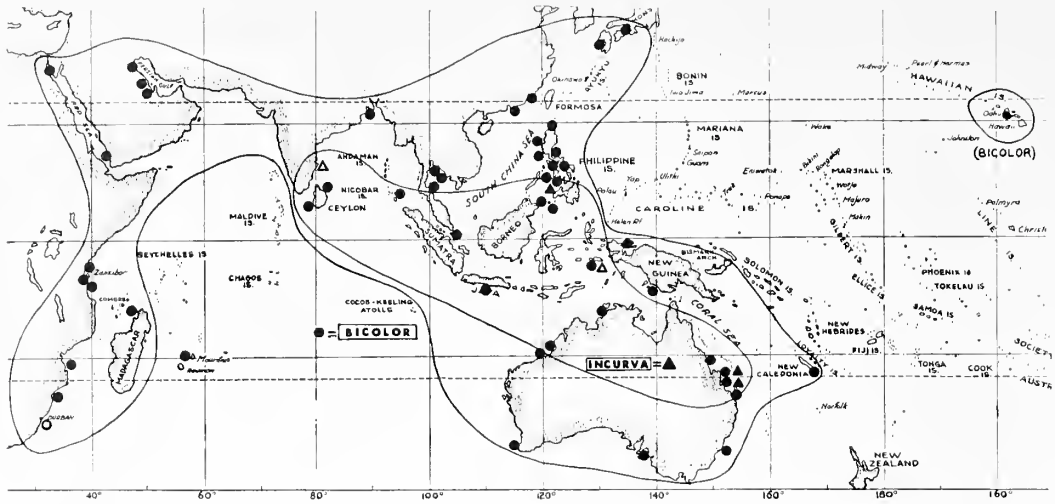

Plate 149. Geographical distributions of *Pinna bicolor* Gmelin (solid dots and circles) and *Pinna incurva* Gmelin (triangles).

moderate in size; subapical, located just anterior to end of longitudinal sulcus. Posterior adductor scar moderately large, subterminal, on ventral half of dorsal lobe; never extending onto ventral lobe. Primary hinge ligament moderately thick, black; extending from the anterior end of shell to near the posterior border of the nacreous layer. Secondary hinge ligament not colored, but evident in intact specimens whose dorsal margins are fused.

Ovary of ripe female a vivid pinkish red; digestive gland green (Personal communication D. F. McMichael, Australian Museum); upon examination of preserved animal collected from Sydney Harbor, N.S.W., in February, 1960, the ovary was found to be full of mature eggs. Posteriorly the mantle margin is grayish black with white vermiculations in preserved specimen; "eyes of Will" usually large, conspicuous, darkly pigmented, closely spaced and sometimes protruding from between inner and middle mantle lobes (see *Remarks on Anatomy*).

Measurements (mm.) —

length	width	
495	180	(large; Philippines)
400	170	(large; Dutch New Guinea)
252	118	(average; Trincomali, Ceylon)
119	58	(small; Tanganyika)

Synonymy —

1791 *Pinna bicolor* Gmelin, Systema Naturae, ed. 13, p. 3366 (in mari rubro); refers to Chemnitz, vol. 8, pl. 90, fig. 780.

1819 *Pinna dolabrata* Lamarck, Animaux sans vertèbres, vol. 6, p. 133 (les mers australes?) Gulf St. Vincent [South Australia] locality restricted by Cotton and Godfrey (1938, p. 84); refers to Chemnitz, vol. 8, pl. 90, fig. 780.

1825 *Pinna atropurpurea* Sowerby, A Catalogue of the shells of the Earl of Tankerville, Appendix, p. v (no locality given); Wilkins, 1953, Proceedings Malacological Society of London, vol. 30, p. 24, pl. 6.

1843 *Pinna deltodes* Menke, Molluscorum Novae Hollandiae Specimen, p. 37 (prope Victoria river [Northern Territory, Australia]) topotype sent by Menke to Reeve, figured in Conchologia Iconica, 1858, pl. 21, fig. 40, fide Winckworth (1929) and Iredale (1939).

1852 *Pinna trigonium* Dunker, Zeitschrift für Malakozoologie, vol. 9, p. 60 (Indiae orientales); figured in Dunker (1858) Novitates Conchologicae Mollusca Marina, p. 27, pl. 8.

1858 *Pinna electrina* Reeve, Conchologia Iconica, vol. 11, Pinna, pl. 14, fig. 25 (Moluccas).

1858 (May) *Pinna fumata* 'Hanley' Reeve, ibid., pl. 15, figs. 27, 28 (San Nicholas, Island of Zebu, Philippines); Hanley [Nov.] 1858, Proc. Zool. Soc. London, p. 227.

1858 *Pinna madida* Reeve, ibid., pl. 17, fig. 31 (Port Essington, New Holland).

1858 *Pinna mutica* Reeve, ibid., pl. 18, fig. 33 (Island of Negros, Philippines).

1858 (June) *Pinna menkei* 'Hanley' Reeve, ibid., pl. 18, fig. 34 (no locality given); Hanley [Nov.] 1858, Proc. Zool. Soc. London, p. 228 (Portus Jacksonicus [New South Wales]).

1858 (June) *Pinna euglypta* 'Hanley' Reeve, ibid., pl. 20, figs. 37, 38 (Amboyna); Hanley [Nov.] 1858, Proc. Zool. Soc. London, p. 228.

1858 *Pinna vespertina* Reeve, ibid., pl. 23, fig. 44 (locality not given); not *P. vespertina* 'Reeve' Clessin, 1891, Conchylien Cabinet, vol. 8, part 1, **Malleacea**, p. 90, pl. 39, fig. 2 [= *Atrina pectinata* Linné; Clessin by error transposed Reeve's figs. 43 and 44].

1858 *Pinna attenuata* Reeve, ibid., pl. 24, fig. 46 (Moluccas).

1858 *Pinna angustana* 'Lamarck' Reeve, ibid., pl. 27, fig. 51 (Moluccas); not *P. angustana* Lamarck, 1819, from the Mediterranean [probably = *P. nobilis* Linné].

1858 (August) *Pinna regia* Hanley, Reeve, ibid., pl. 30, fig. 56 (Amboyna); Hanley [Nov.] 1858, Proc. Zool. Soc. London, p. 227.

1858 *Pinna rostellum* Hanley, Proceedings Zoological Society of London, p. 227 (Insulae Indicae).

1859 *Pinna fimbriatula* Reeve, Conchologia Iconica, vol. 11, Pinna, pl. 33, fig. 63 (Japan).

1859 *Pinna stutchburii* Reeve, ibid., pl. 33, fig. 64 (Moreton Bay, Australia).

1887 *Pinna inermis* Tate, Transactions of the Royal Society of South Australia, vol. 9, p. 71, pl. 4, fig. 5 (from Eucla to the South-East [Western and South Australia]).

?1891 *Pinna cuningii* 'Hanley' Clessin, Conchylien Cabinet, vol. 8, part 1, **Malleacea**, p. 55, pl. 23, fig. 1 (Australien); not *P. cuningii* 'Hanley' Reeve, 1858 [= *Atrina maura* Sowerby, from Eastern Pacific].

1891 *Pinna rollei* Clessin, ibid., p. 77, pl. 30, fig. 1 (locality unknown).

1891 *Pinna molluccensis* Clessin, ibid., p. 82, pl. 33, fig. 1 (Moluccas) [new name for *P. augustana* Reeve, 1858, not *P. augustana* Lamarck, 1819].

1891 *Pinna atrata* Clessin, ibid., p. 83, pl. 32, fig. 2 (locality unknown).

1894 *Pinna epica* Jousseaume, Le Naturaliste, Revue Illustrée Des Sciences Naturelles, Paris, 16th Année (8th Année de la 2nd serie) no. 182, p. 229 (Japon [Japan]); type figured by Habe, 1953a, Publ. Seto Mar. Biol. Lab., vol. 3, pl. 9, figs. 1, 2.

1901 *Pinna cochlearis* H. Fischer, Journal de Conchyliologie, vol. 49, p. 126, pl. 4, fig. 13 (Djibouti [French Somaliland]).

1906 *Pinna natalensis* Smith, Annals Natal Government Museum, vol. 1, p. 60, pl. 8, fig. 9 (Durban [South Africa]).

1924 *Pinna isosceles* Hedley, Records of the Australian Museum, vol. 14, p. 145, pl. 19, fig. 1 (New South Wales: Port Jackson, North Harbour).

1924 *Pinna menkei caviterga* Hedley, ibid., p. 147, pl. 20, fig. 8 (Queensland: Fraser's Island).

1924 *Pinna scapula* Hedley, ibid., p. 148, pl. 19, figs. 6, 7 (Northern Territory: Darwin).

1932 *Pinna densecostata* Turton, Marine Shells of Port Alfred, p. 219, pl. 56, no. 1520 (Port Alfred [South Africa]).

1939 *Exitopinna deltodes ultra* Iredale, Great Barrier Reef Expedition Scientific Reports, vol. 5, **Mollusca**, part 1., p. 315 (Batt Reef; Low Isles; Keppel Bay, Queensland).

Nomenclature — It is no great wonder that general confusion exists concerning the species extant in the family Pinnidae. When one adds to their variability the various and sundry misconceptions which have accumulated over the years regarding the species the confusion becomes compounded. Both Winckworth and Iredale agreed that at least a topotype of the species, *Pinna deltodes* Menke, was available to Reeve (1858, pl. 21, species 40). Although easily mistaken for a specimen of *Atrina vexillum*, the figure, when carefully studied, reveals itself as representing an extremely badly broken and many times repaired specimen of *Pinna bicolor*. Hedley apparently misunderstood this species and placed it in the genus *Atrina*, Iredale (1939) considered *deltodes* a valid species and even named a subspecies, *ultra* (pl. 150, figs. 1 and 2). In the same section he referred *Pinna scapula* Hedley (1924, pl. 19, figs. 4, 5 [6, 7]) to this species. Iredale (pp. 315, 316) suggested, on the basis of the misshapen *deltodes ultra*, that *vexillum* Born is also a member of the "pinnoid" group and not an *Atrina*. Fortunately Born's plate (1780, pl. 7, fig. 8) conclusively shows an *Atrina* with the postero-ventrally lobate shell which is characteristic of *vexillum* thus establishing the latter as a valid species belonging to the subgenus *Atrina* s.s.

The large number of synonyms included under *Pinna bicolor* testify to the variability of this species. The development of the narrow, elongate forms, such as *attenuata* Reeve, may be the result of the effect on the species when it is living near

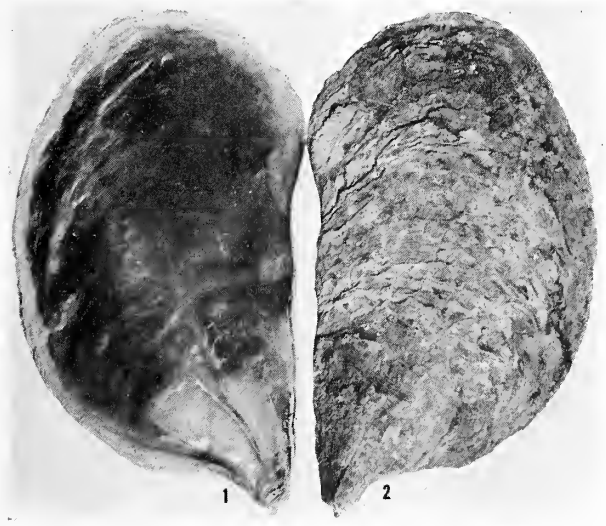

Plate 150. Holotype of *Exitopinna deltodes ultra* Iredale [= a stunted and repeatedly broken specimen of *P. bicolor* Gmelin] Low Isles, Queensland. Fig. 1. Interior of left valve. Fig. 2. Exterior of left valve. (about ¼ nat. size, Australian Museum photo.)

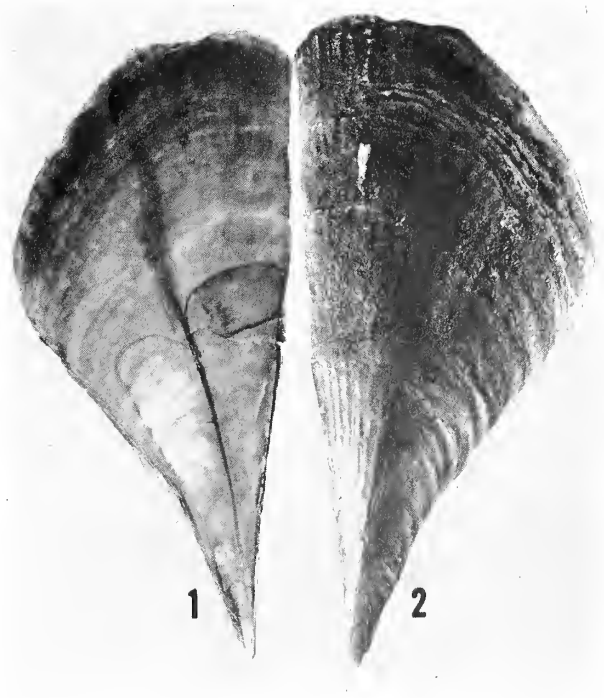

Plate 151. *Pinna bicolor*. Syntype of *P. dolabrata* Lamarck, South Australia. Fig. 1. Interior of left valve. Fig. 2. Exterior of left valve. Specimen is 215 mm. (8.6 inches) in length. (Photograph courtesy of E. Binder, Muséum D'Histoire Naturelle, Geneva.)

the edge of its range (Japanese waters), although light-colored, narrow individuals resembling this phenotype occur with the more typical form in other parts of the range of the species (*stutchburii* Reeve; *angustana* 'Lamarck' Reeve). When attempts are made to separate these forms it is found that intergrades exist. For this reason, at present, it seems best to include all of these apparent variations under one name.

Pinna fimbriatula Reeve was considered a distinct species by Winckworth (1929) and by Habe (1953a.) who placed it in the genus *Atrina* stating: "This species has never been rediscovered . . . and . . . resembles a form of *Atrina vexillum*." Photographs of the holotype of *fimbriatula* (B.M. 1952.8.29.22) including a view of the interior of a valve, show it to be a true *Pinna* and most certainly a synonym of *P. bicolor*. Habe reprinted Reeve's figure 63 of *fimbriatula* without securing a view of the interior. His reference to *vexillum* is thus understandable because there is a strong resemblance, until the characteristic nacreous layer is examined. This short, wide form of *bicolor* was also described by Hedley as *scapula*, by Menke as *deltodes*, and Iredale later named a subspecies, *deltodes ultra* (pl. 150, figs. 1, 2). As mentioned by Hedley this broad shell form probably results from the animal being shallowly imbedded, perhaps in a little sand over rock, the resultant growth producing a more broadly fan-shaped and less elongate shell. Correlated with the wider shell is the greater distance between the nacreous lobes. This was mentioned as a characteristic of *bicolor* by Winckworth, and supposedly served to distinguish *bicolor* from *atropurpurea*. The unreliability of this character in this species is shown through examination of a photograph of the holotype of *Pinna mutica* Reeve (pl. 152, figs. 3, 4). Included in the synonymy of *atropurpurea* by Winckworth (1929, p. 283), the internal view shows the wide posterior separation of the nacreous lobes which that author attributed to *bicolor*.

Habe (1953b, pl. 9, figs. 1, 2) figured the type of *Pinna epica* Jousseaume, including an internal view of the valve which reveals this species to be a true *Pinna* and a synonym of *P. bicolor*. Habe earlier (1953a, pl. 25, fig. 8) figured a specimen collected from Tosa Bay in 70 fathoms which he also called *epica*, placing it in the subgenus *Servatrina*. An internal view of Habe's *epica* was not given in the latter case. The generic misplacement is understandable because the external sculpture of the

Plate 152. *Pinna bicolor* Gmelin. Figs. 1-2. Lectotype of *Pinna fumata* Reeve (erroneously labeled "Holotype") [= *P. bicolor*], San Nicolas, Island of Zebu, Philippines. (241 mm. or 9.6 inches in length). Figs. 3-4. Holotype of *Pinna mutica* Reeve [= *P. bicolor*], Island of Negros, Philippines. (215 mm. or 8.6 inches in length). Fig. 3. Interior of left valve showing wide posterior separation of nacreous lobes supposedly characteristic of *bicolor* in a form more typical of "*atropurpurea*". (British Museum (N.H.) photos.)

shell is similar to that of an *Atrina*, the specimen being somewhat anomalous.

Types – The location of the holotype of *Pinna bicolor* Gmelin from the Red Sea is unknown. The type figure here selected is Chemnitz, vol. 8, pl. 90, fig. 780. A syntype of *Pinna dolabrata* Lamarek is in the Muséum D'Histoire Naturelle, Geneva, and was figured by Hedley (1924, pl. 21, figs. 14, 15). A neotype of *P. atropurpurea* Sowerby was selected and figured by Wilkins (1953, pl. 6) and is in the British Museum (N.H.). The neotype locality is Trincomali, Ceylon. The holotype of *P. deltodes* Menke is presumed lost (Keen, 1958, p. viii), however, Reeve's fig. 40 of the syntype sent to him by Menke is here selected as the type figure of this species (see Winckworth, 1929, p. 291; Iredale, 1939, p. 315). Types of species described by Reeve and Hanley are in the British Museum (N.H.) as is the type of *P. natalensis* Smith. A syntype of *P. inermis* Tate is in the South Australian Museum, Catalogue No. 14607, according to B. C. Cotton (*in litt.*, 1960). A holotype was never designated by Tate. The location of the types of Clessin is unknown. Some of them were said to be in the Rolle collection which was undoubtedly dispersed. The types of *P. conchlearis* Fischer and *P. epica* Jousseaume are in the Muséum D'Histoire Naturelle, Paris. The types of *P. isosceles*, *P. caviterga* and *P. scapula*, all described by Hedley, and *Exitopinna deltodes ultra* Iredale are in the Australian Museum, Sydney. The type of *P. densecostata* Turton is in the Oxford University Museum.

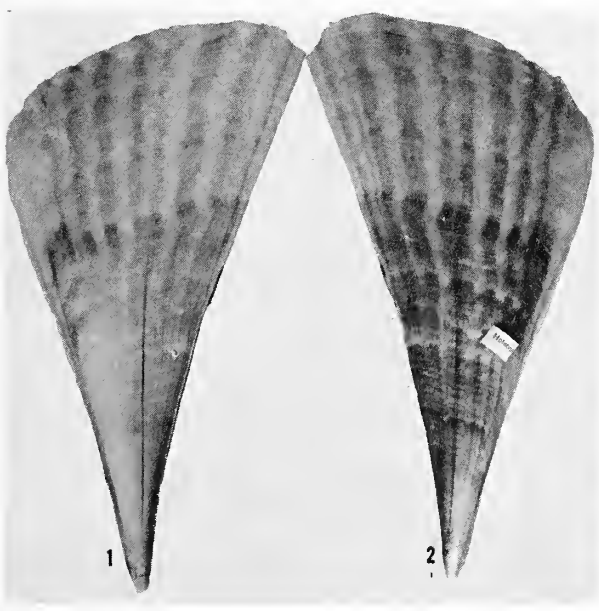

Plate 153. *Pinna bicolor* Gmelin. Lectotype of *Pinna euglypta* Reeve (erroneously labeled "Holotype"), from Amboina. Specimens 177 mm. (7 inches) in length. Fig. 1. Interior of left valve. Fig. 2. Exterior of left valve. (British Museum (N.H.) photo.)

1. *Lectotype Selection:* Reeve (1858, figs. 37, 38) figured two specimens of *Pinna euglypta*. Wilkins (1953, p. 27) listed these and another specimen as syntypes of this species, not selecting a lectotype because *euglypta* was considered a synonym of *P. atropurpurea*. Since *atropurpurea* is, in turn, here considered a synonym of *bicolor* it is probably best to fix the name *euglypta* upon a single specimen at this time. The specimen depicted in Reeve's fig. 37 is here selected as lectotype of *Pinna euglypta* 'Hanley' Reeve: B.M. 1952.8.29.19; length 177 mm., width 90 mm.; type locality: Amboyna (plate 153, figs. 1, 2; photograph courtesy of British Museum (N.H.)).

2. *Lectotype Selection:* A similar case exists regarding *Pinna fumata* 'Hanley' Reeve, 1858 (figs. 27, 28) which is also a synonym of *P. bicolor*. The specimen portrayed by Reeve (fig. 28) is a dark form; that in figure 27 displays the color pattern often seen in *bicolor*. The former specimen (fig. 28, the more mature but dark form) is here selected as lectotype of *Pinna fumata* 'Hanley' Reeve: B.M. 1952.8.29.23; length 241 mm., width 110 mm.; type locality: San Nicolas, Island of Zebu (Cebu), Philippines (plate 152, figs. 1, 2; photograph courtesy of the British Museum (N.H.)).

Selected Records (see map, Pl. 149) – SOUTH AFRICA: Durban (E. A. Smith, 1906). MOZAMBIQUE: Inhaca Id., Delagoa Bay (ANSP); Santa Carolina Id., Bazaruto Bay (MCZ). TANCANYIKA: Mboa Magi, 9 miles south of Dares-Salaam (USNM). ZANZIBAR: Mnazi Moja, Zanzibar City (USNM); 1 mile north of Chuckwani (NSF). RED SEA: near Hodeida, Yemen (R. E. Kuntz, USNM); Suez (USNM). PERSIAN GULF: Ras Tanura, Saudi Arabia (ANSP; MCZ; USNM); Kuwait [Kuwait?] (USNM). MADACASCAR: Ambariotelo, between Nossi Bé and Nossi Komba (A. C. Humes, MCZ; USNM). MAURITIUS [?] (USNM). INDIA: Calcutta (USNM). CEYLON: Trincomali (MCZ; USNM). NICOBAR ISLANDS (ANSP). THAILAND: Sattahip (G. M. Moore, MCZ). MALAYA: Singapore (MCZ; USNM). CHINA: Chip-bee, Amoy (USNM); Port Shelter, Sharp Id. and Rocky Harbour, Tai She Wan, Hong Kong (both A. J. Staple, ANSP). JAPAN: Awaji (MCZ; USNM); Imaizumi, Kakoshima Bay (USNM). PHILIPPINES: many localities (see map; USNM; ANSP; MCZ). INDONESIA: Po Bui Id., Sandakan, North Borneo (USNM); Amboina (USNM; MCZ); Kleine Kombius, Djokjkarta Bay, Java (MCZ). AUSTRALIA: Yallingup (USNM); mouth False Cape Creek, La Grange Bay (ANSP); Broome (MCZ; NSF; ANSP) all Western Australia; Arafura Sea, near Darwin, Northern Territory (A. R. Cahn, ANSP); Hamilton Id., Cumberland Group (J. K. Howard, MCZ); Hervey Bay (J. Kerslake; USNM) both Queensland; Cunnamatta Bay, Port Hacking, south of Sydney, New South Wales (D. F. McMichael, Aust. Mus.; USNM); Outer Harbor, St. Vincent Gulf, South Australia (W. Old. USNM). NEW GUINEA: Moroepi Id., Ambai Group (NSF; MCZ; USNM); Merauke (MCZ). NEW CALEDONIA (USNM); HAWAII: off Barbers Point, Oahu Id. (C. M. Burgess, 1961, USNM).

Fossil Records – Chapman (1920, Proc. Roy. Soc., Victoria, vol. 32, p. 229) recorded *P. inermis* Tate [= *P. bicolor*] from the older Pleistocene deposits of the Ooldea District, Victoria, Australia.

Pinna incurva Gmelin, 1791

(Pls. 149, 154, 155)

Range – East coast of India, Burma and the East Indies (Winckworth); Nicobar Islands (Chemnitz); the Philippines and northern Australia.

Remarks – This species appears to be rather rare in collections. I have seen only three specimens: two from Australia, only one of which is in fair condition; a third from the Philippines is young (pl. 155, figs. 1, 2). Winckworth (1929) stated that *P. incurva* was "a form so distinct from others

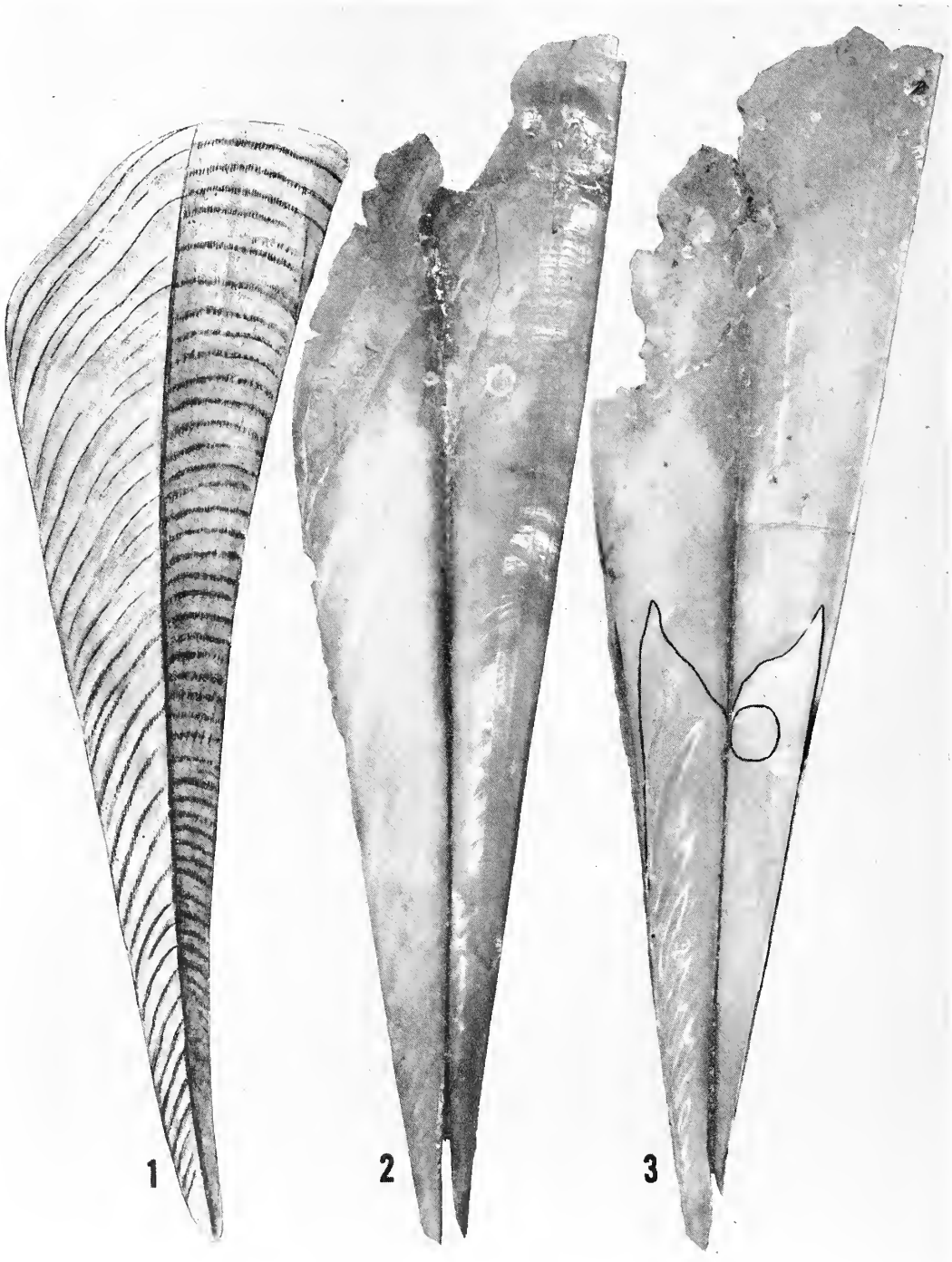

Plate 154. *Pinna incurva* Gmelin. Fig. 1. Type figure (from Chemnitz, 1785, vol. 8, pl. 90, fig. 778). Figs. 2-3. Specimen from Keppel Bay, Queensland. Specimen 290 mm. (11.4 inches) in length. Fig. 2. Exterior of right valve. Fig. 3. Interior of left valve; borders of nacreous lobes and posterior adductor muscle scar outlined in black. (Smithsonian Institution photos.)

of this group that Mörch made a genus *Cyrtopinna* for it . . . . " It is easily separable from *bicolor* and *muricata* because of its narrowly attenuate shape, apparently fairly uniformly light horn color, and the characteristic shapes of the posterior margins of the lobes of the internal nacreous layer which slope sharply obliquely toward dorsal and ventral shell margins. The name *incurva* applied by Gmelin to the species as here restricted probably makes reference to the posterior margin of the shell which slopes (incurves) gradually toward the dorsal margin from a point far down the ventral margin. This character also is responsible for the generic name "*Cyrtopinna*" erected by Mörch for this species (Cyrto: derived from the Greek, *kyrtos*, a combining form meaning "anything curved").

Habitat — Probably lives imbedded deeply in sandy-muddy bottom, below the low tide mark; "dredged . . . in 9-12 fathoms in Port Curtis" [east coast of Queensland, Australia] (Iredale, 1939).

Description — Shell reaching 290 mm. (about 11 inches) in length, narrowly attenuate and wedge-shaped in outline; posterior margin extremely arcuate; subinflated; with a relatively weak longitudinal keel on the anterior half of the shell. Valves thin, fragile and sculptured with nearly obsolete radiating ribs. Shell translucent to nearly transparent, light reddish brown to dilute yellowish horn color. Surface smooth and shining. Radial sculpture hardly observable; consists of about 6 ribs limited to the posterior slope. Concentric sculpture of broadly arcuate growth lines arising on the dorsal margin, turning slightly posteriorly for a short distance, then rapidly arching antero-ventrally to the ventral border; often forming distinct semi-lunar ridges on anterior part of ventral slope. Dorsal margin straight; only occasionally subconvex to subconcave. Ventral margin also straight. Interior of valves light horn to reddish brown in color, smooth and shining. Nacreous layer iridescent, occupying most of the anterior half of the shell and divided along most of its length into two lobes by a narrow, longitudinal sulcus. Both dorsal and ventral lobes with the posterior margins obliquely truncate; sloping from sulcus toward dorsal and ventral shell margins; forming with this equal posterior extension a wide and deep "V." Posterior margins of both lobes may show slight embayments. Anterior adductor muscle scar moderately small, subapical, the sulcus nearly reaching it. Posterior adductor muscle scar medium sized, subterminal on ventral portion of dorsal nacerous lobe. Primary hinge ligament very thin, black, appearing not to extend to posterior tip of dorsal nacreous lobe. Embryonic valves and animal unknown.

Measurements (mm.) —

length	width	
290	78	(average?; Keppel Bay, Queensland)
98	33	(small; Iloilo, Philippines)

Synonymy —

1791 *Pinna incurva* Gmelin, Systema Naturae, ed. 13, p. 3366 (in Oceano indico); refers to Chemnitz, vol. 8, pl. 90, fig. 778, and others; 1818, Wood, Index Testaceologicus, London, p. 60 (Amboyna); 1825, Wood, ibid., pl. 13, fig. 15.

1825 *Pinna incurvata* Sowerby, A Catalogue of Shells of Earle of Tankerville, p. 23 (no locality given); 1858, Reeve, Conchologia Iconica, vol. 11, Pinna, pl. 5, fig. 8 (Moluccas); both refer to Chemnitz, vol. 8, pl. 90, fig. 778; neither are *Pinna incurvata* Born, 1778 [= *P. nobilis* Linné].

Plate 155. *Pinna incurva* Gmelin. Young specimen from Iloilo, Panay, Philippines. Fig. 1. External view, right valve. Fig. 2. Internal view, left valve; the borders of nacreous lobes and posterior adductor muscle scar outlined in black. (slightly enlarged, Smithsonian Institution photo.)

Nomenclature – The several plate references cited by Gmelin for his species, *incurva*, present an unclear concept of this species. This is due to the fact that the Bonanni figures are of *Pinna nobilis*, and the Rumphius, Petiver and Klein figures are of misshapen specimens of *P. muricata*. Subsequent authors (Sowerby and Reeve) have limited their references to *incurva* of Chemnitz, pl. 90, fig. 778, which is done here also. This figure shows an attenuate *Pinna* with the arcuate margin of *incurva* and what appears to be sufficient of the growth line pattern to fix the identity (pl. 154). Although not an excellent likeness of the species, it will do. The name *Pinna attenuata* has apparently been applied to any elongate pinnoid shell. It is quite often used for the Japanese form which, however, has a heavier shell than *incurva* and is a narrow variety of *P. bicolor*.

Types – The location of the holotype of *Pinna incurva* is unknown. Gmelin referred to several authors' figures (see above). Of these, Chemnitz, pl. 90, fig. 778 is here selected as the type figure (see pl. 154, fig. 1). The original type locality given by Gmelin: "in Oceano indico" (Nicobar Islands: Chemnitz) is here restricted to Keppel Bay, Queensland, Australia, a locality from which this species is known to have been collected and from which I have seen material. *Pinna incurvata* Sowerby, 1825, is apparently the earliest valid introduction of that name for the species *incurva*, that of Chemnitz being unavailable as it was introduced in a work not consistently binomial. Chemnitz' figure 778 must also be considered the type figure for this species. Born's earlier introduction of the name *P. incurvata* appears to be synonymic with *P. nobilis* of the Eastern Atlantic; the figures to which he refers are the latter species. Reeve's account of *incurvata* also refers to the Chemnitz figure, although apparently that author had a specimen which he figured.

Locality Records (▲ triangles, pl. 149) – INDIA: Ennur, near Madras (Winckworth, 1929). PHILIPPINES: Iloilo, Panay (USNM). INDONESIA: Amboina (Wood, 1818, p. 60). AUSTRALIA: Keppel Bay (H. Bernard, Australian Museum; USNM); Yepoon (J. Kerslake, Australian Museum; USNM), both Queensland.

Genus Atrina Gray, 1842

Atrina is world-wide in distribution and reaches slightly more northerly and southerly latitudes than does *Pinna*. The reason for this may lie, in part, in its more generalized physiology and resultant wider ecological tolerances.

Two subgenera are here recognized in *Atrina*. *Atrina* (sensu stricto) is world-wide in distribution. *Servatrina* is apparently absent from the Eastern Atlantic (see Table 1).

Description — Shell reaching large size, up to 480 mm. (about 19 inches) in length, wedge, wing-shaped to subglobular in outline. Thin to rather heavy in structure and sculptured with spinose to imbricate, sometimes nearly obsolete, radiating ribs. Nacreous layer not divided by a longitudinal sulcus, occupying entire surface of anterior two-thirds to three-fourths of the inner side of valves. The posterior adductor muscle scar located subcentrally.

Subgenus Atrina Gray, 1842

Type: *Atrina vexillum* (Born, 1778)

Externally, shells of the members of the subgenus *Atrina* have the characteristics of the genus *Atrina* (sensu lato). The subgeneric difference is based on an internal character, the protrusion of the posterior adductor muscle scar beyond the posterior border of the nacreous layer.

There are two Recent species in this subgenus in the Indo-Pacific and related areas, *Atrina vexillum* (Born) and *A. squamifera* (Sowerby). One fossil species from the Miocene of Ceylon is provisionally included here.

Synonymy —

1840 *Atrina* Gray, Synopsis Contents of the British Museum, ed. 42, p. 151 [nomen nudum]; 1842, ibid., ed. 44, p. 83 [described but no species listed]. Type by subsequent selection (Gray, 1847, Proc. Zool. Soc. London, p. 199): *Pinna nigra* Dillwyn [= *Atrina vexillum* (Born, 1778)].

1853 *Pennaria* 'Brownc' Mörch, Catalogus Conchyliorum Comes de Yoldi, p. 51; based on Patrick Browne, Civil and Natural History of Jamaica, London, 1756, p. 412; also Browne, 1789 [fide notes in Division of Mollusks, U. S. National Museum: not binomial and the former is prelinnaean]. Type by subsequent selection (Turner and Rosewater, 1958, p. 310): *Atrina rigida* (Solander, 1786); not *Pennaria* Oken, 1815, not de Blainville, 1818.

Atrina (Atrina?) pachyostraca (Davies, 1923)

Range — From the Miocene of Ceylon.

Remarks — As indicated by Davies, *pachyostraca* may be similar to *Atrina vexillum*. However, this fossil species is based on fragments representing only portions of valves, and its relationship to other fossil or Recent Pinnidae is somewhat obscure.

Synonymy —

1923 *Pinna pachyostraca* Davies, Quarterly Journal Geological Society, London, vol. 79, p. 593, pl. 29, figs. 3-4 (Miocene (Vindobonian): Minihagalkanda, Southern Province (Ceylon))

Plate 156. *Atrina vexillum* (Born). Figs. 1-2. Syntype of *Pinna nigrina* Lam., "L'Océan des grandes Indes" [East Indies] [= *A. vexillum*]. (reduced ½, photograph courtesy of E. Binder, Muséum D'Histoire Naturelle, Geneva.)

Atrina (Atrina) vexillum (Born, 1778)

(Pls. 139, 156-158)

Range — Central east Africa to eastern Polynesia.

Remarks — The Flag *Atrina* received its name due to the fact that the specimen which Born described exhibited a condition often present in this species: an especially lobate ventral margin which somewhat presents the appearance of a flag blowing in the breeze. This condition is quite noticeable in medium sized and large specimens and occasionally develops in smaller individuals. The dark coloration of the interior and exterior of the valves is also present rather uniformly in mature specimens, but younger ones are often lighter and may approach the coloration of the *Atrina squamifera* or *Servatrina pectinata* groups. The posterior adductor muscle scar bulges prominently beyond the posterior border of the nacreous area in mature *Atrina vexillum*. However, as discussed by Turner and Rosewater (1958, pp. 313-314 and pl. 159) this subgeneric character is actually progressively correlated with the size and age of individual specimens: mature *A. vexillum* having the character well-developed, but immature forms often being quite difficult to distinguish from specimens of *Servatrina pectinata*. In *A. vexillum*, the posterior adductor muscle scar is usually contiguous with the posterior border of the nacreous layer in immature specimens before bulging beyond, while in *S. pectinata* it is always located well within the posterior nacreous border.

Atrina (Atrina) vexillum is heavier, broader and more darkly colored than *Atrina (Atrina) squamifera*. *A. vexillum* is usually smooth, *squamifera* grossly spinose, although younger specimens of *vexillum* and the anterior portions of the shells of older ones commonly bear the characteristic pattern of low sculpture (see *Description*). In southeast Africa *vexillum* is apparently replaced by *squamifera*.

Atrina vexillum is probably one of the more economically important members of the family in the Indo-Pacific area. Because it attains a large size, the posterior adductor muscle can be used for food and is said to be quite delicious (personal communication, H. A. Rehder, 1960; "gut zu essen," von Martens, 1880, p. 317). In Polynesia, at least, the black shell of this species is intricately carved by the natives and used to fashion lamps, other decorative articles and as plates for food (personal communication, C. E. Cutress, 1960). Jameson (1902, p. 142) mentions finding pearls in *Pinna nigrina* Lamarck (= *A. vexillum*) in New Guinea. Although black pearls produced by this animal are very beautiful they fracture easily and are soon destroyed because of their radial prismatic structure (see Haas, 1955; Turner and Rosewater, 1958).

Holthuis (1952) noted, from quoted sources, the presence of the palaemonoid shrimp, *Anchistus custos* (Forskal) in the mantle cavity of *Atrina vexillum* (also reported in *Pinna nigra* 'Chemnitz' Dillwyn (= *A. vexillum*). Bruce (in litt., 1960) also reported finding *A. custos* with *A. vexillum* from Mazizini Bay, Zanzibar.

This species does not seem to be at all common in Hawaii. The few records of its presence are based on dredged fragments and a single living individual taken in 120 feet off Waikiki, Oahu. It may live there only in deeper water or perhaps only occasionally invades these comparatively northern islands.

Habitat — This species is usually collected in sandy mud, or in sandy eel grass patches on reefs. It is usually in water from 1 to 2 fathoms in depth, although a specimen from the Philippines was dredged dead, but in good condition, from a depth of 230 fathoms (USNM: 248688). It was collected alive in 20 fathoms in Hawaii.

Description — Shell reaching 480 mm. (about 19 inches) in length, triangular to subglobular to hatchet- (flag-) shaped in outline; inflated; rather heavy to thick in structure and sculptured with

Plate 157. *Atrina vexillum* (Born). Lectotype of *Atrina gouldii banksiana* Iredale [= immature *A. vexillum*], Low Isles, Queensland. (reduced about ½, Australian Museum photograph.)

occasionally spinose radiating ribs. Shell semitranslucent, ranging in color from dark, sometimes reddish, brown to black, but when viewed with transmitted light, a rich reddish purple shines through. Surface of valves usually dull; faintly shining in young specimens. Radial sculpture consists of from about 10 to 17 major, but sometimes obsolete, radiating ribs which become crowded and too numerous to count on the ventral slope; ribs often imbricate anteriorly, and posteriorly occasionally bear large, upright, often twisted spines which are open posteriorly. There are often from 1 to 3 rows of minor ribs between major spine-bearing ribs totaling from about 13 to 25 in addition to the mentioned number. Concentric sculpture consists of fine growth lines which are convex posteriorly. Posterior margin truncate to very broadly oval in outline. Dorsal margin usually nearly straight to definitely convex in flag-shaped specimens. Ventral margin broadly convex posteriorly and concave near the umbo. Interior of valves dark brown to black, but a lighter greenish brown mottling is sometimes present. Occasionally younger specimens have alternate bands of reddish purple and brown, especially conspicuous near the posterior margin; smooth and shining. Nacreous layer iridescent, occupying the anterior half of the interior of the valve. Posterior adductor muscle scar large, subcircular, protruding beyond the posterior border of the nacreous layer in mature specimens; not protruding in immature specimens. Extent of protrusion varies and increases with the age of the specimen. Anterior adductor muscle scar small to moderate in size, located at the anterior tip of the nacreous area. Posterior border of nacreous area with embayment which forms a broadly obtuse angle ventral to the posterior adductor muscle scar; the contour of the ventral border follows the ventral margin of the shell; dorsal border contiguous with dorsal shell margin. Primary hinge ligament thick, black, extending from umbo to the posterior border of the nacreous area; secondary hinge ligament not colored but evident in intact specimens whose dorsal margins are fused. Embryonic valve about 0.5 mm. in length, broadly triangular, subinflated, umbos directed posteromedially; sculptured with closely spaced, concentric, incised lines of growth (pl. 139, figs. 3, 4).

Measurements (mm.) —

length	width	
425	295	(large; Indo-Pacific, USNM)
210	145	(average; Sanga Sanga Id., P. I.)
158	105	(immature; off Waikiki, Hawaii)
123	75	(immature; Suva, Fiji)

Synonymy —

1767 *Pinna rudis* var. *B* Linné, Systema Naturae, ed. 12, p. 1159; refers to Rumphius, pl. 46, fig. L; Gmelin, 1791, Systema Naturae, ed. 13, p. 3363 (in indico et mari rubro).

1778 *Pinna vexillum* Born, Index Rerum Naturalium Mus. Caes. Vindob., p. 118; 1780, Born, Testacea Musei Caesarei Vindobonensis, p. 134, pl. 7, fig. 8 (no locality given); [1956, Rutsch, Nautilus, vol. 69, p. 78].

1786 *Pinna nigricans* Solander, Catalogue of the Portland Museum, p. 147, species 3242 (Otaheite) [nomen nudum].

1791 *Pinna exusta* Gmelin, Systema Naturae, ed. 13, p. 3366 (in Oceano indico australi); refers to Seba, pl. 91, fig. 2; and Chemnitz, vol. 8, pl. 91, fig. 782 (a young specimen).

1798 *Pinna gubernaculum* Röding, Museum Boltenianum, p. 159 (no locality given); refers to Gmelin, 1791, "*Pinna vexillum*" [p. 3366] species 15; and Chemnitz, vol. 8, pl. 91, fig. 783 (a young specimen).

1817 *Pinna nigra* Dillwyn, Descriptive Catalogue of Shells, vol. 1, p. 325 (Inhabits the coasts of Amboyna (Rumphius); Red Sea (Chemnitz); Otaheite (Humphry)); refers to Chemnitz, vol. 8, pl. 88, fig. 774.

1817 *Pinna adusta* Dillwyn, ibid., p. 328 (Inhabits the coasts of Manilla (Chemnitz); New Zealand (Humphry)); refers to Chemnitz, vol. 8, pl. 91, fig. 782 (a young specimen).

1819 *Pinna nigrina* Lamarck, Animaux sans vertèbres, vol. 6, p. 135 (l'Océan des grandes Indes); refers to Chemnitz, vol. 8, pl. 88, fig. 774; 1825, Sowerby, The Genera of Recent and Fossil Shells, part 26, pl. 103.

1858 (May) *Pinna gouldii* 'Hanley' Reeve, Conchologia Iconica, vol. 11, Pinna, pl. 11, fig. 21 (locality not given); Hanley [Nov.] 1858, Proc. Zool. Soc. London, p. 255 ("Amboyna").

1858 *Pinna lystrix* Hanley, Proc. Zool. Soc. London, p. 226 (Amboyna); figured in Reeve, 1859, Conchologia Iconica, vol. 11, Pinna, pl. 32, figs. 60, 61.

1938 *Pinna oahua* Dall, Bartsch and Rehder, Bernice P. Bishop Museum Bull. no. 153, p. 75, pl. 18, figs. 5, 6 (Oahu, Hawaiian Ids., 33-50 fathoms).

1938 *Atrina (Atrina) recta* Dall, Bartsch and Rehder, ibid., p. 76, pl. 17, figs. 3, 4 (Albatross Station 3850, off south coast of Molokai [Hawaii] 33-50 fathoms).

1939 *Atrina gouldii banksiana* Iredale, Great Barrier Reef Expedition Scientific Reports, vol. 5, **Mollusca**, part 1, p. 316, pl. 4, fig. 18 (Low Isles [off Port Douglas] Queensland).

1953 *Atrina (Servatrina) tenuis* Habe, Illustrated Catalogue of Japanese Shells, vol. 1, p. 193, pl. 24, fig. 3 (Tosa Bay, Shikoku).

1953 *Atrina (Servatrina) lingnafelis* Habe, ibid., p. 194, pl. 25, fig. 7 (Tosa Bay, Shikoku, about 200 fathoms in depth).

Nomenclature — As noted by R. F. Rutsch in 1956 (Nautilus, vol. 69, no. 3, p. 78) the earliest reference for Born's *Pinna vexillum* is 1778, and not 1780.

Atrina is a feminine noun (from Latin: *ater, atra* = black colored). It would be expected that the endings of specific adjectival names should agree in gender with this genus. However, the name *vexillum* (Latin = flag) is a substantive noun, not an adjective, and must retain its neuter ending and cannot be spelled "*vexilla*."

The figures referred to by Gmelin for *Pinna ad-*

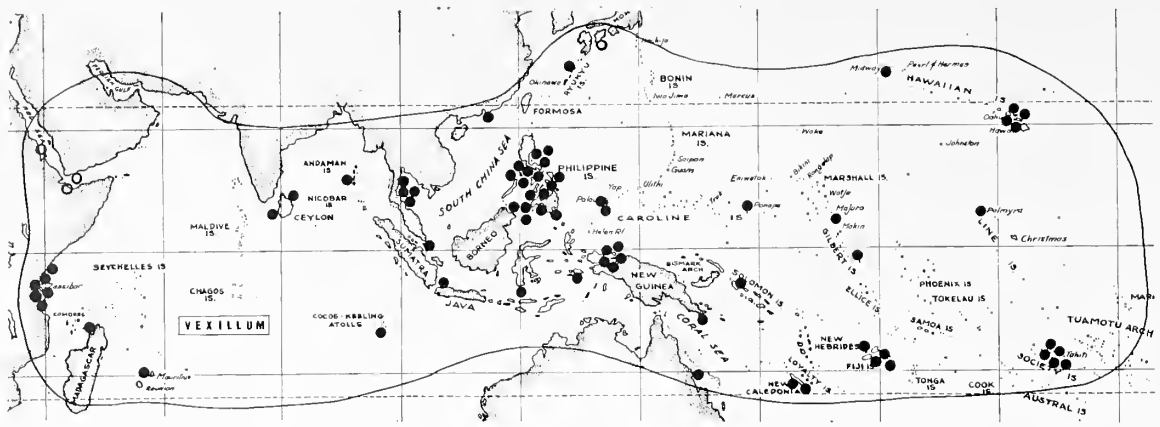

Plate 158. Geographical distribution of *Atrina vexillum* (Born).

usta, by Reeve for *gouldii*, Röding for *gubernaculum* and Dillwyn for *P. adusta* may be questioned as to their specific identity with *Atrina vexillum*. They all represent the shells of fairly young individuals of this species which are admittedly difficult to distinguish from *Atrina pectinata*. However, examination of a geographic series of *vexillum* in which are found representatives of both young and old specimens yields shells similar to those figured or referred to by the above authors and proves their identity.

Pinna hystrix Hanley was included in the synonymy of *P. strangei* by Winckworth. As *strangei* is here considered a synonym of *Atrina pectinata*, it would seem simplest to treat *hystrix* similarly. However, the situation is more complex. Wilkins (1953, p. 27) found three "paratypes" of *hystrix* in the British Museum collection. The holotype in the Museum Hanley was not located and is presumed lost. Reeve (1859, figs. 60, 61) figured two of the paratypes and a photograph of the third (courtesy of the British Museum) is in my hands. The paratypes figured by Reeve apparently represent a middle-aged (fig. 60) and a young (fig. 61) specimen of *Atrina (Atrina) vexillum*. To judge from the growth form, these specimens probably grew rather rapidly under favorable conditions, their sculpture being well-developed. The secondary ribbing characteristic of *vexillum* may be noted especially in the smaller specimen. The third paratype of which photographs have been made is a specimen of *Atrina pectinata*. From all available information, *Pinna hystrix* is a composite species representing both *pectinata* and *vexillum*. This mixture may possibly account for the East African (Red Sea) literature records cited by various authors for *hystrix* and *strangei* (see Lynge, 1909; Lamy, 1928) which are probably traceable to variations of *Atrina vexillum*. As here understood, the range of *Atrina pectinata* does not extend farther west than the coast of India, although additional records may change this. Because the usual interpretation of *P. hystrix* is based on the figures of Reeve which are *Atrina vexillum* it seems best to consider *hystrix* a synonym of *vexillum* (see *Types*).

As noted by Dodge (1952, p. 225) and earlier by Hanley (1855, pp. 148-149) the *variety B* mentioned by Linné under *P. rudis* in the 12th edition of the Systema Naturae, and by Gmelin in the 13th, is without doubt referrable to *Atrina vexillum* Born. Linné's reference to Rumphius, pl. 46, fig. L is *vexillum*, and Gmelin's to Rumphius, pl. 46, fig. 11 [?L]; Gualtieri, pl. 81, fig. A; and Chemnitz, pl. 88, fig. 774 are also this species. Röding (1798, p. 160) cited for his species *P. ferruginea:* Gmelin's *P. rudis var. B*, but gave as the plate reference Chemnitz, pl. 88, fig. 773, which is the true *Pinna rudis* Linné. Although *ferruginea* has been considered a synonym of *rudis* by Winckworth (1929) and Turner and Rosewater (1958) it would be reasonable to suspect that Röding's reference to Chemnitz' fig. 773 was an error for fig. 774 which would then place the name in the synonymy of *vexillum*. On the preceding page (159) Röding cited *P. rudis var. B*, but gave Chemnitz pl. 88, fig. 774 as reference (= *A vexillum*). Therefore, it would seem that Röding did not separate *rudis* and its *var. B*, that his reference to fig. 773 under *ferruginea* was purposeful, and that that name must stand as a synonym of *P. rudis* from the Eastern Atlantic and West Indies.

Types — The holotype of *Pinna vexillum* Born is in the Austrian Museum of Natural History, Vienna. Types of species described by Hanley and Reeve are in the British Museum (N.H.), London, according to Wilkins (1953). In view of the confusion

eoncerning the true identity of *Pinna hystrix*, it may be valuable to restriet the interpretation of this species to *Atrina vexillum* Born; the type figure here selected: Reeve, vol. 11, Pinna, fig. 60, thus remaining consistent with previous usage. As will be noted, the name *P. hystrix* (part) is also eited in the synonymy of *Atrina pectinata*. A syntype of *Pinna nigrina* Lamarek is in the Museum of Natural History, Geneva, Switzerland (pl. 156, figs. 1, 2).

Lectotype Selection: Atrina gouldii banksiana Iredale, 1939, was described from several Great Barrier Reef speeimens. A sketeh was given of one of these from Low Isles [off Port Douglas, Queensland] and it was more fully described than the others, although never speeifieally designated as holotype. This specimen is here seleeted as lectotype of *Atrina banksiana* Iredale: Australian Museum Catalogue number C.62033, length 110 mm., width 60 mm. (pl. 157, figs. 1, 2).

Types of *Atrina recta* and *Pinna oahua* Dall, Bartsch and Rehder are in the United States National Museum. The locations of the types of the following are unknown to me: *Pinna nigricans* Solander, *Pinna exusta,* Gmelin, *Pinna gubernaeulum* Röding, and *Pinna nigra* and *adusta* Dillwyn. The types of *Servatrina tenuis* and *linguafelis* Habe are probably at the Zoological Institute, Kyoto University, Kyoto, Japan.

Selected Records (see map, pl. 158); solid dots: specimens examined; open circles: from the literature — TANGANYIKA: Mboa Magi, 9 miles south of Dar-es-Salaam (USNM); Dar-es-Salaam (MCZ). ZANZIBAR: Pange Id.; Kiwengwa (both NSF); Mnazi Moja, Zanzibar City (USNM). KENYA: Diani Beach, Mombasa (MCZ). RED SEA: Massaua, Eritrea; Djibouti, French Somaliland. GULF OF ADEN: Aden (all Lamy, 1928). MADAGASCAR: Nossi Bé (MCZ). MAURITIUS (ANSP). CEYLON: Hikkaduwa; south shore Ft. Frederick, Trincomali (both G. F. Kline, ANSP). ANDAMAN ISLANDS: Port Blair (MCZ). THAILAND: Prochuap; Mutaponc Id., Chumphon (both G. M. Moore, MCZ); Koh Tao; Koh Phangan (both USNM). MALAYA: Singapore (R. D. Purchon, USNM; MCZ; ANSP). CHINA: Rocky Harbour, Datum Point, Hong Kong (A. J. Staple, ANSP); Hong Kong (USNM). JAPAN: Shikoku (Habe, 1953a, p. 190). RYUKYU ISLANDS: (MCZ; ANSP; USNM), Yaeyama [Retto] (Mus. Zool. U. Mich.). PHILIPPINES: Many localities (see map). INDONESIA: Salajar Id., off southern tip of Celebes (ex Siboga Expedition, MCZ); Amboina, Moluccas (MCZ; USNM); Bantam, Java (USNM). COCOS-KEELING ISLANDS (USNM). AUSTRALIA: Hayman Id., northwest of Hook Id., Whitsunday Passage, Queensland (MCZ). NEW GUINEA: Rouw Id., Aoeri Ids., Geelvink Bay (MCZ; NSF); China Strait, Papua (USNM). SOLOMON ISLANDS: Kieta, Bougainville Id. (ANSP). NEW CALEDONIA: Bourail (NSF). FIJI ISLANDS: Yasawa Ids. (USNM). Suva, Viti Levu (USNM). PALAU ISLANDS: 1 mile south of West Passage, Babelthaup Id. (NSF); Malakal Harbor, Koror Id. (MCZ; NSF; USNM). CAROLINE ISLANDS: Ponape (MCZ; USNM). MARSHALL ISLANDS: Arno Atoll (R. W. Hiatt, USNM). GILBERT ISLANDS: Kingsmill Group (ex A. Garrett, MCZ). HAWAII: Midway Id. (MCZ); off Waikiki, Oahu (Cliff Weaver! ex C. M. Burgess); south coast Molokai Id., 43-66 fathoms (USNM); Auau Channel between Maui and Lanai Ids. (USNM). LINE ISLANDS: Palmyra Id. (ANSP; USNM). SOCIETY ISLANDS: Raititi Point, Bora Bora (R. Robertson); Raiatea; Baie de Maroe, Huahine (both USNM); Tahiti (H. A. Pilsbry! ANSP; MCZ).

Fossil Records — Martin (1910, p. 357) recorded *A. vexillum* as a fossil from Tegal, Java, Indonesia (Upper Miocene, Tjilanang beds and Pliocene) fide Van der Vlerk (1931, p. 269); also see Tesch (1920, p. 91). Martin (1879, Die Tertiärschichten auf Java, p. 120, pl. 19, figs. 5-6) figured a fragment of the fossil he called *vexillum*. Beets (1950, p. 299) recorded fossil *vexillum* from the Tertiary or Quaternary of the island of Mandul, East Borneo.

Atrina (Atrina) squamifera (Sowerby, 1835)

(Pls. 159, 160)

Range — Known only from the east coast of the Union of South Afriea.

Remarks — *Atrina squamifera* is apparently limited in its distribution to the southeastern portion of the Union of South Afriea. It cannot easily be eonfused with any other species since there is nothing like it within its range. The other member of the subgenus *Atrina* in East Afriea, *A. vexillum* Born, seems not to oeeur so far south. *A. squamifera* has a mueh more narrow and less thiek shell than *vexillum;* the number of radiating ribs in *squamifera* is about 12 or less, although 19 to 20 may be eounted on the speeimen figured by Krauss (1848, pl. 2, fig. 8). In *vexillum* there may be from 10 to 30 ribs, but they are usually smooth, although oeeasional spinose individuals oeeur. Shell eoloration in *squamifera* is light tannish brown, while in *vexillum* it ranges from reddish brown to black. There is usually an embayment in the posterior border of the nacreous area whieh forms an acute or nearly 90° angle ventral to the posterior adductor muscle scar in *squamifera;* the same strueture in *vexillum* is usually broadly obtuse.

There are superficial similarities between *Atrina (Atrina) squamifera* Sowerby and *Atrina (Servatrina) tasmanica* Tennison-Woods. However, the two speeies belong to different subgenera and their ranges are separate (see *Remarks* under *tasmanica*).

Nicklès (1953, Bull. Institut roy. Sci. nat. Belgique, vol. 29, no. 13, p. 1, pl. 1, figs. 1, 2) described *Pinna* [*Atrina* s.s.?] *chautardi* from West Afriea, assigning a range from Mauritania to Angola. The figures show a speeimen whieh appears very similar to *A. squamifera*. It is possible that the range of *squamifera* extends from West Africa to southeast Afriea. However, until speeimens are available for comparison, it seems best to eonsider them distinet speeies. There is, as yet, little basis for uniting West and South African faunas (see Stephensen, 1947, Ann. Natal Mus., vol. 11, part 2).

Obvious similarities also exist between *squamifera* and *chautardi*, and *fragilis* of European waters. As pointed out by Tomlin (1922, Jour. Conch., vol. 16, pp. 255-262) present oceanic currents hinder dispersal of northern East Atlantic species toward tropical West African regions. However, the presence of counter-currents and earlier geological distribution patterns must be taken into consideration. These three forms may be the remnants of a former continually distributed species now broken-up into isolated populations which merit specific rank (see Kohn, 1956, p. 572).

Habitat — The development of the large, nearly tubular spines suggests that this species lives in quiet water, probably in bays and other sheltered places. It has also been collected in the lower portions of rivers where the water has a tendency to be brackish.

Description — Shell reaching about 368 mm. (14½ inches, Sowerby, 1904, Marine Investig. South Africa, vol. 4, p. 3) in length, triangularly wing-shaped in outline; moderately inflated; rather thin and fragile in structure and sculptured with strongly spinose radiating ribs. Shell nearly transparent, light tannish brown in color, sometimes with a few repeated transverse bars of violet evident between the ribs. Surface of valves dully shining. Radial sculpture consists of from about 10 to 12 fairly prominent radiating ribs becoming extremely crowded on the ventral slope giving the area a highly rugose appearance; ribs usually have small spines anteriorly and large, semitubular, and often

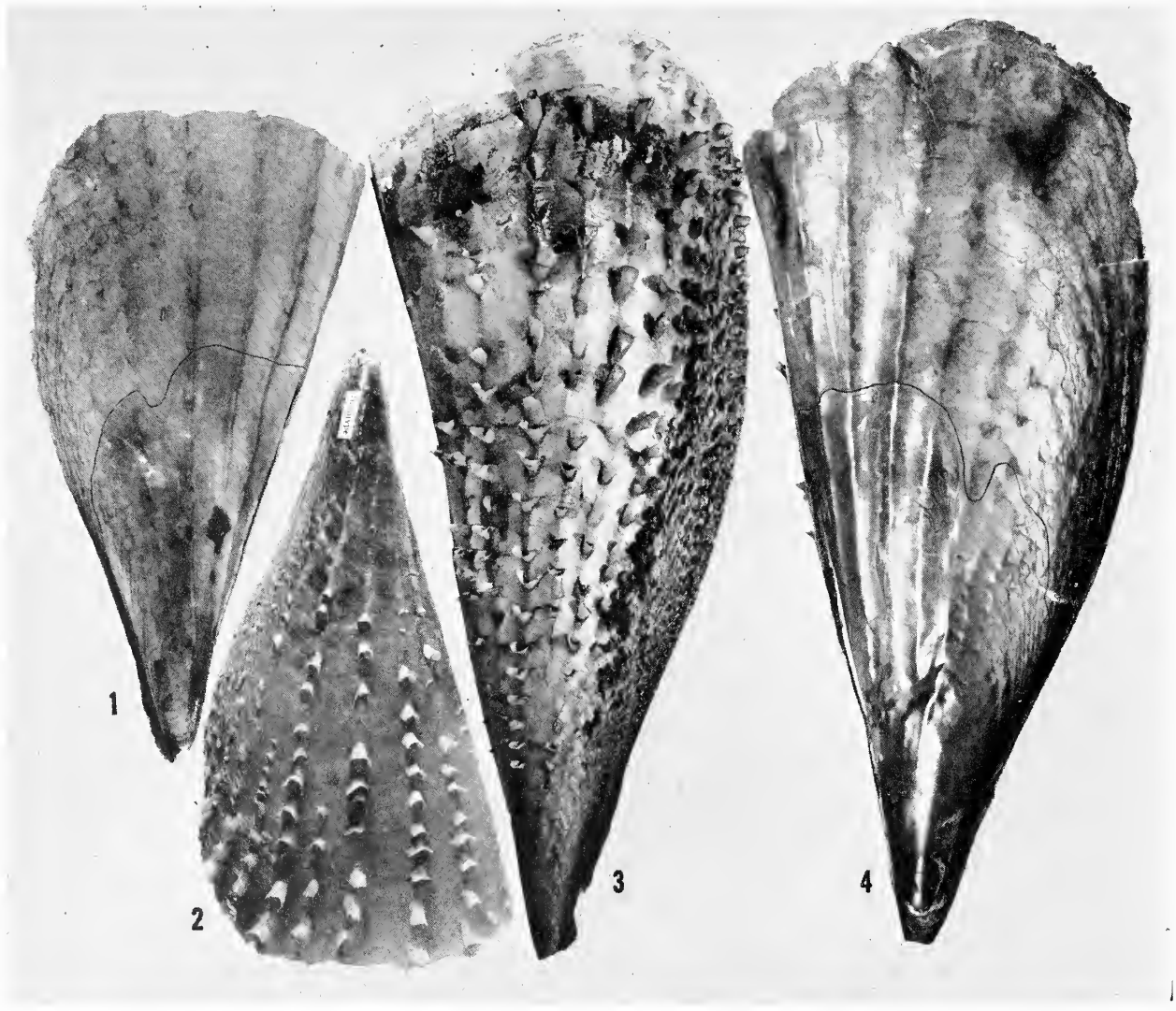

Plate 159. *Atrina squamifera* (Sowerby). Figs. 1-2. Holotype of *Pinna squamifera* Sby., Cape of Good Hope, South Africa. Fig. 1. Interior of left valve; border of nacreous layer outlined with black. Fig. 2. Exterior of left valve. (British Museum (N.H.) photo.) Figs. 3-4. *Atrina squamifera*, Port Alfred, South Africa. (Museum Comparative Zoology photo.) All reduced about ½ nat. size.

twisted spines posteriorly. Concentric sculpture of fine, often irregular growth lines showing signs of past injury. Posterior margin usually truncate; occasionally rounded in stunted specimens (as in *A. alfredensis* Bartsch). Dorsal margin usually straight to slightly convex. Ventral margin slightly convex posteriorly, curving inward anteriorly and becoming somewhat concave. Interior of valves light tannish brown, the violet bars showing through; smooth and highly glossy in some specimens. The rather thin nacreous layer iridescent, occupying about anterior one half to two thirds of interior of valve. Posterior adductor muscle scar medium sized, rounded-oval, protruding beyond posterior border of nacreous area. Posterior border of nacreous area with small embayment usually forming an acute angle ventral to posterior adductor muscle scar; ventral border following ventral margin of shell in contour; dorsal border contiguous with dorsal shell margin. Primary hinge ligament moderately thin, black, extending from umbo to posterior border of nacreous layer; secondary hinge ligament not colored but evident in intact specimens whose dorsal margins are fused.

Measurements (mm.) —

length	width	
290	102	(large; Port Alfred, Cape of Good Hope)
245	96	(large; Port Alfred, Cape of Good Hope)
75	40	(small; Port Alfred, Cape of Good Hope)
67	48	(stunted; Port Alfred, Cape of Good Hope)

Synonymy —

1835 *Pinna squamifera* Sowerby, Proceedings Zoological Society of London, p. 85 (ad Caput Bonae Spei [Cape of Good Hope, Union of South Africa]).

1835 *?Pinna afra* Sowerby, ibid., p. 85 (ad Caput Bonae Spei [Cape of Good Hope, Union of South Africa]).

1848 *Pinna capensis* Krauss, Die Südafrikanischen Mollusken, p. 27, [line 33] (In limo arenoso ad otium flum, Knysna [Cape of Good Hope, Union of South Africa]; *capensis* not figured; *squamifera* figured, pl. 2, fig. 8.

1858 *Pinna kraussii* Hanley, Proceedings Zoological Society of London, p. 226 (Natal [Union of South Africa]).

1915 *Atrina alfredensis* Bartsch, Bull. United States National Museum, No. 91, p. 183, pl. 40, fig. 3 (Port Alfred [Union of South Africa]).

1932 *Pinna segmenta* Turton, Marine Shells of Port Alfred, p. 217, pl. 56, no. 1510 (Port Alfred).

1932 *Pinna whitechurchi* Turton, ibid., p. 218, pl. 56, no. 1512 (Port Alfred).

1932 *Pinna rufanensis* Turton, ibid., p. 218, pl. 56, no. 1513 (Port Alfred).

Nomenclature — With the exception of *Pinna densecostata* (= *P. bicolor*), and *P. anomioides* and *similis* (both = *S. saccata* Linné), all of the new names of Pinnidae introduced by Turton (1932) are synonyms of *Atrina squamifera*. His figures, although mostly of immature shells, are recognizable. The specimens called *Pinna afra* Sowerby and mentioned by Turton as having been identified by Dr. Paul Bartsch are indeed fragments and are represented in the United States National Museum collection (catalogue nos. 187160, 250991) from the Port Alfred area. It is difficult to assign these fragments generically and less specifically. It is proba-

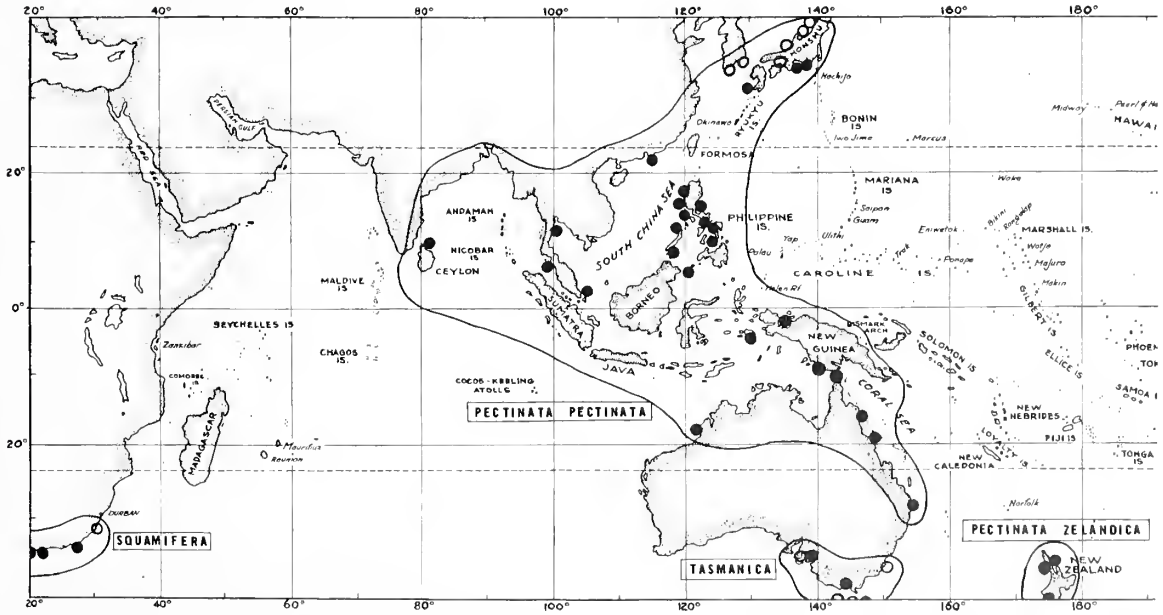

Plate 160. Geographical distribution of *Atrina squamifera* (Sby.) (South Africa); *A. pectinata pectinata* (Linné) (South Asia and Western Pacific); *A. pectinata zelandica* (Gray) (New Zealand); and *A. tasmanica* (Tenison-Woods) (Tasmania and Southeastern Australia).

ble that they are fragments of *squamifera*, badly beachworn. The true identity of *P. afra* is still unclear and the types apparently lost. Considering the type locality and general description of the species, I must agree with Winckworth (1929, p. 290) that *afra* is probably a synonym of *squamifera*.

Types—The holotype of *Pinna squamifera* Sowerby is in the British Museum (N.H.). It is here figured, pl. 159. Locations of the holotypes of *P. afra* Sowerby, *P. capensis* Krauss and *P. kraussii* Hanley are unknown. The Turton types are in the Oxford University Museum. The holotype of *Atrina alfredensis* Bartsch is in USNM, no. 227815.

Records (see map, plate 160) – SOUTH AFRICA: Cape of Good Hope (ANSP); Jeffreys Bay (MCZ; ANSP; Mus. Zool. U. Mich.); Port Elizabeth (MCZ); Kowie River, Port Alfred (MCZ); Port Alfred (MCZ; USNM); Natal (Hanley, 1858).

Subgenus Servatrina Iredale, 1939

Type: *Atrina pectinata* (Linné, 1767)

Externally the shells of the members of the subgenus *Servatrina* have the characteristics of the genus *Atrina* (s.l.). The subgeneric difference is based on an internal character: the posterior adductor muscle scar is enclosed completely within the nacreous area rather than protruding beyond its posterior border as in *Atrina* (s.s.).

This subgenus is world-wide in distribution in tropical and warmer temperate seas; however, it appears to be absent from the Eastern Atlantic. There are 3 Recent species or subspecies in this subgenus in the Indo-Pacific area: S. *pectinata pectinata* Linné, *pectinata zelandica* Gray and S. *tasmanica* Tenison-Woods. In addition, 3 fossil species from the mid-Tertiary of southern Australia are included here.

Synonymy —

1939 *Servatrina* Iredale, Great Barrier Reef Expedition Scientific Reports, vol. 5, **Mollusca,** part 1, p. 317. Type by original designation: *Pinna assimilis* Reeve [= *Atrina pectinata* Linné, 1767].

Atrina (Servatrina) pectinata (Linné, 1767)

Within its relatively narrow range in the Indo-Pacific, *Atrina (Servatrina) pectinata* fulfills the prerequisite of a species of the Pinnidae by exhibiting maximum variation. The species ranges from the pale, translucent, subinflated olivaceous form of south India to the large, tumid, dark "*japonica*" of southern Japan. Throughout this range, however, distribution is probably continuous, thus affording an opportunity for the exchange of genetic material among the several forms. It is doubtful that free genetic exchange occurs between the East Indian and Australian populations of *pectinata* and those of New Zealand. If such does rarely occur, it would be in the southern direction. For this reason it is convenient to consider the New Zealand form of *pectinata* as a subspecies.

Servatrina pectinata pectinata is limited in its distribution to southern and southeast Asia, the East Indies, northern Australia and Melanesia. The subspecies *zelandica* inhabits the islands of New Zealand. With the exception of these two forms the only other representative of the subgenus *Servatrina* present in the Indo-Pacific is S. *tasmanica* Tenison-Woods from northern Tasmania and southeastern Australia.

Atrina pectinata *subspecies* pectinata (Linné, 1767)

(Pls. 139, 160-163)

Range — Southeast India and Ceylon to western Melanesia.

Remarks — The Comblike *Atrina* probably derived its name from the spines which commonly

Plate 161. *Atrina pectinata pectinata* (Linné). Fig. 1. External view of specimen from Fukura, Awaji, Japan, of large size, probably cultivated for food. Fig. 2. Interior of same specimen (⅕ nat. size, Smithsonian Institution photos.) Figs. 3-4. Internal and External views of Holotype of *Pinna serra* Reeve [= *A. pectinata*], Moreton Bay, Queensland. (about ½ nat. size, British Museum (N.H.) photos.)

Plate 162. *Atrina pectinata pectinata* (Linné). Holotype of *Pinna lurida* Reeve. Philippine Islands. Fig. 1. Exterior of right valve. Fig. 2. Interior of right valve. (½ nat. size, British Museum (N.H.) photos.)

protrude from the dorsal-most rib of the shell and resemble the teeth of a comb. These spines may be present even when the remainder of the valve is quite smooth. They are not evident in Linné's reference, Gualtieri, plate 79, fig. A., but are present in similar specimens.

Atrina pectinata cannot be easily confused with any other Indo-Pacific species when the range of its variation is understood. It varies from nearly smooth to finely imbricate in sculpture, and, in the northern part of its distribution, attains a fairly large size. The subgeneric characteristic of an internal posterior adductor muscle scar is constant and is shared only with *Servatrina pectinata zelandica* and *S. tasmanica*.

This species has quite often been dredged in relatively deep water. In fact, dredgings by the United States Bureau of Fisheries Steamer *Albatross* in the Philippines in 1908 yielded large numbers of very thin, broken valves of *pectinata* from depths as great as 300 fathoms (*Albatross* Station 5189). A small living specimen was collected from 170 fathoms at station 5267 off Matocot Point, west Luzon. It has generally been believed that the Pinnidae are a shallow-water group. In the case of *A. pectinata*, however, this appears to have been a misconception, at least partially. It is probable that the usual habitat of pinnas is in shallower water than

that just mentioned. The young living specimen collected in nearly 200 fathoms may have settled there and would not have survived much longer. The quantities of valves collected at 300 fathoms may have been washed to this depth by ocean currents. It seems apparent, however, that *pectinata* does often occur in other than shallow water in certain parts of its range. The species lives in fairly shallow water in the northern portion of its range on the coast of Japan but its vertical distribution ranges to deeper waters here also. Cahn (1951) reports that *Atrina japonica* Reeve (= *pectinata* Linné) is found in depths of from 8 to 60 meters (about 4.4 to 33 fathoms). It is reported from Tosa, Japan, from 100 fathoms. Some of the largest specimens seen are from Japanese waters, reaching nearly 37 centimeters (about 14½ inches) in length. The species is used commercially there for food and fertilizer and is planted intertidally and actively cultivated for subsequent harvest.

A shrimp, *Conchodytes nipponensis* (DeHaan) (identified by Dr. L. B. Holthuis of Leiden, Holland), was found living in the mantle cavity of a specimen of *pectinata* from Japen Island, Dutch New Guinea. This species of shrimp has been reported in *pectinata* previously by Kubo (1940).

Cahn (1951) reported that *pectinata* is dioecious; spawning occurs from June to September in Ariake, Japan; the optimum critical temperature for spawning is between 24 and 27° C.; sexual maturity is reached at about one year.

Yoshida (1956) reported on a study of the early life history of *pectinata* in Japan and figured stages in the development of the veliger. Veligers of *pectinata* were found to be of larger size than any other species of Pinnidae studied. In the present study, the embryonic valves of this species were found to be about twice the size of other species available for study (see pl. 139, figs. 1-6, and the descriptions of *pectinata*, *vexillum* and *muricata*). Yoshida found young (post veligers) of *pectinata* buried in bottom mud and attached to apparatus used in collecting the spat of the ark clam, *Anadara subcrenata*. Comparisons made between young of *pectinata* and "*Pinna (Atrina) japonica*" (of Yoshida) [= *Pinna bicolor* Gmelin?] showed the former to differ from the latter in the shape of the posterior margin and in the lack in *pectinata* of the pinnoid sulcus and dark coloration in the valves.

Habitat — Cahn (1951) has reviewed the Japanese literature concerning the ecology of *Atrina (Servatrina) japonica* Reeve (= *pectinata* Linné). The species lives in sand or sandy mud and is buried almost completely during the summer, but works up so that only the anterior tip is buried in winter. Orientation is with the ventral (open) portion of the shell facing toward the current. The species survives a range of temperatures from 39° C. to 1° C., and is resistant to sea water with lowered salinity. The major foods consumed by *pectinata* in Japan were found to be diatoms, copepods, and protozoans.

Description — Shell reaching 370 mm. (about 14½ inches) in length; triangular-wedge-shaped in outline and moderately to strongly inflated; rather thin and fragile to only moderately heavy in structure; sculptured with radiating ribs which may be nearly spineless, or bear minute imbrications ranging to a few short, upright spines which are open posteriorly. Shell translucent, usually olivaceous tan in color, approaching dark brown in some specimens. Surface of valves faintly shining. Radial sculpture consists of from 15 to 30 radiating ribs on the posterior slope; in young specimens ribs may all be fine and closely spaced; sculpture on the ventral slope becomes crowded and impossible to count. Ribs often smooth but usually ranging from finely imbricate to distinctly spinose. Concentric sculpture of fine lines of growth, convex posteriorly and sometimes wavy. Posterior margin usually truncate; the junction of posterior and ventral slopes projecting farthest posteriorly. Dorsal margin usually nearly straight, often with a series of short spines protruding from the most dorsal rib (from which the name "*pectinata*" is derived). Ventral margin forms a gentle sigmoid curve: convex posteriorly, concave anteriorly. Interior of valves the same olivaceous tan, ranging to dark brown or nearly black in Japanese specimens; smooth and shining. Nacreous layer iridescent, occupying the anterior two-thirds to three-quarters of the valve. Posterior adductor muscle scar medium to large in size, subcircular, located well within the posterior border of the nacreous area, but never protruding beyond. Anterior adductor muscle scar small, located at tip of nacreous area. Posterior border of nacreous layer broadly rounded with no distinct embayment. Primary hinge ligament fairly thin, black and extending from the anterior end of the shell to the posterior border of the nacreous layer; secondary hinge ligament not colored but evident in intact specimens whose dorsal margins are fused. Embryonic valves about 1 mm. in length, broadly triangular in outline, inflated; the umbos directed postero-medially (pl. 139, figs. 5, 6).

Measurements (mm.) –

length	width	
370	185	(large; Japan [Cahn, 1951])
350	220	(large; Fukura, Awaji, Japan)
185	107	(average; Lem Sing, Thailand)
90	40	(small; Biliran Id., Philippines)
48	19	(small; Biliran Id., Philippines)

Synonymy –

1767 *Pinna pectinata* Linné, Systema Naturae, ed. 12, p. 1160 (in India); refers to Gualtieri, pl. 79, fig. A.

?1798 *Pinna inflata* Röding, Museum Boltenianum, Hamburg, pt. 2, p. 159 (nomen nudum, see Winckworth, 1929).

1798 *Pinna vitrea* Röding, ibid., p. 159; refers to Gmelin's *Pinna pectinata var. B*, p. 3364, and Chemnitz, pl. 87, fig. 771 (not *P. vitrea* Gmelin, 1791 = *Streptopinna saccata* L.)

1817 *Pinna inflata* Dillwyn, Descriptive Catalogue of Recent Shells, London, p. 326 (Inhabits the coasts of the Nicobar Islands); refers to Chemnitz, vol. 8, pl. 87, fig. 771; not *P. inflata* Phillips, 1836, a fossil.

1823 *Pinna cancellata* Mawe, Linnaean System of Conchology, p. 77, pl. 17, fig. 2 (Ceylon).

1841 *Pinna chinensis* Deshayes (in Cuvier) Le Règne Animal (Disciples' edition), **Mollusques**, pl. 85 (no locality given).

1858 *Pinna chemnitzii* Hanley, Proc. Zool. Soc. London, p. 136 (Insulae Philippinae); refers to Chemnitz, vol. 8, pl. 87, fig. 770; figured in Reeve, 1859, vol. 11, Pinna, pl. 1, figs. a, b.

1858 *Pinna hystrix* Hanley (in part), ibid., p. 226 (see synonymy of *vexillum*).

1858 *Pinna hanleyi* Reeve, Conchologia Iconica, vol. 11, **Pinna**, pl. 8, fig. 15 (Amboyna).

1858 *Pinna lurida* Reeve, ibid., pl. 13, fig. 24 (Philippine Islands).

1858 *Pinna penna* Reeve, ibid., pl. 21, fig. 39 (Philippine Islands).

1858 *Pinna serra* Reeve, ibid., pl. 23, fig. 43 (Moreton Bay [Australia]).

1858 *Pinna japonica* 'Hanley' Reeve, ibid., pl. 25, fig. 47 (Japan) [attributed to Hanley in error].

1858 (August) *Pinna strangei* 'Hanley' Reeve, ibid., pl. 27, fig. 52 (Moreton Bay [Australia]); Hanley, [Nov.] 1858, Proc. Zool. Soc. London, p. 254.

1858 (August) *Pinna assimilis* 'Hanley' Reeve, ibid., pl. 31, fig. 59 (Raines's Island, Torres Straits); Hanley [Nov.] 1858, Proc. Zool. Soc. London, p. 255.

1891 *Pinna lischkeana* Clessin, Conchylien Cabinet, vol. 8, part 1, **Malleacea**, p. 73, pl. 28, fig. 1 (Japan, Yokohama).

1891 *Pinna vespertina* 'Recve' Clessin, ibid., p. 90, pl. 39, fig. 2 [= *Atrina pectinata* Linné; Clessin by error transposed Reeve's figs. 43 and 44].

1922 *Pinna japonica* 'Hanley' Yokoyama, Journ. College of Science, Imperial University of Tokyo, vol. 44, Art. 1, p. 185, pl. 15, fig. 8 (Shito; Oji in Musashi); 1925, ibid., vol. 45, Art. 5, p. 28, pl. 6, fig. 7 (Shirado Pliocene).

1953 *Atrina (Servatrina) teramachii* Habe, Illustrated Catalogue of Japanese Shells, vol. 1, p. 192, pl. 24, fig. 1, pl. 25, fig. 5 (Tosa Bay, Shikoku).

1953 *Atrina (Servatrina) kinoshitai* Habe, ibid., p. 193, pl. 24, fig. 2 [not fig. 4 as in text] (off Wakayama Pref., Honshu).

1961 *Atrina (Servatrina) lamellata* Habe, Coloured Ills. Shells of Japan (II), Osaka, p. 117, pl. 52, fig. 5; appendix, p. 37.

Nomenclature – A discussion of the nomenclatorial history of *Servatrina pectinata* Linné was given by Dodge (1952, pp. 225-226). I agree with his analysis and can only repeat that it is the great degree of variation in this species which has resulted in the large number of names which must be synonymized with it.

Winckworth (1929) considered *Pinna penna* Reeve to be a synonym of *Atrina (Servatrina) serrata* Sowerby of the Western Atlantic and not from the Philippines as stated by Reeve. Winckworth (1936) later retracted this statement because Prashad (1932, p. 137 and plate 4, figs. 14, 15) claimed to have found *Atrina penna* Reeve in the Philippines. The specimen figured by Prashad, as well as that figured by Reeve, are young *Servatrina pectinata* Linné. The imbricate sculpture which is often so evident in the young shells may be seen in many older specimens where it becomes considerably worn away on the anterior portion of the shell but often remains to form a roughened ventral slope.

The confusion generated by Hanley (1855, p. 149) regarding the similarity between *Atrina fragilis* Pennant and *pectinata* Linné may be easily dispersed. Not only are the two species geographically isolated, the former in the Eastern Atlantic and the latter in the Indo-Pacific, but each is included in a different subgenus on the basis of its nacreous layer: *fragilis* in *Atrina* and *pectinata* in *Servatrina*. Therefore the type locality "in India" cited by Linné is correct and *pectinata* is without doubt an Indo-Pacific species.

The name *inflata* is credited by both Dodge (1952) and Winckworth (1929) to Wood, 1818. As noted earlier by Sherborn (1927) and later by Winckworth (1936, p. 122) *P. inflata* was described by Dillwyn, 1817.

Pinna [*Atrina (Servatrina)*] *cumingii* 'Hanley' Reeve, (May) 1858 was assigned the locality "Australia" by Reeve. Hanley (Nov., 1858) cited "Peruvia" as the type locality. The species is indeed from the Eastern Pacific and a synonym of *Atrina (Servatrina) maura* Sowerby (also see Winckworth, 1929, p. 291). *Pinna minax* Hanley, 1858, whose type locality was cited by Hanley as: "Nov. Guinea? Mexico?" is also very probably synonymous with *maura*.

Winckworth (1929) tentatively considered *Pinna (Atrina) strangei* Reeve a valid species but stated that he had seen no specimens from India or Ceylon, the areas with which he was seriously concerned at the time. Photographs of the holotype of *strangei* (not published here) show this species to be in all probability *Atrina (Servatrina) pectinata*

Linné. Internally, a large oval posterior adductor muscle scar is present located well within the posterior border of the nacreous layer. Externally the sculpture is characteristic of *pectinata*, there being none of the secondary radiating ribs often visible in *Atrina (Atrina) vexillum*. There is also the obsolete sculpture on the ventral slope which is seen so clearly in *pectinata*, although in the holotype the sculpture appears to be rather worn overall. The appearance of the type is that of a mature to older specimen, the shell of which has suffered repeated breakage and repair posteriorly (also see *Pinna hystrix* Hanley under the *Nomenclature* section of *Atrina vexillum*).

Types — The location of the holotype of *Pinna pectinata* is unknown. Linné referred to Gualtieri, plate 79, fig. A, which is here selected as the type figure. The type locality was given by Linné as "in India." Types of species described by Reeve and Hanley are in the British Museum (Natural History). The type of *P. lischkeana* was said by Clessin to be in the Rolle collection which was probably dispersed. The types of *Scrvatrina teramachii* and *kinoshitai*, described by Habe are in the Zoological Institute, Kyoto University, Kyoto, Japan. The type figure here selected of *Pinna inflata* Dillwyn is Chemnitz, vol. 8, pl. 87, fig. 771. The locality of the type specimen of *P. cancellata* Mawe from Ceylon is unknown to me, as is that of *P. chinensis* Deshayes.

Records (see map, pl. 160) — CEYLON (MCZ). THAILAND: Trang (USNM); Praehuap Khiri Khan (G. M. Moore, MCZ). MALAYA: Singapore (ANSP). KOREA: southern tip of Korea (Cahn, 1951). CHINA: Hong Kong (ANSP). JAPAN: western Honshu (Cahn, 1951); Tokyo Harbor (ANSP; USNM); Tosa, Shikoku (ANSP); Kagoshima Gulf, Kyushu (USNM). PHILIPPINES: many localities (see map, MCZ; ANSP; USNM). INDONESIA: Amboina, Molueeas (MCZ). AUSTRALIA: Broome, Western Australia (V. Orr, ANSP; MCZ); Torres Straits (USNM); Buehan's Point, 17 miles north of Cairns (J. Kerslake; Austra. Mus.; USNM); Brampton Reef, Bowen; Southport (both W. Old, Jr., USNM) all Queensland. NEW GUINEA: Samberbaba, Japen Id. (NSF); Merauke (MCZ).

Fossil Records — Yokoyama (1922, 1925, see *Synonymy*) reeorded *Pinna japonica* Hanley (probably = *Atrina pectinata* Linné) from the Pleistoeene, Shito formation, of Oji in Musashi, Japan; and from the Shirado Plioeene.

Atrina pectinata *subspecies* zelandica (Gray, 1835)

(Pls. 160, 164)

Range — New Zealand: North, South Islands, Stewart Island and The Snares (Powell, 1957).

Remarks — This is the only member of the family Pinnidae known to inhabit New Zealand waters and therefore its identification is certain with relia-

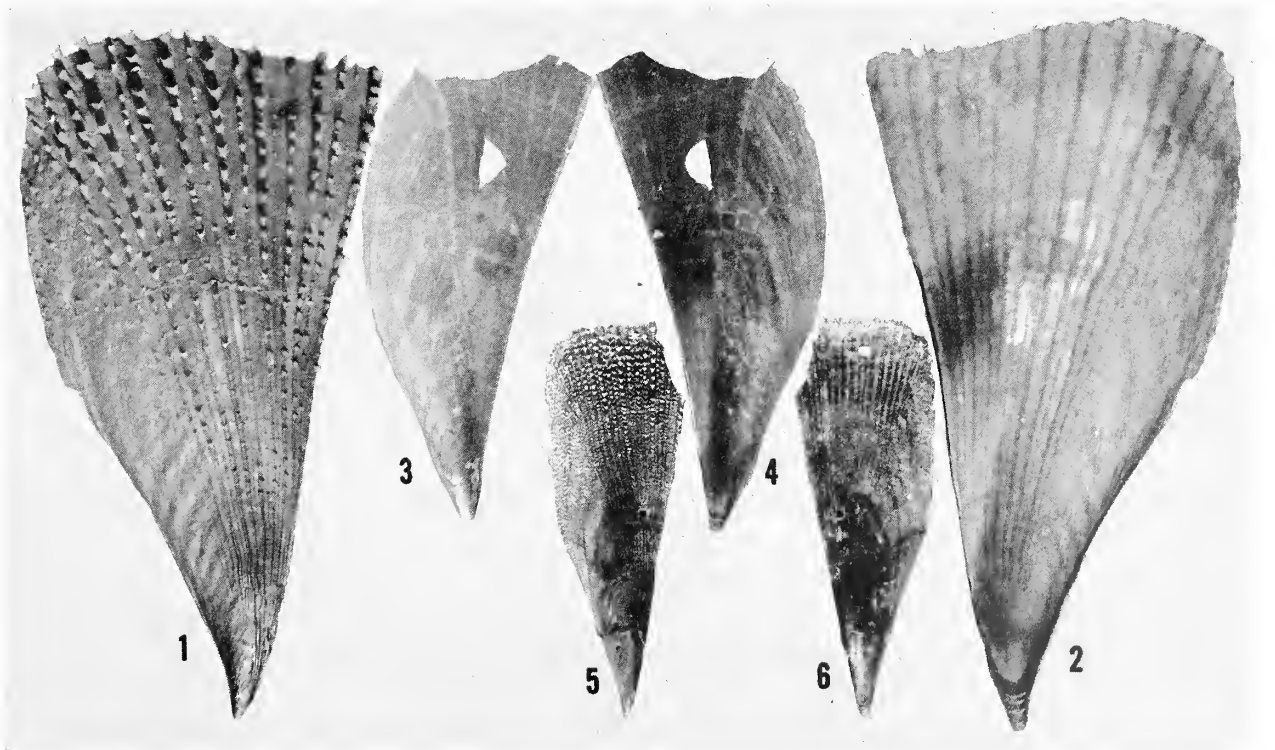

Plate 163. *Atrina pectinata pectinata* (Linné). Figs. 1-2. Syntype of *Pinna assimilis* Reeve, from Raines's Island. Torres Straits. (135 mm. in length). Figs. 3-4. Holotype of *Pinna japonica* Reeve, Japan. (96 mm. in length). Figs. 5-6. Holotype of *Pinna penna* Reeve, Philippine Islands. (79 mm. in length). (British Museum (N.H.) photos.)

ble data. It is probable that pelagic young of *Servatrina pectinata* reached New Zealand from Australia via the East Australian current or that young specimens were carried on floating debris. Since its arrival and the later establishment of isolated breeding populations in New Zealand, the subspecies *zelandica* has become distinct in this area.

Servatrina zelandica may be distinguished from S. *pectinata* by the much more uniformly distributed sculpture of semitubular spines adorning the ribs of the former species; it is usually more narrowly triangular, and the coloration in *zelandica* is usually lighter overall, occasionally with radiating bars of brownish purple, while in *pectinata* usually darker olivaceous hues predominate and no striping has been noted.

Habitat – "Common on mud-flats, buried" (Powell, 1957, Plate 15, fig. 16 caption).

Description – Shell reaching 258 mm. (about 10⅛ inches) in length, elongate-triangular in outline and only moderately inflated; rather thin and fragile in structure, sculptured with radiating ribs which in unworn specimens are usually uniformly covered with short, upright to occasionally recurved semitubular spines. Shell translucent to nearly transparent; ranging from light to darker tan in color with only a trace of olive; occasionally with radiating bars of purplish brown between ribs. Surface of

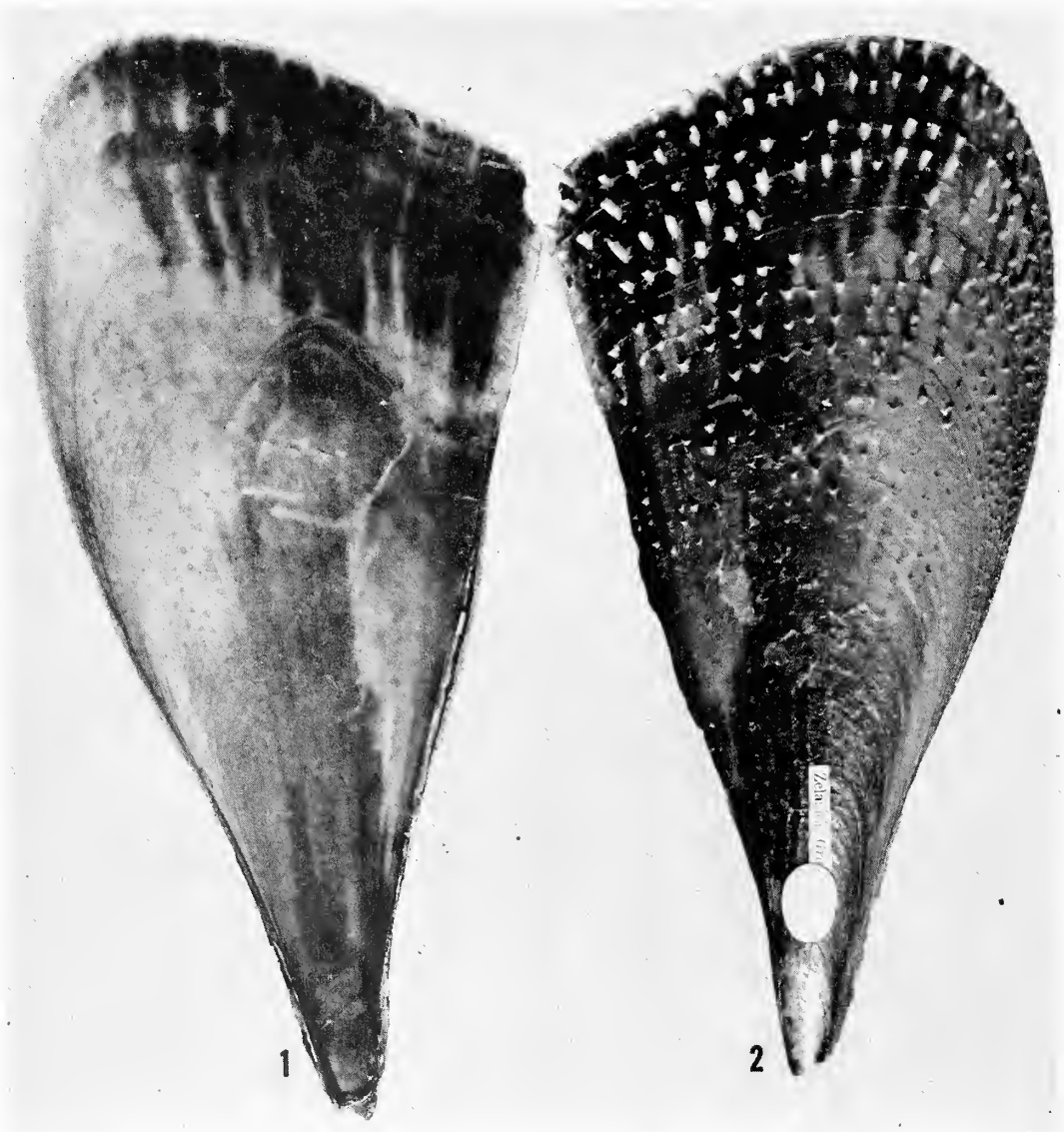

Plate 164. *Atrina pectinata zelandica* (Gray). Neotype of *Pinna zelandica* Gray, New Zealand. Note the dark stripes posteriorly and generally uniform spinosity, characteristic of this subspecies. Specimen 205 mm. (8 inches) in length. (British Mhseum (N.H.) photos.)

valves dully shining. Radial sculpture consists of from 14 to 30 radiating ribs which are easily distinguished on the posterior slope, but which become nearly obsolete and very crowded on the ventral slope. Ribs on posterior slope usually with uniformly distributed spines which also become minute imbrications on ventral slope. Concentric sculpture of fine growth lines, convex posteriorly. Posterior margin truncate, projecting farthest posteriorly at junction of posterior and ventral slopes. Dorsal margin usually straight. Ventral margin nearly straight to only slightly concave anteriorly. Interior of valves light to darker, sometimes olivaceous, tan; with the purplish brown bars showing through. Nacreous layer iridescent occupying anterior three-quarters of valve. Posterior adductor muscle scar moderately large, circular, located within posterior border of nacreous layer, never protruding beyond. Posterior border of nacreous layer usually rounded, but occasionally with a posteriorly directed pointed peak; with no distinct embayment. Primary hinge ligament thin, black, extending from anterior end of shell to posterior border of nacreous layer on the dorsal margin; secondary hinge ligament not colored, but evident in intact specimens whose dorsal margins are fused.

Measurements (mm.) —

length	width	
258	110	(large; New Zealand)
173	78	(medium; Hutt, New Zealand)
87	40	(small; Manukau Harbor, North Island)

Synonymy —

1835 *Pinna zelandica* Gray [in Yate] New Zealand, p. 310 (New Zealand); not originally figured; neotype figured in Reeve, Conchologia Iconica, vol. 11, Pinna, pl. 7, fig. 13 (Wilkins, 1953, p. 25).

1850 *Pinna senticosa* Gould, Proceedings Boston Society of Natural History, vol. 3, p. 312 (New Zealand); not figured; Gould, (1852, U. S. Exploring Exped., vol. 12, **Mollusca and Shells**, pp. 448-449) referred to fig. 574 in the Atlas (1856), a figure never included.

1873 *Pinna zelandica* Gray, Hutton, Catalogue of the Tertiary Mollusca and Echinodermata of New Zealand, p. 26 (Tertiary: Waganui (U.); Shakespeare Cliff; Awatere).

1873 *Pinna lata* Hutton, ibid., p. 26 (Tertiary: Cobden).

1873 *Pinna plicata* Hutton, ibid., p. 26 (Tertiary: Culverden(?), in blue clay) ["a fan-shaped Fucoid", Suter, 1914, p. 10; 1915, p. 53].

1873 *Pinna distans* Hutton, ibid., p. 26 (Tertiary: Caversham).

Types — The holotype of *Pinna zelandica* Gray was apparently lost. A neotype (lectotype?) from the Cuming Collection, from New Zealand, was selected by Wilkins (1953, p. 25) and is in the British Museum (Natural History): B.M. 1952.9.16.24. The

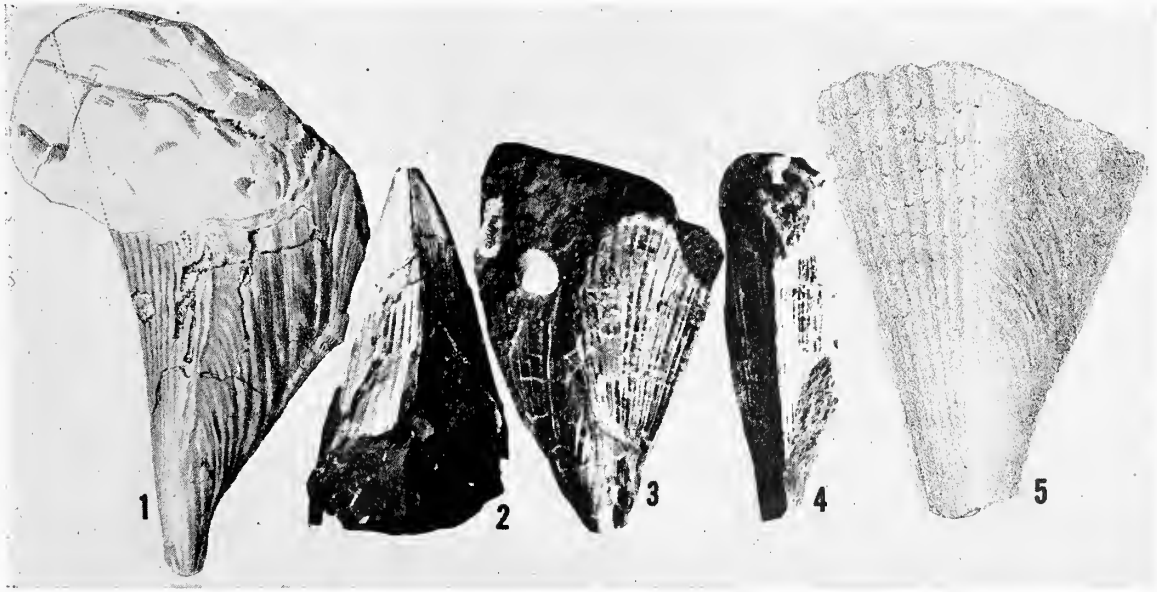

Plate 165. Fig. 1. *Atrina cordata* (Pritchard), Barwon River, near junction with Native Hut Creek, Victoria, Australia. Eocene. Holotype. (110 mm.) (from Pritchard, 1895, pl. 12, fig. 4.). Figs. 2-4. *Atrina janjukiensis* Crespin, Lakes Entrance Oil Shaft, Gippsland, Victoria, Australia. Middle Eocene. (Figs. 2-3. Holotype (140 mm.); Fig. 4. Paratype; from Crespin, 1950, pl. 17, figs. 18, 19, 20). Fig. 5. *Atrina tateana* Hedley, Adelaide and Aldinga Bay, South Australia. Miocene. Holotype. (130 mm.). (from Tate, 1886, pl. 12, fig. 9). (All copies of original plates; Smithsonian Instit. photos.)

specimen was figured by Reeve (1858), Conchologia Iconica, vol. 11, Pinna, pl. 7, fig. 13. The location of the type specimen of *Pinna senticosa* Gould is unknown and it was presumably lost (personal communication, R. I. Johnson, 1960, who has in preparation a catalogue of the types of species described by A. A. Gould). Types of fossil species described by Hutton, *P. lata, plicata* and *distans*, are in the Colonial Museum, Wellington, New Zealand.

Records (see map, pl. 160) – NEW ZEALAND: North Island: beach near Devonport; Auckland (both ANSP); Manukau Harbor (A. W. B. Powell, MCZ; USNM) all Auckland Province; Hutt, Wellington Province (USNM). South Island: Pelorous Sound, northern Marlborough Province (MCZ). Forsterian Marine Province: [Otago, Stewart Id. and the Snares] (Powell, 1957, p. 77).

Fossil Records – Hutton (1873, p. 26) described 3 new species of Pinnidae from the Tertiary of New Zealand. One of these, *P. plicata*, was later discovered to be "a fan-shaped Fucoid" (Suter, 1914, p. 10; 1915, p. 53). Although the types of Hutton's species were not figured, if the remaining two are Pinnidae, they are undoubtedly part of *Atrina pectinata zelandica* Gray. According to Suter (1913, p. 893), *zelandica* appears as a fossil in the Eocene, Miocene and Pliocene of New Zealand.

Atrina (Servatrina) cordata (Pritchard, 1895)

(Pl. 165, fig. 1)

Range – Eocene of Victoria, Australia.

Remarks – It is probable that this species is closely related to *Servatrina tasmanica* Tenison-Woods. The original figure 4, here reproduced (pl. 165) shows a fossil having a shape similar to the Recent *tasmanica*.

Synonymy –

1895 *Pinna cordata* Pritchard, Proceedings Royal Society of Victoria, n.s., vol. 7, p. 228, pl. 12, figs. 4-5 (Eocene sandy limestones, Barwon River, near its junction with the Native Hut Creek. J. Betheras, collector).

Atrina (Servatrina) janjukiensis (Crespin, 1950)

(Pl. 165, figs. 2-4)

Range – From the Middle Miocene (Janjukian Stage) of Victoria, Australia.

Remarks – Like the preceding species, this seems closest to *Servatrina tasmanica* Tenison-Woods and both may be merely earlier forms of the latter. However, neither fossil is sufficiently complete to assure its definite assignment to *tasmanica*.

Synonymy –

1950 *Atrina janjukiensis* Crespin, Proceedings Royal Society of Victoria, n.s., vol. 60, p. 150, pl. 17, figs. 18, 19, 20 (Middle Miocene (Janjukian Stage): The Lakes Entrance Oil Shaft, Gippsland, Victoria).

Atrina (Servatrina) tateana (Hedley, 1924)

(Pl. 165, fig. 5)

Range – Tertiary (Miocene), South Australia, Australia.

Remarks – The figure of *Atrina tateana* here reproduced (pl. 165) indicates that this species is also closely related to *Atrina tasmanica* Tenison-Woods.

Synonymy –

1886 *Pinna semicostata* Tate, Transactions and Proceedings and Report Royal Society of South Australia (for (for 1884-1885) vol. 8, p. 122, pl. 12, fig. 9 (Older Tertiary: Oyster banks, Adelaide and Aldinga Bay); 1899, Transactions Royal Society of South Australia, vol. 23, part 2, p. 276 (Miocene-Aldinga Bay).

1924 *Atrina tateana* Hedley, Records of Australian Museum, vol. 14, no. 3, p. 143 [new name for *Pinna semicostata* Tate, not *Pinna semicostata* Conrad (= *P. muricata* Linné, a recent species)]

Atrina (Servatrina) tasmanica (Tenison-Woods, 1876)

(Pls. 160, 166, 167)

Range – Southern and southeastern Australia and northern Tasmania.

Remarks – The Tasmanian *Atrina* apparently is limited in distribution to the north coast of Tasmania and southern and southeastern Australia. Superficially it appears nearest in its relationship to *Atrina (Atrina) squamifera* Sowerby of South Africa. However the subgeneric characters separate these species. In *Servatrina tasmanica* the posterior adductor muscle scar is placed well within the posterior border of the nacreous layer, but in *A. squamifera* the scar bulges beyond. As in other members of the Pinnidae, a superficial similarity is observed in the external sculpture of these two species. In both, well-defined tubular spines may develop on the radial ribs; the sculpture on the ventral slope becomes crowded, but small spines often persist, giving a prickly appearance to this portion of the valve. Other species of *Atrina* with which *tasmanica* might be confused are *vexillum, pectinata pectinata* and *p. zelandica*. In *pectinata* and *zelandica* the numbers of rows of radiating ribs on the posterior slope are greater than in *tasmanica* (14, 15-30 rather than 10-14). The subgeneric difference easily separates mature specimens of *Atrina*

(Atrina) vexillum from *Atrina (Servatrina) tasmanica*. Also, these species apparently do not occur within the range of *tasmanica*. It appears, therefore, that *Servatrina tasmanica* is a valid and distinct species which is endemic in the South Australian Region.

Habitat — Lives in fairly deep water: 15-45 fathoms (Hedley, 1924, pp. 152-153); probably buried in sandy mud with the posterior portion of the shell protruding from the substrate.

Description — Shell reaching 250 mm. (nearly 9½ inches; [14 inches; Gabriel (1936)]) in length; triangular-wedge shaped in outline; moderately inflated; rather fragile in structure and sculptured with radiating ribs which usually bear strong semitubular spines. Shell translucent, tannish brown in color; surface of valves shining. Radial sculpture consists of from 10-14 moderately prominent radiating ribs on the posterior slope; in older individuals ribs may become nearly obsolete; sculpture on the ventral slope becomes crowded and impossible to count. Ribs often smooth, but usually bear large, upright, occasionally twisted spines which are open posteriorly. Concentric sculpture of posteriorly convex lines of growth which sometimes overlap loosely giving the valves a scaly appearance. Posterior margin usually broadly rounded. Dorsal margin nearly straight to slightly convex. Ventral margin convex posteriorly, concave anteriorly. Interior of valves tannish brown, with occasional dark brown blotches; smooth and shining. Nacreous layer iridescent, occupying anterior three fourths the length of valve. Posterior adductor muscle scar medium sized, subcircular, located well within posterior border of nacreous layer, never protruding beyond. Anterior adductor muscle scar smaller, located at anterior tip of nacreous layer. Posterior border of nacreous layer somewhat peaked centrally and sloping toward dorsal and ventral borders. Primary hinge ligament moderately thin,

Plate 166. *Atrina tasmanica* (Tenison-Woods), Phillips Island, Victoria, Australia. Fig. 1. Exterior of right valve. Fig. 2. Interior of right valve. Specimen 191 mm. (7.5 inches) in length. (National Museum of Victoria photos.)

black and extending along dorsal margin from anterior end of shell to posterior border of nacreous layer; secondary ligament not colored but evident in intact specimens whose dorsal margins are fused. Embryonic valves and animal unknown.

Measurements (mm.) —

length	width	
240	112	(large; San Remo, Victoria, Australia)
191	99.5	(average, Phillip Island, Victoria, Australia)
142	63	(small; North West Tasmania; lectotype)
133	72	(small; Adelaide, South Australia)

Measurements of the center two specimens were kindly supplied by Dr. J. Hope Macpherson, Curator of Molluscs, National Museum of Victoria, Victoria, Australia.

Synonymy —

1876 *Pinna tasmanica* Tenison-Woods, Proceedings Royal Society of Tasmania [for 1875], p. 161 (on the north coast only [of Tasmania] W. Legrand) [not figured].

1924 *Atrina tasmanica* var. *dumosa* Hedley, Records of Australian Museum, vol. 14, p. 153 (South Australia: Tapley Shoal, St. Vincent Gulf, 15 fathoms (Mathews and McDougall)) [not figured].

1938 *Atrina dumosa* Hedley, Cotton and Godfrey, The Molluscs of South Australia, pt. 1, Pelecypoda, p. 85, fig. 71.

Types — Lectotype selection: Pinna tasmanica Tenison-Woods, 1875. Tenison-Woods indicated that the specimens of *Pinna tasmanica* upon which his description was based were collected by Legrand. A designated type has not been found in the National Museum of Victoria, the South Australian Museum, nor the Australian Museum, Sydney. Inquiries kindly made for me by Dr. J. Hope Macpherson have failed to locate the type of *tasmanica* in Tasmania. It appears that Tenison-Woods never designated a type and that the Legrand collection has been lost or dispersed. However, the National Museum of Victoria has in its collection three specimens from within the type locality, "on the north coast only," received in August 1876, following the publication in March (fide Hedley, 1924, p. 152) of the description of *tasmanica*. It is possible that these specimens were among the material examined by Woods and therefore may be considered as syntypes. One of these is here selected as lectotype of the species *Pinna tasmanica* Tenison-Woods: National Museum of Victoria, Catalogue no. F21384A; length 142.5 mm., width 63 mm., depth 24 mm.; from "North West Tasmania"; received August, 1876; it is here figured, pl. 167, figs. 1, 2. It is a young specimen and fulfills the portion of Tenison-Woods' description: "ribs sometimes . . . subnodose." A more mature and "typical" specimen is also figured, pl. 166, figs. 1, 2 (Nat. Mus. Victoria Cat. no. F21385; photographs courtesy of Dr. J. Hope Macpherson and Nat. Mus. of Victoria). The type locality of *Pinna tasmanica* is here restricted to Circular Head, Wellington County, [northwestern] Tasmania, a locality from which specimens of this species have been collected (see Tate and May, 1901).

The location of the holotype of *Atrina tasmanica* var. *dumosa* Hedley, 1924 is unknown. A lectotype has been selected by Cotton (South Australian Mollusca (in press)). Notification of his selection was given (*in litt.*, 1960) and is here quoted with his permission: "The 'subspecies' *Atrina tasmanica dumosa* was described by Hedley from Australian Museum specimens and if a holotype were chosen it should be there. I have selected the specimen figured here, (Pelecypoda 1938, fig. 71) measuring height 132 mm., length 75 mm., from Tapley Shoal, Gulf St. Vincent, as Lectotype, D.14160, S.A. Museum."

Records (see map, pl. 160) — AUSTRALIA: King Island; Circular Head, Wellington County, Port Sorrell, Devon County, all Tasmania (all Hedley, 1924). Norah Head, Northumberland County, New South Wales (Hedley, 1924). San Remo, near Melbourne, Victoria (ANSP). Tapley Shoal, St. Vincent Gulf (Hedley, 1924); Adelaide (ANSP), both South Australia.

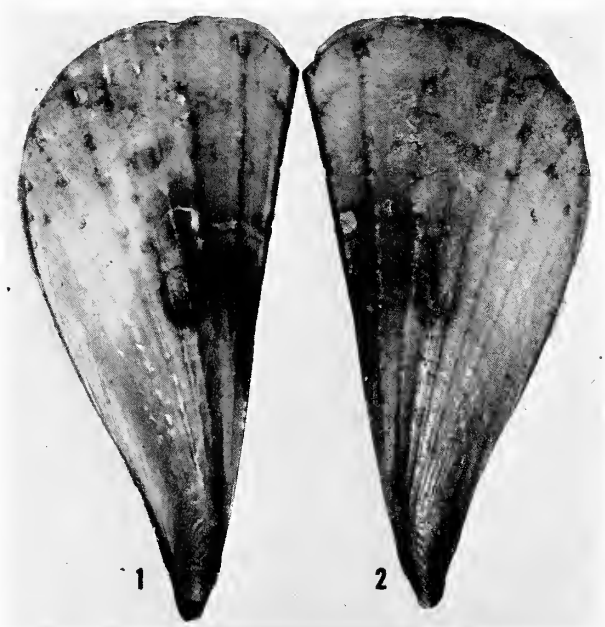

Plate 167. *Atrina tasmanica*. Lectotype of *Pinna tasmanica* Tenison-Woods, northwest Tasmania. Specimen 142.5 mm. (about 5½ inches) in length. (National Museum of Victoria photo.)

Genus Streptopinna von Martens, 1880

Type: *Streptopinna saccata* (Linné, 1758)

This unique genus is found only in the Indo-Pacific faunal region where it is monotypic including the single Recent species *Streptopinna saccata* Linné. Von Martens (1880) introduced *Streptopinna* as a subgenus of *Pinna* and was followed in this use by Winckworth (1929). However, the differences between *Streptopinna*, *Pinna* and *Atrina* are considerable and each is accorded full generic status here. Major generic characters appear to be best demonstrated in the shell. They are: the crowded nacreous layer which occurs only in the dorsal anterior portion of the shell; the appearance of the small anterior adductor muscle scar on an elevated shelf; and the peculiar twisted condition of the posterior portion of the valves. A more complete description follows in the treatment of the species, *saccata*.

Unfortunately the embryonic valves of *Streptopinna* are unknown. This is unusual, considering the hardy nature of the umbonal area of this group. It would be of extreme interest to determine their structure especially in the light of a similarity in the configuration of the nacreous layers between *Streptopinna* and *Crenulata*. The two groups are either extremely convergent in this feature or else they may be related through common ancestral stock.

One southeastern Australian Tertiary fossil possibly belonging to this subgenus is included here.

Synonymy –

1880 *Streptopinna* von Martens, Beiträge zur Meeresfauna der Insel Mauritius und der Seyehellen p. 318. Type by monotypy: *Streptopinna saccata* (Linné, 1758).

Streptopinna? reticosa (Chapman, 1912)

(Pl. 168)

Range – Tertiary; King Island, Tasmania.

Remarks – Chapman (1912, p. 48) compared *reticosa* with *P. cordata* Pritchard, but the latter is probably a *Servatrina* related to *tasmanica*. From the figure given by Chapman (pl. 168), if the fossil *is* a pinnid, it appears to be a small *saccata*-like form. However, this placement is doubtful.

Synonymy –

1912 *Pinna reticosa* Chapman, Memoirs National Museum, Melbourne (Vietoria, Australia), no. 4, p. 47, pl. 6, fig. 8 (Tertiary: polyzoal limestone of Seal River, King Island).

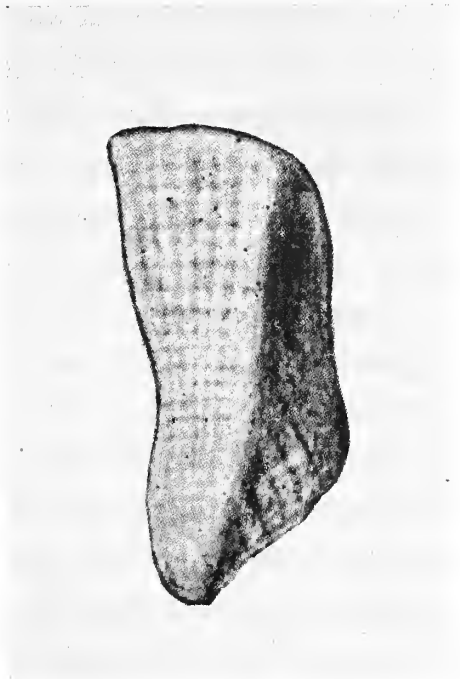

Plate 168. *Streptopinna? reticosa* (Chapman), Seal River, King Island, Tasmania. Tertiary. Holotype, × 4. (from Chapman, 1912, pl. 6, fig. 8). (Smithsonian Institution photo.)

Streptopinna saccata (Linné, 1758)

(Pls. 136, 169-171)

Range – East Africa to eastern Polynesia.

Remarks – *Streptopinna saccata* Linné is widely distributed in the Indo-Pacific (see E. A. Smith, 1903, p. 597). The immature forms of this species are hardly distinguishable exteriorly from young, rather obsoletely sculptured members of the genus *Atrina*. This condition continues through about the first third of the growth of shell as compared to the normal eventual adult size. Thereafter, growth proceeds erratically and the shell of adult specimens may assume an almost unbelievable degree of contortion. There is apparently no predictable form which may be assumed, this lack of uniformity being a basic character for the species. Certain specimens, apparently living under favorable conditions may, indeed, appear quite normally proportioned and identification is questionable until the definitive characteristics of the internal nacreous layer are observed (see *Description*). The reason for the grotesque appearance of *saccata* has its basis in the ecology of the species. It is reported to live under

and between rocks in rocky tide pools and therefore the growth form of the shell is dictated by the curvature of the particular rocks between or under which the young *saccata* settles and commences its normal existence. The viscera are crowded into the dorsal portion of the anterior normal third of the shell. Posterior to the rather small posterior adductor muscle the mantle must extend the additional two thirds the length of the shell to build and maintain the shell and bring its edges into contact with the environment to form the incurrent feeding-respiratory and excurrent waste canals. The valves of *S. saccata* are often so twisted and their growth along the ventral margin so thickened that they actually appear to be fused here as well as along the dorsal margin. There is formed by this fusion of the ventral margin a veritable shell sack in which the animal is contained and, of course, the name "*saccata*" is derived from this fact (also see Jackson, 1890, pp. 385-386).

Although the species is widespread and is found in a great variety of shapes there is no basis for the establishment of more than one species. This is a valid and striking case of environmentally-caused, phenotypic variation in mollusks.

Von Martens (1880, p. 318) remarked that *Streptopinna saccata* lacks a byssus. This is contradicted by the presence of a moderately large byssus in preserved specimens examined. Attachment of the byssal threads to coral and shell debris indicates that this species does protrude the byssus and anchors itself to bottom objects as do other species of the Pinnidae.

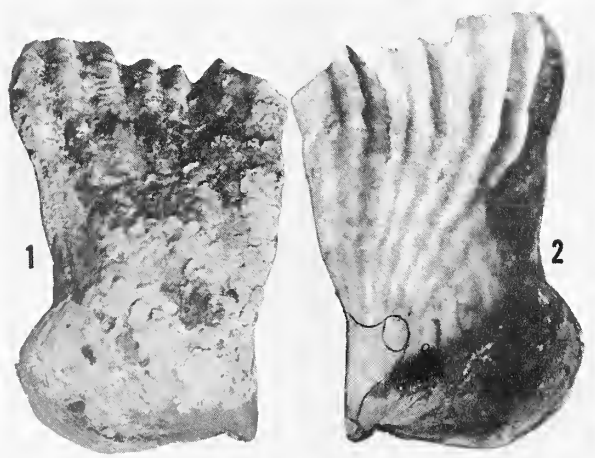

Plate 169. Lectotype of *Streptopinna saccata inusitata* Iredale, Michaelmas Cay, off Cairns, Queensland. Specimen 97 mm. (about 3¾ inches) in length. Fig. 1. Exterior of right valve. Fig. 2. Interior of right valve. (Australian Museum photo.)

Holthuis (1952, p. 109 and the last page of index) noted from the literature the presence of the palaemonoid shrimp, *Anchistus custos* (Forskal), in the mantle cavity of *Streptopinna saccata* from the Red Sea.

Winckworth (1929, p. 282) and Dodge (1952, p. 229) stated that S. *saccata* does not move upward during growth as evidenced in other species of Pinnidae by the series of regular septa laid down anterior to the anterior adductor muscle scar. Obviously, the body of the animal *does* enlarge posteriorly, and lines of the former position of the posterior adductor muscle scar have been noted in specimens examined. Such lines are also in evidence on the anterior adductor scar, and much crowded septa have been noted in complete specimens. It is quite true that the umbonal area seems to survive more nearly intact in this species, whereas it is often worn away in others, perhaps because of its way of life and the lesser degree of its burrowing activities.

Habitat — Under and between rocks in rocky tide pools; also, in cavities of coral (von Martens, 1880, p. 318).

Description — Shell reaching 235 mm. (9¼ inches; not allowing for curvature) in length; roughly triangular in outline: sometimes elongate, but often broad and usually severely contorted posterior to the anterior one third which is normally pinnoid; predominant total flexure may be either to right or left, often producing inequivalve condition, the convex valve often being slightly larger; attaining moderately heavy structure and sculptured with radiating ribs. Shell translucent, occasionally transparent in young specimens; ranging in color from grayish white through tan to dark reddish brown; often light tan anteriorly with the darker color posteriorly. Surface of valves dully shining. Radial sculpture consists of from 5 to 12 radiating ribs on the posterior slope (in some specimens posterior border may have double the number of ribs which show anteriorly, possibly due to injury); ventral slope without ribs, roughened. Ribs usually smooth, but in occasional specimens may bear a few coarse lamellate spines. Concentric sculpture of irregular lines of growth which in some specimens are spaced rather regularly. Posterior margin variable, frequently fractured and truncate, sometimes convex posteriorly. Dorsal margin variable, often grotesquely twisted. Ventral margin also variable posteriorly; anteriorly ventral margin greatly bulges just posterior to umbos; umbonal area usually sud-

denly considerably narrower than posterior portion of valves. Interior of valves grayish white to dark brown; anterior portion often lighter than posterior; surface very irregular, spaces between the external ribs quite clearly defined as "internal ribs"; interior surface shining. Nacreous layer smoky white, crowded into anterior, dorsal one third of valve forming a small triangle with its base toward posterior border of valve. Anterior pallial retractor muscle scar delimited from rest of nacreous layer, small, circular and located centrally in valve ventral to main part of nacreous area. In some specimens additional small patches of irregular nacreous material may appear ventral to nacreous layer, but this appears to be abnormal. Posterior adductor muscle scar small to medium sized, located in postero-ventral corner of nacreous layer. Anterior adductor muscle scar small, located on an elevated shelf at anterior tip of valve and touching anterior major portion of nacreous layer only at its posterodorsal angle. Posterior border of nacreous layer usually with an embayment dorsal to posterior adductor scar; nacreous area widest here. Ventral border proceeding from widest portion to a narrow tip which touches anterior adductor scar. Dorsal border contiguous with dorsal shell margin. Primary hinge ligament thin, black, extending from umbos to posterior border of nacreous layer; secondary hinge ligament not colored but evident in intact specimens whose dorsal margins are fused. Ventral margins of valves often so thickly produced and incrusted with organic material and debris that they present a virtually fused appearance forming a sack-like shell. Embryonic valves missing in all specimens examined. Pallial organ particularly long and vermiform. "Eyes of Will" fairly conspicuous, darkly pigmented, located in fold between middle and inner mantle lobes (see Introduction, *Remarks on Anatomy*).

Measurements (mm.) (not allowing for curvature of valves) —

length	width	
235	78	(large; Keokea, Hilo, Hawaii)
181	98	(large; Suva, Fiji)
124	51	(average; Torres Straits)
112	63	(average; Kahaluu, Hawaii)
78	18	(average; Marongas Id., Philippines)
36	20	(small; Kwajalein Atoll)

Synonymy —

1758 *Pinna saccata* Linné, Systema Naturae, ed. 10, p. 707 (in M. Mediterraneo, Indico); refers to Rumphius, pl. 46, fig. N; and to Cualtieri, pl. 79, fig. F [not *P. saccata* 'Linné' Chemnitz, 1785, pl. 90, fig. 779 = *P. muricata* Linné].

1786 *Pinna lubrica* Solander, Catalogue of the Portland Museum, pp. 61, 139 (nomen nudum); fide Dillwyn, 1817, Descriptive Catalogue, vol. 1, p. 331: = *vitrea* Gmelin [= *Streptopinna saccata* Linné].

1791 *Pinna vitrea* Gmelin, Systema Naturae, ed. 13, p. 3366 (in Oceano indico); refers to Chemnitz, vol. 8, pl. 87, fig. 772 (= *S. saccata* L.); also Gualtieri, pl. 78, fig. C, and pl. 79, fig. 1 (both unrecognizable); [not *Pinna vitrea* Röding, 1798 = *Atrina pectinata* L.].

1837 *Pinna nuttallii* Conrad, Journal Academy of Natural Sciences, Philadelphia, vol. 7, p. 244, pl. 19, fig. 4 (Inhabits muddy marshes in the Sandwich Islands).

1858 *Pinna elongata* Reeve, Conchologia Iconica, vol. 11, Pinna, pl. 4, fig. 6 (no locality given); Winckworth (1929) Proceedings Malacological Society of London, vol. 18, pp. 289, 292; [not *P. elongata* Röding, 1798 (= *P. rudis* Linné)].

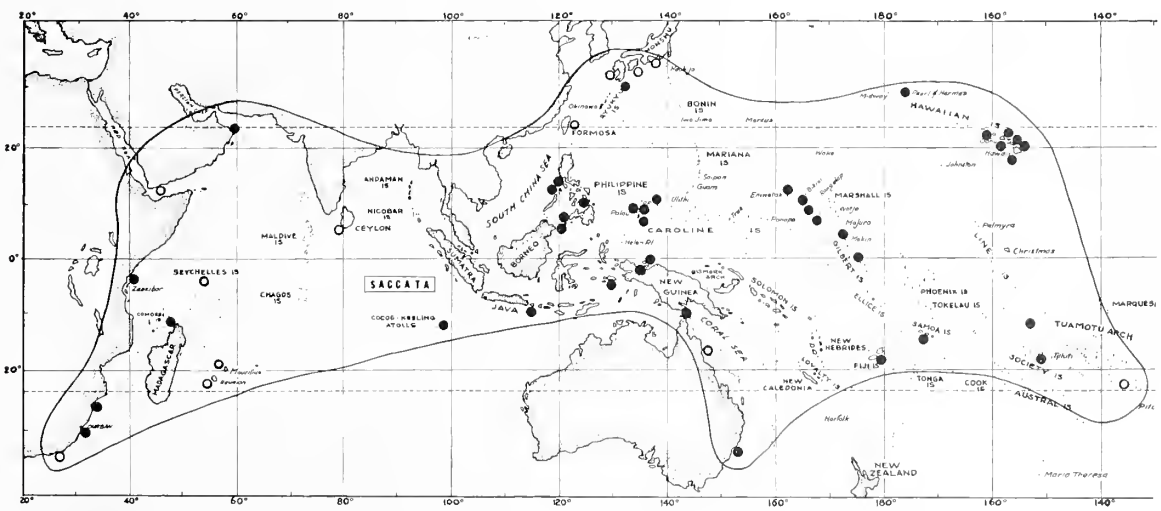

Plate 170. Geographical distribution of *Streptopinna saccata* (Linné).

Plate 171. *Streptopinna saccata* (Linné). Figs. 1-2. Specimen from Keokea, Hilo, Hawaii. (210 mm. or about 8¼ inches in length). Figs. 3-4. Immature specimen from Yaku Shima, Osumi, Japan. Specimen 60 mm. (about 2½ inches) in length. Figs. 2 and 4. Internal views of valves with nacreous areas, anterior pallial retractors and anterior adductor muscle scars outlined in black. (Smithsonian Institution photos.)

1927 *Streptopinna saccata inusitata* Iredale, Australian Zoologist, vol. 4, p. 333, pl. 46, figs. 9-11 (Caloundra, Moreton Bay, Queensland [Michaelmas Cay, off Cairns, Queensland; see *Types*]).

1932 *Pinna saccata* var. *similis* Turton, Marine Shells of Port Alfred, p. 218, pl. 56, fig. 1518 (Port Alfred [South Africa]).

1932 *Pinna anomioides* 'Reeve' Turton, ibid., p. 218, no. 1519 (South Africa).

?1932 *Pinna aenigmatica* Turton, ibid., p. 219, pl. 56, fig. 1521 (Port Alfred) [probably a species of *Malleus*]; Winckworth (1936) Proc. Mal. Soc. London, vol. 22, p. 21.

Nomenclature — Because of the wide variety of forms which may be assumed by this species it is surprising that a larger number of synonyms has not come into being. Surprisingly there are a relatively small number and some of these are questionable as to identity. *Pinna elongata* Reeve is listed by Winckworth (1929) as *P. saccata* variety. It is doubtful that Reeve intended to create a varietal name in this case, and that the word "elongata" is a descriptive Latin diagnosis for the form *P. nuttallii* Conrad.

Pinna aenigmatica Turton is called a "gruesome piece of beach refuse" by Winckworth (1936) who placed it in the synonymy of *saccata*, "if it be a *Pinna* at all." It quite probably is not a member of this family. The strong ridge "down the inside of one of the valves" which has the "hinge at the middle of the wider end" (Turton, 1932) strongly suggests, as does the plate, a species of *Malleus*.

Pinna nuttallii Conrad was the specific name assigned the Hawaiian form of *saccata; Streptopinna saccata inusitata* Iredale was named as a Queensland variety. As *Pinna saccata* is a very widespread species ranging from east Africa to Polynesia it is doubtful that these names have any standing even on a subspecific basis.

Types — The type specimen of *Pinna saccata* Linné, 1758 was said to be in the Linnaean collection according to Hanley (1855) and Winckworth (1929). Dodge (1952) does not mention having found the type, and, therefore, its presence may be questioned. Linné referred to Rumphius, pl. 46, fig. N; and Gualtieri, pl. 79, fig. F. Of the two the Rumphius reference is the better since it represents

a specimen which is more mature and characteristic of the species. Rumphius, pl. 46, fig. N is here selected as the type figure. The type locality originally given by Linné, "in M. Mediterraneo, Indico," is here restricted to Amboina, Moluccas, from which the specimen figured by Rumphius undoubtedly came. *Streptopinna saccata* is not known from the Mediterranean. The type figure of *Pinna vitrea* Gmelin here selected is Chemnitz, vol. 8, fig. 772; the figures of Gualtieri, pl. 78, fig. C, and pl. 79, fig. E, are unrecognizable as any distinct species of Pinnidae. The types of species described by Turton: *P. similis* and *aenigmatica* are in the Oxford Museum according to Turton. The type of *Pinna nuttallii* Conrad should be in the Academy of Natural Sciences, Philadelphia, although it could not be found during a visit there. As *P. elongata* Reeve was probably not actually proposed by Reeve as a species but only used descriptively, there are no types available.

Lectotype Selection: Streptopinna saccata inusitata Iredale was described from three specimens: two from Michaelmas Cay [off Cairns], North Queensland, and one from Caloundra [north of Brisbane], South Queensland. The three specimens were figured by Iredale without strict indication of a holotype. The lectotype here selected of *Streptopinna saccata inusitata* is the syntype specimen shown by Iredale (1927, pl. 46, fig. 11), Australian Museum Catalogue number C.53671; approximate measurements: greatest length 97 mm., width 59 mm.; type locality: Michaelmas Cay, off Cairns, Queensland [erroneously stated by Iredale to come from Caloundra, fide D. F. McMichael, Austr. Mus.]; here figured, pl. 169, figs. 1, 2 (photograph courtesy of the Australian Museum, Sydney).

Records (see map, pl. 170) solid dots: specimens examined; open circles: from the literature – SOUTH AFRICA: Durban (MCZ). MOZAMBIQUE: Inhaca Id., Delagoa Bay (MCZ). ZANZIBAR: outer reef, Kiwengwa (NSF). GULF OF OMAN: Muscat, Oman (ANSP). MADAGASCAR: Nossi Bé (ANSP; MCZ). SEYCHELLES; MAURITIUS; REUNION (all Von Martens, 1880). CEYLON: Galle (Winckworth, 1929). JAPAN: Shikoku; Kyushu; Honshu (all Habe, 1953a); Yaku Shima, Osumi (ANSP; USNM). FORMOSA (Habe, 1953a). PHILIPPINES: 26 miles southwest of Corregidor, Luzon Id. (USNM); Magallanes Bay, north end Mactan Id., eastern Cebu Island (ANSP); Bongao Channel, southwest end Sanga Sanga Id., Sulu Archipelago (ANSP). INDONESIA: Amboina (ex. Siboga Expedition, MCZ). Koeta Beach, Bali (MCZ). COCOS-KEELING ISLANDS (USNM). AUSTRALIA: Torres Strait (USNM); Long Reef, New South Wales (Australian Museum; USNM). NEW GUINEA: 1½ miles southwest of Biak, Schouten Ids. (NSF; USNM); Abroeki Isle, Maransabadi Id., Aoeri Ids., Geelvink Bay (NSF). FIJI ISLANDS: entrance to Suva Harbor, Viti Levu (USNM). PALAU ISLANDS: Ngadarak Reef, north of mouth of Malakal Pass (USNM). CAROLINES: Yap Id. (USNM). MARSHALLS: lagoon, north end Eniwetok Atoll (J. B. Burch, University of Michigan); Namu Id., Bikini Atoll (J. P. E. Morrison, USNM); Ine Village, Arno Atoll (R. W. Hiatt, USNM). GILBERT ISLANDS: Kingsmill Group (MCZ). HAWAII: Pearl and Hermes Reef (MCZ; USNM); Kahaluu, north Kona, Island of Hawaii (C. M. Burgess, USNM). LINE ISLANDS: Flint Id. (ANSP). SAMOA: Vaoto, Vailele Bay, Upolu Id. (NSF). SOCIETY ISLANDS: Port Du Bourayne, southeast of Vaiorea Id., outer reef, Huahine (Bredin-Smithsonian Institution Expedition, USNM). TUAMOTUS: Marutéa du Sud (Dautzenberg and Bouge, 1933, p. 434).

INDEX TO **PINNIDAE** NAMES IN VOL. 1, NO. 4

INDEX TO COMMENSAL **CRUSTACEA** IN PINNIDAE