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.

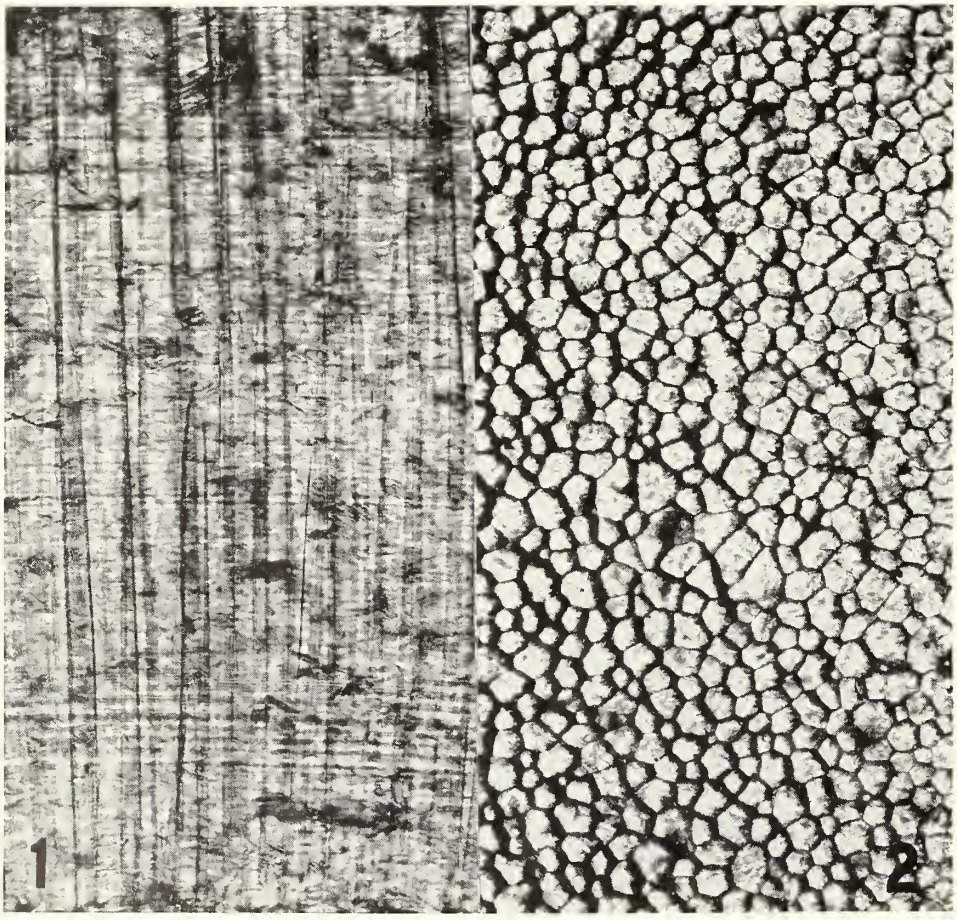


Plate 135. Shell structure of *Pinna carnea* Gmelin (Western Atlantic). Fig. 1. Longitudinal section to show the length of crystals of the prismatic layer. Fig. 2. Cross section to show hexagonal shape; from same area of shell as in Fig. 1 (both × 110; from Johnsonia, vol. 3, no. 38, pl. 151).

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
[*chantardi* (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)
†*tatcana* (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

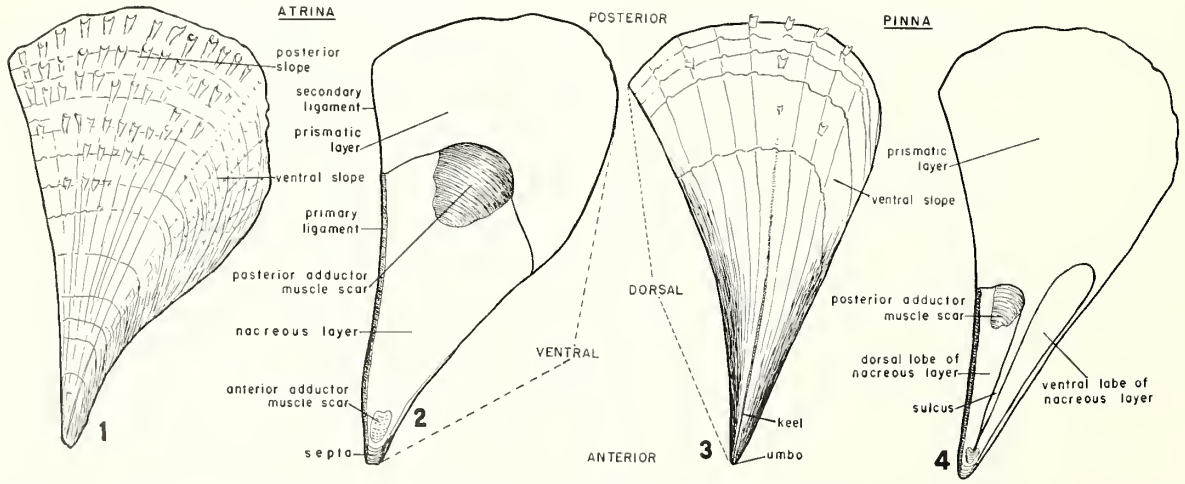
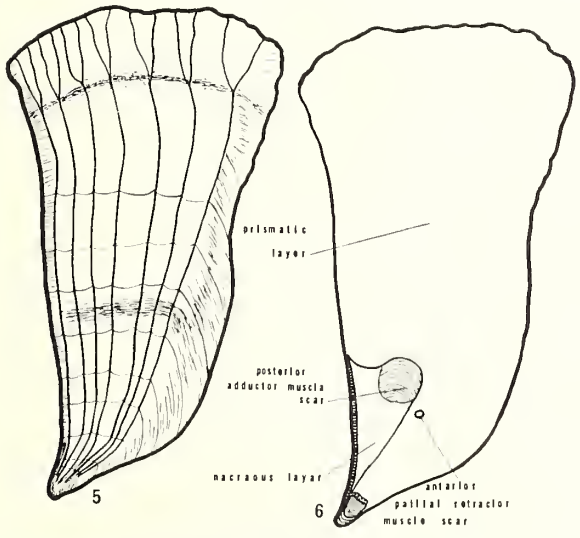


Plate 136. Diagrammatic sketch of the valves of the genera *Atrina*, *Pinna* and *Streptopinna* to show diagnostic characters. Figs. 1-2. External and Internal surfaces of the valves of *Atrina*. Figs. 3-4. The same of the valves of *Pinna*. Figs.

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

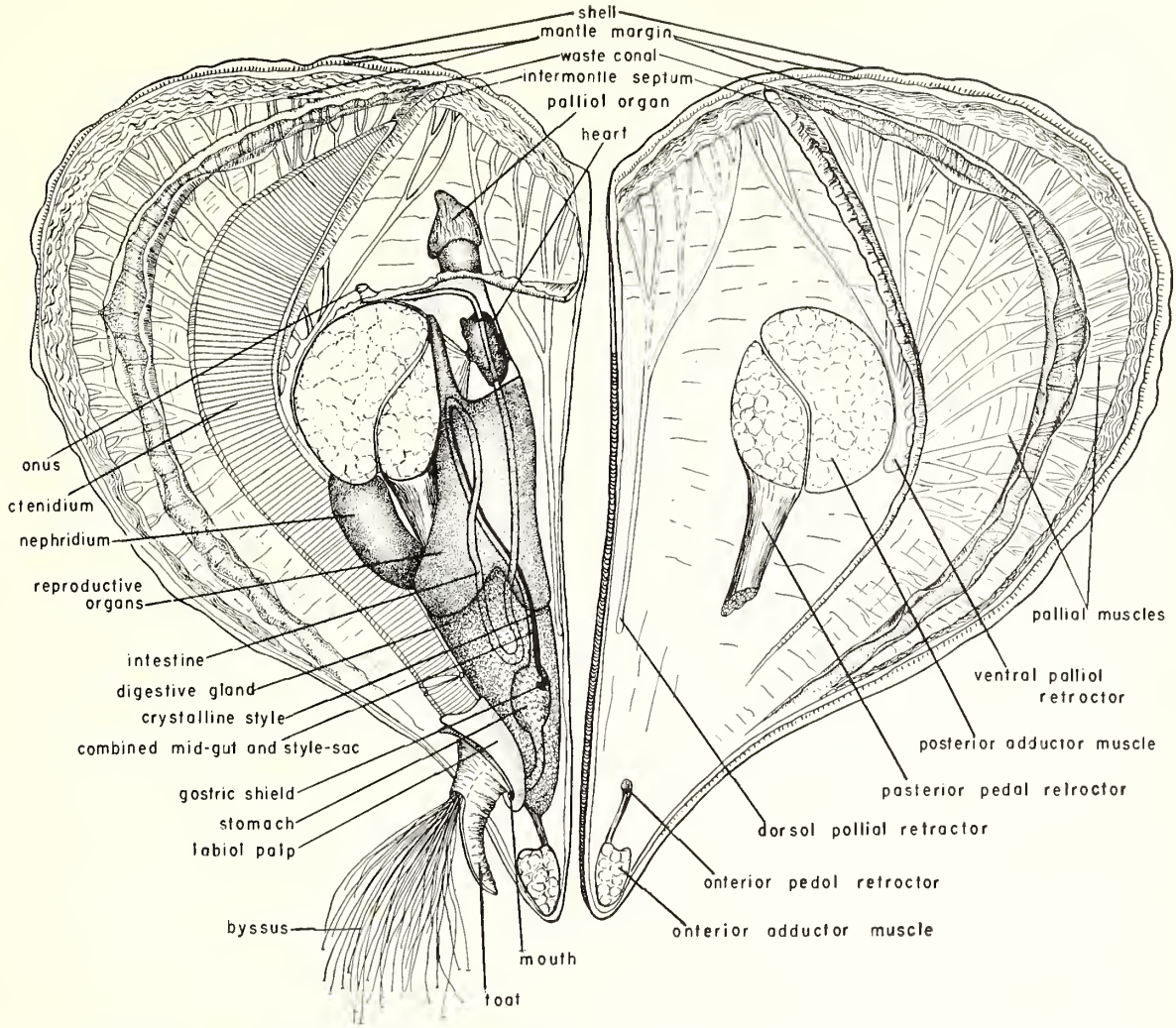


Plate 137. Semidiagrammatic drawing of the anatomy of *Atrina*. The right half shows only the muscles and characteristic features of the mantle (from Johnsonia, vol. 3, no. 38, pl. 152).

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 naereous pattern.

Members of the subgenus *Scrvatrina* of the genus *Atrina* in distant parts of the world may elosely resemble eaeh other. The shells of *A. seminuda* (Lamarek) and *A. scrrata* (Sowerby) of the Western Atlantie are almost inseparable from some speeimens of *A. pcctinata* (Linné) of the Indo-Paeifie. It is of interest to note that while *scminuda* and *serrata* are easily separable in the Western Atlantie, phenotypes somewhat resembling both Atlantie speeies appear to intergrade in *pectinata* in the Indo-Paeifie. Young speeimens of *Atrina maura* (Sowerby) of the Eastern Paeifie also resemble *seminuda*, *scrrata* and *pectinata* but beeome more lamellosely seulptured as adults and quite distinet.

Atrina fragilis Pennant of Europe and *A. chautardi* (Nieklés) of West Afriea are apparently the only members of *Atrina s.s.* present in the Eastern Atlantie. The speeies are quite eonvergent and both somewhat resemble *A. squamifcra* (Sowerby) of South Afriea. The three may have had a eontinuous 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 naereous patterns of the other two are similar.

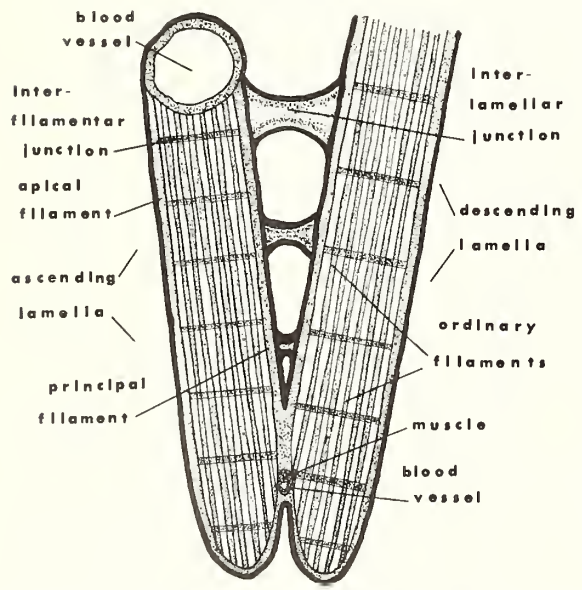


Plate 138. Diagrammatic sketch of gill of *Pinna*. Vertical section of outer demibranch, one-half plica in thickness (looking down on long axis of gill; after Ridewood, 1903, fig. 17).

Atrina rigida (Solander) of the Western Atlantie may be eonsidered the analogue of *A. tubcrculosa* (Sowerby) of the Eastern Paeifie, although the shell of the latter beeomes larger and heavier. Both are elosely related to *A. vexillum* (Born), a widely distributed Indo-Paeifie 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 peeuliar to eaeh of these speeies, undoubtedly brought about through isolation, serve to distinguish them.

The world distribution of living Pinnidae is summarized in Table 1.

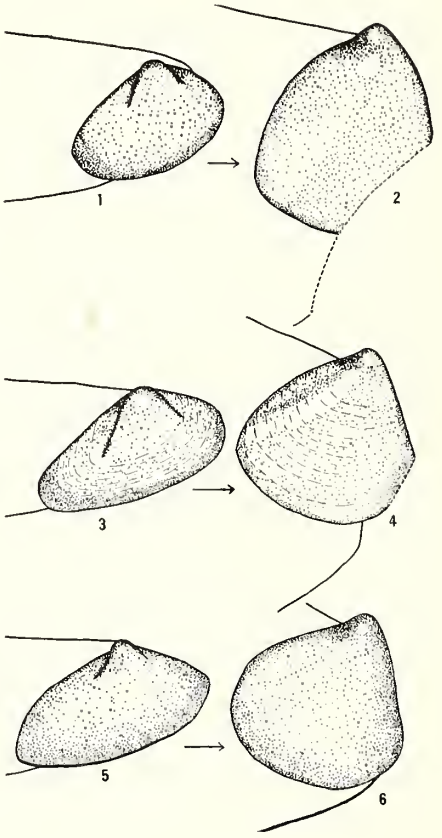


Plate 139. Embryonie valves of Indo-Pacific Pinnidae. Figs. 1-2. *Pinna muricata* Linné from Long Reef, New South Wales, Australia (0.5 mm. in length). Figs. 3-4. *Atrina vexillum* (Born), from Auau Channel, Hawaii (21-28 fathoms) (0.5 mm. in length). Figs. 5-6. *Atrina pectinata* (Linné), from Nagasaki, 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 climinate 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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Bibliography

Most references to the taxonomy of the Pinnidae will be found in the synonymies of the genera and species. Others from the text and those quoted for locality records may be found by consulting the Zoological Record for the year mentioned. The more recent and important references, those concerning biology, and others which might be difficult to find, are listed below.

Abbott, R. Tucker. 1960. The Genus *Strombus* in the Indo-Pacific. Indo-Pacific Mollusca, vol. 1, no. 2, p. 44 [09-842].

Cahn, A. R. 1951. Clam Culture in Japan. Report No. 146, Natural Resources Section, General Headquarters Supreme Commander for the Allied Powers, pp. 1-103.

Comfort, Alex. 1951. The Pigmentation of Mollusean Shells. Biological Reviews, vol. 26, pp. 285-301.

Feen, P. J. v. d. (Jutting, W. S. S. v. B.). 1949. Byssus. Basteria, vol. 13, no. 4, pp. 66-71.

Cabriel, C. J. 1936. Victorian Sea Shells. Handbook, Field Naturalists' Club of Victoria. Brown, Prior, Anderson Pty. Ltd., Melbourne. 67 pp., 6 pls., text figs.

Cilroy, C. C. 1845. The history of Silk, Cotton, Linen, Wool and other Fibrous Substances. Harper and Brothers, New York, 464 pp.

Grave, B. H. 1909 [1911]. Anatomy and Physiology of the Wing-shell, Atrina rigida. Bull. U. S. Bureau Fisheries, no. 29, Document 744, pp. 409-439, 3 pls.

Crégoire, C. 1960. Further Studies on Structure of the Organic Components in Mother-of-Pearl, espceially in Pelecypods (Part 1). Bull. Institut royal des Scienees naturelles de Belgique, vol. 36, no. 23, Brussels, pp. 1-22, 5 pl.

Haas, Fritz. 1955. Natural History of the Pearls. Comunicaciones del Instituto Tropieal de Investigaciones Científieas de la Universidad de El Salvador, (San Salvador, Centro America) Año 4, nos. 3/4, pp. 113-126.

Habe, T. 1953a. Pinnidae, Placunidae and Anomiidae in Japan. Illustrated Cat. Japanese Shells, vol. 1, no. 24, pp. 185-200.

——— 1953b. Notes on the Type Specimens of Three Species of Japanese Molluses Described by F. Jousseaume. Publ. Seto Marine Biol. Lab., vol. 3, (2), pp. 169-172, pl. 9, figs. 1-6.

Hanley, Sylvanus. 1855. Ipsa Linnaei Conchylia, pp. 1-556, 5 pls.

Holthuis, Dr. L. B. 1952. The Decapoda of the Siboga Expedition, Part XI., The Palaemonidae. Monograph 39a[10] Siboga-Expeditie, pp. 1-253, 110 figs.

Iredale, T. 1929. Qucensland Molluscan Notes. Memoirs Queensland Museum, Brisbane, vol. 9, p. 281.

Jackson, R. T. 1890. Phylogeny of the Pelecypoda, the Aviculidae and Their Allies. Memoirs Boston Society of Natural History, vol. 4, no. 8, pp. 277-400, 8 pls., 53 text figs.

Jameson, H. Lyster. 1902. On the Origin of Pearls. Proceedings Zoological Society of London, pp. 140-166, 4 pls.

Kawaguti, Siro and Nariaki Ikemoto. 1957. Electron Microscopy of the Smooth Muscle from the Adductor of Spanish Oysters, *Pinna attenuata* and *Atrina japonica*. Biol. Journ. Okayama Univ., vol. 3, no. 4, pp. 248-268.

Keen, A. Myra. 1958. Sea Shells of Tropical West America. Stanford University Press, Stanford, California, xii + 624 pp.

Kemp, S. 1922. Pontoniinae. Notes on Crustacea Decapoda in the Indian Museum, XV. Records Indian Museum, vol. 24, pp. 113-288, text figs. 1-105, pls. 3-9.

Kohn, A. J. 1956. Problems of Speciation in Marine Invertebrates. Perspectives in Marine Biology. A Symposium, Scripps, pp. 571-588.

Kubo, Ituo. 1940. Studies on Japanese Palaemonoid Shrimps. Journ. Imperial Fisheries Institute, vol. 34 (1), pp. 1-75.

Ladd, H. S. 1960. Origin of the Pacific Island Molluscan Fauna. American Journal of Science, Bradley Volume, vol. 258-A, pp. 137-150.

Lamy, E. 1938. Pinna de l'Indochine. Bulletin Muséum D'Histoire Naturelle, Paris, (2) vol. 10, no. 4, pp. 396-400.

Lister, M. 1685. Historiae sive Synopsis Methodicae Conchyliorum. London.

Nakazima, Masao. 1958. On the Differentiation of Stomach of Pelecypoda (I.). Venus, vol. 20, no. 2, pp. 197-207.

Olsson, A. A. 1961. Panamic-Pacific Pelecypoda Paleontological Research Institution, Ithaca, N. Y., 574 pp. [Pinnidae: pp. 143-145].

Ota, Shigeru. 1961. Identification of the Larva of *Pinna (Atrina) japonica* (Reeve). Bull. Japanese Soc. Sci. Fish., vol. 27, no. 2, pp. 107-112, 3 figs., 1 pl.

Patten, William. 1886. Eyes of Molluscs and Arthropods. Mittheilungen aus der Zoologischen Station zu Neapel, vol. 6, part 4, pp. 542-756, pls. 28-32.

Purchon, R. D. 1957. The Stomach in the Filibranchia and Pseudolamellibranchia. Proceedings Zoological Society, London, vol. 129, part 1, pp. 27-60.

Rawitz, Bernhard. 1890. Der Mantelrand der Acephalen, Zweiter Teil, Arcacea, Mytilacea, Unionacea. Jenaischen Zeitschrift für Naturwissenschaft, vol. 24, N. F. 27, pp. 1-83, 4 pl.

Reyne, A. 1947. On the structure of the shells and pearls of Tridacna squamosa Lam. and Hippopus hippopus (Linn.). Arch. Néerlandaises Zool., vol. 8, liv. 1, 2, p. 208 (footnote).

Ridewood, W. G. 1903. On the Structure of the Gills of the Lamellibranchia. Philosophical Transactions of the Royal Society of London, series B, vol. 195, pp. 147-284.

Rogers, J. E. 1951. The Shell Book. Branford Co., Boston, new edition, pp. xxi + 503 pp. (p. 401).

Salis von Marschlins, C. U. v. 1795. Travels through various Provinces of the Kingdom of Naples, in 1789; translated from the German by Anthony Aufrere. London, viii + 527 pp.

Simmonds, P. L. 1879. The Commercial Products of the Sea. Griffith and Farran, London, pp. 306-310 (viii + 484 pp.).

Smith, E. A. 1903. Marine Mollusca: In: Fauna and Geography of the Maldive and Laccadive Archipelagoes, vol. 2, part 2, pp. 589-630, pls. 35, 36. Edited by J. S. Gardiner, Cambridge, England.

——— 1906. On South African Marine Mollusca. Annals Natal Government Museum, vol. 1, part 1, pp. 60-61.

Suter, H. 1913. Manual of the New Zealand Mollusca, with an Atlas of quarto plates. Wellington, xxiii + 1120 pp.

——— 1914. Revision of the Tertiary Mollusca of New Zealand, part I. New Zealand Geological Survey Palaeontological Bulletin no. 2, 64 pp., 17 pls.

——— 1915. Ibid., part II. New Zealand Geological Survey Palaeontological Bulletin no. 3, 69 pp., 9 pls.

Tesch, P. 1920. Jungtertiäre und quartäre Mollusken von Timor. In: J. Wanner, Paläontologie von Timor, Stuttgart, Lief 8, part 2, p. 91.

Turner, R. D. 1960. Some Techniques for Anatomical Work. Annual Reports for 1959, The American Malacological Union, Bulletin no. 26, pp. 6-8.

Turner, R. D. and Joseph Rosewater. 1958. The Family Pinnidae in the Western Atlantic. Johnsonia, vol. 3, no. 38, pp. 285-326.

Van der Schalie, Henry. 1953. Nembutal as a Relaxing Agent for Mollusks. American Midland Naturalist, vol. 50, no. 2, pp. 511-512.

Van der Vlerk, I. M. 1931. Caenozoie Amphineura, Gastropoda, Lamellibranchiata, Scaphopoda. Leidsche Geologische Mededeelingen, Leiden, deel 5, pp. 206-296.

Vokes, H. E. [1951] Preliminary Classification of the Genera of the Pelecypoda. (An unpublished mimeographed compilation.)

Wada, Koji. 1961. On the Relationship between Shell Growth and Crystal Arrangement of Nacre in Some Pelecypoda. Venus, Fukuyama, vol. 21, no. 2, pp. 204-211, 4 figs.

Wilkins, G. L. 1953. Notes from the British Museum, I. *Pinna*. Proceedings Malacological Society of London, vol. 30, pp. 23-29, 1 pl.

Will, J. G. F. 1844. Ueber die Augen der Bivalven und der Ascidien. Froriep's Neue Notizen aus dem Gebiete der Natur- und Heilkunde, vol. 29, no. 622, pp. 80-87; no. 623, pp. 99-103.

Winckworth, R. 1929. Marine Mollusca from South India and Ceylon, III. *Pinna*. With an Index to the Recent Species of *Pinna*. Proceedings Malacological Society of London, vol. 18, pp. 276-297.

——— 1936. Ibid., X. Further Notes on *Pinna*. Ibid., vol. 22., pp. 20-23.

Yates, J. 1843. Textrinum Antiquorum. Taylor and Walton, London, pp. 152-159.

Yonge, C. M. 1953. Form and Habit in *Pinna carnea* Gmelin. Philosophical Transactions Royal Society of London, series B, vol. 237, pp. 335-374.

Yoshida, H. 1956. Early Life History of Useful Bivalves in the Ariake Sea (I). Journal Shimonoseki College of Fisheries, vol. 6, pp. 115-122, 4 figs.

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. Hoshuyamamura, 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 musele sear 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

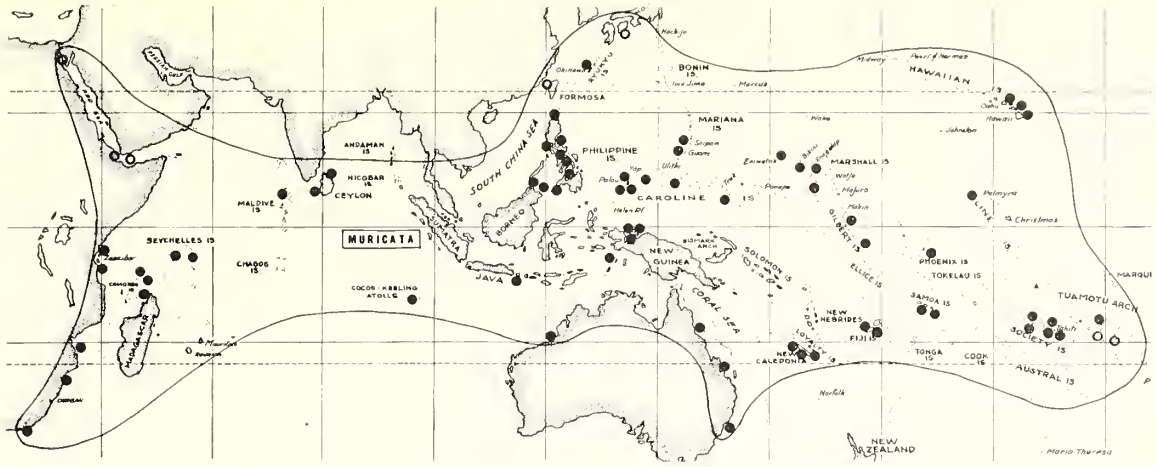

Plate 142. Geographical distribution of *Pinna muricata* Linné.

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.)

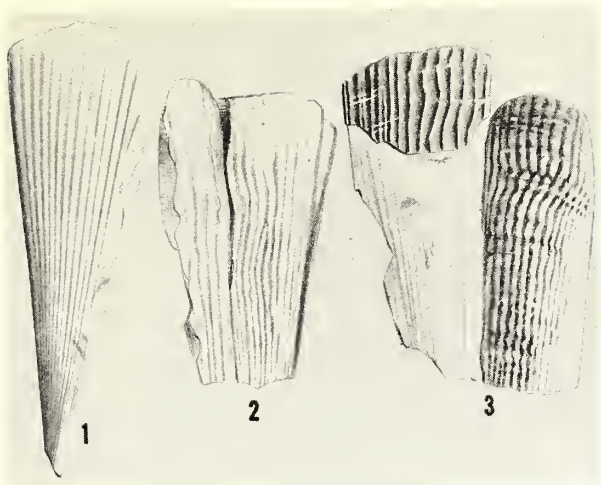

Plate 146. *Pinna blanfordi* Boettger. West Coast of Sumatra, Indonesia. Lower Eocene. (reduced ½, from Boettger, 1880, pl. 3, figs. 4-6; Smithsonian Institution photo.)

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 Poc, 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 area 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

presence 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 close proximity to continental areas. In this respect it differs from *muricata* whose distribution includes oceanic islands. The sporadic appearance of *P. bicolor* in Hawaii is probably the result of chance 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 truncate to more or less evenly convex-rounded and sometimes dorsally convex and sloping ventrally; moderately inflated, a specimen 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, sculptured 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 specimens) sometimes interrupted, giving the color pattern a concentric appearance. Surface of valves generally smooth and shining anteriorly where imbedded in substrate, but dull posteriorly and often encrusted with coralline algae, coral, other organisms and debris. Radial sculpture consists of from about 8 to 17 fairly well defined radiating ribs which may become nearly obsolete and which posteriorly may bear a few flat to tubular spines, in some specimens approaching a lamellose condition; spines usually nearly obsolete except near the posterior margin. Concentric sculpture consisting of fine growth lines which 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 specimens which apparently grow in sheltered areas; outline as stated above. Dorsal margin usually straight, but may be only slightly convex to moderately concave. Ventral margin often duplicating dorsal margin as the arms of an inverted isosceles triangle, but sometimes convex posteriorly and concave anteriorly, almost forming an upright but flattened sigmoid curve. Interior of valves light smoky horn to dark purplish brown in color, often with the radiating bands of alternating dark and light showing through; surface smooth and glossy. Nacreous area iridescent, roughly occupying the anterior half of the shell and is divided along most of its length by a longitudinal sulcus. Dorsal and ventral lobes of the nacreous area moderately well separated, the interlobe distance especially varying posteriorly. Dorsal lobe of nacreous 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 truncate and shorter than the dorsal lobe. Anterior adductor muscle scar 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.)

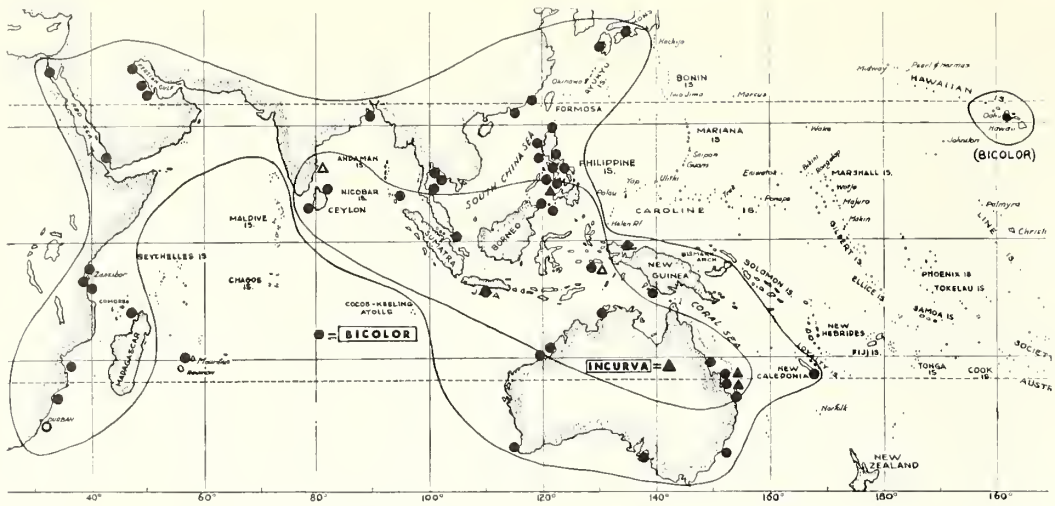

Plate 149. Geographical distributions of *Pinna bicolor* Gmelin (solid dots and circles) and *Pinna incurva* Gmelin (triangles).

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 cumingii* 'Hanley' Clessin, Conchylien Cabinet, vol. 8, part 1, Malleacea, p. 55, pl. 23, fig. 1 (Australien); not *P. cumingii* '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. angustana* Reeve, 1858, not *P. angustana* 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 cavitcrga* 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

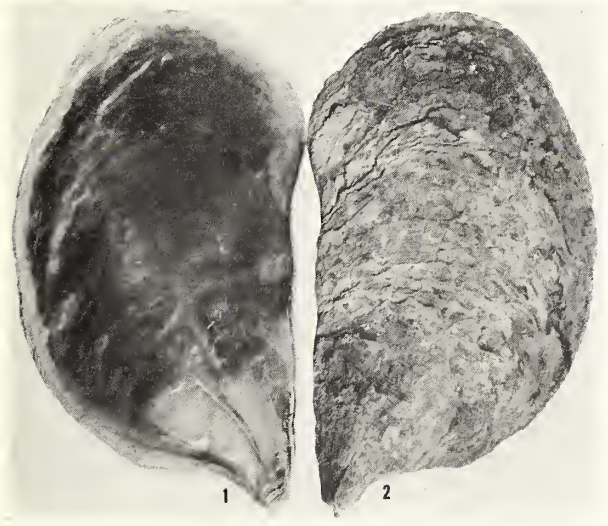

Plate 150. Holotype of *Exitopinna deltodes ultra* Iredale [= a stunted and repeatedly broken specimen of *P. bicolor* Gmelin] Low Isles, Queensland. Fig. 1. Interior of left valve. Fig. 2. Exterior of left valve. (about ¼ nat. size, Australian Museum photo.)

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 speeimen being somewhat anomalous.

Types — The location of the holotype of *Pinna bicolor* Gmelin from the Red Sea is unknown. The type figure here seleeted is Chemnitz, vol. 8, pl. 90, fig. 780. A syntype of *Pinna dolabrata* Lamarck 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 Trineomali, 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 speeies (see Winekworth, 1929, p. 291; Iredale, 1939, p. 315). Types of species deseribed 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, aeeording to B. C. Cotton (*in litt.*, 1960). A holotype was never designated by Tate. The loeation of the types of Clessin is unknown. Some of them were said to be in the Rolle eolleetion 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* Cmelin. Lectotype of *Pinna euglypta* Reeve (erroneously labeled "Holotype"), from Amboina. Speeimens 177 mm. (7 inehes) 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 eonsidered a synonym of *bicolor* it is probably best to fix the name *euglypta* upon a single specimen at this time. The speeimen depicted in Reeve's fig. 37 is here seleeted 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 ease exists regarding *Pinna fumata* 'Hanley' Reeve, 1858 (figs. 27, 28) whieh is also a synonym of *P. bicolor*. The speeimen portrayed by Reeve (fig. 28) is a dark form; that in figure 27 displays the color pattern often seen in *bicolor*. The former speeimen (fig. 28, the more mature but dark form) is here seleeted as leetotype 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: Inhaea 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 Chuekwani (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: Caleutta (USNM). CEYLON: Trineomali (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 Roeky Harbour, Tai She Wan, Hong Kong (both A. J. Staple, ANSP). JAPAN: Awaji (MCZ; USNM); Imaizumi, Kakoshima Bay (USNM). PHILIPPINES: many loealities (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 Croup (J. K. Howard, MCZ); Hervey Bay (J. Kerslake; USNM) both Queensland; Cunnamatta Bay, Port Haeking, south of Sydney, New South Wales (D. F. MeMiehael, Aust. Mus.; USNM); Outer Harbor, St. Vincent Gulf, South Australia (W. Old, USNM). NEW CUINEA: 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, Proe. Roy. Soe., Vietoria, vol. 32, p. 229) reeorded *P. inermis* Tate [= *P. bicolor*] from the older Pleistoeene deposits of the Ooldea Distriet, Vietoria, 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 Möreh made a genus *Cyrtopinna* for it . . . . " It is easily separable from *bicolor* and *muricata* beeause 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 naereous layer whieh slope sharply obliquely toward dorsal and ventral shell margins. The name *incurva* applied by Gmelin to the species as here restrieted probably makes referenee to the posterior margin of the shell which slopes (incurves) gradually toward the dorsal margin from a point far down the ventral margin. This eharacter also is responsible for the generie name "*Cyrtopinna*" erected by Möreh 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 eoast of Quecnsland, Australia] (Iredale, 1939).

Description — Shell reaehing 290 mm. (about 11 inehes) in length, narrowly attenuate and wedge-shaped in outline; posterior margin extremely areuate; 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 translueent 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. Coneentrie sculpture of broadly arcuate growth lines arising on the dorsal margin, turning slightly posteriorly for a short distanee, 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 oeeasionally subeonvex to subeoncave. Ventral margin also straight. Interior of valves light horn to reddish brown in eolor, smooth and shining. Naereous layer irideseent, occupying most of the anterior half of the shell and divided along most of its length into two lobes by a narrow, longitudinal suleus. Both dorsal and ventral lobes with the posterior margins obliquely truncate; sloping from suleus 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 embaymcnts. Anterior adduetor muscle scar moderately small, subapical, the sulcus nearly reaehing it. Posterior adduetor musele sear medium sized, subterminal on ventral portion of dorsal nacerous lobe. Primary hinge ligament very thin, blaek, appearing not to extend to posterior tip of dorsal naereous 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* 'Browne' 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))

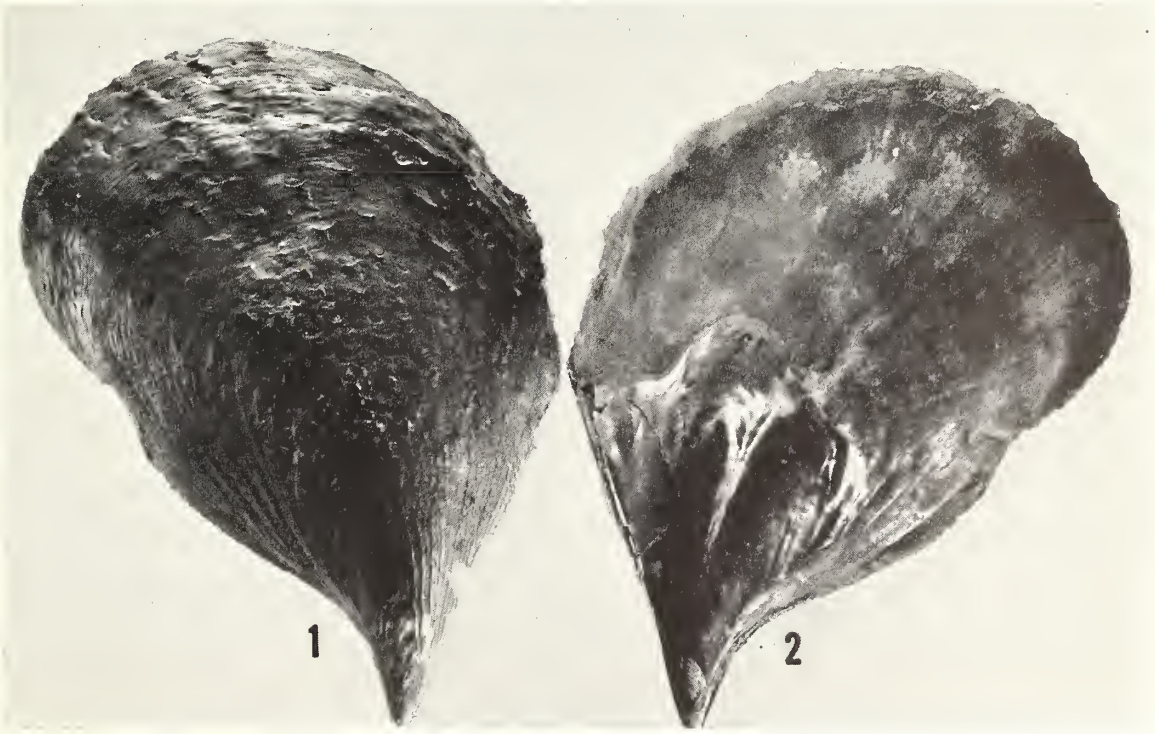

Plate 156. *Atrina vexillum* (Born). Figs. 1-2. Syntype of *Pinna nigrina* Lam., "L'Océan des grandes Indes" [East Indies] [= *A. vexillum*]. (reduced ½, photograph courtesy of E. Binder, Muséum D'Histoire Naturelle, Geneva.)

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, Testaeea 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 Oeeano 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 loeality given); refers to Gmelin, 1791, "*Pinna vexillum*" [p. 3366] speeies 15; and Chemnitz, vol. 8, pl. 91, fig. 783 (a young specimen).

1817 *Pinna nigra* Dillwyn, Deseriptive Catalogue of Shells, vol. 1, p. 325 (Inhabits the eoasts 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 speeimen).

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 Reeent and Fossil Shells, part 26, pl. 103.

1858 (May) *Pinna gouldii* 'Hanley' Reeve, Conchologia Iconiea, vol. 11, Pinna, pl. 11, fig. 21 (locality not given); Hanley [Nov.] 1858, Proc. Zool. Soc. London, p. 255 ("Amboyna").

1858 *Pinna lystrix* Hanley, Proe. Zool. Soc. London, p. 226 (Amboyna); figured in Reeve, 1859, Conchologia Iconiea, vol. 11, Pinna, pl. 32, figs. 60, 61.

1938 *Pinna oalua* 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 Seientific 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) linguafelis* 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-*

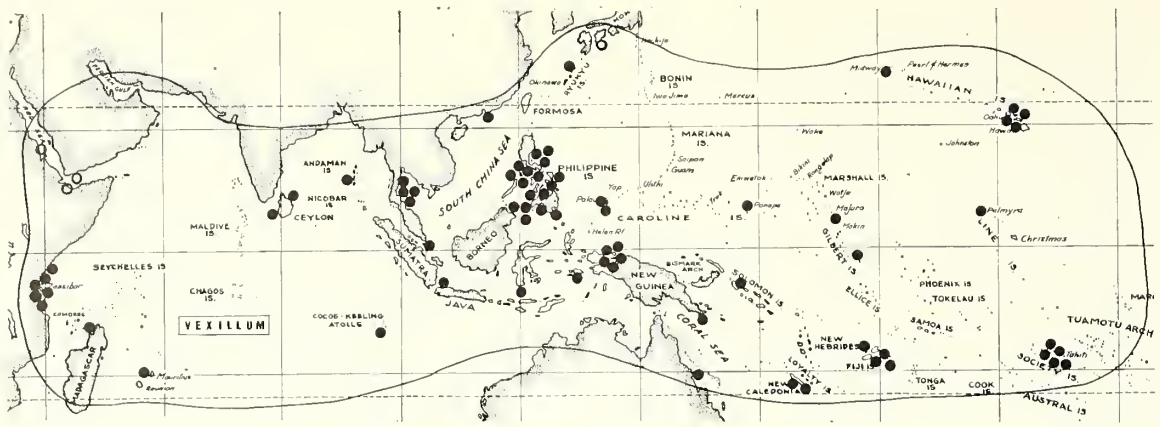

Plate 158. Geographical distribution of *Atrina vexillum* (Born).

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 peetinata*. 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 *peetinata* 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

concerning the true identity of *Pinna hystrix*, it may be valuable to restrict 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 cited in the synonymy of *Atrina pectinata*. A syntype of *Pinna nigrina* Lamarck 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 specimens. A sketch was given of one of these from Low Isles [off Port Douglas, Queensland] and it was more fully described than the others, although never specifically designated as holotype. This specimen is here selected 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 gubernaculum* 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; Mutapone 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 Africa.

Remarks — *Atrina squamifera* is apparently limited in its distribution to the southeastern portion of the Union of South Africa. It cannot easily be confused with any other species since there is nothing like it within its range. The other member of the subgenus *Atrina* in East Africa, *A. vexillum* Born, seems not to occur so far south. *A. squamifera* has a much more narrow and less thick shell than *vexillum;* the number of radiating ribs in *squamifera* is about 12 or less, although 19 to 20 may be counted on the specimen figured by Krauss (1848, pl. 2, fig. 8). In *vexillum* there may be from 10 to 30 ribs, but they are usually smooth, although occasional spinose individuals occur. Shell coloration 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 which forms an acute or nearly 90° angle ventral to the posterior adductor muscle scar in *squamifera;* the same structure in *vexillum* is usually broadly obtuse.

There are superficial similarities between *Atrina (Atrina) squamifera* Sowerby and *Atrina (Servatrina) tasmanica* Tennison-Woods. However, the two species 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 Africa, assigning a range from Mauritania to Angola. The figures show a specimen which appears very similar to *A. squamifera*. It is possible that the range of *squamifera* extends from West Africa to southeast Africa. However, until specimens are available for comparison, it seems best to consider them distinct species. 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 Zoölogy 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-

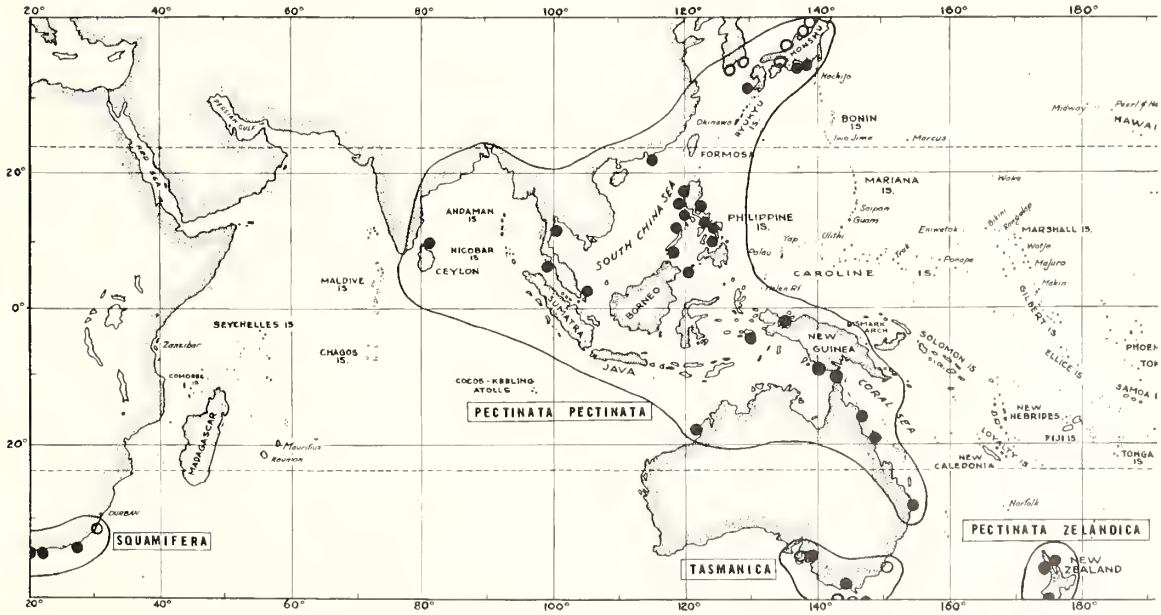

Plate 160. Geographical distribution of *Atrina squamifera* (Sby.) (South Africa); *A. pectinata pectinata* (Linné) (South Asia and Western Pacific); *A. pectinata zelandica* (Gray) (New Zealand); and *A. tasmanica* (Tenison-Woods) (Tasmania and Southeastern Australia).

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 *Servatrina 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); Prachuap 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, Moluccas (MCZ). AUSTRALIA: Broome, Western Australia (V. Orr, ANSP; MCZ); Torres Straits (USNM); Buchan'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*) recorded *Pinna japonica* Hanley (probably = *Atrina pectinata* Linné) from the Pleistocene, Shito formation, of Oji in Musashi, Japan; and from the Shirado Pliocene.

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

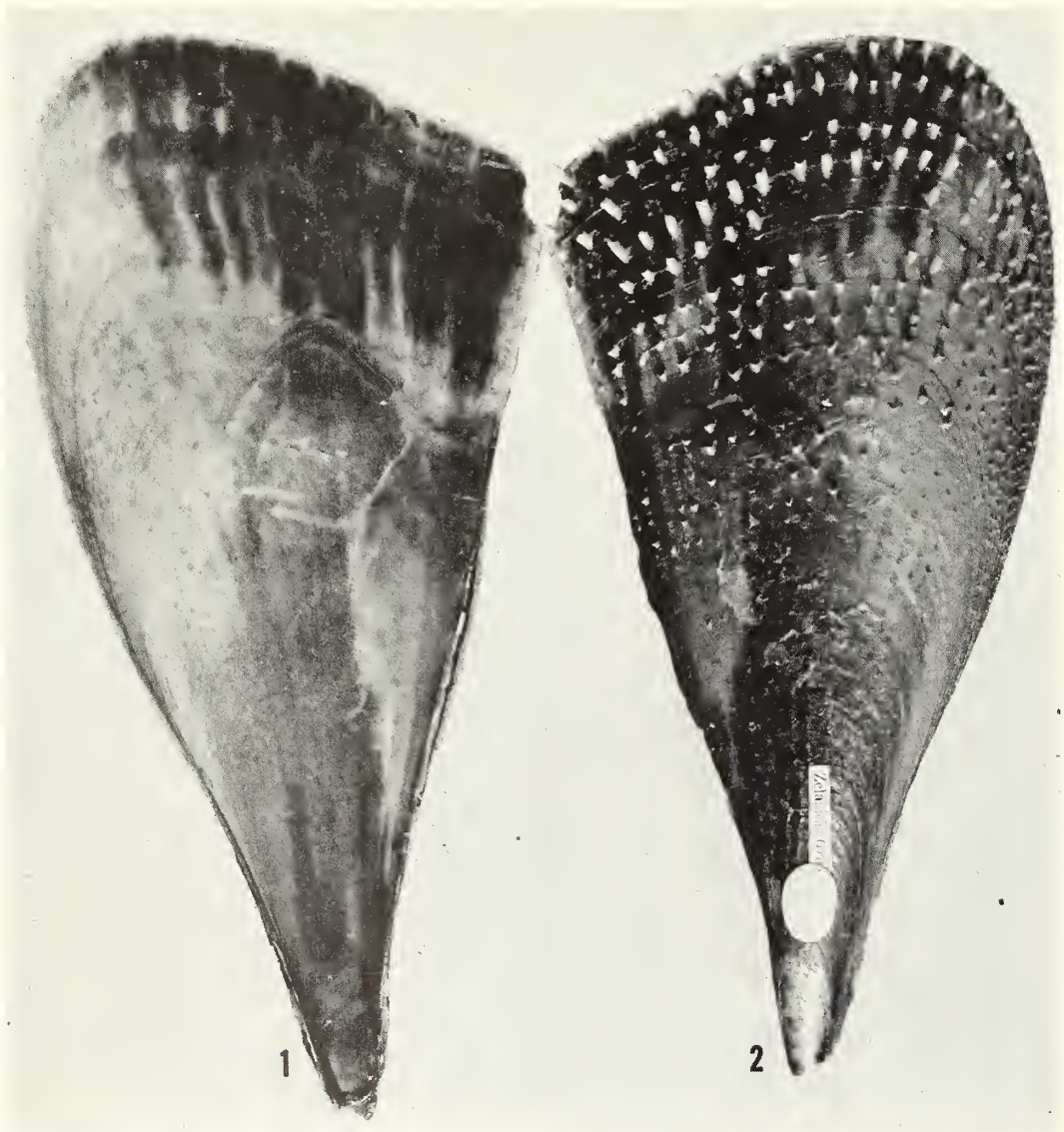

Plate 164. *Atrina pectinata zelandica* (Gray). Neotype of *Pinna zelandica* Gray, New Zealand. Note the dark stripes posteriorly and generally uniform spinosity, characteristic of this subspecies. Specimen 205 mm. (8 inches) in length. (British Mhseum (N.H.) photos.)

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* Could, 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* Cray, 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 Seychellen 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 (Victoria, Australia), no. 4, p. 47, pl. 6, fig. 8 (Tertiary: polyzoal limestone of Seal River, King Island).

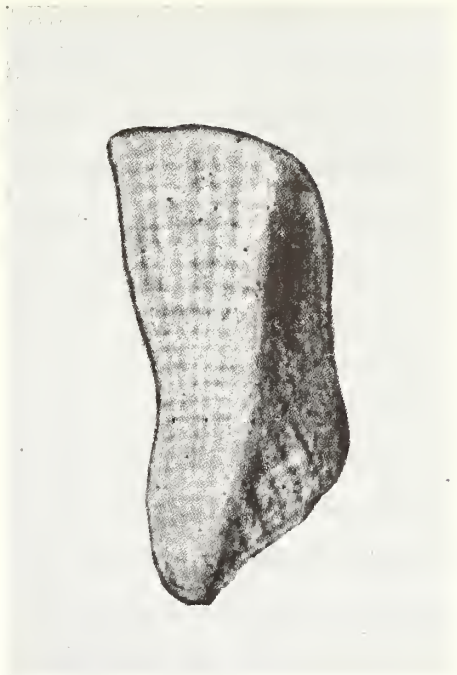

Plate 168. *Streptopinna? reticosa* (Chapman), Seal River, King Island, Tasmania. Tertiary. Holotype, × 4. (from Chapman, 1912, pl. 6, fig. 8). (Smithsonian Institution photo.)

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 Gualtieri, 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, Deseriptive 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); Winekworth (1929) Proceedings Malacological Society of London, vol. 18, pp. 289, 292; [not *P. elongata* Röding, 1798 (= *P. rudis* Linné)].

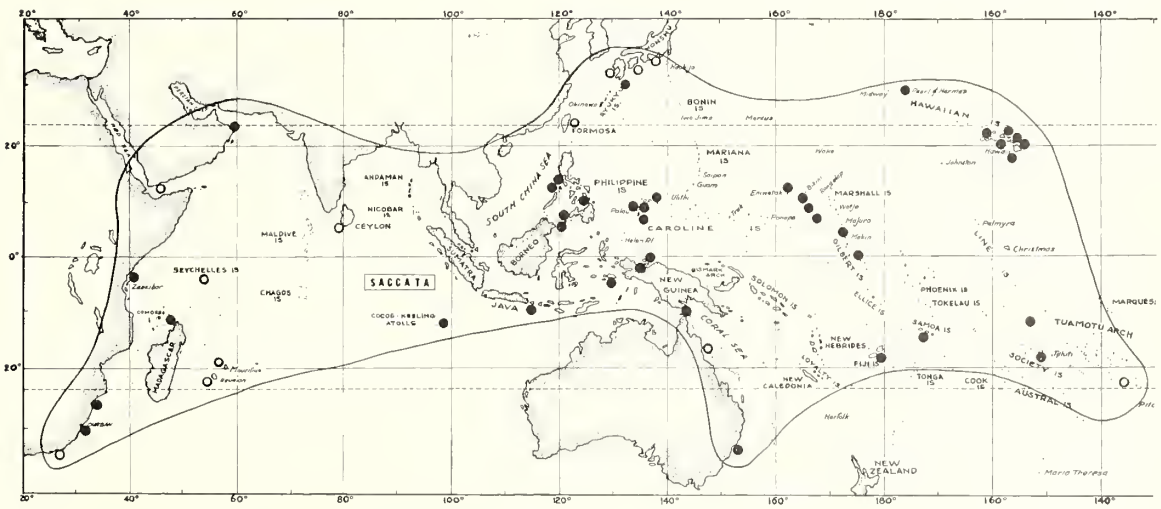

Plate 170. Geographical distribution of *Streptopinna saccata* (Linné).

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).

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