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THE FAMILY PHOLADIDAE IN THE WESTERN ATLANTIC AND THE EASTERN PACIFIC
PART I—PHOLADINAE

BY
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The Pholadidae are a family of highly specialized bivalve mollusks adapted for boring into wood, soft rock, shells, peat, hard clay and mud. They are characterized by having accessory plates in addition to the normal bivalve shell, and for this reason were early classified with the barnacles and the chitons in the Multivalva.

Economic Importance

As has been pointed out previously (Clench and Turner, 1946), the financial loss due to damage caused by wood-boring mollusks probably exceeds by far the amount realized from the use of mollusks for food and all other purposes. Though the entire family Teredinidae is exceedingly destructive, only a few genera of the Pholadidae are of importance in this respect.

Martesia is the most destructive genus in the family as all species in the genus are wood-borers and all may do considerable damage to water front structures. *Martesia striata* Linné is the best known and most destructive species and in some localities such as Cavite, Luzon, Philippine Islands, it may be even more destructive than the Teredinidae. This

Plate 1. *Zirfaea crispata* Linné, Rye Harbor, New Hampshire (about 2x). Photographed in a test tube under water to show the extended siphons; the external anterior adductor muscle, which is covered only by a thin layer of periostracum; the small mesoplax and the expanded foot.

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species has been carried nearly all over the world by man and has recently been introduced into Sydney Harbor, Australia where it is doing considerable damage. It is also a problem in San Juan, Puerto Rico and Pearl Harbor, Honolulu.

Species in the genera *Xylophaga* and *Martesia*, though generally wood-borers, have been known to attack underwater cables causing short circuits (Bartsch and Rehder, 1945 and Purchon, 1941). Species in the genus *Xylophaga* are usually found in floating or waterlogged wood. They seldom occur in fixed structures, but an occasional attack may cause considerable damage. They may also be found in considerable numbers in buoy markers and lobster pot floats.

Of the rock-borers, only *Penitella penita* Conrad has been recorded as definitely destructive. At the time of the San Francisco Bay Marine Piling Investigation, it was found that this species had penetrated the concrete jackets of the piling in several localities about Los Angeles, California. They were boring from a height of two feet above mean low water down to the mudline. It was found, however, that they occurred in numbers only in inferior grades of cement.

Diplothyra smithii Tryon and *Penitella conradi* Valenciennes are both shell-borers, the former going chiefly into *Ostrea* and the latter into *Haliotis*. Neither appears to do any real harm to its host, though heavily infested shells of *Haliotis* are, of course, useless in the jewelry trade.

Most species of the Pholadidae are not of any real economic importance, except perhaps as their borings may aid in minor changes of the coast line and in the reduction of wood in the sea. A few species are used as food occasionally though none is of commercial value. Most species are too difficult to remove from their burrows and too full of sand to make them worth the effort. *Pholas dactylus* Linné was used for food by the early Romans and according to Jeffreys (1865) it was used both for food and fish bait in Normandy and Dieppe. *Cyrtopleura costata* Linné was at one time sold in the markets in Habana, Cuba but it is too rare to be of commercial value today. Mr. E. P. Chace of California writes that the "wart-necked piddock" makes an excellent chowder—one specimen being sufficient for two people—but the work of digging out the specimen is considerable.

Notes on Ecology and Distribution

The family Pholadidae is world wide in distribution with most species occurring from the intertidal zone to a depth of perhaps 250 fathoms. Much greater depths have been recorded for some species but it is uncertain whether these specimens were taken dead or alive. A few species appear to be restricted mainly to floating wood and may be considered pelagic. The family as a whole is restricted locally by the specialized habitat required for each group. Species in the genus *Zirfaea* prefer salt marsh peat and stiff mud, while *Penitella* and *Parapholas* bore into much harder shales and sandstones and *Pholas dactylus* Linné may attack gneiss. *Martesia* and *Xylophaga*, as borers, are restricted mainly to wood.

The greatest development of the family appears to be in the Eastern Pacific which has 13 genera including 23 species, while in the Western Atlantic there are only 8 genera with 13 species. There are seldom more than two or three species per genus in a given region and often there is only one. For the genera, *Zirfaea*, *Barnea* and *Pholas*, there are companion species in the Western Atlantic and the Eastern Pacific and it would appear that in the geologic past they were probably one species. The genera *Penitella*, *Parapholas*, *Pholadidea* and *Chaceia*[1] are not found living in the Western Atlantic so far as is known, but an internal cast of an Eocene (?) fossil taken at Niquero, Oriente, Cuba, would indicate that a representative, probably of the genus *Penitella*, was living in the West Indies at that time. Whitefield (1885) reports a *Parapholas* from the Eocene marls of New Jersey and von Ihering (1907, p. 330) reports a species from the Eocene of Patagonia which he refers to *Martesia* but which on the basis of his figures probably belongs in the genus *Pholadidea*. These genera are now restricted to the Pacific with the exception of *Pholadidea*, one species of which is found in Europe. Only *Zirfaea crispata* Linné and *Barnea truncata* Say are shared by the Western Atlantic and the Eastern Atlantic and it would appear that *B. truncata* Say is probably a fairly recent introduction into West Africa. *Martesia striata* Linné, like many species of *Teredo* and *Bankia*, is often found in European waters, having been carried there in flotsam by the Gulf Stream, but it does not appear to breed in these waters.

The genus *Zirfaea* is restricted to the colder portions of the temperate and the boreal regions of the northern hemisphere and the genus *Talona* is restricted to Africa. All other genera in the family are found both north and south of the equator with the greatest abundance in the subtropical and warm temperate regions. The occurrence of several northern species in Lower California may be explained by the upwelling of cold water at several points along the coast, according to a letter received from J. E. Fitch of the California Fisheries Laboratory, who has also kindly sent us material from that region.

A detailed account of the ecology of *Zirfaea gabbi* Tryon (=*Zirfaea pilsbryi* Lowe) is given by MacGinitie (1935), and J. E. Fitch (1953) gives a brief account of the habitat

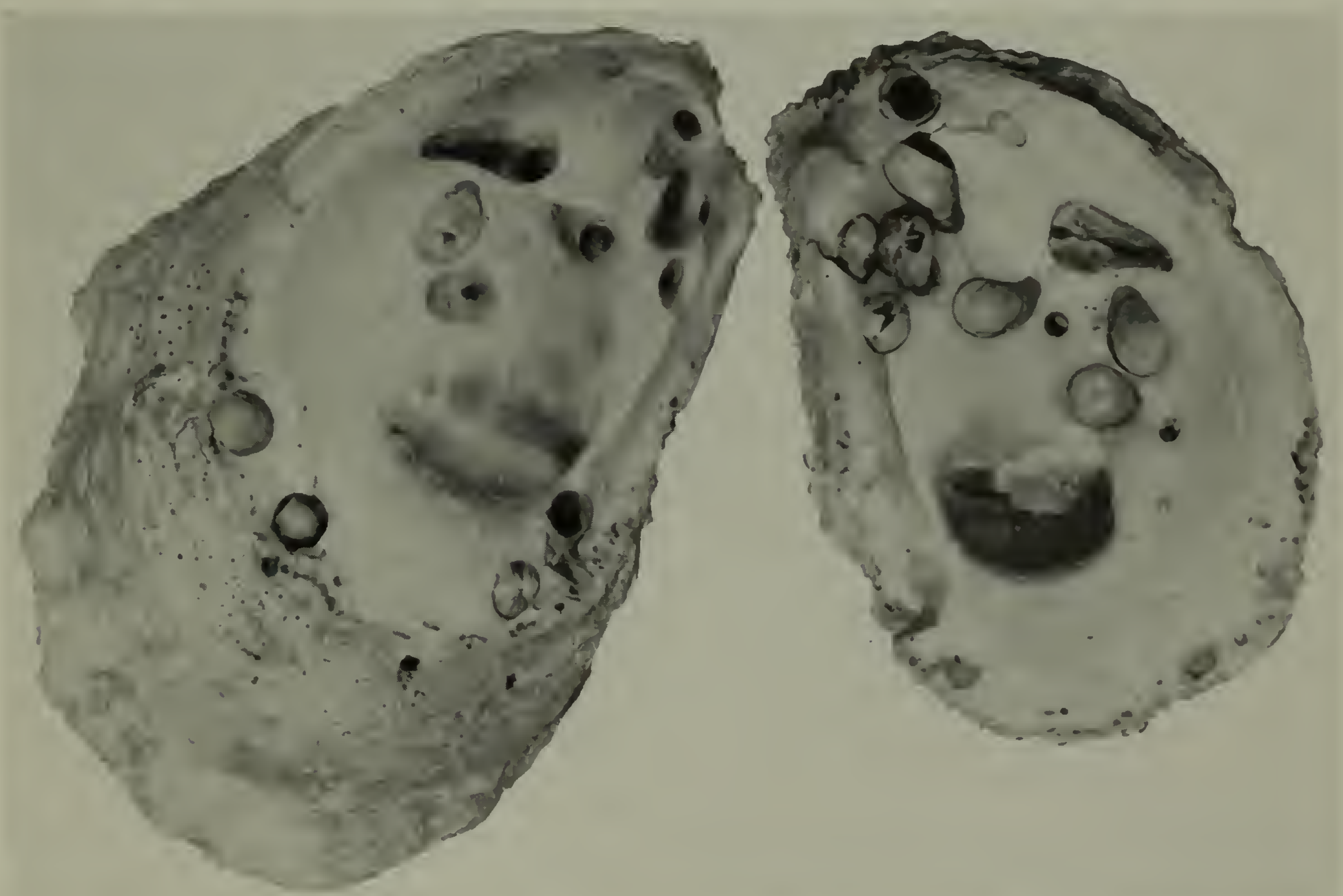


Plate 2. *Diplothyra smithii* Tryon. A specimen of *Crassostrea virginica* Linné split lengthwise showing a heavy infestation of *D. smithii* Tryon. Chesapeake Bay, Maryland (about $1\frac{1}{3}$x).

[1] This new genus will be described in the second part of this study.

and distribution of five species of California pholads. Scattered observations by numerous authors such as Dall, Verrill, Morse and others are noted under the species concerned.

Notes on the Life History of the Pholadidae

Very little is known concerning the life history of the various species of this family. No one species has been completely studied, but varying phases of several species have been worked out and reported upon. Sigerfoos (1894) worked out the early embryology

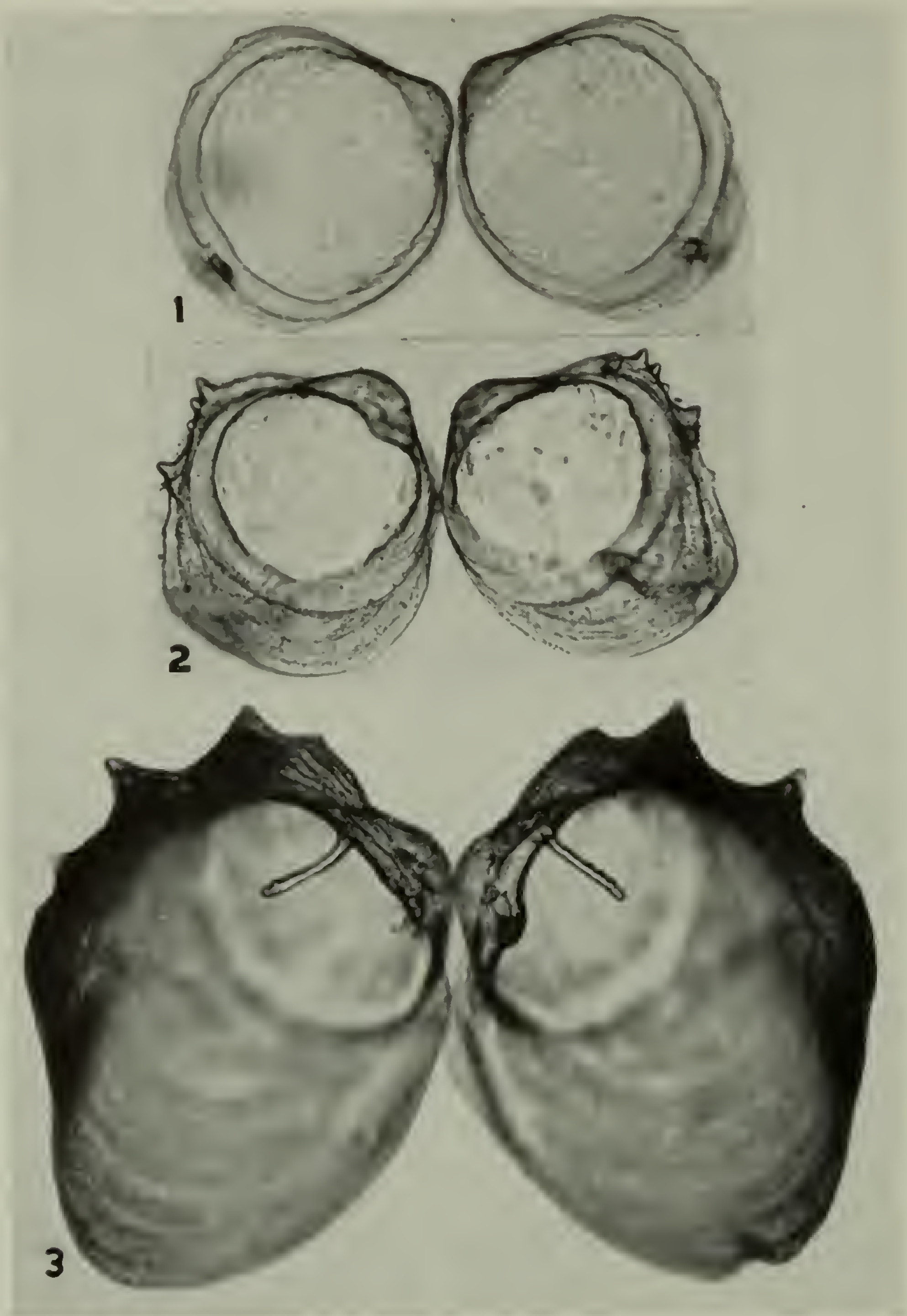


Plate 3. *Zirfaea crispata* Linné (young spat).[1] Fig. 1. At the time of settlement. Fig. 2. With first row of imbrications which are produced immediately after settlement. Fig. 3. With first row of imbrications well developed and showing the beginning of the elongation of the posterior slope and the production of the apophyses (all about 100x).

[1] All figures from C. M. Sullivan 1948, Bivalve Larvae of Malpeque Bay, P. E. I., Fisheries Research Board of Canada, Bulletin 77. We are grateful to Dr. J. C. Medcof and Dr. C. M. Sullivan for the loan of the negatives for these prints.

of *Barnea truncata* Say which he studied at Beaufort, North Carolina. In this species the sexes are separate, fertilization is external and the eggs and sperm are extruded into the water, usually during a few weeks in late April and early May. The eggs are small and rather transparent. Development is so rapid that on warm days the larvae are free-swimming within three hours after fertilization.

According to Bouchard-Chantereaux (1879) fertilization in *Zirfaea* is internal and the young are ejected from the mantle cavity of the adult in the early veliger stage. At Malpeque Bay, Prince Edward Island, Sullivan (1948) found the mature veliger larvae of *Zirfaea crispata* Linné in plankton hauls, from the middle of June to mid-July, when the temperature of the water ranged from 15° to 22° C. She described and figured the larvae and the young spat. Her figures, which we reproduce, show that the apophyses do not develop until the time of settlement. The embryonic shell is about 0.14 mm. in length and nearly circular in outline, with a straight hinge line. Thorson (1946) also illustrates the veliger larvae of this species and he states that in the Sound off Helsingör, Denmark, the larvae are found in the plankton from June through February with the greatest abundance in September.

It has been shown experimentally by Thorson (1946) that the larvae of *Zirfaea crispata* Linné, like those of many marine bottom invertebrates, are able to select actively the substratum on which they settle. He states that in experimental bottles "metamorphosing stages of *Zirfaea crispata* Linné were found in numbers boring into cork floats and only there." He believes that probably most pelagic larvae can delay metamorphosis for a short period of time if they are not on a suitable substratum and he further concludes that even if the current on the bottom is slow this delay would allow for increased survival and dispersal. Though neither Dr. Sullivan nor Dr. Thorson mentioned the attachment of the young spat by a single byssus thread at the time of settlement, such is probably the case. The production of a single byssus in the Teredinidae is well known and our observations would seem to bear this out for *Zirfaea*. Newly settled spat in a test-board submerged at Beverly, Massachusetts were observed to have constructed a small conical covering of cemented wood scrapings for protection during the last stages of metamorphosis. This has also been observed in the Teredinidae, and at this time the young shipworms attach themselves by a single byssus thread, probably to prevent being moved about by the currents. It was also observed on this test-board that the young *Z.*

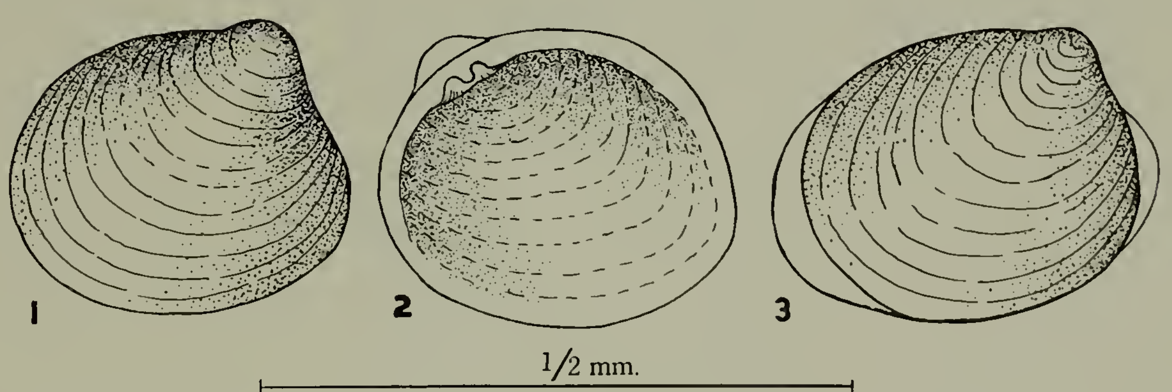


Plate 4. Prodissoconch of *Xylophaga atlantica* Richards. Fig. 1. External view of valve showing marked concentric growth lines. Fig. 2. Internal view of valve showing the two pronounced hinge teeth. Fig. 3. Specimen in the late veliger stage showing the beginning of the elongation of the shell. All specimens taken from the mantle cavity of a preserved specimen which had been taken by the *Albatross* at station 2550, about 160 miles east of Barnegat Bay, New Jersey.

crispata settled only on the horizontal upper surface of the board. Though *Zirfaea* usually are not wood-borers, they are occasionally found in waterlogged wood but their presence in a test-board is most unusual.

On the basis of material which has been available for study it appears that fertilization in *Xylophaga dorsalis* Richards is internal and the young are retained within the parent until the late veliger stage and time for settlement. The accompanying plate shows the shell of the young taken from a preserved adult specimen. Thus it would appear that in the Pholadidae as in the Teredinidae ovoviviparity is at best of no more than generic value taxonomically.

Moore (1947) states that the adults of *Martesia striata* Linné are alternating hermaphrodites and Purchon (1941) records the same for *Xylophaga dorsalis* Turton. In addition Purchon discusses the presence of an accessory genital organ in *Xylophaga* and the storage of spermatozoa in an organ which he terms a "vesicula seminalis." This he believes would allow for self-fertilization, a condition which would be of distinct advantage for a species living in isolated colonies, usually in floating or waterlogged wood as is the case with *Xylophaga*.

The rate of growth undoubtedly varies greatly in all members of the Pholadidae, though we have specific data only on such economic species as *Martesia striata* Linné and *Martesia cuneiformis* Say. Once established in their burrows, the rate of growth depends largely upon the hardness of the substratum and the amount of crowding. Test-board records show that specimens may produce a callum in less than a month and when the shell is only 4 mm. in length. Such specimens, generally termed stenomorphs, may continue to live for some time and are capable of producing large numbers of eggs. Under most favorable conditions a specimen may reach 45 mm. in length before producing a callum and may remain in an active state for several months. Specimens from test-boards at San Juan, Puerto Rico had reached a length of 40 mm. in six months and at Bahía, Brasil, specimens of *Martesia cuneiformis* Say taken from a board submerged on May 3, 1945 and removed on June 2, 1945 had reached a length of 11.5 mm.

The average length of life for any one species of pholad, the breeding age or the number of eggs produced, and the duration of the free-swimming larval life are questions still unanswered.

Additional notes on life history and habits, if known, are included in "Remarks" under the individual species.

Methods of Boring

Since early times scientists have argued over the method by which the various members of the Pholadidae bore. Species of the genera *Pholas*, *Parapholas*, *Penitella*, *Diplothyra* and *Zirfaea* bore into substrata varying in hardness from that of stiff clay to limestone, shale, gneiss and shells such as *Haliotis* and *Ostrea*. Interesting and rather amusing accounts of the various theories of the early 1800's are given by G. Johnston (1850), Forbes and Hanley (1853) and J. G. Jeffreys (1865). Included in their accounts are the arguments supporting theories that boring was accomplished by means of an acid, that the foot did the boring using imbedded siliceous spicules and that the shell was the tool. Buonanni (1684) was the first to believe that the shell was the instrument of boring and Osler (1864), hoping to settle the argument between those who thought boring was accomplished by acid and those who believed in the mechanical theory, spent considerable time observing living animals. He presented a rather detailed paper on his views that boring was mechanical, the shell being used as a tool. The arguments continued, however, and Cailliaud (1855–1857), one of the most ardent of the researchers in this field, wrote numerous papers on the methods of perforation of rocks by *Pholas*. Dubois (1892, p. 34) believed that the siphons alone were responsible for the boring, stating that the musculature of the siphons was sufficient to turn the animal completely around in its burrow. This would mean that the animal was boring like an auger. The action of the foot with the use of sand grains is the theory put forth by Smith (1894) but this could not explain the wood-borers. A rather comprehensive account of the boring mechanisms of several forms that occur in Puget Sound is given by F. E. Lloyd (1887). He goes into particular detail on the musculature of *P. penita* Conrad, showing that in forms which have a ventral adductor muscle, the anterior adductor muscle is divided into two parts. The anterior portion, which he terms the accessory anterior adductor, opposes the posterior adductor muscle. The contraction of the accessory anterior adductor muscle closes the valves anteriorly and opens them posteriorly. The posterior portion, which he terms the anterior adductor muscle, opposes the ventral adductor muscle. The contraction of this portion of the muscle spreads the valves apart ventrally and brings them in contact with the sides of the burrow.

The belief that an acid is employed in boring is no longer held today, but many of the other ideas set forth by early workers fit into the complex picture. The summation of all of these theories along with observations made in the laboratory would indicate that the task of boring is not accomplished by any one organ alone. The shell may be considered the tool which is manipulated by the adductor muscles and is aided by the foot, siphons, mantle, water, and accessory sand grains. An exact procedure does not hold true for all members of the group and even appears to vary somewhat within the species depending upon the hardness and compactness of the substratum into which the specimen is boring. MacGinitie (1935) has given an excellent account of the boring of

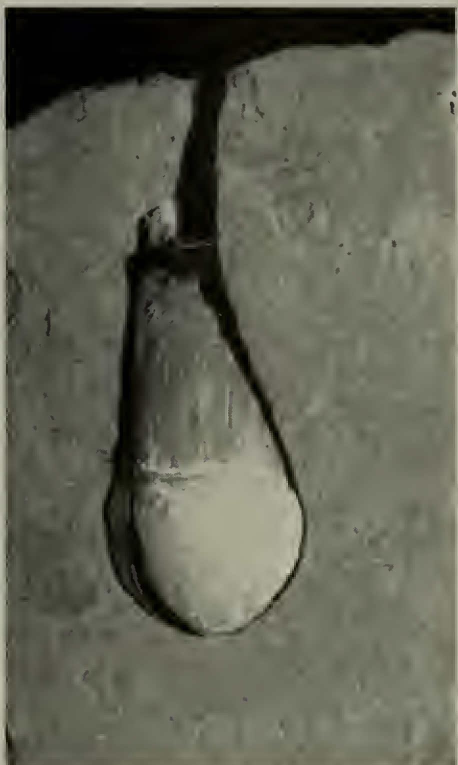


Plate 5. *Penitella penita* Conrad. A typical snug burrow of a *Penitella* boring in soft shale showing the depth to which this group usually bores. White's Point, San Pedro, California (about $1\frac{1}{2}$x).

Zirfaea gabbi Tryon (=*Zirfaea pilsbryi* Lowe) and our observations on *Zirfaea crispata* Linné agree with his. Active specimens of this species, of *Barnea truncata* Say, and of *Martesia striata* Linné, which were observed in the laboratory, all followed the same general pattern. The foot was first attached to the anterior end of the burrow, the contraction of the anterior portion of the anterior adductor muscle and the ventral adductor muscle closed the valves anteriorly as much as possible, and the shell was brought as far forward in the burrow as possible. Then the forcible contraction of the posterior adductor muscle and the posterior portion of the anterior adductor muscle, by opening the valves ventrally and closing them posteriorly, brought the recurved imbrications of the beaks forcibly against the sides of the burrow. The insertion of the anterior adductor muscle on the umbonal reflection in an external position, allows the two sets of muscles to act in opposition to each other and produce a rocking and heaving motion of the valves with the umbos acting as a center.

Mechanically the shell is only capable of boring into a substratum that is as soft as the shell itself or softer. As the shells are composed of aragonite it is possible for them to bore into soft limestone without difficulty. When they are boring into a harder rock such as gneiss, there must be some elements in the rock which are softer than the shell itself or else the rock must be of a friable nature. In such cases the imbrications of the shell can work out the softer portions of the rock, such as the mica, and the harder particles of quartz, feldspar and garnets then fall out. Many of these harder particles apparently are caught in the mucus around the foot, on the thickened frontal margin of the mantle, and many have been observed impressed in the cephalic hood of *Zirfaea*. Particles are also caught between the rows of imbrications on the anterior portion of the valves and these may be in sufficient quantity to cover the worn imbrications. The result is that in species such as *Pholas dactylus* Linné the stone in many cases is worn away with particles of the same hardness.

While watching *Barnea truncata* Say and *Zirfaea crispata* Linné in an aquarium, it was noticed that they are capable of producing a strong and sizeable stream of water just ventral to the foot. This jet is forced out of the mantle cavity, the mantle edge being held close to the foot except for a small area just ventral to the foot. The stream is directed forward and probably is used to flush out the anterior end of the burrow.

Some species, such as *Zirfaea pilsbryi* Lowe (MacGinitie 1935) and *Cyrtopleura costata* Linné, excavate deep, rather roomy burrows and are capable of moving up and down in them at will. During high tide when they are feeding, the siphons may be seen extending a considerable distance out of the opening. Other species such as *Penitella penita* Conrad, as shown in the accompanying plate, excavate a very snug burrow in which movement is limited. This seems to be true of most boring into a hard substratum. The length of the burrow varies greatly with the different species. Some make burrows which are just about equal to the length of the shell, as is the case with *Martesia striata* Linné, while others may be several times the length of the shell. The type of burrow, however, is quite consistent for each species.

Specimens of *Barnea truncata* Say, *Zirfaea crispata* Linné and *Martesia striata* Linné when removed from their burrows are completely incapable of re-burying themselves. If, however, a shallow depression is made in the substratum just sufficient for the animal to attach its foot and bring the anterior edges of the shell into play, it will readily excavate a new burrow.

Little is known as to just how the young, particularly of the rock-boring forms, get started. One of the quaint early theories was that the parent could produce an acid in the tips of the siphons and with this make holes in the rock for the reception of the young. From observations made on *Zirfaea crispata* Linné it would appear that the young probably attach themselves by a single byssus thread in the protection of a minute crevice while metamorphosis takes place and the shell changes into a boring tool.

Notes on the Anatomy and Physiology

The shell is the most unique anatomical feature of the Pholadidae, as no other family among the Pelecypoda has developed accessory plates. In addition, only the Teredinidae share with the Pholadidae the apophyses and the externally placed anterior adductor muscles. While no over-all study of the anatomy of the Pholadidae has been made, the gross morphology of several species has been reported upon and the detailed anatomy of a few is known. The first work was that of Poli (1791) in which he illustrated the anatomy of *Pholas dactylus* Linné, including detailed drawings of the gills, the circulatory and digestive systems. Fischer (1858–1860) described the general anatomy of several widely separated species including *Pholadidea melanura* Sowerby, *Parapholas acuminata* Sowerby and *Jouannetia globosa* Sowerby. Egger (1887) described in great detail the anatomy and histology of *Jouannetia cumingii* Sowerby. In all cases there are no real basic differences in the soft anatomy between these forms and other bivalves. Striking, though not basic differences, include the elongate gills of the pholads which extend into the incurrent siphon and the large triangular to strap-shaped labial palps. Observations on *Nettastomella rostrata* Valenciennes show that in this species the outer demibranchs of the gills are somewhat reduced, and that the labial palps are very small compared with those found in *Zirfaea* and in other genera. In *Xylophaga* only one demibranch remains and this is considered by Ridewood (1903) to be the inner one while Purchon (1941) believes that it is the outer one. Purchon also points out that the labial palps of *Xylophaga* are small and spindle-shaped, with a greatly reduced sorting mechanism. This is a condition that would be expected in wood-boring forms usually found living in floating wood, where most of the material brought in by the siphons is usually more or less uniform in size. In the mud and rock-boring forms, however, the ciliary sorting mechanism is highly developed.

The structure and function of the gills, ciliary mechanism, food tracts and method of feeding of *Zirfaea crispata* Linné were first described by Alder and Hancock (1851). Kellogg (1915) has given an excellent account of the ciliary mechanism in several groups including *Barnea*, *Zirfaea* and *Penitella*. Basically the ciliary mechanism in the species he examined was similar to that in other bivalves; however, several interesting differences were noted. Among these was the development of a covered food groove in *Zirfaea* to insure the delivery to the palps of the food collected on the gills. Of particular interest is his description of the "collecting membrane" found in *Barnea* [= *Cyrtopleura*] *costata* Linné. This membrane, extending from the posterior portion of the visceral mass, collects the excess silt and deposits it in a ball well out in the incurrent siphon whence it is expelled by a sudden contraction of the posterior adductor muscle. This apparently allows feeding at all times even in the very muddy water where this species often lives.

The crystalline style in all species examined was unusually large and, in the callum-building forms, after the foot has atrophied, the style can be seen in the style sac protruding slightly from the anterior end of the visceral mass. Graham (1949) made a comparative study of numerous molluscan stomachs, including several species of pholads and showed their resemblance to the general type.

DuBois (1892) worked on the anatomy and physiology of *Pholas dactylus* Linné, but restricted his studies almost entirely to the siphons, and Purchon (1941) has dealt in detail with the biology and relationships of *Xylophaga*.

The callum-building pholads present two unique and rather interesting phenomena. In most species the animal appears to be able to store a considerable amount of calcium in its system, so that when the time comes the callum is laid down very rapidly. Among the thousands of specimens examined very few were found with the callum partially built. This undoubtedly is one of the reasons why the young stages of callum-building forms have so often been described in separate genera. Early workers, finding adult specimens (ones with a completed callum) which varied greatly in size, believed that the callum could be reabsorbed, that the animal could continue growth and then produce a second or even a third callum at a later date. This, however, is no longer considered the case, as in all of the callum-building forms the foot is absorbed once the callum is completed and boring has ceased. The muscles which work the valves during boring operations do not atrophy as might be expected, because a slight movement of the valves is still possible, and this movement is important for the circulation of water within the burrow.

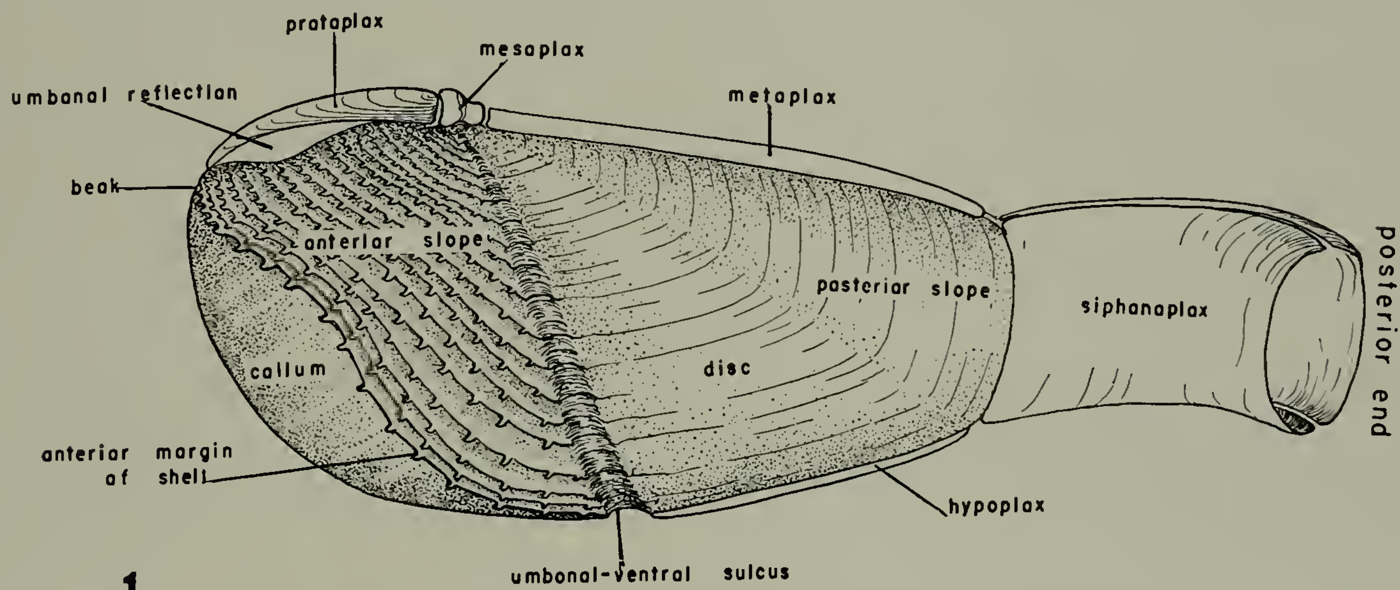
The luminous properties of *Pholas dactylus* Linné have intrigued naturalists since early Greek times. In his writings Pliny speaks of the luminous fluid as being so abundant that the hands and mouths of those who ate them shone. An excellent summary of the experimental work on the bioluminescence of this species is given by Harvey (1952, pp. 255–267). Tomlin (1920) reports that specimens of *Xylophaga praestans* Smith were luminescent at night, but Purchon did not report this for *X. dorsalis* Turton. So far as is known no other species of Pholadidae is luminescent, with the possible exception of *Barnea candida* Linné which, according to Okada (1927), has a weak momentary luminescence when opened. However, the two species most closely related to *P. dactylus* Linné have not been investigated in this respect. The Western Atlantic form, *P. campechiensis* Gmelin, occurs mainly below low tide line and is almost unknown except as dead beach specimens. *Pholas chiloensis* Molina of the Eastern Pacific is more common and should be investigated for this property. Living specimens of *Zirfaea crispata* Linné and *Barnea truncata* Say which we observed both in the laboratory and in the field showed no luminous properties.

All species of the Pholadidae, so far as known, live under strictly marine or only slightly brackish water conditions, with the possible exception of *Martesia rivicola* Sowerby, an Indo-Pacific species, which is recorded as occurring in floating wood in fresh water. Some species, however, appear to be able to withstand dilutions of sea water down to 50% for short periods of time. This would certainly indicate that, though these species are strictly marine, they have the ability to adjust themselves to the hazards of their intertidal habitat. Unlike *Venus*, *Mytilus* and others, they are unable to retract completely within their shells and so shut out the environment when conditions are adverse. A heavy rainfall at low tide could quickly fill the burrows of *Zirfaea* and *Barnea* with nearly fresh water and consequently the ability to adjust to such changes probably has some survival value.

Zirfaea crispata Linné appears to be able to withstand a considerable range of temperature. Specimens placed in a jar of sea water and exposed to freezing temperatures became inactive when slush-ice was formed. On thawing, however, the animals again became active. In the summer they can tolerate water temperatures at least as high as 75° F.

Shell Morphology

The pholad shell is complicated and highly specialized. Besides the two valves common to all pelecypods, some members of the Pholadidae may have as many as four accessory plates and all members have at least one. In some (the Pholadinae and Xylophaginae) there is no basic change from the young to the adult shell, while in others (the Martesiinae) there are two distinct stages in shell growth. The young shell is beaked and widely gaping anteriorly, while in the adult the anterior gape is closed by a calcareous deposit,



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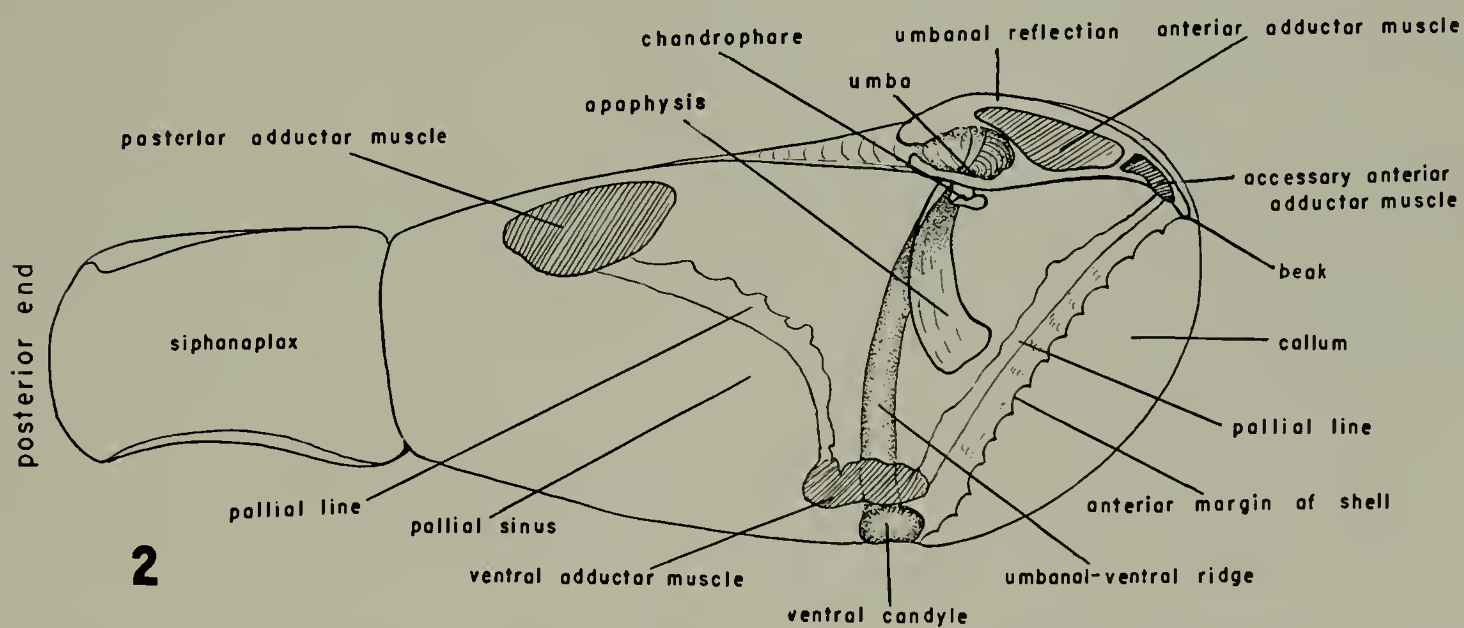

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Plate 6. Diagrammatic, composite drawing of a pholad shell. Fig. 1. External view of the valve to show the approximate relative positions of the various accessory plates and the parts of the valve proper. Fig. 2. Internal view of the valve to show the general arrangement of the muscle scars, the placement of the apophysis and other parts.

the callum. The young stage which has been termed the "working or Zirfaea stage" by Lloyd (1897) continues as long as the animal is actively boring. During this stage the shells of several of the genera closely resemble those of *Zirfaea;* they are beaked anteriorly, rounded posteriorly and the mesoplax, the only accessory plate present at that stage, is a simple transverse plate located across the umbos and beneath the posterior portion of the anterior adductor muscle. The anterior adductor muscle is protected at this stage by a chitinous covering, sometimes referred to as the cephalic hood, a term more commonly used in the Teredinidae. When the excavation is completed and the animal ceases growing, the pedal gape is closed by a callum, the mesoplax is completed and the metaplax, hypoplax, and siphonoplax, if present, are developed. This stage, Lloyd (1897) has called the "resting stage." When the callum develops, the foot atrophies and the pedal gape of the mantle closes except for a minute anterior pore. Finally the completed halves of the callum are joined by a chitinous band, with only a minute anterior pore remaining open.

Most of the Pholadidae have apophyses, large shelly projections which extend from beneath the umbos and serve as the attachment area for the large foot muscles and as a support for the visceral mass. In all of the pholads the dorsal margins of valves are reflected anteriorly, so that the anterior adductor muscle is in an external position and works in opposition to the posterior adductor muscle.

Many of the following terms for the various parts of the shell and the accessory plates were first introduced by Fischer in 1858.

Protoplax. The term protoplax is restricted to the simple, nearly flat dorsal plate which is anterior to the umbos and which rests on top of, but does not enclose, the anterior adductor muscle. It is essentially the same in young and adult shells and its axis is longitudinal. It may be in one piece or divided longitudinally into two equal parts. It may be chitinous or calcareous.

Mesoplax. The mesoplax is a transverse plate, usually wider than long, which straddles the two valves on their dorsal margin. It protects the posterior portion of the anterior adductor muscle and always originates ventrally to the muscle. In the Pholadinae, the mesoplax is simple and essentially the same in the young as in the adult. In the Martesiinae, however, the mesoplax in the young is a simple, more or less semicircular plate situated mainly ventral to the posterior portion of the anterior adductor muscle. In the adult of these forms it grows dorsally and then anteriorly so as to enclose the posterior portion of the anterior adductor muscle. The mesoplax may be in one or two pieces and is always calcareous.

Metaplax. The metaplax is a long, narrow plate which covers the gap between the two valves on the dorsal margin posterior to the umbos. It is usually calcareous and in most species is attached to the dorsal margins of the valves by a chitinous fold. The metaplax may be pointed, rounded or forked posteriorly.

Hypoplax. The hypoplax is the long, narrow ventral plate covering the gape between the two valves on the ventral margin. It extends from the umbonal-ventral sulcus posteriorly, where it may be forked, rounded or pointed. It is usually entirely calcareous and is joined to the ventral margins of the valves by a chitinous fold.

Siphonoplax. This term is applied to any structure which is secreted by the mantle on the posterior margin of the valves, probably for the protection of the siphons. The siphonoplax may be chitinous or calcareous, the two halves diverging or fused to form a tube. In *Jouannetia* the siphonoplax is developed on the right valve only.

Callum. This term refers to the closure of the pedal gape. It may be partial or complete, sculptured or irregularly marked. Generally the two halves of the callum do not quite meet and are joined by a chitinous fold, with only a minute anterior pore remaining open. In *Jouannetia* the callum of the left valve is greatly developed and overlaps that of the right valve. In *Nettastomella* the calcareous portion of the callum consists only of a narrow band extending along the anterior margin of the shell: the main portion of the callum is chitinous. In many species of Martesiinae the callum extends dorsally between the beaks and covers the anterior portion of the anterior adductor muscle.

Umbonal Reflection. This term refers to the reflection of the dorsal margin of the valves anterior to and usually over the umbos. It may be closely appressed to the shell surface, raised well above the surface of the shell, with or without a posterior support, or the space below the reflection may be septate. The anterior adductor muscle scar usually covers most of the umbonal reflection.

Apophyses. These are large, styloid projections, one in each valve, extending from beneath the umbos to which the foot muscles are attached.

Chondrophore. This is a modification of the hinge area to support the internal ligament. The chondrophore of the right valve is a small swelling with a central depression, while that of the left valve is a small shelf-like projection. The chondrophore is found in only certain groups of the pholads.

Siphonal Tube. This term is applied to the tube produced in some members of the genus *Pholadidea*. It is composed of agglutinized particles produced as a result of boring activities. It differs from the 'chimney' of the *Parapholas* in that it is fused to the siphonoplax.

Chimney. A tube formed of agglutinized particles produced as a result of boring activities. It fits over the posterior end of the shell and in some species extends anteriorly nearly to the mesoplax.

Other specialized terms can readily be understood from the accompanying diagram of a composite pholad shell on which all the various parts have been labeled. Only in the genus *Parapholas* are the three main areas of the shell as clearly marked as in the diagram. No one genus has all of the accessory parts indicated.

General Remarks on the Classification

The family Pholadidae is a compact and easily recognized group. All of its genera possess three or more of several characters (such as accessory plates, callum, umbonal reflection, external position of the anterior adductor muscle, apophyses, ventral condyle, and chimney or siphonal tube) found in no other family of Pelecypods except the Teredinidae. No pholad, however, has the elongate body and pallets of the Teredinidae and no teredo has accessory plates, callum or chimney.

The main difficulty faced by the early workers in the Pholadidae was the lack of material in which all the accessory plates were present. The basic shell in many of the species is very similar and when the accessory plates are lacking it is easy to misidentify them. Inadequately understood life histories resulted in the creation of new genera for the young stages of callum-building forms. In addition, the species are exceedingly variable. Therefore it is little wonder the early workers, having the extreme forms of a species with none of the intermediate ones, described them as different species. It is not unusual in this family to have adult specimens of a given species ranging from 3 mm. to 45 mm. in length, and the ratio of length to height is nearly as variable. This range of size and shape is a result of the boring habit of this group. The type of substratum in which the animals bore and the amount of crowding are largely responsible for the variation. Species which normally bore into wood become misshapen, small and thick-shelled when they work in harder materials. Overcrowding produces stenomorphs or greatly stunted forms which assume all of the adult characters though they are perhaps only 1/10 normal size. Conversely, species such as *Penitella conradi* Valenciennes [= *P. parva* Tryon], which normally bore into *Haliotis* or other shells, are equally variable. When they live in softer material, such as heavy clay, the shell is much larger than normal and is far more perfectly formed. Consequently in this study an attempt has been made to obtain large series of preserved material from as many localities as possible in order to have a good picture of the range of size and shape of the species and the various types of malformations that normally occur.

On the death of the animal the accessory plates may become detached and isolated and these on occasion have been described, usually as species of simple gastropods of the type of *Scutum*, *Acmaea* or *Patella*. Mörch (1876) has pointed out that the dorsal plate of *Pholas* (*Monothyra*) *orientalis* Gmelin was described in 1779 by J. E. J. Walch as *Scutum dacicum* and in 1874 G. and H. Nevill again described it as *Scutum ? abnormis*. We have not seen the type specimen of *Scutum abnormis* but from the illustration there is no doubt as to its identity with the oriental species. The apophysis of *Cyrtopleura costata* Linné was described by Conrad as *Capulus shreevei* and it is very possible that *Patella acinaces* Lea 1846 is the dorsal plate of *Barnea truncata* Say. Undoubtedly there are other cases of such misidentifications which will eventually be clarified; some may possibly have been described as plates of barnacles. Isolated accessory plates occurring in fossil beds could prove a real problem to paleontologists.

Though the Pholadidae are known from the Pennsylvanian, the fossil record is meager and scattered and, of course, none of the soft parts have been preserved. On the basis of the present record it is impossible to say whether the Pholadidae and the Teredinidae stemmed from a single ancestor or whether the pholads gave rise to the teredos or vice versa. There is no question that the two families are closely related and that they either stemmed from a common ancestor or that one gave rise to the other. There are four distinct subfamilies in the Pholadidae all of which have accessory plates and an externally placed anterior adductor muscle. Of these four subfamilies, two have apophyses and two lack them. In each group there are callum and non-callum producing genera as shown in the following table.

Subfamilies	*Apophyses*	*Callum*	*Accessory Plates*
Pholadinae	X		X
Martesiinae	X	X	X
Xylophaginae			X
Jouannetiinae		X	X

Family Pholadidae

Shells with a narrow, slit-like to nearly circular pedal gape, which may or may not be closed by a callum in the adult stage. Anterior portion of the valves imbricate or denticulate and often ribbed. This portion is often separated from the posterior portion by an umbonal-ventral sulcus. Hinge teeth usually lacking, a small chondrophore present in some forms, ligament if present, internal. Anterior dorsal margin of the valves reflected, forming the attachment area for the externally placed anterior adductor muscle. The fused mantle edges in many forms are thickened and muscular. The ventral adductor muscle, present in some forms, is a thickened muscular portion of the ventral margin of the mantle. Anterior adductor muscle protected in the young stage by a chitinous covering often referred to as the cephalic hood. In the adult stage of most forms it is covered by accessory plates or by a dorsal extension of the callum. The total number of accessory plates in any one species may vary from one in *Barnea* and *Zirfaea* to four in *Martesia* and *Parapholas.* These last two forms have a mesoplax, metaplax, hypoplax and callum. A chimney is produced by *Parapholas* and *Xylophaga.* Apophyses are present in the Pholadinae and Martesiinae, but absent in the Jouannetiinae and Xylophaginae. For the distribution of the accessory plates in the various genera see the following table. Pallial sinus usually deeply inset. Siphons united, capable of considerable extension, smooth or papillose and often enclosed in a chitinous sheath. Siphonal aperture usually surrounded by cirri. Gills with two demibranchs, except in the Xylophaginae where there is only one, the outer one according to Purchon (1941). In many groups the gills are extended into the siphons. Foot well developed, usually truncate and adapted for suction. The foot in all of the Martesiinae and Jouannetiinae atrophy in the adult stage.

The following arrangement of the genera within the family is an attempt to group similar forms from those that are the simplest structurally to those that are the most complex. It is not intended to show any actual or supposed evolutionary sequence. The entire family is rather old geologically as shown on the following table, which gives the range in time, so far as is known, of the genera considered in this paper. However, it is often impossible to place fossil pholads in their proper genus owing to the fact that they may be only internal casts, that they lack the accessory plates, or that they are young forms. As represented today the family is composed of numerous well marked genera, each genus containing few species and seldom are species transitional between any two genera. This condition is paralleled by other groups in the Mollusca, where families, which are old geologically speaking, have become differentiated generically but now show little breakdown on the specific and subspecific levels.

Subfamily Pholadinae

Shell not closed anteriorly by a callum in the adult stage. Number of accessory plates variable but hypoplax and siphonoplax always lacking. Apophyses present. Valves not divided into two regions by an umbonal-ventral sulcus, except in the genus *Zirfaea* where the sulcus is rather weak and often barely visible in the adult. Foot well developed, not atrophying in the adult. Animal not capable of complete retraction within the shell.

Subfamily Martesiinae

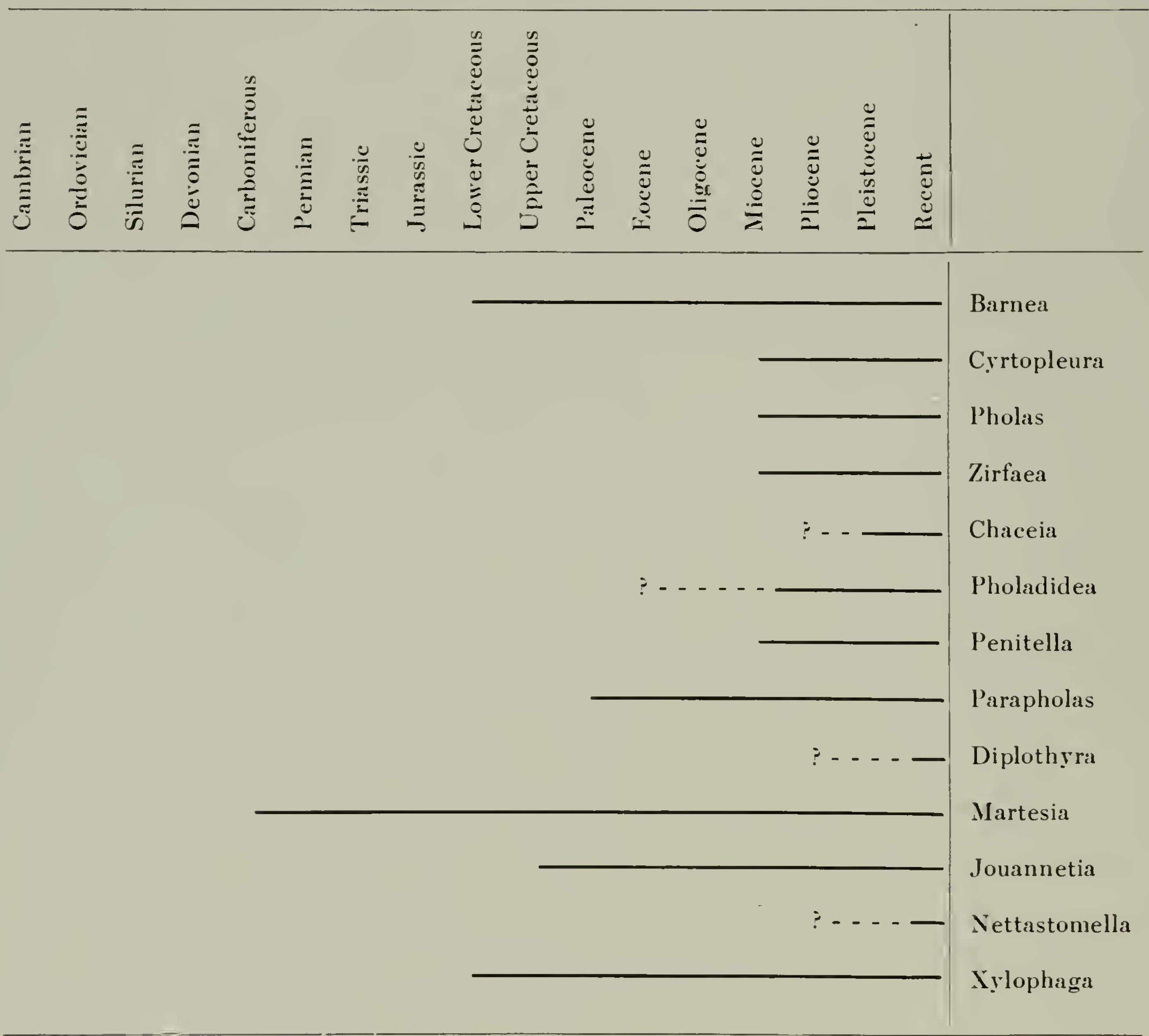
Shells beaked and gaping anteriorly in the young stage but closed by a callum in the adult. Number of accessory plates variable, but always lacking a protoplax. Apophyses present. Valves divided into two distinct areas by an umbonal-ventral sulcus and in addition, in the genus *Parapholas*, a ridge extending from the umbos to the posterior ventral margin divides the valves into three areas. Foot well developed in the young stage but atrophied in the adult. Animal capable of complete retraction within the shell except in the genus *Chaceia*.

Subfamily Jouannetiinae

Shell beaked, gaping very widely anteriorly in the young stage and partially to completely closed by a callum in the adult. The callum in the genus *Nettastomella* exists as a peripheral band of calcareous material with the large central portion being chitinous. In

CHART SHOWING THE PROBABLE GEOLOGIC RANGE OF THE GENERA

(The solid lines are not necessarily indicative of a continuous fossil record)



the genus *Jouannetia* the callum is entirely calcareous and greatly produced. Apophyses lacking, the foot muscles being inserted in the normal position. Accessory plates variable; a rudimentary mesoplax is present in some species. The siphonoplax heavy, calcareous and in *Jouannetia* present only on the right valve. Anterior adductor muscle covered by the dorsal extension of the callum. Shells divided into two distinct areas by the umbonal-ventral sulcus. Foot well developed in the young stage but atrophied in the adult. Animal capable of complete retraction within the shell.

Subfamily Xylophaginae

Shell beaked and gaping anteriorly throughout life. The beaks are truncated at nearly right angles, giving the shell a teredo-like appearance. Valves rounded and closed posteriorly, the animal capable of complete retraction within the shell. Anterior portion sculptured with numerous rows of finely denticulated ridges as in the Teredinidae. Posterior portion sculptured only by growth lines, and separated from the anterior portion by the umbonal-ventral sulcus. Accessory plates consisting only of a small divided mesoplax. Callum and apophyses absent. Umbonal-ventral ridge pronounced and usually with a ventral condyle. Umbonal reflection narrow, simple and closely appressed. Posterior adductor muscle scar large, generally oval in outline and placed high on the posterior slope. Foot muscle inserted in the normal position. Foot not atrophying in the adult.

Distribution of accessory parts in the various genera of the Pholadidae

	Apophysis	Protoplax	Mesoplax	Metaplax	Hypoplax	Siphonoplax	Callum	Chimney
PHOLADINAE								
Barnea	X	X						
Cyrtopleura	X	X	X					
Pholas	X	X	X	X				
Talona	X		X					
Zirfaea	X		X					
MARTESIINAE								
Chaceia	X		X				X	
Penitella	X		X			X *	X	
Pholadidea	X		X			X	X	
Parapholas	X		X	X	X		X	X
Diplothyra	X		X	X	X		X	
Martesia	X		X	X	X		X	
JOUANNETIINAE								
Jouannetia			X *			X	X	
Nettastomella						X	X	
XYLOPHAGINAE								
Xylophaga			X					X

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Many institutions and individuals have been exceedingly helpful in providing material for this study. Before listing these, I wish to express my appreciation to several members of the Museum staff for their help: to Dr. William J. Clench under whose immediate direction the work was done and whose continued interest and philosophy of work have been most important in helping me solve the many problems concerned in this study;

* Present in some but not all species in the genus.

to Dr. Joseph C. Bequaert and Dr. Merrill Champion for their counsel and aid in reading the manuscript; to Professor Henry B. Bigelow and Professor Ernst Mayr for their many helpful suggestions, and to Professor John H. Welsh of the Biological Laboratories for aid on physiological problems.

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From the late William F. Clapp and through the kindness of A. P. Richards and Dorothy Brown of the Clapp Laboratories, Duxbury, Massachusetts, we received for study the entire collection of *Martesia* which they had brought together. This is a particularly important collection, for all specimens were taken from test-boards, thus establishing the occurrence and breeding of the species in a given locality, as well as adding important data on growth rates.

Several friends made a special effort to collect material for which I wish to express my gratitude. Emery P. Chace of Lomita, California, sent not only his collection but also preserved specimens he had collected in and around San Pedro, California. Ruth Coats sent a large collection of preserved material from Tillamook, Oregon. Special thanks are due John Fitch of the Terminal Island Station, California State Fisheries Laboratory for the quantity of preserved specimens from California and Lower California, and for interesting notes on the ecology of several species. David and Nevada Schmidt collected many lots on the west coast of Florida. Piet Kaas, the Hague, Holland and P. Rancurel, Office de la Recherche Scientifique Outre-Mer, Paris, France, sent material from their countries.

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All photographs, unless otherwise stated, are the work of Frank White, Biological Laboratories, Harvard University. The drawings were made by the author with the aid of a camera lucida.

Subfamily Pholadinae

Genus **Barnea** *Risso*

Shells white, more or less elliptical in outline, and beaked or rounded anteriorly. Accessory plate consisting of a simple, calcareous, lanceolate protoplax. Umbonal reflections simple, closely appressed to or raised slightly above the surface of the umbos, but free anterior to the umbos. Space below the umbonal reflections not septate. Pedal gape variable, ranging from a narrow slit to a broad oval. Sculpture consisting of concentric ridges and radial ribs which may cover the entire shell or may be reduced on the posterior slope.

The genus *Barnea* Risso is known from the temperate and tropical seas throughout the world.

Genotype, *Barnea spinosa* Risso (=*Pholas candida* Linné), monotypic.

There are two subgenera in the Genus *Barnea* and they may be differentiated as follows:

Shells rounded anteriorly	*Barnea* s.s.
Shells beaked anteriorly	*Anchomasa*

Subgenus **Barnea** *Risso*

Barnea 'Leach' Risso 1826, Histoire Naturelle de l'Europe Méridionale **4**, p. 376 (genotype, *B. spinosa* Risso, monotypic).

Barnia Gray [sic] 1840, Synopsis Contents British Museum ed. 42, p. 150 [nomen nudum]: Gray 1842, Synopsis Contents British Museum, ed. 44, p. 76 [defined but no species listed].

Barnia Leach [sic] 1852, Synopsis of the Mollusca of Great Britain, London, p. 254 (genotype, *Barnea candida* Linné, monotypic).

Holopholas Fischer 1887, Manuel de Conchyliologie, Paris, p. 1133 (genotype, *Barnea candida* Linné, [here designated]).

Shells white, rounded at both ends, having a slit-like pedal gape and only a slight posterior gape. Umbonal reflections simple and closely applied to the surface of the umbos.

No species of this subgenus is known from the Western Atlantic or the Eastern Pacific. However, a description of the subgenus with a description and figures of *Barnea candida* Linné are included for the sake of comparison. Other species in this subgenus are found in West Africa and the Indo-Pacific.

Barnea (Barnea) candida *Linné*
Plates 7–8

Pholas candida Linné 1758, Systema Naturae, edition 10, p. 669; Hanley 1855, Ipsa Linnaei Conchylia, p. 25.

Pholas papyraceus Spengler 1792, Skrivter Naturhistorie Selskabet **2**, pt. 1, p. 92: *non papyracea* 'Solander' Turton 1822.

Barnea spinosa Risso 1826, Histoire Naturelle de l'Europe Méridionale **4**, p. 376.

Pholas dactyloides Delle Chiaje 1829, Memoire Animali senza Vertebrae Regno Napoli **4**, p. 206, pl. 65, figs. 9–12; *non* Lamarck 1818.

Baruia [sic] *candida* Linné, Gray 1851, Annals and Magazine Natural History (2) **8**, p. 382.

Barnea candida Linné, Bucquoy, Dautzenberg and Dollfus 1896, Mollusques Marins du Roussillon **2**, p. 615, pl. 88, figs. 1–7.

Pholas candida var. *subovata* Jeffreys 1865, British Conchology **3**, p. 108.

Pholas cylindrica J. Sowerby 1818, Mineral Conchology of Great Britain **2**, p. 223, pl. 198 (Crag).

Pholas candida subovata cylindracea Marshall 1914, Journal of Conchology **14**, no. 7, p. 207 (Torre Abbey, Torquay, England).

Barnea candida cylindrica 'Marshall' Lamy 1925, Journal de Conchyliologie **69**, p. 40 [error for *cylindracea* Marshall].

Pholas costulata Goodall 1890, Transactions Norfolk and Norwich Naturalists Society **5**, pt. 1, p. 79, text fig. (Hill Head near Gosport, England) [We have not seen this publication]: Walsingham 1916, Proceedings Malacological Society London **12**, p. 61, text figure.

Distinctive characters. Shell usually 3 inches or less in length, rounded anteriorly, with the sculpture extending over the entire shell and with a single dorsal plate, a protoplax.

Description. Shell subelliptical in outline, reaching about 68 mm. (about $2\frac{3}{4}$ inches) in length and 25 mm. (about 1 inch) in height, thin, rounded anteriorly, tapering posteriorly and gaping slightly at both ends. Color a dull chalky white. Umbos prominent and located near the anterior $\frac{1}{4}$ of the shell. Umbonal reflections closely appressed over the umbo but free anterior to the umbo. Sculpture consisting of concentric ridges and radial ribs. Concentric ridges very strong on the anterior slope, becoming weaker over the disc and on the posterior slope. Radial ribs rather weak, being expressed mainly by radial arrangement of the rows of imbrications which are produced where the concentric ridges and radial ribs cross. Imbrications particularly strong on the anterior slope but clearly visible, though weak, the entire length of the shell. Sculpture below the umbonal reflection consisting of fine growth lines. Interior of the shell white and glazed. Surface sculpture visible on the inner surface of the shell as faint furrows and pits. Pallial sinus extending inward to about $\frac{1}{2}$ the distance to the umbo. Muscle scars faint. Apophysis small, short, slightly flattened and curved. Protoplax elongate oval, broadly arched, and with a central groove extending its entire length. Posterior end of the protoplax sharply

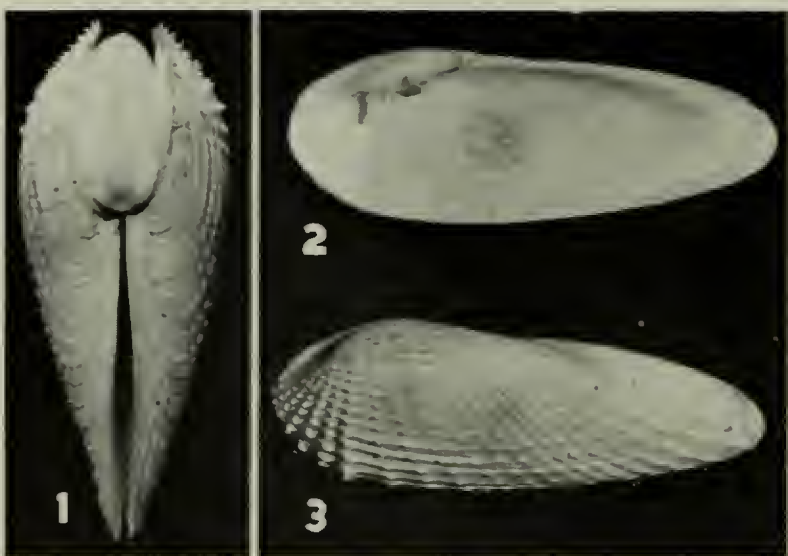

Plate 7. *Barnea candida* Linné. Figs. 1–3. Bréhec, Côtes du Nord, France (all natural size). Fig. 1. Dorsal view with protoplax in normal position. Fig. 2. Internal view showing apophysis, muscle scars and pallial sinus. Fig. 3. External view of valve showing umbonal reflection which is free anterior to the umbos and closely appressed over the umbos.

bent downward, nucleus posterior and concentric growth lines faint. Periostracum thin, straw-yellow and deciduous.

Siphons united, about equal in size and may be extended 4 to 5 times the length of the shell. They are pale brown in color and minutely papillose. The anterior portion of the siphons with a darker brown periostracal sheath which is joined to and extends over the posterior portion of the shell. Siphons tipped with a narrow band of red-brown. Incurrent siphon with 10 to 12 large and several small cirri surrounding the opening. These cirri continue internally as ridges which extend well down in the siphons. The red-brown coloring also extends internally largely between the ridges. Excurrent siphon lacking cirri and with only a very narrow color band internally. Foot white, oblong-lanceolate in outline and truncate. Pedal gape long and narrow, mantle white. The above description was made from preserved animals.

length	height	ratio h:l	
68.2 mm.	25.0 mm.	2.7	Cintra Bay, Rio de Oro, Africa
56.0	19.4	2.8	Ostende, Belgium
52.0	19.0	2.7	Castle Rocks, St. Andrews, Fife, Scotland

Types. According to Hanley (1855, Ipsa Linnaei Conchylia, p. 25) Linné's specimens of *Pholas candida* are still in the Linnean collection. The locality given by Linné was Europe and America, his reference was to Lister 1678, Historiae Animalium Angliae, p. 193, pl. 5, fig. 39. The type locality is here restricted to the Tees River, Middlesbrough, England, the locality given by Lister.

The locations of type specimens of most of the species now considered synonyms of *Barnea candida* Linné are unknown.

Remarks. Barnea candida Linné, similar to all other species in this genus and family, is rather variable in size, proportions and condition of sculpturing depending upon the substratum in which it is boring. This undoubtedly has been responsible for the large number of synonyms noted above. This species is known to bore into a variety of substrata ranging from loose sand to rock.

Through the kindness of Professor C. M. Yonge and Dr. J. M. Dodd of the University of Glasgow, we have received preserved specimens from the Gatty Marine Laboratory, St. Andrews, Scotland. At this station *Barnea candida* Linné bore into mudstone, a form of shale which is quite plastic when wet. They live in the same area as *Zirfaea crispata* Linné, but at a higher tide level and their burrows generally are horizontal while those of *Zirfaea* are nearly always vertical.

Deshayes (1846, Exploration Scientifique de l'Algerie, Histoire Naturelle des Mollusques, Liv. 6, pl. 9) has figured beautifully the general morphology of the soft parts of this species, and Bucquoy, Dautzenberg and Dollfus give a very complete bibliography prior to 1896.

Range. From northern Norway south to the southern coast to France, the eastern Mediterranean, and on the African coast south to Cap Blanc, Sénégal (M. Nicklès, 1950).

Specimens examined. Norway: Malvik, Trondheim Fjord; Beian, Orlandet, Trondheim (both MCZ). Scotland: Oban (MCZ; USNM). England: Huntstonton

(USNM): Scarborough: Kent: Eastbourne, Sussex: Teignmouth: Cornwall (all MCZ): Poole (USNM). NETHERLANDS: Scheveningen (MCZ). BELGIUM: Nieuport (W. J. Eyerdam): Ostende (MCZ). FRANCE: Bréhec, Côtes du Nord: Nantes: Cette (all MCZ): Gulf of Gascogne (USNM). AFRICA: Cintra Bay, Rio de Oro (MCZ).

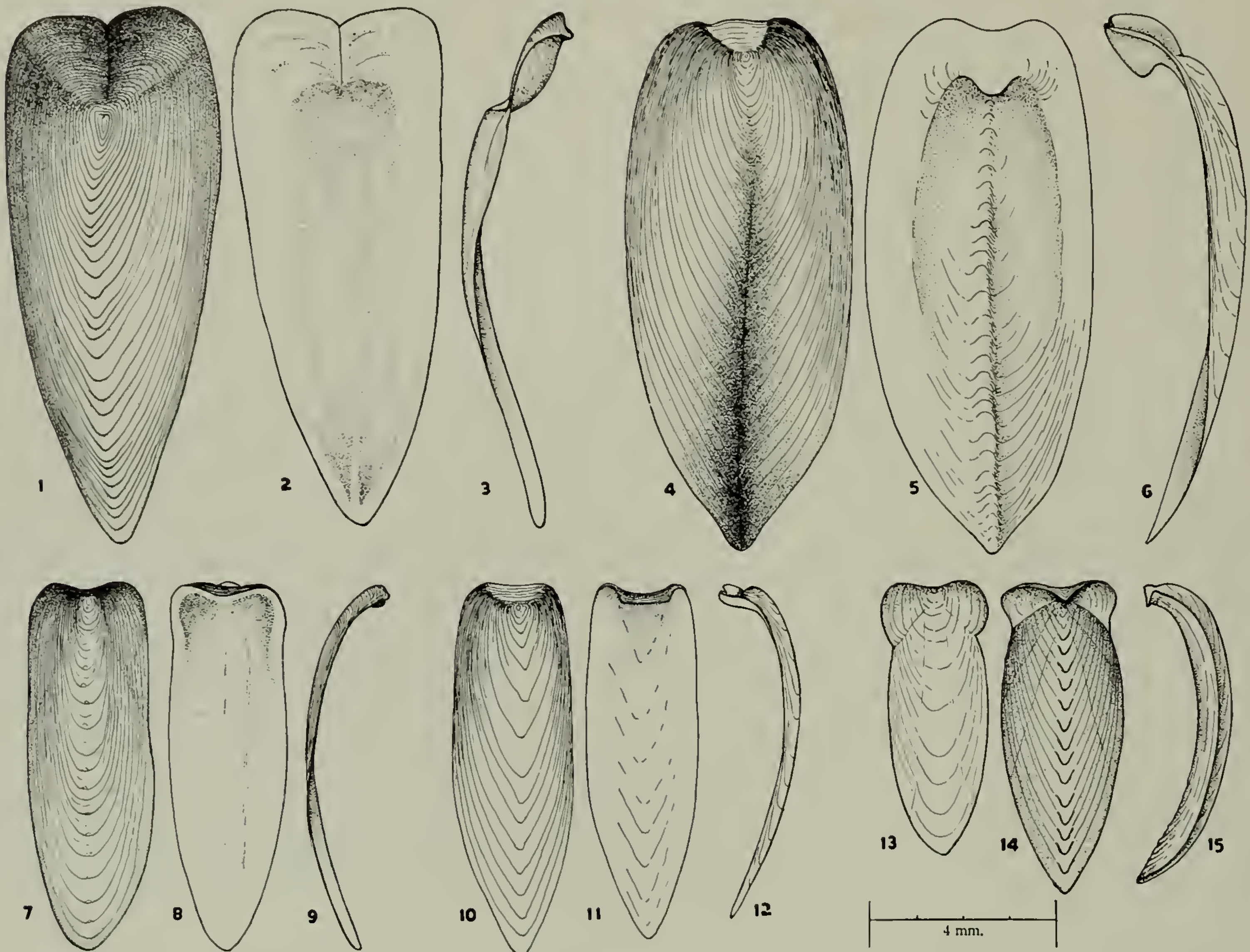

Plate 8. Protoplax of *Barnea*. Figs. 1–3. *Barnea subtruncata* Sowerby, Liddo Isle, Newport Bay, California. Fig. 1. Dorsal view showing the tapering sides, the concentric growth lines and the nucleus which is located well in from the posterior margin. Fig. 2. Ventral view. Fig. 3. Side view to show the curvature. Figs. 4–6. *Barnea candida* Linné, Bréhec, France, Fig. 4. Dorsal view showing the posterior nucleus and the distinct median groove. Fig. 5. Ventral view showing the groove expressed internally as a ridge. Fig. 6. Side view. Figs. 7–9. *Barnea truncata* Say, Third Cliff, Scituate, Massachusetts. Fig. 7. Dorsal view showing the nearly parallel sides, the concentric growth lines and the nucleus which is located close to the posterior margin. Fig. 8. Ventral view. Fig. 9. Side view. Figs. 10–12. *Barnea parva* Pennant, Plymouth, England. Fig. 10. Dorsal view showing the growth lines and the location of the nucleus. Fig. 11. Ventral view. Fig. 12. Side view. Figs. 13–15. *Barnea lamellosa* d'Orbigny, Puerto Militar, Bahía Blanca, Buenos Aires, Argentina. Fig. 13. Dorsal view showing the weak concentric growth lines, the posterior nucleus and the posterior lobes. Fig. 14. Ventral view showing the longitudinal ridge. Fig. 15. Side view showing the curvature and the upturned lateral margins.

Subgenus **Anchomasa** *Leach*

Anchomasa Leach 1852, A Synopsis of the Mollusca of Great Britain, London, p. 253.

Shell beaked anteriorly, with a large oval pedal gape extending back at least as far as the umbo, rounded to truncate posteriorly with a moderate to large and variable posterior gape. Umbonal reflection simple and usually closely applied to the surface of the umbo, free anteriorly.

Subgenotype, *Anchomasa pennantiana* Leach (=*Pholas parva* Pennant), monotypic.

Barnea (Anchomasa) parva *Pennant*

Plates 8–9

Pholas parva Pennant 1777, British Zoology **4**, p. 77, pl. 40, fig. 13 (English shores); *non parva* Sowerby 1834; *non parvus* Donovan 1800.

Pholas crenulatus 'Solander' Spengler 1792, Skrivter Naturhistorie Selskabet **2**, pt. 1, p. 98.

Pholas dactyloides Lamarck 1818, Histoire Naturelle des Animaux Sans Vertèbres **5**, p. 445 (British Seas).

Pholas tuberculata Turton 1822, Conchylia Insularum Britannicarum, p. 5, pl. 1, figs. 7–8 (Torbay, England).

Pholas ligamentina Deshayes 1839, Traité Elémentaire de Conchyliologie **1**, pt. 2, p. 80, pl. 3, figs. 11–12 (Seas of Europe).

Barnia [sic] *parva* Pennant, Gray 1851, Annals and Magazine of Natural History (2) **8**, p. 382.

Anchomasa pennantiana Leach 1852, Synopsis of the Mollusca of Great Britain, p. 253 (Kingsbridge Estuary and Sussex, England).

Zirfaea callosa 'Lamarck' Chenu 1862, Manuel de Conchyliologie **2**, p. 6, figs. 24–25.

Barnea (*Anchomasa*) *parva* Pennant, Tryon 1862, Proceedings Academy Natural Sciences Philadelphia, p. 209.

Barnea parva quadrangula Jeffreys 1865, British Conchology **3**, p. 110 (England).

Holopholas (*Anchomasa*) *parva* Pennant, Fischer 1886, Manuel de Conchyliologie, p. 1133.

Pholas duboisi Locard 1892, Les Coquilles Marines des Côtes de France, p. 246 (coast of France and English Channel).

Pholas (*Barnea*) *parva* var. *major* Pallary 1900, Journal de Conchyliologie **48**, p. 413, fig. 19 (St. Thérèse, Oran [Algeria]).

Distinctive characters. Shell strongly beaked anteriorly, narrowly rounded posteriorly, solid, with a large rounded condyle and a lanceolate protoplax.

Description. Shell reaching 38 mm. (about $1\frac{1}{2}$ inches) in length and about 16 mm. (about $\frac{1}{2}$ inch) in height, rather strong in structure, beaked anteriorly, rounded posteriorly, gaping at both ends and with the sculpture disappearing on the posterior slope. Color a dull chalky white. Umbos prominent and located near the anterior third of the shell. Umbonal reflections narrow, rather thick and raised above the umbos. Sculpture consisting of radial ribs and concentric ridges. Concentric ridges strongly laminated anteriorly, becoming weak on the disc and disappearing on the posterior slope. Radial ribs closely set on the anterior slope, barely visible on the disc and lacking on the posterior slope. Imbrications are produced where the concentric ridges and radial ribs cross one another. In most specimens the radial arrangement of the imbrications is the only evidence of the ribs. Sculpture beneath the umbonal reflection consisting only of laminated

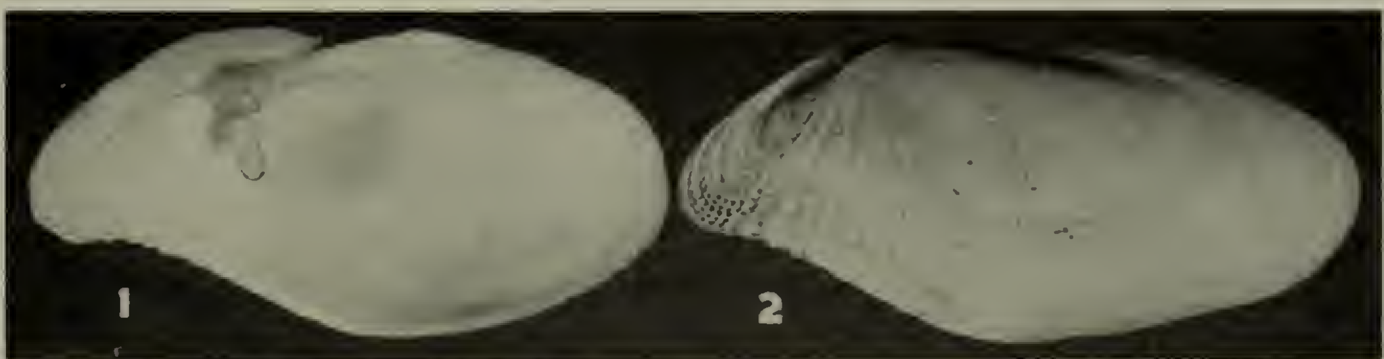

Plate 9. *Barnea parva* Pennant. Fig. 1. Nantes, France (2x). Showing the large knob-like condyle. Fig. 2. Tenby, Pembroke, Wales (2x).

ridges. Interior of shell white and glazed. Pallial sinus wide and deep, extending inwardly almost to the umbo. Pallial line and muscle scars barely visible on the specimens examined. Radial ribs visible internally on the anterior slope. Condyle knob-like, large and heavy and extending inward so that when the two valves are in juxtaposition they are quite widely separated along the dorsal margin. Apophysis narrow and thin. Protoplax lanceolate. Periostracum thin, and straw-yellow in color.

Siphons united and may be extended 1 to 2 times the length of the shell. They are thickly covered with small papillae, fawn-brown in color and have a narrow whitish band surrounding the openings. Incurrent siphon nearly three times the diameter of the excurrent siphon and with three large and several small ridges extending well down within. Excurrent siphon smooth internally. Internal surface of both siphons white to pale yellow. Foot and mantle white to pale yellow. Foot large, nearly circular in outline and truncate. The above description of the soft parts is based on preserved specimens received through the kindness of Dr. F. S. Russell, Director of the Plymouth Laboratory, England.

length	height	ratio h:l	
38.0 mm.	16.0 mm.	2.4	Nantes, France
35.5	16.0	2.2	Tenby, Pembroke, Wales
25.5	13.5	1.8	Plymouth, England
24.0	12.0	2.0	Plymouth, England
22.5	12.0	1.8	Tenby, Pembroke, Wales

Types. The type of *Barnea parva* Pennant is probably in the British Museum. According to Sherborn 1940, the collections of Pennant were deposited in the British Museum in 1912. The type locality is Abergelli [Abergele] in Denbighshire, Wales. The locations of the type specimens of most of the species now considered synonyms of *Barnea parva* Pennant are unknown.

Remarks. Barnea parva Pennant is the type of the subgenus *Anchomasa* and for this reason we include a description of it here. It is a rather small and variable species with an unusually heavy shell for a *Barnea* of this size. It is characterized by its pronounced beak, its closely packed concentric ridges and radial ribs, its prominent dorsal condyles and the narrowly rounded posterior margin. *Barnea parva* Pennant most nearly approximates *Barnea lamellosa* d'Orbigny of Argentina. The posterior margins of both species are rounded and tapering and in both, the hinge area is somewhat knob-like. *Barnea parva* Pennant, however, has a much heavier, more solid shell, with close-set laminated ridges and a simple non-lobed protoplax. From *Barnea truncata* Say which has also been found in the Eastern Atlantic on the African coast, *B. parva* Pennant is distinguished by its rounded posterior margin, more pronounced beaks, heavy shell, and more knob-like development of the hinge area.

Barnea parva Pennant is apparently a rather rare species with a somewhat restricted range. Forbes and Hanley 1853 state that while found with *Barnea candida*, *Pholas dactylus* and *Zirfaea crispata*, it is always far less abundant. It bores into soft sandstone, stiff clay and decaying waterlogged wood, the general shape and size of the specimen depending upon the hardness of the material into which it is boring. It is this variation that has, no doubt, been responsible for the large number of synonyms noted above. The specimens which Pennant cites in his original description as coming from wood taken at Pensacola, Florida, were no doubt malformed specimens of *B. truncata*. When boring in such hard material they often look very much like *parva*, but never are as heavy in structure nor do they possess the large knob-like condyles.

Dr. M. V. Labour[1] states that this species is common in the rocks at Rum Bay, Plymouth, England and that they appear to breed in summer and early autumn. She reared the larvae to the first shell stage and described and figured them. Like most bivalves, the larval shell is very small, being only .08 mm. in length and extremely simple in structure. When .32 mm. in length, it begins to assume the adult form, developing an anterior portion which is imbricated and suitable for boring, and a posterior portion for the protection of the siphons.

Range. Southern British Isles south to Oran, Algeria (Pallary).

Specimens examined. WALES: Tenby, Pembroke (MCZ). ENGLAND: Tor Bay, Devon (Charleston Museum): Brighton, Sussex (W. J. Eyerdam): Plymouth (Plymouth Lab.). FRANCE: Nantes (MCZ). La Rochelle (USNM).

Barnea (Anchomasa) lamellosa *d'Orbigny*

Plates 8 and 10

Pholas lamellosa d'Orbigny 1846, Voyage Amérique Méridionale **5**, pt. 3, Mollusques, p. 498, pl. 77, figs. 20–21 (shore of Patagonia to the south of Río Negro).

Barnea (*Anchomasa*) *subtruncata* var. *lamellosa* d'Orbigny, Lamy 1925, Journal de Conchyliologie **69**, p. 82.

Barnea (*Anchomasa*) *subtruncata lamellosa* d'Orbigny, Carcelles 1944, Revista Museo de la Plata (n.s.) Zoologia **3**, p. 295, pl. 14, figs. 108–109; Carcelles 1950, Anales del Museo Nahuel Huapi **2**, p. 82.

Distinctive characters. Shell white, beaked anteriorly, rounded posteriorly, with the umbonal reflections free for their entire length, with a large rounded condyle and a single dorsal plate, the protoplax, which is strongly keeled and eared posteriorly.

Description. Shell reaching about 43 mm. ($1\frac{3}{4}$ inches) in length and about $18\frac{1}{2}$ mm. (about $\frac{3}{4}$ inch) in height, thin, frail, pointed anteriorly, rounded posteriorly, gaping at both ends, and with the sculpture disappearing on the posterior slope. Color a dull chalky-white. Umbos prominent, partially covered by the umbonal reflections and located near the anterior third of the shell. Umbonal reflection free for its entire length, the space

Plate 10. *Barnea lamellosa* d'Orbigny, Mar del Plata, Argentina (2x). Fig. 1. Showing the free umbonal reflection and high posterior slope. Fig. 2. Showing the muscle scars and apophysis.

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[1] Labour, M.V. 1933, Journal of the Marine Biological Association of the United Kingdom **23**, no. 1, pp. 132–135.

between it and the umbo being very small in young specimens and increasing slightly in older shells. Sculpture consisting of rather strong concentric ridges and moderate to rather weak radial ribs. Concentric ridges laminated anteriorly, becoming smoother and weaker posteriorly until they are nearly obsolete on the posterior slope. Radial ribs generally rather weak and in adult specimens usually completely lacking on the posterior slope. Imbrications are produced where the radial ribs and concentric ridges cross. The strength of these imbrications varies greatly depending on the age of the specimen and the strength of the ribs. On young specimens (up to 12 mm. in length) they may even be present on the posterior slope. In the rather small series available for study the radial arrangement of the imbrications was the only evidence of the existence of the radial ridges, there being no trace of them between the crests of the concentric ridges. Sculpture below the umbonal reflection composed of crowded laminated growth lines. Interior of shell white and glazed, with the concentric lines and ridges showing through the shell. Pallial sinus nearly as wide as the shell is high and extending inward nearly half the distance to the umbo. Apophyses narrow, flattened, and extending downward about $\frac{1}{3}$ of the way to the ventral edge of the shell.

Protoplax lanceolate with a posterior nucleus and well marked growth lines, pointed anteriorly, broad and eared posteriorly, strongly keeled, and with a strong hook at the posterior end which fits over the prominent umbos. Pedal gape rounded anteriorly, pointed posteriorly and extending backward about one half the length of the shell. Periostracum very thin, straw-yellow and deciduous.

The siphons are united and may be extended 4 to 5 times the length of the shell. The covering of the siphonal tubes in preserved material is medium to dark-brown in color and papillose. There are 8 to 10 short stout papillae surrounding the end of the incurrent siphon. These papillae extend inside as marked white ridges almost the entire length of the incurrent siphon, the spaces between the ridges a dark red-brown. The excurrent siphon lacks papillae and is smooth within. The strongly muscular mantle collar surrounding the foot and forming the pedal gape is notched anteriorly at the ante-umbonal gape.

length	height	ratio h:l	
42 mm.	19 mm.	2.2	Mar del Plata, Argentina
38	15	2.5	Puerto Quequen, Buenos Aires, Argentina

Types. The holotype of *Barnea lamellosa* d'Orbigny is in the British Museum, according to Gray 1854, List of the Shells of South America in the Collection of the British Museum Collected and Described by M. Alcide d'Orbigny, p. 55. The type locality is the mouth of the Río Negro, Argentina.

Remarks. *Barnea lamellosa* d'Orbigny is close in its relationship to *B. truncata* Say. It differs, however, in being more rounded rather than truncate posteriorly, in having the umbonal reflection free for its entire length and in having the protoplax strongly keeled, more pointed anteriorly and eared posteriorly. *Barnea lamellosa* d'Orbigny also appears to be a much smaller species and to have much weaker sculpture with more closely set concentric ridges than *B. truncata* Say. See also remarks under *B. parva* Pennant.

Though specimens of *B. lamellosa* are exceedingly rare in museum collections in this country, it is probably not a rare species. It has a limited distribution and is further restricted by its specialized habitat of mud and peat areas. Through the kindness of A. Carcelles we have had specimens from several localities in Argentina for study. We agree with Carcelles that this species is not the same as the one found in Peru, as has been stated by several authors. This species has a characteristic eared protoplax, a heavy condyle and a much more rounded posterior margin than *B. subtruncata* Sowerby, the Eastern Pacific species.

Range. From off Cabo Polonio, Uruguay south to Golfo Nuevo, Argentina.

Specimens examined. URUGUAY: Off Cabo Polonio (S. Lat. 34°42′; W. Long. 54°10′) (A. Carcelles). ARGENTINA: Mar del Plata; Bahía Blanca; Puerto Quequen; Canal la Manuelita; Puerto Belgrano; Bahía San Blas, all in the State of Buenos Aires; 5 miles south of Punta Medano, Río Negro; Puerto Madryn and Golfo Nuevo, Chubut (all A. Carcelles). Río Negro (USNM).

Barnea (Anchomasa) truncata *Say*
Plates 8 and 11 to 13

Pholas truncata Say 1822, Journal Academy Natural Sciences Philadelphia **2**, p. 321 (southern coast of United States).

Pholas (*Cyrtopleura*) *truncata* Say, Tryon 1862, Proceedings Academy of Natural Sciences Philadelphia **14**, p. 202.

Barnea truncata Say, Dall 1898, Transactions Wagner Free Institute of Science, Philadelphia **3**, part 4, p. 816.

Barnea (*Cyrtopleura*) *truncata* Say, Lamy 1925, Journal de Conchyliologie **69**, p. 87.

Distinctive characters. Shell beaked anteriorly, truncate posteriorly, sculpture greatly reduced or entirely lacking on the posterior slope, and with a single dorsal plate, the protoplax.

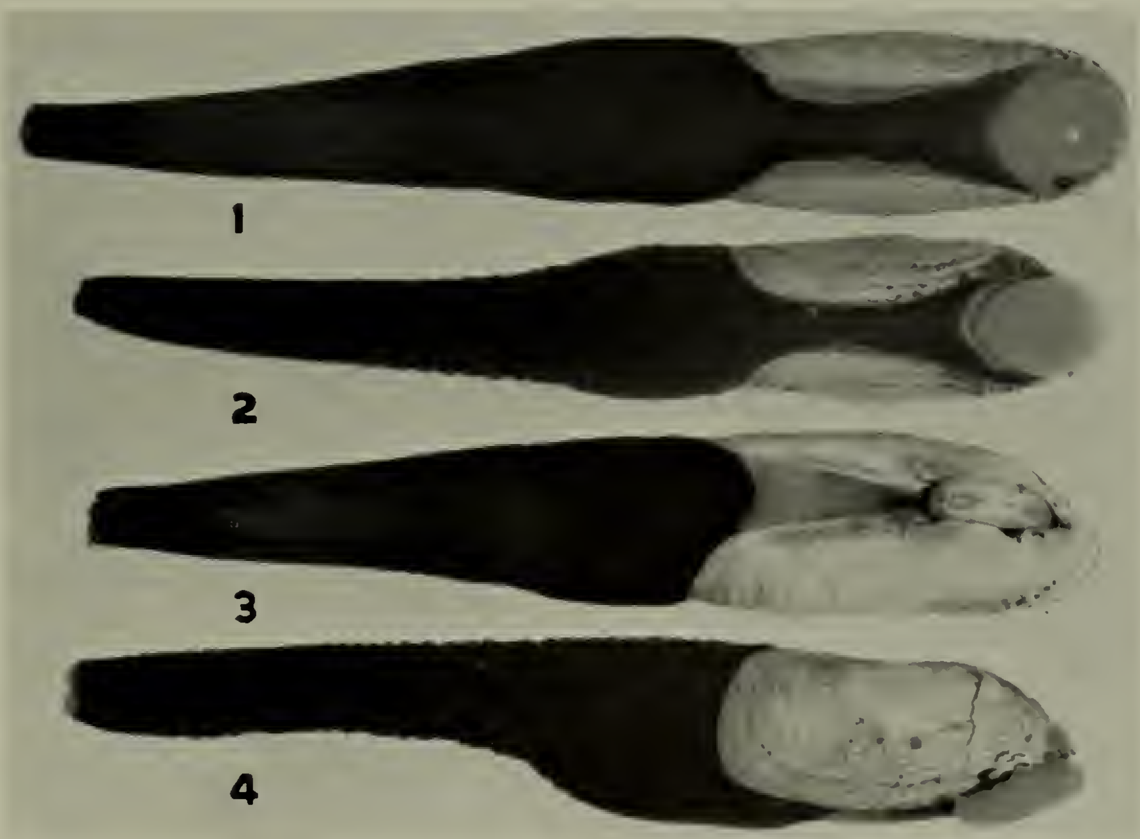

Plate 11. *Barnea truncata* Say. Woods Hole, Massachusetts (natural size). Living specimens photographed in test-tubes. Fig. 1. Ventral view of specimen in a more or less relaxed condition with the longitudinal muscles slightly contracted and showing the extent to which the valves can be separated. Fig. 2. With foot well extended and the longitudinal and circular muscles of the siphons moderately contracted. Fig. 3. Dorsal view showing the protoplax in place and the extent to which the valves can be separated dorsally. Fig. 4. Side view showing the extended foot and the circular muscles of the siphons contracted.

Description. Shell reaching 70 mm. (about $2\frac{3}{4}$ inches) in length and 25 mm. (about 1 inch) in height, light in structure, beaked anteriorly, gaping at both ends and with the sculpture disappearing on the posterior slope. Color a dull chalky-white. Umbos prominent and located near the anterior third of the shell. Umbonal reflections rather closely appressed over the umbos but free anteriorly. Sculpture consisting of radial ribs and concentric ridges. The concentric ridges strong and laminated anteriorly, becoming gradually weaker posteriorly until they are nearly obsolete on the posterior slope. Radial ribs fairly strong on the anterior slope, diminishing in strength on the disc and completely lacking on the posterior slope. Imbrications are produced where the radial ribs and concentric ridges cross. In some specimens, the radial arrangement of these imbrications is the only evidence of the existence of the radial ribs. The degree of sculpturing below the umbonal reflection varies greatly, even among specimens from the same locality, ranging from very weak growth lines to sculpture almost as strong as that on the anterior slope. Interior of the shell white and glazed. Pallial sinus nearly as wide as the shell is high and extending within nearly half the distance to the umbo. Pallial line and muscle scars clearly indicated especially on older specimens. Apophyses long, narrow, curved and blade-like, occasionally broadening slightly at the free end. Protoplax broadly lanceolate, with a posterior nucleus and well marked growth lines. It is curved downward at its posterior extremity to fit over the umbo. Periostracum thin, straw-yellow to light-brown in color and deciduous.

Siphons united and enclosed in a tough, brown, papillose sheath, the incurrent siphon being a little larger than the excurrent. They may be extended 10 to 12 times the length of the shell, and, when fully extended, the periostracal covering is so stretched that they appear a light brownish-gray to white. However, on contraction they become a uniform dark brown their entire length. Incurrent siphon fringed with 8 to 10 short, stout, unbranched papillae. Between these papillae there are brown to mahogany-red markings which extend down inside the siphon. The excurrent siphon lacks the papillae but usually possesses the brown internal markings. The dark periostracal covering extends anteriorly between the valves on the ventral surface so that only the immediate area surrounding the foot is white. Foot white, oval in outline and truncate.

length	height	ratio h:l	
70.0 mm.	27.0 mm.	2.6	Duxbury, Massachusetts
66.5	26.5	2.5	Sarasota, Florida
62.0	29.5	2.1	Mattituck, Long Island, New York
59.0	25.0	2.4	Duxbury, Massachusetts
54.0	23.0	2.3	Cotype
47.0	21.5	2.2	Marion, Massachusetts
44.5	20.0	2.2	Newport, Rhode Island

Types. A probable cotype of *Pholas truncata* Say is in the Academy of Natural Sciences Philadelphia, no. 50775, a specimen received from Mrs. Say. Say's type locality was simply the southern coast of the United States. We here restrict the type locality to Charleston, South Carolina, a region from which Say received much material.

Remarks. Barnea truncata Say is very close in its relationship to *B. subtruncata* Sowerby from the Eastern Pacific. It is, however, generally a smaller, more fragile shell, with less inflated valves and shorter post-umbonal length. In addition, the protoplax is less tapering. In most of the above shell characters, however, there are intergrades, though in a large series the two forms appear quite distinct. For additional remarks on relationship to the west coast form see under *B. subtruncata* Sowerby. See also remarks under *Barnea lamellosa* d'Orbigny.

Specimens of *Barnea truncata* Say are found in mud, clay and peat deposits along the coast from Maine to Brasil wherever strictly marine conditions exist. The distribution of this species north of Cape Cod is extremely local and specimens from Maine, the northern limit of its range, are exceedingly rare. The species again becomes rare on the southern end of its range. It would appear that in this area they are probably living in deeper water, and being deep borers the shells seldom get washed ashore. Harold W. Harry[1] reports that *Barnea truncata* was found commonly in the beach drift at Timbalier Island and Caminada, Louisiana. However, to our knowledge, no living specimens have been collected in the northern Gulf or in the West Indies.

Large specimens of *B. truncata* may bore holes nearly a foot or more in depth and though usually found inhabiting the intertidal region they occasionally may be found at considerable depths. Small specimens of this species were found in a piece of waterlogged wood tossed up on the beach at Cape Canaveral, Florida. These specimens were stunted and malformed, the wood being much harder than the material into which they normally bore. A similar malformed specimen in the collection of the Charleston Museum was labeled as boring in rock in Charleston Harbor. This was probably the hard marl or phosphate rock of that area, a substance much too hard for *B. truncata* to bore into successfully. The beaks of these specimens were greatly produced, the rows of imbrications exceedingly close together, and the posterior slope much reduced in size. Specimens from several localities on the west coast of Florida in the vicinity of Sarasota appear to be some-

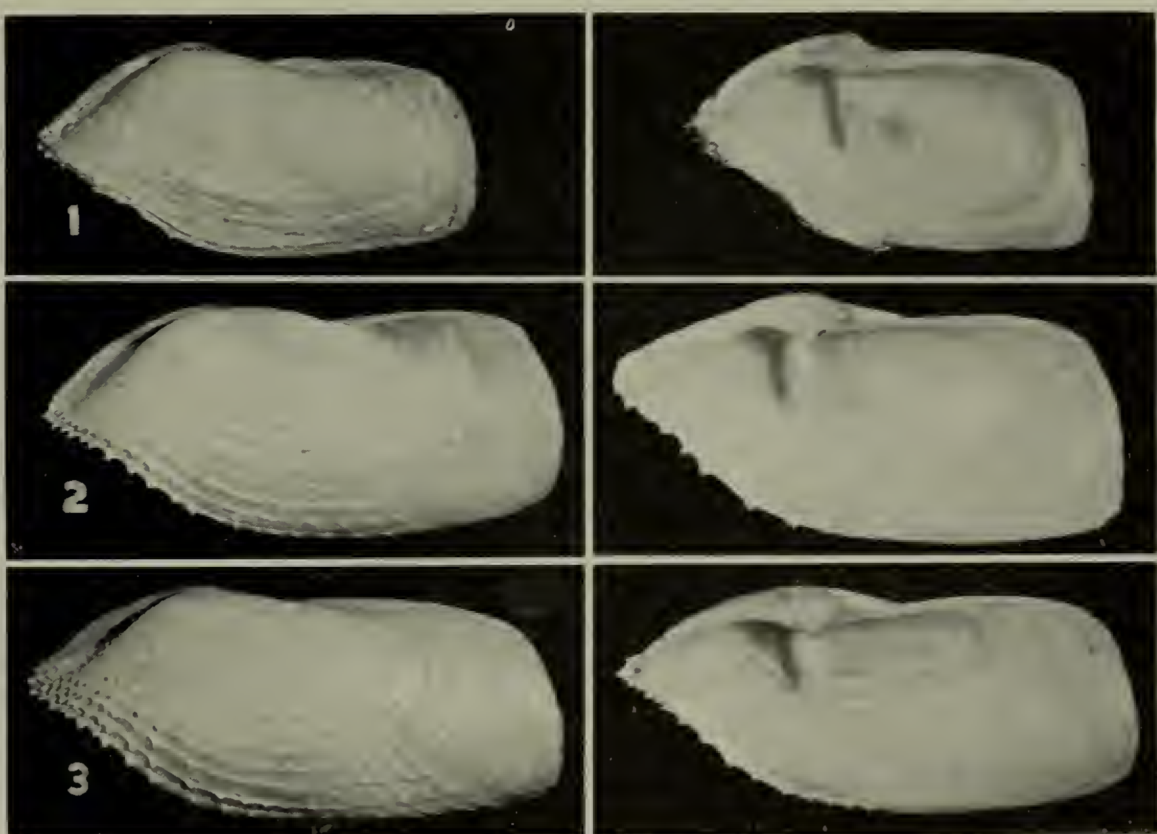

Plate 12. *Barnea truncata* Say. Figs. 1, 3. Newport, Rhode Island. Fig. 2. Duxbury, Massachusetts. Selected series to show variation in the length-height proportion (all natural size).

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[1] Harold W. Harry 1942, Occasional Papers Marine Laboratory, Louisiana State University, Baton Rouge, Louisiana, no. 1, p. 3.

what longer in proportion to their height and to have the posterior margin more rounded than the typical form. This may be due to ideal conditions of the substrata and a good food supply so that the specimens grew more rapidly than usual.

Edward Sylvester Morse found that the animals when cooked were quite edible, but had a peculiar smoky taste.

Addison E. Verrill (1873), appears to have confused the soft parts of *Barnea truncata* and *Zirfaea crispata*, for he describes the siphons of *truncata* as "generally yellowish-white except at the very end, where they are blackish or brownish; the orifices and papillae are also variously marked with purplish brown or dark brown. The dark coloration at the end of the siphon tubes is doubtless for purposes of protection from predaceous fishes, crabs, etc." This description fits perfectly the siphons of *Z. crispata*, but the siphons of *B. truncata* are a uniform grayish-brown their entire length.

Range. Western Atlantic: Maine (C. W. Johnson) south to the Gulf of Mexico, probably in restricted localities throughout the West Indies, and south to Sepetiba Bay, Rio de Janeiro, Brasil.

Eastern Atlantic: From Bel Tir, Dakar, Sénégal south to Accra, Gold Coast.

Specimens examined. Western Atlantic: Massachusetts: Salem (MCZ; USNM); Chelsea Beach (USNM); Scituate; Duxbury; Marion; Dennisport; West Harwich; Hyannis; Woods Hole (all MCZ); Lagoon Pond, Marthas Vineyard; Cuttyhunk Island (both G. Moore); New Bedford (ANSP). Rhode Island: Newport; Warren (both

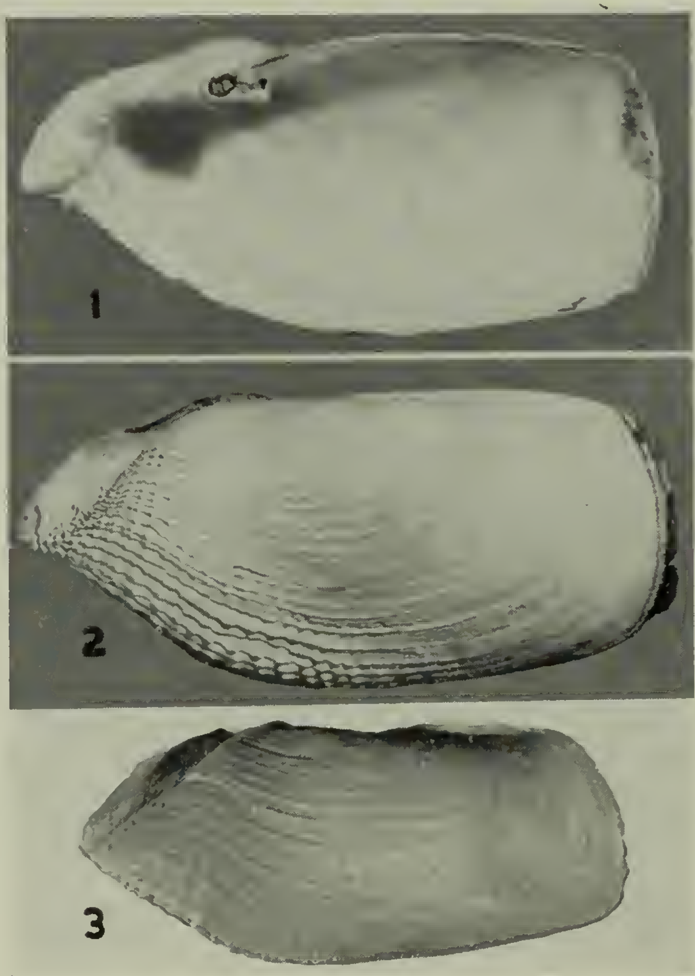

Plate 13. *Barnea truncata* Say. Figs. 1–2. Cotype, from South Carolina (about 1.2x). Fig. 1. Showing muscle scars and pallial sinus. (Apophysis lost.) Fig. 3. Accra, Gold Coast, Africa (natural size).

MCZ): Bristol (AMNH). CONNECTICUT: New Haven (USNM); Branford (MCZ). NEW YORK: Orient and Barren Island, Long Island (both R. Latham); Mattituck Creek, Mattituck and Plum Island, Long Island (both AMNH); Lido Beach, near Atlantic Beach, Long Island (M. K. Jacobson); Staten Island (MCZ; USNM; Univ. of Michigan). NEW JERSEY: Point Pleasant; Sea Isle City (both ANSP); Atlantic City (USNM; ANSP); Cape May (MCZ; USNM; ANSP; Univ. of Michigan); Great Egg Bay (USNM). VIRGINIA: Hog Island, Eastern Shore (USNM). NORTH CAROLINA: Fort Macon (MCZ); Beaufort (MCZ; USNM). SOUTH CAROLINA: Myrtle Beach; Pawleys Island; Isle of Palms; Sullivans Island; Folly Island; Magnolia Beach (all Charleston Museum); Charleston Harbor (Charleston Museum; USNM). GEORGIA: Sea Island, St. Simons Island (USNM; ANSP); Savannah (USNM). FLORIDA: St. Augustine (USNM); Daytona Beach; Cocoa (both MCZ); Flagler Beach; Cape Sable (both Univ. of Miami); Pavilion Key; Lossmans Key (both D. and N. Schmidt); Sanibel Island (MCZ; USNM); Sarasota; Anna Maria Island (both R. Stewart); Bradenton Beach (A. Koto; D. and N. Schmidt); Boca Ciega Bay, St. Petersburg (Univ. of Michigan); Clearwater Beach (ANSP); Port St. Joe (A. Merrill). TEXAS: Sand Point, Calhoun Co.; Carancahua Bay, Matagorda Bay (both USNM). HISPANIOLA: Monte Cristi, Santo Domingo (MCZ). TRINIDAD: Moruga (H. G. Kugler). BRASIL: Parada Sahy, Sepetiba Bay, Rio de Janeiro (H. S. Lopes).

EASTERN ATLANTIC. SENEGAL: Bel Tir, Dakar (Institut Français d'Afrique Noire). GOLD COAST: Accra (MCZ).

Barnea (Anchomasa) subtruncata *Sowerby*

Plates 8 and 14 to 16

Pholas subtruncata Sowerby 1834, Proceedings Zoological Society London, p. 69 (Insula Platae, Columbiae Occidentalis [Ecuador].

Pholas spathulata Deshayes 1843, Magasin de Zoologie (par Guérin-Méneville) (2) **5**, Mollusques, pl. 79 (Seas of Chile); non *Pholas spathulata* Sowerby 1849.

Barnea pacifica Stearns 1871, Conchological Memoranda no. 7, p. 1 (Preliminary description); Stearns 1873, Proceedings California Academy of Science **5**, p. 81, pl. 1, fig. 6, 6a–c (Alameda, San Francisco Bay, California); Stearns 1891, Proc. United States National Museum **14**, p. 314.

Barnea (*Cyrtopleura*) *spathulata* Deshayes, Lamy 1925, Journal de Conchyliologie **69**, p. 89.

Barnea pacifica Stearns, Hertlein and Strong 1950, Zoologica **35**, p. 248.

Distinctive characters. Shell beaked anteriorly, broadly rounded to truncate posteriorly, with the sculpture usually lacking on the posterior slope, and with a long narrow acuminate protoplax.

Description. Shell reaching 67 mm. ($2\frac{5}{8}$ inches) in length and 27 mm. (about 1 inch) in height, light in structure, beaked anteriorly, gaping at both ends and with the sculpture disappearing on the posterior slope. Umbos prominent, usually located near the anterior fourth of the shell. Umbonal reflections closely appressed over the umbos, free anteriorly. Sculpture consisting of concentric ridges and radial ribs. Concentric ridges low, usually rather widely spaced, laminated and scalloped anteriorly, becoming much weaker on the disc and evident only as growth lines on the posterior slope. Radial ribs moderate in strength on the anterior slope, weak on the disc and completely lacking on the posterior slope. Broad and rather weak imbrications are produced where the concentric ridges and radial ribs cross one another. Sculpture beneath the umbonal reflection generally consists of crowded and weak concentric ridges. Interior of shell white and glazed. Muscle scars and pallial lines clearly indicated. Pallial sinus broad and extending inward nearly half the distance to the umbo. Apophyses long, narrow and curved inwardly. Protoplax lanceolate in outline, usually rather broad and truncate posteriorly, acuminate anteriorly, with a posterior nucleus and well marked growth lines. Periostracum thin on the anterior slope, rather heavier posteriorly and ranging from a straw-yellow to a dark-brown in color.

Siphons enclosed in a sheath which ranges from a dark red-brown to dark-gray in color, and usually with a narrow white tip at the posterior extremity, minutely papillose the entire length. In some specimens the dark papillose covering is worn off on the tops of the ridges, giving the specimen a mottled appearance. Incurrent siphon much larger than the excurrent and with two large dorsal ridges and ten small ridges running the entire length of the siphon internally. The interior of the siphon a deep mahogany-red posteriorly, becoming less intense as it extends forward. The exhalant siphon has one large ventral ridge and eleven small ridges internally: the dark-mahogany coloring stopping abruptly just a short distance inside the siphonal opening. These ridges terminate at the opening of the siphon in unbranched papillae. The dark periostracum extends anteriorly between the valves so that only the immediate area surrounding the foot is devoid of periostracum and is white in color. The above description of the animal was based on specimens preserved in alcohol.

length	height	ratio h:l	
73.0 mm.	21.0 mm.	3.5	Alamitos Bay, California
68.0	25.0	2.7	Anaheim Bay, California
66.5	25.0	2.6	" " "
63.0	26.5	2.3	Lectotype of *B. pacifica* Stearns
62.0	31.5	2.0	Lido Island, Newport Bay, California
61.0	22.5	2.7	Alamitos Bay, California
55.5	26.5	2.1	Anaheim Bay, California
55.5	25.5	2.1	Payta, Peru
53.5	25.0	2.1	Anaheim Bay, California

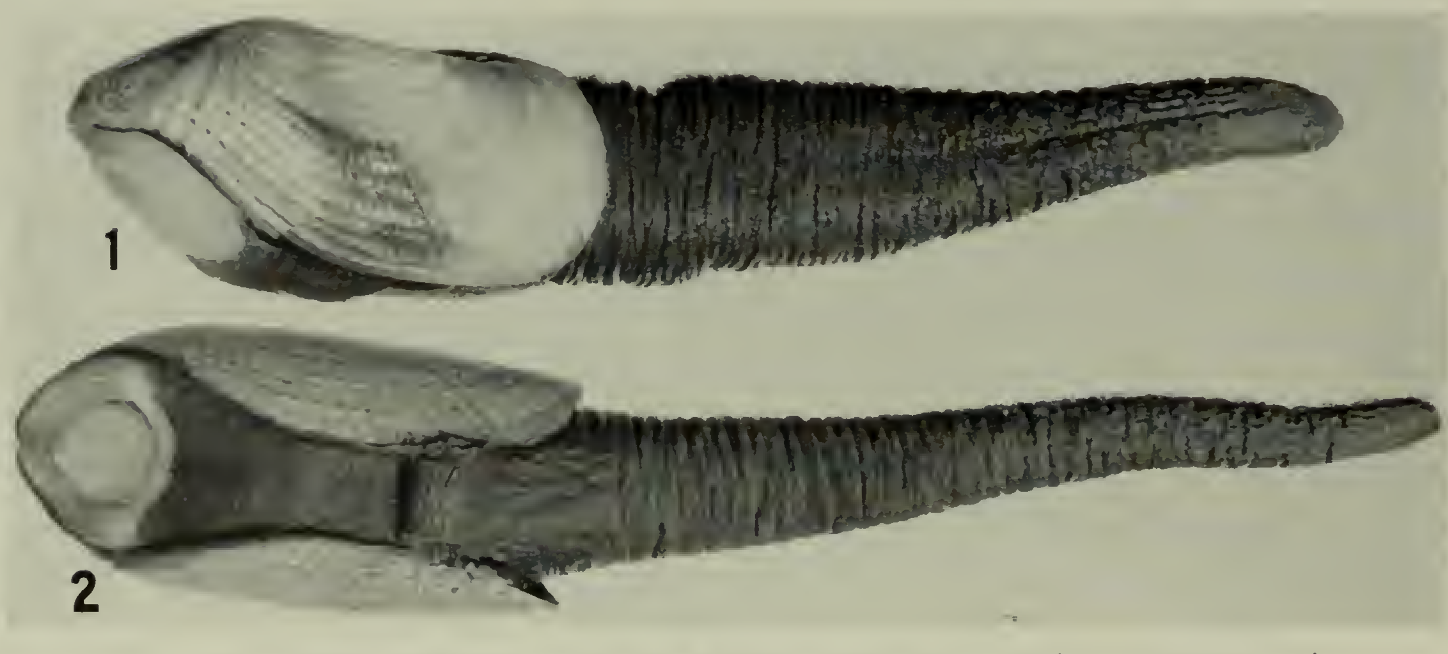

Plate 14. *Barnea subtruncata* Sowerby. Alamitos Bay, California (about natural size). Photograph supplied by John E. Fitch, California Fisheries Laboratory.

Types. The type of *Pholas subtruncata* Sowerby according to Mr. G. L. Wilkins of the British Museum is no longer in existence. The type locality is Insula Platae, Columbiae Occidentalis [Isla la Plata, Ecuador]. The type of *Pholas spathulata* Deshayes is in the Paris Museum according to Lamy (1925, p. 89) and in accordance with Lamy we here restrict the type locality to Payta, Peru. The lectotype of *Barnea pacifica* Stearns from Alameda, San Francisco Bay, California is in the United States National Museum no. 74717, paratypes are in the California Academy of Science and the Museum of Comparative Zoölogy.

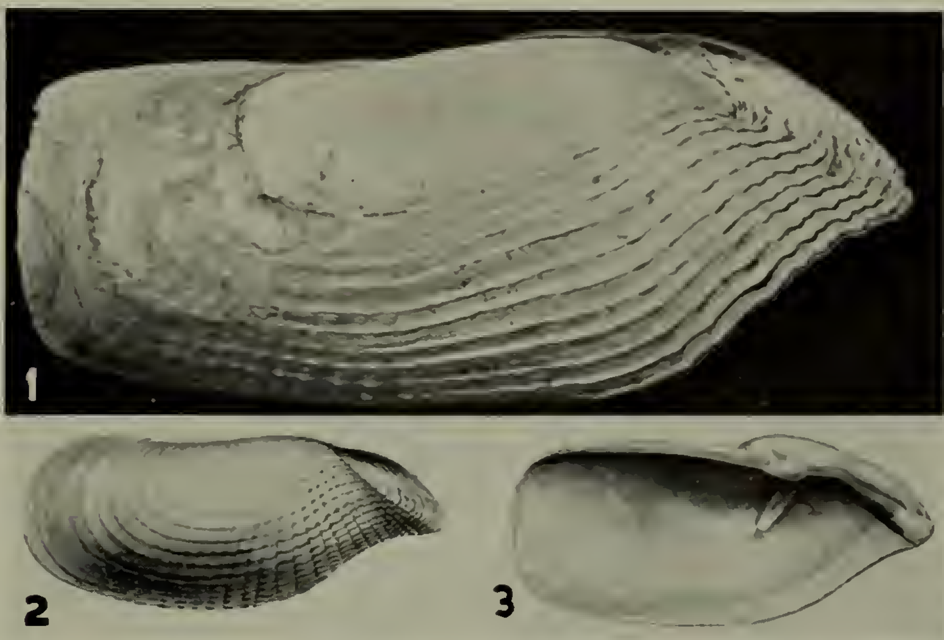

Plate 15. *Barnea subtruncata* Sowerby. Fig. 1. Lectotype of *Barnea pacifica* Stearns (= *Barnea subtruncata* Sowerby) San Francisco Bay, Alameda, California (about $1\frac{1}{2}$x). Figs. 2–3. Copies of the original figures of *Barnea spathulata* Deshayes from the Magazine de Zoologie (2) 5, p. 79 (= *Barnea subtruncata* Sowerby), from Payta, Peru.

Remarks. Barnea subtruncata Sowerby is in all respects very closely related to *B. truncata* Say of the Western Atlantic. Adult shells of *B. subtruncata* Sowerby are usually larger in size and are generally slightly longer posterior to the umbo. The protoplax is usually narrower in proportion to its length and more acuminate anteriorly. In addition, the siphons of the west coast species are somewhat darker in color, as well as being more strongly ridged and colored internally. The siphons of *B. truncata* are nearly smooth internally and usually have medium brown color markings.

Barnea subtruncata Sowerby appears to be the earliest name for this species. Unfortunately the type is not in existence and Sowerby's description is poor. He compares *B. subtruncata* with *B. parva* of England, a species close in its relationship with the present form, and so far as is now known there is only one species in the Eastern Pacific that could be compared with the European species. There seems to be no question that *B. spathulata* Deshayes and *B. pacifica* Stearns refer to the same species, for both Stearns (1891) and Dall (1909) refer to the Peruvian species as *B. pacifica* and give the range as from California to Chile. Consequently on the basis of the material now available and considering our present knowledge of the distribution of the group, these three names all seem to refer to the same species.

Barnea subtruncata, like its Western Atlantic relative *B. truncata* Say, is an extremely variable species both in appearance and habit. These clams are found in mud, clay and peat deposits, but occasionally specimens bore into soft rock or waterlogged wood. These specimens are always more or less stunted, with more produced beaks, more closely set imbricated ridges and with the posterior slope reduced and more rounded. It was probably such a specimen upon which Sowerby based his description, as he said it was boring in soft stone.

Range. From Newport, Oregon south to Atacama Province, Chile (Gigoux 1934, Revista Chilena de Historia Natural **38**, p. 285).

Specimens examined. Oregon: Newport: Yaquina Bay (both ANSP). California: Alameda, San Francisco Bay (USNM): San Francisco Bay (MCZ: ANSP); Anaheim Landing (MCZ; USNM; ANSP); San Pedro Bay (MCZ; E. P. Chace): Lido Island, Newport Bay (E. Baker); Alamitos Bay (J. E. Fitch; E. P. Chace); Bolinas (ANSP); La Playa, San Diego (USNM). Mexico: Kino Bay, Sonora (ANSP); Mendina, Sinaloa (USNM). Galapagos Islands: (USNM). Peru: Payta (ANSP).

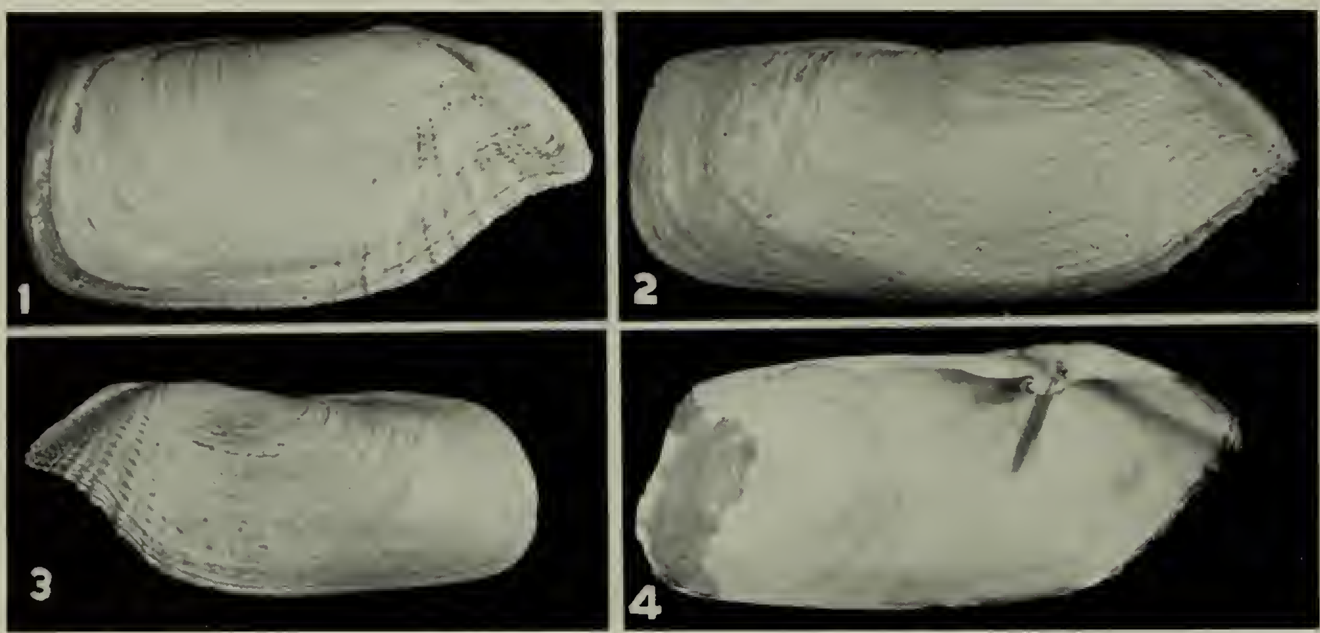

Plate 16. *Barnea subtruncata* Sowerby. Fig. 1. Payta, Peru. Figs. 2-4. Anaheim Bay, California. Figs. 1-3. These figures show the variation in the truncation of the posterior margin and the length of the postumbonal area. Fig. 4. Internal view to show the apophysis, muscle scars and the pallial sinus (all natural size).

Genus **Cyrtopleura** *Tryon*

Cyrtopleura Tryon 1862, Proceedings Academy Natural Sciences Philadelphia, p. 201.

Shells white, more or less elliptical in outline and rounded or beaked anteriorly. Pedal gape variable, ranging from a narrow slit to a broad oval. Accessory plates consisting of a protoplax and a mesoplax. Protoplax entirely chitinous or only slightly impregnated with calcium. Mesoplax transverse, in one or two pieces, calcareous and solid. Umbonal reflections simple, rather narrow, raised well above the umbos and with posterior supports. Sockets are formed in the posterior supports for the reception of the forward extension of the mesoplax. Space below the umbonal reflection not septate.

Genotype, *Pholas crucifera* Sowerby (=*Pholas cruciger* Sowerby), subsequent designation, Stoliczka 1870.

There are two subgenera in the genus *Cyrtopleura* and they may be differentiated as follows:

Shell rounded anteriorly with a slit-like pedal gape	*Scobinopholas*
Shell beaked anteriorly with an oval pedal gape	*Cyrtopleura* s.s.

Subgenus **Scobinopholas** *Grant and Gale*

Pholas Lamarck 1801, Système des Animaux sans Vertèbres, Paris, p. 127 (genotype, *P. costata* Linné, monotypic); non Lamarck 1799; non Linné 1758.

Pholas 'Linné' H. and A. Adams 1856, The Genera of Recent Mollusca **2**, p. 325 (genotype, *P. costata* Linné, subsequent designation, Bayle 1880); non *Pholas* Linné 1758; non Lamarck 1799.

Scobina Bayle 1880, Journal de Conchyliologie **28**, p. 242 (genotype, *Pholas costatus* Linné, original designation). [New name for *Pholas* H. and A. Adams; non Linné 1758.]

Scobinopholas Grant and Gale 1931, Memoirs San Diego Society Natural History **1**, p. 431 [new name for *Scobina* Bayle 1880; non *Scobina* Lepeletier 1825; non Wade 1917].

Subgenotype, *Pholas costatus* Linné, Bayle, original designation.

Shell rounded at both ends and having a long, narrow, slit-like pedal gape. Accessory plates consisting of a triangular to T-shaped, thin, largely chitinous protoplax and a heavy transverse calcareous mesoplax, which may be in one or two pieces. Umbonal reflections well separated from the surface of the umbos and supported at the posterior margins where they bend downward and form sockets for the reception of the forward extension of the mesoplax. Apophyses large, broad, and more or less spoon-shaped.

Cyrtopleura (Scobinopholas) costata *Linné*
Plates 17 and 18

Pholas costatus Linné 1758, Systema Naturae, ed. 10, **1**, p. 669 (Europe).

Capulus shreevei Conrad 1869, American Journal of Conchology **5**, p. 105, pl. 13, fig. 3 (Long Island, South Carolina). [This is the apophysis only.]

Scobina costata Linné, Bayle 1880, Journal de Conchyliologie **28**, p. 242.

Holopholas (*Scobina*) *costata* Linné, Fischer 1887, Manuel de Conchyliologie, Paris, p. 1133.

Pholas (*Barnea*, section *Scobinopholas*) *costatus* Linné, Grant and Gale 1931, Memoirs San Diego Society Natural History **1**, p. 431.

Distinctive characters. Shell oval in outline, rounded at both ends and with strong radial sculpture extending the entire length. Umbonal reflections well separated from the surface of the umbos. Protoplax triangular in outline and largely chitinous. Mesoplax calcareous, transverse and very solid. Apophyses large, broadly spoon-shaped and hollow at the upper end.

Description. Shell oval in outline, reaching about 183 mm. (about 7¼ inches) in length and 75 mm. (about 3 inches) in height, gibbose, rather light but strong, rounded at both ends, with a long narrow pedal gape, and with a strong radial sculpture covering nearly the entire shell. Color a chalky-white, with occasional specimens having irregular bands and markings of pink. Umbos prominent, rather broad, partially covered by the umbonal reflections and located near the anterior fourth of the shell. Umbonal reflections raised well above the surface of the umbos and having a single support at the posterior margin with sockets for the reception of the anterior projections of the mesoplax. Sculpture consisting of relatively weak concentric ridges and very strong radial ribs which exist over the entire length of the shell. Imbrications are formed where the concentric ridges and radial ribs cross one another. These imbrications are strong on the anterior and posterior slopes but are slightly reduced over the disc. Numerous fine growth lines are visible between the concentric ridges. Interior of the shell white and glazed. On occasional specimens there may be irregular bands and markings of pink. The external sculpture is clearly visible internally, giving the inside of the valve a ribbed and pitted appearance. Pallial sinus not apparent, but anterior and posterior adductor muscle scars are fairly well marked. Occasional specimens have a ledge built out below the posterior adductor muscle scar giving more area for the attachment of the muscle. Apophyses short, wide, broadly spoon-shaped and hollow at the end. They are marked with concentric growth lines and occasionally with longitudinal ridges. Protoplax large, thin, triangular in outline, composed largely of chitin, though in older specimens it is usually impregnated with a small amount of calcium. It is pointed and grooved anteriorly, broad and occasionally slightly lobed posteriorly. It has a central nucleus and faint to rather strong growth lines. Mesoplax transverse, more or less triangular in outline, solid, calcareous and in one piece. Periostracum thin, light straw-yellow and deciduous.

Siphons united, smooth, devoid of periostracum, grayish-white to light-ivory in color with an occasional specimen having a band of buff at the distal end. Incurrent siphon slightly shorter than the excurrent siphon but with a much larger aperture. Internally the incurrent siphon has two large dorsal ridges and six to eight small ridges which extend the entire length of the siphon. These ridges terminate at the opening in minute cirri. The area between the ridges is marked with mahogany-red vermiculations. Excurrent siphon edged with brown and colored for a short distance internally with a light straw-yellow. It has one large ventral ridge and numerous smaller ridges which extend but a short distance anteriorly. Mantle and foot white to light-ivory. Foot elliptical in outline and truncate.

length	width	ratio h:l	
183.0 mm.	72.0 mm.	2.54	Mount Hope Bay, Fall River, Massachusetts
165.5	58.5	2.82	Cedar Keys, Florida
147.5	50.0	2.95	Bradenton Beach, Florida
140.0	55.5	2.52	Clam Bayou, Sanibel Id., Florida
100.5	36.0	2.82	Galveston, Texas

Types. According to Hanley 1855, Ipsa Linnaei Conchylia, p. 24, Linné did not have a specimen of *C. costata* in his collection. His only reference was to Gualtieri 1742, Index Testarum Conchyliorum, plate 105, fig. G. We select this figure to represent the type, as it is on the basis of this figure that the species has been well understood. Linné's original locality of Western Europe was corrected to America by Gmelin in the 13th edition of the Systema Naturae in 1790. We here restrict the type locality to Charleston, South Carolina, a locality from which we have a good series and one from which specimens may have reached Europe at that early date.

Remarks. Cyrtopleura costata Linné is one of the largest, most easily recognized, and best known species in the Pholadidae. Adult specimens can be readily differentiated from all other species by their large size and by the coarse sculpture which covers the entire shell. Young specimens might be confused with *C. lanceolata* d'Orbigny, a much smaller species. However, this latter species has a much weaker sculpture and the radial ribs are completely lacking on the posterior slope. From *C. cruciger* Sowerby it differs by being rounded rather than beaked anteriorly and by having strong radial ribs on the posterior slope.

Cyrtopleura costata Linné has a wide distribution throughout the Western Atlantic and can be very abundant in certain restricted areas. These clams live in sandy mud at and just below low water mark in protected areas, or well below the low tide line on exposed outer beaches. They can burrow to a depth of two feet or more in the mud and are capable of moving up and down in their burrows at will. When undisturbed, the siphons are usually seen extending a short distance out of the burrow.

On the west coast of Florida, in an area extending from around Bradenton south to Englewood Beach, there are a number of colonies of *C. costata* in which many of the specimens are variously marked with a bright pink. This pink coloration may be in a broad band around the umbonal area or in a band near the ventral margin. In some specimens it is restricted to the posterior slope and in a few the protoplax may be pink. To date there is no explanation for this rather unusual expression of color in a family which is otherwise practically devoid of color.

Angel Wings, as this species is popularly called, are one of our most beautiful bivalves and are much sought after by collectors. They are considered an excellent food and have appeared on the markets, particularly in Cuba, though not recently.

Capulus shreevei Conrad, described from Long Island, South Carolina beach drift, appears to be nothing more than the apophysis of this species.

Dall 1889, Proceedings of the Academy of Natural Sciences Philadelphia, p. 274.

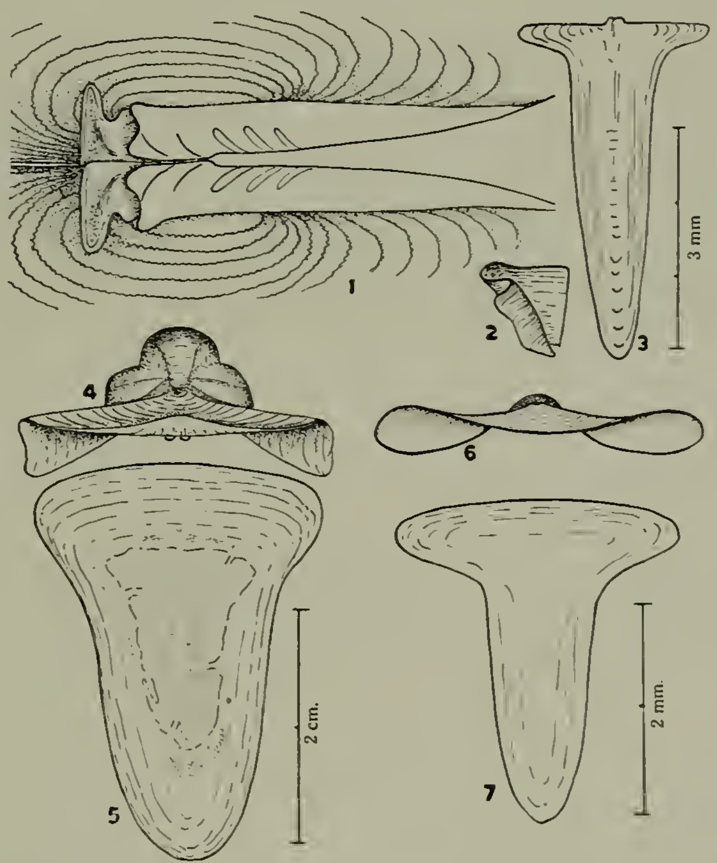

Plate 17. Dorsal plates of *Cyrtopleura*. Figs. 1–3. *Cyrtopleura lanceolata* d'Orbigny, off Cabo Polonio, Uruguay. Fig. 1. Dorsal view of umbonal region of opposed valves to show the divided mesoplax in place. Fig. 2. Dorsal view of the right half of the mesoplax. Fig. 3. Dorsal view of the thin chitinous protoplax. Figs. 4–5. *Cyrtopleura costata* Linné, Sanibel Island, Florida. Fig. 4. Dorsal view of heavy calcareous mesoplax. Fig. 5. Dorsal view of the flat, largely chitinous protoplax. The stippled portions indicate areas of calcification. Figs. 6–7. *Cyrtopleura cruciger* Sowerby, Pacific coast of Panama. Fig. 6. Dorsal view of mesoplax. Fig. 7. Dorsal view of the very thin and entirely chitinous protoplax.

gives a brief account of the gross anatomy of *C. costata*, and Kellogg (1915) discusses the ciliary mechanism.

Range. From Fall River, Massachusetts south through the West Indies to Rio de Janeiro, Brasil.

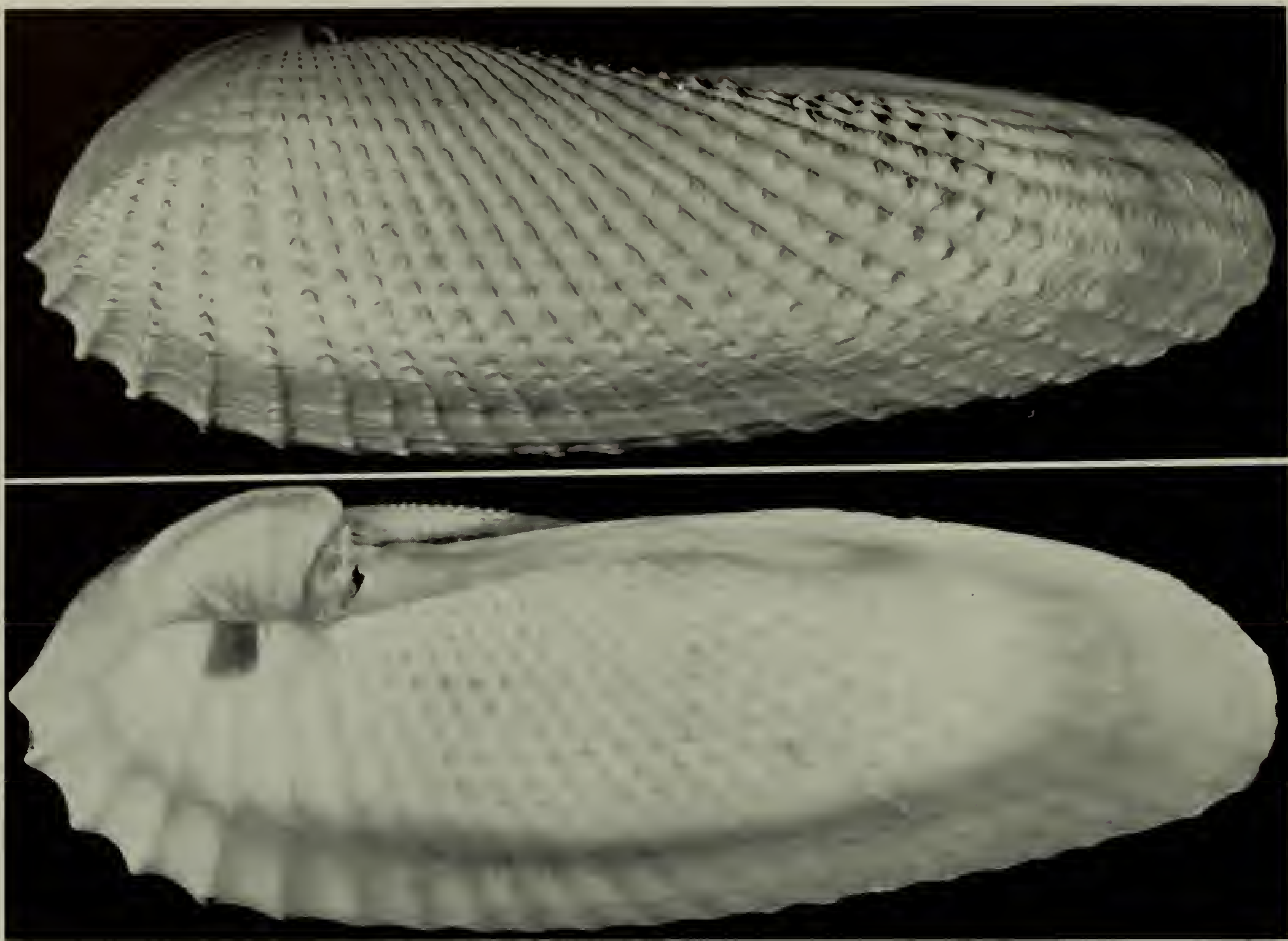

Plate 18. *Cyrtopleura costata* Linné, Bradenton, Florida. A specimen showing the band of pink color (natural size).

Specimens examined. MASSACHUSETTS: Fall River (J. Miller); New Bedford (MCZ; ANSP). NEW YORK: Long Beach Bay, Orient, Long Island (R. Latham). NEW JERSEY: Great Egg Harbor (USNM); Cape May (MCZ; ANSP); Sea Isle City (ANSP). DELAWARE: off New England Creek, Delaware Bay in 4 fathoms (USNM); Rehoboth Beach (ANSP). MARYLAND: off Wolf Trap Light, Chesapeake Bay in 9½ fathoms (USNM). VIRGINIA: Bryants Point, Severn River; Isaac's Island, Northampton County (both USNM); 10 miles south of Virginia Beach (MCZ); Buckroe Beach, Chesapeake Bay (USNM; ANSP); Hog Island, Eastern Shores (USNM). NORTH CAROLINA: Fort Macon, Beaufort; Long Beach, near South Port (both USNM); Cape Fear (ANSP). SOUTH CAROLINA: Myrtle Beach (ANSP); South Island, Georgetown County; Cape Romain; Isle of Palms; Folly Island; Bird Key (all Charleston Museum); Murrell's Inlet (A. Merrill); Bull's Island (J. L. Chamberlin); Sullivan's Island, Charleston (Charleston Mus.; MCZ; AMNH; USNM); Beaufort (MCZ; USNM); Ashe Island, Edisto River (ANSP). GEORGIA: St. Simons Island (MCZ; ANSP); Sea Island, St. Simons Island (USNM; ANSP); Savannah (USNM). FLORIDA: Atlantic Beach, near

Jacksonville (MCZ); St. Augustine (Univ. of Michigan; USNM; ANSP); Anastasia Island (ANSP); Daytona Beach (Univ. of Miami); Cape Canaveral; Cocoa Beach (both MCZ); Cape Sable (MCZ; N.E.Schmidt); Pavilion Key (MCZ); Naples; Caxambas Pass; Bunch Beach; Kice Island; Marco Island; Lemon Bay; Sarasota; Lossmans Key (all N. E. Schmidt); Sanibel Island (MCZ; USNM; ANSP); Punta Rassa (AMNH); Venice (A. Cahn); Bradenton (M. Teare; USNM); St. Petersburg (Univ. of Michigan; USNM; MCZ); Terra Ceia; Bonita Beach; Longboat Key; Sarasota (all USNM); Apalachicola Bay; Fort Myers Beach; Cape Romano (all ANSP); James Island, Franklin County (T. Pulley); Cedar Keys (USNM; ANSP). Alabama: Mobile Bay (MCZ); Fort Morgan; Little Lagoon, Gulf Shores (both H. I. Johnstone). Mississippi: Long Beach (ANSP); Deer Island, Biloxi (MCZ). Louisiana: Calasten Pass; Grand Lake (both USNM); Grand Isle (MCZ). Texas: Matagorda Bay; Keller Bay; Carancahua Bay (all USNM); 25 miles south of Port Arthur; near Corpus Christi (both MCZ); Galveston; High Island, Bolivar Peninsula; Boca Chica, near Brownsville (all T. Pulley); Gulf Beach, Port Isabel (L. A. Weisenhaus). Mexico: Tuxpam; Isla del Carmen, Campeche (both M. Bourgeois); Tampico, Tamaulipas; Boquilla de Piedras; Tecolutla; Nautla; Vera Cruz; Alvarado, all of the last four in the State of Vera Cruz (all T. Pulley). Cuba: Habana (MCZ); Mariel, Pinar del Río (C. G. Aguayo). Hispaniola: Monte Cristi, Santo Domingo (MCZ). Puerto Rico: Río Herrera near Loisa Vieja; Ponce (both MCZ). Lesser Antilles: Moruga, Trinidad (H. G. Kugler). British Guiana: 4 miles east of Georgetown (H. G. Kugler). Dutch Guiana: Matappica (C. Bayer). Brasil: Ilha de Itaparica, Bahía; Ilha do Cardoso, Cananea, São Paulo (both de Oliveira); Nova Almeida (MCZ); Aracaju, Sergipe; Parada Sahy, Sepetiba Bay, Rio de Janeiro (both H. S. Lopes); Rio de Janeiro (USNM).

Cyrtopleura (Scobinopholas) lanceolata *d'Orbigny*
Plates 17 and 19

Pholas lanceolata d'Orbigny 1846, Voyage Amérique Méridionale 5, pt. 3, Mollusques, p. 497, pl. 77, figs. 18–19 (L'Ensenada de Ros au Sud du Rio Negro, Patagonie).

Barnea lanceolata d'Orbigny, Tryon 1862, Proc. Academy Natural Sciences Philadelphia **14**, p. 208; Carcelles 1944, Revista del Museo de la Plata (n.s.) **Zoologia 3**, p. 295, pl. 14, fig. 110.

Distinctive characters. Shell lanceolate in outline and rounded at both ends. Radial sculpture weak and usually entirely lacking on the posterior slope. Protoplax T-shaped,

Plate 19. *Cyrtopleura lanceolata* d'Orbigny. Figs. 1–2. Monte Hermoso, Bahia Blanca, Buenos Aires, Argentina (natural size). Fig. 3. Mar del Plata, Buenos Aires, Argentina (hinge area enlarged to show apophysis).

entirely chitinous and very thin. Mesoplax in two pieces, calcareous and solid. Apophyses short, broad and flattened at the free end.

Description. Shell lanceolate in outline, reaching 69 mm. (about $2\frac{3}{4}$ inches) in length and 21.5 mm. (about $\frac{7}{8}$ inch) in height, thin, rounded to slightly angled anteriorly and narrowly rounded posteriorly. Pedal gape long and narrow, posterior gape slight. Color a dull chalky-white. Umbos prominent and located near the anterior third of the shell. Umbonal reflections well separated from the umbos, and with posterior supports which have sockets for the reception of the mesoplax. Sculpture consisting of well marked concentric ridges and rather weak radial ribs which are indicated mainly by the slight imbrications at the point where the radial ribs and concentric ridges cross. Radial ribs are lacking on the posterior slope in adult specimens but the concentric ridges are well marked. In young specimens, however, well developed imbrications are evident the entire length of the shell. Interior of the shell white and glazed. Pallial sinus wide and deep, extending inward about two thirds the distance to the umbo. Pallial line and muscle scars clearly indicated in older specimens. Apophyses short, broad, rather thin, fragile and flattened at the free end. Protoplax exceedingly thin, entirely chitinous and T-shaped. This protoplax is so thin and so closely attached to the muscle that it is easily overlooked. It curves slightly downward at its posterior extremity, has a posterior nucleus and faint growth lines which are visible when viewed with transmitted light. Mesoplax transverse, calcareous and in two parts. The anterior extensions of the mesóplax fit into sockets formed by the folds of the posterior supports of the umbonal reflections. Periostracum thin, light straw-yellow and deciduous.

Siphons united and covered by a light-brown, minutely papillose, chitinous sheath. Incurrent siphon with seven to eight large and several small, branched cirri surrounding the aperture. The excurrent siphon lacks cirri. Pedal gape and foot elliptical in outline. Foot and mantle white to light-ivory in color.

length	width	ratio h:l	
69.0 mm.	21.5 mm.	3.2	Monte Hermoso, Bahía Blanca, Buenos Aires, Argentina
56.5	18.0	3.1	Playa de Punta Medenas, Buenos Aires, Argentina

Types. The holotype of *Pholas lanceolata* d'Orbigny is in the British Museum, according to Gray 1854, List of the Shells of South America in the Collection of the British Museum Collected and Described by M. Alcide d'Orbigny, p. 55. The type locality is Ensenada de Ros south of Río Negro, Patagonia, Argentina.

Remarks. Cyrtopleura lanceolata d'Orbigny differs from *C. cruciger* Sowerby, with which it might be confused, by having the anterior end of the valves rounded rather than moderately beaked, by being lanceolate rather than oval in outline, by having a much weaker sculpture and by having the mesoplax in two pieces. From young specimens of *C. costata* Linné it may be distinguished by its weak radial sculpture which is lacking on the posterior slope, by its flat rather than spoon-shaped apophyses, by its proportionately longer anterior slope, and also by having the mesoplax in two pieces.

We know nothing of the biology of this species. It has seldom been recorded in the literature and there are but few specimens in the museums of this country. However, through the kindness of A. Carcelles, formerly of the Museo Nacional de Argentina, we have had a fine series to study.

Range. From Santos, Brasil south to the Gulf of San Matias, Argentina.

Specimens examined. Brasil: Santos (USNM); Frances Island, north of Santa Catharina Island, Estado Santa Catharina (H. Lopes). Uruguay: off Cabo Polonio (S. Lat. 34°42′; W. Long. 54°10′) (A. Carcelles). Argentina: Mar del Plata, Buenos Aires; Monte Hermoso, Bahía Blanca, Buenos Aires; Playa de Punta Medanos, Río Negro (all A. Carcelles); Buenos Aires (USNM); Carmen de Patagones, Buenos Aires (Univ. of Michigan; USNM); Río Negro (Redpath Museum, Montreal; USNM).

Subgenus **Cyrtopleura** *Tryon*

Cyrtopleura Tryon 1862, Proceedings Academy Natural Sciences Philadelphia **14**, p. 201.

Shell beaked anteriorly, rounded posteriorly, and having a broad oval pedal gape. Accessory plates consisting of a more or less T-shaped, chitinous protoplax and a transverse, calcareous mesoplax. Umbonal reflections well separated from the umbos and supported at the posterior margins where they curve downward and form sockets for the reception of the anterior extensions of the mesoplax. Apophyses broad and flattened.

Subgenotype, *Pholas crucifera* Sowerby (= *Pholas cruciger* Sowerby), subsequent designation, Stoliczka 1870.

Cyrtopleura (Cyrtopleura) cruciger *Sowerby*
Plates 17, 20 and 21

Pholas cruciger Sowerby 1834, Proceedings Zoological Society London, p. 69 (Puna Island in Gulf of Guayaquil and Bay of Caraccas [Caráques], West Colombia [Ecuador] and in the Gulf of Nocoiyo [Nicoya], Costa Rica).

Pholas crucifera Sowerby 1849, Thesaurus Conchyliorum **2**, pt. 10, p. 489 [error for *cruciger* Sowerby].

Pholas crucigera Sowerby 1849, Thesaurus Conchyliorum **2**, pt. 10, pl. 104, figs. 24–26 [error for *cruciger*, on plate caption only].

Pholas (*Cyrtopleura*) *crucifera* Sowerby, Tryon 1862, Proceedings Academy Natural Sciences Philadelphia, **14**, p. 201.

Cyrtopleura exilis Tryon 1870, American Journal of Conchology **5**, p. 170, pl. 14, fig. 2 (Ins. St. Croix [Virgin Islands], West Indies).

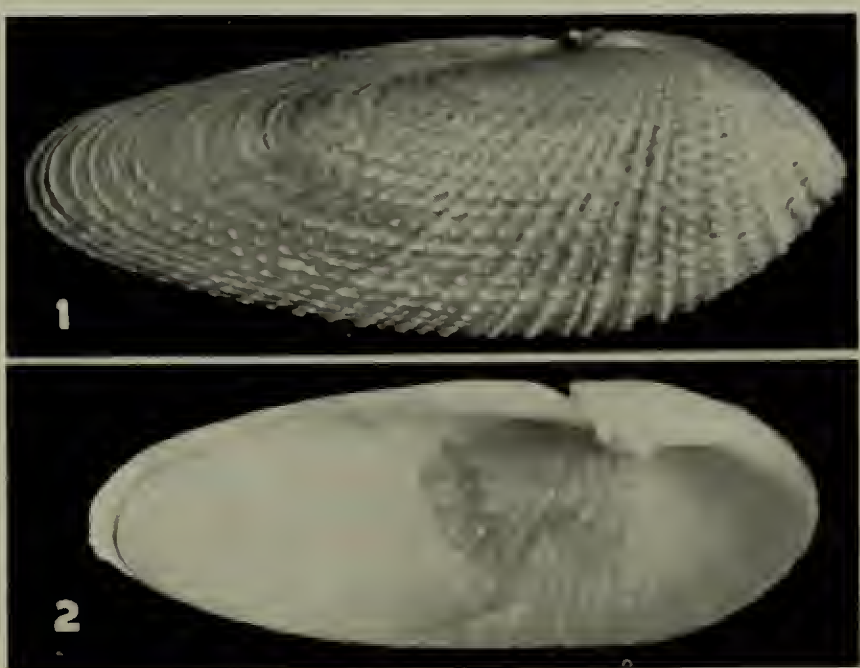

Plate 20. *Cyrtopleura exilis* Tryon (= *cruciger* Sowerby) St. Croix, Virgin Islands. Lectotype, ANSP 51040 (about 3x).

Distinctive characters. Shell beaked anteriorly, narrowly rounded posteriorly and with concentric sculpture extending over the entire surface of the shell. Radial sculpture strong on the anterior slope, becoming weak on the disc and lacking on the posterior slope. Accessory plates consisting of a very thin, chitinous, more or less T-shaped protoplax and a transverse mesoplax.

Description. Shell oval in outline, reaching about 44 mm. ($1\frac{3}{4}$ inches) in length and 18 mm. (about $\frac{5}{8}$ inch) in height, thin but strong, rounded posteriorly and with small rounded beaks anteriorly. Pedal gape large, generally oval in outline and tapering at both ends. Color a dull chalky-white to light-brown. Umbos prominent and located near the anterior third of the shell. Umbonal reflections well separated from the umbos and with a single support at the posterior margins where sockets are formed for the reception of the anterior projections of the mesoplax. Posterior to the umbo, the dorsal margin of the valve is reflected upward and outward forming a sharp angle with the margin of the umbonal reflection. Sculpture consisting of rather strong concentric ridges and radial ribs. Concentric ridges are well marked throughout the length of the shell, while the radial ribs are strong on the anterior slope, weak on the disc, and lacking on the posterior slope. Imbrications are formed where the concentric ridges and radial ribs cross one another. These imbrications are prominent on young and perfect specimens, but on worn adult specimens they may be indicated only as slightly roughened wavy lines. Sculpture below the umbonal reflection consisting of crowded concentric ridges. Interior of shell white and glazed and with the radial ribs clearly showing on the anterior portion. Pallial sinus broad and deep, extending inward about $\frac{2}{3}$ the distance to the umbo. Apophyses short, broadened and flattened, curved sharply inward and solid at the upper end. Protoplax very thin, entirely chitinous and generally more or less T-shaped. Mesoplax transverse, strong, calcareous and in one piece. Periostracum exceedingly thin, light straw-yellow and deciduous.

The siphons may be extended 3 to 4 times the length of the shell; they are light-tan in color and minutely papillose. Incurrent siphon with 6 large and numerous small branched cirri. Foot elliptical in outline, truncate and white to light-ivory in color. Mantle white to light-ivory. The above description of the soft parts is based upon preserved material.

length	height	ratio h:l	
36.0 mm.	17.5 mm.	2.0	Panama
44.0	18.0	2.4	"
38.7	16.5	2.3	"

Types. The types of *Pholas cruciger* Sowerby are in the British Museum. Sowerby listed three localities in his original description: Puna Island in the Gulf of Guayaquil and the Bay of Caraccas [Caráques], Colombia [Ecuador] and in the Gulf of Nocoiyo [Nicoya], Costa Rica. We here restrict the type locality to the Gulf of Nicoya, Costa Rica, a locality from which we have seen specimens. The lectotype of *Cyrtopleura exilis* Tryon is in the Academy of Natural Sciences of Philadelphia, no. 51040. The type locality of St. Croix, Virgin Islands, we believe, is in error.

Remarks. Cyrtopleura cruciger Sowerby is a very distinctive species not closely related to any other in this group. It differs from young specimens of *C. costata* Linné by lacking the radial ribs on the posterior slope, by having the anterior margin of the shell beaked and by having the apophyses solid at the upper end. There are also considerable differences in the dorsal plates which can best be seen by studying the figures. From *C. lanceolata* d'Orbigny it differs by being oval rather than lanceolate in outline, by having a much stronger sculpture, by being beaked anteriorly, and by having the mesoplax in one piece.

Cyrtopleura cruciger Sowerby is apparently a rare species throughout its range and is restricted in its ecological distribution to areas of soft stone. We have seen several specimens of a soft stone taken at Panama with the shells of *C. cruciger* still in place. They generally bore to a depth of about twice the length of the shell and make a rather snug burrow.

Philippi (1851, Abbildungen und Beschreibungen Conchylien **3**, p. 129) was in error when he gave one of the localities for *cruciger* as "sinus Caraccas [sic] in Mari Antillarum." Sowerby in his original description stated that this species, which was collected by Hugh Cuming, came from the "island of Puna in the Gulf of Guayaquil; in soft stone at low water in the Bay of Caraccas; both in West Colombia."[1] This Eastern Pacific species is not known from the Western Atlantic. *Cyrtopleura exilis* Tryon is definitely this species and the locality St. Croix is certainly in error.

Range. From Guaymas, Sonora, Mexico south to Puna Island in the Gulf of Guayaquil, Ecuador.

Specimens examined. Mexico: Guaymas, Sonora (USNM). Costa Rica: Isla San Lucas, Gulf of Nicoya (USNM). Panama: (Redpath Museum; C. M. Dumbauld; MCZ); Panama City (J. Zetek); Old French Canal, Canal Zone (ANSP).

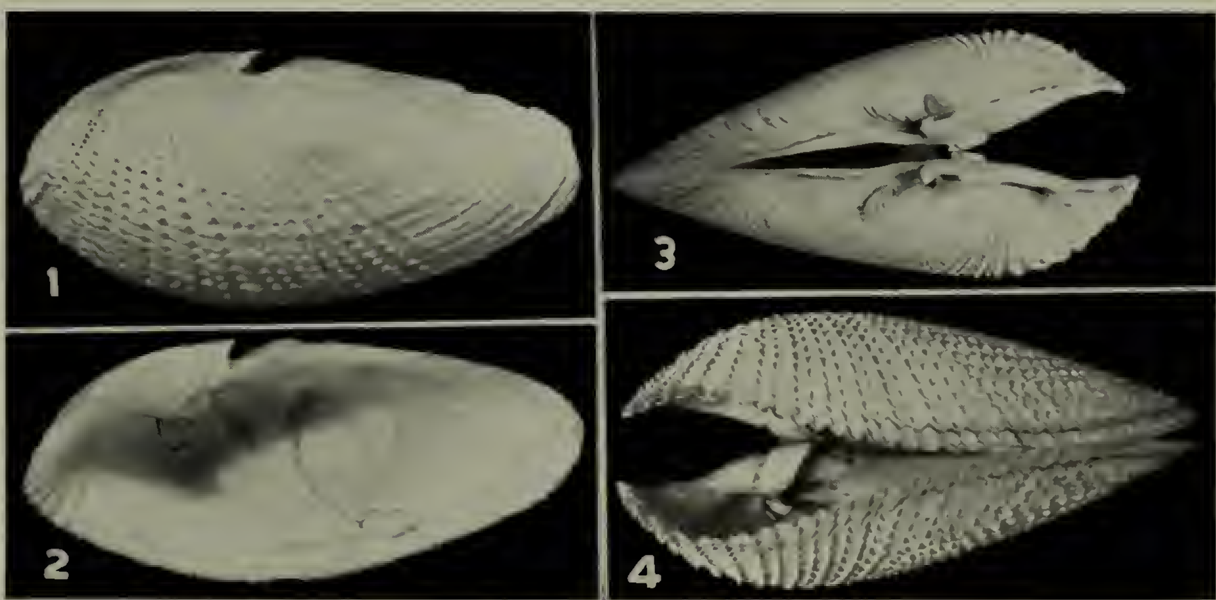

Plate 21. *Cyrtopleura cruciger* Sowerby. Figs. 1–4. Panama (all natural size). Fig. 1. External view showing the umbonal reflection with its posterior support and the notch formed by the reflection of the dorsal margin of the valve posterior to the umbos. Fig. 2. Interior view showing the broad, flat apophysis, the muscle scars and pallial sinus. Fig. 3. Dorsal view of opposed valves showing the narrow umbonal reflection and the supports. Fig. 4. Ventral view of opposed valves showing the beaks and the pedal gape.

[1] The Bay of Carácas in which Hugh Cuming collected was in Colombia, now Ecuador (South Latitude 0°30′). This place is now known as Bahía de Caráques. Clench 1945, Occasional Papers on Mollusks **1**, p. 26.

Genus **Pholas** *Linné*

Pholas Linné 1758, Systema Naturae, ed. 10, **1**, p. 669; Lamarck 1799, Prodrome d'une Nouvelle Classification des Coquilles [in] Mémoires de la Société d'Histoire Naturelle Paris, p. 90; *non* Lamarck 1801.

Genotype, *Pholas dactylus* Linné, subsequent designation, Children 1822.

Shells more or less elliptical in outline, with double, septate umbonal reflections and three accessory dorsal plates. Protoplax oval to quadrangular in outline, thin, calcareous, in one part or divided longitudinally into two parts. Mesoplax transverse and more or less triangular in outline, calcareous and solid in structure. Metaplax long and narrow. Shell beaked or rounded anteriorly. Sculpture extending over the entire shell or lacking on the posterior slope.

The genus may be divided into three subgenera on the basis of the above characters and may be keyed out as follows:

1.	Protoplax divided into two parts	2
	Protoplax in one piece	*Monothyra* (Indo-Pacific)
2.	Shell beaked anteriorly, nuclei of the divided protoplax located near the posterior outer margin	*Pholas* s.s.
	Shell rounded anteriorly, nuclei of the divided protoplax located near the anterior inner margin	*Thovana*

Subgenus **Pholas** *Linné*

Pholas Linné 1758, Systema Naturae, edition 10, **1**, p. 669; Lamarck 1799, Prodrome d'une Nouvelle Classification des Coquilles [in] Mémoires de la Société d'Histoire Naturelle Paris, p. 90; *non* Lamarck 1801.

Hypogaea Poli 1791, Testacea Utriusque Siciliae Eorumque Historia et Anatome **1**, Introduction, p. 29 [name for soft parts only].

Hypogaeoderma Poli 1795, Testacea Utriusque Siciliae Eorumque Historia et Anatome **2**, pp. 251, 257 (type, here selected, *Pholas dactylus* Linné).

Dactylina Gray 1847, Proceedings Zoological Society London, p. 187 (genotype, *Pholas dactylus* Linné, monotypic); non *Dactylina* Zborzewski 1843.

Xylotrya 'Leach' Menke 1830, Synopsis Methodica Molluscorum, p. 121 (genotype, *Pholas dactylus* Linné, subsequent designation, Clench and Turner 1946).

Pragmopholas Fischer 1887, Manuel de Conchyliologie, p. 1133 (genotype, here selected, *Pholas dactylus* Linné).

Phragmopholas 'Fischer' Dall 1898, Transactions Wagner Free Institute of Science, Philadelphia, **3**, p. 814 [error for *Pragmopholas* Fischer].

Subgenotype, *Pholas dactylus* Linné, subsequent designation, Children 1822.

The subgenus *Pholas* is characterized by having the shells beaked anteriorly, by having the protoplax divided longitudinally into two parts, and by having the nuclei of the divided protoplax near the posterior outer margin.

This subgenus is restricted in its distribution to the Eastern Atlantic. The following description of *Pholas dactylus* Linné, the genotype of *Pholas*, is included for the clarification of the genus.

Pholas (Pholas) dactylus *Linné*

Plates 22 and 23

Pholas dactylus Linné 1758, Systema Naturae ed. 10, **1**, p. 669 (Europe); Bucquoy, Dautzenberg and Dollfus 1896, Mollusques Marins du Roussillon **2**, p. 609, pl. 87.

Pholas muricatus DaCosta 1778, Historia Naturalis Testaceorum Britanniae, p. 244, pl. 16, fig. 2 (shores of Great Britain and Ireland).

Pholas dactilus 'Linné' Born 1778, Index Rerum Naturalium Musei Caesarei Vindobonensis, p. 7 [error for *dactylus* Linné].

Hypogaea verrucosa Poli 1795, Testacea Utriusque Siciliae Eorumque Historia et Anatome **2**, p. 251 [name given to the soft parts only].

Hypogaeoderma dactylus Linné, Poli 1795, Testacea Utriusque Siciliae Eorumque Historia et Anatome **2**, p. 257.

Pholas hians Solander 1786, Catalogue of the Portland Museum, p. 102, lot 2240; p. 174, lot 3736 [nomen nudum].

Pholas hians 'Solander' Pulteney 1799, Catalogue of the Birds, Shells, etc. of Dorsetshire, p. 26 [in] Hutchins' History of the County, Dorset, London. (Dorset coast at Waymouth [sic], Swanage and the north shore at Poole); non *Pholas hians* Gmelin 1790.

Pholas callosa Lamarck 1818, Animaux Sans Vertèbres **5**, p. 445 (Bayonne [France]); Lamy 1922, Bulletin Museum National d'Histoire Naturelle, Paris, **28**, p. 245.

Dactylina dactylus Linné, Gray 1847, Proceedings Zoological Society London, p. 187.

Pholas dactylus var. *gracilis* Jeffreys 1865, British Conchology **3**, p. 105 (Exmouth, England).

Pholas dactylus var. *decurtata* Jeffreys 1865, British Conchology **3**, p. 105 (Sussex, England).

Pholas dactylina Locard 1886, Prodrome de Malacologie Française, Catalogue Général des Mollusques Vivantes de France. Mollusques Marins, p. 365 [in foot note].

Pragmopholas (*Dactylina*) *dactylus* Linné, Fischer 1887, Manuel de Conchyliologie, p. 1133, fig. 863.

Distinctive characters. Shell white, beaked anteriorly, rounded posteriorly, with double, septate umbonal reflections and having a divided protoplax, a triangular meso-

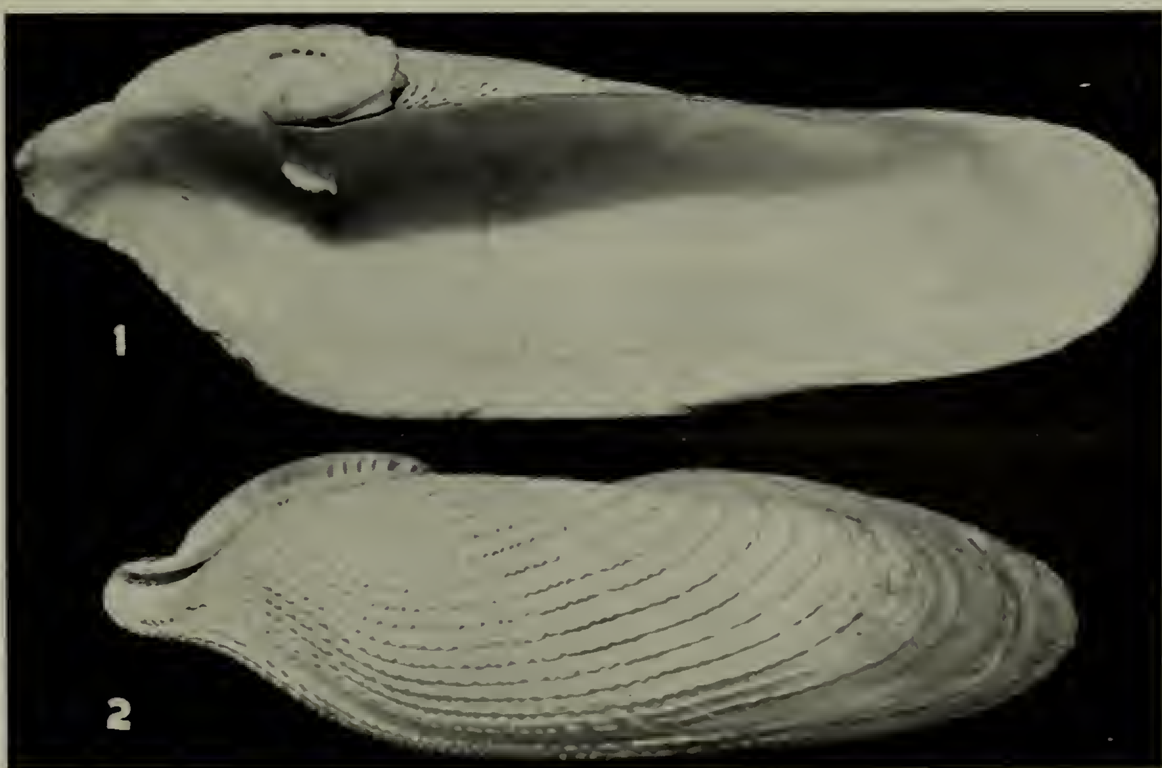

Plate 22. *Pholas dactylus* Linné. Figs. 1–2. Island of Malta (slightly reduced). Fig. 1. Internal view showing the broad flat apophysis, muscle scars and deep pallial sinus. Fig. 2. External view showing the septate umbonal reflection, the beak, and the pronounced concentric sculpture.

plax, and a long narrow metaplax. Nuclei of the divided protoplax located near the outer posterior margin.

Description. Shell subelliptical in outline, reaching about 130 mm. (about 5 inches) in length and 41 mm. (about 1½ inches) in height. Shell thin but strong, beaked anteriorly, rounded posteriorly, with septate umbonal reflections. The sculpture is often weak or absent on the posterior slope. Color a dull chalky-white to grayish-white. Umbos prominent, located near the anterior fourth of the shell and covered by double septate umbonal reflections. There are 10 to 14 septa in the average specimen about 3 inches long. Umbonal reflections free for a short distance over the beaks but closely appressed over the umbos and posterior to them. Sculpture consisting of laminated concentric ridges and radial ribs. Laminated ridges well marked for the entire length of the shell in young specimens, but in older specimens and especially those boring into hard rock they may be entirely lacking on the posterior slope. Radial ribs prominent on the anterior slope but becoming weak over the disc and entirely lacking on the posterior slope. Strong imbricated scales are produced where the concentric ridges and radial ribs cross one another. However, these may be worn down to undulating ridges in specimens boring into a hard substratum. In young specimens the concentric ridges are rather widely spaced and prominent the entire length of the shell. Very young specimens may be imbricate even on the posterior slope. Interior of the shell white and glazed with a slight indication of the radial ribs and concentric ridges showing through. Umbonal reflections usually worn away at the point of contact and rotation of the two valves. Muscle scars and pallial sinus well marked. Pallial sinus broad and deep, extending inwards two thirds the distance to the umbos. Apophyses rather short, solid and strong, flattened and often ridged on the free ends. Accessory plates three, a divided protoplax, a transverse mesoplax, and a long narrow metaplax. Protoplax calcareous, fragile, divided through the middle longitudinally, truncate posteriorly, acuminate anteriorly, with well marked concentric growth lines and with the nuclei near the posterior outer margins. Mesoplax, as shown in plate 23, calcareous and solid. Metaplax long and narrow, rather thin and faintly marked with growth lines.

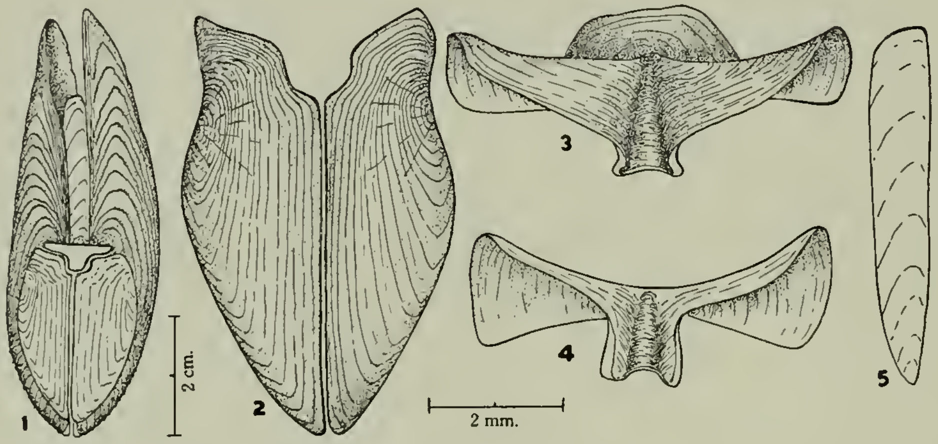

Plate 23. The dorsal plates of *Pholas dactylus* Linné. Fig. 1. Nantes, France. Dorsal view of an entire specimen to show the normal position and arrangement of the dorsal plates. Figs. 2–5. St. Juliac, Dinard, France. Individual plates of a young specimen. Fig. 2. Dorsal view of the divided protoplax showing the faint growth lines and the location of the nuclei near the posterior outer margins. Fig. 3. Dorsal view of the mesoplax tipped forward to show the basal flange. Fig. 4. Mesoplax in normal position. In young specimens this has a deeply curved posterior margin, while in older specimens it is nearly straight as shown in Fig. 1. Fig. 5. Dorsal view of the metaplax showing the fine growth lines.

Siphons extending at least one to two times the length of the shell, white to light-ivory in color, papillose and devoid of periostracum except for a small band near the posterior margin of the shell. Incurrent siphon nearly twice the diameter of the excurrent siphon and with 10 to 14 small-branched cirri surrounding the aperture. Excurrent siphon lacking cirri. We have seen only preserved specimens of this species but the gross morphology has been figured by Poli, Deshayes, and DuBois.

length	height	ratio h:l	
149.5 mm.	41.5 mm	3.5	Malta (fish market)
132.0	43.0	3.1	Malta
113.0	33.0	3.4	Smyrna, Turkey
105.0	32.0	3.3	" "
94.0	32.0	2.9	Cornwall, England
81.0	28.5	2.8	Pouliguen, near Nantes, France
28.0	14.0	2.0	La Rochelle, France

Types. According to Hanley (1855, Ipsa Linnaei Conchylia, p. 24) the types of *Pholas dactylus* are in the Linnean Collection. The type locality given by Linné was Europe. The location of the type of *Pholas muricatus* DaCosta is unknown. The types of *P. hians* Pulteney, *P. dactylus* var. *gracilis* Jeffreys and *P. dactylus* var. *decurtata* Jeffreys are probably in the British Museum.

Remarks. Pholas dactylus Linné is a very variable species both in its appearance and in its habitat. The substrata in which it has been found boring vary from such easily worked material as sand, peat, marl, and waterlogged wood to slate, sandstone and schistose rocks. Jeffreys states that his variety *gracilis* was boring in pure sand and as a consequence it was a thin and delicate shell. His *decurtata*, which he described as stunted and solid with close and usually effaced sculpture, was found in hard rocks. It is this wide range of habitat that has been responsible for these ecological forms and has resulted in the extensive synonymy given above.

Pholas dactylus Linné is perhaps the most famous of all pholads. It was well known to the early naturalists of Europe who were fascinated by its luminescent properties and its ability to bore into hard rock. Much has been written on this and a summary of some of the work is given in the introduction to this paper. In the early Mediterranean countries *Pholas dactylus* Linné was considered a great delicacy and it is still eaten by some today.

Range. From the Firth of Forth, Scotland (Hanley 1853, p. 11) south along the Eastern Atlantic coast to Oran, Algeria; the Mediterranean, Adriatic, and Aegean Seas.

Specimens examined. British Isles: Tenby, Wales; Cornwall, South Devon; Kent County (all MCZ); Broadstairs (Charleston Museum). France: Caleu, near La Rochelle; coast of Pouliguen, near Nantes; Nantes; Rouen; St. Juliac, Dinard (all MCZ); La Rochelle; Touraine (both USNM). Italy: Porto Maurizio; Gulf of Naples (both MCZ). Maltese Islands: Senglea Point, Malta (MCZ). Turkey: Smyrna (MCZ). Algeria: Oran (MCZ).

Subgenus **Thovana** *Gray*

Thovana 'Leach' Gray 1847, Proceedings Zoological Society London, p. 187 (subgenotype, *Pholas oblongata* Say, monotypic).

Gitocentrum Tryon 1862, Proceedings Academy Natural Sciences Philadelphia **14**, pp. 203–204 (subgenotype, here selected, *Pholas campechiensis* Gmelin).

Shell rounded anteriorly, with septate umbonal reflections and three accessory plates. Protoplax divided into two parts longitudinally with the nuclei anterior and more or less centrally located. Mesoplax small and transverse. Metaplax thin, long and narrow.

The subgenus *Thovana* is restricted in its distribution to the Western Atlantic and the Eastern Pacific.

Subgenotype, *Pholas oblongata* Say (=*P. campechiensis* Gmelin), monotypic.

Pholas (Thovana) campechiensis *Gmelin*

Plates 24 and 25

Pholas campechiensis Gmelin 1790, Systema Naturae, edition 13, **1**, p. 3216 (Sinu Campechiensi).

Pholas oblongata Say 1822, Journal Academy Natural Sciences Philadelphia **2**, p. 320 (Georgia, Carolina and East Florida); non *oblongata* Tuomey and Holmes 1858.

Thovana oblongata Say, Gray 1847, Proceedings Zoological Society London, p. 187.

Dactylina (*Gitocentrum*) *campechensis* 'Gmelin' Tryon 1862, Proceedings Academy Natural Sciences Philadelphia **14**, p. 204 [error for *campechiensis* Gmelin].

Pholas candeana d'Orbigny 1842 [in] Sagra, Histoire de L'Ile de Cuba, Mollusques **2**, p. 215, pl. 25, figs. 18–19; (Martinique; Habana, Cuba; Florida).

Pragmopholas (*Gitocentrum*) *campechiensis* Gmelin, Fischer 1887, Manuel de Conchyliologie, p. 1133.

Distinctive characters. Shell white, rounded at both ends, with septate umbonal reflections, with the concentric sculpture extending the entire length of the shell and with three accessory plates consisting of a divided protoplax, a mesoplax and a metaplax.

Description. Shells subelliptical in outline, reaching about 110 mm. (about 4⅜ inches) in length and 35 mm. (1⅜ inches) in height, thin, fragile, rounded, gaping slightly at both ends, and with the sculpture extending over the entire shell. Color a chalky-white to gray-white. Umbos prominent, located near the anterior fourth of the shell and covered by double, septate umbonal reflections. There are 10 to 14 septa in the average specimen of about 3 inches in length. Umbonal reflections free anterior to the umbos, but closely appressed over the umbos and posterior to them. Sculpture consisting of laminated, concentric ridges and radial ribs. Concentric ridges strong on the anterior slope, becoming somewhat weaker over the disc, and in adult specimens, usually weak and occasionally absent on the posterior slope. Radial ribs prominent on the anterior slope, becoming weak on the disc and usually disappearing on the posterior slope. Imbricated scales are formed where the concentric ridges and radial ribs cross one another. In young specimens the concentric ridges are widely spaced, very prominent and imbricate, even on the posterior slope. Sculpture below the umbonal reflections consisting of low, smooth, concentric ridges. Interior of shell white and glazed. Radial ribs and concentric ridges usually visible internally, especially on the anterior slope. Umbonal reflections usually worn away at the point of contact of the two valves. Muscle scars and pallial line well marked. Pallial sinus broad, deep and extending inward nearly two thirds the distance to the umbo. Apophyses fragile, short and broad, and projecting from beneath the umbo at a sharp angle posteriorly. Accessory plates three, a double, nearly rectangular protoplax, a transverse mesoplax, and an elongate narrow metaplax. Protoplax divided through the middle longitudinally, truncate posteriorly, and acuminate anteriorly. The nuclei of the divided protoplax are anterior and nearly centrally located. Mesoplax small, and a broad, flattened triangle in outline when seen in position. Metaplax thin, long and narrow.

We have not seen live or even preserved specimens of this species.

length	height	ratio h : l	
108.5 mm.	32.5 mm.	3.3	Sea Island, Georgia
95.0	31.0	3.1	Harbor Island Marsh, New Hanover County, North Carolina
70.0	22.0	3.2	10 miles south of Sabine, Texas
69.5	23.5	2.9	La Brea, Trinidad
63.5	19.5	3.2	Sénégal, Africa

Types. The location of the type of *Pholas campechiensis* Gmelin is unknown. Gmelin made only one reference and that was to Lister 1770, Historiae Sive Synopsis Methodicae Conchyliorum et Tabularum, Editio Altera, pl. 432, fig. 275. We here select this figure to represent the type. The type locality is the Gulf of Campeche, Mexico. The type of *Pholas oblongata* Say is apparently lost as it is not in the Academy of Natural Sciences, Philadelphia where most of Say's types are located. The type of *Pholas candeana* d'Orbigny from Cuba is in the British Museum according to Gray 1854.

Remarks. Pholas campechiensis Gmelin is most closely related to *P. chiloensis* Molina of the Eastern Pacific. It differs from this species by having a smaller, more delicate shell and by having the sculpture extending over the posterior slope. In *P. chiloensis* the sculpture is usually reduced to growth lines only on the posterior slope. See also remarks under *P. chiloensis* Molina.

Pholas campechiensis Gmelin though apparently not a rare species is very seldom collected alive. All specimens studied were dead and most of them were beach worn. Only

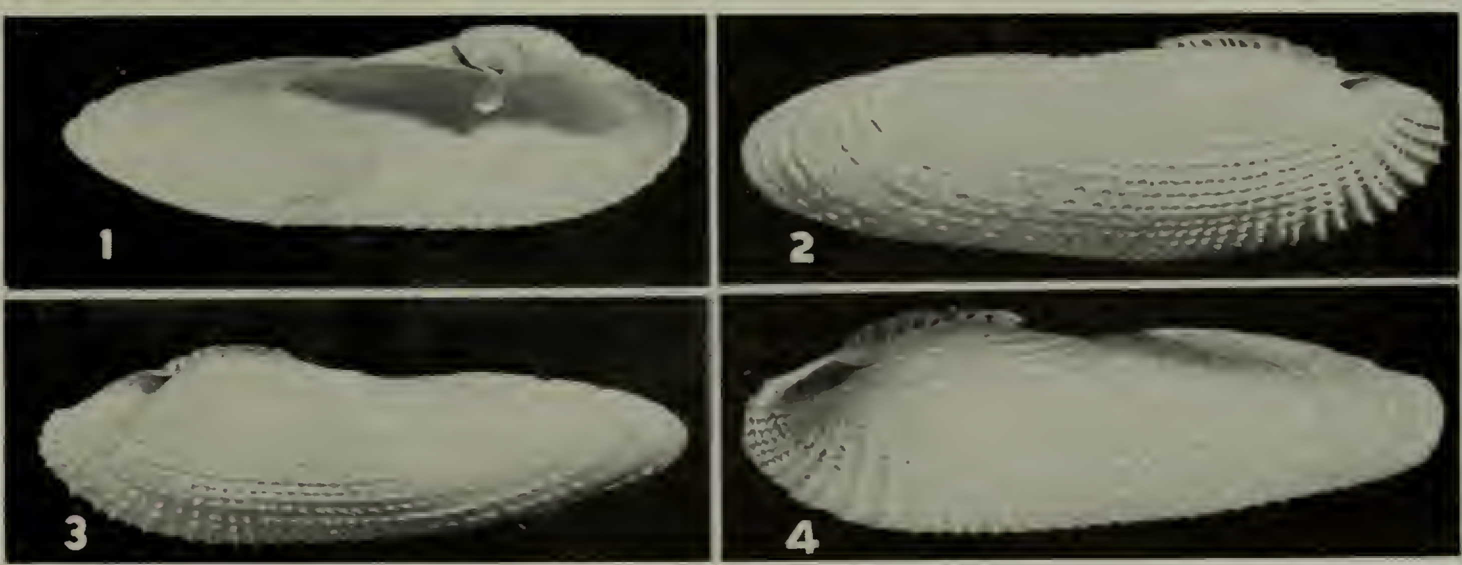

Plate 24. *Pholas campechiensis* Gmelin. Figs. 1–2. La Brea, Trinidad (about natural size). Fig. 1. Showing muscle scars, pallial sinus and spoon-shaped apophysis. Fig. 2. Showing the septate umbonal reflection and sculpture extending over the posterior slope. Fig. 3. Ten miles south of Sabine, Texas, a specimen with the sculpture becoming very weak on the posterior slope (about natural size). Fig. 4. Sénégal, Africa (about $1\frac{1}{3}$x).

two specimens, both of them young, had the accessory plates. In certain areas these shells are common in the beach rubble as indicated by the large number of fragments found in a pint of drift material collected at High Island, Bolivar, Texas by T. E. Pulley. Fragments of the umbonal areas of at least one hundred specimens were in this small amount of drift. This portion of the shell is very strong: it is the last to be destroyed by wave action and consequently accumulates in the beach drift. It seems probable that *P. campechiensis* Gmelin, like *Panope bitruncata* Conrad, lives rather deep in the mud well below the low tide line, and, being deeply buried, the shells are not brought up by dredges. When the animals die the shells remain *in situ*, with the result that only a relatively few specimens are washed out and eventually reach shore.

A specimen received from A. S. Merrill was taken from a piece of waterlogged wood which had washed ashore at Folly Beach, South Carolina. In the same log there were several specimens of *Barnea truncata* Say, *Petricola pholadiformis* Lamarck, and *Martesia cuneiformis* Say. We have a second piece of waterlogged wood that was taken at Daytona Beach, Florida and which also contained several specimens of this species. In both cases the specimens were young but quite normal and did not appear to be stunted or malformed.

From the material we have had for study the shells of *P. campechiensis* Gmelin appear to be far more uniform in shape and sculpture than are most species in this family. This would, perhaps, indicate a limited type of substratum in which this species can survive, probably stiff mud and sand.

Range. From North Carolina south through the West Indies to Sepetiba Bay, Rio de Janeiro, Brasil. EASTERN ATLANTIC: from Dakar, Sénégal south to Liberia.

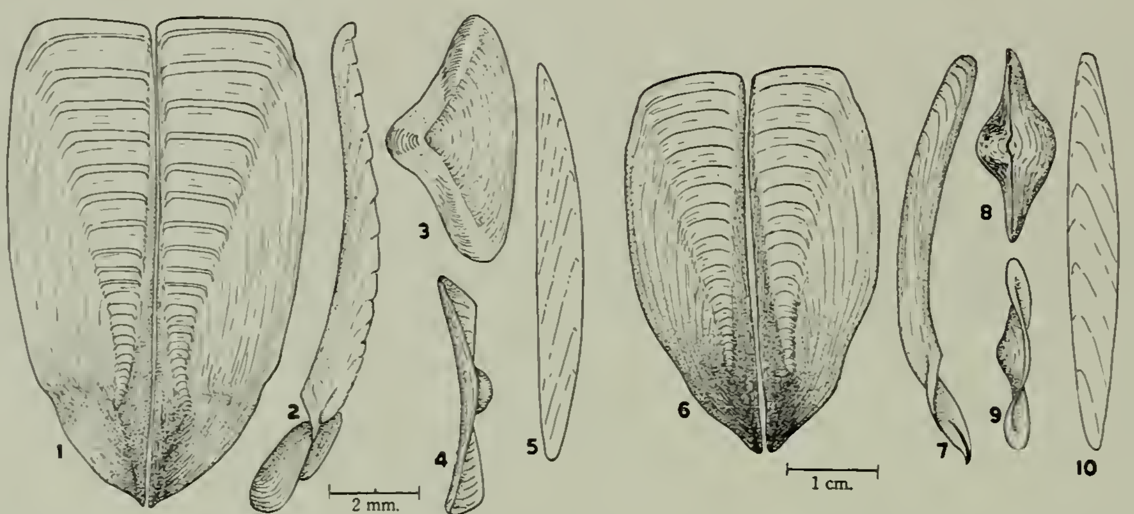

Plate 25. Dorsal plates of *Pholas* subgenus *Thovana*. Figs. 1–5. *Pholas* (*Thovana*) *campechiensis* Gmelin, Folly Beach, South Carolina. The plates of this very young specimen (31 mm. in length) are probably more highly sculptured than would be the case with older specimens. Fig. 1. Dorsal view of divided protoplax showing the nuclei located near the anterior central portion. Fig. 2. Side view of the right half of the protoplax from the outer edge showing the curvature. Fig. 3. Dorsal view of the mesoplax tipped forward to show the basal flange. Fig. 4. Dorsal view of the mesoplax in normal position (anterior to right). Fig. 5. Dorsal view of metaplax which is thin and almost entirely chitinous in young specimens. Figs. 6–10. *Pholas* (*Thovana*) *chiloensis* Molina, Chile. Fig. 6. Dorsal view of divided protoplax showing the nuclei located near the anterior central portion. Fig. 7. Side view of left half of the protoplax from the outer edge to show the curvature. Fig. 8. Dorsal view of the mesoplax tipped forward to show the basal flange. Fig. 9. Mesoplax in normal position (anterior to the right). Fig. 10. Dorsal view of the metaplax which is thin, fragile, and only partially impregnated with calcium.

Specimens examined. North Carolina: Harbor Island Marsh, New Hanover Co. (MCZ). Ocracoke Island (ANSP). South Carolina: Myrtle Beach; Pawleys Island; Sullivans Island, Charleston (all Charleston Museum); Magnolia Beach (MCZ); Charleston (USNM); Folly Island (ANSP; A. Merrill). Georgia: Sea Island, Glynn Co. (MCZ; ANSP); St. Simon's Island (USNM). Florida: Jacksonville Beach (MCZ); St. Augustine (Univ. of Michigan; ANSP; USNM); Daytona Beach (G. Quelch); Cape Canaveral (MCZ); Cape Sable (H. Moore); Sanibel Island (MCZ). Louisiana: Cameron (USNM). Texas: 10 miles southwest of Sabine (MCZ); Galveston (T. E. Pulley; ANSP); Port Aransas (MCZ); Mustang Island (J. Hedgepeth); Gulf Beach, Port Isabel (B. Weisenhaus); High Island (T. Pulley); Brownsville (USNM). Greater Antilles: Jamaica (ANSP). Lesser Antilles: La Brea, Trinidad (MCZ); Moruga and Guayaguagare Beach, Trinidad (both H. J. Kugler). Mexico: Tampico, Tamaulipas; Boquilla de Piedras; Tecolutla; Nautla and Vera Cruz, all in the State of Vera Cruz (all T. Pulley); Tuxpan and Barra de Alvarado, Vera Cruz (both M. E. Bourgeois). Nicaragua: Wounta Haulover (MCZ). Panama: Colón (MCZ). Colombia: Cartagena (MCZ). Brasil: Ilha de Itaparica, Estado de Bahía (J. de Oliveira); Barra Seca, Espirito Santo (Thayer Expedition, MCZ); Aracaju, Estado de Sergipe; Parada Sahy, Sepetiba Bay, Estado Rio de Janeiro (both H. S. Lopes).

Eastern Atlantic: Senegal: Dakar (Inst. Français d'Afrique Noire). Gold Coast: Accra (MCZ). Liberia: Marshall (MCZ).

Pholas (Thovana) chiloensis *Molina*

Plates 25, 26 and 27

Pholas chiloensis Molina 1782, Saggio Sulla Storia Naturale de Chili, p. 204 (Archipelago de Chiloe); King 1832, Zoological Journal **5**, p. 334; Hupé [in] Gay 1854, Historia de Chile, Zoologia **8**, p. 381, Atlas **2**, Mollusks, pl. 8, fig. 3.

Pholas chiloensis var. *parva* Sowerby 1834, Proceedings Zoological Society London, p. 69 (soft stone at 17 fathoms, Island of Plata, West Colombia [Ecuador], H. Cuming collector).

Pholas laqueata Sowerby 1849 [1850] Proceedings Zoological Society London, p. 161 [nude name]; Sowerby 1849, Thesaurus Conchyliorum **2**, pt. 10, p. 486, pl. 103, figs. 19–20 (Isle of Plata, Colombia [Ecuador], H. Cuming collector).

Pholas (*Dactylina*) *retifer* Mörch 1860, Malakozoologische Blätter **7**, p. 177 (Realejo, Nicaragua).

Pholas dilecta Pilsbry and Lowe 1932, Proceedings Academy Natural Sciences Philadelphia **84**, p. 88, pl. 11, figs. 8–9 (Corinto, Nicaragua).

Distinctive characters. Shell white, rounded at both ends, with septate umbonal reflections, with the sculpture greatly reduced or lacking on the posterior slope and with three accessory plates consisting of a divided protoplax, a mesoplax, and a metaplax.

Description. Shells rather large, reaching 123 mm. (about $4\frac{7}{8}$ inches) in length and 44 mm. (about $1\frac{3}{4}$ inches) in height, elliptical to oval in outline, rounded and gaping slightly at both ends, with double septate umbonal reflections, and generally lacking sculpture on the posterior slope. Color a dull chalky-white. Umbos prominent and located near the anterior fourth of the shell. Umbonal reflections free anterior to the umbos, but closely appressed, double and septate over the umbos. There are 14 to 16 septa in the average three to four inch specimen. Sculpture consisting of concentric ridges and radial ribs with imbrications produced where the two cross one another. The concentric ridges are very prominent and laminated on the anterior slope, much lower and weaker on the disc, and generally evident only as growth lines on the posterior slope. The radial ribs are strong on the anterior slope, becoming much weaker on the disc and are completely lacking on the posterior slope. In most specimens there is a rather definite line of demarcation between the sculptured disc and the nearly smooth posterior slope. Interior of shell white and glazed, the external sculpture showing internally as a series of grooves. Muscle scars and pallial line well indicated. The pallial sinus is broad and deep, extending inward three fourths of the distance to the umbo. Apophyses rather heavy, slightly enlarged at the free end, and extending outward from under the umbo at a sharp angle posteriorly. Umbonal reflections usually worn down at the point of contact of the two valves. Protoplax divided longitudinally into two parts. Each half is truncate posteriorly, acuminate anteriorly, has well marked growth lines and anterior nuclei which are located near the inner margin. Mesoplax transverse and nearly diamond-shape in outline. Metaplax long and narrow, exceedingly fragile and only slightly to moderately impregnated with calcium. Periostracum thin, light straw-yellow, and deciduous.

Siphons a pale brown in color (an old preserved specimen), separated slightly at their posterior extremity and with small uniform papillae covering the entire surface. Foot elliptical in outline, long and thin. Foot and mantle light-ivory in color.

length	height	ratio h : l	
122.5 mm.	39.0 mm.	3.1	Kino Bay, Sonora, Mexico
112.5	37.5	3.0	" " " "
114.5	45.5	2.5	Paracas, Peru
93.5	29.0	3.2	Panama City, Panama
90.0	30.0	3.0	Chiloe Island, Chile
75.0	22.0	3.4	Holotype, *P. dilecta* Pilsbry and Lowe
71.6	22.2	3.2	Cotype, *P. laqueata* Sowerby

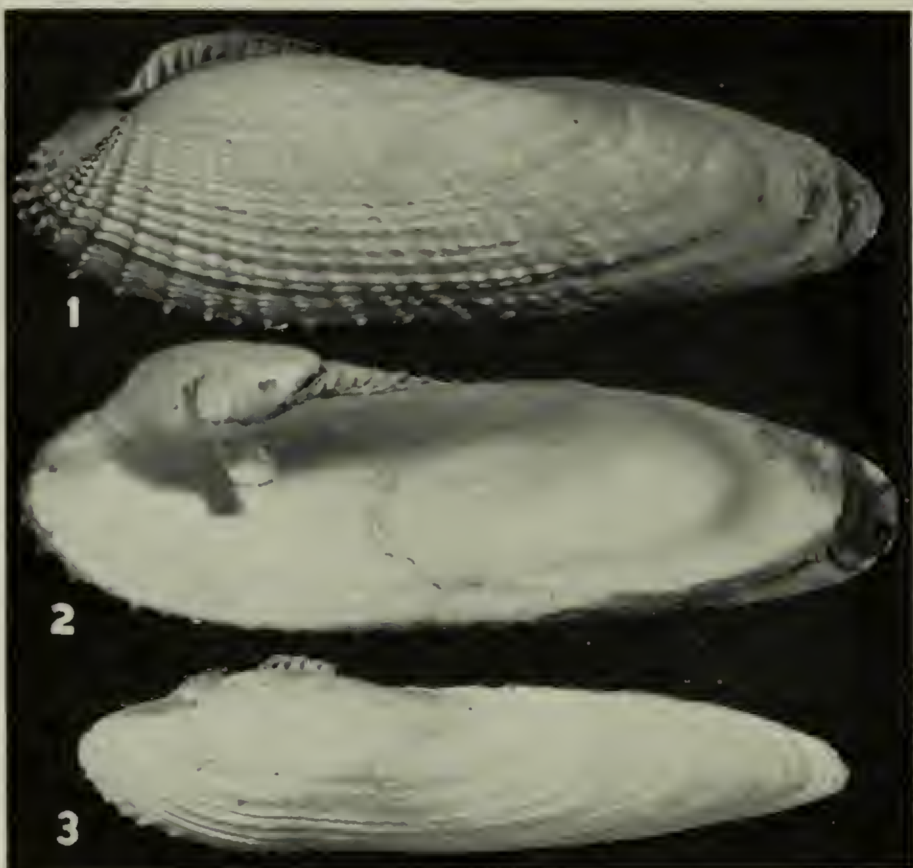

Plate 26. *Pholas chiloensis* Molina. Figs. 1–2. Chiloe Island, Chile. Fig. 3. Holotype of *Pholas dilecta* Pilsbry and Lowe (=*chiloensis* Molina) from Corinto, Nicaragua. This specimen was not photographed in the conventional position but was tipped forward in order to show the remains of the septate umbonal reflection, most of which had been broken off. In this position the shell appears to be narrower than it is (all natural size).

Types. The location of the type specimens of *Pholas chiloensis* Molina is unknown. We here select the figure given by Hupé in Gay 1854, Historia de Chile, Zoologia **8,** p. 381, Atlas **2,** pl. 8, fig. 3 to represent the type. The type locality is Chiloe Island, Chile. We figure a topotype. The type specimen of *P. chiloensis parva* Sowerby from the Island of Plata, Ecuador and *P. laqueata* Sowerby from the same locality are apparently lost. They are not in the Cuming collection in the British Museum according to a letter received from G. L. Wilkins. We have seen a probable cotype of the latter species, originally from the Cuming collection and now in the Zoologische Museum, Amsterdam. The whereabouts of the types of *Pholas retifer* Mörch is unknown. The holotype of *Pholas dilecta* Pilsbry and Lowe from Corinto, Nicaragua is in the Academy of Natural Sciences Philadelphia, no. 155299.

Remarks. Pholas chiloensis Molina is very closely related to *P. campechiensis* Gmelin of the Western Atlantic. Young specimens of the two are difficult or even impossible to distinguish. In older specimens, *P. chiloensis* Molina can be distinguished by its larger size, heavier shell, its generally higher umbonal reflection and its nearly smooth posterior slope.

There is a rather wide range of variation in the ratio of the length to the height of the valves in the species, the length of the shell ranging from two and one half to nearly three and one half times the height. Older specimens are usually higher and have much heavier umbonal reflections.

Through the kindness of Dr. H. A. Pilsbry we were able to study and figure the type of *Pholas dilecta* Pilsbry and Lowe. The holotype specimen appears to be only a rather young, beach-worn specimen of *P. chiloensis.* Specimens from Kino Bay, Sonora, Mexico labelled *P. dilecta* by Lowe are definitely this species.

Very little is known concerning this species beyond the fact that it has a rather wide

Plate 27. *Pholas chiloensis* Molina. Fig. 1. *Pholas laqueata* Sowerby (= *P. chiloensis* Molina) from west Colombia, Hugh Cuming collector, Cotype ($1\frac{1}{2}$x). Fig. 2. Kino Bay, Sonora, Mexico. H. N. Lowe collector (natural size).

range of distribution, extending as it does from northern Mexico to Chiloe Island, Chile. Hupé stated that it was a rather common species on Chiloe Island, boring into soft stone. Captain Phillip King who was on the HMS *Adventure* and the *Beagle* when those ships were surveying the coast of South America stated "the soft parts of *Pholas chiloensis* are considered very delicate by the inhabitants of the Island of Chiloe, by whom the animal is called 'Co-mes.' They are found in great abundance at low water imbedded in the rocks near Sandy Point at San Carlos de Chiloe." Despite this apparent abundance in restricted localities the species is generally rare in collections. We have seen only one preserved specimen and most of the material studied was beach worn.

Range. From Kino Bay, Sonora, Mexico south to Chiloe Island, Chile.

Specimens examined. Mexico: Kino Bay, Sonora (MCZ: ANSP): Laguna de Scammon, Baja California (ANSP): Santo Domingo, Baja California (USNM): Mazatlan, Sinaloa: Acapulco, Guerrero (both MCZ). Nicaragua: Corinto (ANSP; W. J. Eyerdam). Panama: Panama City (MCZ; Univ. of Michigan): Pena Prieta, Panama City (USNM). Ecuador: between Manglaralto and Monte (USNM); Guayaquil (MCZ: Redpath Museum). Peru: North of Payta (USNM): Payta (USNM; ANSP); Paraca Bay (MCZ). Chile: Chiloe Island (AMNH).

Genus **Zirfaea** *Gray*

Zirfaea Gray 1840 [in] Synopsis of the Contents of the British Museum, ed. 42, p. 154 [nude name].

Zirfaea Gray 1842 [in] Synopsis of the Contents of the British Museum, ed. 44, p. 76 [defined, but no species listed].

Thurlosia 'Leach' Catlow and Reeve 1845, The Conchologist's Nomenclator, p. 3 (genotype, *Pholas crispata* Linné, monotypic).[1]

Zirfaea 'Leach' Gray 1847, Proceedings Zoological Society London, p. 188 (genotype, *Pholas crispata* Linné, monotypic).

Zirphaea Leach 1852, A Synopsis of the Mollusca of Great Britain, p. 252 (genotype, *Pholas crispata* Linné, monotypic).

Shell oval in outline, beaked anteriorly, rounded to truncate posteriorly, widely gaping at both ends and having a sulcus extending from the umbo to the ventral margin. There is a single accessory dorsal plate, the mesoplax, which is small and more or less triangular in outline. Apophyses solid, strongly curved, broadened and often spoon-shaped at the free end.

The genus *Zirfaea* is limited in its distribution to the colder waters of the Northern Hemisphere. *Zirfaea crispata* Linné is known from both sides of the Atlantic, while *Z. pilsbryi* Stearns is restricted, so far as known, to the Pacific coast of North America.

Genotype, *Pholas crispata* Linné, subsequent designation, Gray 1847.

[1] It is unfortunate that the name *Thurlosia* was introduced by Catlow and Reeve just two years before Gray set the type for *Zirfaea*.. Should descriptions of genera with no species listed be invalidated in the future, the name *Thurlosia* Catlow and Reeve 1845 will replace *Zirfaea* Gray 1842, unless this later name be placed on the list of Nomina Conservanda.

Zirfaea crispata *Linné*
Plates 1, 3 and 28 to 30

Mya crispata Linné 1758, Systema Naturae, ed. 10, **1**, p. 670 (O. septentrionali).

Pholas crispata Linné 1776, Systema Naturae, ed. 12, **1**, pt. 2, p. 111.

Pholas bifrons da Costa 1778, Historia Naturalis Testaceorum Britanniae, p. 242, pl. 16, fig. 4 (Cornwall, Lincolnshire, Yorkshire, Wales, etc. [British Isles]).

Solen crispus Gmelin 1790, Systema Naturae, ed. 13, **1**, pt. 6, p. 3228 (Teers [Tees River] Angliae).

Pholas parvus 'Pennant' Donovan 1800, The Natural History of British Shells **2**, pl. 69 (non *Barnea parva* Pennant).

Pholas crispa de Blainville 1825, Manuel de Malacologie, p. 578, pl. 79, fig. 7.

Zirfaea crispata Linné, Gray 1847, Proceedings Zoological Society London, p. 188.

Zirfaea crispata var. *truncata* Kaas 1939, Basteria **4**, no. 1, p. 7, pl. 1 (Texel Island, Netherlands).

Distinctive characters. Shells white, beaked anteriorly, rounded to truncate posteriorly, gaping at both ends and having an umbonal-ventral sulcus. Mesoplax very small and triangular in outline. Valves usually in contact for only a short distance near the sulcus. Siphons smooth, without the minute chitinous spots found in the Eastern Pacific species.

Description. Shells reaching 93.2 mm. (about $3\frac{3}{4}$ inches) in length and 49.2 mm. (about 2 inches) in height, beaked anteriorly, broadly rounded to truncate posteriorly, gaping at both ends and with an umbonal-ventral sulcus. Valves usually in contact only at the umbos and a small area on the ventral margin at the sulcus. In young specimens the umbonal-ventral sulcus is quite pronounced and is evident on the inside of the valve as a ridge. In older specimens the internal ridge is no longer visible, and the sulcus exists only

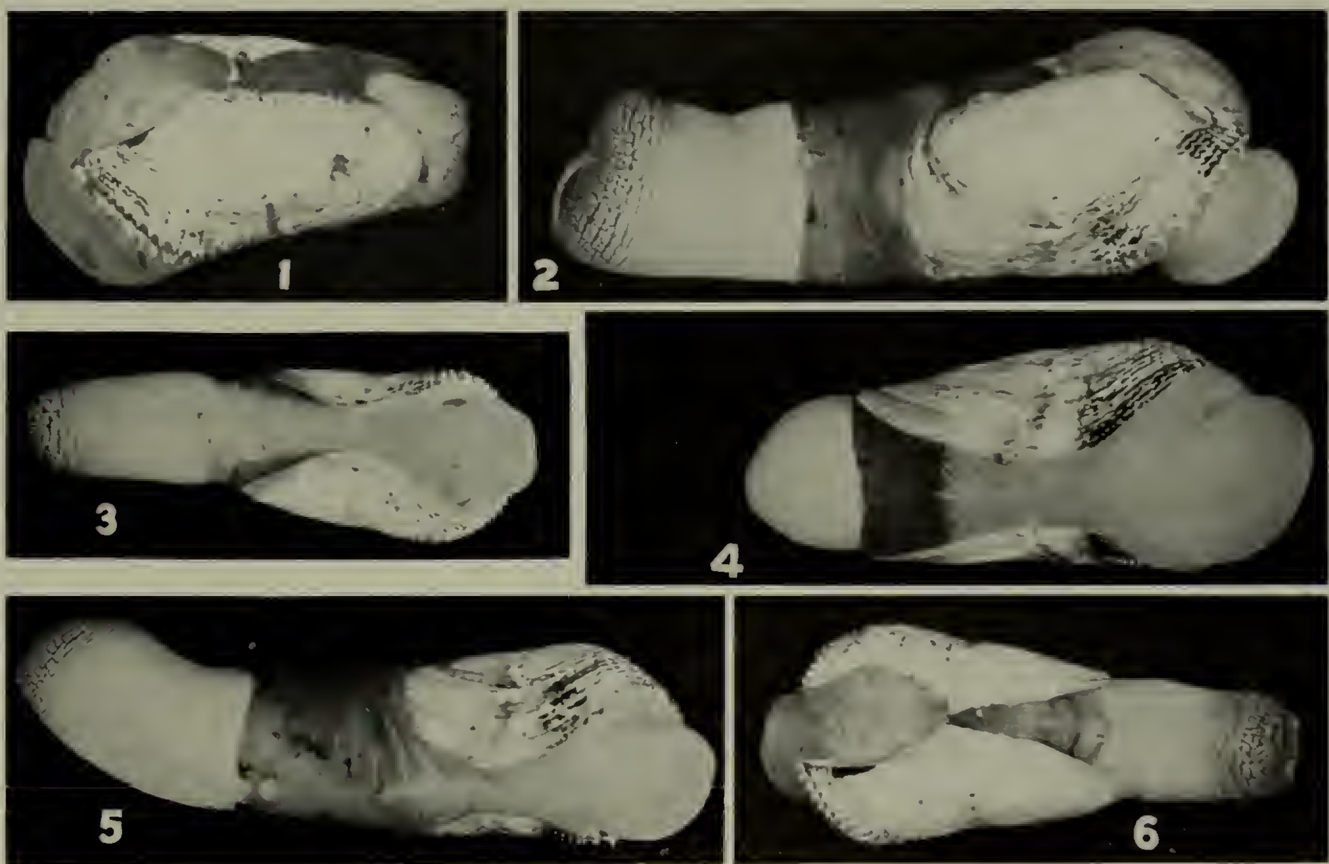

Plate 28. *Zirfaea crispata* Linné. Figs. 1–6. Rye Harbor, New Hampshire. Fig. 1. Shows the extent to which the animal can withdraw into the shell. Fig. 2. Side view to show the expanded foot. Figs. 3–4. Ventral views showing the way in which the animal can form various openings between the mantle and the foot, through which streams of water can be directed into the anterior end of the burrow (all natural size).

as a shallow furrow on the outside of the valve. In many young specimens this internal ridge is swollen at the ventral margin forming an incipient condyle. Color a dull chalky-white. Sculpture consisting of numerous concentric ridges which are laminated and strongly imbricated anterior to the sulcus but are evident only as growth ridges on the posterior slope. Radial ridges, expressed only by the radial arrangement on the rows of imbrications, are strong on the beaks, but are reduced in strength toward the umbos and posteriorly toward the sulcus. In older specimens these imbrications may be reduced to undulating ridges. Umbonal reflections broad and closely appressed over the umbos. Interior of shells white and lightly glazed in young specimens while in older specimens it is usually chalky. Muscle scars and pallial sinus well marked, particularly in older specimens. Pallial sinus broad and deep, and extending anteriorly about three fourths the distance to the umbos. Apophyses solid, strongly curved, broadening at the free edge and becoming quite spoon-shaped in some specimens. Protoplax lacking. Mesoplax small, fragile, triangular in outline, and with a small basal flange. Periostracum thin, light straw-yellow and deciduous.

The siphons are united and may be extended six to eight times the length of the shell. The anterior one half to two thirds of the siphons are covered with a sheath of light straw-yellow to medium-brown periostracum. The remainder of the siphons lack the periostracum and are white in color. The posterior ends of the siphons are marked with very fine reticulations of dark mahogany-red. When the animal is extended, the reticulations are widely spaced giving this region a gray-pink color. Incurrent siphon with dark red, papillose and ciliated ridges running well into the siphonal tube. These ridges terminate in branched cirri at the aperture. Excurrent siphon devoid of the internal ridges.

length	height	ratio h : l	
93.5 mm.	49.2 mm.	1.9	Small Point Beach, Maine
81.5	47.0	1.7	Nahant, Massachusetts
70.0	42.5	1.6	Vaagnas Cape, Tromsö, Norway
45.0	28.0	1.5	Dover, England
34.0	14.0	2.4	Scituate, Massachusetts
30.0	23.0	1.3	Portland, Maine
29.5	21.0	1.4	Paratype of *Z. c.* var. *truncata*

Types. According to Hanley (1855, Ipsa Linnaei Conchylia, p. 26), the type of *Mya crispata* Linné is in the Linnean collection. The type locality given by Linné was "O. septentrionali." It is here restricted to the banks of the Tees River, Middlesbrough, England. This is the locality given by Lister 1678, the only publication to which Linné referred for this species. The location of the types of *Pholas bifrons* da Costa is unknown. The holotype of *Zirfaea crispata* var. *truncata* Kaas is in the collection of Dr. J. Th. Henrard of Oegstgeest, Netherlands. Paratypes are in the collection of Dr. Piet Kaas and the Museum of Comparative Zoölogy, no. 193521. The type locality is Isle of Texel, Netherlands. We are grateful to Dr. Kaas for sending us a paratype specimen.

Remarks. *Zirfaea crispata* Linné is close in its relationship to *Z. pilsbryi* Lowe of the Eastern Pacific. However, it may be distinguished from that species by its smaller size, lighter, more fragile shell, less inflated posterior region, and by its smooth siphons which are devoid of the minute chitinous spots usually found in Eastern Pacific species. In addition, the valves of *Z. crispata* Linné are usually in contact for only a short distance on the ventral margin near the umbonal-ventral sulcus. The young specimens of these two species are difficult and often impossible to distinguish. See remarks under *Z. pilsbryi* Lowe.

The shells of *Z. crispata* Linné are variable in size and weight depending upon the conditions under which the animals are living. Specimens living in soft, easily worked salt marsh peat are elongate-oval in outline, and have rather widely spaced imbricated ridges and fragile shells, indicating rapid growth. Those boring into rock or hard wood are stunted, truncate, and have closely packed, badly worn imbricated ridges and heavy shells, indicating hard work on the substratum and slow growth. It was such specimens that were named *Z. crispata truncata* Kaas. Though this species is usually found in salt marsh peat deposits, specimens have been found in a wide variety of material ranging from stiff mud and blue clay to waterlogged wood, hard pine, poor quality bricks and red sandstone. They are probably most abundant in the lower intertidal zone, but have been taken alive in depths as great as 40 fathoms. They can withstand exposure to temperatures ranging from below freezing to 26.6° C. However, as they live in the lower intertidal zone or below the low tide level they are never exposed to the extremes of temperature for an extended period of time. In laboratory experiments they can withstand a rather wide range of salinity, but they are limited in nature to a marine habitat. Their distribution is spotty though they may be exceedingly abundant in any one locality where proper conditions exist. In one bed we counted over fifty specimens in a square foot of peat. Many of the specimens were stenomorphs as their burrows were too close to allow complete growth. The burrows were vertical and many extended to a depth of six inches or more.

Zirfaea crispata Linné seldom bores into wood unless it is completely waterlogged and softened. However, in a test block submerged at Beverly, Massachusetts, we found 56 minute specimens of this species. Among the thousands of test blocks that have been examined from New England, this is only the second record for *Zirfaea* in the tests at the Clapp Laboratories.

Little is known of the life history of this species, but according to Dr. C. M. Sullivan (1948) the larvae occur in the plankton at Malpeque Bay, Prince Edward Island, from the middle of June to the middle of July, and at that time the temperature of the water ranges from 15° to 22° C. See also the introduction for further notes and figures of the young.

Range. Eastern Atlantic: from Tromsö, Norway south to Boulogne, France. Western Atlantic: from Labrador south to Anglesea, New Jersey. The record given by C. W. Johnson, 1934 for South Carolina appears to be in error.

Specimens examined. Eastern Atlantic: Norway: Vaagnas Cape, Tromsö Sound (Trondheim Museum); Tromsö (W. J. Eyerdam); Lofoten (USNM). British Isles: Oban (MCZ); South Rock, St. Andrews, Fife (Gatty Marine Laboratory); Liverpool (MCZ; AMNH); Hilbre Point, Dee River (Charleston Museum); Dover; Scarborough (both MCZ). Netherlands: Isle of Vlieland (A. N. C. ten Broek); Isle of Texel; Wassenaar, about 6 miles north of The Hague (both P. Kaas); Scheveningen, The Hague (D. Smits). Belgium: Nieuport (W. J. Eyerdam). France: Boulogne (MCZ).

WESTERN ATLANTIC: LABRADOR: (Redpath Museum). NEWFOUNDLAND: (USNM). QUEBEC: Gaspé (Redpath Museum); Coffin Island, Magdalen Islands (MCZ). PRINCE EDWARD ISLAND: Malpeque Bay (J. C. Medcof); Governor's Island (Redpath Museum). CAPE BRETON ISLAND: (USNM). NOVA SCOTIA: Straits of Northumberland (G. H. Cox); Halifax (Redpath Museum); Digby (J. Bradley); off Digby in 40 fathoms (J. Magarvey); Sable Island (USNM). MAINE: Small Point Beach (A. Clarke); Penobscot Bay (MCZ); Casco Bay (MCZ; Charleston Museum); Schoodic Point, Winter Harbor (G. Moore); Portland; Kennebunk Beach (both MCZ); Skillings River, Lamoine (J. Rankin); Jewels Island, Casco Bay; Isle of Shoals; John's Bay, Bristol; Broad Sound (all USNM). NEW HAMPSHIRE: Rye Harbor (G. Moore). MASSACHUSETTS: Plum Island, Newburyport; Ipswich; Salem; Beverly; Lynn; Swampscott; Nahant (all MCZ); Salisbury (A. Clarke); Chelsea (AMNH); Winthrop; Scituate; Manomet Point; North Beach, Orleans; Monomoy, Chatham (all MCZ); Hull; Duxbury (both MCZ; USNM). RHODE ISLAND: Newport (ANSP). NEW YORK: Sag Harbor, Long Island (USNM); Noyack Bay, Long Island (R. Latham). NEW JERSEY: Sandy Hook (AMNH); Asbury Park; Point Pleasant, Atlantic City; Ocean City; Anglesea (all ANSP).

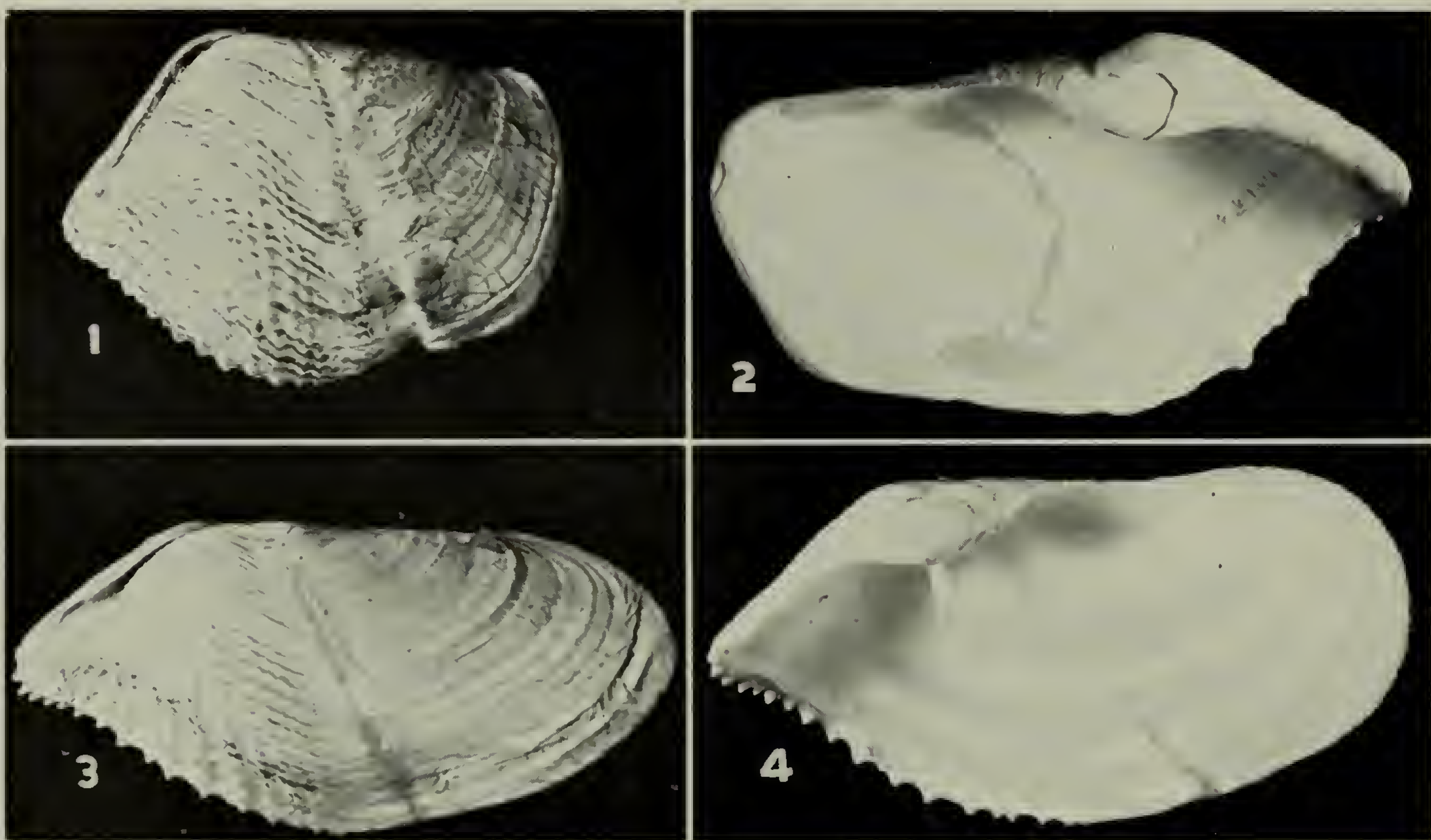

Plate 29. *Zirfaea crispata* Linné. Fig. 1. Paratype of *Zirfaea crispata* var. *truncata* Kaas (= *Zirfaea crispata* Linné). Isle of Texel, Netherlands ($1\frac{1}{2}$x). Fig. 2. Nahant, Massachusetts. An old specimen to show pallial line and muscle scars (apophysis broken off) (natural size). Figs. 3–4. Rivermere, Scituate, Massachusetts. Fig. 4. A young specimen to show the internal umbonal-ventral ridge which more or less disappears in the adult ($1\frac{1}{2}$x).

Zirfaea pilsbryi *Lowe*

Plates 30 to 34

Zirfaea gabbi of authors, not of Tryon.

Zirfaea pilsbryi Lowe 1931, Nautilus **45**, p. 53, pl. 3, figs. 1–2 (Bolinas, California).

Distinctive characters. Shell beaked anteriorly, broadly rounded to truncate posteriorly, gaping at both ends, and having a sulcus extending from the umbo to the ventral margin. Mesoplax small and more or less triangular in outline. Valves usually in contact on the ventral margin for most of their length posterior to the sulcus. Siphons usually with minute chitinous spots.

Description. Shell reaching 122 mm. (about $4\frac{3}{4}$ inches) in length and 68 mm. (about $2\frac{1}{2}$ inches) in height, beaked anteriorly, broadly rounded to truncate posteriorly and widely gaping at both ends. Valves in contact with each other at the umbos and for most of the ventral margin posterior to the pedal gape. Sulcus extending from the umbo obliquely to the ventral margin. In young specimens this sulcus may be barely visible externally but it is clearly indicated internally as a strong beaded rib. In adult specimens the furrow is always distinct externally but may be indicated on the inside of the valve only as a row of isolated beads or it may be completely lacking. Umbonal reflection broad and appressed against the umbo. At the point of contact of the two valves the reflection is always worn away, even in young specimens, as this area acts as an incipient condyle on which the valves rotate. Color a dull chalky-white to light-salmon. Sculpture consisting of numerous concentric ridges which are laminated and strongly imbricated on the anterior slope but are indicated only as growth lines posterior to the furrow. The radial ribs are restricted to the anterior slope and are indicated only by the radial arrangement of the imbrications which are produced where the concentric ridges and radial ribs cross. In young specimens the imbrications are very strong on the ventral margin of the anterior slope, reducing in strength toward the umbo and posteriorly toward the furrow. In old though living specimens, the sculpture on the anterior slope may be reduced to undulating ridges, the free edges of which are recurved, giving an appearance of thick-

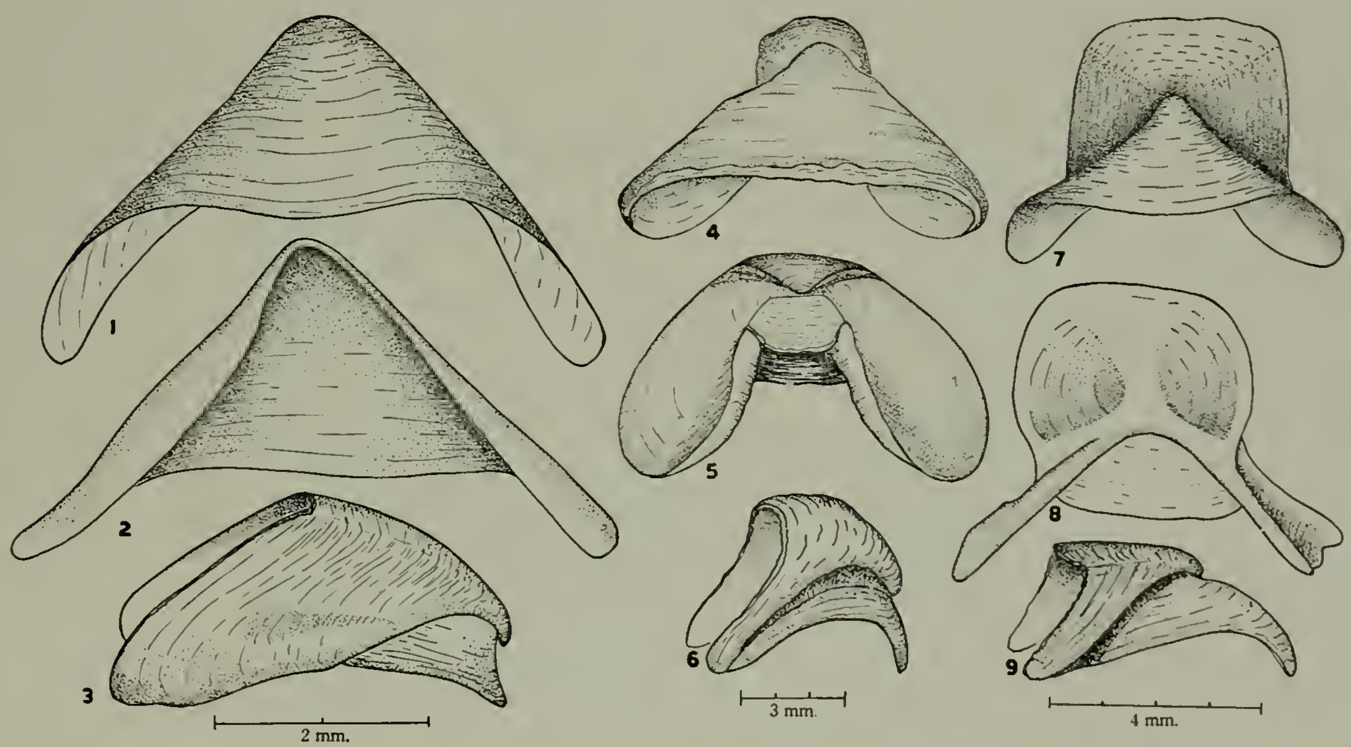

Plate 30. Mesoplax of *Zirfaea*. Figs. 1–3. *Zirfaea crispata* Linné, Rye Harbor, New Hampshire. Fig. 1. Dorsal view. Fig. 2. Ventral view. Fig. 3. Side view showing the basal flange which is generally not visible in either of the other views. Figs. 4–6. *Zirfaea pilsbryi* Lowe, Anaheim Bay, California, an old specimen. Fig. 4. Dorsal view showing the proportionately small basal flange typical of old specimens. Fig. 5. Ventral view. Fig. 6. Side view showing the marked curvature of the basal flange. Figs. 7–9. *Zirfaea pilsbryi* Lowe, Playa del Rey, California, a young specimen with a proportionately large basal flange typical of young and fast growing specimens.

ness. Interior of shell white to light-salmon in color and glazed. Muscle scars and pallial sinus well marked. Pallial sinus broad and deep extending inward nearly to the umbo. Apophyses rather large, solid, strongly curved, moderately to strongly spooned at the ventral margin and marked with concentric growth lines. Protoplax lacking. Mesoplax transverse, small but strong, more or less triangular in outline and usually with a well developed basal flange. Periostracum thin, straw-yellow to red-brown in color, and usually persistent on the posterior slope.

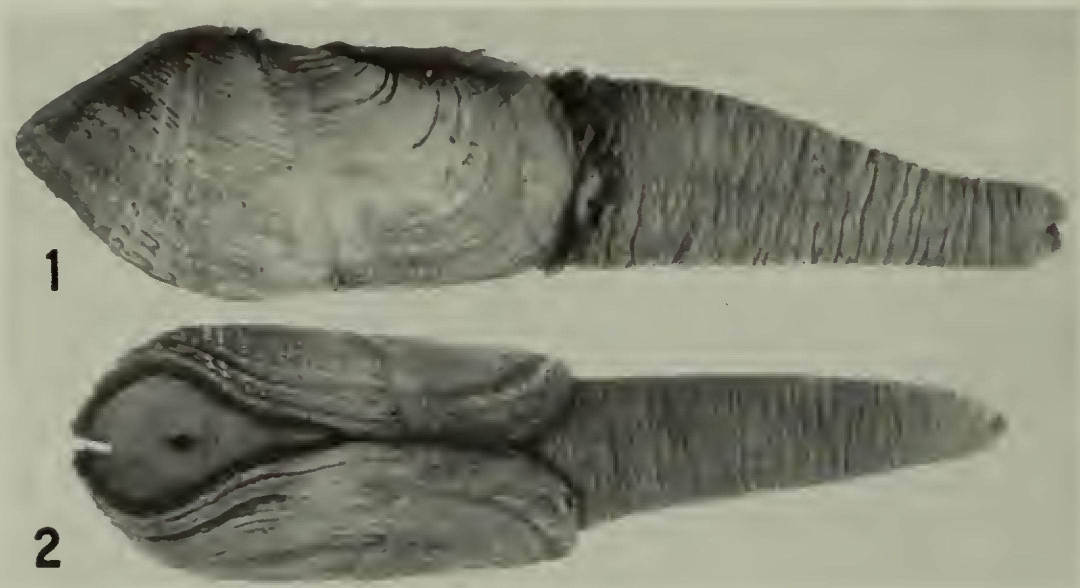

Plate 31. *Zirfaea pilsbryi* Lowe, Alamitos Bay, California (about $\frac{5}{8}$ natural size). Showing the minute chitinous spots on the siphons and the extent to which the valves are in contact on the ventral margin.
(Photographs received through the kindness of J. E. Fitch, California Fisheries Laboratory.)

The siphons are united and they may be extended six to eight times the length of the shell. The anterior one third of the siphons is covered with a dark-horn to red-brown periostracum which also extends over the posterior end of the shell. The remainder of the siphons lacking periostracum, a gray-white to light-ivory in color, and usually irregularly marked with small orange chitinous spots. These spots vary from one half to two millimeters in greatest diameter and never reach the size or thickness of those found on the siphons of *ovoidea* Gould. The area immediately surrounding the siphonal openings is marked with fine reticulations of dark mahogany-red. Incurrent siphon with dark-red, branched cirri at the opening, and these are continued as ridges which extend a short distance within. Excurrent siphon with several minute ridges and small cirri. Foot nearly circular in outline and truncate. Foot and mantle light-ivory in color. The above description of the soft parts is based upon preserved material.

length	height	ratio h:l	
122.0 mm.	67.0 mm.	1.8	Newport, Oregon
115.5	55.2	2.1	Anaheim Bay, California
105.0	68.0	1.5	South Alki Beach, Seattle, Washington
99.5	51.0	1.9	Lisabeula, Washington
76.0	37.0	2.0	Holotype. Bolinas, California
61.5	34.5	1.8	San Diego, California

Types. The holotype of *Zirfaea pilsbryi* Lowe is in the Academy of Natural Sciences, Philadelphia, no. 50809, from Bolinas, California, H. Hemphill, collector. Paratypes are in the Lowe Collection which is now at the San Diego Museum of Natural History.

Remarks. Zirfaea pilsbryi Lowe is closely related to *Z. crispata*, but may be distinguished from that species by its larger size and by having the ventral margin of the valves, especially in older specimens, nearly straight posterior to the pedal gape. This allows the valves to come in contact for a considerable distance along the ventral margin as shown in the figure of the living specimen. In *Z. crispata* the ventral margin is usually in contact for only a very short distance near the base of the umbonal-ventral sulcus. The post-umbonal area of *Z. pilsbryi* is generally longer, more truncate and inflated than in *Z. crispata* Linné, and in addition, the siphons are usually marked with small chitinous spots.

A lot of *Zirfaea* received from Humboldt Bay, California, lacks the small chitinous discs on the siphons, and in other respects these specimens more closely resembled *Z. crispata* of the Western Atlantic. In a letter, J. E. Fitch of the California Fisheries Laboratory informed us that the east coast oyster has been imported at this locality and he stated that there are now in the bay large beds of *Mya* and *Venus* and a number of gastropods all of which came in with the seed oysters of *Crassostrea*. Consequently it may well be that both species of *Zirfaea* now occur at this locality.

Zirfaea pilsbryi Lowe was formerly known as *Z. gabbi* Tryon. Lowe examined the type of *gabbi* and found that it was not in the genus *Zirfaea*, but was the young stage of a *Penitella*, so he placed it in the synonymy of *Penitella penita* Conrad. For a further discussion of this species see the remarks under *Penitella penita* Conrad and *P. gabbi* Tryon which will be covered in Part II of this family.

Zirfaea pilsbryi Lowe is usually found boring into mud and clay banks, the larger specimens burrowing to a depth of ten to fourteen inches (Fitch 1953, p. 95). Occasionally, like its Western Atlantic counterpart, it is found boring into decaying, waterlogged wood.[1] Specimens from the Queen Charlotte Islands which had been boring into sand-

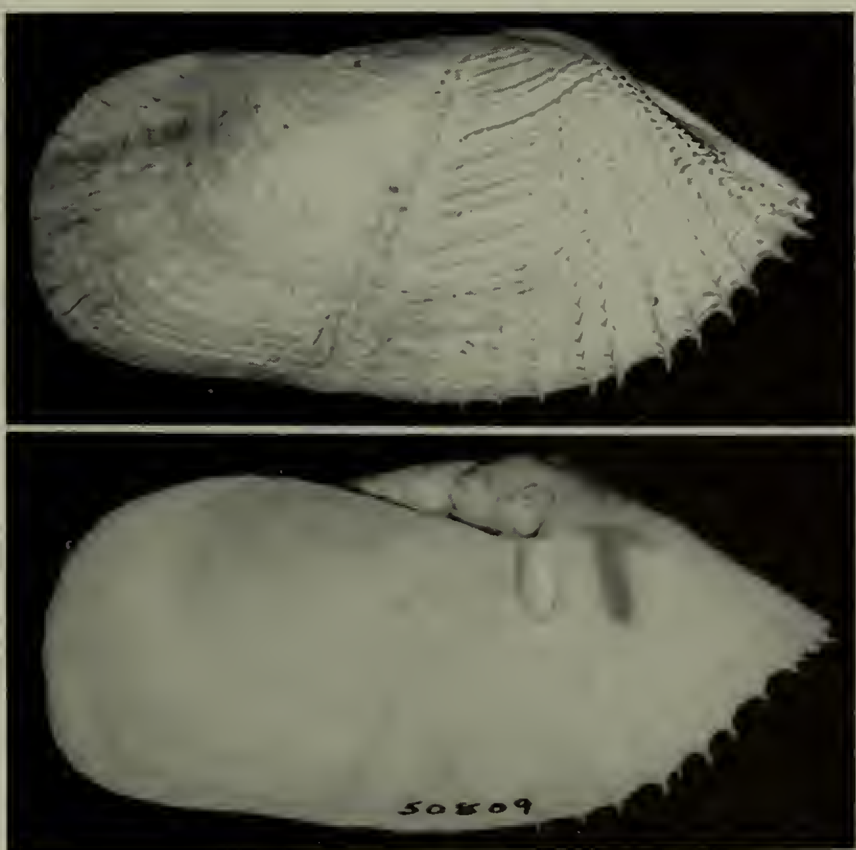

Plate 32. *Zirfaea pilsbryi* Lowe, from Bolinas, California. Holotype (slightly enlarged).

[1] W. K. Emerson 1951, Bulletin Southern California Academy of Sciences **50**, pt. 2, p. 89–91.

stone were stunted and misshapen. An interesting account of the ecology and method of boring of this species is given by MacGinitie (1935, pp. 731–735).

Range. From Nunivak Island, Alaska south to San Jaunico Bay, Baja California (Fitch 1953, p. 95).

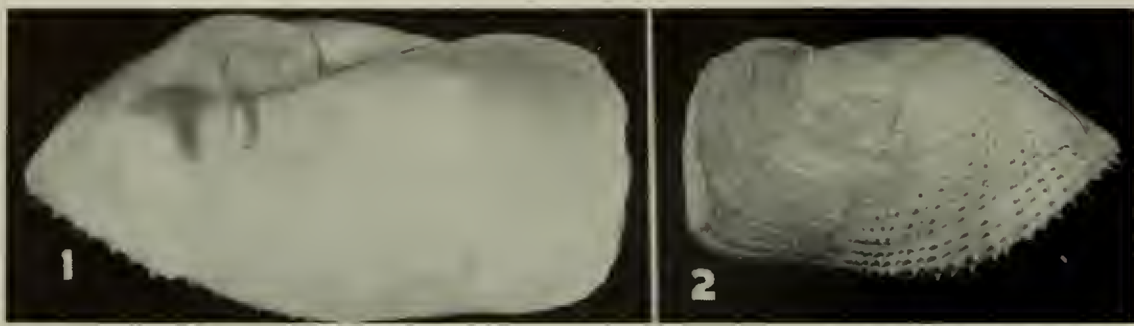

Plate 33. *Zirfaea pilsbryi* Lowe. Fig. 1. Bolinas, California. To show muscle scars and pallial line, umbonal-ventral ridge barely visible. Fig. 2. A truncate form from San Diego, California (both about $\frac{3}{4}$ natural size).

Specimens examined. Alaska: Nunivak Island; Port Möller; Bering Island (all USNM); Cordova (W. J. Eyerdam). British Columbia: Queen Charlotte Islands (USNM). Washington: Port Orchard; South Alki Beach, Seattle; Anacortes; Brainbridge, near Winslow, Kitsap County (all W. J. Eyerdam); Fort Lawton Beach, Puget Sound; Lisabeula (both MCZ); Willapa Bay (E. P. Chace). Oregon: Netarts Bay, Tillamook County (R. Coats); Newport (ANSP). California: Daby Island and Buhne Point, Humboldt Bay (both J. E. Fitch); Bolinas (MCZ; ANSP; USNM); San Francisco; Santa Cruz (both MCZ); Monterey Bay (E. P. Chace); Elkhorn Slough, Monterey Bay (J. E. Fitch); San Pedro Bay (AMNH); Anaheim Bay (E. P. Chace; USNM; MCZ); San Diego (AMNH; USNM); Playa del Ray (W. J. Eyerdam); Alamitos Bay, Long Beach (J. E. Fitch). Mexico: Bahía San Quintín and Punta Abreojos, Baja California [dead and worn specimens] (both USNM).

Plate 34. *Zirfaea pilsbryi* Lowe, Marin County, California. Ventral view of opposed valves to show the apophyses and hinge area (about $1\frac{1}{4}$x).

Notes

Barnea subtruncata *Sowerby*

Two additional Mexican records for this species were received from Dr. S. S. Berry after the section on this species had been printed. These are San Felipe and Punta Cyote, northwest of La Paz, both Baja California in the Gulf of California.

Barnea maritima *'d'Orbigny' Dall*

Barnea maritima 'd'Orbigny' Dall 1889, Bulletin United States National Museum, no. 37, p. 72 (Texas) [nomen nudum].

We have been unable to find a description of this species by d'Orbigny and believe that it was possibly a manuscript name on specimens in the collection of the United States National Museum which Dall had used at the time he worked up his list of the marine mollusks of the southeastern states. Since that time this name has appeared in several lists.

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Book Reviews

Abbott, R. T. 1954: American Sea Shells. D. Van Nostrand Co., Inc., New York, pp. 14+541, 40 plates (24 in color), 100 text figures. Abbott has presented the many students and collectors of our American marine mollusks with a very readable and informative book. He considers the shells of our east coast from Labrador to Texas, including only those West Indian elements that reach Florida, and the west coast from Alaska to southern California. For the professional worker it presents a source of information and answers many queries which arise almost daily. To the beginner and the "professional amateur" it will be helpful in determining their local material as well as giving suggestions on procedure in caring for the collection. Few, if any, of our common species have been overlooked and many of the rarer species have been included. The colored plates are excellent and the black and white plates are, for the most part, exceedingly clear as to detail. Many of the text figures are by J. C. McConnell who was for many years associated with Dall. Few artists have had his ability in pen drawing.

There is much in addition to the taxonomy and descriptive elements in this book. Abbott has included in detail, methods of collecting, life histories, habitats and many other subjects not presented in popular books on mollusks. Chapter 14 is a guide to the literature which is most valuable for locating additional information about our marine mollusks.

The scientific names of our mollusks change with the acquisition of new knowledge. Many new names or new name combinations appear in this book with no explanation for these various changes. This is unfortunate. These must either be accepted blindly or considered individually and restudied, a long and thankless task and a great duplication of effort. However, this criticism is trivial, considering the book as a whole. It is very well done and will do much to advance knowledge among an ever increasing number of competent students.—W. J. Clench

La Rocque, Aurèle 1953, Catalogue of the Recent Mollusca of Canada. National Museum of Canada, Ottawa, Bulletin no. 129, 9–406. This is an exceedingly important piece of research. The catalogue proper is arranged taxonomically from Classes down to Subgenera. Each species has the original citation and one or more references to standard North American monographs or other studies covering the species in question. Type localities are given as well as the known range for each species. The ranges for the marine mollusks of both coasts are now pretty well known, as well as for most species of land shells. The fresh-water species, however, are far less known and many of the ranges given by La Rocque are open to question. This is not at all the fault of La Rocque, but it is because the available literature on our fresh-water mollusks is mainly old, particularly papers of monographic scope, and many of the published data are quite unreliable. The author has a peculiar and somewhat misleading procedure which is to cite a species under its present genus followed by the original reference without the original name combination. For example:

"*Paravitrea multidentata* Binney 1840, Journal Boston Soc. Nat. Hist., vol. 3, p. 425."

The genus *Paravitrea* was established by Pilsbry in 1898, a name, of course, unknown to Binney in 1840. Such entries are readily recognized in the present paper as La Rocque has dated the establishment of each genus. The danger here is that subsequent authors, not having a large library to consult, are very apt to quote as original from La Rocque such name combinations which were not given in the original citation.

There is an excellent bibliography and a complete alphabetic index.—W. J. Clench

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Carcelles, Alberto R. 1953, Catalogo de la Malacofauna Antarctica Argentina. Anales del Museo Nahuel Huapi **3**, pp. 150–250, 5 plates and 1 map. This is a companion report to the three earlier papers on the mollusk fauna of Argentina by Carcelles which were reported upon in Johnsonia **2**, p. 380. This present report covers the Antarctic fauna and lists 338 species included in 175 genera. As in previous reports, the author has given a brief history of the work accomplished in this area. The catalogue is arranged systematically, and for each species there are several references, the known range of the species and the localities for the specimens which he examined. An excellent table is given showing the geographic distribution of the species of this region and their occurrence as well in the Magellanic Province. The plates are excellent and 114 species have been illustrated. This very important piece of work when combined with Carcelles' three other papers, gives a complete summation of the Argentinian marine mollusks. There is also an extensive bibliography.—R. D. Turner