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PINNIDAE

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## THE FAMILY PINNIDAE IN THE WESTERN ATLANTIC

BY

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The Pinnidae is a small family of highly specialized bivalves which belongs to the order Anisomyaria, that is, bivalves which have a large posterior adductor muscle, while the anterior adductor is small or lacking. They are world-wide in distribution in warm-temperate and tropical seas. Most species are found in sandy and muddy areas, from the low water line to depths of about 10 to 25 fathoms. They are wedge- or fan-shaped bivalves which are equivalve but inequilateral. The umbos are terminal and are located at the very narrow, anterior end which is buried in the substratum. Young specimens, at the time of settling, are normal, equilateral bivalves as is shown in Plate 150, figs. 1-6. However, as growth is almost entirely in a posterior direction, the shell very quickly becomes triangular in shape and the umbos become terminal. As the animal begins its burrowing



Plate 149. Cross section of the prismatic layer of *Pinna carnea* Gmelin showing the irregular prisms with conchiolin surrounding them (470x).

activities the anterior end of the shell, being downward, becomes eroded. Consequently, specimens with the embryonic valves still attached are extremely rare. As the shell grows, the body of the animal as well as both the anterior and posterior adductor muscles must move posteriorly (i.e., up). The anterior end of the shell is constantly worn away and the mantle deposits septa across the shell to protect the anterior adductor muscle (Plate 154, figs. 2, 4). Specimens are often found with a series of such septa in the narrow ends of the valves in front of the small anterior adductor muscle scar.

### SHELL STRUCTURE

The shell is very simple in structure and is composed generally of only two layers, the periostracum being extremely thin or entirely absent. The outer prismatic layer is calcitic and composed of very large crystals produced in a framework of conchiolin and set at right angles to the surface of the valves. These prismatic crystals, the largest produced anywhere in the Recent Mollusca, may be readily seen with the aid of a hand lens

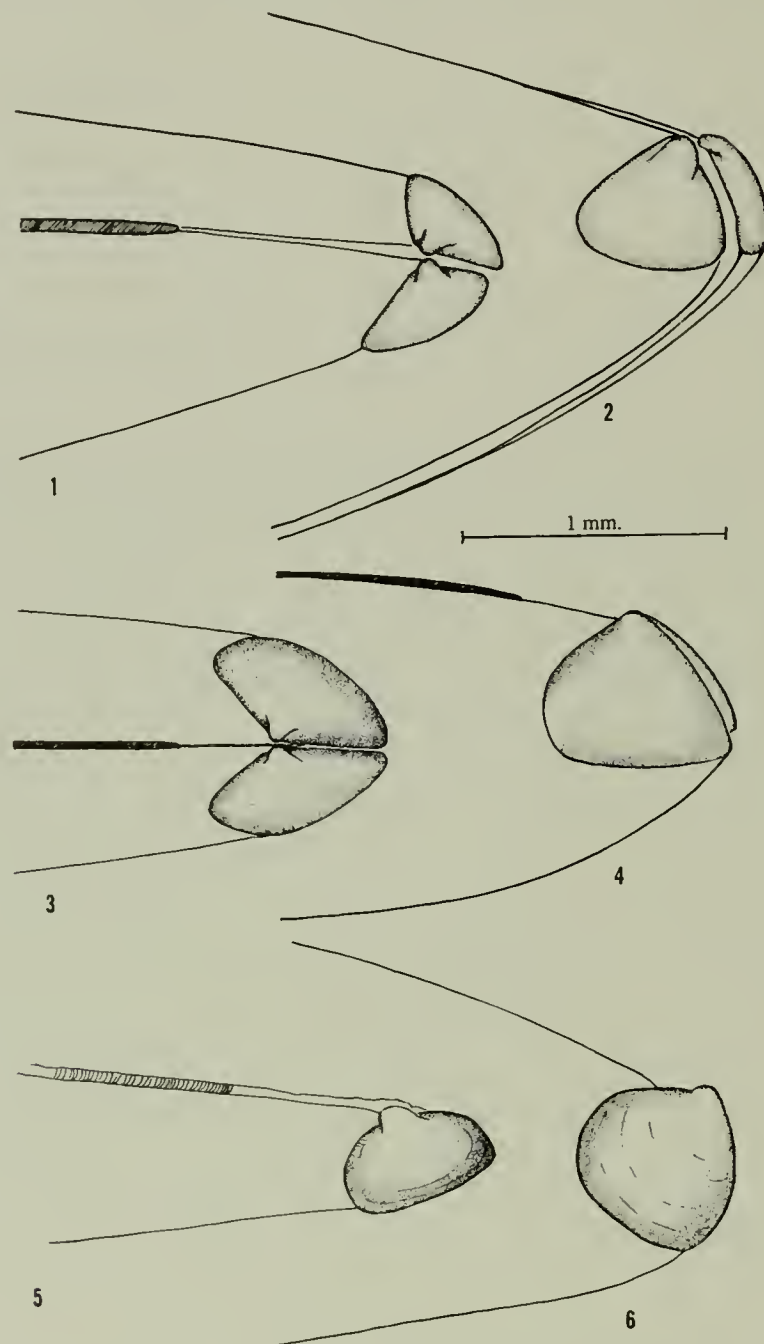


Plate 150. Embryonic valves of Pinnidae. Figs. 1-2. *Pinna carnea* Gmelin from reef northeast of North Point, Elbow Cay, Great Abaco, Bahama Islands. Figs. 3-4. *Pinna rudis* Linné from the Mediterranean. Figs. 5-6. *Atrina (Servatrina) seminuda* Lamarck from off Tobago, Lesser Antilles in 36 fathoms.

and in older specimens are often sufficiently large to be seen without magnification. Transverse and longitudinal sections of the prismatic layer of *Pinna carnea* are shown in Plate 149 and Plate 151, figs. 1-2. That portion of the shell posterior to the large posterior adductor muscle is composed only of this prismatic layer and, because of its high organic content, is slightly flexible in living specimens. The inner, nacreous, layer is produced only in the anterior portion of the valves and mainly in the area between the two adductor muscles (Plate 154, figs. 2, 4). It is composed of flat, shingled layers of aragonitic, nacreous material which parallel the long axis of the valves. The extent and shape of the nacreous layer are important characters in the classification of this family as is shown in the systematic portion of this paper. One of the earliest studies to be made on the structure of the shell was that of Carpenter (1844) in which he described the irregularly hexagonal crystals and the network of conchiolin which holds them together. Additional contributions were made by Biedermann (1901) and Karny (1913). A summary of this work as well as a brief discussion of the shell structure of Recent and fossil Pinnidae and related forms is given by Böggild (1930) in his interesting paper, "The Shell Structure of the Mollusks."

Hinge teeth are lacking and the valves are united along their dorsal margin by a ligament which is divided into two main portions which C. M. Yonge (1953) has termed the primary and secondary ligaments. The ligament proper (primary ligament) extends from the anterior adductor muscle posteriorly to the posterior margin of the inner nacreous layer. The fusion of the valves on the dorsal margin posterior to this is a result of the fusion of the mantle lobes and, though called the secondary ligament, is not a true ligament. The primary ligament in the Pinnidae is not elastic but it is, however, similar in structure to that found in other bivalves.

#### NOTES ON ANATOMY AND PHYSIOLOGY

The Pinnidae have a large, more or less centrally located posterior adductor muscle and a very small anterior adductor muscle. The soft parts are confined mainly to the area between the two muscles; only the greatly enlarged posterior lobes of the mantle and the elongate ctenidia or gills extend beyond the posterior adductor muscle. Both the mantle and the gills are capable of retraction to the muscle. There are no true siphons, but the mantle cavity is divided into incurrent and excurrent chambers by an intermantle septum. The anatomy of *Pinna nobilis* Linné has been described and figured by Poli (1795), that of *Atrina rigida* Solander by B. H. Grave (1911) and of *Pinna carnea* Gmelin by C. M. Yonge (1953). Since the general morphology of the soft parts of these species varies but little they will be discussed together, the differences being noted where necessary.

There are many unique characters in this family which fit it for its peculiar mode of life. Members of the Pinnidae generally live embedded vertically in a soft substratum attached to stones or other objects by a large byssus. Usually that portion of a shell not occupied by the soft parts (i.e., the portion posterior to the posterior adductor muscle) protrudes above the surface where it is exposed and is often broken. This protrusion of the shell above the soft substratum, however, allows the animal, which does not have extendible siphons, to get water from well above the bottom and so to avoid much of the debris which might otherwise be drawn into the mantle cavity. The Pinnidae burrow more deeply into the substratum as the shell grows, the anterior end being worn away while the growth of shell is almost entirely at the posterior margin. Though the mantle

adheres closely to the shell it is attached only at two points and so can be readily retracted. The greatly enlarged and retractable portion of the mantle is supplied with numerous pallial muscles which radiate from the two pallial retractor muscles as shown in Plate 152. The fact that the mantle can be retracted quickly on the slightest stimulus prevents injury to the mantle proper and thus allows rapid repair of the shell if it has been broken. When completely retracted the mantle and gills lie folded closely against the posterior adductor muscle and in this condition cover only the area corresponding to the inner nacreous layer of the shell.

A unique and very important structure in the Pinnidae is the waste canal by means of which particles of sand and other debris are carried from the incurrent portion of the mantle cavity. The waste canal consists of slightly raised channels, one on each lobe of the mantle, which oppose each other to form a tube. The inner surfaces of the channels are lined with strong cilia and are supplied with mucous glands. The canal extends nearly the length of the mantle and parallels the outer margin of the gills. All material entering the canal is carried rapidly posteriorly (upward) and is consolidated with mucus into strings and ejected. Although the waste canal is highly developed in the Pinnidae, it is analogous to the ciliary tracts which function in the ejection of particles from the incurrent siphon in other bivalves.

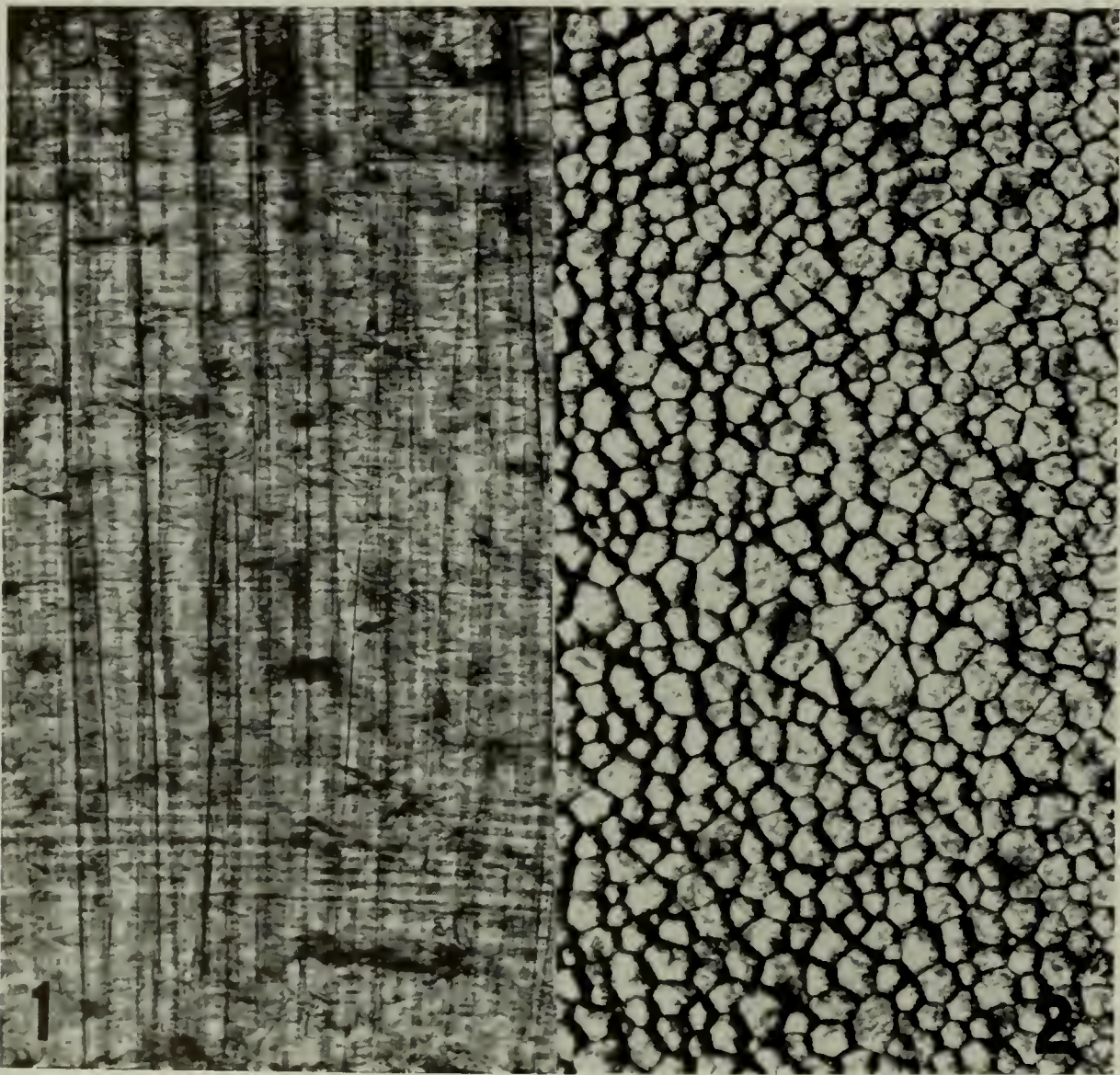


Plate 151. *Pinna carnea* Gmelin, shell structure. Fig. 1. Section to show the length of the crystals of the prismatic layer (i. e., thickness of the shell). Fig. 2. Section to show surface of the crystals in cross section from the same area of the shell as in Fig. 1. (Both 110x.)

The mantle is important in cleaning and in repairing the shell, but the Pinnidae possess in addition a unique structure, the pallial organ, which, according to C. M. Yonge, probably functions only when the shell has been broken. At such times, after the mantle has been retracted, the pallial organ may be distended so that it is large and turgid. It can then be protruded to the edge of the valves where it actively pushes out broken pieces of shell and debris. The pallial organ at such times is extremely active and many of its movements appear aimless, but there seems to be little doubt that its function is that of clearing away the larger particles which are too heavy for the cilia of the mantle to handle. The mantle gradually extends to the edge of the break and the repair and rebuilding of the shell begin. These shells are so fragile and so subject to breakage that one seldom finds a large specimen which does not show evidence of numerous breaks. Grave (1911) reported that a hole one half by three fourths of an inch was completely repaired in three days.

Our observations on living specimens would indicate that the pallial organ functions whenever the mantle is partially contracted, even if the shell is not broken. If one valve of *Pinna* or *Atrina* is carefully removed and the specimen kept in a pan of well-aerated

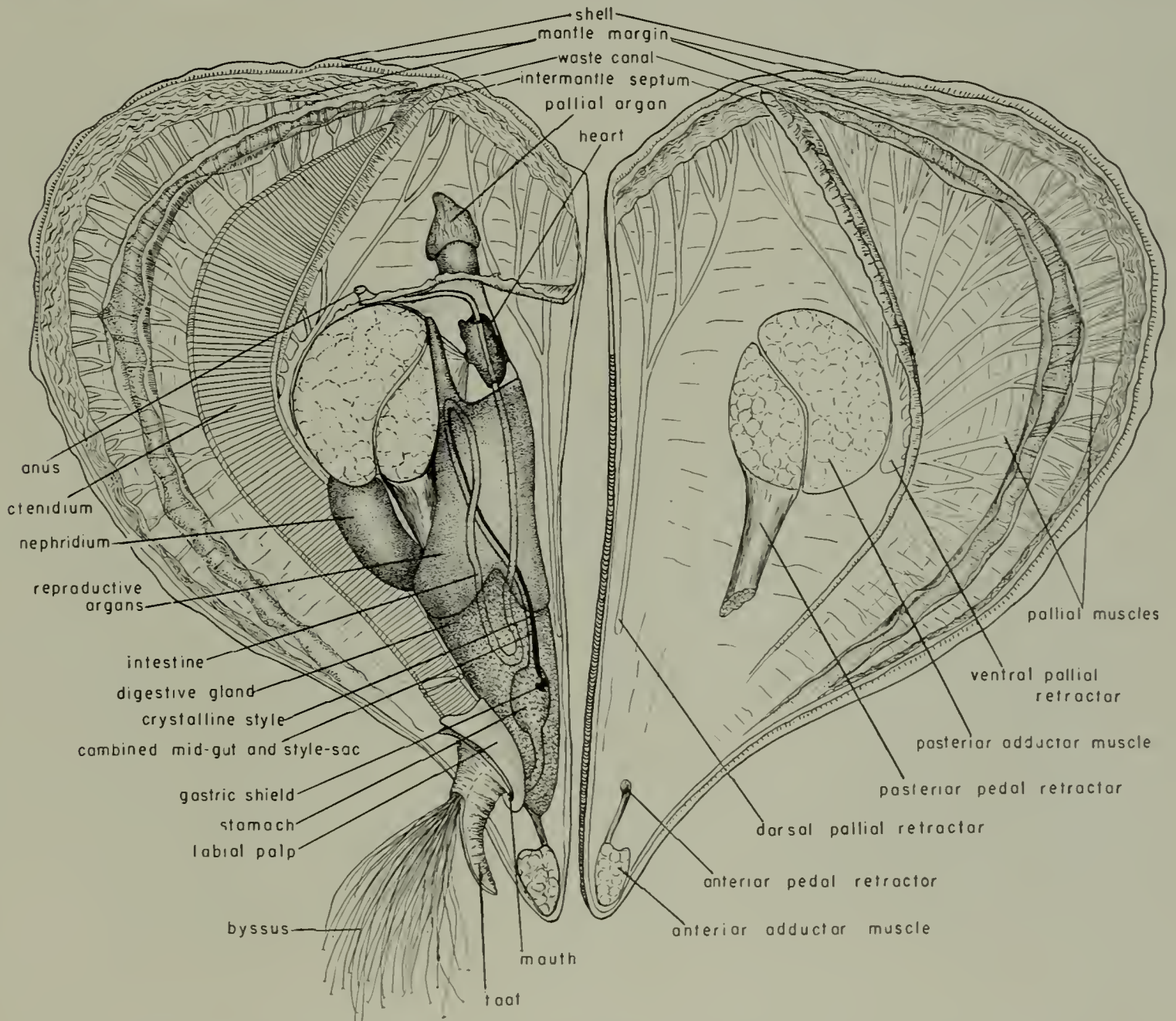


Plate 152. Semidiagrammatic drawing of the anatomy of *Atrina rigida* Solander. The right half shows only the muscles and the characteristic features of the mantle.

sea water, the live animal can be observed easily. With the mantle partially retracted due to the fact that one valve had been removed, the material carried posteriorly by the waste canal could not be carried beyond the valve and it collected at the posterior end of the canal. When a sizeable ball of this matter had collected, the pallial organ (in one of the three live specimens studied) extended and pushed it out of the shell. When not observing the animal we replaced the valve and in this way were able to keep it fairly active for three days.

On Plate 152 we present a semidiagrammatic drawing of the gross anatomy of *Atrina rigida* Solander. To make this sketch the adductor muscles were cut just inside the mantle on one side so that only the mantle and portion of the cut muscles were left adhering to the right valve. On the left valve we have shown the animal as it can be seen without dissection. We have, however, indicated (as if the animal was transparent) the esophagus, stomach, combined mid-gut and style sac, and the intestine which cannot be seen without dissection for these are embedded in the large digestive gland and reproductive organs. The crystalline style in *Atrina* is unusually large—a specimen 150 mm. long having a style 48 mm. long and 2 mm. in diameter at the anterior end.

Purchon (1957) described in detail the stomachs of *Atrina vexillum* Born and *Pinna atropurpurea* Sowerby, both species of the Indo-Pacific region. He mentioned in particular the development of a long slender tongue on the major typhlosole, a fold in the interior of the stomach. This tongue extends into the food-sorting caecum of the stomach, greatly increasing the efficiency of the latter. This development of the tongue on the typhlosole is shared with the Arcidae, Glycymeridae, Mytilidae, Vulsellidae [= Isognomonidae], Pteriidae and Ostreidae. Purchon considered that the evolution of such a tongue could neither have arisen independently in several lines nor did he believe that the tongue, once produced, could have been lost independently. Therefore he concluded that these families are monophyletic, but before definite relationships between these families can be established, studies of other organs and the shells must be made. Certainly the Mytilidae, Vulsellidae, Pteriidae and Pinnidae are close in their relationship and this similarity in stomach structure is one more factor relating them. Our observations on the stomach of *Atrina rigida* Solander agree closely with those of Purchon.

A discussion of pinnaglobin, the brown pigment in the body fluid of the Pinnidae, was given by Suto (1938). Suto did not believe that it had much oxygen-holding capacity and he suggested that further work is needed on this problem.

In a recent paper on the physiology of *Pinna* muscle, Abbott and Lowy (1956) have shown that, in this group, the posterior adductor muscles behave similarly to those of other bivalves. They show that there is a fast and slow acting portion to the muscle and that the economy of these muscles is due to their slow rate of relaxation following contraction. On this basis it is interesting to note that, though the Pinnidae do not have an elastic ligament against which the muscles must work to keep the shells closed, the valves themselves, due to their high organic content are flexible and probably take over the function of the ligament in opening the valves.

#### ECONOMIC IMPORTANCE

The Pinnidae cannot be classed rightfully among the important economic mollusks though probably no other family of mollusks yields so many products. The large adductor muscles of both *Pinna* and *Atrina* are eaten in many countries where species of these

genera occur. However, European writers state that they require much cooking and are rather tough, though of excellent flavor.

In Japan, according to A. R. Cahn (1951), there is an active and important fishing industry for *Atrina japonica* Reeve. The posterior adductor muscles are marketed fresh and the clam meats, exclusive of the muscles, are sold either raw or as dried meats which have first been boiled. They are highly esteemed as food. Even the discarded shells are used as a cultch for seed oysters and, when ground, they are used as fertilizer. No part of the animal is wasted in these Japanese fisheries. When *Atrina* occur intertidally they are harvested on the night low tide by torchlight, using a stick with a hook to extricate the shell. In areas where the species occurs in deeper water, fishing is done by divers operating from a boat. They use a regulation diving suit with air hose and work for periods as long as six hours in depths of twenty meters. The clams are usually pulled out with a barbed spear which penetrates the valves of the shell. So important is this fishery in Japan that there are government regulations concerning the season for harvesting and the quantity that can be taken.

On the west coast of Mexico in the vicinity of Mazatlan, *Atrina maura* Sowerby and *Pinna rugosa* Sowerby are important items of food among the natives. Pilsbry and Lowe (1932) described the heaps of empty shells found there and stated that the large muscle tastes like that of giant scallops. Mexicans call the shells "hachas" or hatchets and they are fished in much the same manner as that described for the Japanese fisheries. Mr. John Fitch of the California Fisheries Laboratory has written us recently that there is an active fishery for *Atrina maura* at San Blas, Nayarit, Mexico.



Plate 153. The byssus of the Pinnidae. Fig. 1. Byssus of *Atrina rigida* Solander from Bunch Beach, Florida to show the long fine threads which may be used in weaving (about  $\frac{2}{3}$  natural size). Fig. 2. *Pinna nobilis* Linné, from Cannes, France, the large Mediterranean species which produces a byssus used in the manufacture of garments (about  $\frac{1}{4}$  natural size). Fig. 3. A glove knitted from byssus fibers at Tarento, Italy (USNM no. 149395; about  $\frac{3}{8}$  natural size).

No one seems to have used the Pinnidae of the Western Atlantic for food though Mr. Harvey Bullis of the U.S. Fish and Wildlife Service, Bureau of Commercial Fisheries, Pascagoula, Mississippi says they are excellent either raw or cooked.

All species in this family produce nacreous pearls, and though they are often irregular in shape, perfect specimens are quite valuable. Pliny mentioned the practice of diving in the Mediterranean for *Pinna* in order to obtain the pearls, and Poli (1795) reported taking twenty pearls from a single specimen of *Pinna nobilis* Linné. However, it was apparently in India where the fishing of Pinnidae for pearls was an important industry among the ancients. In the records of Alexander's Indian Expedition it was mentioned that in Indian seas these shells were obtained by diving for the sake of the pearls. Grave (1923) stated that he found pearls in about one fifth of all the specimens of *Atrina rigida* he examined for his studies. According to his account the pearls were black, usually spherical and quite smooth. He said they had been used in the manufacture of brooches and other articles of jewelry and he could see no reason why they should not be used more extensively. In an interesting paper on the "Natural History of the Pearls" Hass (1955) described the structure of pearls in the Pinnidae. These pearls have radially arranged prisms, a condition quite unlike that of all other pearls. This is a result of the unusual structure of the shell as discussed previously. Because of the radially arranged prisms and the large amount of organic material between the prisms, the pearls usually fragment on drying out and so are rather short-lived. As a result they are considered of relatively little value at the present time. However, pearls produced in the anterior portion of the mantle which lays down laminated, nacreous material would be composed of concentric layers rather than radial prisms. Such pearls should be durable and valuable.

The most famous product produced by the Pinnidae is the byssus fiber, which is an extremely fine and soft but strong fiber produced by a gland in the foot of the animal for the purpose of anchoring the shell. The byssus fiber of some of the larger species in this family is sufficiently long so that it can be spun and then woven or knitted to make small garments. It has a beautiful golden bronze sheen and was often combined with silk when used in making larger garments. Most authorities believe that the use of the byssus

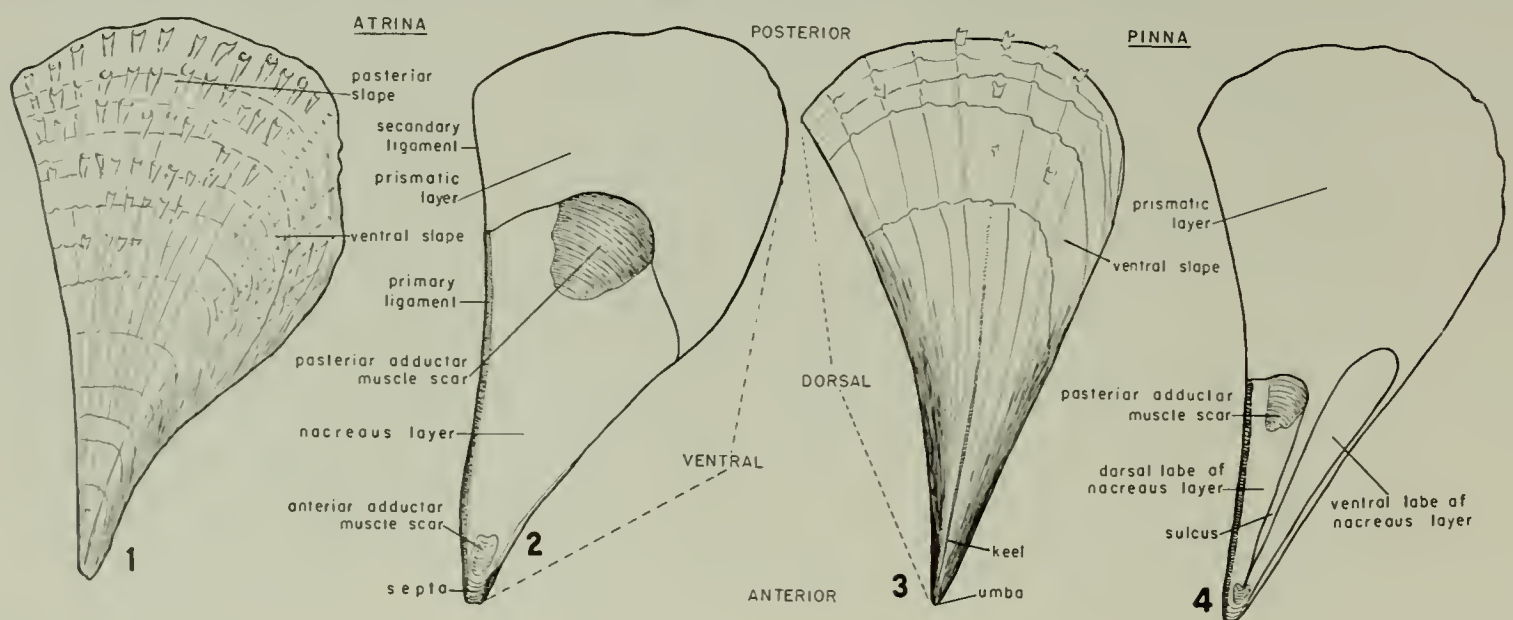


Plate 154. Diagrammatic sketch of the valves of *Pinna* and *Atrina* to show diagnostic characters. Fig. 1. External surface of valve of *Atrina*. Fig. 2. Internal surface of valve of *Atrina*. Fig. 3. External surface of valve of *Pinna*. Fig. 4. Internal surface of valve of *Pinna*.



Plate 155. *Pinna rudis* Linné from Pointe Noire, Gaboon, French Equatorial Africa. Fig. 1. Internal surface of valve showing the difference in length of the two lobes of the nacreous layer in a large adult specimen (about  $\frac{1}{3}$  natural size). Fig. 2. External surface of the valve showing the large spines of a typical specimen (about  $\frac{1}{2}$  natural size).

as a fiber in making garments probably originated in India near Colchi. This is based on the fact that the earlier Greek and Roman writers referred to *Pinna* but did not mention the use of the byssus before the time of Tertullian (150–222 A.D.). Tarento was the center of the industry in Italy, and Procopius, who wrote on the Persian Wars about 550 A.D., stated that the five hereditary satraps (governors) of Armenia who received their insignia from the Roman Emperor were given chlamys (or cloaks) made from *lana pinna* (*Pinna* “wool,” or byssus). Apparently only the ruling classes were allowed to wear these chlamys. Even today a small remnant of the former industry remains in Italy and a few articles such as gloves, hats, shawls and stockings are made mainly for the tourist trade. According to Simmonds (1879) in “The Commercial Products of the Sea,” the byssus formed an important article of commerce among the Sicilians, for which purpose considerable numbers of *Pinna* were annually fished in the Mediterranean from a depth of 20 to 30 feet. He also said, “a considerable manufactory is established at Palermo; the fabrics made are extremely elegant and vie in appearance with the finest silk. The best products of this material are, however, said to be made in the Orphan Hospital of St. Philomel at Lucca.” Though the modern gloves and shawls are knitted, the chlamys, gloves and stockings of the ancients were woven, for knitting was not known until about 1500 according to Yates (1843). Articles made from *Pinna* byssus are extremely strong and durable except that they are readily attacked by moths so that great care must be taken in their preservation. There are, as a consequence, very few examples of the early garments in existence. On Plate 153 are shown the cleaned byssus of *Atrina rigida* Solander; the shell of *Pinna nobilis* Linné, the species from which the byssus was obtained for the Italian industry; and a glove made from byssus fiber at Tarento, Italy.

The etymology of the word “byssus” was discussed by van der Feen (1949, pp. 66–71). It was shown that the word was derived from two very similarly sounding Greek terms, one denoting depth (of the sea or a river), the other referring to fine vegetable fibers which were woven into valuable fabrics by the ancients. In 1476 Gaza, through an error in translation of a section concerning *Pinna* in Aristotle’s “Historia Animalium,” originated the use of the word byssus as it is applied to the holdfast fibers of the Pinnidae, Mytilidae, Pteriidae, etc. He did this by confusing the Greek word for depth, as used by Aristotle in describing the ecology of *Pinna*, with the term for the vegetable fibers and may have genuinely believed that Aristotle intended the word to be applied to the holdfast. In 1555, Rondelet perpetuated and popularized this mistake and in this way the term became established. Gesner in 1558 was the first to oppose the erroneous use of byssus and criticized Gaza’s work. Since that time various workers have taken a stand against the use of the word and a few have championed it including Sir d’Arcy Thompson in 1910. Although the word byssus is used universally today in referring to the holdfasts of bivalve mollusks it is interesting to reflect upon the uncertain basis for its use and history of origin.

Because the Pinnidae are such unique bivalves and have intrigued man since early historic times there are a host of common names for this group. In France they are known as ‘jambons’ or ham-shells, because of their shape, and the Mexicans refer to them as ‘hachas’ or hatchets. In England they are known as fan-mussels, fin-shells or sea-wings and in the United States they are often referred to as pen-shells or sea-pens. The Australians refer to them as razor backs or razor clams as it is so easy to cut one’s feet on them. This common name should not be confused with that of *Ensis* or *Siliqua* which are also called razor clams because of their shape.

## ASSOCIATES OF THE PINNIDAE

The Pinnidae are host to a number of organisms which live both upon the outside of the valves and in the mantle cavity. Most of the associated organisms use the shell only as a point of attachment and support. Perry (1936) reported finding a total of twenty-five different organisms living in association with *Atrina rigida*. From a fine shipment of this species which we received from Harvey Bullis, dredged from 3-4 fathoms off Tampa Bay, Florida, we removed 28 species of mollusks of which 12 were living, as well as barnacles, tube worms, hydroids, algae, bryozoa, tunicates and brittle stars.

Some of the organisms associated with the Pinnidae, particularly crustaceans, have an interesting commensal relationship with them. Aristotle was the earliest writer to mention the interesting association of a crab with *Pinna*. Chemnitz (1785) fully described this small crab, *Pinnotheres*,<sup>1</sup> which lives in the mantle cavity of *Pinna*. The crab was said to leave the cavity periodically, but always to return when danger threatened, thus warning the *Pinna* which would thereupon close its valves protecting both itself and the *Pinnotheres* within. This fanciful story of the "friendship" of these two animals was made famous by Pliny and additional accounts of this relationship have been written by Poli (1795), Montagu (1803), Johnston (1850), Jeffreys (1863) and others. Apparently,



Plate 156. Holotype specimen of *Pinna varicosa* Lamarek [= *P. rudis* Linné] from Trinidad, Lesser Antilles.

Fig. 1. Outer surface of valve. Fig. 2. Inner surface. Fig. 3. Sketch of the inner surface of the valve to show arrangement of nacreous layer and the muscle scar. The photographs and drawing by courtesy of Dr. J. Gaillard and the Muséum d'Histoire Naturelle, Paris (all about  $\frac{1}{2}$  natural size). This specimen is typical of the stunted form of *rudis* as it occurs in the West Indies.

<sup>1</sup> *Pinnotheres*, from the Greek: *Pinna* + *terein*, to guard, i.e., the *Pinna* guardian.

wherever members of the Pinnidae occur there are some small crabs which live with them. In fact, W. L. Schmitt (1931) stated that "edible mollusks in all parts of the world are infested by commensal crabs." Dr. Schmitt also stated that shrimp have adopted this way of life, that one rarely finds more than one adult shrimp or crab in a shell and this is usually a female. The adult males visit from shell to shell, but the females seldom if ever voluntarily leave the mantle cavity of their hosts. These crustaceans live in their sheltered homes sharing the food which is brought into the mantle cavity of the mollusk during its normal feeding process. They are of no benefit to the bivalve as was supposed by early writers and according to Christensen and McDermott (1958) they probably cause some damage to the gills. This is certainly true of *Pinnotheres ostreum* Say which is associated with *Crassostrea virginica* Linné. These authors made a complete study of *P. ostreum* and gave a summary and bibliography of work done on the life history of *Pinnotheres*. We have seen specimens of *P. maculatus* Say taken from *Atrina rigida* which



Plate 157. *Pinna carnea* Gmelin from Port Royal, Cat Island, Bahama Islands. Fig. 1. Outer surface of valve showing the pronounced keel at the anterior end and the few small spines. Fig. 2. Inner surface of valve showing the arrangement of the nacreous layer (both about  $\frac{1}{2}$  natural size).

were collected at Sanibel Island, Florida. A shrimp was observed living in the mantle cavity of a large *Pinna carnea* at Bimini, Bahama Islands, by Robert Robertson of the Museum of Comparative Zoölogy. The shrimp sat on top of the posterior adductor muscle of the *Pinna* in an exposed position, but when disturbed it moved backwards and down around the muscle until hidden from view.

#### NOTES ON THE FOSSIL RECORD

The fossil record shows that the Pinnidae were reasonably well represented in geologic time. Although many fossils have been reported, very few whole valves have been figured. This is probably due to the fact that these fragile shells are not readily preserved as fossils. Usually only fragments representing the prismatic layer remain and there is seldom any indication of the extent or shape of the nacreous layer. As this portion of the shell is very important in the classification of the family, few conclusions can be drawn from the fossil record concerning the evolution of this group. Hyatt (1892) discussed the fossil Pinnidae and their relationship to recent forms. He suggested that when material was available it would probably be found that in the early stages the nacreous layers of *Atrina* and *Pinna* would be quite similar in outline with the carina and division of the nacreous layer of *Pinna* appearing at a later stage. Our observations on very young specimens has shown this to be true as well as the fact that on the embryonic valves the umbos are not terminal though in the adult stage they virtually come to take this position.

Hyatt, and later Zittel, recorded the family as having existed since the Devonian. *Atrina* Gray which is known from the Carboniferous is apparently the oldest of the Recent genera in the Pinnidae, for the earliest known record of *Pinna* Linné was from the Jurassic. Another factor which suggests that *Atrina* is the oldest genus is the internal structure of the shells. The nacreous layer of *Atrina* is undivided, with the muscle scar more or less medial, while that of *Pinna* is divided by a longitudinal sulcus and has the muscle scar displaced toward the dorsal margin. These differences may be indicative of a change from simple to more complex shell structure. It has been pointed out (cf. Beecher 1898) that in mollusks the development of more complex shell structure is a sign of aging in a group. Of course, the situation is always complicated by the possibility of a secondary redevelopment of more simple characters, but this does not seem to have occurred in the Pinnidae.

Paleontologists have assigned several extinct genera to the family Pinnidae. One of these, *Palaeopinna* Hall 1870 from the Devonian, is the earliest record for the family. The shell of *Palaeopinna* (cf. Shimer and Shrock 1944, p. 387, pl. 150, fig. 12) lacks the external keel of *Pinna*, has convex umbos, and very fine radiating ribs. *Arviculopinna* Meek from the Carboniferous and Permian differs from Recent Pinnidae in that the umbos are located subterminally so that a small wing is present in front of them. A third fossil genus, *Pinnogena* 'Saussure' Bronn 1836, was reported from Jurassic and Cretaceous rocks. It somewhat resembles an oyster. The figure of *Pinnogena seebachi* Böhm, in Zittel (p. 368, fig. 621) shows a nearly entire shell with an enormous elongate, centrally located muscle scar. On the exterior of the valves there are large, convex ribs which radiate out from a central groove. The genus *Sulcatopinna* was proposed by Hyatt for Carboniferous forms having extremely elongate shells with a straight hinge line, approximately terminal umbos and with the valves ridged on the dorsal area. He suggested that this group may have been the forerunner of *Pinna*.

The general form of a very early member of the Pinnidae gained from a survey of representative genera is something resembling both *Pteria* and *Pinna*. This is most evident when the fossil genus *Aviculopinna* is considered. *Palacopinna* bears a general resemblance to both the Pteriidae and the Mytilidae, families generally placed near the Pinnidae by neontologists.

There is reason to believe, from the fossil findings, that the family Pinnidae was quite differently distributed in the past than it is today. Present data show that there are no species found on the west coast of North America north of Mexico, except *Atrina oldroydi* Dall which has been taken in 25 fathoms in San Pedro Bay in southern California. However, Crickmay (1930, p. 47) reported having found a *Pinna* in Jurassic strata of British Columbia, and Vokes (1939, p. 50) described an Eocene *Pinna* from San Joaquin Valley, California. Ivanov (1926, p. 175) listed *Pinna (Aviculopinna) membranacea* Kon. from the Carboniferous of Moscou [Moscow]. Grant and Gale (1931, pp. 145-147) reported two species of *Pinna* from the Pliocene and a species of *Atrina* from the Miocene of California.

From the foregoing discussions it seems reasonable to conclude (on the basis of shell structure, anatomy and the fossil record) that the Mytilidae, Isognomonidae, Pteriidae, Pinnidae and probably the Ostreidae, evolved from some common ancestor.

#### NOTES ON CLASSIFICATION

Though the family Pinnidae is characteristic and easily recognized, classification below the family level is difficult and the opinions of the various authors who have worked with this family vary considerably. Iredale (1939) recognized seven genera in contrast to the single genus with three subgenera recognized by Winckworth (1929) and the single genus with only two subgenera by Thiele (1934). There appear to be, however, three well marked and easily recognized genera (the subgenera of Winckworth), *Pinna* Linné, *Atrina* Gray and *Streptopinna* von Martens. This generic classification was used by Habe (1953) in his paper on the Pinnidae of Japan. He recognized three subgenera of *Pinna* and two subgenera of *Atrina*. Only *Pinna* s.s. and two subgenera of *Atrina* are represented in the Western Atlantic.

On the specific level there is even less agreement among authors. Winckworth in his catalogue listed 175 names as having been introduced into the literature concerning this family. Of these he regarded only 29 as being valid species. Iredale commenting on this great reduction of names said, "this seems obviously a *reductio ad absurdum*, and is probably as far from the facts as the total number of names is." It should be taken into consideration, however, that Winckworth included in his catalogue not only all validly introduced names but also errors in spelling, nomina nuda and names from pre-Linnean authors and non-binomial works. There are 37 such entries in his catalogue which gives a ratio of about one in five remaining as a valid species. Just how many species will be recognized when the Pinnidae of the world have been adequately studied is hard to say but the number probably will be slightly higher than that of Winckworth, perhaps 45 to 50.

Linné (1758) instituted the genus *Pinna* and described eight species, three of which are unrecognizable and a fourth referred to the pen of a *Loligo*. These have been treated by Hanley, Winckworth and Dodge. Lamarck also described eight species, the type

specimens of which have been discussed by Lamy. The two outstanding illustrated monographs are those of Chemnitz in the "Conchylien Cabinet" and Reeve in the "Conchologia Iconica." The latter is particularly important as the type specimens of Reeve and Sowerby (some 39 species) were all figured in this study. Hedley (1924) reviewed the Australian Pinnidae, recognizing 19 species and two subspecies for that area and Winckworth covered the species of India and Ceylon. There has been no world-wide treatment of this group since that of Reeve except the catalogue by Winckworth.

The confused state of the taxonomy of this family and the differences of opinion of the various authors are probably the result of a number of difficulties inherent in the study of this group. Shells of the Pinnidae are extremely fragile and have a tendency to fracture spontaneously on drying out. This fragility, combined with the large size and generally unattractive appearance of these shells have made collectors reluctant to gather and ship them. Consequently museum collections are small, they lack comparative material of a geographic nature and seldom contain lots of more than 4 or 5 specimens from a given



Plate 158. *Atrina (Atrina) rigida* Solander from Coconut Grove, Florida. Fig. 1. External surface of valve showing the tubular spines and the sculptured ventral slope. Fig. 2. Internal surface of the valve showing the nacreous layer and the protruding muscle scar (both about 3/5 natural size).

locality. Growth series are almost completely lacking. The Pinnidae as a whole have a capacity for ecologically induced variation and this has resulted in specimens of species which are widely separated geographically, such as *Atrina inflata* Dillwyn of Australia and *Atrina serrata* Sowerby of the Western Atlantic, having almost identical external appearances. However, when series are examined, the two species are found to be quite distinct. A similar problem may also arise with two species from the same locality, but actually belonging to different subgenera such as *Atrina (Atrina) rigida* Dillwyn and *A. (Servatrina) seminuda* Lamarck. These factors combined with the lack of large series in museum collections has resulted in many misidentifications as well as the naming of numerous forms which were apparently only ecologic variants. If the characteristics of the inner surface of the valves (the shape and extent of the nacreous layer and the muscle scars) are considered in conjunction with the external characters, most species can be determined readily. Unfortunately, however, few of the early descriptions either mentioned or illustrated the interior of the valves. Consequently, when using works such as Reeve's "Conchologia Iconica," it is often difficult, if not impossible, to place a species in the proper genus. Winckworth, Hedley and others have mentioned the importance of the muscle scars and the pattern of the nacreous layer in the classification of this family and our work has shown that these are among the best taxonomic characters.

Very little is known of the anatomy of most species of the Pinnidae and almost nothing is known of their breeding habits and life history. Further study on these problems will undoubtedly contribute to an understanding of the classification of the family and its relationships. Our observations on living animals show that the colors of the various organs, the position and curvature of the waste canal, as well as the size and shape of the pallial organ, are all excellent taxonomic characters.

We have included in the synonymies of the various species considered in the systematic portion of this paper only those names which we were certain referred to the species in question. Undoubtedly there have been some omissions, particularly in the synonymy of *Pinna rudis* Linné, an Eastern Atlantic species which occurs only sporadically in the West Indies. When reviewing the literature, one finds names such as *muricata* Linné applied to species belonging to both *Pinna* and *Atrina*, and coming from nearly all parts of the known range of the family. This is also the case with a number of other names though to a lesser degree.

#### ACKNOWLEDGMENTS

Many individuals and institutions have contributed valuable material used in this study as is shown in the records and we wish to acknowledge all of them. We are grateful to G. Usticke, St. Croix, Virgin Islands; Germaine Warmke of the Institute of Marine Biology, University of Puerto Rico, Mayagüez; Harvey Bullis of the United States Fisheries Laboratory, Pascagoula, Mississippi; and David and Nevada Schmidt of Sarona, Wisconsin for the material they collected especially for this study. Particular thanks are due Jean Foshee and Kathleen Johnstone of Mobile, Alabama and Robert Work of the Marine Laboratory, University of Miami who have sent both living and preserved material. H. A. Rehder of the United States National Museum and R. T. Abbott of the Academy of Natural Sciences, Philadelphia were helpful during our visits to these institutions to examine the collections. The collections of the California Academy of Sciences (CAS) and the San Diego Museum of Natural History (SDM) were also examined and

we wish to thank L. G. Hertlein and E. P. Chace for their cooperation. For the photographing of type specimens we are grateful to I. C. J. Galbraith of the Mollusca Section, British Museum (Natural History) and J. Gaillard of the Muséum d'Histoire Naturelle, Paris. Credit for these photographs is given in the plate captions. To W. J. Clench, M. E. Champion and our associates in the Mollusk Department, we are grateful for the discussion of several problems and for the reading of the manuscript: R. Robertson in addition aided in making the sections of the *Pinna* shell (Plates 149 and 150). We are indebted to Professor John H. Welsh, Biological Laboratories, Harvard University, for discussing with us certain physiological problems.

### WESTERN ATLANTIC PINNIDAE

The species of Pinnidae in the Western Atlantic may be identified by means of the following key which is based on adult specimens (see Plate 154).

1. Nacreous layer divided by a sulcus . . . . . 2 (*Pinna*)  
Nacreous layer not divided by a sulcus . . . . . 3 (*Atrina*)
2. Ventral lobe of nacreous layer longer than dorsal lobe; valves usually pale red-orange, thin, with few if any spines; ribs 8-12 . . . . . *Pinna carnea*  
Dorsal lobe of nacreous layer longer than ventral lobe; valves usually dark red-brown, thick, with large spines; ribs 5-7 (in the Western Atlantic usually stunted, deformed and devoid of spines, but in Eastern Atlantic large and spinose) . . . . . *Pinna rudis*
3. Posterior adductor muscle scar enclosed within nacreous layer . . . . . 4  
Posterior adductor muscle scar protruding beyond posterior border of nacreous layer . . . . . *Atrina rigida*
4. Valves with numerous, crowded, fine ribs armed only with imbrications; ribs over 30; shell light greenish tan . . . . . *Atrina serrata*  
Valves usually with few ribs armed with spines; ribs less than 20; shell grayish tan to black . . . . . *Atrina seminuda*

### Genus *Pinna* Linné

*Pinna* Linné 1758, Systema Naturae, ed. 10, p. 707 (type species, *Pinna rudis* Linné, by subsequent selection, Children 1823, Gray 1847).

*Chimaera* Poli 1791, Testacea Utriusque Siciliae 1, p. 31 (type species, *Pinna nobilis* Linné, by subsequent selection, Winckworth 1929).

*Chimaeroderma* Poli 1795, Testacea Utriusque Siciliae 2, p. 259 (type species, *Pinna nobilis* Linné, here selected).

*Pinnarius* Duméril 1806, Zoologie Analytique, p. 169, 340; Iredale 1939, Great Barrier Reef Expedition, Scientific Reports 5, no. 6, p. 309 [new name for *Pinna* Linné].

*Pinnula* Rafinesque 1815, Analyse de la Nature, ou Tableau de l'Univers et des Corps Organisés, Palerme, p. 147 (a substitute name for *Pinna* Linné).

*Cyrtopinna* Mörch 1853, Catalogus Conchyliorum Comes de Yoldi, part 2, p. 51 (type species, *P. incurva* Gmelin, by monotypy).

Type species, *Pinna rudis* Linné, by subsequent selection, Children 1823, Gray 1847.

Shell medium to large, reaching about 700 mm. (about 26 inches) in length, wedge-shaped, generally thin in structure and often sculptured with spinose or imbricate radiating ribs. Nacreous layer divided by a longitudinal sulcus into a dorsal and a ventral lobe, the

large posterior adductor muscle scar being on the dorsal lobe of the nacreous layer adjacent to the ligament.

This genus is found in nearly all tropical and subtropical seas with a few species reaching into temperate waters. Specimens are usually found living in sandy-muddy bottoms where they are firmly attached by large byssi, though in some areas they may be found living in crevices on rocky shores. A discussion of the biology of the group is given in the introduction.

There has been a great deal of controversy concerning the type species of this genus. Since Children's work (1823) it has been considered as *Pinna rudis* Linné. However, as Iredale (1939) has pointed out, Children selected types only for Lamarckian genera and so, even though Linné's and Lamarck's interpretations of *Pinna* were the same, the first selection of a type species of *Pinna* Linné was that of Gray in 1847. He selected as type *Pinna rudis* Linné and this selection has been recognized since that time. Unfortunately, Grant and Gale (1931), attempting an absurdly strict interpretation of the Rules of Zoological Nomenclature, stated that according to Article 30d and Opinion 16 the type would have to be *Pinna muricata* Linné. They based their argument on the fact that

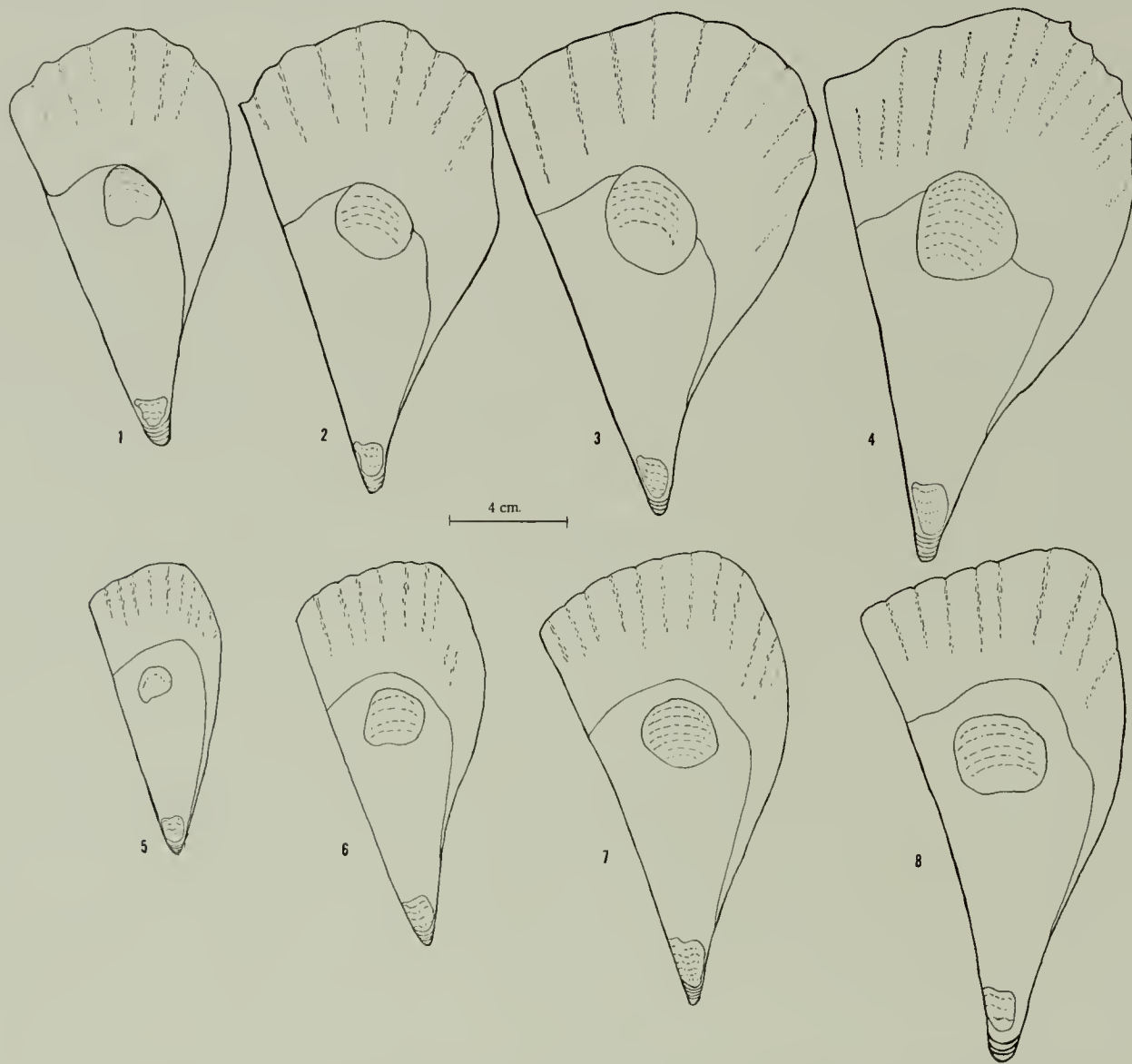


Plate 159. Variations with age in *Atrina* (*Atrina*) *rigida* Solander and *Atrina* (*Servatrina*) *seminuda* Lamareck. Figs. 1-4. *Atrina rigida* Solander from off Tampa Bay, Florida in 3-4 fathoms. A series from one locality showing the gradual protrusion of the posterior adductor muscle scar with increase in age. Figs. 5-8. *Atrina seminuda* Lamareck from Aransas Bay, Texas. A series to show the relatively smaller posterior adductor muscle scar and its inclusion within the nacreous area. All drawings were made with the aid of a Berville camera lucida.

under this species Linné in the *Systema Naturae*, ed. 10, p. 707, referred to "Concha Pinna" in Hasselquist,<sup>1</sup> making this the type by absolute tautonymy. This has upset a designation which has been understood for well over one hundred years. In addition, even Grant and Gale admitted that "there has been doubt about the recognition of *Pinna muricata* Linné." Hanley (1855) discussed fully the confusion concerning this species and Winckworth (1929), following Hanley, stated that the original description of *muricata* Linné was a composite, but that Linné in the *Museum Ulricae* (1764, p. 545, no. 143) gave a recognizable description of this species and limited the references to Rumphius (1741, pl. 46, fig. M) and Gaultieri (1742, pl. 79, fig. D). The locality, "M. Mediterraneo," as given by Linné in 1758 has long been considered in error as there is nothing in the Mediterranean which approaches his description. Thus, the name *muricata* Linné had been restricted to the Indo-Pacific species and the reference to Hasselquist eliminated.

Therefore, considering the confusion as to the identity of *P. muricata* Linné, the subsequent limitation of the name by both Linné and Winckworth, and especially the fact that the Hasselquist reference was to a species which no one has been able to recognize, we agree with Iredale (1939) and Habe (1953) that the type species of *Pinna* Linné should remain *Pinna rudis* Linné, Gray 1847.



Plate 160. *Atrina* (*Servatrina*) *seminuda* Lamarck. Holotype specimen of *Pinna* (*Atrina*) *seminuda* Lamarck from Brasil. Fig. 1. External view of left valve. Fig. 2. Internal view of right valve (both natural size). Photographs courtesy of the Muséum d'Histoire Naturelle, Paris.

<sup>1</sup> Hasselquist, F. 1757, *Iter Palaestinum*, p. 448 [not 447 as given by Linné 1758], no. 137, Stockholm.



*Types.* According to Hanley (1855) and Dodge (1952) there is no specimen of *Pinna rudis* in the Linnaean collection. Linné's reference was to d'Argenville 1742, l'Histoire Naturelle, pl. 25, fig. F, which we here select as the type figure. It is a poor figure, but combined with Linné's description could certainly refer to this species. Hanley stated that the name *rudis* has generally been associated with the figure of Chemnitz (1785) in the Conchylien-Cabinet 8, fig. 773. The type locality was given by Linné as the Mediterranean Sea. The type of *Pinna paulucciae* de Rochebrune is in the Muséum d'Histoire Naturelle, Paris, according to Lamy (1911, p. 319). The type of *Pinna varicosa* Lamarek is also in the Paris Museum and the type locality is Trinidad. Lamarek's type is a stunted specimen, typical of *P. rudis* of the West Indies. Through the kindness of Dr. J. Gaillard of the Muséum d'Histoire Naturelle, Paris, we are able to figure the holotype specimen (Plate 156). Röding made reference to Chemnitz 8, pl. 88, fig. 773 under both *Pinna ferruginea* and *P. elongata*, and this figure is here selected as the type

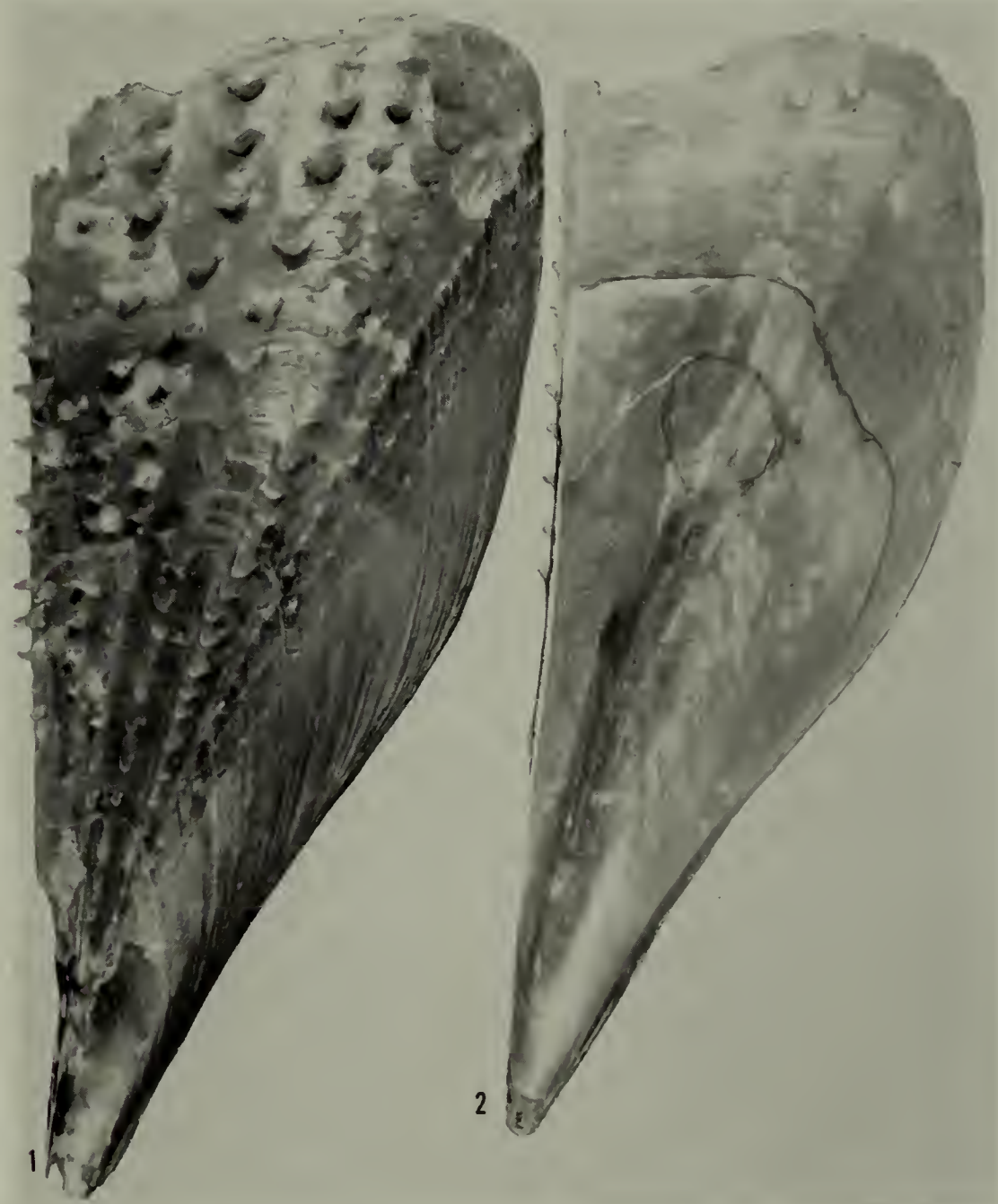


Plate 161. *Atrina (Servatrina) seminuda* Lamarek. Fig. 1. External view of the left valve of a specimen from Peruhybe, Itanhaem, São Paulo, Brasil, showing the smooth ventral slope and the open flute-like spines. Fig. 2. Internal view of right valve of a specimen from Itanhaem, São Paulo, Brasil, showing the well-inset muscle scar (both slightly enlarged).

figure for these two names. The type figure, here selected, of *P. pernula* Röding is Chemnitz 8, pl. 92, fig. 785, the only figure to which Röding referred. The type locality of *P. pernula* is St. Croix, Virgin Islands, those of the other two Röding names are unknown.

*Remarks.* See also *Remarks* under *Pinna carnea* Gmelin. As indicated in the measurements, *Pinna rudis* in the Eastern Atlantic is a large, robust species. It is closely related to *carnea* Linné and the young are easily confused with that species. However, in *P. rudis*, the dorsal lobe of the nacreous layer usually extends well posterior to the ventral lobe, with occasional specimens, particularly young, having the two lobes of equal length. In *P. carnea* the two lobes may be about equal in length, but usually the dorsal lobe is shorter than the ventral lobe. The ventral lobe of the nacreous layer is usually truncate in *rudis*, while in *carnea* it is rounded to pointed.

We have seen three lots of *P. rudis* from the Western Atlantic. All are small and deformed and they appear to have been living under adverse conditions. There are a number of records of Pinnidae taken from floating logs, ship bottoms, buoys and other such objects and the few records of *rudis* from the West Indies are apparently the result of such mechanical transport. Though these introduced adults may spawn, conditions for the growth of the young are apparently unsatisfactory for, to our knowledge, no lasting colony of this species has ever been established in the West Indies. Specimens of *P. rudis* in the West Indies are a much darker red-orange and have a more solid shell than specimens of *P. carnea* of the same size.

In the synonymy of *Pinna rudis* Linné we have included only those names which we considered were without question synonyms of *rudis*. There has been so much misidentification and misinterpretation of *rudis* Linné as well as other species in the Eastern Atlantic that if we included a reference to each of the misidentifications, the synonymy would become meaningless.

*Range.* EASTERN ATLANTIC: Western Mediterranean, Madeira, Canary and Cape Verde Islands, and the Atlantic coast of Africa south to St. Paul-de-Loanda, Angola.

WESTERN ATLANTIC: Occurs sporadically in Puerto Rico and the Virgin Islands south to Trinidad and Tobago, Lesser Antilles.

*Specimens examined.* EASTERN ATLANTIC: CANARY ISLANDS: Ténériffe (MCZ). FRENCH WEST AFRICA: Gorée, Sénégal (A. Humes). FRENCH EQUATORIAL AFRICA: Pointe Noire, Gaboon (A. Humes). BELGIAN CONGO: Banana (SDM). ANGOLA: St. Paul-de-Loanda (MCZ).

WESTERN ATLANTIC: PUERTO RICO: Aguadilla (A. Phares). VIRGIN ISLANDS: Christiansted, St. Croix (G. Usticke). LESSER ANTILLES: Tobago (MCZ); Trinidad (Muséum d'Histoire Naturelle, Paris).

### *Pinna carnea* Gmelin

Plates 149: 150, figs. 1-2; 151; 157

*Pinna carnea* Gmelin 1791, Systema Naturae, ed. 13, 1, p. 3365 (no locality given) [refers to Knorr 1771, Verlostigung 2, pl. 23, fig. 1].

*Pinna degenera* Link 1807, Beschreibung der Naturalien-Sammlung der Universität zu Rostock, p. 159 (no locality given) [refers to Chemnitz 8, pl. 87 [not 86 as given in Link], fig. 769.

*Pinna flabellum* Lamarck 1819, Histoire Naturelle des Animaux sans Vertèbres 6, p. 130 [in part, references to Chemnitz 8, pl. 86 [87], fig. 769, and to *Pinna carnea* Gmelin].

*Description.* Shell reaching 270 mm. (about 11 inches) in length, wedge-shaped, sub-inflated, with a weak to moderately strong longitudinal keel at the anterior end: valves thin, fragile, and sculptured with radiating ribs. Shell translucent, particularly in young specimens, and ranging in color from light tan to pink and salmon with occasional specimens becoming rather dark orange-brown. Surface generally glossy (except where incrustated with organisms and mud). Sculpture consisting of from 8 to 12 moderate to strong radiating ribs, often with intermediate riblets. These ribs may be smooth or provided with a few hollow spines which open posteriorly. Concentric sculpture consisting of inconspicuous lines of growth which are convex posteriorly. Posterior margin irregular, usually undulate and frequently fractured: it is convex, oblique or nearly straight. Dorsal margin variable, ranging from broadly concave to nearly straight. Ventral margin convex to slightly concave, but usually convex posteriorly and concave anteriorly. In some specimens it may be nearly straight. Interior of valves glossy and light tan to



Plate 162. Holotype of *Pinna listeri* d'Orbigny [= *Atrina seminuda* Lamarck] from Brasil (about 3/5 natural size). Photograph courtesy of the British Museum (Natural History).

salmon or orange-brown in color. Nacreous layer iridescent and extending from the anterior end of the shell to and including the area of the posterior adductor muscle scar. It is divided by a longitudinal sulcus which extends nearly to the anterior end of the valve. Ventral lobe of the nacreous layer usually rounded and longer than the dorsal lobe though in young specimens the two lobes are often approximately equal in length. Anterior adductor muscle scar small, nearly as wide as the valve and located just anterior to the termination of the longitudinal sulcus. Posterior adductor muscle scar large, bounded posteriorly by the end of the nacreous layer and ventrally by the longitudinal sulcus. Primary hinge ligament thin, black and extending from the anterior end of the shell to the posterior border of the nacreous layer. Secondary ligament not colored but evident in fresh specimens, the dorsal margins of which are fused throughout; not usually seen in dried specimens the valves of which often gape from the end of the primary ligament to the posterior margin. Embryonic valves triangular, not inflated, the umbos central, prominent and directed medially (Plate 150, figs. 1-2).

length	width	
270 mm.	122 mm.	Bermuda
258	121	Alice Town, N. Bimini Id., Bahama Islands
247	108	Fish Point, Guantánamo Bay, Cuba
192	99	West Summerland Key, Florida
92	55	St. Thomas, Virgin Islands

*Types.* Gmelin's only reference under *Pinna carnea* was to Knorr 1771, pl. 23, fig. 1, and this is the type figure. The type locality is here designated as Guantánamo Bay, Cuba, an area from which we have seen material and from which specimens could have reached Europe at that early date.

*Remarks.* There has been considerable discussion concerning the species of *Pinna* in the Western Atlantic. This has arisen from the fact that species in this genus are variable, that *carnea* Gmelin of the Western Atlantic and *rudis* Linné of the Eastern Atlantic are close in their relationship and that young or worn specimens are difficult or even impossible to distinguish. When reviewing the literature for this group it was found that about half of the authors referred to all Western Atlantic specimens as *carnea* while others considered them to be *rudis*; still others have considered that both species are found here side by side. We agree with Dodge (1952) and Abbott (1954) that the common species throughout the West Indies is *Pinna carnea* Gmelin, though *rudis* does occur rarely in Puerto Rico and the Lesser Antilles. Though the West Indian specimens of *rudis* are small and usually lack spines they are readily distinguished by the pattern of the nacreous layer and muscle scar. *Pinna rudis* Linné in the Eastern Atlantic is a large, heavy species, having only 5-8 radiating ribs and much coarser spines than those of *carnea*. Specimens of *Pinna rudis* may reach 565 mm. in length and have spines 10.7 mm. wide at the base. The largest specimen of *carnea* in the collection of the Museum of Comparative Zoölogy is only 270 mm. in length with spines 4.5 mm. wide at the base. See *Remarks* under *P. rudis* Linné.

An interesting account of the anatomy and physiology of *Pinna carnea* is given by C. M. Yonge (1953). Structures peculiar to the Pinnidae in general are discussed and comparisons are made with other groups regarding form and evolution.

We have seen specimens of this species taken from a buoy off Key West, Florida and from the inside of an ocean buoy anchored just south of Miami. These specimens were all small (averaging about 50 mm. in length), thin, and medium to pale salmon in color. A single specimen taken from a buoy block from off Key West had reached a length of 180 mm. and was a normal *P. carnea* even though it had lived entirely on the surface of the block with no opportunity to burrow. This species, occurring as it does on buoys, must have a free swimming larval stage.

*Range.* From Lake Worth, Florida, south through the Florida Keys: Bermuda: the West Indies and from Veracruz, Mexico south probably to Trinidad.

*Specimens examined.* FLORIDA: South Inlet, Lake Worth (MCZ; USNM): Crandon Park, Miami: off Miami from the inside of an ocean buoy (both R. Merrill): Biscayne Key (J. K. Howard; J. Schwengel): 4 miles NE of The Elbow, Key Largo in 66 fathoms: off Carysfort Light, Key Largo (both MCZ): reef off Teatable Key (Peabody Mus., Yale Univ.: J. Schwengel; ANSP): Tavernier Key (R. Flipse): Little Duck



Plate 163. Holotype of *Pinna subviridis* Reeve [= *Atrina seminuda* Lamarck] from South Carolina (about  $\frac{1}{2}$  natural size). Photograph courtesy of the British Museum (Natural History).

Key (MCZ; G. Kline); Grassy Key (MCZ; ANSP; G. Kline); Pigeon Key; Missouri Key; Ohio Key; West Summerland Key (all D. and N. Schmidt); Key Vaca (J. Schwengel; D. and N. Schmidt); Big Pine Key (MCZ); Looe Key (J. Schwengel); Key West (MCZ; ANSP; USNM; CAS); off Key West from a buoy (R. Merrill); Fort Jefferson, Dry Tortugas (MCZ); Bird Key and Garden Key, Dry Tortugas (both USNM). BERMUDA: Richardson Inlet, St. George Island (MCZ); Castle Harbour in 4–5 fathoms (R. Foster). BAHAMA ISLANDS: West End, Grand Bahama (MCZ); Hope Town, Great Abaco (G. Kline); south end, Elbow Cay, Great Abaco (R. Robertson); Alice Town, North Bimini Id. (MCZ; ANSP); North Cat Cay, Bimini Islands (J. Schwengel); South Riding Rock, 30 miles S of Bimini Island; NW coast South Bimini (both R. Robertson); Nassau, New Providence (Peabody Mus., Yale Univ.; USNM); Adelaide Beach, New Providence (R. Robertson); Sandy Point, Savannah Sound, Eleuthera (ANSP; MCZ); Port Royal; Arthurs Town and Northeast Point, all Cat Island; Little San Salvador, 18 miles W of Cat Island; Matthew Town, Great Inagua (all MCZ); Big Wood Cay, Andros; George Town, Exuma (both G. Kline); Hog Cay, Exuma (R. Robertson). CUBA: Cabo Cajon, Pinar del Río; Cayo Jutia and Bahía de Cabañas, Pinar del Río (all MCZ); Cayo Francés, Caibarién, Las Villas (P. J. Bermudez; R. Humes); Castillo de Jagua, Bahía de Cienfuegos, Las Villas (ANSP); Caletón de Don Bruno, 4 miles SW of Cienfuegos and Punta de la Milpa, Cienfuegos, both Las Villas (both MCZ); Cayo off Punta San Juan, Bahía de los Perros, Camagüey (ANSP); Cable Beach and Fish Point, Guantánamo Bay, Oriente (both MCZ). JAMAICA: Port Royal (USNM). HISPANIOLA: South of Punta Mangle, Bahía de Samaná, Dominican Republic (USNM). PUERTO RICO: Aguadilla and Mayagüez (both A. Phares); Punta Algorrobo and Punta Guanajibo (both G. Warmke); Culebra Island (USNM). VIRGIN ISLANDS: near Christiansted, St. Croix (G. Usticke); St. Thomas (MCZ; USNM; San Diego Mus.); St. John (ANSP; USNM); Tortola and Guana Island (both MCZ); Gorda Sound, Virgin Gorda (R. Foster). LESSER ANTILLES: Saint Martin (ANSP); Antigua (ANSP; USNM); Barbados (MCZ; Peabody Mus., Yale Univ.; USNM; ANSP); Tobago (MCZ). CARIBBEAN ISLANDS: Old Providence Island (USNM). MEXICO: Veracruz, Veracruz (T. Pulley; USNM). COLOMBIA: Cartagena (CAS; SDM); Santa Marta (USNM).

### Genus *Atrina* Gray

*Atrina* Gray 1840, Synopsis Contents of the British Museum, ed. 42, p. 151 [nomen nudum]; Gray 1842, Synopsis Contents of the British Museum, ed. 44, p. 83 [described but no species listed]; Gray 1847, Proceedings Zoological Society of London, p. 199.

*Pennaria* 'Browne' Mörch 1853, Catalogus Conchyliorum Comes de Yoldi, part 2, p. 51 (type species, *P. rigida* Solander [= *Atrina rigida* Solander] here selected), non *Pennaria* Oken 1815, non de Blainville 1818.

*Pinnaria* 'Browne' Paetel 1890, Catalog der Conchylien-Sammlung, p. 208 [error for *Pennaria* Browne].

Type species, *Pinna nigra* 'Chemnitz' Dillwyn, by subsequent selection, Gray 1847.

Shell reaching about 350 mm. (14 inches) in length, wedge- or wing-shaped in outline. Thin to rather heavy in structure with terminal umbos and often sculptured with imbricated radiating ribs. Nacreous layer extending about two thirds to three fourths the length of the shell and not divided by a longitudinal sulcus. The large posterior adductor muscle scar located subcentrally.

Species in this genus are found in nearly all tropical and subtropical seas with a few species reaching warmer temperate waters.

### Subgenus *Atrina* Gray

The external features of the species included in this subgenus are similar to those of the genus as a whole. The characteristic feature of the subgenus is the protrusion of the posterior adductor muscle scar beyond the posterior margin of the nacreous area (Plate 159, figs. 1-4).

There is only one species in this subgenus in the Western Atlantic, *Atrina rigida* Solander.



Plate 164. *Atrina* (*Servatrina*) *seminuda* Lamarck from Bogue Island, North Carolina (about  $\frac{3}{4}$  natural size). A typical specimen showing the smooth ventral slope (fig. 1) and the thin, translucent quality of the shell often evident in this species (fig. 2).

*Atrina (Atrina) rigida* Solander

Plates 158: 159, figs. 1-4

*Pinna rigida* Solander 1786, Catalogue of the Portland Museum, p. 136, species 3040 (no locality given) [refers to Knorr 1771, pl. 26, fig. 1].

*Pinna carolinensis* Hanley 1858, Proceedings Zoological Society London, p. 225 (Carolina Amer. Sept.); Reeve 1848, Conchologia Iconica 11, *Pinna*, pl. 34, fig. 66.

*Description.* Shell large, reaching about 286 mm. (about 11½ inches) in length, wedge-shaped, usually somewhat inflated, thin, fragile and sculptured with spinose radiating ribs. Shell translucent, ranging in color from a purplish brown to nearly black, but all specimens when viewed with transmitted light are a mottled golden to rich red-brown. Surface generally dull, particularly in older specimens. Sculpture variable, ranging from specimens which are nearly smooth to those having numerous ribs. The sculpture on the posterior slope consists of from 6 to 17 ribs which usually bear large, slightly recurved, tubular spines which may reach 15 mm. in length. Young specimens may have only 3 to 4 ribs; the additional ribs are intercalated as the shell grows in size. Sculpture on the ventral slope variable, ranging from rather heavy spines to fine imbrications. Concentric sculpture consisting of irregular lines of growth. Posterior margin irregular, usually rounded but frequently fractured. Dorsal margin usually slightly concave. Ventral margin strongly convex posteriorly and concave anteriorly. Interior of the valves iridescent, somewhat mottled, dark greenish brown to purple-black, usually greenish around the edges. Nacreous layer extending about two thirds the length of the shell. The large nearly circular posterior adductor muscle scar is situated at the posterior end of the nacreous layer, its posterior margin protruding beyond it. The extent of protrusion varies and increases with the age of the shell. Anterior adductor muscle scar small and nearly as wide as the anterior end of the shell.

In living specimens the posterior, thickened margin of the mantle is black with small, irregular white vermiculations; the ventral margin is a gray-white. Inside this thickened margin the mantle is a bright golden orange. It is most intense near the margin, fading to a pale orange at the waste canal. The ctenidia are a medium to pale translucent orange-buff. The pallial organ, even when contracted, has a large conical "head" which is an opaque cream color. The stalk of the pallial organ is a translucent grayish ivory. The foot is cream colored. The sexes are separate and are readily distinguished—the testes being a cream-white and the ovaries a medium magenta.

length	width	
286 mm.	180 mm.	Gulfport, Florida
237	133	Beaufort, North Carolina
235	128	Cayo Francés, Caibarién, Cuba
230	144	Off Pan American Airport, Coconut Grove, Florida
226	158	Alice Town, North Bimini Id., Bahama Islands
215	111	Chadwick Beach, Lemon Bay, Florida
177	97	Santa Barbara de Samaná, Dominican Republic

*Types.* The location of the type specimens of *Pinna rigida* Solander is unknown to us. Solander referred to Knorr 1771, pl. 26, fig. 1, which we here consider the type figure. The type of *Pinna carolinensis* Hanley may be in the British Museum (Natural History), though Wilkins (1953) does not list it. The type locality is here restricted to Beaufort, North Carolina.

*Remarks.* This is a common species in the Florida region. It is close in appearance to *Atrina seminuda* Lamarck with which it has generally been confused. Externally, the two species often cannot be separated, but the relative positions of the muscle scar and the nacreous layer readily differentiate them. In *Atrina rigida* the posterior adductor muscle scar is proportionately larger in relation to the size of the shell. The posterior margin of the muscle scar is continuous with the posterior border of the nacreous area, and in older specimens, protrudes well beyond it (Plate 159, figs. 1-4). In *Atrina seminuda* Lamarck the muscle scar is set within the nacreous area with a border of nacreous material margining it posteriorly (Plate 159, figs. 5-8). Other characters used in separating *rigida* and *seminuda* are often less definite. However, *A. rigida* generally has a heavier shell, which is rounded rather than truncate posteriorly and its dorsal border is often slightly concave rather than straight as in *seminuda*. *Atrina rigida* is usually more spinose, particularly on the ventral slope which is generally smooth in *A. seminuda*. In color, the shell of *A. rigida* is far darker, usually being a purple-black in adult specimens, while in *seminuda* it is mottled tan and purple. If living material is available *rigida* may be readily separated from *seminuda* by the color of the soft parts. The most conspicuous difference is the bright golden-orange mantle coloration of *rigida* while the same area is

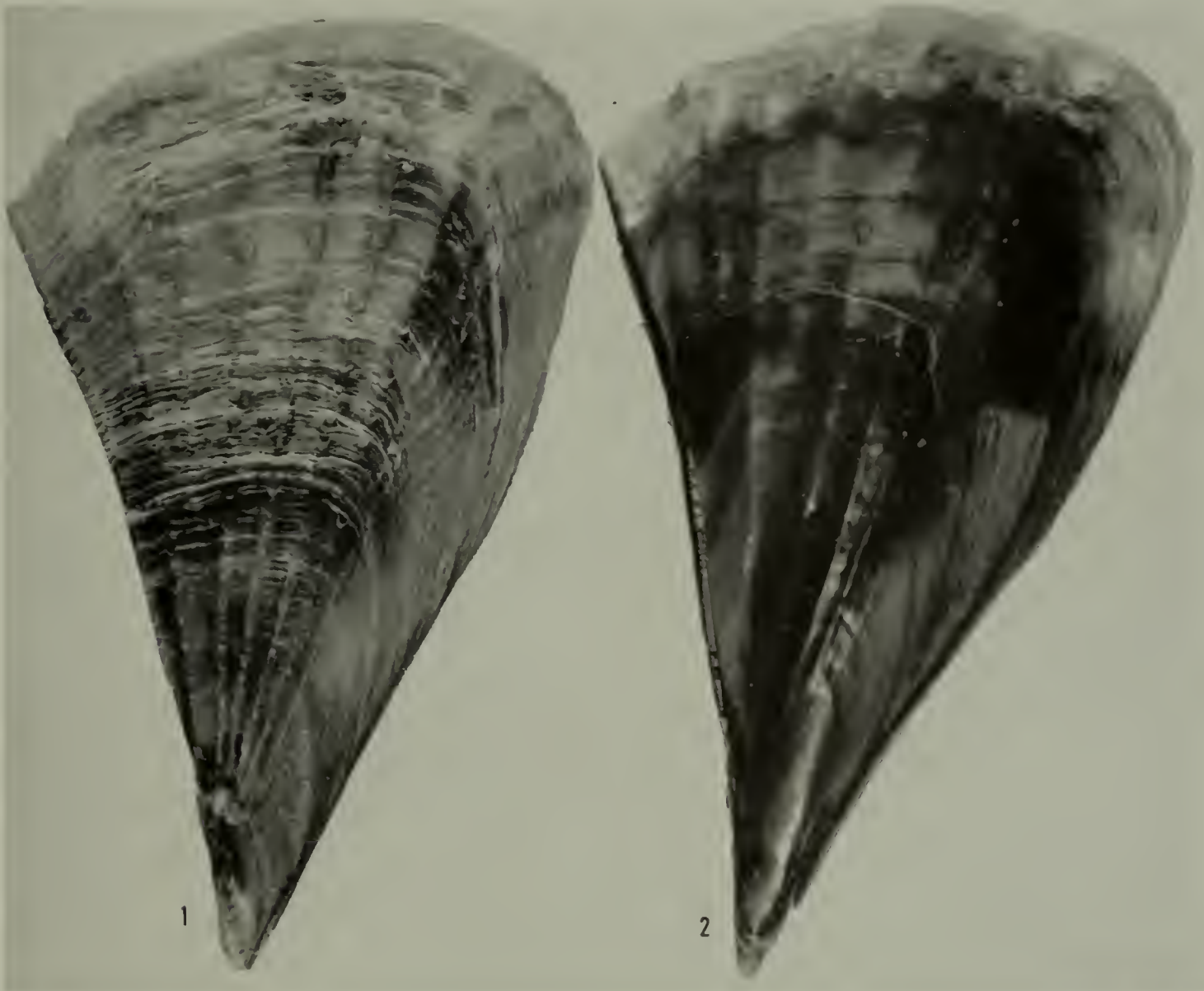


Plate 165. *Atrina (Servatrina) seminuda* Lamarck from Port Isabel, Texas. Fig. 1. Outer surface of a typical specimen from the Texas area showing the nearly smooth, almost spineless valves and the truncate posterior margin. Fig. 2. Inner surface showing the dark color of the shells from this area (both about  $\frac{3}{4}$  natural size).

a pale yellow in *seminuda*. The gills of *rigida* are a pale orange-buff while those of *seminuda* are intense brownish orange. The "head" of the pallial organ of *rigida* is large and conical while that of *seminuda* is small and rounded. See *Remarks* under *A. seminuda* Lamarek.

An account of the anatomy and physiology of *Atrina rigida* is given by Grave (1911). This species is usually found living in sandy mud from the intertidal area to depths of about three to fifteen fathoms. Specimens are very abundant in certain areas and may be a real hazard to fishermen who report that their nets are often badly torn when dragging over a bed of *Atrina*.

*Atrina tuberculosa* Sowerby is the Eastern Pacific analogue of this species, though it is a larger and heavier shell. It is known mainly from the Gulf of California, ranging from Puerto Peñasco, Sonora to La Paz, Baja California, Mexico.

*Range.* From Cape Hatteras, North Carolina, south through the Florida Keys and the west coast of Florida as far north as Panama City; the Bahamas; Cuba and Hispaniola. This species apparently does not occur on the northern Gulf coast, in Texas or in Central America.

*Specimens examined.* NORTH CAROLINA: Buxton, Cape Hatteras (USNM); Beaufort (MCZ; San Diego Mus.); Wilmington (MCZ); Smith Island, Cape Fear (ANSP). FLORIDA: Jacksonville Beach; Daytona Beach; New Smyrna; Cape Canaveral (all MCZ); Lake Worth (G. Kline; MCZ; ANSP; USNM; San Diego Mus.); off Hillsboro Inlet, Pompano (MCZ); Crandon Park, Miami (R. Merrill); Biscayne Bay (ANSP; R. Work); Key Biscayne, Miami (J. K. Howard); Little Pine Key and Grassy Key (both ANSP); Sandy Key, Cape Sable (USNM); off Everglades (MCZ); Cape Romano (ANSP); Bonita Beach, Bonita Springs (MCZ); Punta Rassa (D. and N. Schmidt); Sanibel Island (MCZ; ANSP; J. S. Schwengel; San Diego Mus.); Captiva Island (MCZ; J. S. Schwengel); Boca Grande, Gasparilla Id. (ANSP); Chadwick Beach, Lemon Bay (MCZ); Long Key, off Sarasota (MCZ; USNM); Mullet Key, Tampa Bay; Boca Ciega Bay, St. Petersburg (both ANSP); St. Petersburg (USNM; San Diego Mus.); off Tampa Bay in 3-4 fathoms (H. Bullis); Gulfport (MCZ); Cedar Keys (USNM; CAS; SDM); near Sea Horse Key, Cedar Keys (MCZ; ANSP); St. Joseph Bay (ANSP); Panama City (USNM). BAHAMA ISLANDS: Rocky Point, East Bimini (R. Robertson); Alice Town, North Bimini Id. (MCZ). CUBA: Cayo Francés, Caibarién, Las Villas; Fish Point, Guantánamo Bay (both MCZ); Cayo Galindo, Cárdenas, Matanzas (ANSP). HISPANIOLA: Santa Barbara de Samaná, Dominican Republic (MCZ).

### Subgenus *Servatrina* Iredale

*Servatrina* Iredale 1939. Great Barrier Reef Expedition, Scientific Reports 5, no. 6, p. 317.

Type species, *Pinna assimilis* Reeve, by original designation.

Externally the shells are similar to those of other *Atrina*. The characteristic feature of the subgenus is found on the inner surface of the valves. The large posterior adductor muscle scar is enclosed completely within the nacreous area rather than protruding beyond it as in *Atrina* s.s.

The subgenus is world-wide in distribution in the warmer temperate and tropical seas.

***Atrina (Servatrina) seminuda* Lamarck**

Plates 150, figs. 5-6; 159, figs. 5-8; 160-169

*Pinna semi-nuda* Lamarck 1819, Animaux sans Vertèbres 6, pt. 1, p. 131 (les Mers d'Amérique); Lamy 1932, Bull. Muséum National d'Histoire Naturelle (2) 4, p. 896 (Brasil); non *P. seminuda* Bowdich 1825; non *seminuda* 'Lamarck' Reeve 1858.

*Pinna alta* Sowerby 1835, Proceedings Zoological Society London, p. 84 (Sinu Honduras); Reeve 1858, Conchologia Iconica 11, Pinna, pl. 6, fig. 11.

*Pinna listeri* d'Orbigny 1846, Voyage l'Amérique Méridionale 5, pt. 3, Mollusques, p. 641, pl. 85, fig. 1 (côtes du Brésil); Carcelles 1944, Revista del Museo de la Plata (n.s.) Zoologia 3, p. 278, pl. 10, fig. 77.

*Pinna patagonica* d'Orbigny 1846, Voyage l'Amérique Méridionale 5, pt. 3, Mollusques, p. 641, pl. 85, fig. 2 (l'embouchure du Rio Negro, Patagonie); Carcelles 1944, Revista del Museo de la Plata (n.s.) Zoologia 3, p. 278, pl. 10, fig. 78.

*Pinna subviridis* Reeve 1858, Conchologia Iconica 11, Pinna, pl. 17, fig. 32 (South Carolina).

*Pinna ramulosa* Reeve 1858, Conchologia Iconica 11, Pinna, pl. 28, fig. 52 (West Indies).

*Pinna d'orbignyi* 'Hanley' Reeve, Aug. 1858, Conchologia Iconica 11, Pinna, pl. 26, fig. 49 (West Indies); Hanley, Jan. [Nov.] 1858, Proceedings Zoological Society London, p. 228.

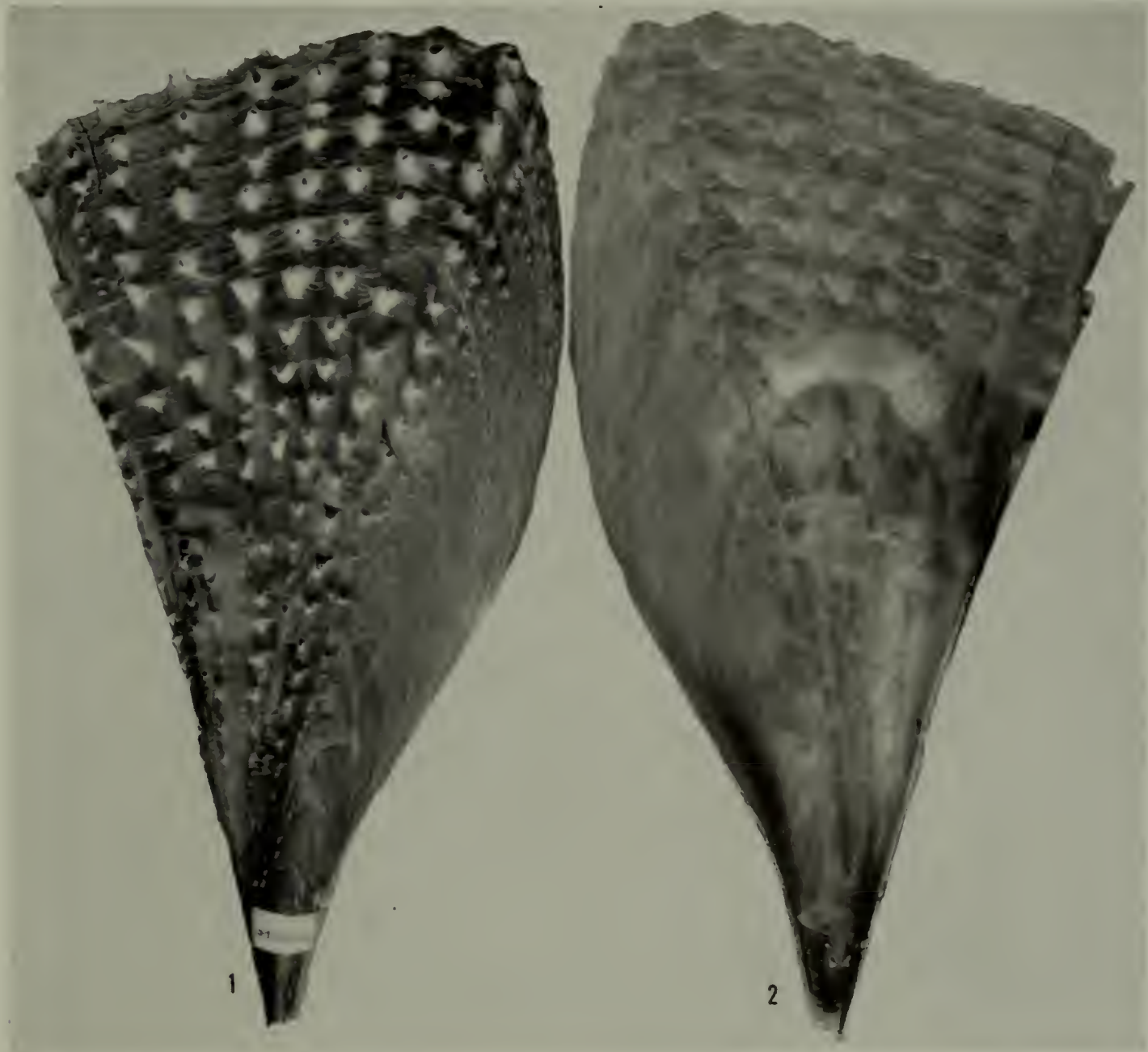


Plate 166. Holotype of *Pinna ramulosa* Reeve [= *Atrina seminuda* Lamarck] from the West Indies (about  $\frac{3}{4}$  natural size). Photograph courtesy of the British Museum (Natural History).

*Description.* Shell reaching 243 mm. (about  $9\frac{5}{8}$  inches) in length, wedge-shaped, usually somewhat inflated, thin, fragile and sculptured with spinose radiating ribs, but with the ventral slope usually smooth. Shell translucent, ranging in color from a uniform grayish tan to a mottled tan and purple or purple-brown, particularly when viewed with transmitted light. Surface usually somewhat glistening, particularly in young specimens. Sculpture variable, ranging from specimens which are smooth or nearly so to those having numerous, spinose, radiating ribs. The sculpture on the posterior slope consists of from 5 to 16 radiating ribs which may be smooth or armed with spines. These spines are usually tubular and slightly recurved, though on occasional specimens they appear as coarse, upright flutes. Sculpture on the ventral slope usually consisting of fine growth lines and indistinct radiating ribs, with occasional specimens having small spines near the posterior margin. Concentric sculpture consisting of irregular growth lines. Posterior margin irregular, usually somewhat truncated with a distinct angle at the union of the ventral slope and the posterior slope. Dorsal margin slightly concave. Ventral margin convex posteriorly and only slightly concave anteriorly. Interior of valves iridescent, ranging in color from a nearly uniform tan to a mottled tan and purple-brown. Nacreous layer extending about one half to two thirds the length of the shell. Posterior adductor muscle scar small in relation to the size of the shell, oval in outline and usually lying well within the nacreous area. In occasional specimens there is only a very narrow border of nacreous material edging the muscle scar posteriorly, but the muscle scar never protrudes beyond the nacreous area. Anterior adductor muscle scar small and nearly as wide as the anterior end of the shell. Embryonic valves subcircular, inflated, the umbos prominent and directed slightly posteriorly (Plate 150, figs. 5-6).

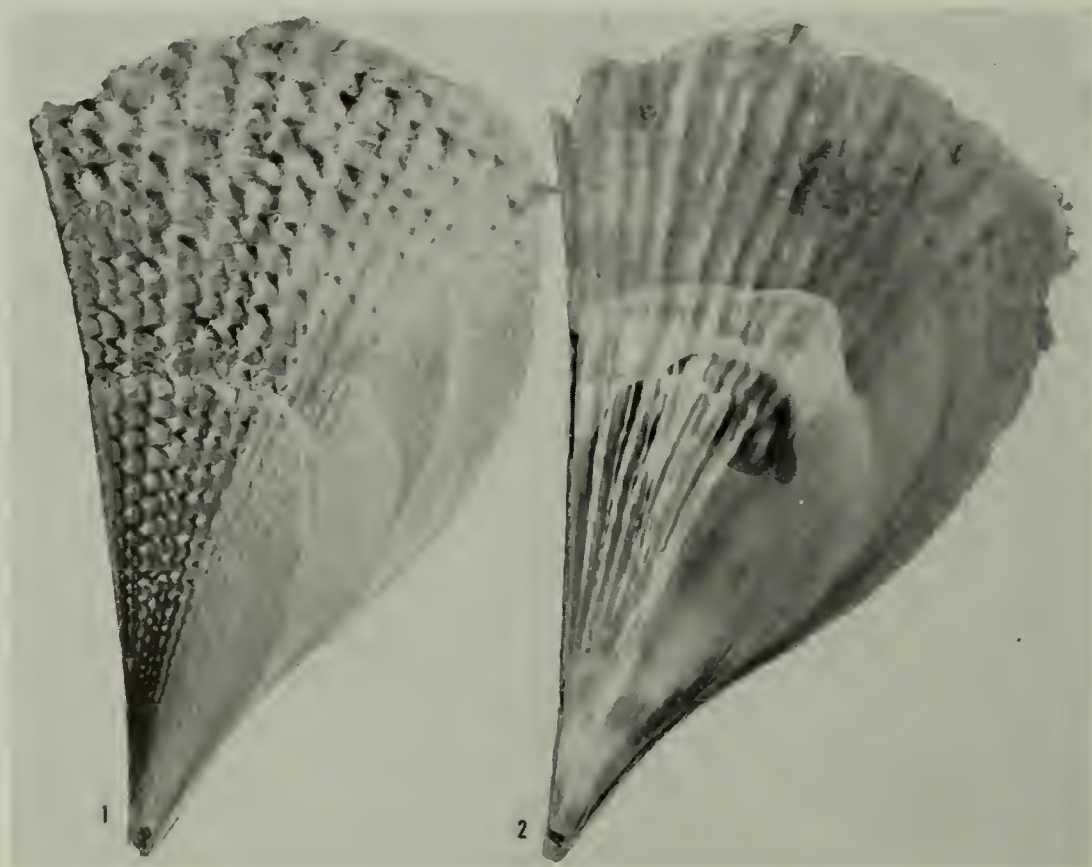


Plate 167. *Atrina (Servatrina) seminuda* Lamarck from Kingston, Jamaica. A specimen typical of this species in the West Indies, showing a slight broadening of the valves posteriorly and an increase in the number of radiating ribs and spines (about  $\frac{1}{3}$  natural size).

In living specimens the posterior and thickened margin of the mantle is black with reddish markings. Inside the margin the mantle is pale yellow, the color being most intense near the thickened margin, fading to white at the waste canal. The ctenidia are an intense brownish orange and very conspicuous. The pallial organ, when contracted, has a small rounded "head" which is a light salmon in color. The stalk of the pallial organ is a translucent white. The foot is light yellow. The sexes are separate—the ovaries are a bright pink-orange. A male specimen was not seen.

length	width	
243 mm.	125 mm.	Charleston, South Carolina
177	90	Aransas Bay, Texas
169	112	Kingston, Jamaica
151	92	West Trinidad
151	87	Gulfport, Florida
140	67	Tuxpan, Veraacruz, Mexico
125	52	Itanhaem, Estado de São Paulo, Brasil

*Types.* The holotype of *Pinna seminuda* Lamarck is in the Muséum d'Histoire Naturelle, Paris. The type locality is Brasil according to Lamy (1932, p. 396). Through the kindness of J. Gaillard of the Paris Museum we are able to figure the holotype (Plate 160). The type locality is here restricted to Rio de Janeiro, Brasil.

The holotypes of the following species are all in the British Museum (Natural History): *P. listeri* d'Orbigny from Brasil, no. 1854.12.4.814; *P. alta* Sowerby from the Bay of Honduras, no. 1952.8.29.1; *P. ramulosa* Reeve from the West Indies, no. 1952.8.29.45; *P. subviridis* Reeve from South Carolina, no. 1952.8.29.62; and *P. d'orbignyi* Reeve



Plate 168. Paratype of *Pinna alta* Sowerby [= *Atrina seminuda* Lamarck] from the Bay of Honduras (about  $\frac{1}{2}$  natural size). An unusually broad form. Photograph courtesy of the British Museum (Natural History).

from the West Indies, no. 1952.8.29.15. Through the kindness of I. C. J. Galbraith of the Mollusca Section of the British Museum (Natural History) we are able to figure all of the above type specimens.

*Remarks.* *Atrina seminuda* Lamarck is a very variable species which has generally been considered a synonym of *A. rigida* Solander. However, on the basis of its muscle scars and the extent of the nacreous layer, it belongs in the same subgenus as *A. serrata* Sowerby. See *Remarks* under *A. serrata*. Externally, *A. seminuda* is often difficult to distinguish from *A. rigida*, and for this reason has long been confused with that species. There is no single, external character which will separate these two species for the range in variation of each overlaps with that of the other. In general, *seminuda* is lighter in color and less strongly sculptured, the ventral slope is usually devoid of spines and the valves are usually truncate posteriorly. The tremendous range of variation in the sculpture of *seminuda* appears to be largely a reflection of ecologic conditions. However, on the basis of the material which we have studied, there does seem to be an increase in the number of ribs and the size of the spines on specimens from near the center of the range. Specimens from Brasil and North Carolina are quite similar in appearance, while those from the West Indies are usually more spinose. Specimens from the Texas coast are generally darker in color, smoother, often being completely spineless, and more truncate than those from elsewhere in the range. The relationship of the width to the length of the shell in this species is also extremely variable, as is shown by the measurements and illustrations. *Atrina alta* Sowerby is an example of an unusually broad and spinose form while *d'orbignyi* Reeve is a young, elongate and spinose form. Wilkins (1953) believed the type locality of *d'orbignyi* Reeve to be in error and placed this species in the synonymy of *squamifera* Sowerby from South Africa. However, there are in the Museum of Comparative Zoölogy several specimens from the West Indian region which approximate the figure of the type specimen very closely (Plate 169). We therefore consider *d'orbignyi* Reeve to be a synonym of *seminuda*. The most dependable character to use in distinguishing *seminuda* from *rigida* is that of the position, size and relationship of the muscle scar and the nacreous layer. In Plate 159 we have indicated the change in position of the muscle scar with the growth of the shell for these two species. Young specimens and those which have grown rapidly are sometimes difficult to distinguish. In some fairly large specimens of *seminuda* the muscle scar is only slightly inset in the nacreous area while in some equally large but rapidly grown specimens of *rigida* the muscle scar has not protruded. However, in these cases, other characters, such as the general outline of the nacreous area, the shape of the shell and the lack of sculpture on the ventral slope aid in determining the species. The muscle scar of *seminuda* never protrudes beyond the nacreous area and it is usually much smaller in proportion to the size of the shell than that of *rigida*. If a series of specimens from a given locality is available there is no difficulty in determining the species and when working with animals that are so readily affected by their environment, as are all species of *Atrina*, large series are essential. When living material is available *seminuda* is readily differentiated by the coloration of the soft parts. See *Remarks* under *rigida*.

*Atrina maura* Sowerby is the Eastern Pacific analogue of this species. It is the most common species in the Eastern Pacific, ranging from Bahía Magdalena, Baja California, Mexico, south to Peru. This species is commonly eaten by the Mexicans.

*Range.* We are unable to account for the absence of *A. seminuda* in southern Florida, the Florida Keys and the Bahama Islands. Except for these areas, its range compares with that of *Laevicardium laevigatum* Linné, *Trachycardium muricatum* Linné and *Macrocallista maculata* Linné all of which extend from North Carolina to southern Brasil or Argentina.

*Specimens examined.* NORTH CAROLINA: Cape Lookout (USNM); Beaufort (ANSP: USNM); Bogue Id. (MCZ); Long Beach near Southport (USNM); Smith Id., Cape Fear (ANSP). SOUTH CAROLINA: 4 miles SW of Myrtle Beach (ANSP); Isle of Palms (MCZ); Sullivans Id. (CAS: MCZ); Charleston (MCZ). GEORGIA: Sea Id. Beach (ANSP); St. Simons Id. (USNM); Cumberland Id. (MCZ). FLORIDA: Amelia Id. (ANSP: USNM); St. Augustine (USNM); Anastasia Id., St. Augustine; Daytona Beach; Lake Worth (all ANSP); Coronado Beach (MCZ); Fort Myers Beach (ANSP); Sanibel Id. (J. S. Schwengel; ANSP); Captiva Id., and Indian Beach, Sarasota (both MCZ); St. Petersburg (USNM); Pass-a-grille, Pinellas Co. (MCZ); Clearwater Bay, Pinellas Co. (ANSP); Gulfport (SDM; MCZ); Panama City (USNM). ALABAMA: Dauphin Island (J. Foshee). LOUISIANA: American Bay, St. Bernard Parish (R. Parker); Grand Isle (MCZ); Freemason Id., Chandeleur Islands (D. Moore). TEXAS: Galveston



Plate 169. Holotype of *Pinna d'orbignyi* Reeve [= *Atrina seminuda* Lamarck] from the West Indies (natural size). Fig. 1. A young specimen which was probably growing in quiet water allowing unusual development of the spines. Fig. 2. Inner surface of the opposite valve which, though somewhat overgrown with Bryozoa, does show the muscle scar and nacreous layer. Photographs courtesy of the British Museum (Natural History).

(T. E. Pulley: USNM): San Luis Pass, Galveston (T. E. Pulley); Matagorda Bay (SDM: CAS: USNM); Indianola (USNM); Aransas Bay (J. L. Baughman; SIO; USNM); Port Isabel (E. Weisenhaus; R. Parker); Brownsville (MCZ); 60 miles S of Brownsville in 12-14 fathoms (C. L. Branch). CUBA: Varadero Beach, Matanzas (USNM). JAMAICA: Kingston (MCZ; ANSP; USNM); Rock Fort and Port Royal (USNM). HISPANIOLA: Port au Prince, Dépt. de l'Ouest; Les Cayes and Torbeck, Dépt. du Sud, all Haiti (all USNM). PUERTO RICO: Bahía de Añasco (MCZ); Punta Algorrobo and Punta Guanajibo (both G. Warmke); Mayagüez (MCZ; G. Warmke). VIRGIN ISLANDS: St. Thomas (MCZ; ANSP; USNM; SDM); Gorda Sound, Virgin Gorda (R. Foster). LESSER ANTILLES: off Fort George, Scarborough, Tobago in 36 fathoms (R. Foster); Pointe à Pierre; La Brea; and Erin, all Trinidad (all MCZ); Port of Spain, Trinidad (ANSP). CARIBBEAN ISLANDS: Curaçao (USNM). MEXICO: Tuxpan, Veracruz (T. E. Pulley); Veracruz, Veracruz (ANSP). COLOMBIA: Cartagena (CAS; USNM); Puerto Colombia (USNM). VENEZUELA: Barcelona (USNM); Campano, Estado Suerre (ANSP). BRASIL: Rio de Janeiro (MCZ; ANSP); Praia Grande, Itanhaem, Estado de São Paulo (M. J. Oliveira); Peruhybe, Itanhaem, Estado de São Paulo (H. S. Lopes). URUGUAY: Cape Polonia, Dept. Rocha (USNM). ARGENTINA: Río Negro, Patagonia (USNM).

### *Atrina (Servatrina) serrata* Sowerby

Plates 170: 171

*Pinna serrata* Solander 1786, Catalogue of the Portland Museum, pp. 71, 165 [nomen nudum].

*Pinna serrata* Sowerby Feb. 1825, Catalogue of Shells of Earl of Tankerville, London, p. 23, appendix, p. v; 'Solander' Sowerby Nov. 1825, The Genera of Recent and Fossil Shells, Liv. 26, **Pinna**, (no locality given); Reeve 1841, Conchologia Systematica 1, pl. 103; Reeve 1859, Conchologia Iconica 11, **Pinna**, pl. 34, fig. 65 (West Indies).

*Pinna squamosissima* Philippi 1849 [in] Roemer, Texas, Bonn, p. 454 (near Galveston, Texas).

*Pinna seminuda* 'Lamarck' Reeve 1858, Conchologia Iconica 11, **Pinna**, pl. 2, fig. 2 (South Carolina); non *Pinna seminuda* Lamarck 1819.

*Pinna muricata* 'Linné' Holmes 1860, Post Pleiocene Fossils of South Carolina, Charleston, S.C., p. 15, pl. 3, fig. 3 (Simmons'; Abbapoola [Abbapoola Creek, Johns Id.], both near Charleston, South Carolina); non *Pinna muricata* Linné 1758.

*Description.* Shell reaching 295 mm. (about 11½ inches) in length, wedge-shaped, inflated, thin, fragile and sculptured with numerous imbricate, radiating ribs. Shell translucent, ranging in color from a light tan to a medium greenish brown. Surface, between the rows of spines, somewhat glistening. Sculpture remarkably uniform for this genus. On the posterior slope it consists of about 30 inconspicuous ribs which are indicated mainly by the imbrications arming them. Sculpture on the ventral slope consisting of concentric growth lines and fine imbrications. Posterior margin usually truncate with a distinct angle at the union of the posterior and ventral slope. Dorsal margin straight to slightly concave. Ventral margin convex posteriorly and concave anteriorly. Interior of the valves iridescent, light tan to greenish brown in color. Nacreous layer thin and usually extending over three fourths the length of the valve. Posterior adductor muscle scar nearly circular in outline and set well within the nacreous layer. Anterior adductor muscle scar small, nearly as wide as the anterior end of the valve.

length	width	
295 mm.	167 mm.	Sanibel, Florida
245	136	Shackelford Id., North Carolina
227	112	12 miles S of St. Augustine, Florida
180	86	Port Isabel, Texas

*Types.* The holotype of *Pinna serrata* Sowerby is in the British Museum (Natural History), no. B3054 from the Tankerville Collection. The type locality is here designated as Charleston, South Carolina, a locality from which a great deal of material was sent to Europe at that time. We are grateful to I.C.J. Galbraith of the British Museum for the figure of the holotype (Plate 170). The location of the type of *Pinna squamosissima* Philippi is unknown to us. The type of *Pinna seminuda* 'Lamarck' Reeve is in the British Museum and that of *P. muricata* Holmes is in the Charleston Museum, Charleston, South Carolina.

*Remarks.* *Atrina serrata* is close in its relationship to *A. seminuda* Lamarck; however, it may be readily distinguished by its thinner shell, more numerous, crowded ribs, and low imbricate spines. In *A. seminuda* the spines are usually tubular and slightly recurved. The posterior adductor muscle scar of *seminuda* is usually smaller, proportionately, than that of *serrata* and the nacreous layer of *seminuda* extends only about one half to two



Plate 170. *Atrina (Serratrina) serrata* Sowerby. Holotype of *Pinna serrata* Sowerby [= *Atrina serrata* Sowerby]. A small, fragile specimen showing the row of spines on the dorsal margin typical of young specimens (natural size). Photograph courtesy of the British Museum (Natural History).

thirds the length of the valve, while that of *serrata* extends at least three fourths the length of the valve. In addition, *A. serrata* is a far more inflated species: a specimen 240 mm. (about  $9\frac{1}{2}$  inches) in length had a thickness of 57 mm. ( $2\frac{1}{4}$  inches), compared with a specimen of *A. seminuda* of the same length which is only 41 mm. ( $1\frac{5}{8}$  inches) thick when measuring the distance through the apposed valves in the vicinity of the posterior adductor muscle.

*Range.* From Hatteras Inlet, North Carolina, south through the Florida Keys and in the Gulf of Mexico to Texas and south to Colombia. It is apparently rare in the West Indies, having been recorded only from Cuba, Puerto Rico and Trinidad. The paucity of records in Central America is probably due to lack of collecting.

*Specimens examined.* NORTH CAROLINA: Point Buxton, Cape Hatteras (USNM); Hatteras Island, Hatteras Inlet (J. K. Howard); Shackleford Island (MCZ); Fort Macon, Beaufort (USNM); Bogue Island (MCZ); Cape Fear (ANSP). SOUTH CARO-

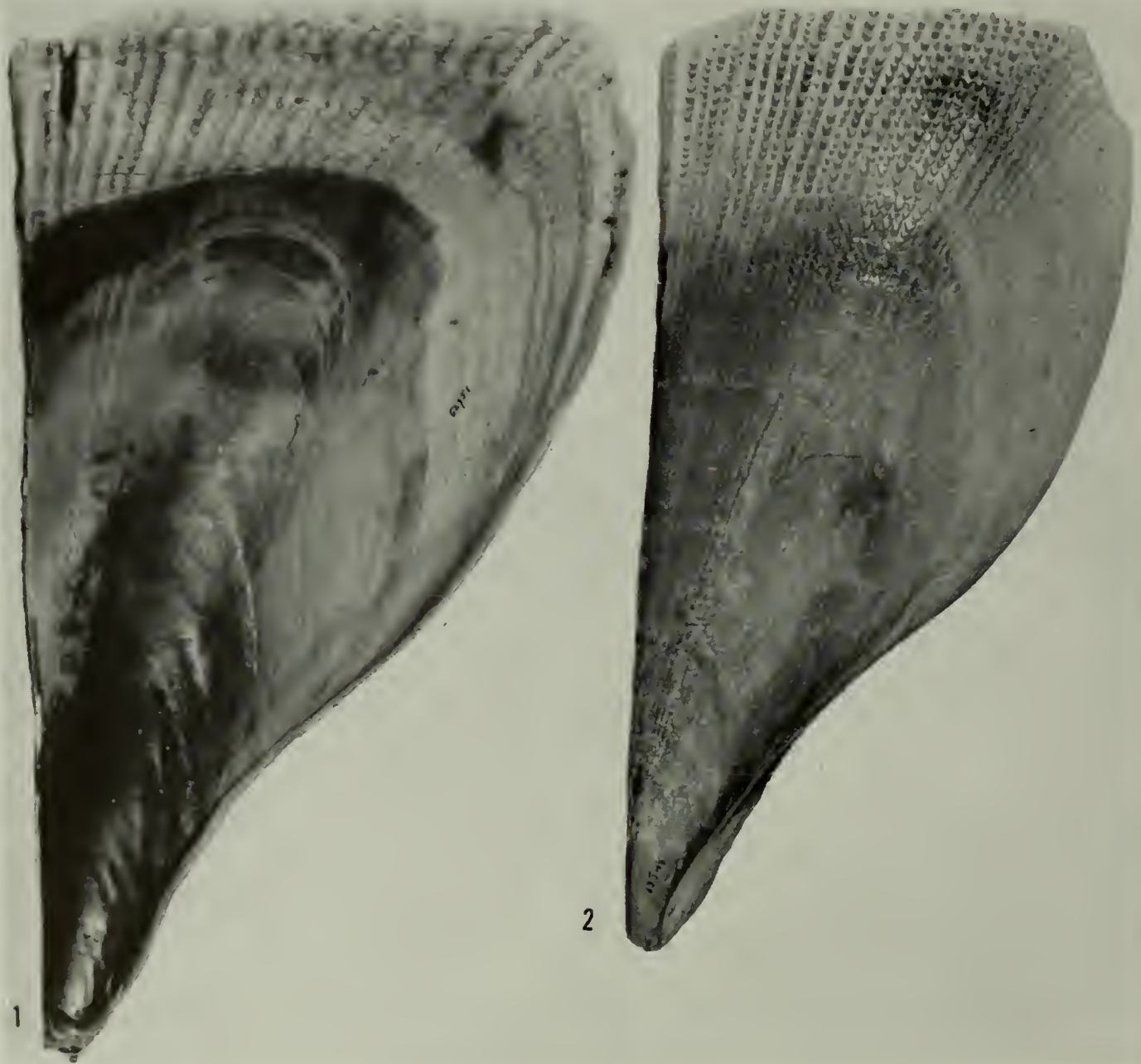


Plate 171. *Atrina (Servatrina) serrata* Sowerby. Fig. 1. From Mitchell's Beach, Gulfport, Florida. Inner view of valve to show the extent of the nacreous layer and the position of the muscle scar. Fig. 2. From Sanibel Island, Florida. External view of the valve showing the numerous fine, radiating ribs (both about  $\frac{1}{2}$  natural size).

LINA: Myrtle Beach (ANSP); Isle of Palms (E. B. Richardson); Charleston (MCZ: USNM); Ashe Island, mouth of Edisto River (ANSP). GEORGIA: Sea Island, Glynn Co. (MCZ: ANSP); St. Simons Island (ANSP: USNM); South Beach, Brunswick (ANSP). FLORIDA: Fernandina (ANSP); Amelia Island (MCZ: ANSP: USNM); Pablo Beach, near St. John River (MCZ: ANSP); Atlantic Beach, near Jacksonville (MCZ); South Beach, Anastasia Island, St. Augustine (ANSP); 12 miles S of St. Augustine (MCZ); 7 miles S of Matanzas River, St. Johns Co. (ANSP); Ormond Beach; Coronado Beach; New Smyrna; Cape Canaveral; off Beacon D, The Elbow, Key Largo in 50 and 100 fathoms; 5 miles SE of Sombrero Light, Marathon, Key Vaca (all MCZ); Cape Romano; Fort Meyers Beach (both ANSP); Sanibel Island (ANSP: MCZ: USNM; SDM; J. Schwengel; G. Kline); Captiva Island (J. Schwengel); Boca Grande, Gasparilla Island (ANSP); Long Key, off Sarasota (MCZ); Anna Maria Key, Sarasota Bay (USNM); Mullet Key, Tampa Bay (ANSP); Pass-a-Grille (CAS); Mitchell's Beach, Gulfport (MCZ); Clearwater Bay (ANSP); Cedar Keys (SDM); St. Joseph's Bay, Calhoun Co. (ANSP); Port St. Joe (MCZ: USNM); Panama City (USNM); Pensacola (SDM). MISSISSIPPI: Horn Island (D. Moore). LOUISIANA: Breton Island (R. Parker); Mississippi Delta (K. Johnstone). TEXAS: Galveston (T. E. Pulley); Matagorda Bay (CAS: USNM); Port Aransas (MCZ: ANSP); Padre Island, near Port Isabel (R. Parker); Port Isabel (E. Weisenhaus). MEXICO: Tuxpan, Veracruz (T. Pulley). COLOMBIA: Cartagena (CAS). PUERTO RICO: Punta Guanajibo, 4 miles S of Mayagüez (G. Warmke). CUBA: Varadero Beach, Matanzas (ANSP). LESSER ANTILLES: off Fort George, Scarborough, Tobago in 36 fathoms (MCZ). Near Erin River, Trinidad (H. G. Kugler).

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## The Works of Georgius Everhardus Rumphius 1626 - 1693

The work of Rumphius though published in 1705, some fifty-three years prior to the appearance of the tenth edition of Linné's *Systema Naturae*, is of great importance to all malacologists because of the many references which Linné made to it. At the time Linné wrote the tenth edition of the *Systema Naturae* in 1758, the starting point of our binomial system of nomenclature, he did not have in his collection a number of the species which he named in his book. In addition, the *Systema Naturae* was not illustrated and consequently, to aid in the understanding of his species, Linné referred to one or several illustrations in other works. One of those most quoted by Linné was that of Rumphius, *D'Amboinsche Rariteitkamer*, referred to by Linné as "*Rumph. mus.*" Consequently, in many cases the figures in Rumphius have been selected by subsequent authors as the "type figures" of Linné's species.

Rumphius, or Georg Eberhard Rumpf as his name was known in Dutch, was born in Hanau, a small town in Hesse, Germany in 1626 and apparently moved to Holland. According to Bickmore, Rumphius "having studied medicine, at the age of twenty-eight went to Bavaria, entered the merchantile service of the Dutch East India Company,

and thence proceeded to Amboina, where he passed the remainder of his life. At the age of forty-two, while contemplating a voyage back to his native land, he suddenly became blind and therefore never left his adopted island home; yet he continued to prosecute his favorite studies in natural history till his death, which occurred in 1693, when he had attained the ripe age of sixty-seven." According to Swainson, he was at one time governor of Amboina.

The first edition of his great work on the shells of Amboina "D'Amboinsche Rariteitkamer" or Amboina Curiosities was published in folio edition at Amsterdam in 1705, twelve years after his death, and for many years it was the standard work on the mollusks of this area. Another edition, also in Dutch appeared in 1741 using the same plates. It is this edition that is most commonly seen today. This edition is divided into three parts or books, the first including pages 1-54 and plates 1-16 covered the crustaceans and echinoderms, the second including pages 55-194 and plates 17-49 dealt with the marine mollusks of Amboina and the third, covering pages 195-340 and plates 50-60 described the minerals, stones and artifacts. The illustrations are for the most part good for the time though many of the shells are reversed as some of the illustrations were apparently cut directly on wood blocks and not from a mirror image, a practice which later became universal with all engravers. To make such reversed specimens look natural one should look at them in a mirror.

A German edition of this work entitled "Amboin Raitäten-Kammer" which was translated by Müller and emended by Chemnitz was published in Wien in 1766. In this edition a number of the plates and much of the text were changed. It cannot, therefore, be used in conjunction with Linné's work.

The "Thesaurus Imaginum Piscium Testaceorum, etc." by Rumphius was published in 1711. This book was a folio edition containing 60 plates, the same used in the "D'Amboinsche Rariteitkamer" but the text was reduced to the plate captions and an index.

According to Bickmore, when Holland became a province of France in 1811, attempts were made to make Paris the center of science and literature in Europe and the Rumphius collection was taken from Leyden to Paris. Though it was later returned, much damage had been done to the collection during the two transfers and a large portion of the specimens had disappeared. Louis Agassiz apparently knew of this loss and realized that an understanding of many of Linné's species depended upon a knowledge of the specimens which Rumphius had figured in his great work. Consequently, in 1865 he sent Albert S. Bickmore, one of his students, to Amboina for the express purpose of duplicating the Rumphius Collection. Much of this material is now in the Museum of Comparative Zoölogy.

Rumphius also wrote extensively on the botany of Amboina and he is generally credited with having laid the foundations of botanical and zoological research in the East Indies. During his trip to Amboina, Bickmore located the grave of Rumphius which was marked by a small square pillar erected in 1824 by G. A. Phillipus, the royal governor to replace the original marker which had been destroyed.

Bickmore, Albert S. 1869. Travels in the East Indian Archipelago. D. Appleton and Company, New York, 553 pages, 36 plates.

—RUTH D. TURNER

### *Book Review*

Olsson, A. A., A. Harbison, W. G. Fargo and H. A. Pilsbry 1953. Pliocene Mollusca of Southern Florida with special reference to those from North Saint Petersburg. The Academy of Natural Sciences Philadelphia: Monographs—Number 8, pp. viii+1-457; 65 plates; 2 text figs.; 2 maps. From the time of its discovery in 1938 by A. P. Cales, the Pliocene fossil bed of North Saint Petersburg has been well explored and collected. The site represents the farthest known northwest extension of the Caloosahatchee formation of southern Florida which is well known as a result of the work of Dall in 1890 to 1903. This recent publication is a study of the mollusks, predominantly marine, which have been collected at the St. Petersburg site. Several authors have reported on the material: Part I, by Olsson and Harbison, is a systematic consideration of the Classes Palecypoda, Scaphopoda and Gastropoda; Part II, on the gastropod family Turridae, was done by Fargo who also gave a summary of the geology of the Saint Petersburg region which is included in the general introduction; Parts III-A and III-B, by H. A. Pilsbry are devoted, respectively, to studies of the gastropod family Vitrinellidae, and the freshwater gastropods and pelecypods.

As noted by Fargo in the introduction to the study, the Pliocene shells of Saint Petersburg were readily distinguished from Recent or Pleistocene specimens in the area because of their distinctive buff or pale reddish color. For this reason placement in geologic time was more certain than it may be in other areas. Mollusks of the Pliocene which also extend into the Recent were found to comprise 32.49% of the species studied from this site. It was pointed out in the introduction that one difficulty in a study of this type is the determination of the actual number of fossil species which extend into the Recent. This is particularly difficult because of the lack of a complete census of the living mollusk fauna of the West Indian and Gulf areas.

The authors have named 10 new genera, 30 subgenera and 1 new section of mollusks. Of the 517 species and subspecies treated in this report, 137 were described as new. This systematic study will be found extremely useful by malacologists interested in either fossil or recent mollusks of the Florida area.

The Pyramidellidae from the Saint Petersburg collection were sent to the U. S. National Museum and were treated by Dr. Paul Bartsch in his 1955 publication: "The Pyramidellid Mollusks of the Pliocene Deposits of North St. Petersburg, Florida"; Smithsonian Miscellaneous Collections 125, no. 2, pp. 1-102, 18 plates.

—JOSEPH ROSEWATER