

REEF AND SHORE FAUNA OF HAWAII

By
CHARLES HOWARD EDMONDSON

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Reef and Shore Fauna of Hawaii

By CHARLES HOWARD EDMONDSON

INTRODUCTION

It is not strange to find in an island community such as Hawaii a genuine and widespread interest in the natural history of both land and sea. Our knowledge concerning the inhabitants of the ocean, however, remains relatively meager and fragmentary, because of the obscurity in which they live and the difficulties experienced in gaining information about their habits and modes of life. Although, aside from form and structure, little is known about many common organisms of the sea, by reason of this limitation an inquiry into the intricate relationships of that world of water life becomes the more enticing.

In presenting this condensed pictorial treatise on the marine fauna of Hawaii, the primary purpose is to quicken human interest in the dwellers of the sea, so near at hand, yet so little understood. For many years teachers of biology throughout the territory have been calling for guidance in directing the younger generations in their enthusiastic curiosity about familiar things of their native shores. In an attempt to meet an apparent need, this authoritative information, brief as it may be, about local marine animals was brought together for the benefit of students, teachers, and others who were interested in this particular phase of the organic world in Hawaii.

That serious-minded investigators might know something of the general character, the scarcity or abundance, and the relative accessibility of the main groups of marine animals available for purposes of research about the shores of Hawaii, has also been an important consideration.

Knowledge about Hawaiian marine fauna has been accumulating for more than 110 years, through the efforts of numerous collectors and investigators. Several organized scientific expeditions have made valuable contributions, among them the United States Exploring Expedition in 1840, the *Challenger* Expedition in 1875, and the expedition of the United States Fish Commission, consisting of a shore party in 1901 and the

Albatross in 1902. To the operations of the *Albatross* is due most of the information known regarding animal life in the waters about Hawaii, from offshore zones down to great depths. The *Tanager* Expedition in 1923 included an extensive exploration of the reefs and shallow waters of the leeward islands of Hawaii as far as Kuré (Ocean Island).

This treatise covers the principal groups of marine fauna from the Protozoa through the lower Chordata, including fishes, and gives preference to common forms typical near shore. Some species usually found at moderate depths but which occasionally migrate into shallow water are also included, as are a few forms known in Hawaii only about the low leeward islands. Brief mention is made of species reported from Hawaii many years ago but not observed since, and of certain species whose Hawaiian record needs verification.

It should not be assumed, however, that this is an exhaustive treatment of local marine fauna. Doubtless some common forms have inadvertently been omitted. Many have not been determined specifically, and certain neglected phyla and subdivisions are, for this reason, mentioned only in a very general way. Furthermore, the Hawaiian shore line is extensive and the reefs and shallow waters have been by no means thoroughly explored. Observing collectors are still rewarded by the discovery of new species or forms previously unrecorded from this region.

Although Hawaii is much nearer the American continent than any other large land area, few shallow-water forms are common to the two regions. The general trend of the shore fauna of the central Pacific area has apparently been from the Indian Ocean spreading out through the Pacific Ocean to eastern Polynesia, southern Japan, and Hawaii. Some of the common shore forms range all the way from Madagascar and the Red Sea to Hawaii by way of the East Indian route. Hawaii is a northeastern frontier for many species.

Collections of Hawaiian marine fauna are to be found in various museums of Europe and the United States. Probably the most complete is in the United States National Museum, the result of the work of the *Albatross*. There are also valuable collections in Bernice P. Bishop Museum and the University of Hawaii, as well as several extensive privately owned ones, chiefly of Mollusca, in Honolulu.

For the advantage of those who wish to observe marine shore fauna under natural conditions, or to collect them, some of the more accessible and productive localities about the principal islands are mentioned. It is obvious that some species are widely distributed about the shores of all

the islands, whereas others are more or less localized. It should also be remembered that many inhabitants of the reefs and shallow water, especially invertebrates, find concealment during the day either in the sand, under stones, or in crevices of rocks. Many forms are, as a general rule, more active at night; if collected during the day one must search for them in their hiding places.

The coast of Oahu is surrounded by a fringing reef with white sand beaches alternating with rocky shores and headlands and indented by numerous bays. Such open reefs as Waikiki and sections of the windward side of the island support a varied fauna. By examining the under surface of loose stones or breaking up dead coral blocks, one may procure many specimens. An excellent locality for general collecting is the Kahala side of Black Point. Here the sand, the under surfaces of stones, and the porous rocks yield a great variety of animal forms, among which are echinoderms, worms, crustaceans, and mollusks. In the gravel beds at the south side of Hanauma Bay are to be found species of *Callianassa* (p. 260), annelid worms (p. 103), gephyreans (p. 62), and other burrowing forms; and the loose stones in that vicinity support many other invertebrates. The rough headland of Makapuu and the rocky shores of Waimanalo are interesting to those wishing to collect gastropod mollusks.

Kaneohe Bay harbors a large population of marine animals. Here is one of the best exhibitions of living corals to be seen about the islands, and sponges of many colors are interspersed among coral colonies (fig. 1, a). The "coral gardens" off Haleiwa, though quite different from those of Kaneohe Bay, rival them in interest. At low tide considerable areas of Kawela Bay are made accessible to the collector. Here is found a varied fauna. On a small reef at Maili Point specimens of the starfish, *Asterope carinifera*, the holothurian, *Stichopus tropicalis*, and the brightly colored shrimp, *Stenopus hispidus*, are plentiful.

Pearl Harbor with its extensive shore line is a natural aquarium for many varieties of marine animals. Sponges, clams, and other mollusks, barnacles, and other crustaceans are abundant about the shores, on piling and floats. A large jellyfish (p. 28) is plentiful in the harbor during the winter months. The long snake-like holothurian, *Ophcodesoma spectabilis*, is common in Pearl Harbor as well as in Kaneohe Bay.

Many other localities about Oahu are of interest to the marine zoologist. Dredging operations in Honolulu Harbor, at Kewalo, and at Waikiki have yielded forms of animals not usually seen by the shore collector.

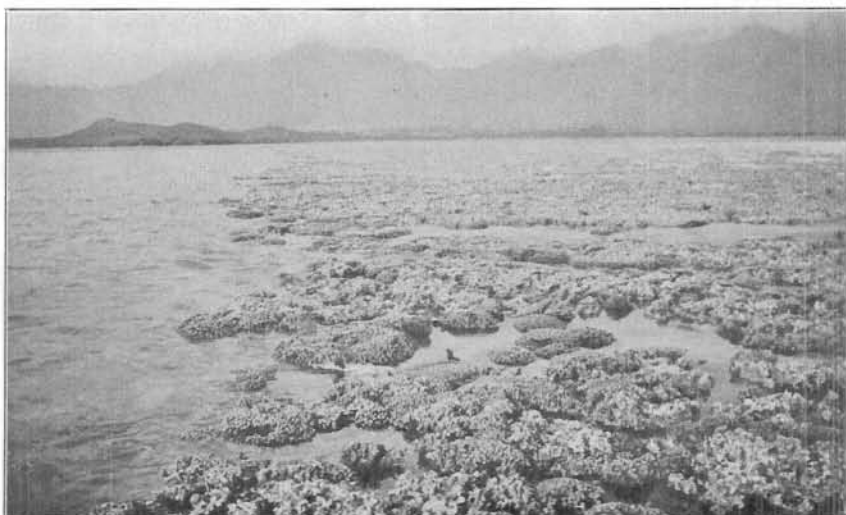
*a**b*

FIGURE 1.—Oahu and Maui localities harboring marine fauna: *a*, reef in Kaneohe Bay, Oahu, at low tide; *b*, shore westward from Maalaea Bay, Maui.



Much of the shore line of Maui is bordered by steep cliffs at the foot of which are lava rocks but no reefs. Such localities support a varied molluscan fauna but are often inaccessible to the collector. The shores of Hana Bay are inhabited by crabs, barnacles, gastropods, and tectibranch mollusks. Along the accessible Maliko coast, on and among the lava stones which line the shore, are to be found gastropod mollusks and crabs. A pulmonate mollusk, *Siphonaria*, with heavy ribs is typical of this region.

One of the best localities for general collecting about Maui is the west side of Maalaea Bay where the sandy beach merges into the rock-covered shore (fig. 1, *b*). On the under surface of the loose stones are many marine organisms. Here in large numbers is a small starfish, *Coscinasterias acutispina*, which undergoes rapid division by fission. Bordering the shore near Makena, Maui, are small reefs accessible at low tide and supporting living corals with the usual fauna typical of such localities. Under the lava stones which line the shore south of Makena lives a small crab, *Cyclograpsus granulatus*, known only from Maui. Here, also, the shore isopod, *Ligia exotica*, is plentiful.

Collecting on Kauai is profitable on the south, east, and north shores. There has been but little investigation along the almost inaccessible Napali coast to the northwest, and long stretches of sandy beaches to the southwest support little animal life. The rocky shores of the Spouting Horn region and those of the east coast in the vicinity of Wailua yield a varied fauna of mollusks, crustaceans, and echinoderms. The north shore from Kalihiwai Bay to Haena is of interest to the collector. On some of the beaches between Hanalei (fig. 2, *a*) and Haena quantities of marine shells are washed ashore, indicating a rich molluscan fauna in the offshore water. On the shore of Kalihiwai Bay, under the lava stones, are found the isopod, *Ligia kauaiensis*, and several rather uncommon species of shore crabs including *Cyclograpsus henshawi*.

The north, or windward, shore of the long, narrow island of Molokai is quite inaccessible to the collector of marine organisms because of the abrupt cliffs. Along the low southern coast, however, a flat reef platform of considerable width extends the length of the island. Corals grow luxuriantly, especially in the vicinity of Pukoo, and the entire southern shore is of interest to the marine zoologist. Tide pools at the eastern and western extremities of the island are habitats of a varied fauna.

The island of Hawaii is bordered, for the most part, by an exceedingly rough and rugged coast line, making shore collecting hazardous or impos-

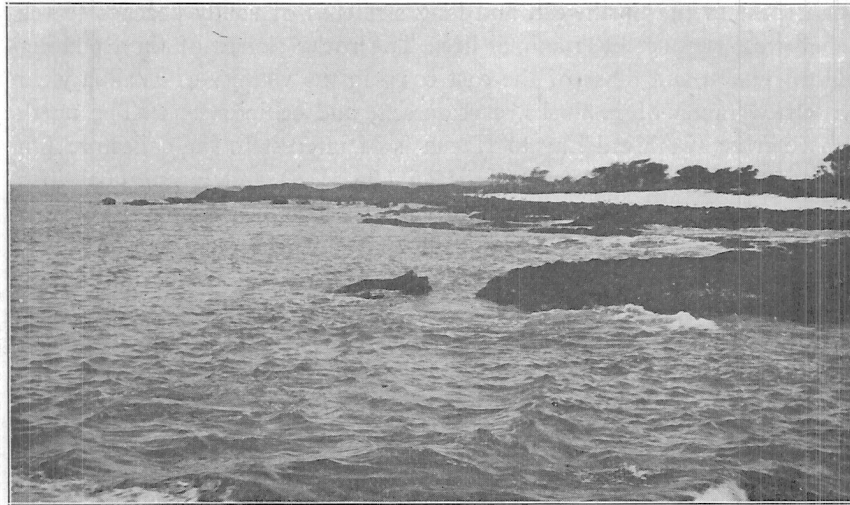
*a**b*

FIGURE 2.—Kauai and Hawaii shore lines: *a*, Hanalei Bay, Kauai, from photograph by R. J. Baker; *b*, shore north of Kailua, Hawaii.

sible in many localities. Volcanic action in prehistoric and more recent times is responsible for the present condition of the shore and also for the paucity of reefs about the island. (See fig. 2, *b*.) In only a few places and but to a slight extent have corals become established in the near-shore areas. Whereas the more exposed coasts of the island are somewhat barren of animal life except a molluscan fauna characteristic of such an environment, in some protected localities the general collector may find his efforts well repaid. Of numerous places examined on the west coast of Hawaii in 1931, the best collecting was found to be at Honaunau. In this small, sheltered bay bordering the ancient city of refuge is a rich invertebrate fauna. More than 20 species of echinoderms are represented here, and many forms of worms, mollusks, and crustaceans. Localities in the vicinity of Hilo, including the area about Coconut Island and the rocky shore to the southward, are among the most accessible and profitable on the east coast of Hawaii.

The technique of collecting fishes differs from that of taking fixed forms or slow-moving invertebrates. Some of the smaller fishes, such as gobies, are found under stones along the shores, others may be procured by breaking open branched coral heads in which they find concealment. With proper nets and other equipment many species of fishes may be taken on the reefs and in the shallow bays about the islands.

In this work the photographs and figures supplementing the text were made by me, except where credit is otherwise given, from living or preserved animals or casts. Many of the living specimens were photographed under water. The size of specimens is indicated in inches unless the dimensions are less than one inch, when the millimeter scale is used (25 mm. = 1 inch).

At the end of the text is a glossary in which are defined some of the technical terms used. This is followed by a bibliography, which includes the principal sources from which information was obtained, and an index of scientific names.

PHYLUM PROTOZOA

Protozoa are microscopic or minute animals consisting of but a single cell throughout their existence. They inhabit both fresh water and the sea, and many are parasitic, living in the fluids of other animals. Some live as free, independent cells. Others form colonies by the association of individuals.

The four subdivisions (classes) of the phylum usually recognized, and their characteristics, are as follows: Sarcodina which move by protoplasmic extensions of the body (pseudopodia); Mastigophora which bear whiplike organs of locomotion (flagella); Sporozoa which lack organs of locomotion in the adult stage; and Infusoria which move by short, hair-like structures (cilia) during their whole life or in the larval phase only, the adults of some possessing suctorial processes.

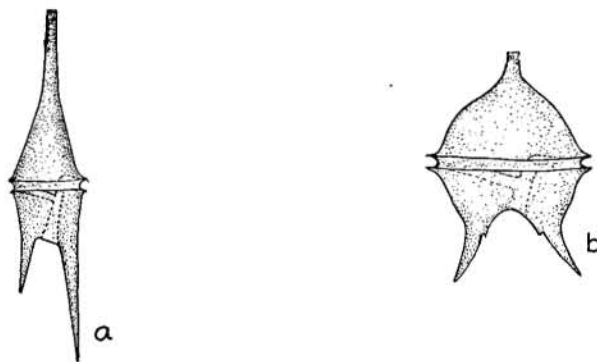


FIGURE 3.—Protozoa: a, *Ceratium* species; b, *Peridinium* species.

Protozoa are well represented in the sea, where they live in shallow water and from the surface to great depths. The presence of some forms, though they are of minute size, may be indicated by certain properties possessed by them. The pelagic flagellate *Noctiluca* which is luminous at night is responsible, in part, for the so-called "phosphorescent light" so often seen at sea. When myriads of individuals are assembled this unicellular organism may cause the surface of the ocean to be brightly illuminated. Some shell-bearing forms of Protozoa also float on or near the surface of the sea, their shells (tests) of siliceous or calcareous material sinking when the animals die and entering into the composition of the ooze at the bottom of the ocean. Certain of the Dinoflagellates, such as species of *Ceratium* (fig. 3, a) and *Peridinium* (fig. 3, b) are abundant

at the surface near shore. Individuals of the long-horned *Ceratium* are sometimes joined together in a chain. This form is not often found in reef water but is more typical of the open sea.

Many examples of marine Protozoa, as naked ameboid forms, flagellates, and ciliates, may be obtained by submerging seaweeds in a dish of standing sea water. In a few days a large population of microorganisms collects in the scum at the surface of the infusion. Stalked ciliates and suctorians live attached to the branches of marine algae and hydroid colonies. Parasitic forms (Sporozoa) infest the intestinal tracts and tissues of fishes, mollusks, arthropods, and other inhabitants of the sea.

Of the test-bearing Protozoa in the shallow water about the islands the Foraminifera are among the most familiar. They are Sarcodina with delicate pseudopodia which branch and anastomose into a network outside the test. The tests may be of foreign particles picked up by the animal from its surroundings, apparently with some degree of selection, or secreted by the organism itself. Calcium carbonate is a chief constituent of many of the secreted tests. Some of these have the walls perforated by minute pores (foramina), in addition to the chief aperture, through which fine threads of protoplasm stream. Others have but a single aperture.

Tests of Foraminifera consist of one, a few, or many chambers. The forms assumed are many. Some are linear in outline and others are coiled somewhat like minute nautiloid mollusk shells.

About islands bordered by coral reefs, Foraminifera may be collected in large numbers in the sand on the beaches and near-shore areas, among seaweeds, in sediment on rocks, as well as in the deeper off-shore water.

Recent collections of Hawaiian Foraminifera include nearly 100 species taken by the *Tanager* Expedition among the leeward islands from moderate depths and the shore zone. The following list is from the shore sand of Oahu and represents but a few of the more common forms.

CLASS SARCODINA
ORDER FORAMINIFERA
FAMILY MILIOLIDAE

Foraminifera of this family are well represented in the shallow waters of warm seas, and numerous species are common in Hawaiian shore sands. The tests are, in most forms, calcareous and are without foramina. Their chambers are coiled in a longitudinal direction with the aperture at one end.

In the genus *Quinqueloculina* five chambers are visible externally and are coiled in five planes. The surface is smooth or ornamented by pits, striations, or costae. Some of the common local forms are of doubtful determination, but several widely distributed species are recognized. In *Q. seminulum* (Linnaeus) (fig. 4, *a*) the test is elongate, smooth with rounded margins. The aperture is oval with a bifid tooth. Specimens are about 1.5 mm. long. The species *Q. reticulata* (d'Orbigny) has the test marked with rows of pits. It is 1.5 mm. long. The tests of *Q. parkeri* (H. B. Brady) is recognized by its transverse ridges or crenulations. It is about 1 mm. long. Specimens resembling *Q. bicostata* d'Orbigny, with paired costae ornamenting the chambers, are occasionally seen. They may reach 1.25 mm. in length.

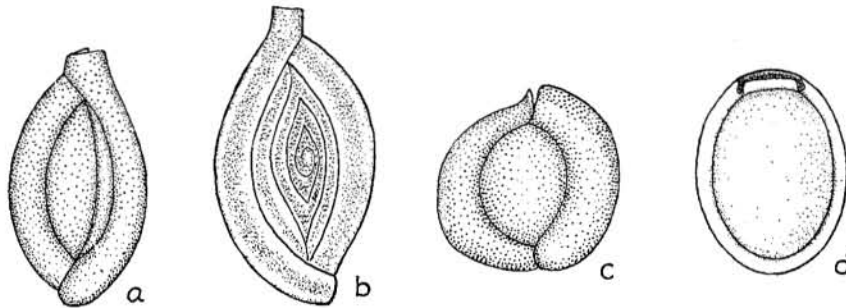


FIGURE 4.—Miliolidae: *a*, *Quinqueloculina seminulum*; *b*, *Spiroloculina grateloupi*; *c*, *Triloculina circularis*; *d*, *Pyrgo* species.

In the genus *Spiroloculina* the tests are flattened, as the later chambers are coiled in one plane. A circular aperture terminates a neck. The species *S. grateloupi* d'Orbigny (fig. 4, *b*) is thin in the middle with a thicker periphery. The chambers are evenly rounded, the last one projecting at both ends. Specimens are about 1 mm. long. In *S. canaliculata* d'Orbigny the periphery of the chambers is concave with sharp edges. A circular aperture with a flaring lip terminates the neck. Specimens are about 1 mm. long. A form resembling *S. antillarum* d'Orbigny is common on local reefs. The circular chambers of the test are ornamented by longitudinal or oblique costae and there is a long cylindrical neck. Specimens are about 1 mm. long.

In species of *Triloculina* only three chambers are visible externally in the adult stage. A common local species is *T. circularis* Bornemann (fig. 4, *c*), which has a rounded, compressed test with a smooth surface. The

aperture is crescent shaped with a semicircular tooth. Specimens observed are less than 1 mm. long. In *T. linnaeana* d'Orbigny the test is compressed and ornamented by prominent ridges with deep depressions between them. The rounded aperture has a bifid tooth. Specimens may reach 2 mm. in length.

In species of *Pyrgo* (*Biloculina* of some authors) there are but two chambers visible from the exterior. They seem to be less numerous in Hawaii than other members of the family. (See fig. 4, d.)

FAMILY OPHTHALMIDIIDAE

A Hawaiian example of this family is *Cornuspira involens* (Reuss) (fig. 5, a), which consists of a simple tube coiled in one plane. There is a short central initial chamber and a long, spiral second one, the open end of which is the aperture. There are no foramina. Large specimens are about 1 mm. in diameter.

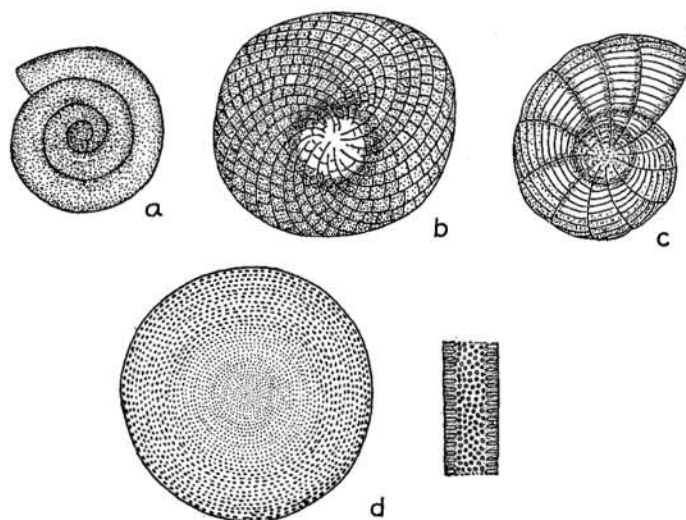


FIGURE 5.—Foraminifera: a, *Cornuspira involens*; b, *Heterostegina suborbicularis*; c, *Peneroplis pertusus*; d, *Marginopora vertebralis*, side and marginal views.

FAMILY CAMERINIDAE

A common representative on the reefs is *Heterostegina suborbicularis* d'Orbigny (fig. 5, b). The chambers are spirally arranged, forming a disklike test thick in the middle and thin toward the periphery. The chambers become increasingly long from the center outward and are divided by

many partitions. A row of pores on the thin margin represents the aperture. Most specimens taken near shore are not more than 4 or 5 mm. in diameter. Some dredged off Waikiki, Oahu, at depths of 40 to 50 fathoms, are 15 mm. across.

FAMILY PENEROPLIDAE

One of the most common species in the shore sands of Hawaii is *Peneroplis pertusus* (Forskål), which assumes many forms of growth. The early chambers are closely coiled, but the later ones may flare out or tend to uncoil. Typically the test is compressed and the chambers are undivided. Large specimens are 2 mm. across. (See fig. 5, *c*.)

Members of the genus *Spirolina* are associated with those of *Peneroplis*. The early chambers are closely coiled, the later ones uncoiled. The circular aperture is terminal. Specimens are 2 mm. long.

Several other representatives of the family have flattened, disklike tests and resemble each other in general appearance, but differ in microscopic details. In each the chambers are annular in arrangement and are divided by many partitions. In *Marginopora vertebralis* Quoy and Gaimard (fig. 5, *d*) the apertural pores are numerous in the margin of adult individuals. Among specimens dredged off Waikiki, Oahu, at depths of 40 to 50 fathoms, one is 20 mm. in diameter. Those taken near shore are smaller. Two other species, *Sorites marginalis* (Lamarck) and *Amphisorus hemprichii* Ehrenberg, are distinguished from *Marginopora vertebralis* and from each other by the pores of the margin. In *S. marginalis* there is a single row of pores and in *A. hemprichii* the pores are in two alternating rows. Specimens of both species 3 or 4 mm. in diameter are common in shallow water.

FAMILY HETEROHELICIDAE

Specimens of *Bolivinita rhomboidalis* (Millett) are occasionally taken on Hawaiian reefs. The chambers of the test alternate and the periphery is concave. The white calcareous wall is coarsely perforated. Specimens are about 0.6 mm. long. (See fig. 6, *a*.)

A common form, *Bolivinitella folium* (Parker and Jones) is thin, compressed. The chambers increase in length and result in a fan-shaped test. The length is about 0.5 mm.

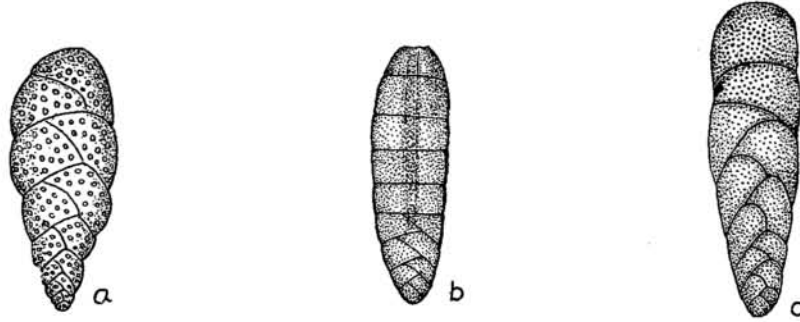


FIGURE 6.—Foraminifera: *a*, *Bolivinita rhomboidalis*; *b*, *Rectobolivina bifrons*; *c*, *Loxostomum* species.

FAMILY BULIMINIDAE

Examples of the genera *Rectobolivina* and *Loxostomum* occur in shallow water about the islands. In *Rectobolivina* the test is biserial at first and then becomes uniserial. It is almost circular in cross section. The aperture is terminal at the larger end. A local species, probably *R. bifrons* (H. B. Brady), is 0.5 mm. long. (See fig. 6, *b*.)

In *Loxostomum* the test is usually compressed and may be slightly twisted. It is biserial at first, but the later chambers extend entirely across the test. A common local form (fig. 6, *c*) is about 1 mm. long.

FAMILY ROTALIIDAE

Members of this family have calcareous tests either spirally coiled in one plane or trochoid and perforated by foramina. In the simpler forms represented by the genus *Spirillina* there are but two chambers, a small initial one in the center, and a second long tubular one coiled in a single plane, all the whorls being visible on both sides. Undetermined species of *Spirillina* are occasionally taken on the reefs. The one illustrated (fig. 7, *a*) is 0.3 mm. in diameter. Trochoid forms are rarely observed in local shallow waters, and none have been determined with certainty.

FAMILY AMPHISTEGINIDAE

Specimens corresponding to *Amphistegina madagascarensis* d'Orbigny are common in shore sands. The test is unequally biconvex with the periphery sharp. The chambers are few and the sutures have a distinct angle. Except for granules near the aperture, the test is smooth. Large specimens are 1.5 mm. in diameter. (See fig. 7, *b*.)

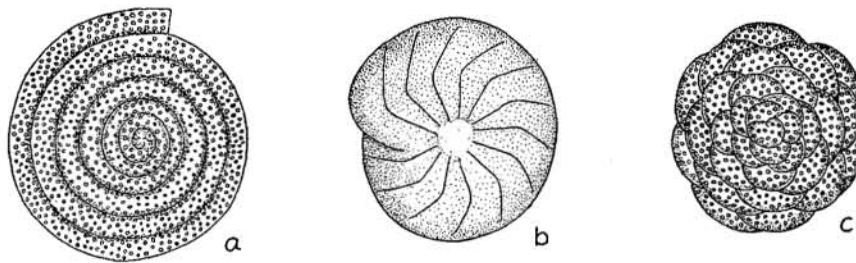


FIGURE 7.—Foraminifera: *a*, *Spirillina* species; *b*, *Amphistegina madagascariensis*; *c*, *Cymbaloporella tabelaeformis*.

FAMILY CYMBALOPORETTIDAE

A Hawaiian reef form, *Cymbaloporella tabelaeformis* (H. B. Brady) (fig. 7, *c*), illustrates the general features of the family. The test is flattened below and convex above. All the numerous perforated chambers are visible from a dorsal view. Specimens are about 1 mm. in diameter.

Another species, *Tretomphalus bulloides* (d'Orbigny), is occasionally taken near shore. A group of perforated chambers like those of *Cymbaloporella* forms a cap over the final, spherical chamber. The aperture consists of numerous small pores through the ventral surface of the inflated chamber. One of the larger pores has a neck which projects internally. The species is a pelagic form. Hawaiian specimens are about 0.8 mm. in diameter.

PHYLUM PORIFERA

Sponges are the lowest forms of many-celled animals. All are aquatic, some inhabiting fresh water, but most of them living in the sea, where they are distributed from the shore to great depths. Their body walls are perforated and provided with a system of canals and cavities through which the water passes. Water enters the sponge through numerous pores (incurrent pores) and is finally expelled through one or more openings (oscula). The outer surface of the sponge is covered by a flattened layer of cells (ectoderm) and the canals are lined by another layer (entoderm). In certain canals and cavities the entodermal layer consists of elongated cells, each bearing a collar and flagellum. These are called collar cells. As the flagella beat in unison, a current of water is drawn through the sponge. Food, consisting of minute organisms, is absorbed by the collar cells and passed on to others.

Beneath the entoderm is a gelatinous layer (mesogloea) supporting cells which produce spicules or spongin, the skeletal structures, and those which develop into ova and sperm, the reproductive elements.

The supporting or skeletal structure of a sponge consists of spongin or spicules or both. Spongin is a fibrous substance forming a dense network supporting the living cells. When the organism dies the spongin remains as an elastic skeleton, the character and consistency of which largely determines the commercial quality of sponges. Spicules are calcareous or siliceous elements which constitute a supporting framework for the living tissue and serve as a screen guarding the aperture of surface canals. In some sponges they are useful as holdfasts or anchors furnishing means of attachment. Spicules assume many forms in sponges and are important structures by which these animals are classified. In such commercial sponges as the bath sponge, there are no spicules; the skeleton is formed of soft tough spongin.

Besides reproducing by means of ova and sperm, sponges often increase by budding and other asexual methods. Some multiply by extending from the body processes which break away, mass together, and grow into new individuals.

Marine sponges are common in the shallow waters of Hawaii. Many are incrusting forms of small size, coating the under surface of stones or attached to other supports. Some develop into upright, branching colonies. Most of them are conspicuously colored, commonly in shades of red, orange, purple and yellow. Some are black and some white or gray.

In protected waters about the islands, sponges abound. Some of them grow to a height or diameter of a foot or more. In the shallows of Pearl Harbor, Oahu, about Ford Island, large areas of the bottom are carpeted by sponge colonies. Black, columnar sponges, many of them branched, are conspicuous among the coral colonies in Kaneohe Bay, Oahu. The larger sponges serve as shelters for many small animals, especially crustaceans and brittle stars, which conceal themselves in the canals.

Sponge crabs (p. 268) are often observed about the shores. Fragments of living sponges are carried on the backs of these crabs, held in place by the specialized posterior legs of the crustaceans.

A survey of the waters about Hawaii might reveal the presence of commercially valuable sponges. Although the shore forms are small, coarse in texture, fragile, and usually supplied with sharp spicules, larger and more compact sponges are known to live in local waters at depths of a few fathoms. Some of these of the horny type, free from spicules, are occasionally washed ashore or dredged. While the spongin of these forms is rather coarse, proper curing might render them valuable. Few Hawaiian sponges have been studied systematically. A very general classification, therefore, with some of the common forms tentatively placed in the larger groups must, for the present, suffice.

CLASS CALCAREA

Sponges of this class have spicules of carbonate of lime which are unbranched, needle-like, or branched with three or four rays. The sponges have a simple canal system and are typically elongated and upright in position. There is a large body cavity and an osculum at the free end. Some forms are more flattened and spread over surfaces with an increase in the number of oscula.

Most Hawaiian sponges of this class are white or brown and are attached to the under surface of stones in shallow water. Most simple cylindrical forms are less than 1 inch long. (See fig. 8, *c.*) Flattened, irregular forms 2 or 3 inches across are occasionally observed. Branched spicules form a network in the wall and in some species long needle-like spicules encircle the osculum like a collar. (See fig. 9, *a.*)

CLASS HEXACTINELLIDA

Deep-sea sponges with six-pointed, branched spicules of silica are included in this group. There are no representatives in shallow water.

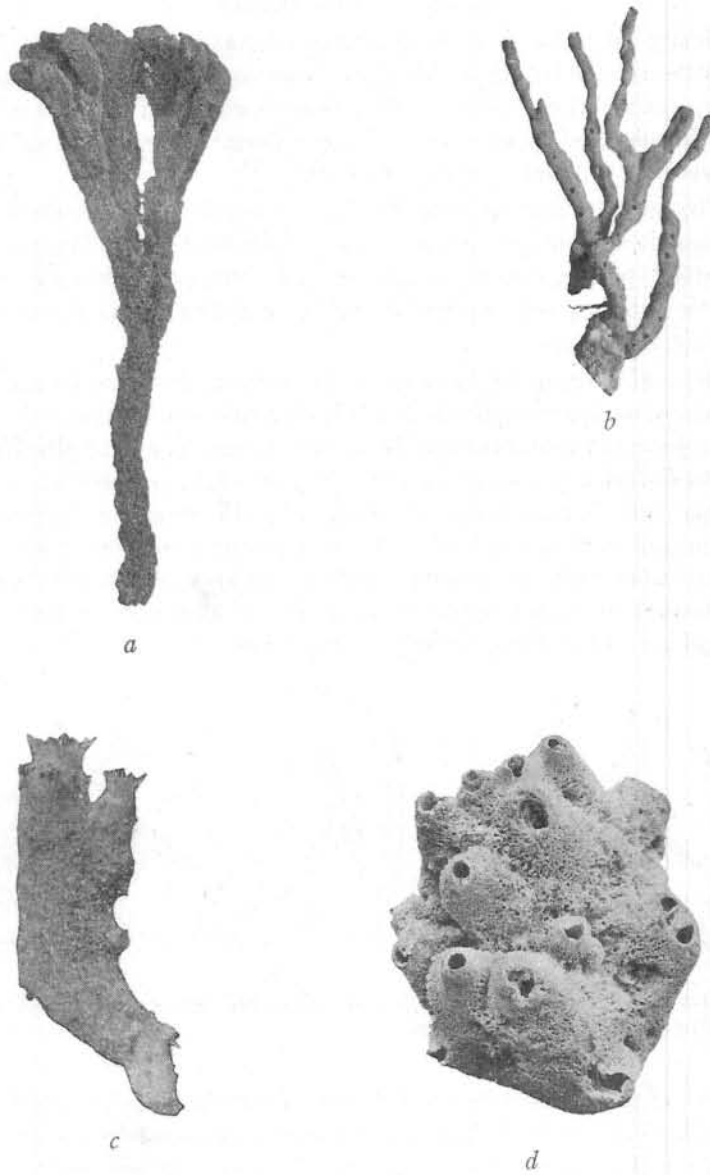


FIGURE 8.—Porifera: *a*, non-calcareous sponge (black); *b*, non-calcareous sponge (purple when living); *c*, calcareous sponge, upright form; *d*, non-calcareous sponge (red when living).

CLASS DEMOSPONGIAE

Nearly all sponges of the Hawaiian shores or of moderate depths about the islands belong to this class. They are the most highly specialized forms, and their skeletons, when present, consist of siliceous spicules, or of spicules and spongin, or of spongin alone. Some known as "fleshy sponges" are without a definite skeleton.

The most familiar sponges of this class are the thin, incrusting colonies found on the under surface of stones in shallow water. Many of them are bright purple, orange, yellow, or red. Others are black or white. Rounded masses and upright branching colonies are also common. (See fig. 8, *a, b, d.*)

Depending upon the character of the skeleton, there are several kinds of Demospongiae recognized. Some have four-rayed spicules; these apparently are not common about Hawaiian shores. The most plentiful are forms in which the spicules are typically needle-like. The spicules may be straight, bent, or undulating. (See fig. 9, *b.*) They may be sharp-pointed at both ends or at one end only. Others are bluntly rounded at both ends, and crescent-shaped forms are present in some sponges. In many sponges the spicules are bound together by spongin into a network supporting the cells which, in life, form the walls of the canals.

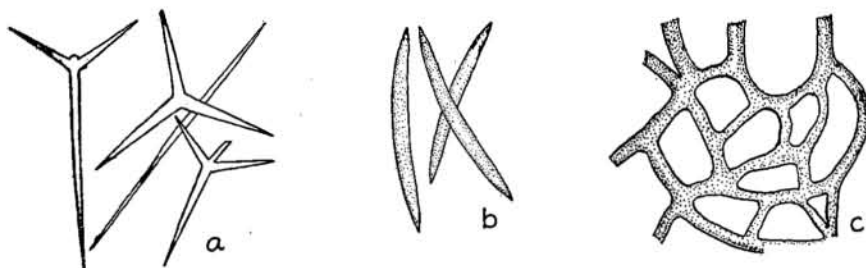


FIGURE 9.—Porifera: *a*, spicules of calcareous sponge; *b*, spicules of red sponge; *c*, spongin of horny sponge.

One of the common forms is *Donatia deformis* (Thiele), which has a hemispherical form an inch or less in diameter and is pale yellow or nearly white in color. It is found clinging to the under surface of stones near shore and develops rapidly on the walls of the tanks in the Honolulu Aquarium. The sponge is of special interest because of its asexual method of reproduction. Stellate bodies, comparable to gemmules, are developed

from the surface and when released, either separately or in aggregate masses, form new sponges. Filamentous processes also are often extended from the surface of the sponge. If severed, each will contract into a spherical mass and develop into a sponge (fig. 10, *a, b, c*).

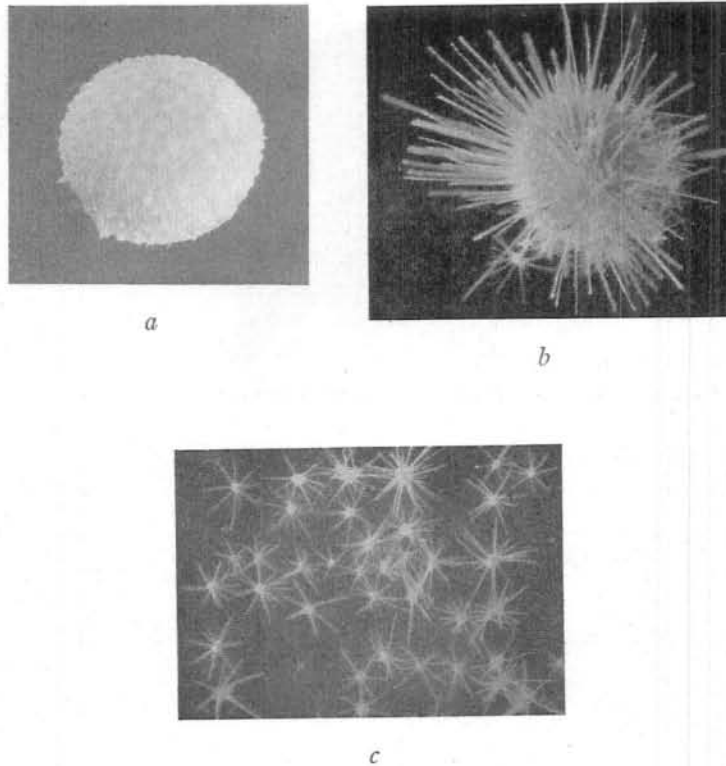


FIGURE 10.—*Donatia deformis*: *a*, normal condition when not in process of asexual reproduction; *b*, showing development of gemmules and filaments; *c*, gemmules after being released.

Horny sponges, in which the skeleton consists wholly of spongin fibers (figs. 9, *c*; 11), do not frequent the island shores, but are occasionally taken from depths of a few fathoms or are washed ashore. If any commercially valuable sponges exist in Hawaiian waters, they are representatives of this group. The specimen illustrated in figure 11 was washed up on the shore of the island of Lanai. It is about 10 inches thick.

Representatives of this class known as "fleshy sponges" are found in shallow water attached to the under surface of stones. They are typically small, flat bodies of tough leathery consistency, with a single osculum and no skeleton. Most colonies are gray or dark brown, 2 or 3 inches across, and about 12 mm. thick.



FIGURE 11.—Horny sponge.

PHYLUM COELENTERATA

The coelenterates include a large number of animals and a great variety of forms, all of which are alike in having the digestive tract opening to the exterior by the mouth alone. As in sponges, only two cell layers, with a middle noncellular gelatinous layer (mesogloea), compose the body wall. Radial symmetry is exhibited by these animals, and all are provided with defensive and offensive weapons in the form of stinging cells called nematocysts.

Some coelenterates develop as flowerlike polyps consisting of a cylindrical column with the mouth surrounded by tentacles. A polyp may grow singly, as a sea anemone, or may be joined with others forming a colony, as in most corals. Others develop into umbrella-like bodies which float in the water as jellyfish and medusae.

Skeletons are secreted by some coelenterates. They are formed by elements taken from the sea water and deposited by the cells of the animals and include complex calcareous, horny, or chitinous supporting structures.

Stinging cells (nematocysts) vary in form, but typically each consists of a cell inclosing a coiled or looped thread which may be shot out with force enough to penetrate the bodies of other animals. An irritating fluid is injected by means of this hollow thread. On being discharged, the stinging cells, which are of no more service, die. Others are formed to replace them.

Reproduction in coelenterates is by the sexual method (ova and sperm) or by the asexual process of budding. In corals the colony increases in size by budding, but new colonies are formed by planulae which are minute, multicellular organisms developed by the sexual method within the polyps. The ciliated planulae escape from the mouths of polyps and swim about for a period of a few days to a few weeks and then settle down and become fixed by the aboral ends. Tentacles develop about the mouth at the free end. This fixed polyp gives rise by budding to a new colony.

Alternation of generations (metagenesis) is illustrated by certain coelenterates. By budding some hydroids produce medusae, small bell-shaped jellyfish, most of which are free-swimming. They, in turn, bear ova and sperm and by the sexual method give rise to a fixed colony.

Three classes of the phylum are recognized: Hydrozoa, Scyphozoa, and Anthozoa.

CLASS HYDROZOA

This class includes hydroids and closely related forms. Hydroids are plantlike in appearance and many are mistaken for seaweeds. They develop, in most species, as branched colonies, the stem and branches rigidly supported by an outer layer of chitin but hollow within, the canal being lined by cells bearing cilia which keep the water in circulation. Polyps called hydranths, are attached to the branches, each with a mouth and tentacles. Food enters the colony through the mouths of the hydranths, which are all connected with the canal system of the stem and branches. Stinging cells are carried on the tentacles of the hydranths and in some forms on special defensive bodies.

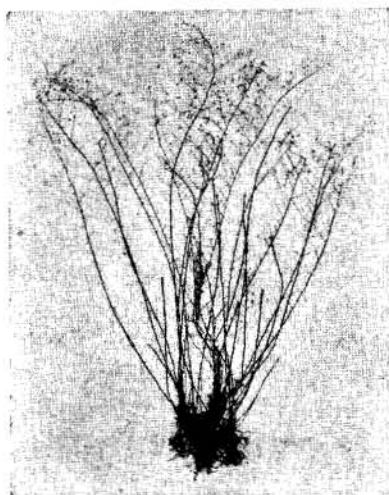


FIGURE 12.—Colonies of *Pennaria* species.

There are apparently few species of hydroids in the shallow water about the islands. In such localities as Pearl Harbor and Kaneohe Bay, Oahu, a species of *Pennaria* is found attached to stones, piling of old wharves, buoys, and other floats. It seems to be identical with *Pennaria tiarella* McCrady of the Atlantic coast and may have been transported to Hawaii on the bottoms of ships. Colonies reach a height of 6 inches. The black color of the stem and branches is sharply contrasted with the white polyps (hydranths) carried on pedicels attached to the branches. In *Pennaria* the polyps are not protected by chitinous sheaths. Reproduction is by means of sessile medusae which produce ova and sperm but remain attached to the colony. (See figs. 12; 13, a.)

On some of the reefs, colonies of a small plumelike hydroid are common. The branches bear hydranths on their upper borders only, a feature characteristic of the family Plumularidae, to which this undetermined species belongs. (See fig. 13, *d*.) Chitinous sheaths inclose both hydranths and special defensive bodies (sarcostyles) in cuplike structures. The sheaths protecting hydranths are called "hydrothecae", and those inclosing sarcostyles are called "nematophores." In this form of hydroid, reproductive bodies are also inclosed in chitinous sheaths (corbulae). The species is abundant on Waikiki reef, Oahu, attached to the under surface of stones about 150 feet from shore. Colonies are about 1 inch high.

One or more undetermined species of hydroids of the family Campanularidae are attached to seaweeds near shore. In these forms chitinous sheaths (hydrothecae) protect the hydranths, which are attached by pedicels. A very young specimen is represented by figure 13, *c*. The family Sertularidae is represented by at least one form in shallow water about the islands. In this family the hydrothecae are arranged on two sides of the stem or branches and in the Hawaiian form are opposite and in contact for part of their length.

Caprellids, curiously shaped amphipods, are common parasites on hydroid colonies, where they feed ravenously on the polyps.

Hydroids are more numerous in deep water about Hawaii than on the reefs. Forty-nine species were collected about the islands by the *Albatross* in 1902, most of them at depths of from 10 to 500 fathoms. Hydroids attached to other deep-water organisms are sometimes brought to the surface by the lines of fishermen. A colony of *Antipathes* (p. 49) more than 7 feet high, taken by a fisherman off Kawaihae, Hawaii, from 80 fathoms, had its stem and branches thickly covered with solitary corals and fine colonies of plumularian hydroids.

Few free-swimming hydroid medusae have been observed about Hawaii. The five forms collected by the *Albatross* in 1902 were taken from the surface of the ocean or at moderate depths. A very small undetermined medusa is occasionally taken in the tow net on Waikiki reef and in Pearl Harbor, Oahu. (See fig. 13, *b*.) It is not known from which hydroid colony the medusa comes, but it is probably from a species of Campanularidae.

Although free-swimming medusae are uncommon about Hawaii, curious forms of creeping medusae are abundant among *Ulva* and other seaweeds along the shores. These medusae cannot swim but amble about

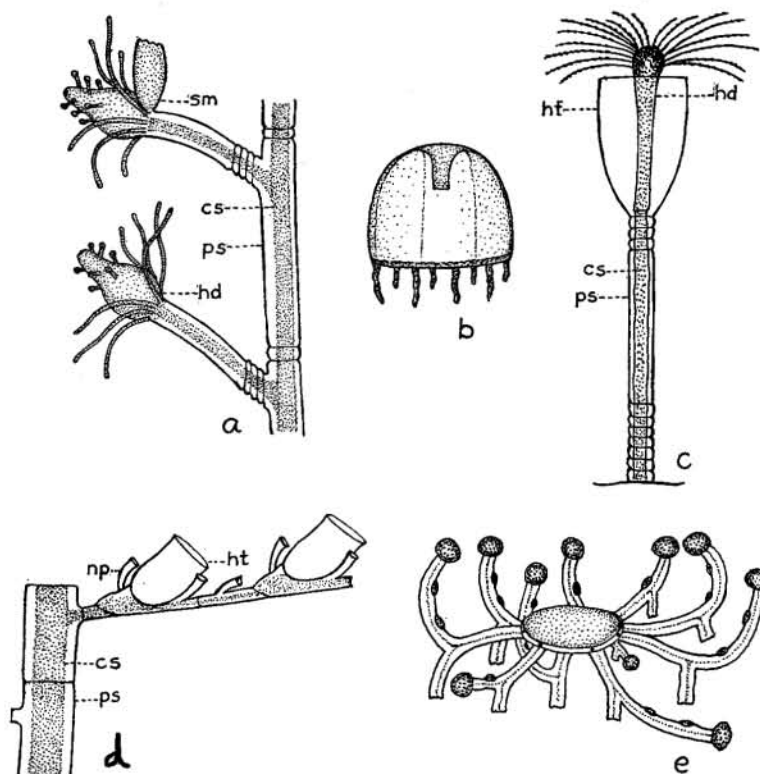


FIGURE 13.—Hydrozoa: *a*, portion of colony of *Pennaria* species (*cs*, coenosarc; *hd*, hydranth; *ps*, perisarc; *sm*, sessile medusa); *b*, a hydroid medusa; *c*, a young campanularian hydroid (*cs*, coenosarc; *hd*, hydranth; *ht*, hydrotheca; *ps*, perisarc); *d*, portion of plumularian hydroid (*cs*, coenosarc; *ht*, hydrotheca; *np*, nematophore; *ps*, perisarc); *e*, a creeping medusa, *Eleutheria oahuensis*.

on the tips of branched tentacles. The ventral branch of the tentacle bears a sucker, and the dorsal branch is provided with groups of stinging cells. Four species have been described from about Oahu, all of the genus *Eleutheria*. They differ from each other chiefly in the character of the tentacles and in the arrangement of the groups of stinging cells. The most common species, *E. oahuensis* Edmondson (fig. 13, *e*), has numerous tentacles, the dorsal branch of each having two clusters of stinging cells on the aboral border in addition to those of the capitate extremity. In *E. bilateralis* Edmondson there is one group of stinging cells on the aboral border of the tentacle, and two others are bilaterally arranged, one on either lateral border proximal to the aboral group. The species *E. acumi-*

nata Edmondson has the dorsal tentacular branch tapering toward its distal extremity. It bears groups of stinging cells on the aboral, lateral, and ventral borders, besides those of the capitate end. In *E. alternata* Edmondson, the stinging cells are in alternate groups on the aboral border of the tentacle in addition to those of the capitate extremity. All Hawaiian species observed are less than 1 mm. in diameter of bell. The creeping medusae are believed to be developed from tubularian hydroids, though no fixed hydroid stage has been seen for any of the Hawaiian forms. Copepods (p. 221) serve as the principal food of these minute medusae, and three or four crustaceans are sometimes captured at the same time by a single individual. The body of the medusa becomes greatly distorted in the effort to ingest the crustacean, which may be larger than itself.

Hydroid corals (Hydrocorallina) secrete a calcareous skeleton as do stony corals, but the polyps and soft parts are more nearly like those of a hydroid colony. In *Millepora* the skeleton is light brown or yellowish, in *Stylaster*, bright red or pink. No hydroid corals are known to occur in Hawaiian shallow waters. The locality nearest to Hawaii where they have been observed is Johnston Island, 750 miles southwest of Oahu.

Free-swimming colonial forms of Hydrozoa are typical of the open ocean, where they float on or near the surface. High winds often drive them to the shores. The Portuguese man-of-war, *Physalia utriculus* Eschscholtz, although a small species, is doubtless familiar to all who frequent the beaches. It consists of a float, from the under surface of which are suspended organs (zooids) of three kinds. The upper part of the float is filled with gas held in a closed compartment. The lower part is in communication with the zooids beneath, and a circulation of water and food comparable to that of a hydroid colony is maintained.

Of the three kinds of zooids (persons) attached to the float, one consists of tubelike polyps which take in food, another of long bandlike tentacles hanging far down in the water and carrying stinging cells, and the third of small oval bodies attached to short stalks. These are male reproductive bodies. As only male colonies of *Physalia* are recognized, some authorities have suggested that the female zooids may become detached at an early stage as free-swimming medusae whereas the male zooids remain attached to the colony.

The stinging cells of this animal are among the most powerful known. Arranged along one edge of the bandlike tentacles are batteries of large cells, which, when stimulated, discharge threads conveying an irritating secretion capable of penetrating the human skin with painful results. The

tentacles are highly extensile and retractile. In this way small organisms paralyzed by the stinging cells can be drawn up to the feeding zooids.

The Hawaiian species is widely distributed in the central Pacific Ocean. Its brightly colored iridescent float is usually 1 to 2 inches long. By reason of prevailing trade winds, the floating colonies are commonly seen along the north shores of the islands, but south winds may drive them onto the leeward shores. During heavy storms they are cast upon the beaches in large numbers.

Another colonial form, *Veleva pacifica* Eschscholtz, is also frequently driven ashore by strong winds. It consists of a flattened, elliptical float, bluish green in color, with an oblique sail above, and feeding, defensive, and reproductive zooids suspended beneath. The margin of the float is fringed with tentacles, and there is a large central feeding zooid. Medusae are produced by the reproductive bodies. Stinging cells are well developed, but less powerful than those of *Physalia*. The float is 2 to 3 inches long.

A few other free-swimming colonial forms were taken in Hawaiian waters by the *Albatross*. They represent species of wide distribution in the tropical Pacific area, but are unlikely to be observed near shore.

CLASS SCYPHOZOA

Included in this class are free-swimming, bell-shaped jellyfish, some of which attain great size, and small stalked or sessile forms. The margin of the bell is typically lobed and in most species bears tentacles and special organs of equilibrium (statocysts).

Few representatives of the class have been observed in Hawaiian waters. Of the five free-swimming species collected by the *Albatross* in 1902, two were taken in deep water, two from the surface and at moderate depths, and one from the surface only. Pelagic forms seldom approach the shores unless driven there by high winds. Some, however, frequent harbors and partially inclosed arms of the sea.

Specimens of *Charybdea moseri* Mayer, having a bell about 2 inches wide and nearly twice that height, are occasionally observed on the reefs of Oahu. Each of the four tentacles has a broad expansion at its base. The species is typically a pelagic form.

At certain times of the year, usually during the winter months, a large undetermined species of jellyfish is abundant in Pearl Harbor, Oahu. It belongs to the group Rhizostomata, which is characterized by the absence of tentacles on the margin of the bell and the reduction of the

mouth to a few small apertures due to the fusion of the oral lobes. These lobes form the bulky tissue suspended from the under surface of the bell. The margin of the bell is scalloped into numerous short, rounded lobes between which, at intervals, are special organs of equilibrium (statocysts). Each of the eight oral lobes bears a flattened tentacle 3 or 4 inches long which is easily detached when the specimen is roughly handled. The specimen photographed (fig. 14) is without the oral tentacles. The bell is marked by round white spots, each surrounded by a zone of brownish algal cells embedded in the tissue. Specimens with few algal cells are bluish in color; those well supplied with such cells have a brownish tint. Large specimens exceed 12 inches in diameter. Young specimens of a fish (p. 335) are often found living in the gastric cavity of this jellyfish, in commensal relation to the coelenterate.



FIGURE 14.—A pelagic jellyfish.

Stalked or fixed medusae are small jellyfish having an aboral stalk, by means of which they are attached. At least one species, *Kishinouyea pacifica* Edmondson, occurs about the shores of Oahu attached to seaweeds. Its margin has eight lobes fused in pairs, each lobe bearing 16 to 21 short, capitate tentacles. Contracted specimens are about 10 mm. high. (See fig. 15.) Most of the known stalked medusae inhabit the shallow waters of cold latitudes.

scaphomedusa

CLASS ANTHOZOA

Representatives of this class differ from hydroids in having a gullet leading from the mouth to the body cavity or stomach. Longitudinal folds of tissue, known as mesenteries, partially subdivide the digestive tract. Two subclasses are recognized.

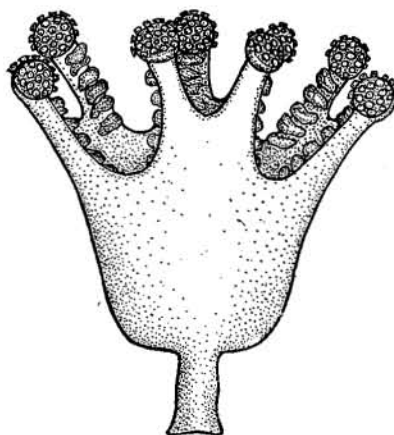


FIGURE 15.—A stalked medusa, *Kishinouyea pacifica*.

SUBCLASS ALCYONARIA

Alcyonarians vary greatly in size and general appearance, but all have eight branched (pinnate) tentacles and eight mesenteries. In some forms minute supporting structures (spicules) are embedded in the tissues.

Only one alcyonarian, *Sarcothelia edmondsoni* Verrill, has been reported from the shallow waters of Hawaii. The colony consists of a soft incrusting base, from which arise densely crowded polyps about 8 mm. high when expanded (fig. 16, a). There are no spicules in this species. Its bright purple or lilac color will help to identify it. At Maili Point near Nanakuli, Oahu, it has been found near shore growing over the surface of stones in patches 4 or 5 inches across. It also occurs on Waikiki reef, Oahu, and is plentiful at Keauhou and Kahaluu on the Kona coast of Hawaii.

Many other alcyonarians grow in deep water about the islands, but are unknown on the reefs. Sixty-eight species were dredged in this vicinity by the *Albatross* in 1902. Gorgonians, which are alcyonarians with branched skeletons of calcareous or horny material covered by a "crust" of fused spicules supporting the polyps, are sometimes pulled up from deep water on the lines of fishermen. Sea fans with the branches fused and growing in one plane are typical gorgonians. Sea pens are other examples of deep-water alcyonarians. To this subclass, but not present in Hawaii, also belong the "organ-pipe" coral and the red or "precious" coral.

SUBCLASS ZOANTHARIA

Representatives of this group include sea-anemone forms, true sea anemones, stony corals, and antipatharians. The polyps of all have unbranched, hollow tentacles, and in most forms the mesenteries are numerous.

Key to Orders of Subclass

- A. Zoantharia without skeletons; solitary or colonial forms.
 - B. Mesenteries and tentacles few, solitary.....**Edwardsiidea.**
 - BB. Mesenteries and tentacles numerous.
 - C. Usually solitary.
 - D. Not occupying tubes, attached by basal disk.....**Actiniaria.**
 - DD. Occupying tubes and burrowing in sand.....**Cerianthidea.**
 - CC. Usually colonial**Zoanthidea.**
- AA. Zoantharia developing skeletons.
 - B. Skeleton calcareous**Madreporaria.**
 - BB. Skeleton horny**Antipathidea.**

ORDER EDWARDSIIDEA

The order includes primitive Zoantharia resembling sea anemones.

FAMILY EDWARDSIDAE

Soft-bodied, cylindrical animals found on the surface of the sand or under stones in shallow water represent this family. They resemble minute sea anemones, but are unattached to a support. In organization they are comparatively simple, having as few as eight well-developed mesenteries, with additional rudimentary ones, and in some species but sixteen tentacles. They are in the habit of partially concealing themselves with a coating of fine sand.

One species, *Edwardsiella carneola* Verrill (fig. 16, *b*), has been collected at Nawiliwili, Kauai. It has 24 tentacles and is less than 1 inch long. An undetermined species with 16 tentacles has been observed on the reefs of Oahu. It expands to a length of 2 inches.

ORDER ACTINIARIA

Most true sea anemones develop as solitary polyps and when expanded are flower-like in appearance. They are attached to some support and are without skeletal structures.

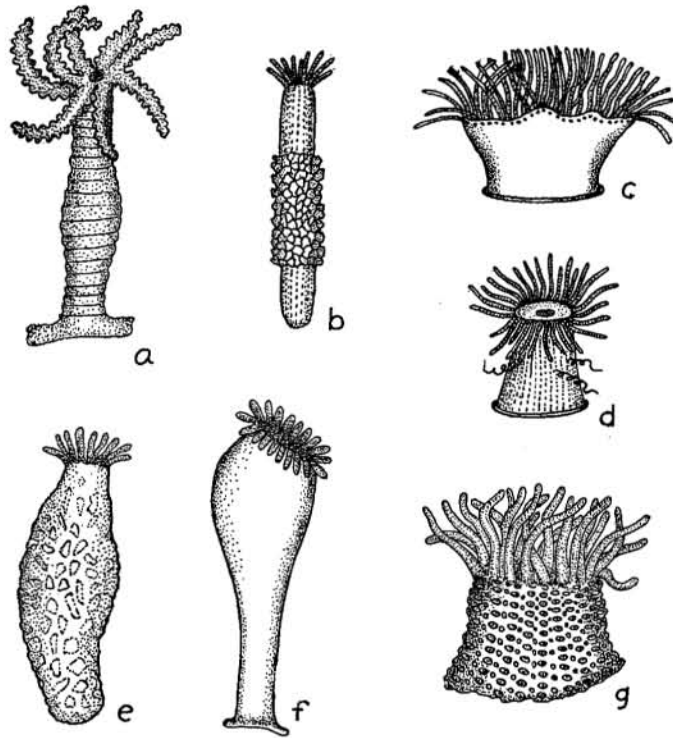


FIGURE 16.—Anthozoa: *a*, a single polyp of *Sarcothelia edmondsoni*; *b*, *Edwardsiella carneola*; *c*, *Anemonia (Anthea) mutabilis*; *d*, *Sagartia pugnax*; *e*, *Phellia humilis*; *f*, *Sagartia longa*; *g*, *Tealiopsis nigrescens*. (*a-d* after Verrill.)

Key to Families of Order

- A. Sea anemones without acontia (threadlike organs with stinging cells).
 - B. Sphincter muscle not well developed, therefore tentacles not retractile.
 - C. Surface of column smooth or provided with adhesive verrucae **Anemonidae.**
 - CC. Surface of column usually covered with non-adhesive verrucae **Aliciadae.**
 - BB. Sphincter muscle well developed, therefore tentacles retractile.....
 - **Utricinidae.**
- AA. Sea anemones with acontia; column smooth or with adhesive suckers
 - **Sagartidae.**

FAMILY ANEMONIDAE

In Hawaiian waters the largest species of this family is *Marcanthea cookei* Verrill (fig. 17, a), which is nearly 12 inches long and has about 600 tentacles when expanded. It lives almost completely buried in sand and mud in shallow water. Specimens have been collected at Laie and Kaneohe Bay, Oahu, and it probably occurs in other localities where there is a soft bottom.

Another species, *Anemonia (Anthea) mutabilis* Verrill (fig. 16, c), is about 1.5 inches high, dark green, and has a smooth surface. Large specimens have more than 300 tentacles. It is a shallow-water species and may be seen in the tanks of the Honolulu Aquarium.

A delicate little species, *Nectothelia lilae* Verrill, lives attached to the marine flowering plant *Halophila*. It is transparent or flesh colored and has the ability, when detached, to swim like a jellyfish by constantly changing its form. Specimens expand to a height of about 12 mm.

FAMILY SAGARTIDAE

Sea anemones of this family are characterized by threadlike structures (acontia) covered with stinging cells which are capable of being projected from pores in the sides of the body. The tentacles are numerous and capable of being completely retracted.

Several species are common about the shores, attached to seaweeds or the under surface of stones. A smooth delicate form, *Sagartia pusilla* Verrill, is about 12 mm. high when expanded and has 24 to 48 tentacles, but few stinging threads (acontia). It usually assumes the color of the support to which it is attached, being green when on *Ulva*.

Two small crabs, *Lybia tessellata* and *Polydectus cupulifer*, habitually carry a tiny sea anemone in each claw. The anemone carried by *Lybia* is *Sagartia pugnax* Verrill (fig. 16, d), a pure white species. The one carried by *Polydectus* is brown with green and white tentacles and probably represents an undetermined species of *Sagartia*. When disturbed the crabs hold the actinians up and use them like boxing gloves. There is probably a mutual advantage in this association (symbiosis), as the crabs are doubtless protected by the stinging cells of the anemones and the actinians have access to more food and oxygen than if they were stationary.

Attached to the under surface of stones in shallow water is a smooth, soft-bodied species, *Sagartia longa* Verrill (fig. 16, f). It is light brown

with short tentacles which are green, mottled with white. Large specimens are 3 inches long, larger in diameter at the free end than at the base.

On the shells of such mollusks as *Turbo* (p. 164) and *Tonna* (p. 145), occupied by large hermit crabs, are often found specimens of a brightly colored sea anemone, *Calliactis armillatas* Verrill. Large specimens, when expanded, are 2 or 3 inches high and about the same diameter at the base. The color is variable, but commonly yellow, mottled with red and brown. There may be more than 200 tentacles, each ringed with narrow white lines. Stinging threads are shot out in large numbers when the animal is disturbed, but the nematocysts are too weak to penetrate the human skin. The relation of the sea anemone to the hermit crab is another example of symbiosis.

A small species, *Phellia humilis* Verrill (fig. 16, *e*), about 12 mm. high, is found clinging to the under surface of stones in very shallow water. It can easily be detached from the rock and is covered with a firmly adhering coat of sand. The tentacles are about 24 in number.

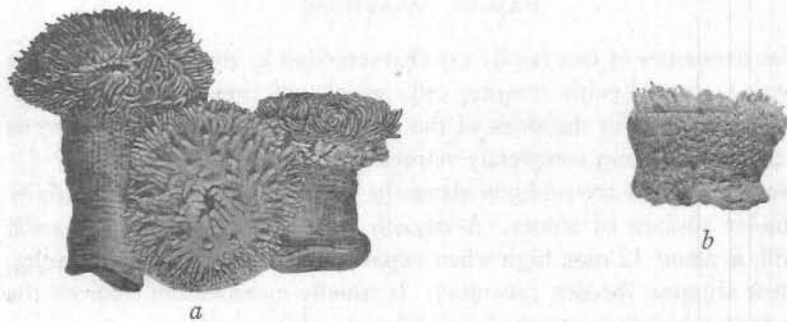


FIGURE 17.—Actiniaria: *a*, *Marcanthea cookei* (after Verrill); *b*, *Cladactella manni*.

FAMILY ALICIADAE

Representatives of this family have the surface of the body covered with rows of tubercles (verrucae) which are hollow but not adhesive, so that the animal is free from sand or other foreign particles. The tentacles are long but not very retractile.

The most common species of the family about Hawaii seems to be *Cladactella manni* Verrill (fig. 17, *b*). It is dark green with an orange base. Large specimens are about 3 inches in diameter and 4 inches high when expanded. It has been collected at Nawiliwili, Kauai, and at several localities about Oahu.

A small form, *Cladactella obscura* Verrill, has been observed in the tanks of the Honolulu Aquarium and has also been collected from Pearl Harbor, Oahu. It is purplish brown or dark brown with long, pointed, grayish-green tentacles with pale tips, each marked with two longitudinal white lines. Specimens are about 15 mm. high when expanded.

On the shore rocks at Kawailoa, Oahu, has been observed an undetermined sea anemone, probably of the genus *Cladactella*. It is greenish yellow, mottled with gray. The tubercles of the surface are not closely crowded and not adhesive. Large specimens are 1.5 inches in diameter.

FAMILY UTRICINIDAE

In species of this family the tubercles (verrucae) of the surface are sucker-like. To them adhere sand, pieces of shells, and other foreign material.

The only described species in Hawaii is *Tealiopsis nigrescens* Verrill (fig. 16, *g*), which is dark brown or black with lighter brown tentacles. It expands to a height of about 1 inch and is usually well coated with adhering particles of shell and sand. Specimens may be found on the under surface of stones in shallow water or in crevices of rocks exposed at low tide. It is also abundant in the Honolulu Aquarium.

Numerous undetermined species of Actiniaria live in shallow water about the islands. The following forms have been observed on the reefs of Oahu. By careful investigation their general distribution throughout Hawaii would probably be revealed.

A pure white sea anemone of doubtful position, with few, thick tentacles is common on the under sides of stones at Black Point, Oahu. It has a smooth column, which expands to a height of 10 mm. A minute species has frequently been taken from seaweeds on Waikiki reef. It is green, inclosing brown algal cells. It expands to a height of 3 mm. and is very flexible, often being looped over, partially resting on the tentacles.

Another form, collected on rocks near the shore at Kahala, Oahu, and on oyster shells in the shallow water of Kaneohe Bay, Oahu, has a short column and a broadly expanded disk. The tentacles, which are arranged in radial rows on the disk, are reduced to short, rounded processes. The base and column are salmon-pink and the disk is green. Large specimens are 20 mm. across the disk when expanded.

On the under surface of stones in Hanauma Bay is found a species with very short column, which expands into a broad disk. The tentacles are numerous, large, long, and inflated in the middle. The deep reddish-

brown color of the disk is extended into the axes of the tentacles, leaving their borders a lighter shade. The species is easily detached from its support. Specimens are nearly 1 inch across the disk when expanded.

ORDER MADREPORARIA

Stony corals which comprise this order secrete calcareous skeletons. Most of them form colonies, a few being solitary. A typical coral colony consists of a large number of polyps joined together by thin layers of living tissue, each polyp occupying a depression (calice or corallite) in the skeletal substance. The polyps are held in place by series of thin calcareous partial partitions (septa) and pillars (columella) around which the soft tissue is folded. Each polyp resembles a minute sea anemone with column, disk, and tentacles. It expands in a flowerlike manner when feeding but may retract within the protecting walls of the calice. The skeleton is built up of salts taken from the sea water and deposited by the ectodermal cells of the polyps. As more and more calcareous material is laid down, the polyps climb up so that they are always at the surface of the colony.

Shallow-water corals typically carry unicellular algae (Zooxanthellae) within the endoderm. The plant cells give color to the coral, and the association is probably of mutual advantage (symbiosis). In some brightly colored corals, however, no Zooxanthellae are present; the color is due to diffused pigments of other character. Corals typical of the reefs soon die if placed under conditions of total darkness. This partially explains why these species do not live in very deep water. Although species vary greatly in ability to resist altered physical and chemical changes in their environment, favorable growing conditions for shallow-water corals include, in addition to proper light, normal salinity and temperature of the sea water, little silt, and sufficient food.

Coral colonies increase in size by budding. New colonies are formed by planulae which are developed by the sexual process within polyps. The planulae are extruded from the oral apertures of the polyps as free-swimming organisms. After a short time they settle, and each becomes fixed by the aboral end and grows into a polyp. The deposition of calcareous material begins at once, successive buds are developed, and a new colony results. (See fig. 18, *a, b*.)

The rate of growth of corals differs with species. Optimum conditions of food, temperature, salinity, and other factors doubtless favor rapid growth. Two specimens of the same species, however, side by side and subjected to similar conditions, often show wide variations in the rate of

growth. In Hawaii massive heads of coral may grow in height about 0.5 inch a year and increase in weight more than 100 percent. Some branching forms on local reefs grow in height from 1 to 2 inches annually, for a period of years at least, and gain more than 300 percent in weight per year.

The normal food of corals comprises such minute animal organisms as copepods and larvae of crustaceans. These organisms are paralyzed by the stinging cells of the tentacles of the corals and drawn into the oral apertures of the polyps.

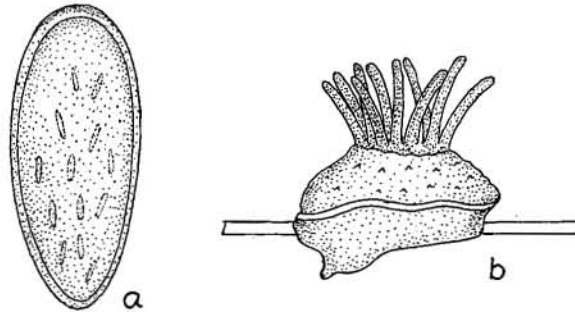


FIGURE 18.—*Madreporaria*: *a*, a coral planula; *b*, a coral polyp 33 days old.

Reef-building corals are confined to tropical and subtropical waters. The Hawaiian Islands are situated on the northern edge of the reef-forming belt; for this reason, perhaps, their reefs present a decadent appearance. Living corals may be found on all the reefs of Hawaii, but in few localities do they seem to be in a flourishing condition. In Kaneohe Bay, Oahu, many species still grow luxuriantly, and on the outer border of the reef platform in other localities large colonies may be found.

Many organisms other than corals contribute to the growth of a reef. Among them are calcareous seaweeds, sponges, echinoderms, mollusks, and other animals having shells or skeletal structures of hard and enduring composition. Lime-secreting seaweeds serve as binding agents on a reef and are often elements of major importance.

More than 120 species and varieties of corals are known from Hawaiian waters. Seventy-five species are known from the shore line to a depth of 25 fathoms. On a typical reef, such as Waikiki, Oahu, more than 20 species and varieties may be collected in less than one fathom of water. No attempt is made here to list or illustrate all of the Hawaiian corals to be found in shallow water. Only a few of the more common and more easily recognized forms which may be observed or collected on local reefs within walking distance of the shore at low tide are mentioned.

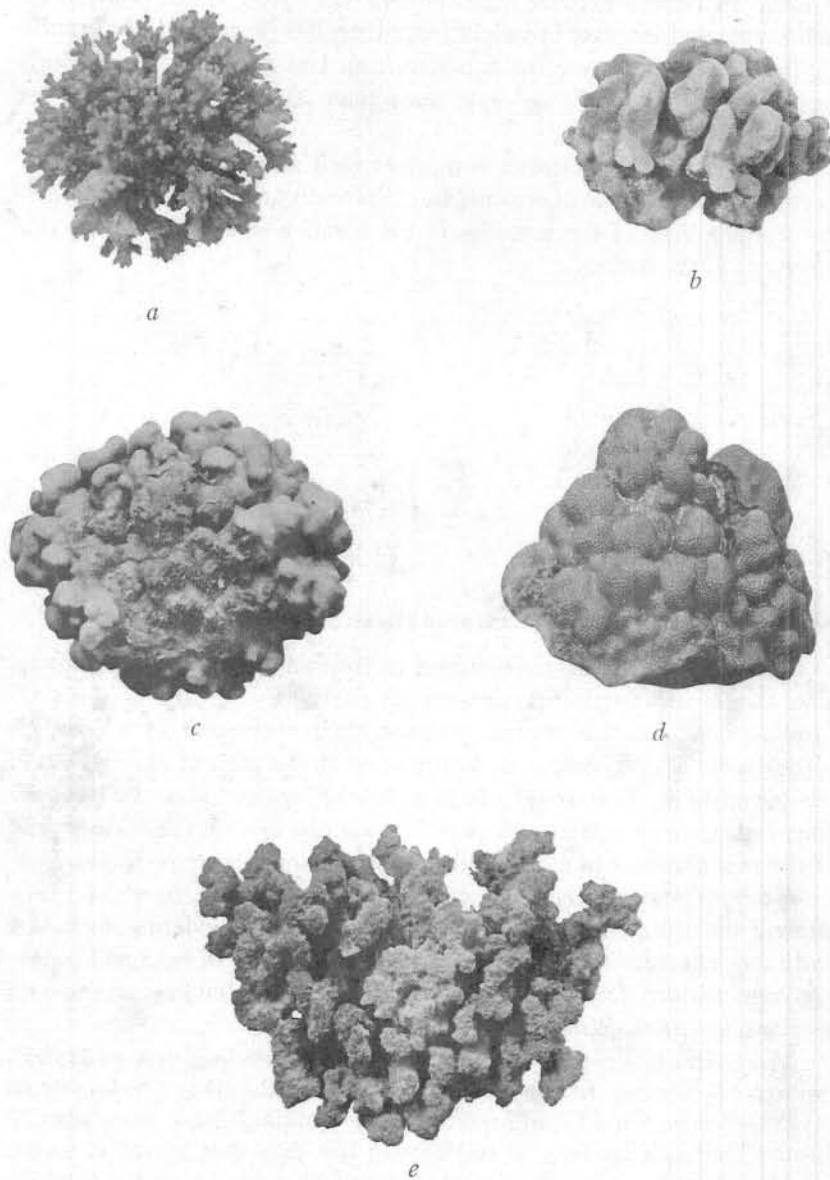


FIGURE 19.—Madreporaria: a, *Pocillopora damicornis*; b, *Porites compressa* form *angustisepta*; c, *Porites evermanni*; d, *Porites lobata* form *centralis* subform *alpha*; e, *Porites* (*Synaraea*) *irregularis*.

Seven families of corals are included here, members of which can be recognized by brief descriptions of the species supplemented by accompanying figures.

FAMILY POCILLOPORIDAE

One of the most common corals on Hawaiian reefs is *Pocillopora damicornis* (Linnaeus) (fig. 19, a). It grows in rounded, finely branched clumps, which may be 6 inches in diameter but commonly are less. On Waikiki reef, Oahu, it is nearer the shore than any other coral. In Hawaii this species is the principal one which develops "galls" inclosing the crab *Hapalocarcinus marsupialis* (fig. 169). Living specimens of this coral are yellowish or brown. Some authorities consider *P. cespitosa* Dana identical with *P. damicornis*.

Another common representative of this family is *Pocillopora meandrina* variety *nobilis* Verrill, which develops branched hemispherical colonies 1 to 2 feet in diameter. The branches are regularly forked and may be rounded, flattened, or sinuose at the tips. Living colonies are usually brown, but greenish or purplish ones are not uncommon. It grows best well out on the reef platform and ranges into moderately deep water.

Colonies of *Pocillopora ligulata* Dana are also well distributed on Hawaiian reefs. The species equals *P. meandrina* variety *nobilis* in size and resembles it in color, but the branches are narrower and thinner.

FAMILY PORITIDAE

Some corals of this family develop massive heads and others produce branched and foliaceous colonies. The calices are typically small and crowded together. More than 40 species and varieties, most of them living on shallow reefs, have been recognized in Hawaii.

Difficulty is often experienced in distinguishing certain forms of *Porites*, as a species may show considerable variation in mode of growth. For this reason many specific or varietal differences are confined to minute structural features requiring microscopic examination. Since technical taxonomic distinctions are of little significance to any but the specialist, only a few of the common species and varieties of *Porites*, easily recognized and readily accessible on the reefs, are here considered.

A familiar species on many Hawaiian reefs is *Porites evermanni* Vaughan (fig. 19, c), which forms rounded columns, lobes, or massive heads. The calices are shallow, almost flush with the surface. Living colonies may be gray, brown, or purple.

Some of the larger, massive coral heads are formed by *Porites lobata* form *infundibulum* Vaughan, which develops into upright columns with lobulated sides. Living colonies are green or brown. In *Porites lobata* form *lacera* Vaughan the upright columns are smooth. Colonies 1 to 2 feet high may be seen on Hawaiian reefs.

In *Porites pukoensis* Vaughan the typical mode of growth is in pointed columns which tend to fuse together along their sides. The calices are polygonal with thin, perforated walls. The species was described from Molokai. Fine colonies grow in Hanauma Bay, Oahu.

A species, probably *Porites* (*Synaraea*) *irregularis* (Verrill), is found in Hanauma Bay, Oahu. It grows in upright masses of irregular branches which fuse together. The tips of the branches are nodular and roughly eroded. The calices are small and close together with sharp granulations between. The species is brown with the nodular tips yellowish white or gray. Colonies are 6 to 8 inches high. (See fig. 19, e.) This may be the species described by Vaughan as *Porites* (*Synaraea*) *hawaiiensis* from specimens taken at Kalihi Harbor, Oahu.

Several varieties of *Porites lobata* do not develop columns but form incrusting layers over rocks. A common one is *Porites lobata* form *centralis* subform *alpha* Vaughan (fig. 19, d). Its surface is very irregular and the edges have a tendency to turn up. Living colonies are green and may range from a few inches to 1 foot or more across. Rounded heads with lumpy surfaces and edges turning under are developed by *Porites lobata* form *centralis* subform *beta* Vaughan. Such colonies, 4 to 6 inches in diameter, are usually found loosely on the reef. Smooth, spherical colonies of *Porites lobata* form *centralis* subform *gamma* Vaughan are occasionally seen on the reefs. This unattached, ball-like form is 1 to 4 inches in diameter.

Many forms of *Porites* develop as colonies of fingerlike branches. They are, for the most part, varieties of *Porites compressa*. The arborescent corals seen from the glass-bottom boat in Kaneohe Bay, Oahu, are representatives of this species. Here colonies have grown upon colonies. The basal portion of this coral jungle is dead, but the branches of the more superficial layers extending up toward the surface are alive.

Although the casual observer may not be able to determine many varieties of the branching *Porites*, two or three of the common ones are easily recognized. Colonies of *Porites compressa* form *angustisepta* Vaughan (fig. 19, b) consist of short, blunt lobes, often bent and distorted. The color is gray or brown. Detached colonies 4 to 5 inches

across are common on Waikiki reef, Oahu, about 150 feet from the shore. Another variety, *Porites compressa* form *granimurata* Vaughan, develops into slender, fingerlike lobes, often angular and contorted. It is yellowish green or light brown. On Waikiki reef it is associated with and grows to about the same size as *P. compressa* form *angustisepta*.

FAMILY ACROPORIDAE

In the Pacific Ocean, outside of Hawaii where coral reefs are present, *Acropora* is the typical genus of the family. The species *Acropora echinata* (Dana) was reported from Hawaii many years ago, but it apparently has not been observed in local waters by recent investigators. However, a fine colony of an undetermined species of *Acropora* (fig. 20) was collected in comparatively shallow water at French Frigate Shoal in 1936.

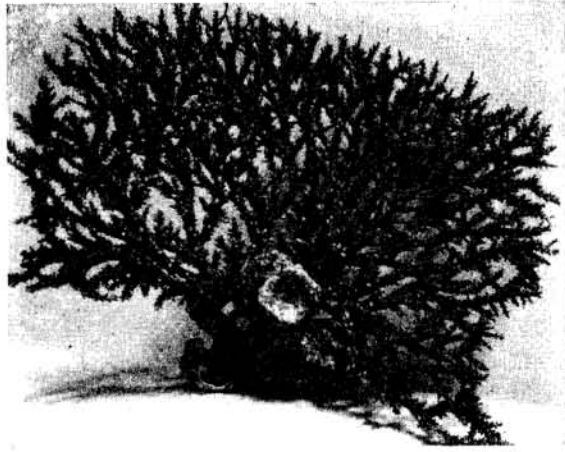


FIGURE 20.—*Acropora* species.

Hawaiian corals of this family are represented by several species of the genus *Montipora* of which *M. verrucosa* (Lamarck) (fig. 21, a) is the most common. Colonies grow as thin, incrusting plates, from which irregular lobes are thrown up, or as compact masses. The surface between the calices is covered with nipple-like papillae. Living specimens range in color from almost white to deep chocolate brown. The species has a wide distribution on Hawaiian reefs and is found in irregular, isolated clumps a few inches across or in patches covering several square yards.

On passing over the edge of the reef platform in the glass-bottom boat at Haleiwa, Oahu, one sees among corals magnificent bracketlike colonies of this and other species of *Montipora* which thickly cover the ledges 25 or 30 feet below the surface.

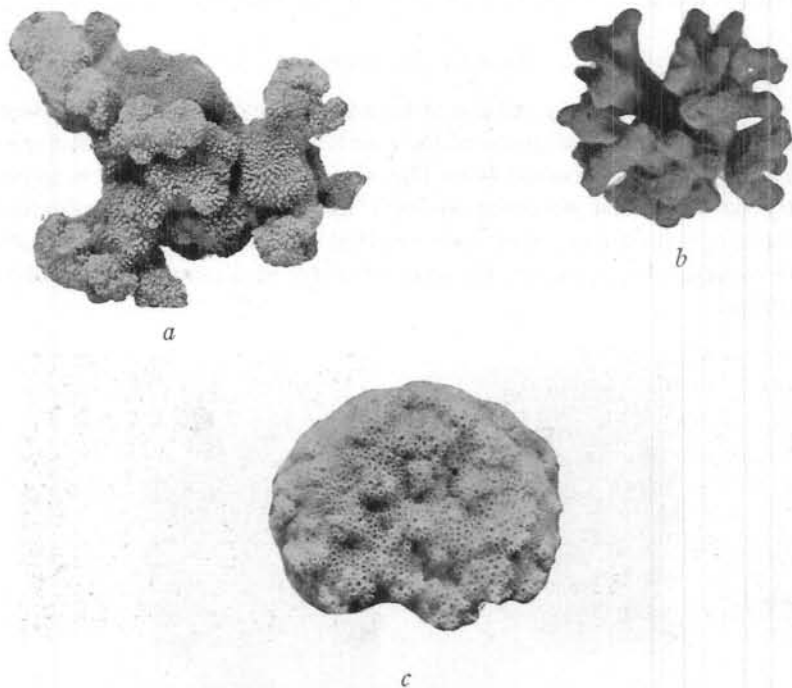


FIGURE 21.—Madreporaria: a, *Montipora verrucosa*; b, *Psammocora stellata*; c, *Cyphastrea ocellina*.

Another incrusting species, recognized by its bluish-purple color when living, is *Montipora flabellata* Studer. It differs from *M. verrucosa* in that the papillae of the surface are fused into concentric ridges. Small colonies, a few inches across, coating the surface of rocks, are common on Waikiki reef, Oahu, 300 feet from the shore.

Other species of *Montipora* occasionally seen in shallow water are *M. patula* Verrill and *M. verrilli* Vaughan. In *M. patula* the surface is covered with small, unequal, round-topped papillae bearing rough projections. The calices of *M. verrilli* are ringed by tubercles which may be fused into tubes. Both species are brown. They coat rocks or grow in bracketlike plates sometimes more than 1 foot in diameter.

FAMILY AGARICIIDAE

Two species of *Pavona*, very different in form of growth, are found on local reefs. The most common, *Pavona varians* Verrill (fig. 22, a), incrusts rocks, its surface assuming the irregularities of the support. The calices are sinuose and confluent. In life the color is pale yellow or light brown. Irregular colonies a few inches to 1 foot across are common. The less common species, *Pavona explanulata* Lamarck (fig. 22, c), forms solid upright lobes or columns. The calices are small, of uniform size, with septa common to adjoining ones, which gives them a stellate appearance. Flattened columns 4 or 5 inches broad and about as high is the usual method of growth. The color in life is pale brown. There are specimens in Bishop Museum from Molokai, and the species has been collected on Waikiki reef and in Hanauma Bay, Oahu. A small crab, *Cryptochirus crescentus*, lives in crescent-shaped pits in this coral.

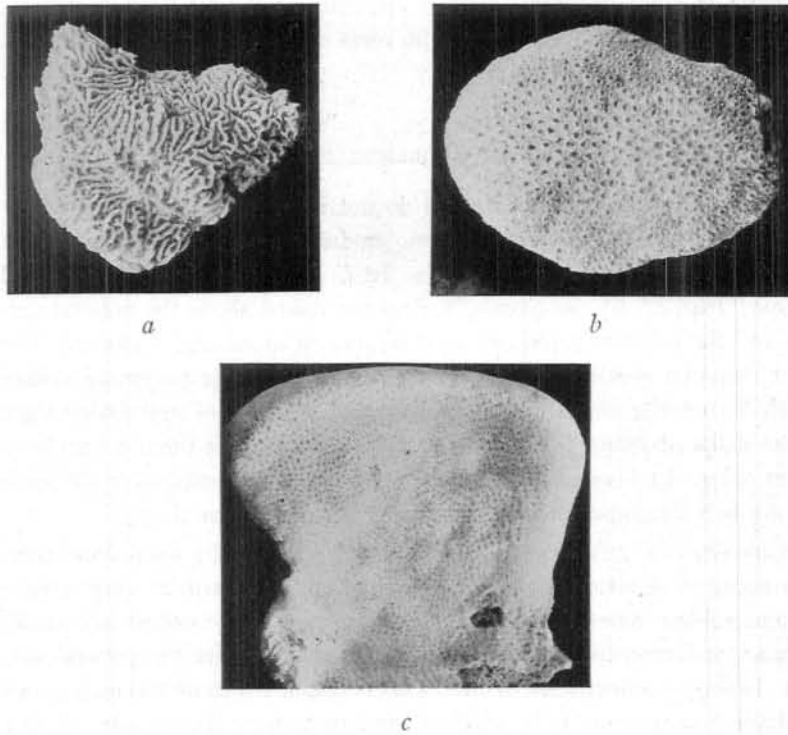


FIGURE 22.—Madreporaria: a, *Pavona varians*; b, *Leptastrea bottae*; c, *Pavona explanulata*.

Colonies of *Psammocora* grow as many-branched, hemispherical clumps, 2 or 3 inches in diameter, or as incrusting layers spreading over the surface of stones. In *P. stellata* (Verrill) (fig. 21, *b*), the most common of the branched forms, the calices are in shallow depressions. In *P. brighami* (Vaughan) the branches are cylindrical and bifurcated near the tips, and the calices are level with the surface. Both species are brown, and they live in association. On Waikiki reef, Oahu, colonies are found beyond 150 feet from shore. Another species, *Psammocora verrilli* Vaughan, is an incrusting form with an irregular upper surface. The calices have definite centers but indefinite boundaries and are in series separated by crests which take a meandering course. The septa are thick and close together, and their free edges are covered with minute denticles and granules. This colony bears a slight, superficial resemblance to that of *Pavona varians* because of the elevated crests, but the microscopic structure is quite different. Living specimens are pale brown or gray. The species has been taken from the reefs of Molokai and in Hanauma Bay, Oahu, but it is not common.

FAMILY ORBICELLIDAE

Corals of this family in Hawaii do not form large heads but incrust small areas of rocks or develop into nodular masses. Two species of *Leptastrea* are common on the reefs. In *L. bottae* (Milne Edwards and Haime) (fig. 22, *b*) the circular calices are raised above the general surface and the primary septa are more or less exerted and thickened. The other common species, *L. purpurea* (Dana), has large polygonal calices which do not rise above the skeletal surface. Masses of unicellular algae in the disks of living polyps of this species often give them a purple or green color. In Hawaii these species are well distributed over the reefs but are best developed at considerable distance from the shore.

Colonies of *Cyphastrea ocellina* (Dana) (fig. 21, *c*) form thin layers over rocks or develop into small nodules. They are usually very irregular and seldom more than 4 or 5 inches across. The calices are small, circular, and crowded together, their walls rising above the general surface. Living specimens are brown. This is one of the most common corals in shallow water, and it is widely distributed about the islands. A tiny crab, *Cryptochirus minutus*, inhabits round pits in *Cyphastrea ocellina*.

FAMILY EUPSAMMIDAE

One of the most brilliantly colored corals in Hawaii is *Dendrophyllia manni* (Verrill) (fig. 23, *c*), which is bright orange or vermilion when living. Diffused pigments in the soft tissue give color to this coral, for no algal cells are associated with the species. The colonies are formed by clusters of calices in the shape of tubular cups 1 to 2 inches high. Large colonies are 3 or 4 inches in diameter. The species is common in Kaneohe Bay, where it seems to thrive under ledges in diffused light at depths of from 6 to 10 feet. The planula of this coral is the same color as the living polyps.

FAMILY FUNGIDAE

Mushroom corals are disklike, free in the adult stage, simple or compound. Buds give rise to attached, mushroom-like young individuals, the disks of which break from the stalks and become free after a period of growth.

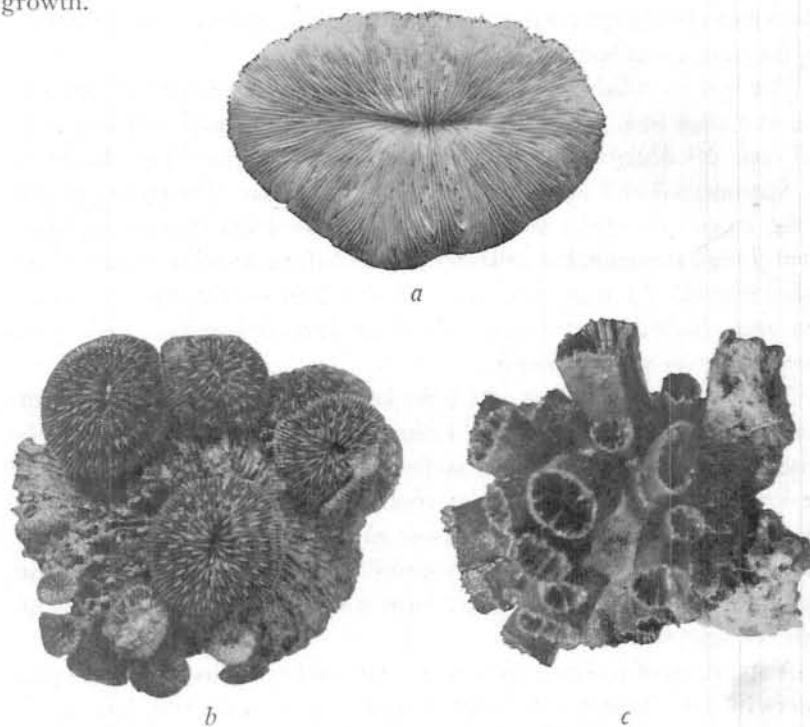


FIGURE 23.—Corals: *a*, *Fungia scutaria*; *b*, young specimens of *Fungia* before becoming detached; *c*, *Dendrophyllia manni*.

The most common form about Hawaii, *Fungia scutaria* Lamarck (fig. 23, a), represents a single calice, oval in shape, flattened above and below. The under surface is costate, the ridges radiating from the center. Septa of the upper surface, which are numerous and of several series, radiate from the central region occupied, in life, by the mouth of the polyp. Slight elevations (tentacular lobes) of the upper edges of the septa are scattered over the surface. These mark the position of tentacles in the living animal.

There is considerable variation in the degree of convexity of the upper surface of this species and in the height of the tentacular lobes. Forms having very high tentacular lobes have been called varieties *dentigera* and *verrilliana*.

This species nicely illustrates the feeding responses of corals. Currents of mucus maintained by cilia of the surface cells are aroused by the stimulus of food dropped on the disk. Particles are swept toward the mouth or away from it, depending upon the response to the stimulus. Food may take a meandering course over the disk before being ingested or rejected, for the currents are often variable and reversible.

The species inhabits clear water from a few feet to several fathoms. It is abundant in Kaneohe Bay, Oahu, and is occasionally taken on Waikiki reef. Its distribution is probably general throughout the islands.

Specimens 6 or 7 inches long are not uncommon. The rate of growth of the species decreases with age. Large individuals increase in length about 5 mm. annually, but small specimens before detachment from their stalks (fig. 23, b) may grow more than 1 inch in diameter during the first year. Normally the young individuals become free from their stalks after about one year's growth.

Two or three specimens of a form known as *Fungia oahensis* Doderlein, collected on the shore of Oahu many years ago, are in Berlin museums. The upper surface is arched very high, and the middle area of the lower surface is covered with rounded lumps. Both the lumps and the ribbed marginal area of the lower surface are thickly set with short spinules. The largest specimen recorded is slightly more than 5 inches long. Apparently it is a very rare form and, so far as is known, has not been collected recently.

A specimen of *Fungia paumotensis* Stutchbury, collected in Hawaiian waters by the *Challenger* Expedition and now in the British Museum, is 8 inches long, oval, slightly arched, and without tentacular lobes. It has not been recorded from Hawaiian shores in recent years.

Some authorities would unite *F. paumotensis*, and probably *F. oahensis*, with the species *F. scutaria* because of the similarity of young specimens and the great variation seen among adults.

In the Natural History Museum of Berne, Switzerland, is a specimen of *Fungia echinata* (Pallas) recorded from Hawaii. It is 16 inches long but very narrow. The under surface is covered with thorny spines. No other specimen has been collected in the islands.

Two other species of *Fungia*, *F. patella* (Ellis and Solander) and *F. fragilis* (Alcock), are known about Hawaii only from dredged material. In *F. patella* the skeleton is nearly circular and slightly arched above. Most Hawaiian specimens are less than 3 inches in diameter. In typical specimens of *F. fragilis* taken from moderate depths about the islands the skeleton is deeply incised on one side instead of being circular. The upper surface is slightly arched and the greatest breadth is about 1 inch. Neither of these species is likely to be found in shallow water on Hawaiian reefs.

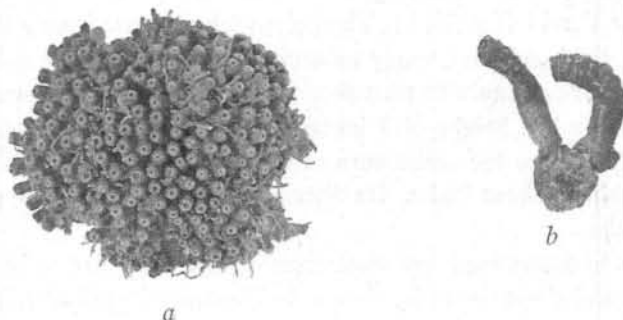


FIGURE 24.—Zoanthidae: *a*, *Zoanthus confertus*; *b*, *Isaurus elongatus*.

ORDER ZOANTHIDEA

FAMILY ZOANTHIDAE

Included in this order and family are compound Zoantharia which form clusters incrusting stones and other objects in shallow water. These organisms are sometimes called "soft corals." Individual polyps arise by budding from a basal tissue or from stolons. No skeletons are formed, but sand grains may become embedded in the tissues and give support and firmness to the polyps.

A common species on Hawaiian reefs is *Zoanthus confertus* Verrill (fig. 24, *a*), which consists of closely crowded, smooth polyps which

expand to a height of about 3 inches. Their color is grayish green. Masses of algal cells (Zooxanthellae), probably occupying a commensal relationship, are inclosed within the polyps at their free ends.

Another common form is *Zoanthus vestitus* Verrill, the polyps of which have rough, harsh surfaces due to adhering sand grains. They are grayish brown with purple disks. The polyps which inclose unicellular algae are shorter and thicker than those of *Z. confertus*. Both of these species are widely distributed about the islands and often grow near together. At Kualoa, windward Oahu, they cover large areas of stones near shore and are exposed at low tide.

A small species, *Zoanthus nitidus* Verrill, forms clusters of few polyps growing from a thin basal membrane or from stolons. The polyps, when contracted, are about 15 mm. high. They have smooth surfaces and are dark green with the upper part lighter green. The species has been collected on Waikiki reef, Oahu, but has not been observed often, due probably to its small size.

A curious form with polyps in small clusters or singly is *Isaurus elongatus* Verrill (fig. 24, *b*). The polyps which grow from a fleshy base are very rigid and have warty tubercles (verrucae) on the column near the disk, more on one side than the other. Living specimens are greenish and may reach a height of 3 inches. The species is common at Black Point, attached to the under surface of stones near shore, and occurs in other localities about Oahu. Its distribution is probably quite general in the islands.

Some undetermined representatives of this order are to be found on the reefs and about the rocky shores. In Hanauma Bay, Oahu, large areas of rocks at the outer border of the reef platform are incrustated by a species having a thick, compact base in which the polyps are almost completely embedded. This variety of soft coral which has a consistency similar to hard rubber is generally distributed about Oahu and probably occurs throughout Hawaii.

ORDER ANTIPATHIDEA

FAMILY ANTIPATHIDAE

In deep water about the islands are colonies having horny axial skeletons, which in some species are branched like trees. Minute polyps are scattered over the surface of the skeleton; their bases are fused together and form a thin living tissue. There are no calcareous spicules present.

These treelike forms are mentioned here because of the curiosity they arouse when brought to the surface, as they are occasionally, by the lines of fishermen. A specimen of *Antipathes grandis* Verrill taken by a fisherman from 80 fathoms of water near Kawaihae, Hawaii, was more than 7 feet tall. Another colony of the same species about 4 feet high, taken off the coast of Maui, is in Bishop Museum.

ORDER CERIANTHIDEA

An undetermined species of *Cerianthus* (fig. 25) lives embedded in the sand on the north shore of Kaneohe Bay, Oahu. Large specimens may be 5 inches long and 5 mm. in diameter. In color, the basal portion of the body is a deep shade of brown fading out toward the oral end, where the mouth is surrounded by numerous banded tentacles. The species is enclosed by a thin tube formed from mucus secreted by the animal and mixed with grains of sand. In some localities far out on the reef

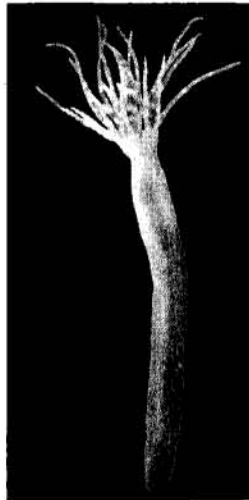


FIGURE 25.—*Cerianthus* species, without tube.

where the sand is about 12 inches deep the species is abundant. At low tide small round holes in the surface indicate the position of the contracted specimens. Although there is no record of *Cerianthus* occurring elsewhere in Hawaii, it is likely to be found in other localities similar to those in Kaneohe Bay.

PHYLUM CTENOPHORA

Although considered as coelenterates by some authors, ctenophores, in the opinion of others, possess characteristics sufficiently distinct to place them in a separate phylum. They are free-swimming animals. Some are spherical or conical and others are flattened, ribbonlike. The term "comb-jelly" is applied to them because of the eight longitudinal rows of swimming plates along the sides of the animals. Each swimming plate consists of a row of cilia fused at the base forming a "comb." The animal is propelled through the water by the "combs", all working in unison.

There is a mouth at one pole of the body and an excretory pore at the other. The digestive tract consists of a series of bilaterally arranged canals. Most species have two contractile tentacles with short branches bearing adhesive cells which take the place of stinging cells.

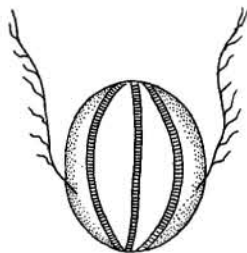


FIGURE 26.—A ctenophore.

Ctenophores are typically pelagic animals, and their transparency renders them inconspicuous in the water. Apparently few approach Hawaiian shores, as but two species were taken among the islands by the *Albatross*. Both of these are of wide distribution in the south Pacific Ocean. An undetermined, spherical form, about 3 mm. in diameter, has occasionally been observed in shallow water on Waikiki reef, Oahu. In this form the swimming plates extend from pole to pole of the body (fig. 26). A slightly larger species common in the surface waters of Pearl Harbor, Oahu, has short swimming plates extending from the aboral pole about one half the distance toward the oral pole.

PHYLUM PLATYHELMINTHES

Flatworms are unsegmented, soft-bodied animals dorso-ventrally compressed, living a free existence in water or moist earth or a parasitic life in the bodies of other animals. They represent a more advanced group than the coelenterates, in that they are bilaterally symmetrical and have a true middle germ layer (mesoderm). As in the coelenterates there is but one opening to the digestive tract and a blood system is wanting. In flatworms both sexes are united in the same animal.

CLASS TURBELLARIA

Representatives of this class are familiar objects about the shores of Hawaii. Upon examining the under side of a stone in shallow water one may see flat, leaflike animals moving rapidly over the surface. These are turbellarians and their movements are made possible by fine cilia which cover the ectoderm. When detached from the surface the animals swim by an undulating motion. Most of the common turbellarians seen in shallow water are known as "polyclads" because there are many lateral branches to the main digestive tract. Some of them are very delicate and are readily torn to pieces when an attempt is made to pick them up. It is difficult to preserve them in a normal flattened condition because of the tendency of the worms to curl up and become distorted.



FIGURE 27.—An undetermined polyclad.

There are apparently numerous species of polyclads about the shores, some of them minute in size, but few Hawaiian forms have as yet been studied systematically. For this reason it is impossible to give more than a very general account of those most frequently observed.

One of the most common polyclads of shallow water is uniformly white and from 1 to 2 inches long. It lives on the under surface of stones and is a very fragile species. Another familiar one is variegated and mottled with brown, yellow, and orange. It is somewhat larger and firmer than the preceding species.

A species slightly exceeding 2 inches in length is occasionally taken at Kahala, Oahu. The dorsal surface is covered with bluish-black papillary processes giving the animal a velvety appearance. It is a very delicate form. Another undetermined species has the black upper surface covered with pale yellow or white oval spots and is violet tinted below. It is about 2 inches long (fig. 27). A specimen collected at Waianae, Oahu, is black in general color with a green border and a whitish central area. Its length is 1.5 inches.

Some polyclads have a pair of tentacles at the anterior end which are formed by folds of the margin. Commonly observed specimens are small, most of them less than 1 inch long. One form is pale brown, speckled with golden pigment spots (fig. 28, *a*). Another one has the surface thickly covered with nipple-like processes, each darkly pigmented except for the light-colored apex which bears a black spot in the center.

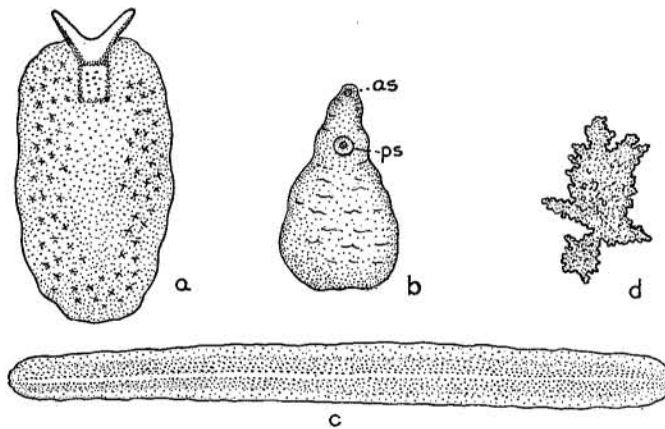


FIGURE 28.—Platyhelminthes: *a*, an undetermined polyclad bearing tentacles; *b*, a trematode from the stomach of a fish (*ono*) (*as*, anterior sucker; *ps*, posterior sucker); *c*, polyclad worm (*Taenioplana teredini*); *d*, pigment spot of *c*.

Taenioplana teredini Hyman, a polyclad suspected of parasitic habits, is often found in burrows of shipworms in test blocks of wood placed in Honolulu Harbor and at Waikiki for experimental purposes. The mollusks are always dead in burrows occupied by the polyclad. The worm may reach a length of 2 inches or more with a width of 5 or 6 mm. Its general color above is reddish brown caused by heavy pigmentation, the pigment being more crowded in the median longitudinal area. The lower surface is very much lighter in color (fig. 28, *c*, *d*).

CLASS CESTODA

Cestodes, commonly known as tapeworms, are highly specialized internal parasites and are mentioned here because many Hawaiian fishes are infested by them as well as by other parasitic worms.

Tapeworms are elongated flatworms. The head (scolex) is small and provided with hooks or suckers, followed by a series of segment-like sections (proglottides). These worms lack digestive and circulatory systems but have a highly developed reproduction system.

Little study has been devoted to any of the internal parasites of the Hawaiian marine fauna, and no specific classification of them has been made. The difficulty of learning the full life history of a cestode is great, because at least two hosts are necessary for its development; the larval stage is carried in one animal and the adult phase in another.

Among Hawaiian food fishes the *mahimahi* (*Coryphaena hippurus* Linnaeus) is usually heavily infested with internal parasites, including tapeworms. Although parasites are seldom found in the flesh or muscles of the fishes, it is a safeguard to health to see that fishes are well cooked before being eaten.

CLASS TREMATODA

Trematodes are parasitic worms provided with one or more suckers by which they cling to their hosts. As ectoparasites they are occasionally found attached to the gills of Hawaiian fishes, but more frequently as endoparasitic forms they are taken from the stomachs of fishes.

No taxonomic work has been done with those forms occurring in Hawaiian waters and no specific classification of them can be made at this time. An undetermined species commonly occurs in the stomach of the *ono*, *Acanthocybium solandri* (Cuvier). The worm has a thick, pyriform body with a tough skin. There are two suckers close together on the ventral surface. Each of four specimens taken from the stomach of a fish was about 1 inch long when partially contracted. (See fig. 28, *b*.)

Another species taken from the stomach of a fish (species unrecorded) at Pearl and Hermes Reef is light brown, mottled with dark brown. It is 3 inches long when partially contracted.

The larval phases of these endoparasites, although unknown, are probably developed within other marine animals which become the prey of the fish acting as the final host.

PHYLUM NEMATHELMINTHES

Worms with elongated, cylindrical bodies are grouped in this phylum. They are commonly known as "round worms" or "thread worms."

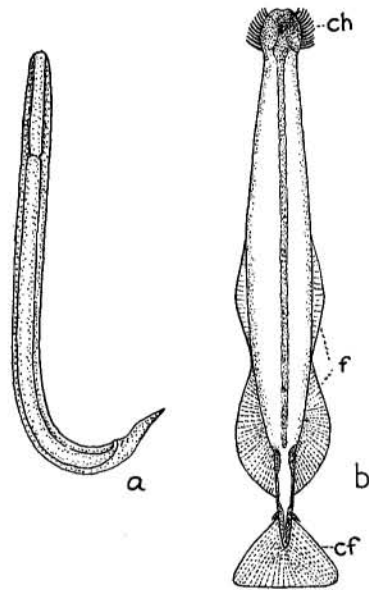


FIGURE 29.—Nemathelminthes: *a*, a marine nematode; *b*, an arrow worm, *Sagitta* species (*cf*, caudal fin, *ch*, chitinous hooks; *f*, lateral fins).

CLASS NEMATODA

Nematodes are slender, cylindrical worms more or less pointed at both ends. Many are parasitic in the tissues of plants or animals. Others are free-living and are found in soil, decomposed organic matter, in fresh water, and in the sea. Marine free-living nematodes occur about the shores among algae, in sediment on stones, and are sometimes taken on the surface of the water by means of a tow net. Hawaiian marine forms have not been studied, and the species are yet undetermined. Those commonly observed are clear, quite transparent animals only a few millimeters in length (fig. 29, *a*).

CLASS CHAETOGNATHA

Arrow worms are elongated, transparent animals typical of the surface waters of the ocean, where they may be taken near shore by means of a tow net. The head bears two eyes and the ventral mouth is bordered on each side by a series of chitinous hooks. There is a transversely expanded caudal fin about the posterior extremity. Some authorities recognize as many as seven genera of arrow worms, of which representatives of *Sagitta* and *Spadella* are frequently seen. In species of *Sagitta* there are two pairs of lateral fins, the posterior pair being partly on the body and partly on the tail (fig. 29, *b*). In species of *Spadella* there is but one pair of lateral fins.

ANIMALS OF DOUBTFUL RANK

The zoological position of certain groups of invertebrates is uncertain. Authorities are not in accord as to the relationship they show to other animals and what rank they deserve in the recognized system of classification.

Four such groups, among which are some of the familiar forms of the Hawaiian seashore fauna, are here considered without designation of taxonomic position.

NEMERTINEA

This group of wormlike animals, most of which live in the sea, is placed by some authorities among the flatworms, which they remotely resemble. They are unsegmented, externally ciliated, and most are non-parasitic.

A typical nemertean has an elongated, cylindrical, or slightly flattened body with a threadlike proboscis which may be extended from the anterior end, or entirely retracted. This organ is inclosed in a sheath dorsal to the digestive tract and when everted is turned wrong side out. Its function is probably sensory and defensive.

The systems of organs of the animal are well developed. There are complete digestive tracts and vascular, nervous, excretory, and reproductive systems. In most species the sexes are separate. The animals are very extensile and retractile. They may usually be recognized by their tendency to coil and twist into a tight knot when stimulated.

In some species, numerous pigment spots or ocelli are borne on the sides of the head. Other species lack ocelli.

Four species from Hawaiian waters have been described by W. R. Coe, and two or three other forms are known to occur about the islands. Those determined range in length from less than one inch (contracted) to several feet when fully expanded. Most of them are conspicuously marked by bands or stripes of various colors. Specimens are usually taken among seaweeds or in coral blocks on the reefs near shore.

The largest Hawaiian species observed, *Baseodiscus cingulatus* (Coe) (fig. 30, a), is distinguished by numerous narrow, reddish-brown rings, some of which are incomplete on the ventral surface. On each lateral margin of the head are 35 to 50 ocelli. Fully expanded specimens have reached a length of 4 feet. It ranges from near shore to depths of about 40 fathoms. Two other species of *Baseodiscus* are known locally. In *B. univittatus* (Coe) there is a narrow, reddish-brown longitudinal stripe

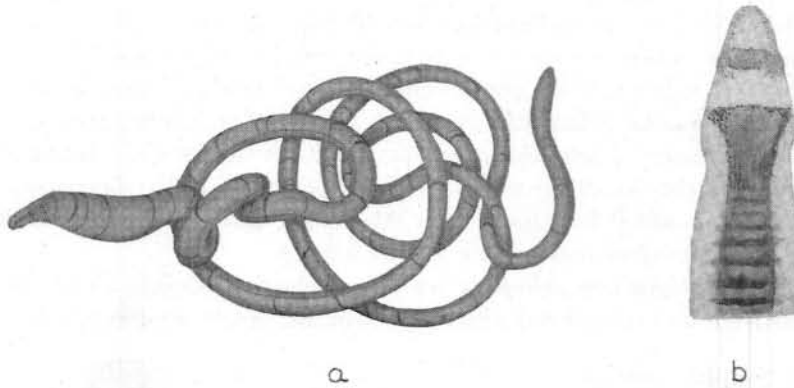


FIGURE 30.—Nemertinea: a, *Baseodiscus cingulatus*; b, *Baseodiscus edmondsoni* (after Coe).

along the mid-dorsal line of the body. Ocelli are apparently absent. *B. univittatus* exceeds a foot in length when expanded. It has been taken from the reefs of Oahu and dredged from depths of 250 to 260 meters between Molokai and Maui. Another small species, *B. edmondsoni* (Coe), is marked by a broad reddish-brown stripe along the dorsal mid-line of the anterior part of the body. Narrow transverse bands of the same color cross the longitudinal stripe. There is also a transverse band of the same color on the upper surface of the head. Numerous ocelli are on the lateral margins of the head. This species may exceed 1 foot in length. Specimens have been taken from Oahu and Kauai and the species is also known from Wake Island (fig. 30, b). A very small specimen of *Lineus albifrons* Coe was taken from the reef at Kahala, Oahu. It is recognized by the colorless anterior tip of the body which is followed by a deeply pigmented region covering about one third of the rest of the body but fading out posteriorly. Ocelli are inconspicuous or absent. A single known specimen in a preserved condition is 14 mm. long.

BRYOZOA (POLYZOA)

The Bryozoa assume many modes of growth. Primitive forms grow singly or develop simple colonies. More specialized types produce upright, branching colonies which superficially resemble seaweeds and hydroids, or grow in a flat incrusting manner over rocks, shells, sponges, and other objects. Colonies consist of closely united units (zoecia), each

of which incloses an independent animal (fig. 31, *d*). In some forms spherical structures (ooecia) rest on the upper edge of the zooecia serving as brood-pouches in which the ova undergo development. Ova and sperm occur in the same individual. Peculiar structures (avicularia) are found in some colonies. Each avicularium is shaped like the head of a bird and attached to the side of the zooecium by a short stalk. In life the avicularium is in constant movement from side to side and the jaws open and shut. The structure may be defensive in function.

Each independent animal has a true coelomic cavity in which the digestive tract is suspended with its anterior and posterior openings close

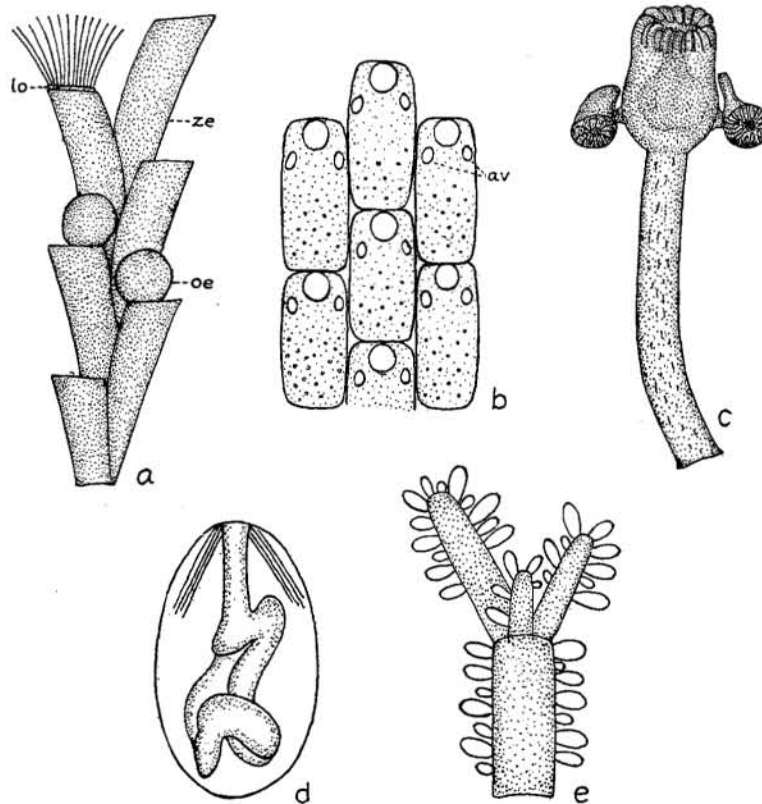


FIGURE 31.—Bryozoa (Polyzoa): *a*, portion of *Bugula neritina* (*lo*, lophophore; *oe*, ooecium; *ze*, zooecium); *b*, portion of an encrusting bryozoan showing position of avicularia (*av*); *c*, *Loxosoma* species; *d*, a zooecium of *Zobotryon pellucidus* with an inclosed animal; *e*, portion of *Zobotryon pellucidus* with zooecia attached along the branches.

together. A specialized structure (lophophore), consisting of a ridge bearing ciliated tentacles for drawing food into the mouth, is also a characteristic feature (fig. 31, *a*).

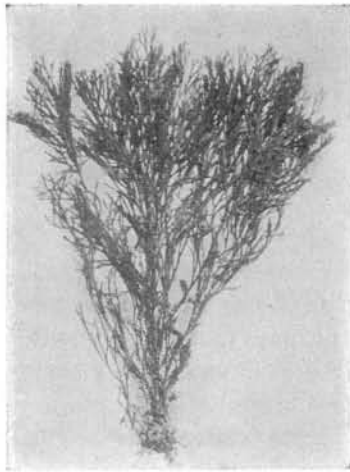
Two subdivisions of the group are recognized, depending upon the position of the posterior opening of the digestive tract.

ENTOPROCTA

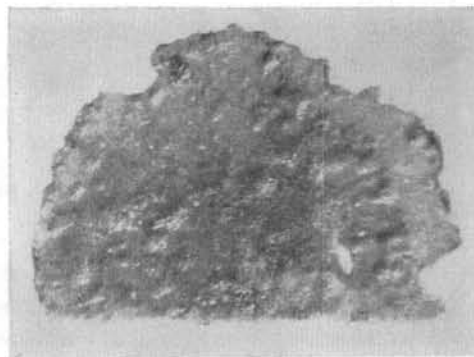
This subdivision includes the primitive Bryozoa in which the anal opening of the digestive tract is within the circle of tentacles. An undetermined species of *Loxosoma* is abundant about Oahu, among *Ulva* growing at the water's edge. The stalked form grows singly. Fourteen ciliated tentacles form a whorl about the distal extremity of the body and their ends curve inward surrounding the mouth and anal opening. Young individuals are budded from the side of the body of the adult; a short stalk, functional tentacles, and other organs are developed before final separation from the parent. Adult specimens are about 1.5 mm. tall. (See fig. 31, *c*.)

ECTOPROCTA

In the more highly specialized Bryozoa the anal opening is located outside the circle of tentacles. Both flat and upright colonies are developed.



a



b

FIGURE 32.—*a*, colony of *Bugula neritina*; *b*, colony of *Schizoporella* species.

Many incrusting forms grow in shallow water attached to seaweeds, stones, sponges, and other supports. When highly magnified they are seen to consist of many chambers or cells (zoecia) closely joined together. In life each zoecium incloses an independent animal. The local incrusting species (fig. 31, *b*) have not been determined, but representatives of the genus *Schizoporella* seem to be abundant (fig. 32, *b*).

Colonial forms of Bryozoa, in which the zoecia are grouped in upright, branching structures, are also known in Hawaiian waters. A widely distributed species, *Bugula neritina* Linnaeus (figs. 31, *a*; 32, *a*), is common in harbors and bays. Colonies are reddish brown, 3 or 4 inches high and resemble seaweeds in general appearance. No avicularia are present in this form. It is one of the most common of the numerous organisms which habitually foul the bottoms of boats in local waters. An undetermined species, probably a *Bugula*, much smaller than *B. neritina* but associated with it, is provided with avicularia (fig. 33). Branched

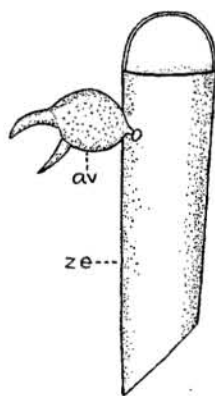


FIGURE 33.—Zoecium of *Bugula* species, supporting an avicularium (*av*, avicularium; *ze*, zoecium).

colonies of soft consistency, which become recumbent with age, are represented by *Zobotryon pellucidus* Ehrenberg, in which the zoecia are attached along the soft, cylindrical branches (fig. 31, *e*), and by a species of *Amathia* with the zoecia arranged spirally. Both of these form masses of twisted, translucent branches several inches across. Minute species spreading over surfaces by means of stolons are not uncommon. Forms of *Aetea truncata* (Landsborough) and *Catenaria lafonti* (Audouin) are negligible as fouling organisms, however, as their sparse vertical growths are usually but 2 or 3 mm.

BRACHIOPODA

Brachiopods are animals with bivalve shells attached to supports by long or short stalks. Because of the superficial resemblance to clam shells they were once considered members of the molluscan group. In brachiopods, however, the valves of the shell are dorsal and ventral instead of lateral, as in a typical clam.

The organism within the shell includes a specialized structure (lophophore) consisting of two thin, coiled plates bearing ciliated tentacles which draw food toward the mouth. The possession of a similar specialized structure by Bryozoa (p. 57) has led some authorities to join those animals with brachiopods under the phylum Molluscoidea.

Brachiopods live in nearly all oceans of the world ranging from shallow water to great depths. They apparently represent a disappearing group, as they were much more abundant in the seas of earlier geological periods than at the present time.

Few species have been taken from Hawaiian waters, and the extent of this fauna about the islands is unknown. In Kaneohe Bay, Oahu, is a long-stalked form of *Lingula*, probably *L. reevii* Davidson (fig. 34, *a*). The thin, bluish-green shell is supported by a stalk 3 or 4 inches long. The animal lives in sand-covered areas in shallow water and is almost completely buried, only the tip of the shell protruding.

Another species, *Megerlia sanguinea* Chemnitz, with an inflated shell

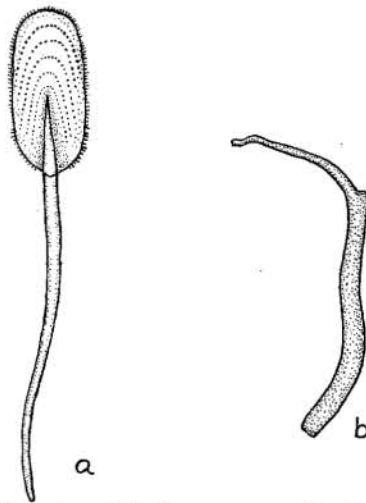


FIGURE 34.—Brachiopoda and Gephyrea: *a*, a stalked brachiopod, *Lingula reevii* (?); *b*, a gephyrean, *Aspidosiphon* species.

marked by irregular, radiating blotches of red, has been dredged from Honolulu Harbor. Empty shells, washed up from greater depths, are occasionally taken on the reefs and beaches. The shell is about 5 mm. in diameter.

GEPHYREA

Gephyreans are peculiar, wormlike animals, some of which show traces of segmentation. For this reason they are grouped, by some authorities, with the Annelida. They are elongated, cylindrical in form. Some have a retractile anterior portion of the body (introvert) and others have a long, grooved proboscis which is easily detached from the body. The digestive tract is complete. The anal opening is located, in some, on the side of the body near the anterior extremity; in others it is terminal at the posterior end of the body.

These worms are abundant about Hawaiian shores, where they bore into dead coral blocks, burrow in sand and gravel, or conceal themselves in crevices of porous rocks. Representatives of two groups are easily distinguished.

SIPUNCULOIDEA

In this group are forms having an introvert and commonly a fringe of tentacles surrounding the mouth. The anal opening is dorsal in position—nearer the anterior than the posterior end. Some forms have rigid bodies and habitually live in burrows made by themselves in dead but solid coral heads. Others burrow in mud and gravel along shores exposed at low tide. Although the Hawaiian species have not been classified, members of two or three genera are recognized by internal structural features.

In the genus *Physcosoma* the longitudinal muscle layer is in separate bands and finger-shaped tentacles are in a semicircle about the mouth. Hooks are usually present on the introvert. There are two or four internal retractor muscles, and the slender muscle around which the intestine is spirally coiled is attached to the body wall at both ends.

The more common rock-boring forms of Hawaii probably belong to this genus and seem to agree with *Physcosoma pelma* Selenka and de Man. In this form there are four retractor muscles, no hooks or spines on the introvert, and the papillae of the trunk of the body are formed by few rows of concentric plates. Small chitinous bodies are scattered between papillae. Specimens are 2 or 3 inches long when expanded (fig. 35, a).

In the genus *Aspidosiphon* the proboscis is narrower than the trunk and arises excentrically and ventral to the anal opening. There is a shield-

like plate about the anal opening and one at the posterior end of the body. This genus is represented in Hawaii by undetermined, rock-boring species. One very slender form is about 2 inches long (fig. 34, *b*).

Species of the genus *Sipunculus* are found in mud and gravel beds, where they burrow just beneath the surface. Both longitudinal and circular muscles are in bands, and the slender muscle around which the intestine is coiled is free from the body wall at the posterior end. The tentacles are leaflike folds about the mouth.

Specimens of one or more undetermined species are abundant in mud and gravel at the south end of Hanauma Bay, Oahu. Some of these have a glistening white skin. Others are coated more or less by a thin layer of brown epidermis. Large specimens expand to a length of 6 inches. (See fig. 35, *d*.)

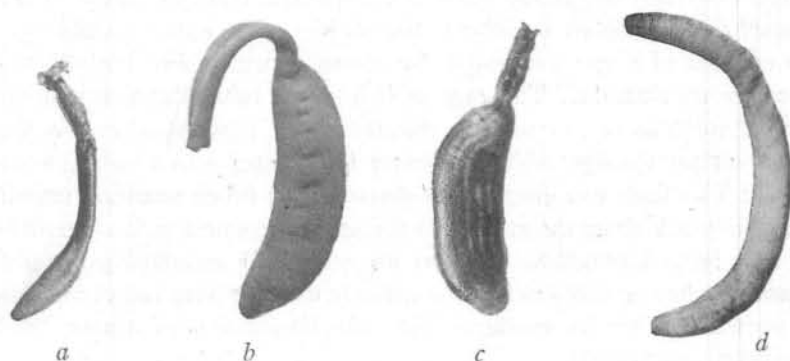


FIGURE 35.—Gephyrea: *a*, *Physcosoma pelma*; *b*, *Echiurus* species; *c*, *Thalassema* species; *d*, *Sipunculus* species.

ECHIUROIDEA

Soft-bodied gephyreans having traces of segmentation are included in this group. The folded proboscis is incapable of being retracted into the body but is easily detached and the anal opening is terminal. The Echiuroidea are found under stones near shore or in crevices of porous rocks. Although Hawaiian species are undetermined, two or more genera are probably represented. In the genus *Echiurus* are tentatively placed those forms which are grayish white and of large size, some reaching a length of 6 inches (fig. 35, *b*). The genus *Thalassema* is represented by common forms, some of which are brightly marked by longitudinal stripes of green, while others are uniformly dark green. Most are 4 or 5 inches long when expanded. (See fig. 35, *c*.)

PHYLUM ECHINODERMATA

The echinoderms, which include starfishes, sea urchins, brittle stars, holothurians, and crinoids, form a peculiar and distinct group of animals. The phylum is unique among the invertebrates, there being no other group to which it seems to be even distantly related. Adult specimens approach radial symmetry in their organization; the larvae are bilaterally symmetrical, the change taking place during an early period of development. An apparent similarity exists between the larvae of echinoderms and those of certain primitive chordates (Enteropneusta) (p. 316). This may indicate a common ancestry for these two widely separated groups.

Echinoderms are typically provided with calcareous skeletons in the form of shells (tests), plates, or other supporting structures. In most groups externally projecting spines are distinctive features. Some of the internal organs also are peculiar to the phylum. The water-vascular system consists of a series of canals by means of which soft, tentacle-like processes are extended. This system, in a typical echinoderm such as the starfish, includes one or more perforated plates (madreporites) on the dorsal surface through which the water is admitted into a canal (stone canal). This leads to a circum-oral channel from which radiating vessels carry the water along the grooves of the arms to connect with and inflate the tube feet. The hollow tube feet are commonly arranged in definite areas and when suctorial at the free ends are used for purposes of clinging to surfaces or for locomotion. They are doubtless also sensory and respiratory in function.

Such skeletal features as tests, plates, and spines vary with the different groups of echinoderms. In most forms the digestive tract is complete. The nervous system is a generalized one with no centralized brain, but a nerve cord surrounds the mouth and gives rise to radial nerves which branch to various parts of the body.

Five classes of echinoderms are recognized.

CLASS ASTEROIDEA—STARFISHES

A starfish consists of a central disk from which radiate five or more rays or arms. The rays, which vary greatly in different species, are, in most starfishes, broad at their bases and seem to be drawn out from the disk but not sharply differentiated from it. The ventral surface is recognized by the central mouth from which furrows (ambulacral grooves) radiate along the arms and contain rows of tube feet. One or more per-

forated plates (madreporites), and the anal opening which is present in most species, are on the dorsal surface.

The skeleton of a starfish consists of a network of calcareous plates which usually bear spines. The spines, which are solid and comparatively short, are of many forms and arranged in distinctive ways in different groups of starfishes. Paxillae, characteristic of some species, are rosette-like groups of minute spines arranged about a short column. Between the plates of the skeleton arise soft, fingerlike, hollow processes (papulae) which serve as respiratory organs. About the bases of the spines in many starfishes are numerous short bodies (pedicellariae) with two or three jaws which open and close. These structures, which are modified spines, are believed to aid in ridding the animal of foreign particles by grasping them, passing them along, and thus finally removing them from the surface (fig. 42).

The digestive system leads from the mouth into a stomach, with which is connected a pair of saclike organs (pyloric caeca) lying in each arm. The caeca serve as digestive glands and consist of a pair of elongated, bulbous pouches attached to the dorsal wall of the cavity of each arm and occupying a large part of this space. Each pair opens into the stomach by a common duct.

Reproductive glands lie in the body on each side of the base of the arms. Their ducts open in the angles between the arms. The sexes are separate.

Comparatively few species of starfishes are seen in the shallow waters of Hawaii. Most of the 60 or more species dredged by the *Albatross* in 1902 live in off-shore water and are seldom seen on the reefs.

Hawaiian starfishes are closely related to those of the south and west Pacific areas. Apparently, few species are common to Hawaii and the west coast of America. Many, however, are common to the waters of Hawaii, Japan, Australia, and the Indian Ocean.

In the following treatment of this class only those starfishes are mentioned which are known to occur in comparatively shallow water, or are likely to occur there. Some species which are included have been collected only from the leeward islands, but careful searching of other reefs may show them to be more generally distributed.

The results of a recent survey of some Hawaiian echinoderms by Charles A. Ely, entitled "Shallow-water Asteroidea and Ophiuroidea of Hawaii", are made the basis of the classification of the following sections on starfishes and serpent stars.

ORDER PHANEROZONIA

Key to Families of Phanerozonia

- A. Tube feet without suctorial disks; aboral plates of skeleton bearing paxillae.
 - B. Superomarginal plates not replaced by paxillae; anal opening sometimes present; papulae simple.....**Astropectinidae.**
 - BB. Superomarginal plates replaced by paxillae; no anal opening; papulae compound**Luidiidae.**
- AA. Tube feet suctorial.
 - B. Disk large, rays relatively short; no papulae on oral surface.
 - C. Body thick, rays very short, covered by granulated skin.....**Oreasteridae.**
 - CC. Body not very thick, covered by a tough, smooth skin..**Asteropidae.**
 - BB. Disk small, rays relatively long, narrow; papulae sometimes on oral surface**Ophidiasteridae.**

FAMILY ASTROPECTINIDAE

Starfishes of this family have flattened bodies with the dorsal and ventral surfaces covered with rosette-like groups of short spines (paxillae). There are two rows of prominent marginal plates along the arm grooves. The anal opening is very small or wanting.

The two representatives of this family known to occur in shallow water have been observed only about the leeward islands. One of these, *Astropecten polyacanthus* Müller and Troschel, is distinguished by a row of prominent, erect superomarginal spines along the rays except on the second and third plates. One specimen was taken by the *Tanager* at French Frigate Shoal in shallow water, and one was dredged by the *Albatross* in 20 fathoms off Nihoa. The specimen from French Frigate Shoal has an expanse of 2.5 inches. The known distribution is from the Red Sea to Hawaii. The range is from the shore to about 25 fathoms.

In *Astropecten triseriatus myobrachioides* Fisher (fig. 36, a) the upper and lower marginal spines along the arms are in transverse rows of threes. This subspecies differs from the typical species, which is known only from Australia, in having the arms shorter and the three inferomarginal spines of almost equal sharpness. The Hawaiian form was taken at Pearl and Hermes Reef in shallow water. It has an expanse of about 3 inches. No species of this family has been recorded from the reefs of the larger islands of Hawaii, though nearly a dozen are known to occur in the deeper off-shore water.

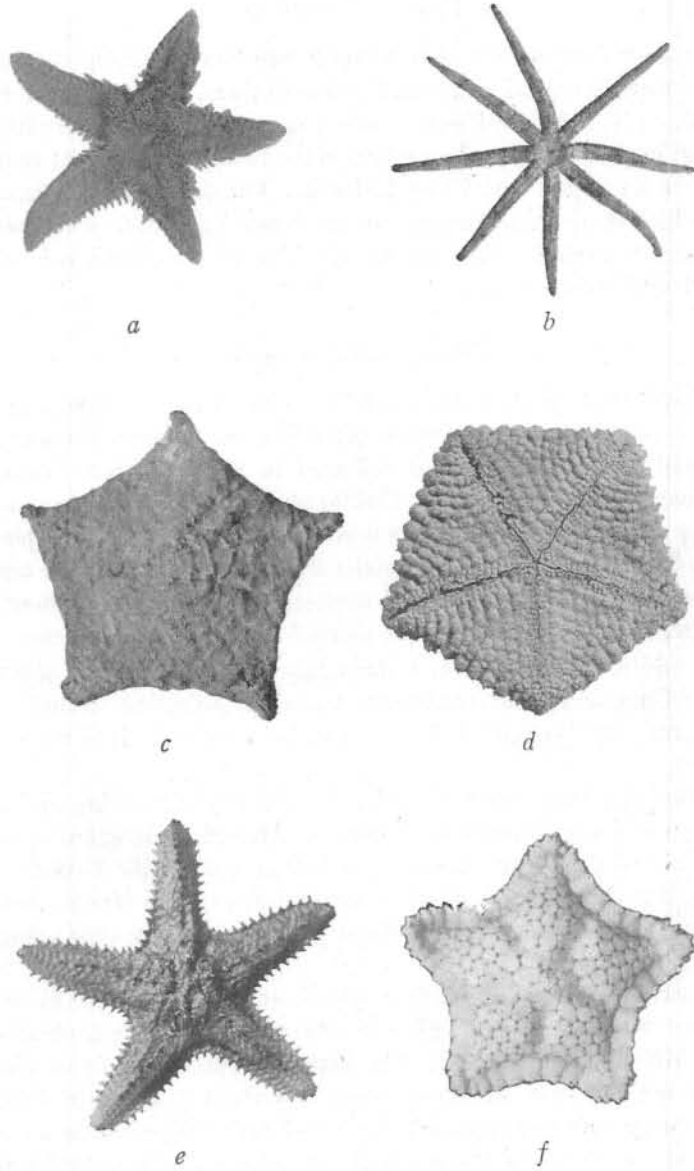


FIGURE 36.—Asteroidea: *a*, *Astropecten triseriatus myobrachi*; *b*, *Luidia hys-trix*; *c*, *Culcita novaeguineae* form *arenosa*; *d*, *Culcita*, young; *e*, *Asterope carifera*; *f*, *Asterope*, young.

FAMILY LUIDIIDAE

Although four species of this family are known among the islands, none of them is typical of the reefs. One of them, *Luidia hystrix* Fisher (fig. 36, *b*), is mentioned here as it is a species somewhat more likely to be found in shallow water than others of the family. It has eight arms and may have an expanse of 10 or 12 inches. On the plates just lateral to those which border the arm grooves are borne long three-jawed pedicellariae, one to a plate. (See fig. 42, *b*.) The color in life is pale yellow, mottled with brown.

FAMILY OREASTERIDAE

Thick-bodied, pentagonal starfishes with arms so short that they appear to be absent are occasionally taken in a few fathoms of water about the islands. Among specimens collected in Pearl Harbor, Oahu, two forms have been recognized. In *Culcita novaeguineae* form *arenosa* Perrier (fig. 36, *c*) the dorsal surface is covered with minute sharp spinelets. In *Culcita novaeguineae* form *nesiotis* Fisher small tubercles of unequal size are scattered over the dorsal surface. Both forms are yellowish in life. Large specimens of each may reach 7 or 8 inches in diameter.

An undetermined form of *Culcita* taken in a fishtrap off the south shore of Oahu and transferred to the Honolulu Aquarium, where it lived for several years, is reddish brown, mottled with red. It is 9 inches in diameter.

Authorities have great difficulty in properly classifying species of *Culcita*, and many varieties have been established. The genus is widely distributed in the warm parts of the Indian and Pacific Oceans. It is unlikely that these starfishes will be found near shore in Hawaii, but they may occur on the outer edge of reefs or in shallow bays and are sometimes taken in fishtraps.

A starfish collected in shallow water near Hilo, Hawaii, by H. W. Henshaw was described by Fisher in 1906 under the name *Goniodiscides sebae* (Müller and Troschel). The flattened, pentagonal form with the sides of the disk only slightly concave was about 3 inches in diameter. Under the generic term *Goniodiscus* it had been recognized as a distinct species for more than 60 years, with a known range from Madagascar and the Red Sea through the Indo-Pacific region to Fiji, the Gilberts, and the Marshall Islands. The Hawaiian record considerably increased this range.

In 1908 Clark, by collections from Amboina, showed that *G. sebae* was a young phase of *Culcita novaeguineae*. This relationship is now recognized by all authorities. Recently a young specimen was collected at Maili Point, Oahu. (See fig. 36, *d*.)

FAMILY ASTEROPIDAE

The widely distributed species, *Asterope carinifera* (Lamarck), occasionally has been taken in shallow water about Oahu, especially at Maili Point and Black Point. Typical forms are regularly pentamerous with rather large disk and arms broad at the bases. The whole surface is covered with a leathery membrane. The sides of the arms have a serrated appearance due to stout conical spines which stand straight out. Six to eight blunt spines form a row along the mid-dorsal line of each arm (fig. 36, *e*). Large specimens may have an expanse of 6 or 7 inches. Small forms, probably young of this species (fig. 36, *f*), are also taken in shoal water. Those seen are less than 1 inch across, very flat and symmetrical, with short arms and heavy marginal plates. The species ranges widely, from the Red Sea through the Indian and Pacific Oceans to Panama and Lower California.

FAMILY OPHIDIASTERIDAE

Key to Genera of Ophidiasteridae

- A. Aboral plates not arranged in regular longitudinal series; adambulacral plates bearing granules in two or three series; no pedicellariae.....**Linckia**.
- AA. Aboral plates in regular longitudinal series (not clearly so in Ophidiaster); pedicellariae in some genera.
 - B. Covered by thick, smooth skin; pedicellariae in some species..**Leiaster**.
 - BB. Covered by skin bearing granules or tubercles.
 - C. Granules of skin uniformly disposed, larger on convex surfaces**Ophidiaster**.
 - CC. Granules or tubercles in clusters in center of each skeletal plate**Dactylosaster**.

Members of this family have small disks and long, narrow, cylindrical rays. There are no prominent spines and species even of different genera bear considerable resemblance to each other. None of the representatives of the family is uniformly distributed over the reefs of the islands. Even those most plentiful seem to be limited to one or to a few localities.

A species abundant on the shallow reef off the north shore of Kaneohe Bay, Oahu, is *Linckia multifora* (Lamarck) (fig. 37, *a*). In this form,

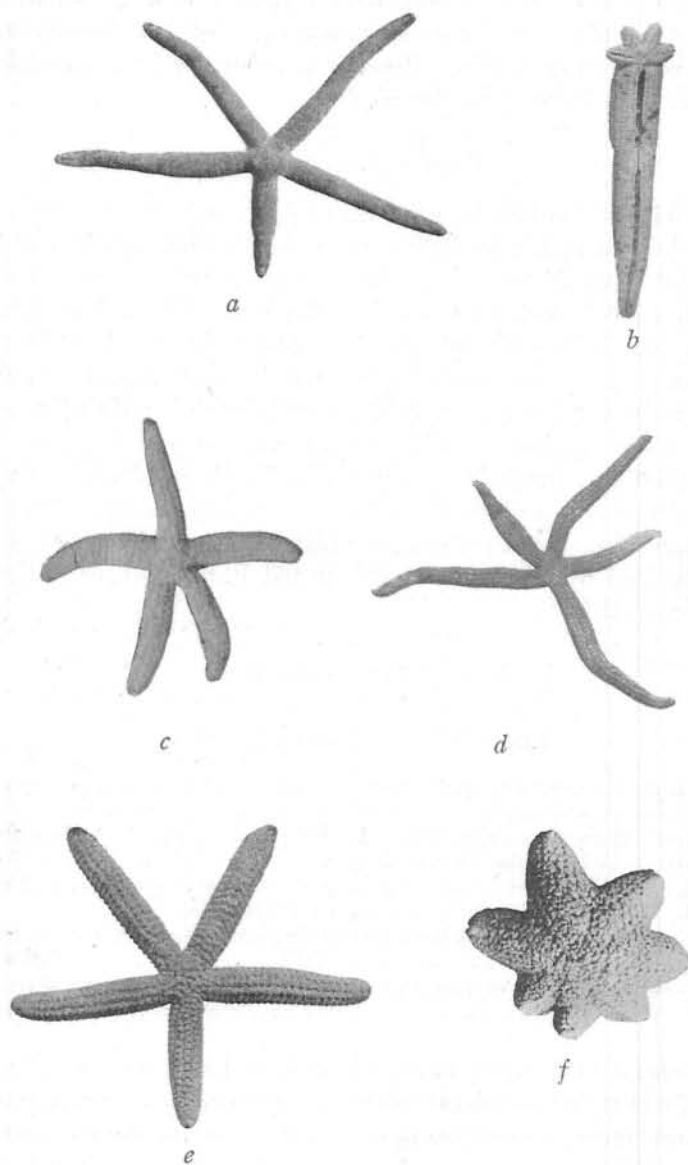


FIGURE 37.—Asteroidea: *a*, *Linckia multifora*; *b*, comet of *Linckia multifora*; *c*, *Ophidiaster lorioli*; *d*, *Leiaster leachii hawaiiensis*; *e*, *Dactylosaster cylindricus pacificus*; *f*, *Asterina anomala*.

the small spines bordering the ventral furrows are nearly equal in size and are separated by four or five granules. There are two or three madreporites. The species is yellowish or reddish brown, often spotted with dark red. Large specimens have a total expanse of 5 or 6 inches. The arms are of the greatest diameter at the disk and gradually taper toward the tips.

When the tide is low specimens may be found on top of or partially concealed by coral heads, or even spread out on the white sand, under but a few inches of water, exposed to the rays of the sun. In aquarium tanks they have a tendency to climb up the walls to the surface of the water. This starfish, like some others, breaks off its arms (autotomy), and almost every specimen collected shows evidence of regeneration in one or more of its arms. The portion of an arm broken off may also regenerate rays at the stump end and eventually develop into a new starfish. Arms thus developing, and known as "comets", are often found on the reef (fig. 37, *b*).

Another species associated with *L. multifora* in Kaneohe Bay, but less abundant and larger in size, probably should be called *Linckia guildingii* Gray. There is some uncertainty as to its identity with *L. diplax* (Müller and Troschel), but H. L. Clark believes they differ and that the Hawaiian form is *L. guildingii*. Large specimens may have a total expanse of 15 to 20 inches. The arms, four to six in number, are slightly constricted at the disk, widening somewhat, then tapering to a blunt point. No granules separate the spinules of the ventral furrows of the arms. Usually two madreporites are present, but the number varies. Adult specimens are usually dark brown. Small forms probably of this species, taken at Honaunau, Hawaii, were gray, spotted with red. This widely distributed species is recorded from Laysan Island.

There is no certainty that *Linckia laevigata* (Linnaeus) occurs in Hawaii, but it is distributed among the Line Islands and ranges widely in the Indo-Pacific area. It grows larger than *L. multifora* and is blue or greenish blue in color.

A small yellowish species, *Ophidiaster lorioli* Fisher (fig. 37, *c*)—with cylindrical arms, two madreporites, and papular areas in groups of threes—was collected near shore on the south coast of Molokai. It is not common in Hawaii. In Bishop Museum are specimens from Samoa and Wake Island. The total expanse is about 3 inches.

One specimen of *Ophidiaster squameus* Fisher was collected in shallow water at Black Point, Oahu, by Ely, and two others were dredged

from about the islands by the *Albatross*. The specimen has a total expanse of about 4 inches. The arms, five in number, taper but slightly toward a blunt point ending in a large terminal plate. The skeletal plates are convex, covered with granules and arranged in longitudinal series with deep furrows between the rows, and marked off transversely by more shallow grooves. It is mottled with brown, pink, red, yellow, and white.

One specimen of *Leiaster leachii hawaiiensis* Fisher (fig. 37, *d*) was taken at Koloa, Kauai, in 1900. The small spines bordering the ventral furrows are usually in groups of threes. The longest arm of the type specimen is slightly more than 4 inches.

Several specimens of the subspecies *Dactylosaster cylindricus pacificus* Fisher (fig. 37, *e*) were taken by the *Tanager* Expedition in shallow water about Laysan Island and Kuré (Ocean) Island. It has also frequently been taken at Black Point, Oahu. It has five cylindrical arms, slightly constricted at the disk and hardly tapering to the blunt end. Skeletal plates are convex, arranged in nine longitudinal rows, each plate capped by a cluster of granules. The color in life varies with specimens. Usually they are mottled with shades of red, violet, brown, and white. Specimens may have a total expanse of 4 or 5 inches. This subspecies differs from *D. cylindricus* of the Indian Ocean in lacking pedicellariae.

ORDER SPINULOSA

Key to Families of Spinulosa

- A. Skeleton of imbricating plates bearing small spines in tufts or fans..... **Asterinidae.**
- AA. Skeleton of plates forming an open meshwork, bearing isolated spines or groups of spinelets but not in fans.
 - B. Disk small, rays long, skin and obtuse spines bearing scales or spinelets; no pedicellariae **Mithrodiidae.**
 - BB. Disk large, rays short and numerous; plates bearing sharp spines; pedicellariae two-jawed **Acanthasteridae.**

FAMILY ASTERINIDAE

The smallest starfish in Hawaii is *Asterina anomala* Clark, which is not uncommon under stones near shore at Waikiki and Black Point, Oahu, and which has been taken on the north coast of Maui and at Honaunau, Hawaii. Typically the species is seven-rayed but undergoes rapid fission through the disk, so that living specimens vary greatly in size and shape. Tufts of spinules thickly cover both the dorsal and ventral surfaces. Those of the ventral surface are arranged in rows from the furrows outward.

Granulated spinules bordering the ventral furrows are in fanlike crescents of five or six. (See fig. 37, f.) Some specimens are grayish brown above, lighter beneath. Those from Hawaii are brick red above and lighter beneath. The color renders them inconspicuous when closely attached to a stone. Large specimens are 12 to 15 mm. across.

The species is recorded from Mer Island, Murray Island, and Torres Strait.

FAMILY MITHRODIDAE

Small specimens of *Mithrodia bradleyi* Verrill (fig. 38, a) are occasionally seen in shallow water, but large forms thrive from the outer edge of the reef platform to depths of more than 100 fathoms. The disk is small, and each of the five long cylindrical arms is constricted at the base. Minute, blunt granules cover the plates, ridges, and spines of the reticulate skeleton. There are few spines on the dorsal surface of the adult, but one lateral and two ventral rows are borne on each side of an arm. Large specimens have a total expanse of 20 inches. This species is widely distributed in the Indo-Pacific region and is one of the few starfish common to Hawaii and the west coast of America, where it has been reported from the Gulf of California. The color varies with specimens but usually is some shade of vermilion with the ventral furrows yellowish or brownish.

Another species, *Mithrodia fisheri* Holly, was described from a specimen taken at Pearl and Hermes Reef. The disk is relatively larger than in *M. bradleyi*, and the arms are not constricted at the base. Scattered, low tubercles cover the surface and the color is said to be cinnamon with pink and maroon at the end of the arms. Specimens corresponding to this species have not been taken about the larger islands of Hawaii, but two specimens, probably of this form, were dredged near Bird Island by the *Albatross*.

FAMILY ACANTHASTERIDAE

This family in Hawaii is apparently represented by but one species, *Acanthaster planci* (Linnaeus) (fig. 38, b). A specimen taken at Haleiwa, Oahu, is 14 inches in diameter, has 16 arms, and is thickly covered with long thorny spines. There are several madreporites. In life the color is brown or yellow. It has been taken at Pearl and Hermes Reef, but is not common in Hawaiian waters. The species ranges through the Indian and south Pacific Oceans and is abundant about Christmas Island (Pacific Ocean) in 2 or 3 fathoms of water.

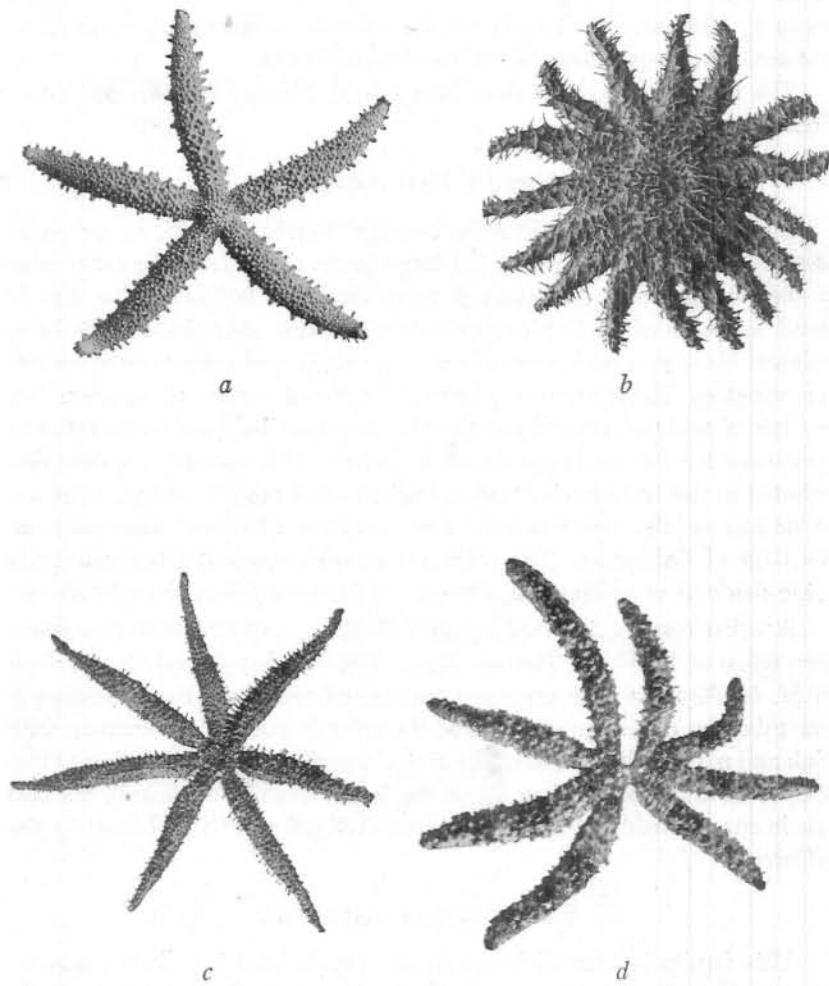


FIGURE 38.—Asteroidea: a, *Mithrodia bradleyi*; b, *Acanthaster planci*; c, *Coscinasterias acutispina*; d, *Coscinasterias acutispina*, in division.

ORDER FORCIPULATA

FAMILY ASTERIIDAE

Members of this family are characterized by skeletons composed of a loose network of rodlike plates. The tube feet are in four rows. Four species are known from Hawaiian waters, three of them, however, from dredged material only.

The shoal water species, *Coscinasterias acutispina* Stimpson (fig. 38, *c*), was collected at Kuré Island and Pearl and Hermes Reef by the *Tanager* Expedition, and may be found in Kaneohe Bay, Oahu, where it is associated with *Linckia multifora*. Large specimens may reach a total expanse of 8 inches or more. The dorsal surface is provided with acute spines which have groups of small pedicellariae near their bases. There are two kinds of pedicellariae, large ones which are usually sessile and small ones on pedicels. The number of rays varies, often being seven or eight. Each ray is constricted at the base, then becomes swollen and tapers toward the end. The color ranges from yellow to chocolate brown. In Maalaea Bay and Kahului Harbor, Maui, there is a small variety of the species which is constantly undergoing rapid fission, the break being through the disk. The division takes place between two pairs of the four madreporites which are usually present (fig. 38, *d*).

CLASS OPHIUROIDEA—BRITTLE STARS, SERPENT STARS

Animals of this class are called brittle stars, because their arms or rays are very brittle and break off readily. They are also called serpent stars, because of the wriggling movements they make during activity. Although brittle stars are often called starfishes, they differ from true starfishes in the following respects: the arms, usually five in number, are sharply marked off from the central disk; the internal organs are, for the most part, confined to the disk and do not extend out into the arms as in a starfish; there is no anal opening in the brittle star, the pouchlike stomach having but one external opening, the mouth, through which food enters and wastes are discharged; the madreporite is ventral in position and there are no pedicellariae; as the arms of the brittle star are composed chiefly of calcareous material they are easily broken.

Of all echinoderms the brittle stars are the most active. Their movements are due to the peculiar structure of the arms. The arm is seg-

mented, each segment being somewhat quadrangular in cross section and bounded by four plates, a dorsal, a ventral, and a lateral plate on each side. Each lateral plate bears a vertical row of spines which assist in movements. A typical starfish has ventral rows of tube feet which have suctional ends. In a brittle star the organs corresponding to tube feet are reduced to papillae-like processes extending between the lateral and ventral plates, one pair to each segment. They are probably tactile and respiratory organs; they have no function in assisting the animal to move or to cling to surfaces.

The central part of each segment of an arm consists of a calcareous ossicle (vertebra) to which are attached four strong muscles extending as bands throughout the length of the arm. Articulation of adjoining vertebrae permits the muscles to move the arm freely in a lateral direction and, to a lesser degree, up and down.

Extending into the arm, above the vertebrae, is the remnant of the coelomic cavity, and below are the radial water canal, blood canal, and nerve. The water canal connects by small ducts with the rudimentary tube feet (papillae).

As in other animals in which parts are easily broken off, the arm of the brittle star may be regenerated when lost. Many specimens show partial regeneration of one or more arms.

The sexes are separate in brittle stars. Ova and sperm are discharged from slitlike openings on the edge of the disk close to the arms, and fertilization occurs in the water.

Unlike starfishes, several species of brittle stars are very abundant in shallow water about Hawaii.

Key to Orders of Class

- A. Disk usually covered with imbricating scales which are sometimes spinulose **Gnathophiurida.**
- AA. Disk covered with plates or scales (not imbricating) which usually are granular **Chilophiurida.**

ORDER GNATHOPHIURIDA

Key to Families of Order

- A. Oral papillae present but no dental papillae..... **Amphiuridae.**
- AA. Oral papillae absent but dental papillae well developed..... **Ophiotrichidae.**

FAMILY AMPHIURIDAE

Key to Genera of Family

- A. Paired infradental papillae present.
 - B. Not more than three oral papillae on either side of oral slit.
 - C. Oral papillae two or three, separated from each other by a wide interval; oral slit open.....**Amphiura.**
 - CC. Oral papillae three on each side, the outer one large; oral slit closed**Amphipholis.**
 - BB. Four or five oral papillae on each side in a continuous row, closing the oral slit**Amphioplus.**
- AA. No paired infradental papillae.....**Ophiactis.**

Members of this family in Hawaii, thus far recognized, are small forms with disks about 5 mm. or less in diameter, and are white, tan, or greenish in color.

A white species, *Amphiura immira* Ely (fig. 41, *a*), has been collected at Black Point, Oahu. It has 5 arms and a disk about 2.5 mm. in diameter, covered by imbricating scales. Radial shields are long and narrow, in contact distally, diverging centrally, the intervening area filled by two or three plates. The dorsal arm plates are broadly oval; ventral ones longer than broad, slightly concave on the lateral borders. Side arm plates small, each bearing 5 or 6 spines. One tentacle scale is present.

In *Amphipholis squamata* (Delle Chiaje) (fig. 41, *b*) the disk which may reach a diameter of about 5 mm. is covered by imbricating scales. Radial shields are large and contiguous distally but are separated centrally by a wedge-shaped plate. The arms are five in number. Arm spines are three in number, except the third and fourth segments which may bear four spines. There are two small tentacle scales, one lateral to the other. The color is light tan, sometimes mottled with another shade of tan. In young specimens the disk may have an orange tint. The species is widely distributed along the Atlantic shores of Europe and the Americas and through the south Pacific Ocean. It has been taken at Laysan Island and at Black Point, Oahu.

Another small species, *Amphioplus caelatus* Ely (fig. 41, *c, d*), having a disk diameter of about 2 mm., was collected at Black Point, Oahu. The disk is covered with coarse imbricating scales. The radial shields are contiguous throughout their length. The arms are five in number. Dorsal arm plates are broadly elliptical; ventral ones are pentagonal, thick, becoming thinner laterally. Arm spines are three in number. Two overlapping tentacle scales are present, the ventral one much shorter than the

dorsal one. The species is white, except for light tan stains on the upper arm spines and on the proximal ventral arm plates.

Species of the genus *Ophiactis* are small forms, greenish in color. In *O. modesta* Brock (fig. 41, *e*) the disk may reach a diameter of 3 or 4 mm. and the arms are five or six in number. The disk is covered with rounded imbricating scales, which in the interradial areas bear a few spines. The dorsal arm plates are much broader than long, rectangular with rounded angles, becoming more spherical nearer the tip of the arm. The ventral arm plates are broader than long, each plate with an hour-glass depression in the center. Arm spines usually four or five. There is one large oral papilla and one tentacle scale. The species is usually bluish green, variegated with cream color. It has been taken in Pearl Harbor and Kaneohe Bay, Oahu, and occurs in Japan and along the northern Australian coast. Another very common species in Hawaii is *Ophiactis savignyi* (Müller and Troschel) (fig. 39, *a*). The arms are usually six in number but may be five or seven. The upper surface of the disk is covered by small, rough scales, which increase in size in the space between the very large radial plates. Scales on the under surface are very fine and imbricating. There are a few spines on the upper surface of the disk and more in the interradial areas. Upper arm plates are broader than long and roughened on the surface with minute round knobs. The ventral arm plates are heptagonal, a little longer than broad. The side arm plates usually have six or seven spines, or only five near the tip of the arm. There are two or three oral papillae and one tentacle scale, except in the first segment where there may be two. This species is usually light green and gray, or, in some specimens, almost wholly gray. It is abundant in Pearl Harbor, Kaneohe Bay, and other localities about Oahu. The range of the species is very wide, including Japan, the south Pacific, and the warmer waters of the west and east coasts of the Americas.

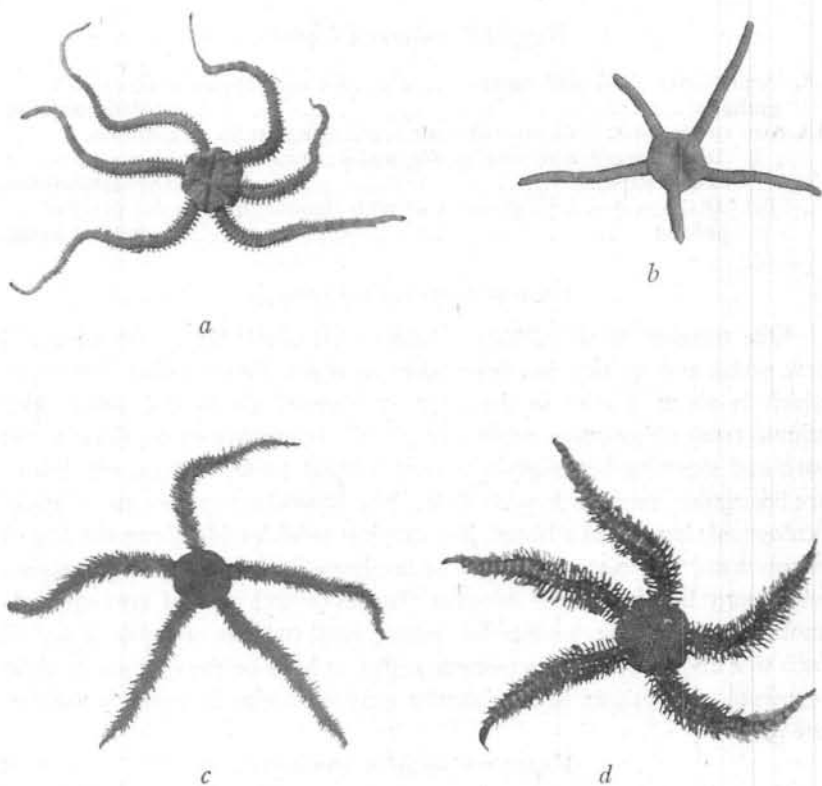


FIGURE 39.—Ophiuroidea: a, *Ophiactis savignyi*; b, *Distichophis clarki*; c, *Ophiocoma erinaceus*; d, *Ophiocoma pica*.

FAMILY OPHIOTRICHIDAE

One species of the family, *Ophiotrix demessa* Lyman, is widely distributed among the islands in shoal water, although not abundant in any locality. Large specimens may have disks 10 mm. across and relatively long arms, of which there are five. The arm spines are long, delicate, and hyaline, and have fine spinelets along their length. The color varies from white to bluish or reddish tints. It usually is found curled up in crevices of porous rocks near shore. The species ranges from the Red Sea through the Indian and south Pacific Oceans to Hawaii, which is the type locality.

ORDER CHILOPHIURIDA

Key to Families of Order

- A. Arm spines short and numerous; disk and oral angles covered with granules **Ophiodermatidae.**
- AA. Arm spines long; disk covered with overlapping scales or granules.
- B. Disk covered with overlapping scales; arms long and slender; no dental papillae **Ophiochitonidae.**
- BB. Disk covered with granules or with smooth skin; dental papillae present **Ophiocomidae.**

FAMILY OPHIODERMATIDAE

One member of this family, *Distichophis clarki* Ely, representing a new genus and species, has been taken at Black Point, Oahu. The disk, which is about 4 mm. in diameter, is covered above and below with minute truncate granules which are pitted. It has five arms, thick at the base and tapering but slightly toward a blunt point. Dorsal arm plates are triangular, about as long as wide. The ventral arm plates are typically pentagonal, longer than broad, but varying considerably along the length of the arm. The lateral arm plates are large with seven or eight spines which may lie flat against the arm. Inside of each row of arm spines is another series of fine needle-like spines. Oral papillae are nine or ten on each side and there are two tentacle scales, at least on the first six or eight segments. Specimens are uniformly gray or white in color. (See figure 39, b.)

FAMILY OPHIOCHITONIDAE

This family is represented by *Ophionereis porrecta* Lyman (fig. 41, f), the disk of which is usually not more than 15 mm. across. The arms may be 4 to 6 inches long. The disk is covered with fine scales, smooth on the dorsal surface but some of them granular on the ventral surface. The arms are five in number. The dorsal arm plates are much broader than long, with an extra piece on each side. The ventral arm plates are pentagonal, as broad as long. Lateral arm spines number three to five. The color is variegated buff, brown, and blackish, with the arms distinctly banded. The species is found in crevices of porous rocks near shore. It is widely distributed through the south Pacific and Indian Oceans.

FAMILY OPHIUCOMIDAE

The family is represented in Hawaii by one genus, *Ophiocoma*, of which there are several species in shallow water.

Key to Species of Genus

- A. Five arms; granules of disk spherical, not spinous; medium to large forms.
 - B. Granules of disk coarse, not completely covering ventral surface; dorsal arm spines longer than ventral ones.
 - C. Granules very coarse; arm spines four to five; coloration black or black and whitish.
 - D. Coloration dark, under arm plates, at least proximally, more or less whitish.....*O. scolopendrina*.
 - DD. Coloration uniformly black.....*O. erinaceus*.
 - CC. Granulations moderately coarse; arm spines five or six, finer and sharper toward the tip of the arms; coloration brown with golden-yellow streaks and specks on disk.....*O. pica*.
 - BB. Granules of disk fine, completely covering the ventral surface; dorsal arm spines shorter than ventral ones.
 - C. Color variegated.
 - D. Ground color gray, variegated with brown and white.....*O. brevipes*.
 - DD. Color some shade of brown, variegated with gray.....*O. insularia* var. *variegata*.
 - CC. Coloration uniformly brownish black.....*O. insularia*.
- AA. Six arms; granules of disk more or less spinous; small forms.....*O. parva*.

This family includes, for the most part, the larger forms of brittle stars in Hawaii, a few species of which are plentiful in shoal waters. Most of the species are recognized without difficulty, but others offer considerable uncertainty.

One of the larger species which is easily distinguished is *O. erinaceus* Müller and Troschel (figs. 39, *c*; 41, *g, h*). It is uniformly deep black in color. The disk may be 1 inch in diameter and the arms 4 or 5 inches in length. The upper arm plates are typically triangular, broader than long with concave sides. The ventral arm plates are pentagonal, about as long as broad. The arm spines are five near the disk but are reduced to four and to three nearer the tip of the arm. There seems to be uncertainty about including *O. scolopendrina* Lamarck among the Hawaiian fauna. Some authorities believe it is not specifically different from *O. erinaceus*. Those who see a difference would designate as *O. scolopendrina* those forms which have relatively longer arms (4.75 to 7.5 × disk diameter) and show some whitish coloration on the under surface of the arms. Notching of the distal margin of the ventral arm plates has also been cited as a valid characteristic. If such forms occur locally, they will be associated with *O. erinaceus*.

Large specimens of *Ophiocoma pica* Müller and Troschel (fig. 39, *d*) are nearly 1 inch across the disk, but the arms are relatively short, about

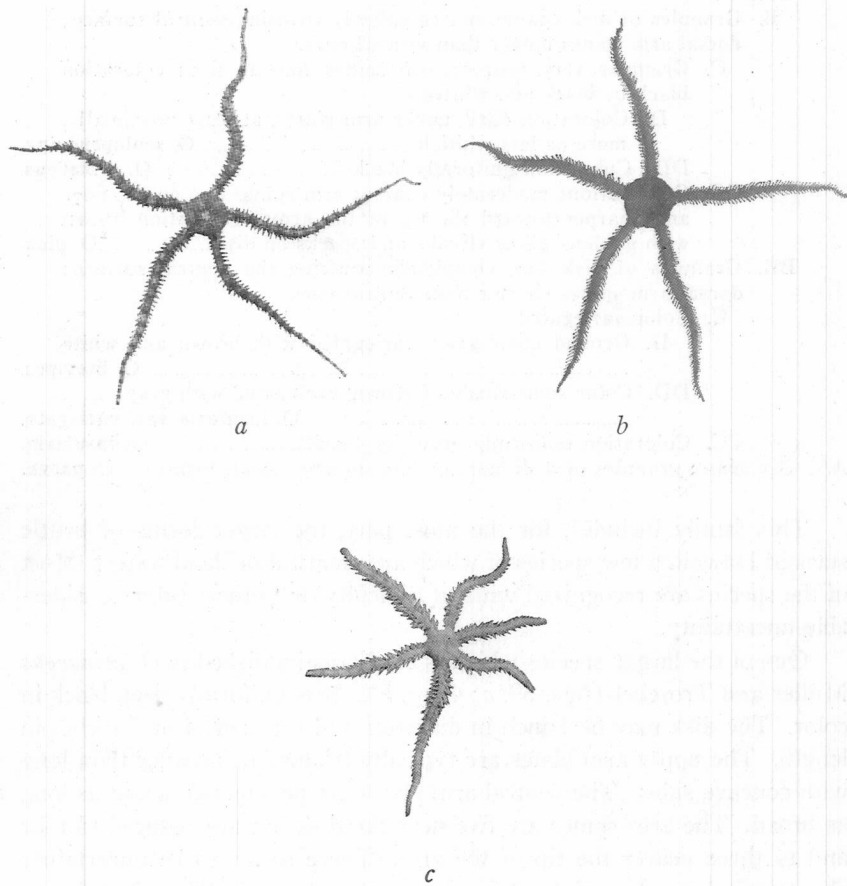


FIGURE 40.—Ophiuroidea: a, *Ophiocoma brevipes*; b, *Ophiocoma insularia*; c, *Ophiocoma parva*.

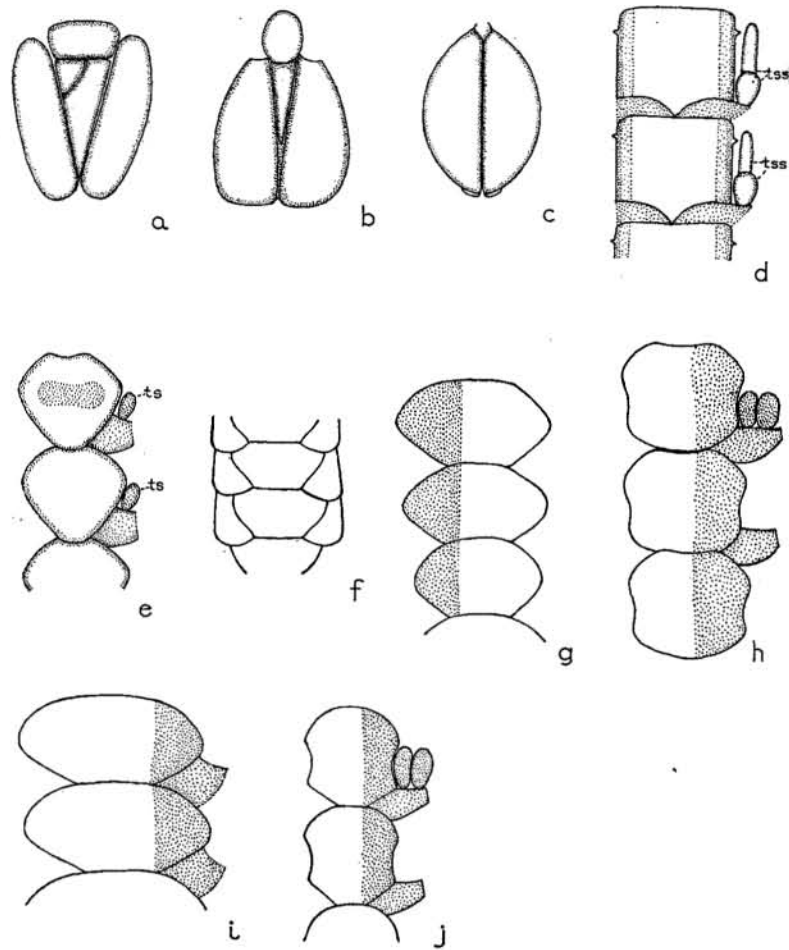


FIGURE 41.—Ophiuroidea, structural features: *a*, *Amphiura immira*, radial shields with intervening plates; *b*, *Amphipholis squamata*, radial shields with intervening plate; *c*, *Amphioplus caelatus*, radial shields; *d*, *Amphioplus caelatus*, ventral arm plates (*tss*, tentacle scales); *e*, *Ophiactis modesta*, ventral arm plates (*ts*, tentacle scale); *f*, *Ophionereis porrecta*, dorsal arm plates; *g*, *Ophiocoma erinaceus*, dorsal arm plates; *h*, *Ophiocoma erinaceus*, ventral arm plates; *i*, *Ophiocoma insularia*, dorsal arm plates; *j*, *Ophiocoma insularia*, ventral arm plates.

3 inches long. The species is dark brown or almost black with golden-yellow lines and specks on the disk and arms. It is less common than *O. erinaceus*. Another species easily recognized by its color is *O. brevipes* Peters (fig. 40, *a*). It is variegated with green, gray, and white, and the arms are usually banded. The disk usually is less than 1 inch across, and the arms are 3 or 4 inches long. It is not abundant locally.

Two other closely allied forms of brittle stars are found in local waters. One is *Ophiocoma insularia* Lyman (figs. 40, *b*; 41, *i, j*) and the other is a variety of that species called *O. insularia* var. *variegata* (E. A. Smith). In *O. insularia* the disk may exceed 1 inch in diameter, and the arms are 4 or 5 inches in length. Its color is uniformly dark brown. The dorsal arm plates are triangular, and much broader than long. The ventral ones are slightly longer than broad, somewhat pentagonal in shape. The arm spines are four close to the disk and three nearer the tip of the arm, the dorsal ones the shortest. In some localities the species is very abundant under stones near shore. The variety, *variegata*, differs from the species only in color, its disk being variegated with dark and light brown and the upper surface of the arms banded with shades of brown and gray. The two forms are associated with each other.

The smallest of the genus in Hawaii is the six-rayed species *Ophiocoma parva* Clark (fig. 40, *c*). The disk usually does not exceed 5 mm. in diameter, and the arms are about 1 inch or less in length. Scattered spinules are borne on the granules of the disk. The color is brown, gray, or whitish. The species has been taken about Oahu, but is not common here. It was collected at several of the windward Hawaiian Islands during the *Tanager* Expedition, and is known from Wake and Palmyra Islands as well as the Torres Strait region.

Most of the species of *Ophiocoma* represented in Hawaii are widely dispersed through the Indo-Pacific area.

CLASS ECHINOIDEA—SEA URCHINS

Sea urchins, heart urchins, and cake urchins comprise this class. All lack distinct arms, such as those of the starfish and brittle star. The areas corresponding to the arms are included in the disk. A regular sea urchin is globular or dorsoventrally compressed. The mouth is in the center of the more flattened surface and surrounded by a membranous peristome. The anal opening is at the opposite pole of the animal, surrounded by an area known as the periproct. (See fig. 42, *d*.)

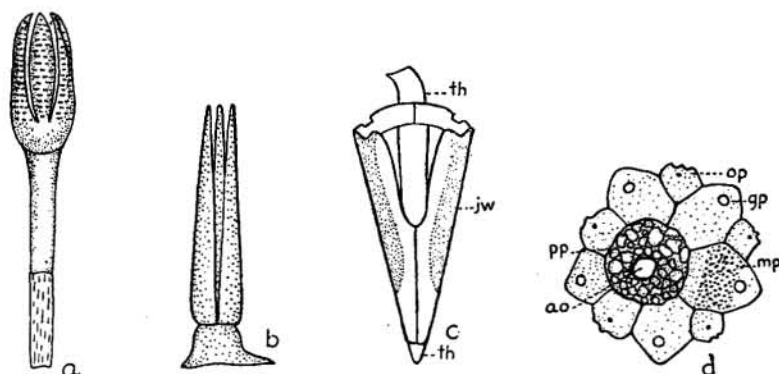


FIGURE 42.—Echinodermata: *a*, a pedicellaria of a sea urchin; *b*, a pedicellaria of a starfish; *c*, a jaw and tooth of a sea urchin (*jw*, jaw; *th*, tooth); *d*, apical region of a sea urchin (*ao*, anal opening; *gp*, genital pore; *mp*, madreporite; *op*, ocular pore; *pp*, periproct).

The shell is formed by 10 double rows of calcareous plates extending meridionally from the border of the peristome to the plates surrounding the periproct. Five double rows, which constitute the ambulacral areas from which tube feet project, alternate with five double rows of plates which form the interambulacral areas. The plates bear low, rounded tubercles with which movable spines articulate. At the aboral end of each ambulacral area is a small ocular plate bearing the terminal tentacle of the water-vascular system and a group of pigment cells forming an eye spot. Alternating with the ocular plates are five larger genital plates, each with a pore for the exit of ova or sperm. The madreporite occupies one of the genital plates. These ten plates form the apical system surrounding the periproct, which is usually covered by small granular plates and is pierced by the anal opening.

Pedicellariae with three jaws are typical of the echinoids (fig. 42, *a*). They are generally scattered over the surface, including the peristome, are of several kinds, and vary in size, form of jaws, and stalk. Some are provided with poison glands and their chief function seems to be to protect the surface from the accumulation of foreign matter.

Spines of echinoids are movable and articulate with the tubercles of the shell by ball and socket joints. They vary in size and character both in different species and in the same species. Spines are useful for protection, in some species being poisonous, and for locomotion, the animals moving about on their tips; by means of them some echinoids are able mechanically to hollow out cavities in soft rocks in which they live.

Tube feet protrude from small pores arranged in symmetrical rows in the ambulacral areas. They are usually suctorial at the free ends and may be distended beyond the tips of the spines. By means of them the animal is able to cling to surfaces or move about. They also serve as sensory and respiratory organs.

The internal organs of an echinoid differ somewhat from those of a starfish. In a typical sea urchin the mouth opens in the middle of the peristome through a complicated organ known as "Aristotle's lantern." This consists of five calcareous jaws capable of independent movement, each bearing a tooth. (See fig. 42, *c.*) The tips of the teeth can be seen protruding through the opening in the peristome. From the base of the lantern, which is directed inward, the tubular digestive tract makes one loop about the body, turns back on itself, and terminates at the anal opening.

A water-vascular system consists of a stone canal leading from the madreporite, which admits water, through the body to a ring vessel about the base of the lantern. From this ring vessel radial canals extend on the inside of the shell along the middle of the ambulacral areas to the ocular plates. Lateral canals connect with ampullae and distend the feet.

A blood system, similar to that of the starfish, consists of a series of spaces and canals, by means of which coelomic fluid is transported to various parts of the body. A nerve ring about the base of the lantern sends radial nerves along the ambulacral areas to the ocular plates and branches to all parts of the animal.

The sexes are separate. Gonads occupy the interambulacral areas of the body cavity, and ova or sperm are passed through the genital pores at the apex of the shell. (See fig. 42, *d.*) Fertilization occurs in the water.

In the shallow waters of Hawaii, including the leeward islands, about 20 species of Echinoidea are known. These represent nine families. Some of them are found almost at the water's edge, some toward the outer border of the reef platform, and others typically in deeper water, but occasionally near the shore. Most of the Hawaiian shore species are widely distributed through the Indian and south Pacific Oceans.

Key to Orders of Class

- A. Test of regular form; periproct at center of upper surface; mouth at center of lower surface.
 - B. Ambulacral plates simple; no sphaeridia or peristomal gills..**Cidaroida.**
 - BB. Ambulacral plates usually compound; sphaeridia and peristomal gills present**Diadematoida.**
- AA. Test of irregular form; periproct and sometimes the mouth also excentric**Exocycloida.**

ORDER CIDAROIDA

FAMILY CIDARIDAE

Full-grown specimens of *Eucidaris metularia* (Lamarck) (fig. 43, *a*) are about 1 inch in diameter. The globular test (shell) bears 10 vertical rows of heavy spines with bare furrows between them. These spines are thicker in the middle, bluntly rounded at the tips, and marked by longitudinal rows of low tubercles. Flat spines border the bare furrows, surround the bases of the large spines, and cover the peristome. The flat spines are reddish in color, and the heavy ones are usually marked by alternating bands of red and pale yellow or white.

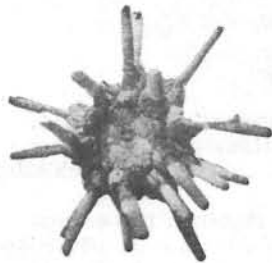
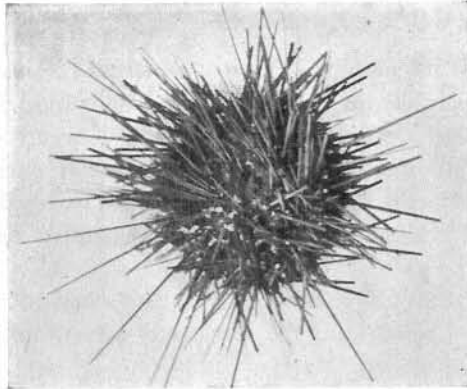
*a**b**c**d*

FIGURE 43.—Echinoidea: *a*, *Eucidaris metularia*; *b*, *Lytechinus verruculatus*; *c*, *Centrechinus paucispinus*; *d*, *Tripneustes gratilla*.

The species has been collected in shallow water, but is more common at depths of several fathoms. Specimens in Bishop Museum are from Hilo, Hawaii, Oahu, and the leeward islands as far as Kuré Island. The species has been dredged off Waikiki, Oahu, at depths of 30 to 50 fathoms.

A large sea urchin, *Chondreocidaris gigantea* A. Agassiz, known only from Hawaiian waters, is included here because it is peculiar to this locality and because of its unique structural features. The shell is closely covered with granules bearing minute spines. The long spines are roughened by lobes and lamellae along their sides, and their tips are broad and flat. Large specimens have shells 4 inches in diameter and spines 6 inches long. It is not a reef dwelling form, but is taken at moderate depths in off-shore water.

ORDER DIADEMATOIDA

Key to Families of Order

- A. Border of test circular in outline; (somewhat pentagonal in *Tripneustes*).
 - B. Primary spines hollow; (applicable to Hawaiian shoal water forms) **Centrechinidae.**
 - BB. Primary spines not hollow.
 - C. Ambulacral plates typically of three elements; test without pits or sculpturing..... **Echinidae.**
 - CC. Ambulacral plates typically of four or more elements; coronal plates without pits or sculpturing..... **Strongylocentrotidae.**
- AA. Border of test elliptical in outline..... **Echinometridae.**

FAMILY CENTRECHINIDAE

One of the larger Hawaiian sea urchins is *Centrechinus paucispinus* (A. Agassiz) (fig. 43, *c*), which has long black spines. The spines, in adult specimens, equal in length the diameter of the shell—nearly 4 inches. Fine, delicate spines are interspersed among the longer ones. All are hollow. In some specimens the larger spines are banded with pale yellow rings. Bluntly pointed scales, arranged spirally, ornament the surface of the larger spines.

This species is poisonous and should be handled with care when alive. The spines, which are capable of penetrating the skin, carry an irritating secretion that results in a painful wound.

Adult specimens are usually found well out on the reef platform, but the young are sometimes seen in tide pools along the shore. Small specimens less than 0.5 inch in diameter have purplish-red spines more than 1 inch long.

Another poisonous species is *Echinothrix diadema* (Linnaeus), which usually has its long spines banded with pale yellow or white alternating with green. Old specimens are almost black. The heavier spines in large specimens are approximately the length of the diameter of the shell, which is 2.5 to 3 inches. This species is frequently collected on the reefs. The ornamentation of the larger spines consists of narrow scales arranged in longitudinal rows.

A few records of *Echinothrix calamaris* Pallas are from Hawaiian waters. It has been taken from Puako Bay, Hawaii, and was dredged off the south coast of Oahu, but apparently is not widely distributed about the islands. There are no specimens from Hawaii in Bishop Museum, but there is a damaged one from Palmyra Island. Its flat shell is 1.8 inches in diameter and the purplish spines are 2 inches long. The scales of the spines are rounded at their free ends.

There is one specimen of *Astropyga radiata* Leske in Bishop Museum, taken by a fisherman from an unknown locality about Oahu. The dried disk is 5 inches in diameter, of a dull yellow color with traces of reddish brown. The longer spines, about 70 mm. in length, are banded by red and white. It has a wide distribution in the Indian Ocean and has been taken at the Loyalty Islands. There are previous records from Hawaii, results of the *Challenger* Expedition. The species is not likely to be found near shore in shallow water, but at depths of several fathoms.

FAMILY ECHINIDAE

A very active little sea urchin, *Lytechinus verruculatus* (Lütken) (fig. 43, *b*), is about 20 mm. in diameter and densely covered with yellowish spines less than 3 mm. long. The shell when devoid of spines shows greenish patches of color. It has been taken at Hilo, Hawaii, Waikiki reef, and Kaneohe Bay, Oahu, and probably is generally distributed among the islands.

Large specimens of *Tripneustes gratilla* (Linnaeus) (fig. 43, *d*) are 4 to 5 inches in diameter, but the spines are very short, little more than 12 mm. long. The spines densely cover the shell and are purplish black tipped with light brown. The pentagonal shape of this species is characteristic and is best seen when the shell is devoid of spines. It is not a poisonous species and may be handled without danger. At Punaluu, Oahu, it is a common form in 2 or 3 feet of water, and it occurs in many other localities on the Hawaiian reefs.

FAMILY STRONGYLOCENTROTIDAE

The species *Echinostrephus aciculatum* A. Agassiz, known as the "rock borer", seems to be common about the leeward islands from shallow water to moderate depths, but has not often been reported from the larger islands of Hawaii. A shell from Midway Islands is 1.8 inches in diameter, though most specimens observed are smaller. The spines of the dorsal region may equal in length the diameter of the shell and are bronze colored, but those of the ventral surface are very short. By means of the short spines the animal is able to burrow into soft rocks. The species was taken by the *Tanager* Expedition at Johnston and Wake Islands, and probably occurs throughout the south Pacific Ocean. It is closely related to *Echinostrephus molare* (Blainville) of the Indian Ocean.

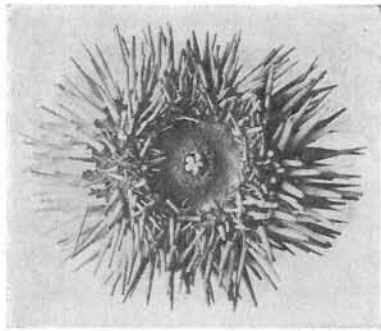
One of the most attractive sea urchins in Hawaii is *Pseudoboletia indiana* (Michelin). The symmetrical shell is covered with purplish spines (lighter at the tips) of very uniform length. In a specimen from Kaneohe Bay, Oahu, with a shell 3 inches in diameter, the spines are 15 mm. long. The species seldom occurs on the reefs near shore, but is commonly found at depths of 1 to 2 fathoms. Its distribution is general throughout Hawaii. The *Albatross* dredged the species among the islands from depths of 28 to 56 fathoms.

FAMILY ECHINOMETRIDAE

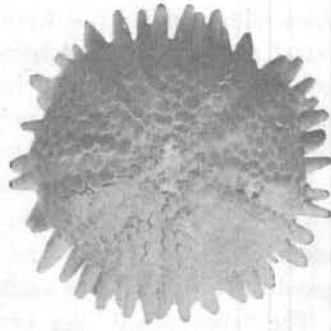
The most common shallow-water sea urchin in Hawaii is *Echinometra mathaei* Blainville (fig. 44, *a*). Large specimens are about 2.5 inches long, the shell a little longer than broad, with spines 1 inch in length. The spines are thick at the base and usually taper to a sharp point. Their color may be green, gray, or reddish brown, but not black. The species is found under stones and in crevices of porous rocks often within a few feet of the shore. It is probably the most common sea urchin in the world and ranges through the entire Indo-Pacific area.

Associated with *Echinometra mathaei* and resembling it in form and size of shell, is a common black species, *Echinometra oblonga* Blainville. In *E. oblonga*, however, the spines are typically shorter, thicker, and blunter than those of *E. mathaei*, and the color is dark purple or black. Some authorities have expressed doubt about any specific distinction between the two forms.

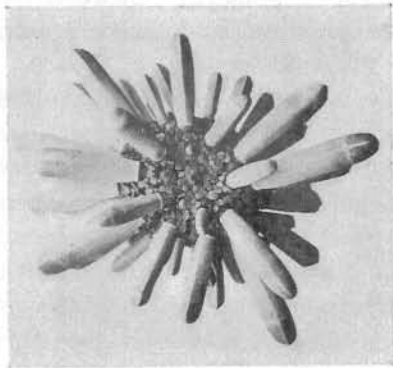
No other sea urchin in Hawaii can be confused with *Podophora atrata* L. Agassiz (fig. 44, *b*), which has short, flat, tablelike spines over the



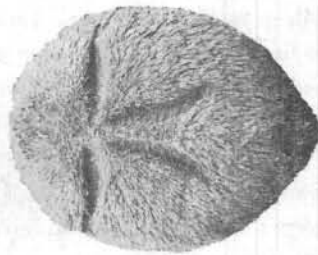
a



b



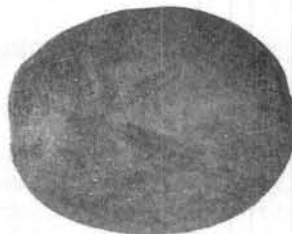
c



d



e



f

FIGURE 44.—Echinoidea: a, *Echinometra mathaei*; b, *Podophora atrata*; c, *Heterocentrotus mammillatus*; d, *Brissus latecarinatus*; e, *Clypeaster reticulatus*; f, *Metalia spatagus*.

entire dome of the shell, making a smooth surface. Longer, flattened spines with rounded tips form uneven rows about the margin. On the ventral surface are small spines and stout tube feet. The color of the dorsal and marginal spines is commonly a deep purple, of the ventral spines and tube feet some shade of brown. Shells of large specimens are 3 inches across and slightly longer in one direction.

The species is found on rocky shores washed by the surf, where it clings tightly by the tube feet and marginal spines. It ranges from the Indian Ocean to Hawaii and is closely related to *Podophora pedifera* Agassiz and Desor of the south Pacific Ocean.

The "slate pencil" sea urchin, *Heterocentrotus mammillatus* (Linnaeus) (fig. 44, *c*), is recognized by the long, thick primary spines, triangular in cross section, with blunt tips. Short, flat spines with expanded tips cover the surface between the bases of the primaries. The short ventral spines are flattened. Shells of large specimens may be nearly 4 inches long, and the large spines are of about the same length.

The species is a very attractive one, ranging in color from yellowish to deep chocolate-brown. In some specimens the tips of the large spines are banded with cream color and brown. The species frequents the outer border of the reef platform, but young specimens are sometimes seen near shore. The species is known from the Red Sea to Hawaii and is typical of the northern equatorial regions. A related species, *Heterocentrotus trigonarius* Brandt, typical of the Southern Hemisphere, has longer and sharper spines and is purple. Bishop Museum possesses specimens from Johnston and Wake Islands in the north Pacific Ocean and from Jarvis, Baker, and Howland Islands just south of the equator, but apparently the species does not range into the Hawaiian area.

ORDER EXOCYCLOIDA

Key to Families of Order

- A. Oral opening central; anal opening excentric.
 - B. Test greatly compressed dorso-ventrally.....**Clypeastridae.**
 - BB. Test not greatly compressed dorso-ventrally.
 - C. Dorsal petals not extending ventrally to the oral opening.....**Fibulariidae.**
 - CC. Dorsal petals extending ventrally to the oral opening.....**Echinoneidae.**
- AA. Oral and anal openings both excentric.....**Spatangidae.**

FAMILY CLYPEASTRIDAE

Typical cake urchins have flattened disks with the ambulacral areas dorsal in position and arranged in the form of "petals." The anal opening is ventral or marginal. Most Hawaiian species are of small size. Sand dollars, so abundant on many shores of the world, have not been observed in Hawaii.

The most common representative of this family in Hawaiian waters is *Clypeaster reticulatus* (Linnaeus) (fig. 44, e). It has a shell longer than broad with the sides somewhat parallel. The mouth is centrally located at the bottom of a concavity. There is a compressed "Aristotle's lantern." Five symmetrically arranged "petals" occupy a depressed area on the dorsal surface. Living specimens are densely covered with very short spines. A specimen from Midway Island is 1.6 inches long. The species is seldom taken near shore, but lives at depths of 2 or 3 fathoms.

A much larger species, *Clypeaster eurypetalus* Clark, 4.5 inches long, was described from Pearl and Hermes Reef. The petals cover more than 80 percent of the upper surface.

FAMILY FIBULARIIDAE

The only known species of this family in Hawaii is *Fibularia australis* Desmoulins, which has a rather thick shell, evenly oval in outline, about 18 mm. long. The five dorsal petals are narrow and incomplete at the tips. Both the mouth and anal opening are ventral and slightly depressed. Specimens in Bishop Museum came from Hilo, Hawaii, Midway Island, and Pearl and Hermes Reef. The form is not common on the shallow reefs about the larger islands.

FAMILY ECHINONEIDAE

A broadly oval species, *Echinoneus cyclostomus* Leske, about 1.9 inches long, 1.5 inches wide, and 22 mm. high, occurs about the leeward islands and has been collected in Kaneohe Bay, Oahu. The narrow petals of the dorsal surface extend ventrally to the mouth. The anal opening is near the mouth. In young specimens there is a lantern which disappears before the adult state is reached. In life the color is usually reddish. The species is widely distributed in tropical waters and ranges from near the shore to depths of several fathoms.

FAMILY SPATANGIDAE

The common representative of the heart urchins in Hawaii is *Brissus latecarinatus* (Leske) (fig. 44, *d*). Many specimens are 4 to 5 inches long, and one in Bishop Museum from Johnston Island is 7.6 inches long. The petal-like ambulacral areas are dorsal and are five in number, the anterior, unpaired one being aborted and without pores for the tube feet. The ventral surface is slightly convex with a crescent-shaped mouth near one end and a large anal opening close to the opposite margin. There is no lantern. In life the shell is covered with short, slender, light brown or green spines.

The species has a wide range among the Hawaiian Islands. It is seldom taken alive near the shore, but more often on the outer border of the reef platform or at depths of 1 to 2 fathoms. The distribution of the species is from Mauritius through the Indian and Pacific Oceans to Panama and the Mexican coast.

A young specimen of *Metalia spatagus* (Linnaeus) (fig. 44, *f*) was collected on Waikiki reef, Oahu. It is 1.2 inches long and covered with short, delicate spines making a velvetlike coat. The color is light brown. The species probably occurs in deep water about the islands. Its range is known to be parallel with that of *Brissus latecarinatus*.

CLASS HOLOTHUROIDEA—SEA CUCUMBERS

In general appearance holothurians, or sea cucumbers as they are called, show little similarity to starfishes, brittle stars, or sea urchins. Although they have no arms, the presence of tube feet and the arrangement of their internal organs indicate holothurians to be echinoderms.

The skeletal system in holothurians is reduced to minute calcareous plates deposited in the skin and an internal calcareous ring which represents a modified Aristotle's lantern surrounding the digestive tract just inside the oral aperture. A whorl of extensile and retractile tentacles, representing tube feet, surrounds the mouth at one end of the body. These tentacles are used to assist in ingesting sand and mud, from which the animal gets its food. The digestive tract is a thin-walled tube which leads from the mouth to the anal opening at the opposite end of the body and makes one or more loops in its course. Most holothurians have, opening into the posterior region of the digestive tube (cloaca), a pair of long, much-branched tubes open at the ends, called a respiratory tree. Through these tubes water is forced into the body cavity, carrying oxygen to the tissues. In some holothurians other slender tubes (Cuvierian organs)

open into the cloaca. These are glands which secrete a substance discharged from the anal opening, when the animal is disturbed, as a mass of white, sticky threads serving a defensive purpose.

The water-vascular system, which distends the tentacles and the true tube feet, consists of one or more internal madreporites. These admit water from the body cavity through short stone canals to a ring canal near the mouth, from which five radial tubes branch to the tentacles and extend longitudinally inside the body wall in radii corresponding to ambulacral areas in the sea urchin. Through branches the radial canals reach the tube feet, which are usually arranged in definite areas on the body. Inflated inner ends of the tube feet (ampullae) contract and force water into those appendages, distending them. By means of the suckorial tube feet the animal moves about or clings to surfaces. In some holothurians a powerful force of adhesion is exhibited in the suckorial ends of the tube feet, the appendages rupturing instead of being released when the animal is lifted from the surface to which it is clinging.

In holothurians the sexes are separate. Gonads are branched tubes developing ova or spermatozoa which escape by a small duct through the dorsal body wall posterior to the mouth. Fertilization occurs in the water.

Holothurians are numerous in local waters. Forty-six species were taken by the *Albatross* Expedition in 1902; many of these, however, were dredged and are not represented among the shore fauna. Among the 22 species collected by the *Tanager* Expedition in 1923-24 no new forms were recorded. More than a dozen species of holothurians occur on the reefs and about the shores of Hawaii. Most of them are widely distributed through the south Pacific and Indian Oceans, and some are also known from the Atlantic Ocean.

It is difficult to preserve holothurians in their natural form, as the strong muscles contract and distort the body when placed directly in a preserving fluid. On adding a small amount of magnesium sulphate (epsom salts) to a container of sea water in which the animals are placed they are gradually relaxed with tentacles and tube feet extended. After several hours of this treatment the animals are usually sufficiently stupefied so that they do not contract when transferred to the preserving fluid. Unless neutralized, formalin is not as good as alcohol for preserving holothurians if the deposits in the skin are to be examined later, as traces of acid will dissolve the calcareous elements.

The calcareous deposits of the skin are important features in determining species of holothurians. It is often necessary to make microscopic

chill
rapidly
slit
10% formal
wash
75% alc.

examination of these skeletal fragments. A weak solution of caustic potash, slightly heated, will free the deposits from a piece of skin, and they can then be examined. The skeletal remnants assume various forms, some of which have received distinctive names. Flat, oval plates, perforated by a few pairs of holes, are known as "buttons." A "table" consists of a rounded basal plate perforated by holes, and four short, upright pillars forming a spire which is often terminated by teeth. Other deposits in the form of "rods", "granules", "anchors", "wheels", and so forth occur in various species. In most holothurians several varieties of deposits are found, but in some species one kind may predominate or be present exclusively. Each species has calcareous deposits peculiar to itself. (See fig. 45, a-f.)

A high degree of regeneration is exhibited by holothurians, and in a peculiar manner. When the animals are strongly stimulated or irritated by such a change of environment as transference to fresh water, a sharp contraction of the body muscles may cause sufficient internal pressure to rupture and completely sever the digestive tube. Together with the respiratory tree, if present, the severed portion of the digestive tube is discharged from the anal opening. In time new internal organs are regenerated in place of those lost.

also release
of
white
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— Dried holothurians known as "trepang" or "bêche-de-mer" are used extensively as food in some parts of the world. Small amounts of this commercial product were once imported into Hawaii, but almost no utilization of local species as food is made.

Two orders of the class are recognized.

ORDER ACTINOPODA

In this order are included holothurians having a ring of tentacles about the mouth and pedicels (tube feet) or papillae, or both, scattered over the body and all connected with the circular water canal. Most of the Hawaiian forms belong to this order and to one family.

FAMILY HOLOTHURIDAE

Key to Genera of Family

- A. Anal teeth present.....**Actinopyga.**
 AA. Anal teeth absent.
 B. Dorsal surface not bearing large wartlike protuberances; pedicels scattered over the entire surface or occasionally confined to the ventral surface.....**Holothuria.**
 BB. Dorsal surface bearing large wartlike protuberances; pedicels confined to the ventral surface.....**Stichopus.**

An easily recognized species, *Actinopyga mauritiana* (Quoy and Gaimard) (fig. 46, a), is reddish brown, splotched with white. There are about 25 tentacles surrounding the mouth, which opens ventrally. As in other species of the genus, five calcareous teeth surround the anal opening. The flat ventral surface bears pedicels (tube feet) and is distinct from the dorsal surface, which is marked by scattered papillae. Deposits in the skin include rough branched rods and minute smooth particles. (See fig. 45, c.) Large specimens are 10 inches long.

^{Cerapidae} A slender fish, ^{Echinophilus} ~~Jordanicus~~ *gracilis* (Bleeker), 4 to 6 inches long, lives inside some holothurians, including *Actinopyga mauritiana*. This commensal fish leaves and enters the holothurian by way of the anal opening.

The species *Actinopyga parvula* (Selenka) is a small black holothurian, 2 to 4 inches long. The ventral surface is covered with tube feet and is clearly distinguished from the dorsal surface. There are about 20 tentacles surrounding the mouth. Deposits in the skin include tables, buttons with a variable number of holes, curved rods, and perforated plates. The species discharges its Cuvierian organs on very slight stimulus.

H. (Platyperona)
parvula
= obscurilis

Two other species of *Actinopyga* are occasionally taken in shallow water about the islands. In *A. obesa* (Selenka) the body is stout, blunt at both ends, dark brown in color, and about 6 inches long. Deposits in the skin consist of granulated rods, straight or slightly curved. Specimens have been taken from Laysan Island and also from Oahu.

The species *A. nobilis* (Selenka) is a large, robust form, dark brown above and lighter beneath. The characteristic deposits in the skin are numerous ellipsoids and irregular perforated plates in the bases of the papillae. A few tables with perforated bases and spirals with numerous teeth also occur. The species has been taken at Laysan Island and on Waikiki reef, Oahu. It may exceed 1 foot in length.

H. (Microthela)
nobilis

Of the genus *Holothuria* there are eight or ten common shore forms in Hawaii, most of them readily distinguishable by color markings. A thick, plump form, *H. cinerascens* (Brandt) (fig. 46, b), uniform purplish in color, is common under stones near shore, often partially embedded in sand and gravel. The dorsal and ventral surfaces are distinct. It is a firm species and may be preserved nicely with the tentacles expanded. Deposits in the skin include tables and branched granular rods. (See fig. 45, d.) Large specimens are 6 inches long.

Another form found under stones is *H. pervicax* (Selenka) (fig. 46, c), which is grayish brown ^{often} with six broad transverse bands of olive or greenish brown across the dorsal surface. Olive-green dots mark the

several to

ventral surface which has the tube feet arranged in four longitudinal bands. Deposits in the skin consist of tables, buttons, and irregular plates. Many of the buttons are imperfect. This is a soft-bodied species and discharges its Cuvierian organs on slight stimulus. Its length is about 6 inches.

The species *H. atra* Jager (fig. 46, *d*) has a tough, leathery integument of uniform black color. Deposits in the skin include rather tall narrow tables and irregular plates. Large specimens are 12 inches long. Associated with *H. atra* and sometimes confused with it, is *H. fuscrobura* Théel, which has a very soft, thin integument. Deposits in the skin include tables and buttons, both of which are often imperfect. Both *H. atra* and *H. fuscrobura* are common on some of the reefs and have the habit of covering themselves with a coating of fine sand.

H. (Thymiosyca) hilla
 Under stones near shore is found a soft-bodied sea cucumber, *H. monocaria* (Lesson), yellowish brown with the papillae and areas around them much lighter than the general surface. The tentacles are greenish yellow. Long papillae of the dorsal surface are arranged in four rows, and the tube feet of the ventral surface are in three rows. Large specimens are 8 inches long. Deposits consist of buttons, irregular plates, and tables. (See fig. 45, *b*.)

An easily recognized species, *H. arenicola* Semper, is slender, cylindrical, grayish white, with two longitudinal rows of brown spots on the dorsal surface. Deposits are buttons, tables, and perforated plates. Large specimens are 8 inches long. Young specimens are more brownish than adults. The species is found near shore, under stones, and often partially embedded in sand.

Lasius colaris
Cuvieria argentea
 On Hawaiian reefs *H. pardalis* Selenka is less common than most other species of the genus. Its color is variable, some specimens being straw colored, others dark brown or spotted with brown on the dorsal surface. Dorsal and ventral surfaces are not clearly separated. Deposits include tables with spiny disks and spires with crowns having about eight teeth. Buttons are numerous and many of them are irregular and incomplete. There are also curved rods with perforated ends. Large specimens are 6 inches long.

The character of the surface and the color of *Holothuria impatiens* (Forskål) are usually sufficient to distinguish it. Typically the skin is rough and wrinkled by the deposits in it. Its color is light or dark reddish brown often with two or three bands of a deep reddish hue encircling the anterior half of the body. There is no marked distinction between

dorsal and ventral surfaces as prominent suctorial papillae resembling tube feet are scattered over the entire body. Deposits in the skin include tables, buttons with 6 holes, and scattered perforated rods. Specimens are 4 to 6 inches long.

Another species easily recognized when living is *Holothuria edulis* Lesson, which is deep salmon pink on the ventral surface and purplish black above. It may reach a length of 10 inches. Deposits in the skin include long narrow tables and perforated plates. The species was found to be abundant on a reef in Kaneohe Bay, Oahu. Previously it was not known east of the Caroline Islands or north of Fiji. A large form *H. vagabunda* Selenka, has been recorded from local reefs. It is dark brown above and whitish beneath. There are 20 tentacles, and the dorsal pedicels are supported by transverse spinous rods. Deposits are tables with small disks and spires with eight to 10 teeth. There are buttons of normal shape, usually with 6 holes. The species has a very wide distribution.

Several specimens of a doubtful form, *Holothuria* species ?, have been taken at Waikiki, Kahala, and Kualoa, Oahu. It is a shallow-water species living under rocks near shore. In color it resembles the coral sand on which it lies and with which it thinly coats itself. Two longitudinal rows of minute brown spots mark the dorsal surface. Deposits in the skin include tables with circular bases having numerous holes and low spires, and peculiar knobbed buttons. Specimens are about 6 inches long.

Two species of the genus *Stichopus* have been recorded from Hawaii. In *S. tropicalis* Fisher the dorsal and ventral surfaces are distinct; the dorsal bears four rows of large wartlike protuberances, and the ventral three longitudinal bands of pedicels, the middle band being much wider than the lateral ones. The typical color is dark green, mottled with brown. Deposits in the skin consist of two kinds of tables and of variously shaped rods and plates. One form of table is large with a spire tapering to a single point; the other is small with eight to 12 teeth on the spire. (See fig. 45, a.) This species is found under stones near shore, but individuals are not numerous. Large specimens are 10 inches long.

Another species, *Stichopus chloronotes* Brandt, was recorded from Hawaii many years ago, but apparently has not been collected locally since. It differs from *S. tropicalis*, in that the protuberances of the sides and dorsal line of the body are arranged in double alternating rows and in that large tables among the deposits of the skin are absent and the color is olive-brown or olive-green. There are specimens in Bishop Museum from Palmyra and Wake Islands.

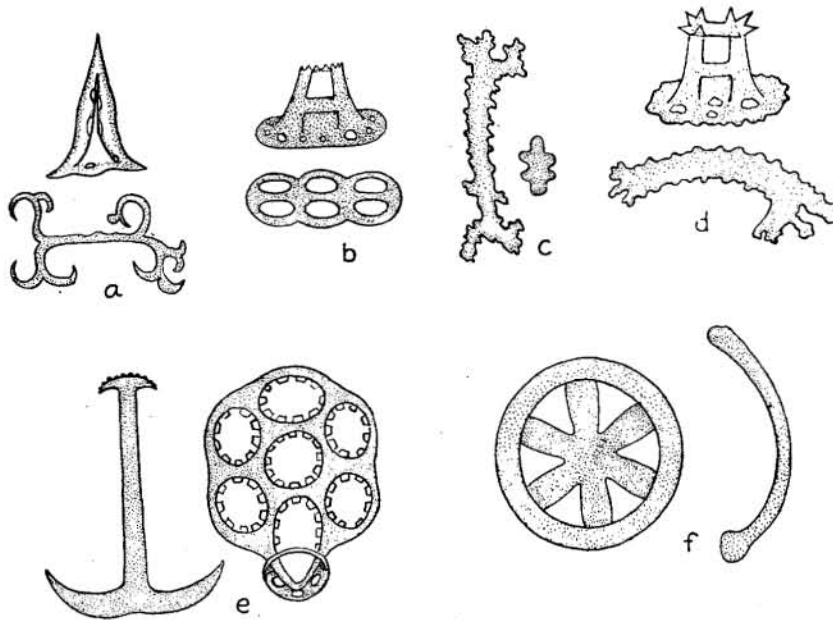


FIGURE 45.—Skin deposits (spicules) of holothurians: *a*, *Stichopus tropicalis*; *b*, *Holothuria monocaria*; *c*, *Actinopyga mauritiana*; *d*, *Holothuria cinerascens*; *e*, *Ophcodesoma spectabilis*; *f*, *Chiridota rigida*.

ORDER PARACTINOPODA

The order includes holothurians having only a ring of tentacles about the mouth connected with the circular water canal. There are no pedicels and no respiratory tree. The body wall is thin and flexible. One family is recognized.

FAMILY SYNAPTIDAE

Key to Genera of Family

- A. Calcareous deposits in the skin consisting of anchors and anchor plates.
 - B. Handle of anchor plates with two large holes and several smaller ones.
 - C. Pinnate tentacles normally 15; calcareous ring absent.....**Euapta**.
 - CC. Pinnate tentacles normally 25; calcareous ring present.....**Polyplectana**.
 - BB. Handle of anchor plates with one large hole and several smaller ones.....**Opheodesoma**.
- AA. Calcareous deposits in the skin consist of wheels, and straight or curved rods, and granules.....**Chiridota**.

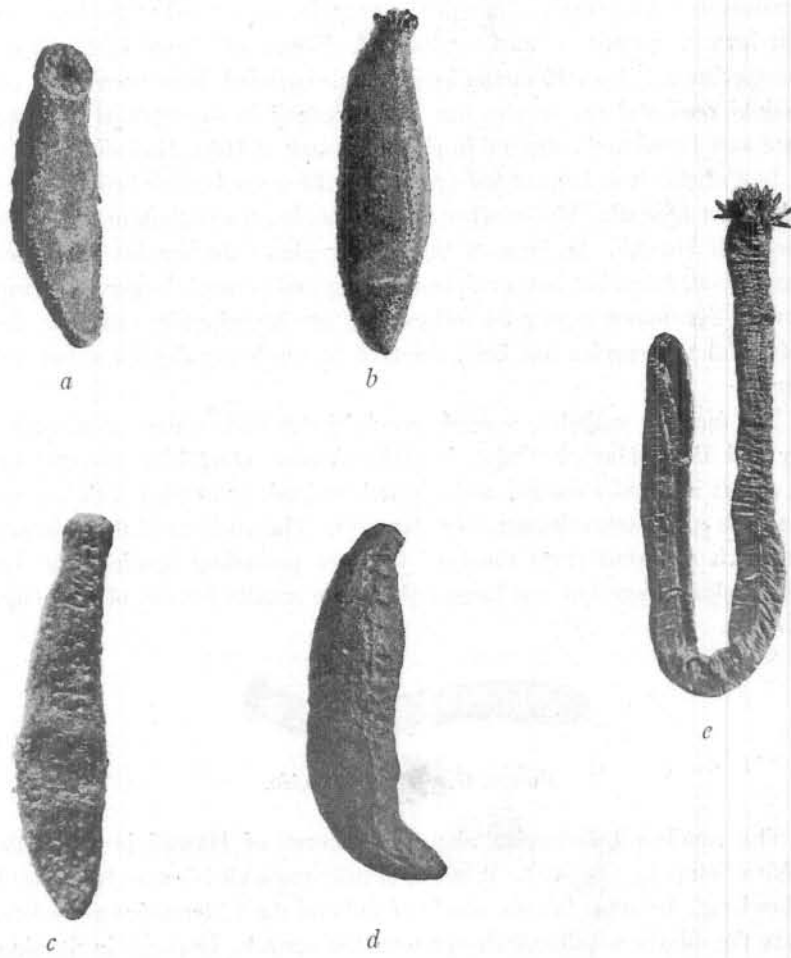


FIGURE 46.—Holothuroidea: *a*, *Actinopyga mauritiana*; *b*, *Holothuria cinerascens*; *c*, *Holothuria pervicax*; *d*, *Holothuria atra*; *e*, *Ophcodesoma spectabilis*.

A slender, elongated species, *Euapta godeffroyi* (Semper), is seen occasionally on the reefs. Its color is grayish, variegated with shades of light brown, spotted, striped, or banded. There are about 15 tentacles. The specimens, about 10 inches long when expanded, have been taken on Waikiki reef, and the species has been dredged in the channel between Maui and Lanai and collected in shallow water at Hilo, Hawaii.

In *Polyplectana kefersteinii* (Selenka) the color is dark brown above and lighter beneath. The number of tentacles is greater than in any other species in Hawaii. In form of the anchor plates the species resembles *Euapta godeffroyi* but has a calcareous ring and is much larger when full grown. Specimens nearly 24 inches long are occasionally taken on the reefs, and the species has been dredged at moderate depths about the islands.

The familiar snakelike species seen in the shallow waters of Kaneohe Bay and Pearl Harbor, Oahu, is *Opheodesoma spectabilis* Fisher (fig. 46, *e*). It is usually reddish and spotted, striped, or banded with brown. The dark green tentacles number about 15. The anchors of the skin are not much different from those of the two preceding species, but the anchor plates have but one large hole in the handle instead of two (fig. 45, *e*).



FIGURE 47.—*Chiridota rigida*.

The smallest holothurian about the shores of Hawaii is *Chiridota rigida* (Semper) (fig. 47). When it is fully expanded it may be about 3 inches long. Its color is some shade of red and the 12 tentacles are white, as are the minute papillae scattered over the surface. Deposits in the skin are wheels with six heavy spokes, curved rods and minute granules (fig. 45, *e*). The species lives just beneath the surface of the sand in shallow water. According to some authorities, *Chiridota hawaiiensis* Fisher, described from Waikiki reef, Oahu, is identical with *C. rigida*.

PHYLUM ANNELIDA

Worms of this phylum are characterized by an elongated body, distinctly segmented externally and internally. They have a higher degree of organization than animals of any of the phyla previously considered. Structural features of typical annelids include bilateral symmetry, a complete and specialized digestive tract, a true blood system and excretory organs, a nervous system showing considerable concentration, and well-developed sense organs.

Two classes of annelids are here given consideration. The first, Chaetopoda, comprises most of the marine segmented worms of Hawaiian shores. To the second, Hirudinea (leeches), belong a few marine forms.

CLASS CHAETOPODA

Fresh-water, terrestrial, and marine worms having bristle-like locomotor appendages (setae) are placed in this class. A familiar example of a chaetopod is the earthworm. Only marine worms, however, are considered in this treatise. They are included under one order.

ORDER POLYCHAETA

Polychaete worms are characterized by muscular processes (parapodia) borne on the segments of the body, typically a pair to each segment. A parapodium, which consists of a dorsal and a ventral branch, each bearing bristles (setae) and soft, flexible organs (cirri), serves primarily as an organ of locomotion but is also respiratory in function (fig. 48, *a, b*). In some polychaetes gills are developed as branches of the dorsal cirri of the parapodia. The prostomium, a lobe anterior and dorsal to the mouth, bears eyes, tentacles, and fleshy, lobelike processes (palps), when these organs are present. Tentacle-like processes are, in some species, borne on the first (peristomium) or on the second body segment. (See fig. 49, *a, c, g*.)

No adequate study of marine shallow-water polychaetes of Hawaii has been made. Species taken by the *Albatross* Expedition, mainly in deep water, and the few collected on the *Tanager* Expedition have been determined, but the shore forms have been neglected. As worms are easily fragmented and destroyed by rough handling, dredging operations are not satisfactory means of collecting those species which range from moderate depths to shallow water. Shore collecting by hand with careful

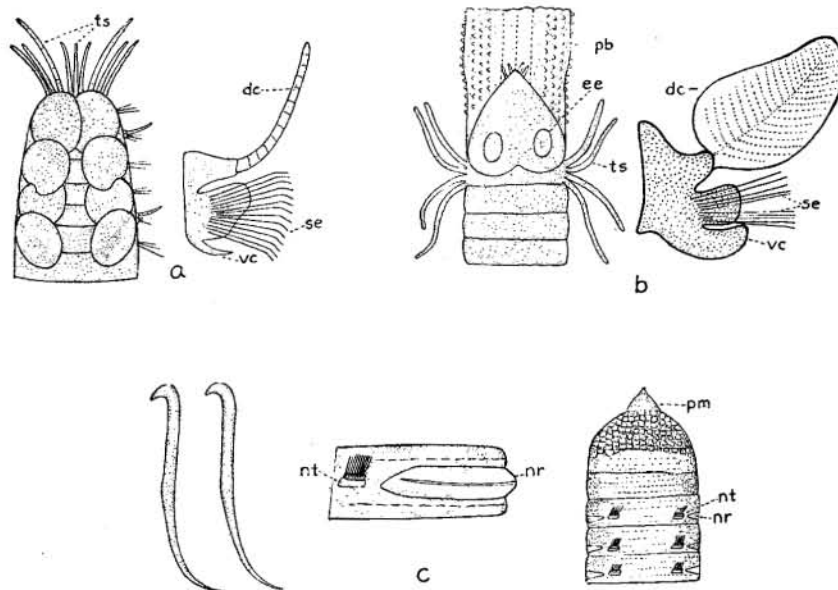


FIGURE 48.—Polychaeta: *a*, anterior extremity and parapodium of a polynoid worm; *b*, anterior extremity with the proboscis extended and a parapodium of a phyllodocid worm; *c*, *Arenicola* species, two hooked setae of neuropodium, dorsal view of right side of segment, and anterior extremity, dorsal surface. (*dc*, dorsal cirrus; *ee*, eye; *nr*, neuropodium; *nt*, notopodium; *pb*, proboscis; *pm*, prostomium; *se*, setae; *ts*, tentacles; *vc*, ventral cirrus.)

preservation of the material is the most successful method of obtaining perfect specimens.

The general taxonomic position of many Hawaiian polychaetes is known, but the specific classification of few of the local shore forms is possible at this time. In the following treatment of the group, therefore, an attempt is made to bring the more common examples within family groupings with mention of definite species when known.

Differences in polychaete worms, for purposes of classification, are observed in features of the head, including tentacles, palps, eyes, and jaws; in the parapodia; and in scales (elytra) which, if present, are borne on the dorsal surface of the body.

FAMILY SYLLIDAE

Members of this family have three long, jointed tentacles which in some species are moniliform. There are a pair of palps and four eyes.

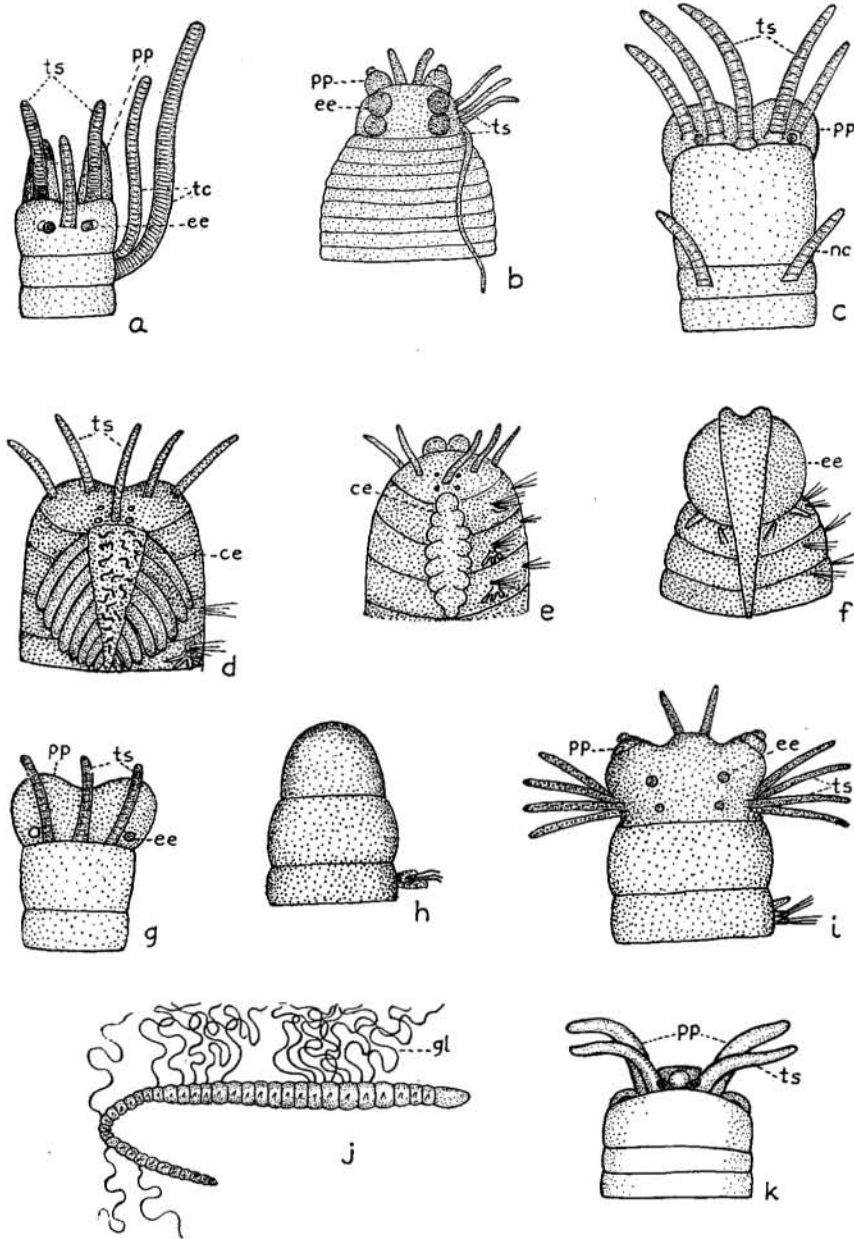


FIGURE 49.—Polychaeta: a, head of *Typosyllis crassi-cirrata*; b, dorsal surface of anterior extremity of *Nereis kobiensis*; c, dorsal surface of anterior extremity of *Leodice collaris*; d, dorsal surface of anterior extremity of *Hermodice pennata* (?); e, dorsal surface of anterior extremity of *Eurythoe pacifica*; f, dorsal surface of anterior extremity of an alciopid worm; g, dorsal surface of anterior extremity of *Lysidice fusca*; h, anterior extremity of *Lumbriconereis* species showing absence of head tentacles; i, dorsal surface of anterior extremity of a fresh-water nereid; j, *Cirratulus zebuensis* (?); k, anterior extremity of *Staurocephalus australiensis*. (ce, caruncle; ee, eyes; gl, gill; nc, nuchal cirrus; pp, palp; tc, tentacular cirri; ts, tentacles.)

The first segment of the body carries two pairs of tentacular cirri. The dorsal cirri of the parapodia are segmented and typically long. In some species, however, they are alternately long and short.

Representatives of the family are abundant among seaweeds and sponges in shallow water. Most shore forms observed are small; few are more than 1 inch long.

The species *Typosyllis crassi-cirrata* Treadwell (fig. 49, a) was described from Laysan Island, where it was collected among seaweeds. The median tentacle arises from the dorsal surface of the prostomium and is shorter than the lateral ones, which arise from the anterior margin of the prostomium. Of the four eyes, the anterior pair is embedded in the prostomium ventral to the posterior pair. Of the two tentacular cirri on each side of the first body segment, the dorsal one is longer and stouter than the ventral one. The dorsal cirri of the parapodia are segmented and are alternately long and short, but all decrease in length posteriorly. The species is less than 1 inch long.

An undetermined species, having tentacles and lateral cirri of the first segment of the body approximately equal in length, is common among seaweeds near shore.

FAMILY POLYNOIDAE

Dorsal overlapping scales (elytra) arranged in two longitudinal rows characterize this family.

The species *Iphione muricata* Savigny is an elongate-oval, flattened form, reddish brown in color. There are 13 pairs of elytra. Each scale is kidney shaped with the surface marked by hexagonal areas and the broader end and the free border ornamented by minute papillae. Large specimens slightly exceed 1 inch in length. The species clings to the under surface of stones in shallow water but is capable of moving rapidly when disturbed. It is a common form at Kahala, Oahu, and in 1931 was plentiful at Honaunau on the Kona coast of Hawaii.

Several undetermined species of the family are frequently observed about the islands. A silver-colored form banded with brown inhabits crevices of porous rocks. It reaches a length of 4 or 5 inches. (See fig. 48, a.) Associated with the brittle star *Ophiocoma insularia* is a species about 1 inch long with scales of uniform dark brown color. Another form with variegated scales (black and gray) is occasionally seen. It is about 2 inches long. Care must be used in collecting and preserving polynoid worms, as they are easily fragmented and the scales are readily lost.

FAMILY PHYLLODOCIDAE

Representatives of this family usually are recognized by the leaflike dorsal cirri of the parapodia. There are four long tentacular processes on each side of the head and four or five short tentacles attached to its front border.

There are probably several local species. A form taken on Waikiki reef, Oahu, has a heart-shaped head with two prominent eyes. The proboscis is tubular when extended and partially covered with papillae. The dorsal cirrus of the parapodium is foliaceous, serving the function of a gill. Specimens are 6 to 8 inches long. (See fig. 48, *b*.)

FAMILY ARENICOLIDAE

Worms of this family are modified for burrowing habits. There are no palps or tentacles on the head region, and jaws are wanting. The mouth is surrounded by series of papillae which may be retracted or protruded. The prostomium is small and may be retracted with the mouth papillae. In these worms the parapodia consist of papillae-like elevations (notopodia) from which setae project and which are dorso-lateral in position. Muscular ridges (neuropodia) partially encircle the segments which bear notopodia. Each neuropodium is provided with a narrow slit from which small, hooked setae project. (See fig. 48, *c*.) Branched gills are borne on some of the segments.

One or more species of the genus *Arenicola* live in the mud and gravel beds on the south shore of Hanauma Bay, Oahu, and probably under similar habitat conditions elsewhere about the islands. They live in burrows beneath the surface. The notopodia and neuropodia are specialized for creeping instead of swimming, as in most polychaetes.

A common local unidentified species may reach a length of 8 inches. It is dark gray and somewhat resembles an earthworm in general appearance. The conical prostomium may be retracted with the mouth papillae. The surface of the skin presents a reticulated appearance. In this form the neuropodia nearly meet on the ventral surface. The gills, which are hollow extensions of the skin, may appear bright red in living specimens because of the large amount of blood flowing through them. Eyes have not been detected in Hawaiian forms. As in other known species of the genus, the eyes probably sink during the larval development and become concealed by the pigmented skin in the adult stage.

Another undetermined form, reddish brown in color and expanding to a length of about 10 inches and a diameter of 10 mm., has been taken from the sands of Kaneohe Bay.

In preserved specimens the setae and gills of these worms are sometimes completely retracted. To be studied to advantage, the animals should first be expanded by some narcotizing agent. A weak solution of magnesium sulphate may be used for this purpose. Great care should also be exercised in collecting these worms in order to get perfect specimens, for they are easily fragmented.

FAMILY ALCIOPIDAE

Worms of this family are characterized by large eyes which occupy the entire side of the head. None of the few local forms observed have been specifically determined. In a specimen from Pearl Harbor, Oahu, a triangular plate of tissue separates the eyes dorsally and extends posteriorly over three segments of the body (fig. 49, f). The dorsal cirrus of the parapodium is a narrow flattened leaflike process. The specimen is 2 inches long.

FAMILY NEREIDAE

Nereids are recognized by structures of the head which include a pair of lobelike palps, a pair of small tentacles between the palps, and four long tentacles on each side. There are four eyes.

These worms are numerous about the islands among sponges and seaweeds in shallow water, and probably several species are represented. Common shore forms, however, have not been determined. Most of those observed are of small size and range in length from 1 to 3 inches. (See fig. 49, b, i.) Some nereids have been taken from lowland taro patches and are apparently adapted to fresh-water conditions.

A pelagic species, *Nereis kobeensis* McIntosh, has been collected from the surface of the ocean at various localities, especially in the vicinity of Pearl and Hermes Reef. It may be recognized by the two large eyes on each side of the head, fused together (fig. 49, b). The parapodia vary in form at different points along the body but typically consist of a dorsal and a ventral cirrus and several blunt lobes between which the setae project. The male is about 1 inch long and slightly smaller than the female.

FAMILY AMPHINOMIDAE

Worms with a folded lobe of sensory tissue (caruncle) on top of the head and extending over two or three segments of the body belong to this family.

One of the most conspicuous worms on the local reefs is *Eurythoe pacifica* Kinberg (figs. 50, *c*; 49, *e*). In this flattened, thick-bodied species the parapodia bear tufts of glistening white bristles, which, if touched by the fingers, penetrate the skin and result in an irritating wound. The caruncle is an elongated, thick lobe folded or indented on the borders. There are four eyes. Because of the thickness of the body the dorsal and ventral setae of the parapodia are some distance apart. Branched gills are borne on the parapodia beginning with the second pair. The species is very common under stones and in porous rocks near shore. It is gregarious in habit. Large specimens are 6 inches long.

An undetermined species of *Eurythoe*, thick-bodied and pink, is found upon breaking open dead coral heads. Specimens 12 inches long are common. An orange-colored shrimp, *Joussecaumea mauiensis*, is nearly always associated with this worm.

Species of the genus *Hermodice* differ from those of *Eurythoe* in that the caruncle is a plumelike lobe with a central portion and lateral processes (fig. 49, *d*). Specimens of a form which is probably *Hermodice pennata* Treadwell have been collected from the shores of Molokai and Oahu. One taken at Kahala, Oahu, is 8 inches long.

A small form, probably *Chloëia* species, was collected near shore at Makena, Maui. The parapodia of the dark-brown body bear dense tufts of long, glistening, white bristles. Branched gills begin on the fifth parapodium. The caruncle, in a partially contracted specimen, is elongated and folded on an oval area. It covers five segments. The preserved specimen is 1.75 inches long.

Numerous small flat worms have been taken from within the shells of specimens of *Lepas anatifera* attached to a drift log on the windward shore of Oahu. The species is probably *Hipponoe gaudichaudi* Aud. et Milne Edwards which is widely distributed and has previously been reported associated with barnacles. Adult specimens are nearly 1 inch long and bright orange.

FAMILY LEODOCIDAE

Worms of this family are cylindrical in form of body and some inhabit parchment tubes. The tentacles of the head, when present, vary in num-

ber. Most forms have three or five tentacles, but in some species two additional ones (nuchal cirri) are to be found on the dorsal surface of the second body segment. Branched gills are borne on some of the parapodia.

Several genera are represented among local shore forms. In species of *Leodice* there are five tentacles and a pair of nuchal cirri. The parapodia begin on the third segment. Nearly a dozen species of the genus have been recorded from the islands, most of them from moderately deep water. A species, probably *L. collaris* Grube, is common in porous rocks near shore. It is dark brown, the surface covered with minute white spots. The eyes are between the bases of the two lateral tentacles. The fifth segment is lighter in color than adjacent ones. Gills appear on parapodia about the seventeenth segment. Some specimens are 8 inches long. (See fig. 49, *c.*) The worm breaks into pieces easily, and great care is necessary to procure perfect specimens.

Another shore form is *Leodice interrupta* Treadwell. The tentacles are moniliform. Gills first appear on the fifth parapodium as a single branch which increases to three up to the fifteenth segment, where a reduction to two branches occurs. Some specimens observed are 2 inches long. The species *Leodice dubia* Woodward has been reported from Lisiansky Island.

Species of the genus *Marphysa* are quite like those of *Leodice* but are without nuchal cirri. One representative, *M. teretiusecula* (Schmarda), is recorded from the Honolulu reef.

In the genus *Lysidice* there are no nuchal cirri and the head bears three tentacles instead of five. A common species on local reefs is *L. fusca* Treadwell. In addition to three tentacles the head bears two broadly rounded palps and two prominent eyes. (See fig. 49, *g.*) Specimens are from 4 to 6 inches long.

Some members of this family are without head tentacles, the anterior extremity resembling, in some degree, that of an earthworm. Species probably of the genera *Lumbriconereis* or *Arabella* are occasionally observed among seaweeds on local reefs. They are very slender worms, but some reach a length of 3 inches. (See fig. 49, *h.*)

FAMILY CIRRATULIDAE

Species of this family are characterized by long, threadlike gills developed from the segments of the body. They live just beneath the surface of the sand along the shore, in crevices of rocks, among seaweeds and sponges.

A common form in the sand near the shore line is probably *Cirratulus zebuensis* McIntosh. It is reddish and about 1 inch long (fig. 49, j). A dark violet species with orange-colored gills, *Cirratulus capensis* Schmarda, has been reported from Hawaiian reefs. An undetermined species, bright orange in color, about 1.5 inches long, is common among sponges in Pearl Harbor, Oahu.

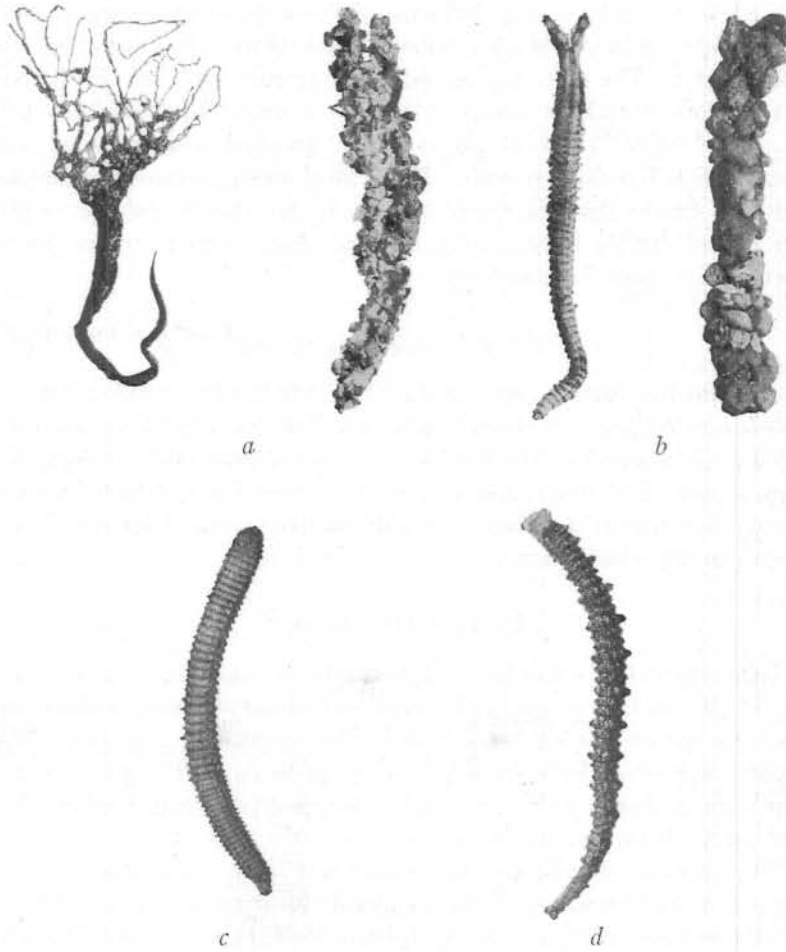


FIGURE 50.—Annelida and Hirudinea: *a*, body and tube of an undetermined terebellid worm; *b*, body and tube of an undetermined hermellid worm; *c*, *Eurythoe pacifica*; *d*, a parasitic marine leech.

FAMILY HERMELLIDAE

Local representatives of this family occupy rough tubes which are composed of sand grains, small pebbles, and shells and are attached to the under surface of stones in shallow water (fig. 50, *b*).

The anterior portion of the body of the worm is split back to the mouth on the ventral side, presenting a forked appearance. The divergent lobes are bordered by strong chitinous bristles some of which have curved ends. There is a pair of black, chitinous hooks on the dorsal surface at the forked region. The first four parapodia are greatly modified. Each consists of a long dorsal cirrus and two groups of setae. The dorsal group is fan shaped with 11 (third parapodium) flattened setae rounded and bluntly pointed at the free ends. The ventral group, somewhat removed from and smaller than the dorsal one, is also fan shaped and bears eight narrow and sharply pointed setae directed almost ventrally. Specimens observed are about 3 inches long.

FAMILY STAUROCEPHALIDAE (part of Dorvilleidae)

A yellowish, flattened representative of this family, probably *Staurocephalus australiensis* McIntosh, is common on local reefs, usually concealed in porous rocks. The head bears a pair of long, thick, tentacle-like palps, a pair of tentacles, and four eyes. A prominent, rounded papilla between the bases of the tentacles is a distinctive feature. (See fig. 49, *k*.)

Specimens are 4 inches long.

FAMILY SABELLIDAE

Representatives of this family are encased in membranous tubes. Two tufts of gills carried on the head branch into numerous pinnate filaments. Most species are brightly colored and, when expanded, flowerlike. The pinnate filaments which serve primarily as respiratory organs (branchiae) are, in some species, provided with eyes on the outer border. Few local species have been described.

The tubes of sabellid worms are attached to stones, piling, or other supports in shallow water. They are usually brown and somewhat longer than the inclosed worm. A common form in Pearl Harbor, Oahu, is bright red and occupies a brown tube about 2 inches long.

A small, nearly colorless species, *Dasychonopsis pallidus* Bush, was described from Honolulu. The 18 branchiae are about one half the length

of the body, which is 8 mm. Another small form, *Sabella hawaica* Kinberg, is recorded from Hawaiian waters. It has 44 segments, 13 branchiae, and is slightly less than 10 mm. long.

FAMILY TEREPELLIDAE

Worms of this family inhabit tubes of mucus reinforced by pebbles, grains of sand, shells, and other foreign material. Their bodies are thickened at the anterior extremity and taper toward the posterior end. The head bears numerous tentacles capable of great extension, and branched gills are carried on some of the anterior segments of the body.

Specimens may be found among seaweeds, on the under surface of stones and embedded in the sand in shallow water. A species attracting attention on Hawaiian reefs is recognized by its white tentacles, which creep over the sand for a radius of several feet. The body of the worm encased in its tube is often completely embedded in the sand under stones or gravel, so that considerable effort is required to dislodge it. Occasionally the tubes are found adhering to the under surface of large stones in shallow water. Large specimens are 1 foot long. (See fig. 50, *a*.)

Living as a commensal in the tube of this worm is a small white crab, *Aphanodactylus edmondsoni*.

FAMILY CHAETOPTERIDAE

On sand-covered reefs close to shore may be found masses of slender membranous tubes reinforced by grains of sand. These tubes which may be branched are partially or completely buried in the sand and are occupied by worms of this family. Some tubes may be occupied by more than one worm. Especially on the Kahala side of Black Point and in Kahana Bay, Oahu, are chaetopterids abundant. The worms are delicate forms, easily ruptured, so that complete specimens are obtained only by collecting them with great care. The body presents two or three distinct regions and may be with or without eyes. Local species have not been determined, but there seem to be representatives of more than one genus. A typical form from the sand at Black Point is shown in figure 51. The tubes of chaetopterids may be three or four inches long, but the worms are much shorter.

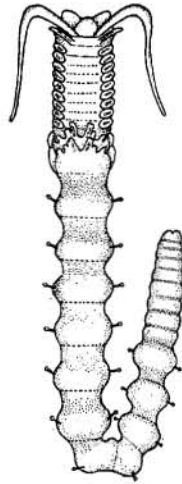


FIGURE 51.—Chaetoperid worm, removed from tube.

FAMILY SERPULIDAE

Serpulid worms secrete calcareous tubes in which they live, the tubes being firmly attached to rocks, shells, or other supports. The head of the worm bears numerous gills, which, in an expanded condition, spread out like the petals of a flower. Most species have an operculum which closes the tube when the animal is drawn in.

There are numerous species in shallow water about the islands, some of which have not yet been determined. A widely distributed form, *Hydroides norvegica* Gunnerus, is the most common local one. The tube may reach a length of nearly 3 inches and is usually marked on the upper surface by two longitudinal ridges (fig. 52, a). In *H. lunulifera* (Claparède) the tube is larger and thicker than in *H. norvegica*. The operculum of each of these species is characteristic (fig. 53, a, b). Species of *Vermiliopsis* have short, rough tubes, usually triangular in cross section and conical, club-shaped opercula (fig. 53, c). A species of *Protula* with a long smooth tube, found under stones close to shore, like other members of the genus, has no operculum. Masses of slender, fragile tubes are developed by *Salmacina dysteri* Huxley (fig. 52, c). This minute species reproduces rapidly by transverse fission. On the under surface of flat stones are minute, closely coiled tubes of *Spirorbis* (fig. 52, b). An undetermined species of the genus *Mercierella*, which has a membranous operculum resembling a minute sea anemone, was abundant on the bottom of a boat at Waikiki (fig. 53, d).

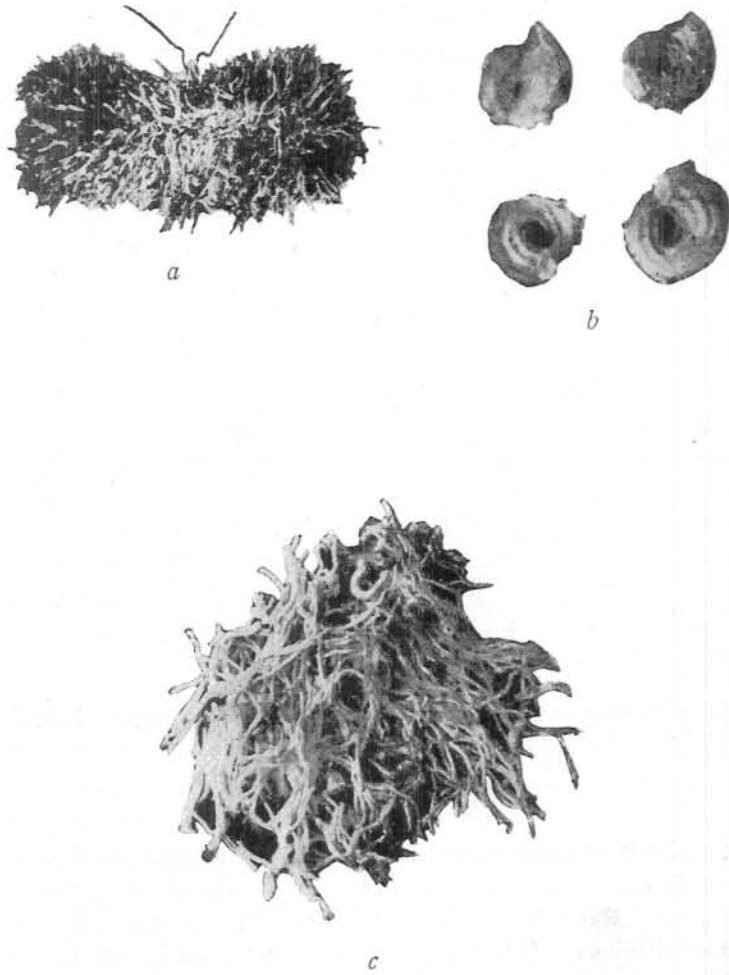


FIGURE 52.—Serpulid worms: *a*, block of wood with masses of *Hydroides norvegica* attached; *b*, tubes of *Spirorbis* species; *c*, mass of tubes of *Salmacina dysteri*.

Serpulid worms are among the more common organisms which foul the bottoms of ships in local waters.

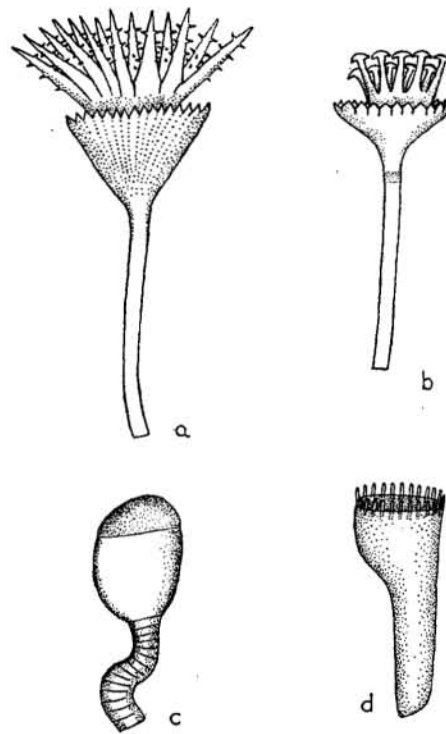


FIGURE 53.—Opercula of serpulid worms: *a*, *Hydroides norvegica*; *b*, *Hydroides lunulifera*; *c*, *Vermiliopsis* species; *d*, *Mercierella* species.

CLASS HIRUDINEA

Some leeches are known to inhabit the sea. Among these are familiar ectoparasites often found attached to the fins or gills of fishes. Sharks frequently carry them. They have long, slender cylindrical bodies with a sucker at either end. The annulations are roughened by wartlike protuberances. Large specimens are 4 inches long. (See fig. 50, *d*.)

A minute form with a dark green, smooth body has been taken from the under surface of a stone on the reef at Kahala, Oahu. It apparently represents a free-living marine leech of doubtful genus and species. There is a sucker at either end, and the annulations are indistinct. Its length is 1 inch.

PHYLUM MOLLUSCA

In Hawaii this phylum comprises the largest group of marine invertebrates, and because of the number and diversity of forms attracts the attention of both the general collector and the scientific investigator. A conservative estimate of the number of species of marine mollusks about the Hawaiian Islands is not less than 1,500.

Although many of the smaller forms of the local reefs and shallow water have not yet been studied or described, the larger mollusks are, for the most part, known. Considerable confusion in classification of local species exists, however, as no complete and authentic report on Hawaiian marine forms is available at this time. The multiplicity of terms employed by authors in designating identical species is very perplexing, and no doubt some of those applied in the following discussion will be altered or discarded when monographers bring the group up to date.

Marine mollusks frequent a great variety of habitats. Some are literally shore dwellers and are conspicuous at the water's edge or on rocks between the tide marks; some are concealed under stones or in crevices of porous rocks and must be searched for carefully; others live far out on the reefs or in off-shore water down to great depths. Diving or dredging must be resorted to in obtaining those forms lying beyond the shallow reefs.

Although molluscan forms vary greatly, in general appearance they possess some features in common. Unsegmented bodies characterize all mollusks, and each has a foot, by means of which most forms accomplish locomotion. Soft lateral folds (mantle folds), commonly thin and plate-like, may more or less completely inclose the body proper.

Some mollusks have well-developed shells, within which the soft bodies may be completely concealed; some have rudimentary shells; others have none in the adult phase.

Included in the phylum are clams, oysters, snails, chitons, squid, octopods, and others. The generally accepted classification separates mollusks into five classes.

CLASS AMPHINEURA

Chitons are bilaterally symmetrical mollusks, flattened dorsoventrally with a shell consisting of eight transverse plates (valves). The plates occupy a median position and are held in place by a muscular peripheral girdle. The posterior border of each of the plates, except the last, over-

laps the anterior border of a successive plate. Sculpturing and structural features of the dorsal surface of the valves and girdle vary in different genera and species of chitons.

On the ventral surface of the animal the mouth is observed at the anterior end of the body and the anal opening at the posterior end. Gills lie between the broad foot and the mantle.

Chitons may be found clinging to the under surface of stones in shallow water and to rocks along the shore which are exposed during low tide. Few species have been recognized in Hawaii.



FIGURE 54.—Chitons: *a*, *Acanthochiton viridis*; *b*, an undetermined species; *c*, *Ischnochiton petaloides*.

The largest local species is *Acanthochiton viridis* Pease (fig. 54, *a*). Its semilunar valves possess slits and are smooth in the middle and granulated on the sides. Tufts of bristles extend from pores in the girdle. The general color of the animal is greenish. The tufts of bristles are dark green. Large specimens are 1.6 inches long.

Another very common Hawaiian species, *Ischnochiton petaloides* Gould (fig. 54, *c*), is roundly arched above, with the valves slightly keeled longitudinally in the mid-line. A transverse rib crosses the posterior valve. The central areas of the valves are somewhat rugose and punctate, and the lateral areas are granulated and have a few radiating striae. Minute imbricating scales cover the upper surface of the girdle. The species is exceedingly variable in color. It may be yellowish, bluish, dark green, or gray, mottled and streaked with red and tints of other colors. Large specimens are 12 mm. long.

There are, without doubt, other and undescribed chitons in Hawaiian waters. A doubtful form (fig. 54, *b*) in Kaneohe Bay, Oahu, differs from *Ischnochiton petaloides* in the character of the valves and in the larger and less numerous scales of the girdle. Specimens are about 12 mm. long.

CLASS GASTROPODA

Gastropods are unsymmetrical mollusks living in the sea, in fresh water, and on land. Most of them have more or less complete, spirally coiled shells. They are commonly known as univalves because the shell is composed of a single piece in contrast with bivalves, which possess shells consisting of two pieces (valves). Although the shells of most gastropods are coiled to the right (dextral), those of some forms turn to the left (sinistral). Both dextral and sinistral shells are occasionally found in some common species, and a few genera are wholly sinistral. Some gastropods retain only rudimentary shells, or none at all, when adult, but possess well-developed shells in the larval phase, an indication that their ancestors were shell-bearing forms.

In many gastropods, a more or less complete closure of the aperture is effected by a horny, chitinous, or calcareous plate (operculum) attached to the foot, when the animal is retracted into the shell.

Mollusks of this class have an expanded ventral surface of the body on which they creep about or by means of which they swim, hence the name Gastropoda (stomach-footed). Most of those which live submerged in water breathe by means of gills. Terrestrial forms are provided with lungs. Transitional species, evidently in the course of migration from an aquatic mode of life to a terrestrial one, show adaptation for existence in both water and air.

In Hawaii, gastropods constitute by far the largest division of the phylum, both in number of species and in individuals. Of the marine forms some are numerous about the shores at the water's edge or high up on the rocks seldom washed by the waves. At low tide other species may be collected under stones, in crevices of rocks, and in the sand not far from shore. Still others are typical of the outer edge of the reef platform or depths of a few fathoms and are only occasionally seen alive. Deep-water species are obtained by dredging. Pelagic forms, living on the surface of the sea, are sometimes driven ashore by winds. Empty shells of mollusks which live in off-shore water may be washed up on the beaches. Hermit crabs, which habitually inhabit discarded gastropod shells, frequently drag them into places unnatural to the living mollusks.

If shells of marine mollusks are to be preserved in a dried condition, the living animals must first be killed and removed. This may be done by placing them in fresh water for a day or two or in hot water for a brief time, after which the soft tissue may be washed out or otherwise removed. Some shells, especially cones, are often partially or completely covered

by calcareous deposits which must be scraped off to reveal the characteristic markings. If an operculum is present, it should also be preserved.

It is very difficult to preserve in their natural form mollusks such as nudibranchs, which do not have shells. They may, however, be relaxed and stupefied, with more or less success, by slowly adding such agents as ether, menthol, or epsom salts to the water surrounding them. When completely torpid they may be preserved in alcohol, formaldehyde, or other mixtures.

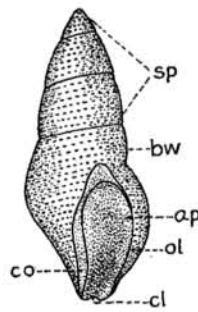


FIGURE 55.—A gastropod shell showing morphological features (*ap*, aperture; *bw*, body whorl; *cl*, canal; *co*, columella; *ol*, outer lip; *sp*, spire).

In the following discussion of Hawaiian gastropods, common forms of the shores and shallow water are given primary consideration. Some species typical of depths of a few fathoms but occasionally seen on the reefs are also included. A complete treatment, however, of even the near-shore species of Hawaiian gastropods is not attempted here. The taxonomy of some groups is not yet clear, and many forms, especially minute ones, have been neglected by collectors. A complete revision of the Hawaiian marine gastropods from a taxonomic point of view is needed.

That the features of the shells referred to in the following descriptions may be clearly understood, figure 55 should be consulted.

Key to Orders of the Class

- A. Gastropoda with aquatic respiration; gills usually present.
 - B. Gills, if present, are in front of the heart; shells usually well developed; sexes separate.....**Prosobranchia.**
 - BB. Gills, if present, posterior to the heart, but often replaced by secondary branchiae; shells often reduced or absent; sexes united.....**Opisthobranchia.**
- AA. Gastropoda without gills, the wall of the mantle cavity serving as a lung**Pulmonata.**

ORDER PROSOBRANCHIA

A large majority of the shell-bearing mollusks typical of the reefs and shores of Hawaii are members of this order. Forty-eight families are here listed, but only the more representative species of each are mentioned.

FAMILY TEREBRIDAE

Representatives of this family are commonly known as "auger shells." They are elongated and have many whorls to the spire, which tapers to a fine point. The short aperture is closed by an operculum.



FIGURE 56.—Terebridae: *a*, *Terebra maculata*; *b*, *Terebra crenulata*.

Although more than 30 species of *Terebra* are recorded from Hawaiian waters, few are found living on the reefs or near shore, and those coming into shallow water also range to depths of several fathoms. Dredgings from Honolulu Harbor and its entrance indicate an abundance of these mollusks in such localities at depths of 5 to 8 fathoms. On certain beaches of the north shore of Kauai shells of several species of *Terebra*, washed up from off-shore water, are abundant.

Only a few typical species of the genus are here considered, including some of those occasionally observed in a living condition on the reefs or those whose shells are found about the shores. Among these, *Terebra maculata* Linnaeus (fig. 56, *a*) is the largest. Specimens often reach a length of 4 or 5 inches, and one in Bishop Museum from Honolulu Harbor is 9 inches long. The shell is flesh colored, encircled by broken bands of yellowish brown and alternating broad and narrow broken bands of dark purple. In *Terebra gouldii* Deshayes there is a nodulose band below each suture and the whorls are longitudinally plicate. It is yellowish white with circular bands of pale brown. Large specimens are 2.5 inches long.

The shell of *Terebra pertusa* Kiener has sutural bands ornamented with white ribs. The whorls are flesh colored, mottled with brown and encircled by fine brown lines. It is about 3 inches long. Another species, *Terebra crenulata* Linnaeus (fig. 56, *b*), is nodulose below the sutures, and the cream-colored shell is encircled by rows of brown spots. Large specimens are 5 inches long.

Empty shells of several species of *Terebra* are washed ashore in large numbers on some of the beaches. Among these will be found shells of *T. confusa* E. A. Smith, which has a broad base and is chocolate colored with a white band at the suture and on the periphery of the body whorl. The longitudinal ribs are small and usually cover the entire shell. Specimens are 1.5 inches long. Shells of *T. peasei* Deshayes are also found on the beaches. They are yellowish white or orange with a white band at the suture. The longitudinal ribs are rounded and slightly curved. Specimens are about 1.5 inches long.

FAMILY CONIDAE

Cones are distinguished by the conical shape of the shell, which usually has a broadly expanded end, terminating in a more or less flattened spire or apex. The opposite extremity tapers toward a narrow end representing the base in typical gastropod shells. A long narrow aperture is closed by an operculum.

Because of the striking color patterns which many species show when the calcareous deposits covering the shells are removed, this family is one of the most attractive to collectors.

The eggs of cones are deposited in white, flattened capsules attached in clusters to the under surfaces of rocks. Each capsule incloses many eggs. (See fig. 57, *h*.)

More than 30 species of *Conus* are known to occur about the islands. Many of these are typical inhabitants of the reefs, where they may be found under stones and in the surface sand. Species of cones are identified by the shape of the shell, its sculpturing, and color markings. Among local species there is considerable contrast in size, ranging from about 1 inch to 6 or 8 inches in length. The larger forms are seldom observed near shore but are more frequently taken in the outer areas of the reef platform or at depths of one or more fathoms.

In *C. literatus millepunctatus* Lamarck (fig. 57, *a*) the shell often reaches a length of 6 inches. There is a specimen in Bishop Museum 8 inches long and weighing nearly 4 pounds. The shell is white, marked by

rings of closely set black spots. Another large species, *C. cingulum* Martyn, has a yellowish shell spirally marked by fine lines of brown and longitudinally striated. The apex of the raised spire is sharp. Specimens are 4 to 5.5 inches long. The cylindrical shell of *C. striatus* Linnaeus is striated spirally and longitudinally. It is whitish and stained, spotted, and streaked with pale rose and black. Large specimens are 4.5 inches long. In *C. distans* Hwass the elongated shell is slightly constricted in the middle. It is reddish yellow, encircled by distantly separated lines, and the raised spire is ornamented by tubercles. Specimens 4 inches long are

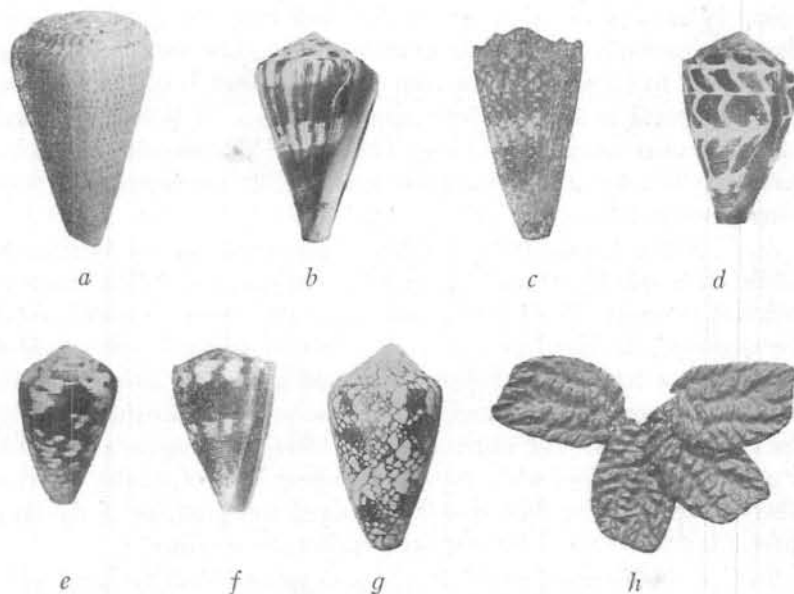


FIGURE 57.—Conidae: a, *Conus literatus millepunctatus*; b, *Conus sumatrensis*; c, *Conus imperialis*; d, *Conus hebraeus*; e, *Conus catus*; f, *Conus rattus*; g, *Conus omaria* (?); h, four egg cases of *Conus* species.

not uncommon. The pale yellow shell of *C. sumatrensis* Hwass (fig. 57, b) is marked by broad longitudinal brown lines, some of which are interrupted in the middle. It is about 3.75 inches long. The species *C. imperialis* Linnaeus (fig. 57, c) has an elongated shell with the depressed spire ornamented with large tubercles. It is encircled by two brown bands and marked by black dots and interrupted lines. Large specimens are 3.5 inches long. In *C. miles* Linnaeus the pale yellow shell is

marked by a dark, reddish band and by narrow, wavy, longitudinal lines of the same color. The base is dark brown. The shell may reach 4 inches in length.

Several smaller but well-known species are often found near shore, where they are concealed, during the day, under stones or partially buried in the sand. They range from 1.5 to 2.5 inches long. One of the most common cones in Hawaii is *C. hebraeus* Linnaeus (fig. 57, *d*) which has a solid shell, white or rose-tinted, marked by irregular rhomboidal black spots. The spire is also spotted with black. The shell of *C. vermiculatus* Lamarck differs from that of *C. hebraeus*, of which it is considered a variety by some authorities, in that the black spots are fused with each other longitudinally and sometimes transversely. The shell is sometimes granulated. In *C. catus* Hwass (fig. 57, *e*) the shell is spirally grooved and ornamented at the base with nodulose ridges. It is whitish, variegated with olive or reddish brown. The shell of *C. abbreviatus* Reeve is bluish gray in color, with a pale band in the middle and encircled by rows of dark-brown dots.

In *C. lividus* Hwass, the greenish shell has a pale narrow band in the middle. It is spirally striated and granulose at the base. White tubercles ornament the spire. The interior of the aperture is purple-violet in color. The species *C. flavidus* Lamarck has a yellow-tinted shell, with a reddish or pale-yellow band in the middle. Elevated transverse striae mark the surface. The apex is rose-tinted, and the interior of the aperture is violet. The spire is smooth. The white shell of *C. vitulinus* Bruguiere is marked by a dark-brown band with wavy longitudinal lines of similar color on either side of it. The shell is spirally ridged and granular at the base, where it is dark brown both inside and outside the aperture.

In *C. rattus* Hwass (fig. 57, *f*), the olive-colored shell has large white spots on the upper part and white dots on the base. It is spirally striated and grooved at the basal end. The aperture is violet. The dwarf cone, *C. nanus* Broderip, is a small form, 1 inch or less in length. The shell is white, purple-tinted toward the base, and in life is covered with a yellowish or olive-colored epidermis.

Cones with reticulated surface presenting irregular white triangular spots interspersed with brown blotches, are not uncommon on the reefs. They vary in color pattern, and difficulty is experienced in determining their specific position. Local forms probably belong to one of the three following species. In *C. auratus* Bruguiere the shell is cylindrical and elongated, the surface marked by numerous transverse lines. The color

pattern consists of irregular, longitudinal rows of white spots and chestnut-brown blotches. The spire is greatly elevated. Specimens are about 2.5 inches long. The shell of *C. omaria* Bruguiere is cylindrical but not so elongated as that of *C. auratus*. The whitish shell is reticulated by orange-brown, resulting in numerous white blotches on the surface. The spire is concavely exerted. Specimens are about 2.5 mm. long. Most specimens collected on the reefs probably belong to this species (fig. 57, g). In *C. textile* Linnaeus the shell is cylindrical, ovate, whitish, and is encircled by two rows of large, irregular orange blotches. It is reticulated by orange-brown, resulting in numerous white spots. The shell is streaked by wavy longitudinal brown lines. The spire is elevated. Specimens may exceed 3 inches in length. The species is rarely seen on local reefs.

Numerous other cones inhabit the bays and off-shore waters at depths of a few fathoms. They are brought to the surface by dredging or by divers, and occasionally their shells are washed into shallow water. Only a few of these are considered here.

In *C. lithoglyphus* Reeve, the reddish-brown shell is black at the base and banded in the middle and on the upper part with white spots. Its length is about 1.5 inches. Another species, usually dredged, is *C. pulicarius* Bruguiere, which has a whitish shell covered with oval black spots usually massed together at the base. Large specimens are 2.25 inches long. In *C. nussatella* Linnaeus the elongated cylindrical shell is spirally marked by raised striae, some of which are granulated. It is whitish, spotted with yellow or orange, and encircled with brown dots. Its length is about 2.5 inches.

That care should be taken in collecting cone shells is emphasized in a recent paper, "The poison cone shell", by Clench and Kondo (see bibliography). The authors review numerous cases of poisoning by various species of cones and show the anatomical relationship of the poison gland to other organs of the pharynx in *Conus striatus*. They conclude that it is wise to consider all living cone shells as potentially dangerous.

FAMILY TURRITIDAE

Mollusks of this family are characterized by fusiform shells with the whorls somewhat flattened on the upper side. The elongated aperture has a straight canal and the outer lip is notched near the suture. Some species have an operculum. Few Hawaiian species have been described, but there are probably numerous representatives of the family in local

waters among the minute forms which have not been adequately studied.

One of the more common species is *Philbertia crassicostata* Pease (fig. 58, *a*). The yellowish or pink shell is ribbed longitudinally and encircled by fine striae. The canal is short and there are teeth within the outer lip. Its length is about 8 mm. In *Philbertia lutea* Pease the solid, shining shell has convex whorls and is traversed in a regular manner by longitudinal and transverse ridges. Its length is 5 mm.

In the species *Daphnobela pumila* Mighels the pinkish-white shell is beaded by longitudinal and transverse furrows. An orange band encircles it near each suture and one crosses the middle of the last whorl. The length is about 5 mm. A tiny species, *Daphnobela minutissima* Garrett, has a brown shell and is furrowed longitudinally and transversely. Its length is about 2.5 mm.

In species of the genus *Daphnella* the last whorl is elongated and there is no operculum. One local species, *D. maculosa* Pease (fig. 58, *b*), has the surface finely ribbed transversely and longitudinally and marked with brown spots. Its length is 8 mm. In *D. sandwichensis* Pease the shell has a smooth appearance, though the upper part of the body whorl is faintly striated longitudinally and the lower part is spirally costate. The shell is mottled with brown. Its length is 10 mm.

There are probably numerous species of *Drillia* in Hawaiian waters, but few have been determined. They have fusiform shells and are usually ornamented by longitudinal ribs. In *D. exilis* Pease (fig. 58, *c*) the chestnut-colored shell has small whitish ribs. There is a dark band below the middle of the body whorl. Specimens are from 6 to 8 mm. long. In *D. acuminata* Mighels the chocolate-brown shell has a white band at the suture, and the white ribs terminate about the middle of the body whorl. It is slightly larger than *D. exilis*.

FAMILY HARPIDAE

Species of *Harpa* are occasionally observed on the reefs, but their typical habitat is deeper water. The shells have large apertures and swollen whorls. They are longitudinally ribbed and brightly colored. The animal is characterized by a very large foot, incapable of being fully retracted into the shell. There is no operculum.

Of the two more familiar species, *H. conoidalis* Lamarck (fig. 58, *d*), is bulbous in form and may exceed 3 inches in length, while *H. amour-etta* Bolton is narrower and usually less than 2 inches long.

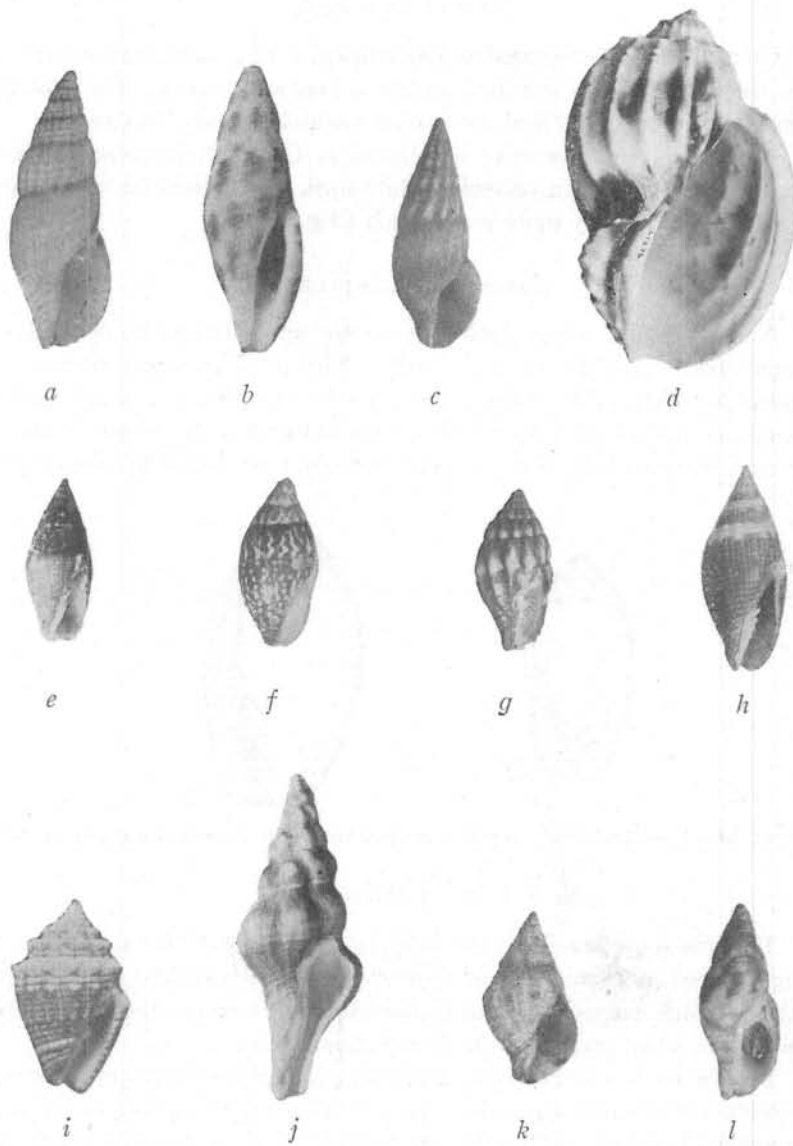


FIGURE 58.—Prosobranchia: *a*, *Philbertia crassicostata*; *b*, *Daphnella maculosa*; *c*, *Drillia exilis*; *d*, *Harpa conoidalis*; *e*, *Mitra astricta*; *f*, *Mitra litterata*; *g*, *Mitra consanguinea*; *h*, *Mitra lugubris*; *i*, *Mitra patriarchalis*; *j*, *Latirus nodus*; *k*, *Peristerina chlorostoma*; *l*, *Pisania tritinoidea*.

FAMILY OLIVIDAE

Olive shells are elongated and cylindrical with a short, pointed spire. The surface is smooth and the aperture is long and narrow. The animals burrow in the sand and feed upon other mollusks, chiefly bivalves.

A common representative in Hawaii is *Oliva sandwichensis* Pease (fig. 59, *a*), which has a yellowish-white shell, spotted with brown. Large specimens are slightly more than 1 inch long.

FAMILY MARGINELLIDAE

A small, glossy white shell with narrow aperture and no operculum characterizes members of this family. The familiar representative in Hawaii is *Marginella sandwichensis* Pease (fig. 59, *b*), which has a smooth, oval shell with four folds on the columella. Its length is about 2.5 mm. Empty shells of the minute form are often found in beach sand.

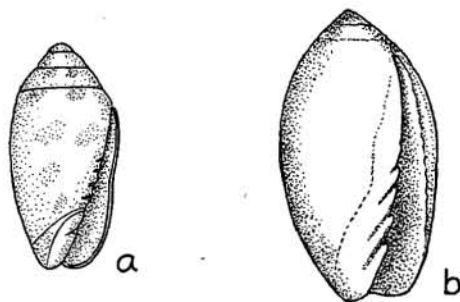


FIGURE 59.—Prosobranchia: *a*, *Oliva sandwichensis*; *b*, *Marginella sandwichensis*.

FAMILY MITRIDAE

The mitres are known by the solid, fusiform shells which usually have long, pointed spires and narrow apertures with plaits (folds) on the columella. A long, extensile proboscis characterizes the living animal, and the operculum, when present, is small and rudimentary.

The family is a large one and includes several hundred species, most of which are in warm seas. More than 50 known species occur in Hawaiian waters, many of which, however, inhabit off-shore water or depths of several fathoms. Relatively few forms may be considered common on local reefs or along the shores. Being nocturnal in habit, the mollusks are usually concealed during the day in crevices of porous rocks, under stones, or in the sand. Some species may be collected more easily by

breaking open dead coral blocks. The more familiar representatives of the genus *Mitra* frequenting the near-shore areas are here given first consideration.

One of the common species is *M. astricta* Reeve (fig. 58, *e*), which is olive-brown in color, usually quite smooth, and sometimes encircled with narrow brown lines placed close together. There are four plaits on the columella. Large specimens slightly exceed 1 inch. In *M. litterata* Lamarck (fig. 58, *f*) the whitish shell is marked with irregular, longitudinal spots of dark brown. The columella has four plaits. Its length is about 1 inch. The shell of *M. auriculoides* Reeve is reddish brown with a narrow white band on the upper part of the body whorl and the surface sometimes dotted with white. There are five plaits on the columella. Large specimens are 1 inch long. Another common species is *M. consanguinea* Reeve (fig. 58, *g*). The dark red shell is ribbed longitudinally and striated transversely. There is a row of white spots about the middle. The columella bears four plaits. Its length is less than 1 inch. A species occasionally found near shore, *M. ticaonica vagans* Pilsbry, is chestnut-brown. The whorls of the short spire are spirally traversed by 5 lines, and the body whorl is smooth, except for a series of furrows at the base. The aperture is dark brown and the columella bears four plaits. It is about 1 inch long. The shell of *M. fuscescens* Pease somewhat resembles that of *M. ticaonica vagans* except that the aperture is white and the plaits on the columella are five in number. It is an inhabitant of shallow water although not commonly observed near shore.

Among the numerous species of *Mitra* which seem best adapted to a depth of a few fathoms, only six have been selected for consideration. Some of these are occasionally collected on the reefs. A large species, *M. ambigua* Swainson, is orange-brown, marked by faint spiral grooves which are punctate. There are usually pale bands below the sutures. Six plaits are borne on the columella, and the outer lip is crenated. It may reach a length of 2.5 inches. Another of the larger species, *M. stictica* Lamarck, is elongated, turreted at the sutures, and encircled by punctate grooves. The color is whitish marked with spiral bands of irregular quadrangular spots. Large specimens are 2 to 3 inches long. The shell of *M. lugubris* Swainson (fig. 58, *h*) is reddish brown. The sutures are uneven and the surface is roughened by faint spiral grooves and longitudinal wrinkles. The whorls just beneath the sutures are white, as is often the base of the shell. There are five plaits on the columella. Its length is about 1 inch. A subspecies, *M. lugubris honoluluensis* Pilsbry, differs

from the typical form chiefly in the presence of a row of white tubercles just below the suture. The subspecies has been dredged and also collected on the reefs. In *M. nodosa* Swainson the oval, stout shell is covered with tubercles. It is white and sometimes marked with a brown band or row of spots in the middle. There are four plaits on the columella, and the upper one is the largest. The length is 18 mm. The oval shell of *M. patri-archalis* Lamarck (fig. 58, *i*) is encircled by numerous nodular ridges, and the nodules are stronger on the upper part. The color ranges from yellow to dark brown, with the spire, the upper part of the body whorl, and the base usually lighter. The columella bears four plaits, the upper one the largest. The length is about 20 mm.

FAMILY FASCIOLARIIDAE

Members of this family have fusiform shells with elongated spires and straight canals. The aperture is elongate-oval with an operculum. The largest species in local waters, *Fusinus sandwichensis* Sowerby, has a white shell in which both the spire and canal are greatly elongated. Large specimens are more than 4 inches long. The species seems to be best adapted to depths of 4 or 5 fathoms and is seldom taken alive on the reefs or near shore. A smaller species, *Latirus nodus* Martyn (fig. 58, *j*), is occasionally found on rocky shores. The spire is ornamented with low, rounded nodules. Under the epidermis the color is yellowish and the aperture is rose-tinted. Large specimens are about 3 inches long.

The genus *Peristerina* is represented among the shore fauna. The most common species is *P. chlorostoma* Sowerby (fig. 58, *k*). It has a greenish-yellow shell with brown tints, encircled by fine granular ridges and furrowed longitudinally. Its length is about 15 mm. A less common species, *P. thaanumi* Pilsbry, has a yellowish-white shell marked by spiral ridges and shallow longitudinal furrows. The outer lip bears a row of teeth. The shell is about 15 mm. long.

FAMILY BUCCINIDAE

In this family the shells are elongate-oval with the surface costate or tuberculate. There is a short canal and an operculum. The most familiar local forms are species of *Pisania*. In *P. tritinoidea* Reeve (fig. 58, *l*) the shell is usually yellowish mottled with chestnut or white and is encircled by fine costae. The outer lip is smooth. Large specimens are 1.5 inches long. Dark brown or chestnut-colored specimens are occasionally seen. Another species, *P. billeheusti* Petit, has a whitish shell with chestnut

spots and is roughened by fine transverse and longitudinal ridges. Within the outer lip is a row of teeth. The species may reach 1.5 inches in length.

Shells of *Engina* are sculptured by transverse and longitudinal furrows resulting in a tuberculate or nodulose surface. Several species have been recorded from Hawaii, but they are not readily distinguishable; and, because of their small size, they may easily be confused with young specimens of other gastropods. The shells are solid and the outer lip is thick and usually bears teeth on the inner surface. Specimens taken in shallow water and empty shells collected from reef sand have been assigned to this genus with some doubt as to their identity.

FAMILY COLUBRARIIDAE

Two species of *Colubraria* are known in Hawaiian waters. In *C. distorta* Schubert and Wagner (fig. 60, *d*) the elongated shell has a curved spire and the whorls are crossed by an oblique row of tubercles. The surface is uniformly reticulated. It is light brown clouded with darker brown. Large specimens slightly exceed 2 inches in length. The species *C. obscura* Reeve differs from *C. distorta* in being more slender and in having a straight spire.

Although empty shells of species of *Colubraria* may be found on the reefs and in shallow water, very seldom has a living specimen been taken. They are apparently exceedingly shy and adept at concealing themselves from observation.

FAMILY ALECTRIONIDAE

Members of this family are typical of sand-covered reefs or shallow bays. They are carnivorous, feeding upon other mollusks, especially bivalves, which they find by burrowing about in the sand.

The most familiar species is *Alectrion hirtus* Kiener (fig. 60, *a*), which has a yellowish or orange-brown shell. The sutures are deep and the surface is longitudinally ribbed. The species is about 1 inch long. A less common but larger species, *Alectrion papillosus* Linnaeus, is whitish, blotched with brown. The surface is furrowed transversely and longitudinally. Large specimens slightly exceed 2 inches in length. In *Alectrion graphiterus* Beck the spire is ribbed longitudinally but the body whorl is smooth and polished. The shell is usually mottled with white, yellow, and brown. Large specimens are 1 inch in length.

A small oval species of *Alectrion* has a shell ornamented by numerous longitudinal ribs discontinuous at the sutures, and smaller spiral ribs. A

brown sutural band encircles the shell, and three spiral ribs are stronger than the others. Both lips are plicated. There is a short, narrow but deep anterior canal. Specimens are slightly more than 8 mm. long.

FAMILY COLUMBELLIDAE

The columbellids have small shells, usually with short spires. The aperture is narrow, protected by an operculum, and the outer lip is thickened. Because of the abundance of these little shells they are employed in the manufacture of ornaments of various kinds. Leis are sometimes made of them. Numerous species in Hawaii inhabit the near-shore areas, where they may be found under stones and among seaweeds.

Of the more common species, *Columbella varians* Sowerby (fig. 60, *b*) is the most familiar. Its shell is ovate, usually smooth, and longitudinally ribbed. It is white with broken bands of brown spots. Specimens are about 10 mm. long. In *Columbella zebra* Gray (fig. 60, *c*) the spire is more elongated than in *C. varians*, and the white surface is marked longitudinally by zigzag or broken lines of brown. Its length is 12 mm. The fusiform shell of *Columbella lachryma* Gaskoin is cancellated by longitudinal furrows and fine spiral grooves. It is white with faint brown blotches. Specimens are about 8 mm. long. A stout, ovate form, *Columbella margarita* Reeve somewhat resembles *C. varians* but lacks the longitudinal ribs. The obtuse spire is smooth or slightly wrinkled. It is yellowish white with spots or faint bands of brown. Its length is about 10 mm. A very common species among seaweeds near shore is *C. lineolata* Kiener. It is elongate with the whorls longitudinally ribbed and nodulose at the shoulders. Specimens are white or marked with spiral and zigzag series of brown spots. The species is about 15 mm. long. The shell of *C. orphia* Duclos varies greatly in color but is usually brown, marked with white spots. Its surface is smooth. Specimens are about 8 mm. long. A minute species, *C. peasei* von Martens, apparently lives at depths of a few fathoms, but the shell is often found in shore sand. It is longitudinally ribbed, usually whitish or pale brown with a narrow, dark brown line encircling the whorls. It is less than 5 mm. long.

FAMILY MURICIDAE

Mollusks of this family have solid, heavy shells with tuberculate or spiny surfaces. The aperture is narrow and protected by an operculum. A row of strong teeth is usually borne on the inner border of the outer lip

and sometimes on the columella also. There are more than 40 known species about Hawaii. Many of these are inhabitants of shallow water, and some are among the most common shore forms. They are carnivorous, feeding on other mollusks, both gastropods and bivalves.

The genus *Morula* is represented by several species usually readily distinguished by the surface sculpturing. The most common one on shore rocks is *M. tuberculata* Blainville (fig. 60, e), which has the shell covered with rows of black, blunt tubercles with numerous spiral striae between. The aperture is black and the teeth and columella are partly black. The species is about 1 inch long. In *M. nodus* St. Vincent the shell is whitish or orange with a violet aperture. There is one spiral rib between the rows of black tubercles of the surface. The shell is about 1 inch long. The shell of *M. fuscoimbricata* Sowerby is white with sharp, red tubercles. Large specimens are 1 inch long. In *M. foliacea* Conrad (*M. brunneolabrum* Dall) the shell is roughened by transverse striae and folds. The tubercles are stronger and sharper on the upper part of the body whorl. Specimens slightly exceed 1 inch in length. The species *M. porphyrostoma* Reeve (*M. dumosa* Conrad) (fig. 60, g) has a yellowish-white shell grooved longitudinally and encircled by numerous costae. Its length is about 20 mm.

In *M. ochrostoma* Blainville the white or cream-colored shell is ornamented by oblique rows of tubercles and is tinted ochraceous within the aperture. It is about 1.5 inches long. Another common species (fig. 60, f), resembling *Morula fiscella* (Chemnitz), has the shell crossed obliquely by six ribs and transversely by numerous costae and folds resulting in rectangular depressions between the ribs. Adult specimens reach a length of about 1 inch.

Species of *Drupa* cling to the rocks where the surf is strong. A common form is *D. ricinus* Linnaeus (fig. 60, i). The shell has oblique rows of sharp tubercles. The elongated ones bordering the outer lip are produced by folds of the margin. The length is about 1.25 inches. In *D. horrida* Lamarck the heavy, bulbous shell bears rows of blunt tubercles. Large specimens are 1.75 inches long. The species *D. speciosa* Dunker has a yellowish-white shell with prominent tubercles in spiral series. It is about 1.5 inches long.

The genus *Thais* is represented by at least three species in local waters. In *T. aperta* Blainville the shell is massive, domelike, and bears short tubercles. It reaches a length of 3 inches. The yellowish-white shell of *T. intermedia* Kiener is mottled with brown and roughened by blunt,

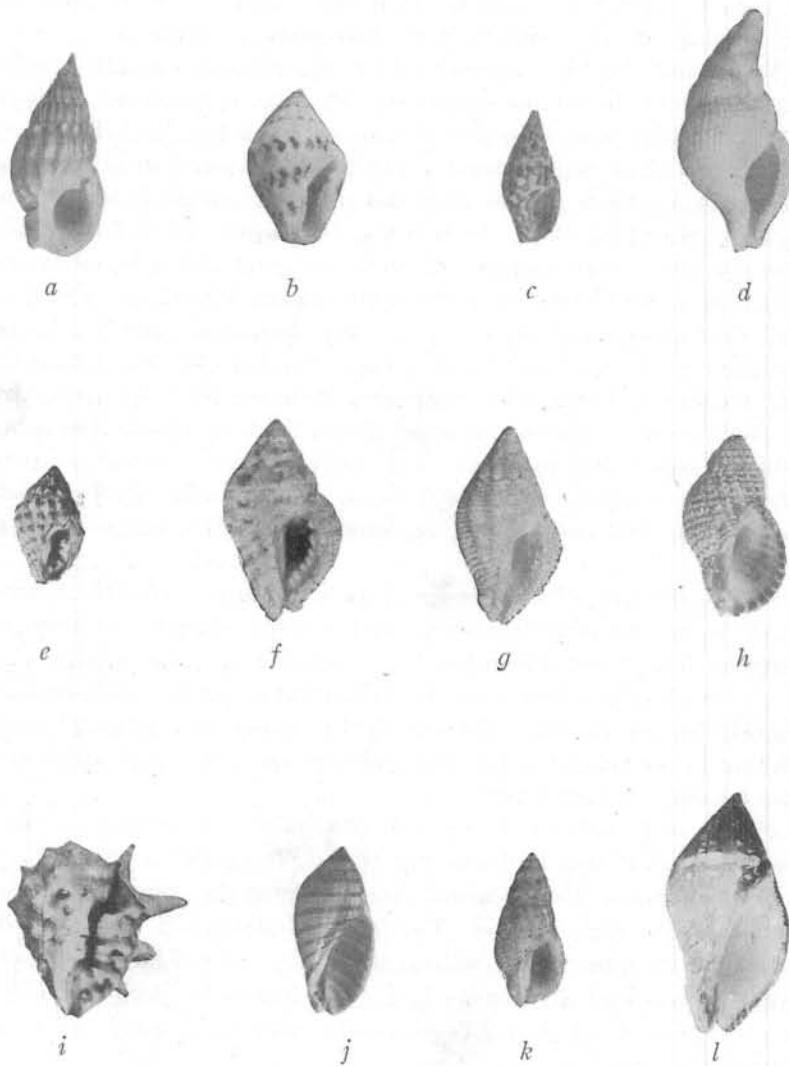


FIGURE 60.—Prosobranchia: a, *Alectrion hirtus*; b, *Columbella varians*; c, *Columbella zebra*; d, *Colubraria distorta*; e, *Morula tuberculata*; f, *Morula* species; g, *Morula porphyrostoma*; h, *Thais harpa*; i, *Drupa ricinus*; j, *Vexilla taeniata*; k, *Maculotrion bracteatus*; l, *Nassa sertum*.

obscure tubercles. It is about 2 inches long. In *T. harpa* Conrad (*Nucella harpa* Conrad) (fig. 60, *h*) the brown shell is encircled by costae and spotted with white. Its length is 1.25 inches.

Among species of *Vexilla* the most familiar one is *V. taeniata* Powis (fig. 60, *j*) (probably *V. vexillum* Chemnitz). The brown shell is spirally marked with six to eight narrow, light brown bands. Its length is 1 inch. A slightly smaller species, *V. striatella* Garrett, has a dark brown shell encircled with narrow white lines. Its aperture is relatively longer than that of *V. taeniata*. Specimens are about 20 mm. long.

In *Maculotriron bracteatus* Hinds (fig. 60, *k*) the shell has an elongated spire and is encircled by granulated ridges which, in young specimens, bear whitish tubercles tipped with dark brown. Older shells are smoother and less highly colored than young ones. The shell is about 20 mm. long. The shell of *Nassa sertum* Bruguiere (fig. 60, *l*) is smooth or finely striated and varies in color from brown with yellowish-white blotches to purplish red with light purple spots. Large specimens slightly exceed 2 inches in length.

An easily distinguished species, *Pinaxia versicolor* Gray, has a yellowish shell clouded with the same color and encircled by narrow bands of brown. The aperture is large and yellow within. Adult specimens are about 18 mm. long. The species lives among seaweeds.

The white, fusiform shell of *Vitularia sandwichensis* Pease is ornamented by six oblique varices. The aperture is oblong with a short canal and teeth within the outer lip. Large specimens are about 1 inch long. In *Aspella anceps* (Lamarck) the white shell is plicated between the varices and encircled by spiral lines. It may reach 1 inch in length. The living animal is seldom observed, and most shells collected are old and worn in appearance.

A well-known form, brought within the genus *Vexilla* by some authorities, is tentatively listed here under the name *Ussilla fusconigra* Pease. It differs from *Vexilla* in having a sharp spire and narrow aperture. The dark brown or nearly black shell is roughened by circular, granulated ribs. Specimens are about 15 mm. long. It bears close resemblance to species of Planaxidae (p. 153), to which family it may rightly belong.

FAMILY CORALLIOPHILIDAE

Species of *Coralliophila* are found in crevices of porous rocks in shallow water or attached to colonies of living coral. Their shells are bulbous

in form encircled by ribs of more or less prominence. An operculum is present.

In *C. neretoidea* Lamarck (fig. 61, *a*) the white shell has a short, blunt spire and is purple within the aperture. Its length is about 1.5 inches. Some authorities consider *C. bulbiformis* Conrad, with the spire prominent, the spiral ribs strong, and the margin of the outer lip wrinkled, a subspecies of *C. neretoidea*. Its length is about 1.25 inches. Another species, *C. deformis* Lamarck, has a small acuminate spire and a greatly inflated aperture. It is 1.5 inches long.

Other representatives of the family also are associated with living corals. The species *Rhizochilus madreporarum* Sowerby which has a low, domelike shell with a broad aperture is found attached to coral colonies. Large specimens are 1 inch long.

Species of *Magilus* are bulbous forms found embedded in living corals. The aperture of the shell is large, and the spiral end is more or less pointed. As the coral colony grows, the mollusk embedded within it develops a calcareous tube at the aperture by means of which it communicates with the exterior. Two local species are known. In *M. striatus* Rüppell the shell is more bulbous, less pointed at the spiral end, and smaller than *M. lamarckii* Deshayes. Specimens of the smaller form 10 mm. long are frequently found in colonies of *Cyphastrea ocellina*, but other corals harbor one or the other species of mollusk.

FAMILY EPITONIIDAE

Members of this family have white, polished shells with numerous whorls and an entire, circular aperture protected by an operculum. The surface is ornamented with longitudinal ribs or lamellae. These mollusks are considered to be closely related to those of the family Ianthinidae, though they are adapted for creeping instead of floating.

At least a dozen species of the genus *Epitonium* have been recorded from Hawaiian shores. Some of these are but seldom observed. The largest species of the islands and apparently the most common is *E. perplexum* (Pease) (fig. 61, *b*) which has eight inflated whorls with numerous thin longitudinal ribs. The shell is smooth between the ribs, flesh colored and darker at the sutures. Its length is about 1.5 inches. In *E. furcatum* (Pease) the shell has 10 strong ribs with spiral striae between them. It is white clouded with brown and is about 15 mm. long. The species *E. decussatum* (Pease) has a white shell with seven stout ribs and spiral striae between them. It is less than 10 mm. long. The slender

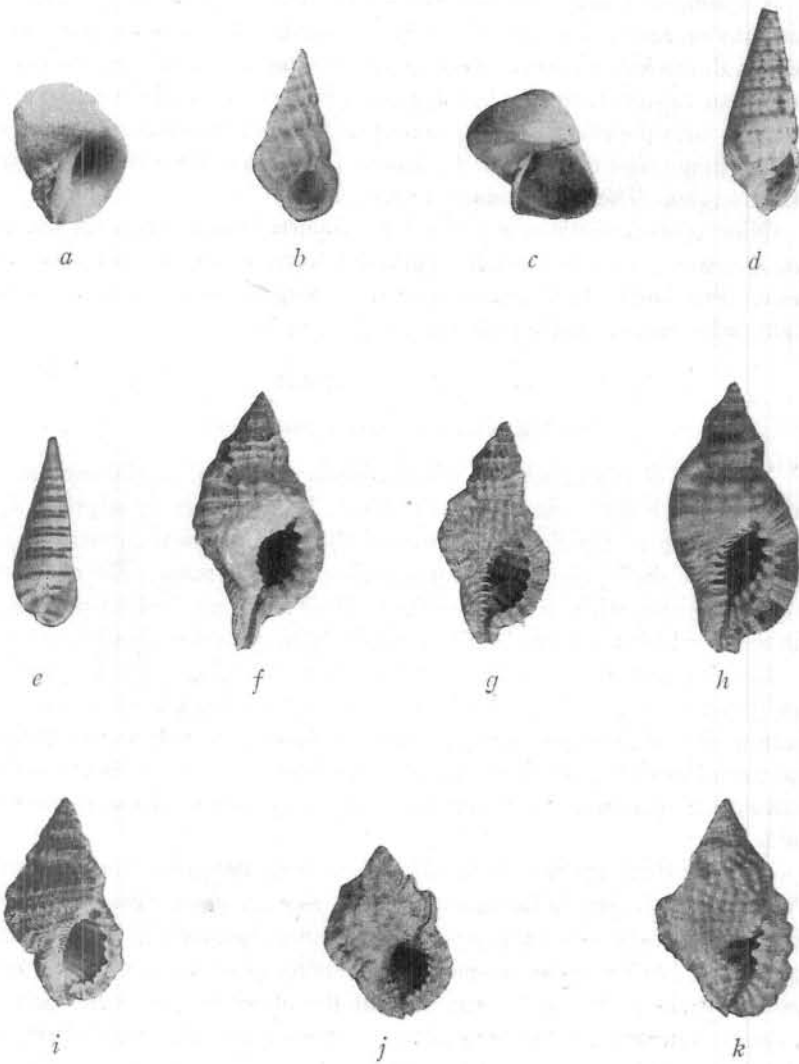


FIGURE 61.—Prosobranchia: *a*, *Coralliophila neretoidea*; *b*, *Epitonium perplexum*; *c*, *Lanthis fragilis*; *d*, *Pyramidella sulcata*; *e*, *Pyramidella terebellum*; *f*, *Cymatium tuberosum*; *g*, *Cymatium gemmatum*; *h*, *Cymatium pileare*; *i*, *Bursa affinis*; *j*, *Bursa siphonata*; *k*, *Distorsio anus*.

white shell of *E. kanemoe* Pilsbry is slightly less than 12 mm. long and has eight delicate ribs on the last whorl with spiral lines between them. In *E. oahuense* Pilsbry the thin shell is clouded with brown and has 14 thin ribs on the last whorl. It slightly exceeds 12 mm. in length. The shell of *E. ulu* Pilsbry has 21 delicate ribs on the last whorl. It is slightly more than 12 mm. long. In *E. attenuata* (Pease) the shell is narrow and tapering, with the ribs on the last whorl nodose and indistinct. It is about 12 mm. long. The thin ribs of *E. alatum* (Sowerby) have sharply angulated margins. The shell is about 18 mm. long.

Other species of the genus have been reported from Hawaiian waters but, like some of those already mentioned, have been taken only once or twice. The family is a difficult one for the taxonomist because of the slight differences which separate some of the species.

FAMILY IANTHINIDAE

(IANTHINIDAE OF SOME AUTHORS)

Mollusks of this family are pelagic forms supported on the surface of the ocean by a float secreted by the foot. The eggs are attached to the under surface of the float. Because of their habits these animals have light, fragile shells, globular in form, and with few whorls. The aperture is quadrangular, without an operculum. Most shells are violet-tinted, and the spires which are turned up toward the light are more deeply colored.

Floating species are often widely distributed, and mollusks of this family become a part of the Hawaiian fauna by drifting ashore or into the shallow waters about the islands. They are believed to feed upon jellyfish and are observed about Hawaii associated with *Velevella* (p. 28) and the Portuguese man-of-war. When disturbed they secrete a violet-colored fluid.

At least three species of *Ianthina* have been recorded from Hawaii. Two of these, *I. fragilis* Lamarck (fig. 61, c) and *I. globosa* Swainson, are about equal in size when full grown, being 1.5 inches across. In *I. fragilis* the whorls are somewhat angular. In *I. globosa* they are rounded and there is a short channel at the base of the aperture. A third species, *I. exigua* Lamarck, is much smaller and more conical than either of the other two. Its breadth is about 18 mm.

FAMILY MELANELLIDAE

Mollusks with elongated, highly polished shells belong to this family. More than 30 known species inhabit the shallow waters about Hawaii;

but they are distinguished with difficulty, as they vary but slightly from each other and generally lack ornamentations and color. Some are free-living and others are parasitic on or in echinoderms. Among the common sea cucumbers, *Holothuria atra* and *Holothuria cinerascens*, especially, are parasitized. The tiny white shells are partially embedded in the tough skin and probably suck the juices from it. Some representatives of the family completely bury themselves in the tissue of starfishes, causing tumors to develop in the host. Sea urchins are also common hosts of certain of these gastropods.

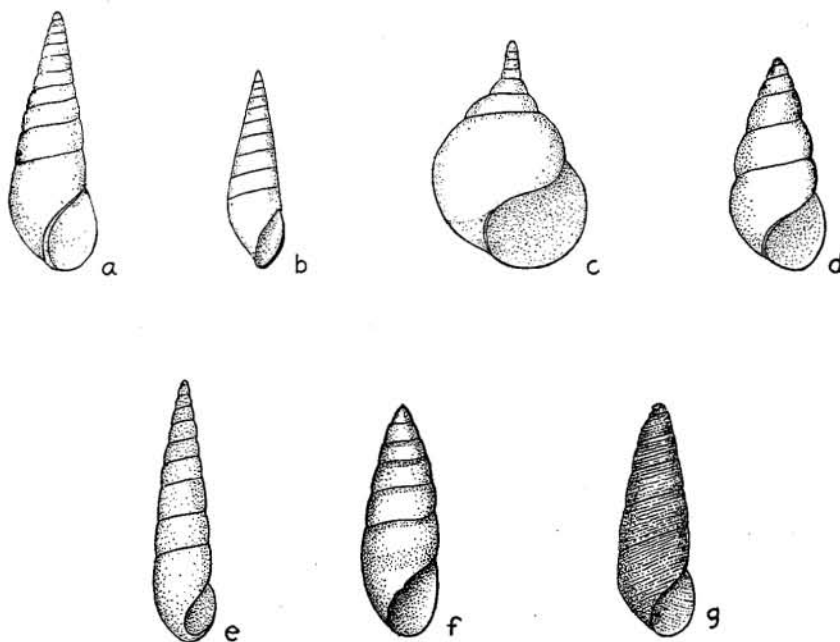


FIGURE 62.—Prosobranchia: a, *Melanella cumingi medipacifica*; b, *Melanella aciculata*; c, *Stylifer mittrei* (young specimen); d, *Mucronalia nitidula*; e, *Turbonilla elizabethae*; f, *Odostomia prima*; g, *Odostomia electa*.

Species of *Melanella*, *Stylifer*, *Mucronalia*, and *Strombiformis*, are recognized in local waters. In *Melanella* the whorls are flat, the shell gradually tapering to the apex. In *Stylifer* the whorls are bulbous and the spire is narrow and very sharply pointed. In *Mucronalia* the whorls are slightly inflated and the shell ends rather abruptly in a narrow apex.

About 20 species of *Melanella* have been described from Hawaiian

waters, only a few of which are mentioned here. Among the larger, free-living forms are *M. cumingi medipacifica* Pilsbry (fig. 62, a), *M. thaanumi* Pilsbry, and *M. labiosa* Sowerby. In *M. cumingi medipacifica* the white shell has about 13 whorls, an almost straight spire, and is about 1.4 inches long. The shell of *M. thaanumi* is glistening white, has a curved spire, and is about 1 inch long. In *M. labiosa* the curved shell differs from that of *M. thaanumi* in being more conical. Its length is 1 inch.

Among the smaller and usually parasitic forms of *Melanella* are *M. aciculata* Pease (fig. 62, b), *M. vafra* Pilsbry, *M. bryani* Pilsbry, and *M. ima* Pilsbry. In *M. aciculata* the slender, shining shell has a slightly bent spire and is about 8 mm. long. In *M. vafra* the spire is curved in two directions. It is bluish white and 10 mm. long. The shell of *M. bryani* is large at the apertural end and is slightly curved. Its length is 20 mm. In *M. ima* the white shell, which is less than 5 mm. long, is slightly curved.

Several species of *Stylifer* have been recorded from the islands. Two of these, *S. mittrei* Petit and *S. thaanumi* Pilsbry, are parasitic on the sea urchin *Echinothrix diadema*. In *S. mittrei* (fig. 62, c) the yellowish-white, glossy shell abruptly expands from a narrow apex to the bulbous apertural end. Its length is about 10 mm. The shell of *S. thaanumi* is globose at the apertural end and gradually tapers to a sharp slender apex. It is about 5 mm. long.

The subspecies *S. deformis hawaiiensis* Pilsbry has been taken from Honolulu Harbor. The thin white shell has the upper fourth flattened and acuminate, with the rest more inflated. The whorls are strongly convex. Its length is about 10 mm. Another subspecies, *S. deformis remotissimus* Pilsbry, was collected at Pearl and Hermes Reef. The first nine whorls are narrow, flat, and slightly curved. The next two whorls become abruptly larger. The rest of the shell is cylindrical. The length slightly exceeds 8 mm. Another species, *S. robustus* Pease, is white, somewhat ovate, with the surface faintly striated longitudinally and the last whorl swollen.

The species *Mucronalia nitidula* Pease (fig. 62, d) is a common form on *Holothuria atra*. The shell is thin, polished, with five somewhat convex whorls, of which the three nuclear ones are slightly distorted. It usually has a brownish tint. Large specimens are 5 mm. long.

Another representative of the family occasionally observed in shallow water is *Strombiformis metcalfi* (A. Adams). It is a free-living form. The shell has few whorls, and the last is large. The white sur-

face is marked with interrupted bands and oblique lines of brown. Large specimens are about 12 mm. long.

FAMILY PYRAMIDELLIDAE

Mollusks with elongated, pyramidal shells, smooth or sculptured, represent this family. The columella, in some forms, bears folds or teeth, and there is an operculum. Young shells have the initial whorls sinistral while the later ones of the adults are dextral.

In species of the genus *Pyramidella* there are three folds on the columellar lip of the shell. The familiar Hawaiian form *P. sulcata* A. Adams (fig. 61, *d*) has a smooth white shell marked with longitudinal dashes of brown or circular rows of dots of the same color. It is 1.5 inches long. In *P. terebellum* Müller (fig. 61, *e*) the smooth white shell has three or four spiral brown lines on the body whorl and two on each of the other whorls. Its length is 1 inch. The shell of *P. nitida* A. Adams is longitudinally ribbed. It is white, mottled with pale brown. Large specimens are 10 mm. long. Species of *Pyramidella* are typical inhabitants of shallow bays, where they conceal themselves just beneath the surface of the sand.

Species of *Turbonilla* and *Odostomia* somewhat resemble each other in that most forms have slender shells with numerous whorls. In *Turbonilla*, however, the columella lip is smooth, whereas in *Odostomia* it bears a tooth. Species of both genera range from the shore line into deep water. Their empty shells mingle with the beach sand, and living specimens are occasionally collected on the reefs.

About a dozen species of *Turbonilla* have been described from Hawaii, only a few of which are here considered. In *T. elizabethae* Pilsbry (fig. 62, *e*) the shell is marked by faint spiral striae. It is white, except for the first four or five whorls of the spire, which are pink. Specimens are 6 mm. long. The shell of *T. laysanensis* Pilsbry differs from that of *T. elizabethae* chiefly in being a little broader and in having fewer whorls although it is usually longer. Its length is about 8 mm. In *T. ablectamentum* Pilsbry the shell is sculptured by longitudinal ribs—about 17 on the last whorl. The ribs become indistinct on the base of the body whorl. The shell length is 2.5 mm. The shell of *T. kauaiensis* Pilsbry differs from that of *T. ablectamentum* in being slightly longer, more slender, and ornamented by more numerous and straighter ribs which extend over the base of the last whorl as faint lines.

Twenty or more species of *Odostomia* are found about the shores. A few of the more common ones are here considered. In *O. prima* Pilsbry (fig. 62, *f*) the glossy white shell is smooth with a gray band below the suture and a yellowish one in the middle of the last whorl. Its length is 6 mm. The shell of *O. electa* Pilsbry (fig. 62, *g*) is slender, white, marked by weak longitudinal lines and fine unevenly spaced spiral threads. Its length is slightly less than 5 mm. Some specimens are encircled by two brown bands. In *O. haleiwiensis* Pilsbry the shell differs from that of *O. electa* chiefly in having stronger longitudinal lines and the spiral striae more evenly spaced. The shell of *O. gulicki* Pilsbry is thin, smooth, and white, with the apex obtuse and the sutures deep. It is about 2.5 mm. long. The species *O. letsonae* Pilsbry is characterized by the two spiral ridges on each whorl, those of the last whorl being farther apart. The aperture is oblique. The length is slightly more than 2.5 mm. One of the smaller forms is *O. kahoalawensis* Pilsbry, which has a whitish shell with a blunt apex and convex whorls. Opaque spiral bands mark the surface. The tooth on the columella is sharp and there are several spiral lines on the inner surface of the outer lip. The length is about 1.5 mm. A strongly sculptured species, *O. pupu* Pilsbry, has a white, solid shell encircled by three smooth, raised keels. Fine longitudinal lines mark the spaces between the ribs. It is 2.5 mm. long. The shell of *O. secunda* Pilsbry is pale brown in color with a gray band at the suture. A few faint longitudinal lines mark the surface. It is slightly less than 5 mm. long.

FAMILY CYMATIIDAE

Tritons and their allies are distinguished by heavy, elongated shells which are roughened by wrinkles and varices. In some the surface is covered with a hairy epidermis. Both the columella and the thick outer lip are generally crenated or toothed. An operculum is present. There is a well-developed anterior canal and in some species a posterior one also. Large and beautifully colored shells are produced by some representatives of the family. All are scavengers, feeding on decaying organic matter.

In the genus *Cymatium* the aperture is elongated, and there is a row of teeth on the inner border of the outer lip. Several well-known species inhabit the rocky shores and reefs. The shell of *C. tuberosum* Lamarck (fig. 61, *f*) is brownish, longitudinally ribbed, and especially

distinguished by a long, slightly bent canal. Its length is 2.5 inches. In *C. gemmatum* Reeve (fig. 61, *g*) the whitish or orange-yellow shell is roughened by longitudinal ribs and spiral ridges with nodules between. Its length is about 1.5 inches. The species *C. chlorostoma* Lamarck is white with red or chocolate-brown spots and a bright orange aperture. It may reach a length of 3 inches. In *C. pileare* Linnaeus (fig. 61, *h*) the yellowish-brown shell is marked by lighter or darker brown bands. The columella and aperture are orange-red with white plications. Living specimens are covered with a thin olive-colored epidermis bristling with hairs. Large specimens are 3 to 5 inches long.

The genus *Bursa* is characterized by a slightly compressed shell with a row of varices on each side and a short, curved canal. Several species are recognized in shallow water. The shell of *B. affinis* Broderip (fig. 61, *i*) is yellowish white with irregular spots of brown, and rose-tinted at the apex. The tubercles are larger at the angle and sometimes subdivided. The shell is about 2 inches long. In *B. bufonia* Gmelin the shell is white with brown spots. The interior of the aperture is yellowish or white. There is a curved canal at either extremity of the aperture. The length is 2 inches. Both forms, *B. siphonata* Reeve (fig. 61, *j*) and *B. venustula* Reeve, which are considered by some authorities to be varieties of *B. bufonia*, often have the columella and outer lip stained dark purple. In *B. cruentata* Sowerby the shell is yellowish or brownish white and has tubercles spotted with red. The aperture is white or rose-tinted, and the columella is sometimes marked with red spots. Its length is about 1.5 inches.

In the genus *Distorsio* the shell has an irregular, distorted spire and a very rough surface. The contracted aperture is bordered by teeth. The species *D. anus* Linnaeus (fig. 61, *k*) reaches a length of about 2.5 inches. It is less common on the reefs than at depths of 4 or 5 fathoms. A smaller species, *D. pusilla* Pease, with an oblong-ovate shell about 1 inch long, is occasionally taken in shallow water.

The species *Gyrineum polychlorum* Tapparone, also known as *Ranella pusilla* Broderip, has a compressed shell with varices on the borders. It may vary from white with rose tints and yellow varices to brown with a white median band. Large specimens are 20 mm. long.

The large triton, *Charonia tritonis* Linnaeus (fig. 63, *c*), which reaches a length of about 16 inches, occurs in shallow bays and in off-shore water about the islands. It is beautifully decorated with white, yellow, and brown markings. The spire is pink and the aperture orange-

red. A large hermit crab, *Dardanus punctulatus*, often occupies the shell of this triton.

FAMILY CASSIDIDAE

Cassis shells are thick, globular, with short spires. The surface is smooth or rough, and the aperture has a short, narrow canal and an operculum. A growth of shelly material (callus) is developed on the columnar area.

The best-known Hawaiian species is *Cassis vibex* Linnaeus (fig. 63, *b*), which has a smooth, ash-colored shell, marked with brown bands or longitudinal stripes. It is orange-brown within the aperture. Large specimens are 3 inches long. The species occurs in shallow water about the leeward islands and has been dredged from Honolulu Harbor. It is seldom collected alive on the reefs of the larger islands. In *C. torquata* Reeve, considered by some authorities to be a variety of *C. vibex*, the shell is flesh colored with rows of brown spots on the sutures. Its length is about 1.75 inches.



FIGURE 63.—Prosobranchia: *a*, *Tonna perdirix*; *b*, *Cassis vibex*; *c*, *Charonia tritonis*.

A large species, *Cassis cornuta* Linnaeus, has the shell roughened with spiral rows of tubercles. It is yellowish white, spotted and tinted with brown. Living specimens have been reported from about the leeward islands and shells are occasionally washed ashore, but the species is not a usual inhabitant of shallow water. Large specimens reach a length of 12 inches.

FAMILY DOLIIDAE

Mollusks with thin, globular shells and large, inflated apertures represent this family. The adult has no operculum. Among the few Hawai-

ian species, *Tonna perdirix* Linnaeus (fig. 63, a) is the most familiar. Its shell is reddish brown, marked with whitish spots and encircled by low ribs. Large specimens are 6 inches long. It is occasionally taken on the reefs. Some of the larger hermit crabs often occupy the shells of this species. The largest local species is *Tonna melanostoma* Jay, which grows to a length of at least 9 inches. It has broad encircling ribs with small ridges and grooves between. The columella and outer lip are dark brown. Some very large specimens have been taken about the leeward islands, but few are seen on the reefs of the main islands. A smaller species, *Malea pomum* Linnaeus, has a white or light brown shell with the surface spirally ribbed and both lips dentate. Its length is from 2 to 3 inches. It seems to frequent depths of 4 or 5 fathoms and does not often come into the more shallow water of the reefs.

FAMILY CYPRAEIDAE

Members of this family are known as cowries. A typical adult has a broadly oval shell with a highly polished surface and a long narrow aperture with teeth on the borders. There is no operculum. In young or half-grown specimens the shell is very thin and shows the true spiral form. The spire becomes gradually enclosed by an overgrowth of the shell, and in the adult is entirely invisible from the outside. Complete development of the teeth bordering the aperture is also an indication of the adult stage.

When the cowry is active, the mantle lobes of the animal are extended up over the convexity of the shell, completely concealing it. In this condition numerous branched, tactile processes are developed from the surface of the mantle.

The eggs of cowries when laid are enclosed in short, cylindrical capsules which are attached by one end and stand erect in crowded clusters. It has been observed that the animal rests with the foot spread over the capsules until the eggs are hatched.

Because of their color, species of *Cypraea* are among the most attractive of mollusks to the collector of marine shells. Twenty-nine known Hawaiian species, of which five are endemic, range from the shore to depths of several fathoms. Considerable variation is sometimes seen in the size and form of shells of the same species taken from different localities. Unknown factors in the environment seem to influence the growth of the shell in particular directions. By patient searching, living

specimens of about a dozen species may be found on the reefs. Others are represented by shells washed up on the beaches or in dredged material. Few species are plentiful in shallow water.

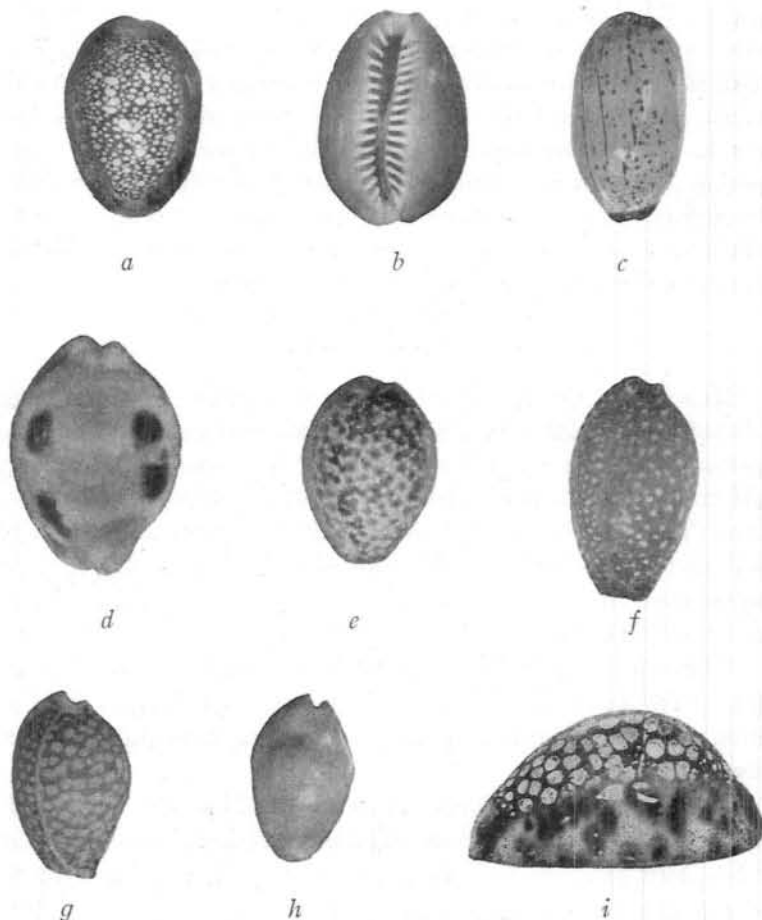


FIGURE 64.—Cypraeidae: a, *Cypraea caputserpentis*, dorsal surface; b, *Cypraea caputserpentis*, ventral surface; c, *Cypraea isabella*; d, *Cypraea tessellata*; e, *Cypraea helvola*; f, *Cypraea semiplota*; g, *Cypraea peasei*; h, *Cypraea moneta*; i, *Cypraea reticulata*.

Among the shallow water *Cypraea*, the most familiar is *C. caputserpentis* Linnaeus (fig. 64, a, b), which has a dark brown shell flaked above with white specks. The base is lighter and the teeth are white. It

is a gregarious species found under stones near shore. Its length is about 1.25 inches. A less common species, *C. isabella* Linnaeus (fig. 64, c), is cylindrical, grayish, with longitudinal black streaks above. Its length is 1.5 inches. In *C. helvola* Linnaeus (fig. 64, e) the shell is olive-brown with a bluish tint, spotted above with white and brown. The sides and base are reddish and the extremities violet. Large specimens are about 1 inch long. It is occasionally taken near shore. Another species, *C. moneta* Linnaeus (fig. 64, h), has a yellowish-white, depressed shell, the margins of which are thick and the teeth blunt. It may reach a length of 1.5 inches. In *C. madagascariensis* Gmelin, an endemic species, the white or pale yellow shell is marked by transverse ribs bearing small tubercles above. It slightly exceeds 1 inch in length. Both *C. moneta* and *C. madagascariensis* are apparently widely dispersed about the islands but seem to be more common in certain localities than others. Neither species is common about Oahu. Another species occasionally observed on the reefs is *C. peasei* Sowerby (fig. 64, g). The pale yellowish shell is spotted above with white and the margins and base are dotted with reddish brown. It is about 1 inch long.

There are a few species of *Cypraea* inhabiting local reefs which are recognized by transverse bands of color, but none of them are considered to be common in shallow water. The shell of *C. carneola* Linnaeus is pale brown, crossed by four or five bands of deeper brown. It is from 1 to 3 inches long. The species *C. tessellata* Swainson (fig. 64, d), endemic in Hawaii, has a yellowish-brown shell, crossed by three broad bands of brown and marked on the sides by brown and white squarish spots, of which four chocolate-colored spots are very conspicuous. It is 1 to 2 inches long. The smallest local species is *C. fimbriata* Gmelin, which is slate colored with a brown central band, and violet-tinted at the extremities. In length it is about 15 mm.

The most common of the smaller species of *Cypraea* about local shores, *C. semiplota* Mighels (fig. 64, f), has a light brown shell typically ornamented with minute white spots. Specimens vary considerably in form, size, and color. Large shells are nearly 1 inch long. It is endemic in Hawaii.

Among the larger Hawaiian species inhabiting rocky shores exposed to the dash of the waves, or the outer edge of the reef where the surf is strong, are *C. reticulata* Martyn and *C. mauritiana* Linnaeus. In *C. reticulata* (fig. 64, i) the upper surface is covered with white or pale brown spots crowded or run together. The base is white or bluish,

with a brown spot on the columellar side near the middle. Large specimens are 3 inches long. In *C. mauritiana* the back is humped and covered with light brown or white spots of irregular size. The sides and base are black. Large specimens are 4 inches long.

There is evidence that the large spotted cowry, *C. tigris* Linnaeus, lives in offshore water about the islands, and occasionally it is taken on the outer reefs in a few feet of water. The species seems to attain a larger size in Hawaii than in localities south of the equator, where it is abundant. A living specimen taken in 6 feet of water off Hauula, Oahu, had a shell 5.75 inches long.

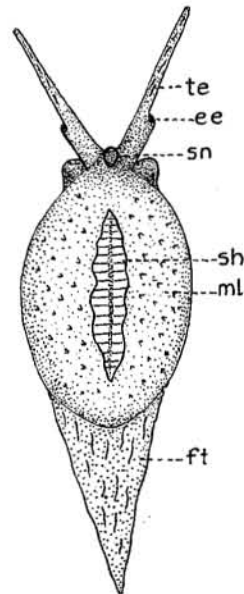


FIGURE 65.—*Trivia insecta* drawn from a living specimen (*ee*, eye; *ft*, foot; *ml*, mantle; *sh*, shell; *sn*, siphon; *te*, tentacle).

FAMILY TRIVIIDAE

Species of *Trivia* which resemble miniature forms of *Cypraea* are ornamented by fine transverse ribs, and some have a depression along the mid-dorsal line. Living specimens are found in crevices of rocks in shallow water, and their empty shells are often taken in beach sand. When alive they are very active, and the soft parts are beautifully tinted and colored. (See fig. 65.)

Among Hawaiian species, *T. insecta* Mighels (fig. 66, *a*) is common. The shell is elongate-ovate, white, with a long dorsal furrow. It is about 5 mm. long. In *T. oryza* Lamarck the ovate shell is white, with the extremities somewhat produced. Its length is 8 mm. The species *T. tremeza* Duclos is recognized by the oval white shell which is stained with rose-red. Its length is 5 mm. In *T. pilula* Kiener the white shell is round, 5 mm. in diameter.

Associated with species of *Trivia* in shallow water is another tiny mollusk, *Erato sandwichensis* Pease (fig. 66, *b*). The pale, rosy-white shell is smooth with a short spire and a long narrow aperture, the outer lip of which is thickened. Two faint brown bands cross the shell. The length is about 5 mm.

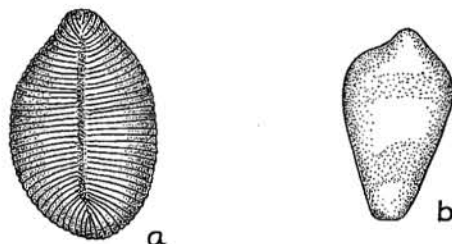


FIGURE 66.—Triviidae: *a*, *Trivia insecta*; *b*, *Erato sandwichensis*.

FAMILY STROMBIDAE

Species of *Strombus* have thick shells with cone-shaped spires. The aperture may be broad with a dilated outer lip, or narrow with both lips thickened. An operculum is present. The living animal has highly specialized eyes like those of a cephalopod, and a foot, unadapted for creeping, which serves as a lever in the leaping movement characteristic of these mollusks.

The most common species about Hawaii is *S. maculatus* Nuttall (fig. 67, *a*). It has a smooth, polished shell with the spire encircled with fine striae. The surface is white, clouded and mottled with brown. The shell length is 1.5 inches. In *S. helli* Rousseau the inflated shell is longitudinally ribbed and the narrow aperture is bordered by thickened lips. It is occasionally taken in shallow water, but more frequently dredged from depths of a few fathoms. Its length is 1 inch. The species *S. tridentatus* Lamarck has an elongated, smooth shell slightly grooved at the base. The white surface is often mottled with brown, and it is purple within the aperture. Three teeth are borne on the anterior margin of the outer lip.

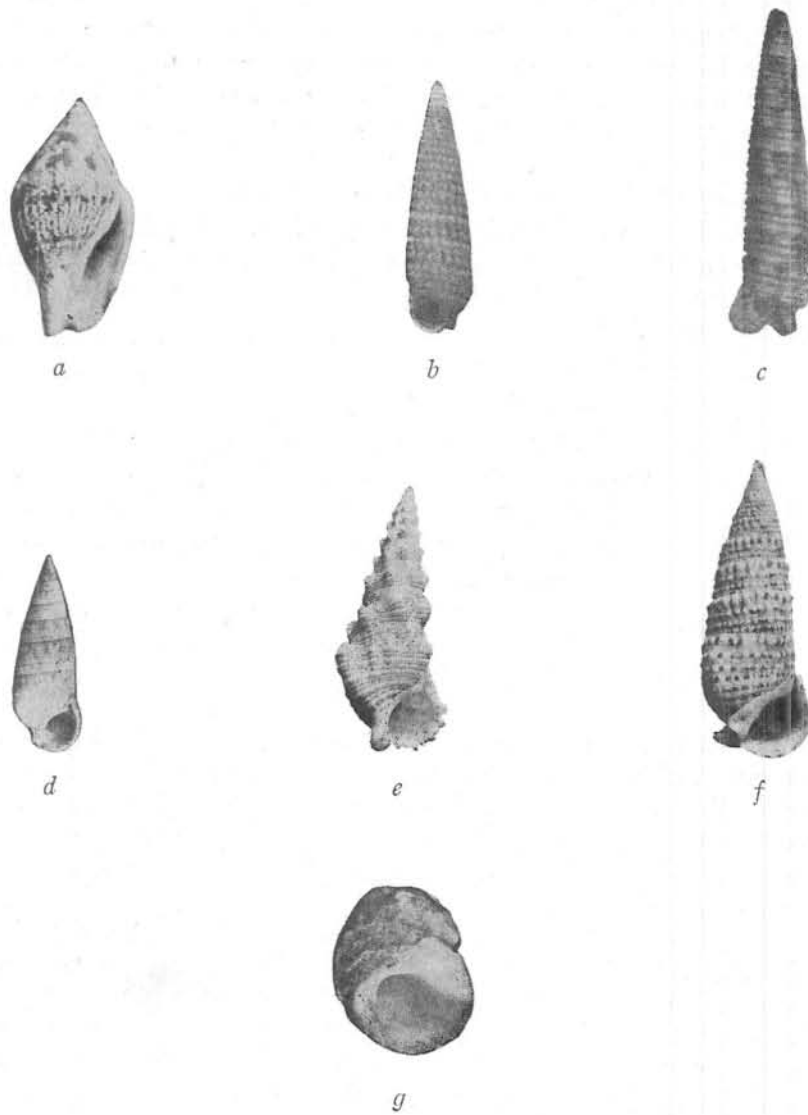


FIGURE 67.—Prosobranchia: *a*, *Strombus maculatus*; *b*, *Triforis pallidus*; *c*, *Triforis incisus*; *d*, *Cerithium nesioticum*; *e*, *Cerithium columna*; *f*, *Clava obeliscus*; *g*, *Modulus tectum*.

The species is an inhabitant of depths of 4 or 5 fathoms. Its length is about 1.75 inches. Another species, *S. hawaiiensis* Pilsbry, has the outer lip produced into a winglike expansion, and circular ribs and blunt tubercles roughen the surface. The species was described from the leeward islands, where numerous specimens were taken. It has also been dredged from Honolulu Harbor. Its length is about 3 inches.

FAMILY TRIFORIDAE

Mollusks of this family have small shells with many whorls coiled to the left (sinistral). The surface is sculptured and the small aperture has a tubular canal. An operculum is present.

Apparently many of the numerous Hawaiian species are quite similar in appearance, and their determination is difficult. Among those more easily recognized, *Triforis cingulifera* Pease is common. The shell has 10 whorls, marked by shades of yellow and brown and encircled by alternate rows of large and small rounded granules. Its length is about 6 mm. In *Triforis incisus* Pease (fig. 67, c) the whorls are encircled by three smooth ribs and are finely striated longitudinally. The shell is mottled with yellow, white, brown, and purple. Specimens are about 10 mm. long.

In *Triforis bicolor* Pease the numerous whorls are ornamented by rounded granules in three spiral series. Two spiral bands of color, one white and the other black, mark the whorls. The sutures are deep. The shell length is 6 mm. The white shell of *Triforis pallidus* Pease (fig. 67, b) is smooth and polished, the surface ornamented by granules in three series. Its length is 6 mm. The shell of *Triforis triticea* Pease is ovate, fusiform, with three spiral rows of granules. It is purplish red with the granules dusky white. Specimens are less than 5 mm. long.

In the shell of *Triforis tuberculata* Pease there are three series of granules, and the middle one is the smallest. White and brown spots are irregularly disposed on the surface. The shell is about 8 mm. long. The robust, solid shell of *Triforis oryza* Pease is encircled by three series of equal-sized granules, the upper series of which is white. Its length is less than 5 mm. A large species, *Triforis clavata* Pease, has the whorls bordered on each side by a row of granules, and the spaces between the granules are spirally striated. The shell is yellowish or whitish with the striated areas purple or reddish brown. It is 12 mm. long.

Many other species, showing but slight differences, may be found on the reefs and in offshore water.

FAMILY CERITHIIDAE

Representatives of this family have elongated shells with many whorls which are usually roughened by tubercles or coarse ridges. The sub-circular aperture is protected by an operculum. They are vegetable feeders, and some species frequent brackish water.

Numerous species are found about the shores of Hawaii, ranging from the water's edge to moderate depths. Minute forms, probably young specimens, are abundant among seaweeds near shore. They are difficult of classification because of their small size, and some of them probably represent undescribed species.

An easily distinguished species, *Clava obeliscus* Bruguiere (fig. 67, f), has a yellowish-white shell spotted with brown. The whorls are encircled by tuberculated ribs with granulated striae between. There is a short, bent anterior canal. Large specimens are about 2.5 inches long. In *Cerithium columna* Sowerby (fig. 67, e) the inflated whorls are spirally ridged and crossed longitudinally by low broad ribs. The shell is about 1.5 inches long.

Among the smaller, well-known species of *Cerithium* about the islands are *C. baeticum* Pease, *C. nesioticum* Pilsbry and Vanatta, and *C. thaanumi* Pilsbry. In *C. baeticum* the thin shell is marked spirally by alternate, shallow yellow grooves and low, brown ridges. The whorls of the spire are longitudinally ribbed and tuberculate. The length is 10 mm. The shell of *C. nesioticum* (fig. 67, d) is solid, turreted, and white with brown spots below the sutures. Low ridges encircle the whorls and the lateral lines of the shell are somewhat convex. The length is 20 mm. In *C. thaanumi*, the shell is more slender than in *C. nesioticum* but is encircled by coarser ridges, with the aperture more laterally expanded. Its length is about 15 mm.

FAMILY MODULIDAE

One representative of this family, *Modulus tectum* Gmelin (fig. 67, g), is occasionally collected on local reefs. The shell is thin, bulbous, with a depressed spire. It is white, mottled with brown. The surface is spirally striate and slightly roughened by tubercles. An almost circular aperture is protected by an operculum. Specimens are about one inch in diameter.

FAMILY PLANAXIDAE

Species of this family have ovate shells with elevated spires. The columella is flattened and the outer lip is smoothly rounded. An operculum is present.

The widely distributed representative of the family in Hawaii is *Planaxis labiosus* A. Adams (fig. 68, *b*). It has a solid, smooth shell, brown and spirally marked with narrow, dark brown bands. Living specimens are covered with a short, pilose epidermis. Adults are about 12 mm. long. Shells of this species, occupied by small hermit crabs, are often found in large numbers under stones at the shore line.

FAMILY CAECIDAE

Young mollusks of this family have spirally coiled shells which become tubular in the adult stage; in some species the spiral nucleus disappears. A septum closes the nuclear end of the tube when the nuclear portion is removed, and a horny operculum closes the aperture.

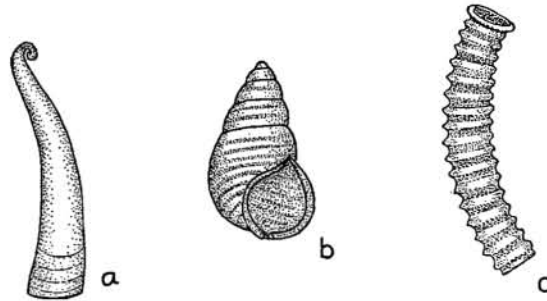


FIGURE 68.—Prosobranchia: *a*, *Strebloceras subannulatum*; *b*, *Planaxis labiosus*; *c*, *Caecum sepimentum*.

Several genera are represented in Hawaii. Some species are dredged from moderate depths and also taken near shore. Their shells are often found in the sand of reefs and beaches. In species of *Caecum* the nucleus, which is coiled in one plane, disappears, leaving an arched tube. The most familiar form is *C. sepimentum* de Folin (fig. 68, *c*), ornamented by 17 or 18 strong rings. Its length is about 2.5 mm. In *C. oahuense* Pilsbry the tube is encircled by about 40 small rings. A fragmented specimen, probably of this species, shows 35 rings. It is slightly less than 2.5 mm. long. Another species, *C. crystallinum* de Folin, was dredged off Honolulu in 40 fathoms. The shell expands near the aperture, is then constricted, and terminates in a reflected lip. It was described from a fragmented specimen.

In the genus *Strebloceras* the coiled nucleus persists in a plane obliquely perpendicular to the adult tube. The species *S. subannulatum* de Folin (fig. 68, *a*) has been dredged off Honolulu and also taken from about the shores of Oahu and Maui. The shell increases in diameter from the nucleus toward the aperture and is curved in two planes. It is glossy white, marked by faint circular lines. Its length slightly exceeds 2.5 mm.

The young shell of the genus *Meioceras* is loosely spiral in more than one plane. The adult is truncate behind, somewhat inflated, and smooth, with an oblique aperture. The operculum is concave externally. The species *M. sandwichensis* de Folin was described from the Hawaiian Islands without specified locality. The shell is dull white and strongly arched, the dorsal border being almost a semicircle. The ventral border is not arched in such a regular manner. Its length is less than 2.5 mm.

FAMILY VERMETIDAE

The shells of mollusks of this family are tubular in form, closely or loosely coiled, and often firmly attached to rocks. They resemble, in some degree, tubes of serpulid worms (p. 114) but differ from them in having internal septa and in being composed of three calcareous layers instead of two. When the living animals are observed the distinction between the mollusk and the worm is readily seen. In some forms of these mollusks there is a well-developed operculum; in others it is rudimentary or absent.



FIGURE 69.—Vermetidae, two undetermined species.

Although representatives of the family are not uncommon about the shores, where they may be found cemented to rocks in shallow water, the number of local species is probably not large. There is some doubt, however, about the determination of Hawaiian forms, and no attempt is made here to classify them specifically. (See fig. 69.) Tubes of large specimens may reach a length of 8 inches.

FAMILY LITTORINIDAE

The periwinkles, as these mollusks are called, are typical of the shore line. They often creep out of the water high up on rocks or stone walls and remain exposed to the air for a long time. A specimen of *Littorina pintado* remained attached to the plastered wall of the Marine Biological Laboratory, Honolulu, for nearly a year. When it was returned to sea water it regained its activity in a few minutes.

The shell of the periwinkle is globular with a short, pointed spire. The subcircular aperture is protected by an operculum, and the margin of the outer lip is entire.



FIGURE 70.—Littorinidae: a, *Littorina scabra*; b, *Littorina pintado*.

Among local species of *Littorina* the most common one is *L. pintado* Wood (fig. 70, b). The shell is yellowish white or gray, smooth or finely striate. Its surface is marked by minute brown dots, and on the inside of the aperture is a series of spiral streaks of dark brown. It is widely distributed on rocks along the shore and above the waterline. Large specimens are 20 mm. long. Another species, *L. picta marmorata* Philippi, less numerous and about one half the size of *L. pintado*, is brown speckled with white and roughened by spiral costae. The largest local species, *L. scabra* Linnaeus (fig. 70, a), which grows to a length of a little more than 1 inch, is yellowish or gray, marked with oblique brown bands. Along some shores this species is very abundant. A small conical species, *Peasiella tantilla* Gould (fig. 71, b), has four or five whorls with carinate borders. It is grayish, marked with radiating brown lines. Specimens are about 5 mm. in diameter.

FAMILY FOSSARIDAE

The family is represented by mollusks having small, sculptured shells with semicircular apertures. An operculum is present. Among the more familiar species of *Fossarus* in local waters are *F. multcostata* Pease,

F. garretti Pease, and *F. ephora* Pilsbry. In *F. multicosata* (fig. 71, *a*) the ovate white shell is marked by numerous spiral costae, there being a dozen or more on the last whorl with finer ones between. The species is about 5 mm. long. The shell of *F. garretti* is white, bulbous, with a very short spire. The last whorl is encircled by four or five thin, rather high costae, with finer lines between. The diameter is about 2.5 mm.

In *F. ephora* the white shell has a dark brown apex. Three prominent spiral ridges encircle each whorl with one or two finer ones on the last whorl. The diameter is about 2.5 mm.

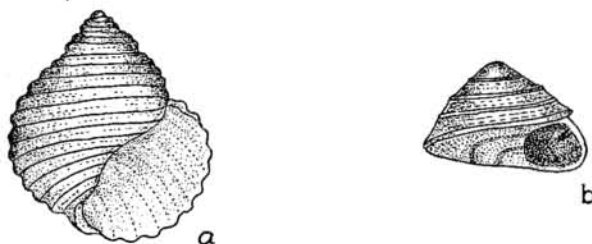


FIGURE 71.—Prosobranchia: *a*, *Fossarus multicosata*; *b*, *Peasiella tantilla*.

FAMILY SOLARIIDAE

Mollusks having flattened or conical shells with closely coiled whorls represent this family. The aperture, which is usually angular, is closed by an operculum, and there is a conspicuous umbilicus in the center of the base. Several well-known species are included in the Hawaiian fauna, but none are common near shore or in the shallow water of the reefs.

The largest local species, *Architectonica perspectiva* Lamarck (*Solarium perspectivum* Linnaeus) (fig. 72, *a*), has a flattened, pale brown shell, spirally marked with interrupted bands of deep chocolate-brown, two bands on each whorl of the spire and five on the body whorl. The umbilicus is wide and the operculum is thin. Large specimens are about 2.5 inches in diameter. The species is seldom observed close to shore, but frequents depths of 6 to 8 fathoms.

In the genus *Torinia* the operculum is thick and conical and consists of a number of whorls. The shell of *T. mighelsi* Deshayes is a depressed cone, ash colored, with four or five spirally striated whorls. Its diameter is about 10 mm. In *T. variegata depressa* Philippi (fig. 72, *b*) the depressed shell is white with radiating brown streaks. Its diameter is 15 mm.

In *T. cingulum* Kiener the flattened shell is spirally striated and ribbed at the periphery and near the umbilicus. It is whitish, the upper part of the whorls being yellowish brown. The pale brown base is slightly convex. Large specimens are nearly 1 inch in diameter. The subspecies *T. discoidea starkii* Pilsbry and Vanatta (fig. 72, *c*) has a depressed,



FIGURE 72.—Solarüidae: *a*, *Architectonica perspectiva*; *b*, *Torinia variegata depressa*; *c*, *Torinia discoidea starkii*.

biconvex shell with a flattened periphery. Five beaded spiral lines traverse the upper part of the shell, the first and fifth being the larger. Seven such lines mark the base. The last whorl is gray with white and brown spots along the periphery. Its diameter is about 5 mm. Another species recorded from Hawaii, *Torinia trochoidea* Deshayes, is more conical than others. It is grayish white, the whorls longitudinally striated and spirally ribbed. The rib at the periphery is elevated, strong, and granular. The margin of the umbilicus is crenulated. The shell is 20 mm. high.

FAMILY RISSOIDAE

Members of this family have small, solid shells with somewhat rounded apertures and thick lips. An operculum is present. They are near-shore dwellers, and their empty shells are plentiful in the sand of the reefs and beaches. A few of the more familiar species of the genus *Rissoina* are considered here.

In *R. tridentata* Mighels (fig. 73, *b*) the shell is smooth and usually has three teeth within the outer lip. The white shell resembles species of *Melanella* (p. 140), but the thick lip distinguishes it. Large specimens are about 8 mm. long. The shell of *R. ambigua* Gould has 20 narrow longitudinal ridges and is encircled by fine striae. Its length is about 8

mm. The form *R. multcostata* Garrett (fig. 73, *a*) is longitudinally ribbed and encircled by a brown band. Some authorities have considered it a variety of *R. ambigua*. In *R. turricula* Pease the white shell is turreted. The six whorls are longitudinally ribbed and transversely striated. The last whorl is encircled by a groove at the base. The shell is less than 5 mm. long. The tiny species *R. triticea* Pease has five convex whorls, the last more than half the shell. Nine prominent longitudinal ribs are continuous over the sutures. The shell is less than 5 mm. long. In *R. gracilis* Pease the slender, elongated shell is reddish brown and longitudinally ribbed. It is less than 5 mm. long. The white shell of *R. balteata* Pease is ornamented by fine, longitudinal ribs. It is less than 5 mm. long. Another form occasionally observed is *R. striatula* variety *hawaicensis* Pilsbry. Its shell is spirally marked by fine, closely placed striae, and its length is about 8 mm.

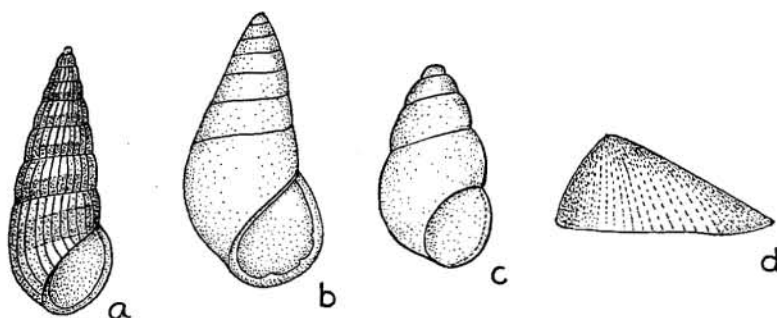


FIGURE 73.—Prosobranchia: *a*, *Rissoina multcostata*; *b*, *Rissoina tridentata*; *c*, *Diala* species; *d*, *Hipponyx pilosus imbricatus*.

FAMILY LITIOPIDAE

A very common but undetermined representative of the family, *Diala* species (fig. 73, *c*), lives near shore among seaweeds and on the under surface of stones. It has a tiny brown shell with an elevated spire, the surface being finely spirally striated. The aperture is oval and the outer lip smooth and thin. The length is about 2.5 mm. Empty shells of this form are frequently taken in shore sand. Many of these are white, having lost the natural brown color.

FAMILY HIPPONICIDAE

Members of the family have small conical shells, with no visible whorls and apex curved backward. They are inhabitants of shallow water, where they are attached to the smooth surface of stones. The common name "hoof-shells" is applied to these forms because the muscular impression on the ventral surface is shaped like the hoof of a horse. In the genus *Hipponyx* a shelly plate is secreted by the bottom of the foot and rests on the surface to which the mollusk is attached.

The most common local species is *Hipponyx pilosus imbricatus* Gould (fig. 73, *d*), which has a low apex and a diameter of about 12 mm. The surface is radially striated and covered with a pilose epidermis. In *Hipponyx antiquatus* Linnaeus the surface is concentrically laminated. Its diameter may reach 18 mm. Another species, *Hipponyx barbatus* Sowerby, has the apex of the shell curved backward and the surface radially and concentrically striated. It is covered with a pilose, brownish epidermis and is often coated with a calcareous deposit. Large specimens are 18 mm. in diameter.

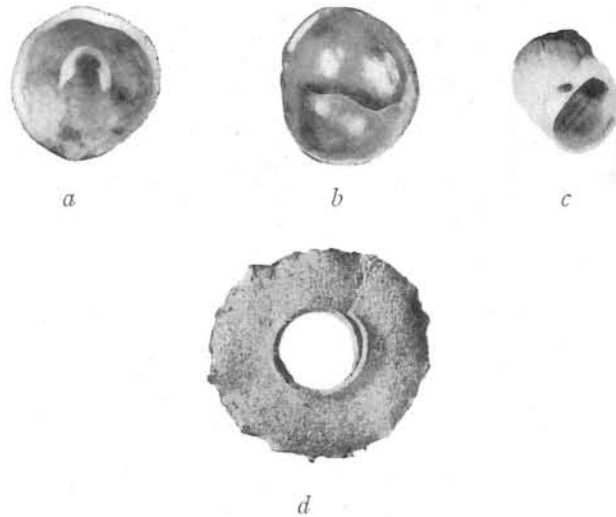


FIGURE 74.—Prosobranchia: *a*, *Cheilea dillwyni*; *b*, *Crepidula aculeata*; *c*, *Natica macrochiensis*; *d*, nest of *Natica macrochiensis*.

The species *Cheilea dillwyni* Gray (fig. 74, *a*) has a circular, slightly convex shell, white or light yellow. It is radially striated and often crenulated on the margin. No shelly base is formed as in *Hipponyx*, but a thin,

crenate-shaped plate rises from the bottom of the concavity of the shell. The shell has a diameter of about 1.25 inches. It is occasionally observed on rocky shores.

FAMILY CAPULIDAE

A small, easily recognized species, *Amathina bicarinata* Pease, is occasionally seen in shallow water. The shell is elongated, angular, and boxlike, with the apex curving backward and to one side. The radial striae are riblike at the angles of the shell. The elongated aperture is truncated in front. Its color is light brown. Large specimens are 5 mm. long.

FAMILY CALYPTRAEIDAE

There seems to be but one species, *Crepidula aculeata* Gmelin (fig. 74, *b*), representing this family about the shores of Hawaii. The surface is brownish and marked by radiating striae. In outline the shell is oval, slightly convex, with a low, spiral apex directed posteriorly and laterally. The columella is expanded into a shelf which covers nearly the posterior half of the aperture. Large specimens are 1.5 inches long.

FAMILY NATICIDAE

Mollusks with globular shells and short spires represent this family. The aperture is halfmoon shaped, protected by an operculum, and has an entire outer lip. There is a well-developed umbilicus in the base of the shell. These mollusks are typical inhabitants of sand-covered reefs or shallow bays. The animal has a large foot for plowing its way through the sand in search of other mollusks which serve as its prey.

Two genera, *Natica* and *Polinices*, are distinguished by the operculum, which in *Natica* is shelly and rigid, but in *Polinices* is thin, corneous, and flexible. The common shore species in Hawaii is *Natica macrochiensis* Gmelin (fig. 74, *c*), which is gray or yellowish brown in color, spirally marked with several broken bands of dark brown spots. Large specimens slightly exceed 1 inch across. Nests of this species, consisting of ribbons of sand and particles of mud bound together in the form of circular collars by mucilaginous secretions from the mollusks, are familiar objects on the surface of sand flats exposed at low tide. (See fig. 74, *d*.) The eggs are embedded in the substance of the collars, from which, upon hatching, the young shell-bearing forms break out.

Two species of *Polinices* frequent depths of a few fathoms and are occasionally observed on the reefs. In *P. melanostoma* Gmelin the shell is whitish, marked with spiral lines and light brown bands. The columella and umbilicus are chocolate-brown. Large specimens are 1.25 inches across. The shell of *P. pyriformis* Recluz (*Natica mamilla* Linnaeus) is white and shining, its length slightly exceeding its breadth. The columella is thickened and covers the umbilicus. Large specimens are 2.5 inches long.

FAMILY VANIKORIDAE

Tiny mollusks somewhat resembling miniature specimens of *Natica* belong to this group. The shells are usually white, and the last whorl is relatively large. A velvety epidermis often covers the surface, which is usually ornamented by striae. The semicircular aperture is closed by a horny operculum and there is a large umbilicus. These mollusks frequent shallow water, where they may be found under stones or in the crevices of porous rocks. Small hermit crabs often occupy their empty shells.

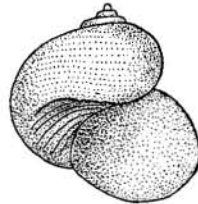


FIGURE 75.—*Vanikoro hawaiiensis*.

At least five species of *Vanikoro* have been reported from Hawaii, but the differences between some of them are very slight. In the species *V. hawaiiensis* Pilsbry (fig. 75) the shell is subglobose with a small, conical spire, the apex of which is brown. Some of the early whorls are beaded, and uneven spiral threads mark the last whorl. The umbilicus is funnel shaped and plicated within. The species is about 5 mm. long. The shell of *V. kanakarum* Pilsbry has the last whorl encircled by rather coarse threads, between which are one to three finer threads. It is slightly smaller than *V. hawaiiensis*.

Other species of the genus recorded from local waters include *V. acuta* (Recluz), *V. semiplicata* Pease, and *V. imbricata* Pease. In *V. acuta* the shell is ornamented with fine spiral lines. The umbilicus is wide and smooth within. The diameter is about 10 mm. The shell of *V. semipli-*

cata has the spire longitudinally ribbed and the last whorl spirally marked by raised striae with finer striae between. The border of the umbilicus is finely grooved. The size is not recorded. In *V. imbricata* the shell is very oblique and the surface is ornamented by longitudinal ribs crossed by spiral striae. The umbilicus is ribbed within. The size is not recorded.

FAMILY PATELLIDAE

Limpets having non-spiral, conical shells with a closed apex slightly anterior to the middle represent this family. Radiating ribs mark the surface, and there is no operculum.

These mollusks are typical inhabitants of surf-beaten shores, where they cling firmly to the smooth faces of rocks. Their shells are often overgrown with seaweeds or calcareous deposits. They are of considerable economic importance as food and find ready sale in the Honolulu fish markets.



FIGURE 76.—Patellidae: *a*, *Helcioniscus exaratus*; *b*, *Helcioniscus exaratus* variety; *c*, *Helcioniscus argentatus*.

The most common Hawaiian species is *Helcioniscus exaratus* Nuttall (fig. 76, *a*), in which the shell slopes straight from the apex and the surface is ornamented with numerous black ribs. Large specimens are about 1.5 inches long. A form with a very high apex is occasionally taken. It is probably a variety of *H. exaratus* (fig. 76, *b*). The largest Hawaiian species is *Helcioniscus argentatus* Sowerby. From the blunt apex the shell slopes convexly to the margin, and the surface is marked with many fine, unequal ribs. Large specimens may reach a length of 3 to 4 inches. (See fig. 76, *c*.)

FAMILY PHASIANELLIDAE

Mollusks of this family have minute, conical-shaped shells which are brightly colored and, in most species, smooth and polished. A calcareous operculum is present. These forms live near the shore. Their empty shells are abundant in the sand of reefs and beaches. Two genera are well

represented by Hawaiian species, *Phasianella*, in which the columella is smooth, and *Alcyna*, in which it bears a strong tooth.

Among species of *Phasianella* a common one is *P. variabilis* Pease (fig. 77, *b*), which has a thin, ovate shell encircled with fine striae. It is white, spotted and lined with pink. Specimens slightly exceed 2.5 mm. in length.

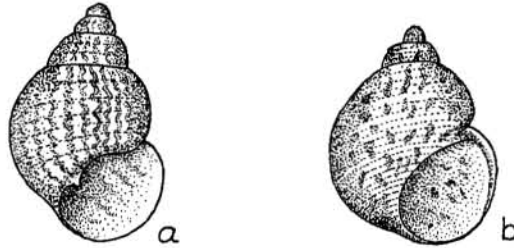


FIGURE 77.—Phasianellidae: *a*, *Alcyna rubra*; *b*, *Phasianella variabilis*.

Local species of *Alcyna* include *A. rubra* Pease, *A. lineata* Pease, *A. subangulata* Pease, and *A. kapiolaniae* Pilsbry. Each of these is somewhat less than 2.5 mm. long. In *A. rubra* (fig. 77, *a*) the smooth polished shell is red or blotched with red and white and encircled with red lines. The shell of *A. lineata* is solid, thick, and transversely ridged—the ridges red, the furrows white. In *A. subangulata* the shell has a raised spire, and its surface is spirally striated. Its color is red with oblique, light red lines. The outer lip is thickened externally. In *A. kapiolaniae* the last whorl of the glossy pink shell is encircled with narrow bands of rose or red. The columella is vertically grooved, and the tooth is directed downward.

FAMILY STOMATELLIDAE

This family is characterized by shells which have very small spires and large body whorls. The aperture is long and broad, and in some species there is no operculum. These forms are inhabitants of shallow water, where they are found under stones or in crevices of rocks. Hawaiian species of the genus *Stomatella* are small and range in greatest breadth from 3 to 5 mm.

In *S. concinna* Gould (fig. 78) the surface of the shell is ornamented with finely beaded spiral ribs. It is white with oblique broken bands of red. A subspecies, *S. concinna inconcinna* Pilsbry, was described from Oahu. It is greenish white with opaque white dashes and sometimes small brown spots on the base. Fine spiral lines mark the surface.

FIGURE 78.—*Stomatella concinna*.

FAMILY TURBINIDAE

The turbine shells are thick, and spiral in form. The surface is ornamented by striae, costae, or tubercles. A thick, calcareous operculum closes the nearly circular aperture. In the larger forms the opercula, commonly called "cat's eyes", have a beautiful iridescent luster. They are typically shallow-water mollusks and are found under stones and in crevices of rocks near shore.

The most familiar local species is *Turbo intercostalis* Menke (fig. 79, *b*). Its convex whorls are spirally striated and typically colored by black, green, and brown lines. Large specimens are 2 inches long. A form having elevated scales on the spiral costae of the last two whorls, making a very rough shell, occurs about some of the leeward islands and is common at Maili Point, Oahu. It is probably a variety of *T. intercostalis*. (See fig. 79, *a*.)

FIGURE 79.—Turbinidae: *a*, *Turbo intercostalis* variety; *b*, *Turbo intercostalis*.

Eight or ten Hawaiian species of the genus *Leptothyra* have been recorded, but they are small and inconspicuous and few of them are well known. In *L. rubricincta* Mighels (fig. 80), the globular shell has four whorls encircled by coarse white ribs. The furrows between the ribs are

deep red. The shell diameter is about 2.5 mm. The shell of *L. verruca* Gould has five whorls and is spirally costate, with the stronger costae in the middle of the whorl. It is white encircled by red or brown squarish spots. Large specimens are 5 mm. in diameter. In *L. candida* Pease the white shell is thin, orbicular, with raised spiral striae. Its diameter is about 4 mm.



FIGURE 80.—*Leptothyra rubricincta*.

FAMILY LIOTIDAE

Among local representatives of this family is a minute, turbanate shell described as *Haplocochlias* (*Lophocochlias*) *minutissimus* Pilsbry. It is white with a brown spire. The last whorl is spirally keeled, and the aperture is nearly circular. Its length is 1 mm. The species was described from Mokapu Point, Oahu.

FAMILY TROCHIDAE

A conical shell with a flattened base and an oblique aperture closed by a horny operculum characterizes members of this family. The common species, *Trochus intextus* Kiener (fig. 81, *a*), has a tall straight spire and



FIGURE 81.—Trochidae: *a*, *Trochus intextus*; *b*, *Euchelus gemmatus*.

a beaded surface. It is gray or whitish, with spots, stripes, or zigzag lines of red and purple. Large specimens are 1 inch in diameter at the base.

One of the smaller species, *Euchelus gemmatus* Gould (fig. 81, *b*), has a thick solid shell encircled by fine granular ribs and dotted or striped longitudinally with red. Its diameter is 5 mm.

In *Monilea striatula* Garrett the shell is thin and shining. It is marked by fine spiral lines and oblique striae. It is rosy white or buff, mottled with brown and encircled by narrow lines of white and brown. The outer lip is thin, and the umbilicus is striated within. Large specimens are 8 mm. in diameter.

FAMILY NERITIDAE

Both marine and fresh-water mollusks are represented in this family. Their shells are turbinated with a halfmoon-shaped aperture, a shelf-like columella, and an operculum. Two genera are recognized.

In the typically marine genus *Nerita* the mollusks have thick, bulbous shells. They are among the most familiar molluscan forms on rocky shores, where they often creep high out of the water. In *Neritina* the shells are usually thinner, flatter, and broader than in *Nerita*, and the species, for the most part, have become more fully adapted to fresh-water habitats.

Of the genus *Nerita* the most common species is *N. picea* Recluz (fig. 82, *b*), which has a black, polished shell faintly speckled with white and marked with fine spiral lines. There are few teeth on the margin of the columella. Large specimens are 20 mm. across. In *N. polita* Linnaeus (fig. 82, *a*) the smooth gray surface of the shell is spotted with white, yellow, orange, red, or black. The columella has few teeth. Large specimens are about 1.5 inches across. The species *N. plicata* Linnaeus (fig. 82, *c*) has the inner surface of the outer lip plicated, and the columella bears blunt teeth. It is about 1.5 inches across. The shell of *N. albicilla* Linnaeus (fig. 82, *e*) is sculptured by heavy ribs. It is 1.5 inches across. A smaller species, *N. neglecta* (Pease) (fig. 82, *d*), is obliquely ovate, spirally and longitudinally striated. It is black, spotted with white. The columella bears 7 or 8 teeth. Specimens are about 12 mm. across.

Four species of *Neritina* are known in Hawaii. Two of them show tendencies to depart from a marine environment in favor of fresh-water conditions and are found near the mouths of rivers and in brackish water near the sea. One species seems to be strictly marine and one is confined to fresh water. Of the brackish-water forms, *N. vespertina* Nuttall (fig. 82, *f*) has a flattened shell with thin margins. It is olive-brown without markings. Large specimens are 1 inch across. The shell of *N. cariosa* Gray (fig. 82, *g*) is black with minute yellow spots and is usually more convex than that of *N. vespertina*. It is about 1 inch across.

A minute species, *N. bryanae* Pilsbry, is globular in form and pale gray with four spiral bands of white spots and two zones of reddish longitudinal lines. The edge of the columella bears two or three small teeth. The diameter is about 2.5 mm. The species has been dredged from depths of a few fathoms, and empty shells are found in beach sand.

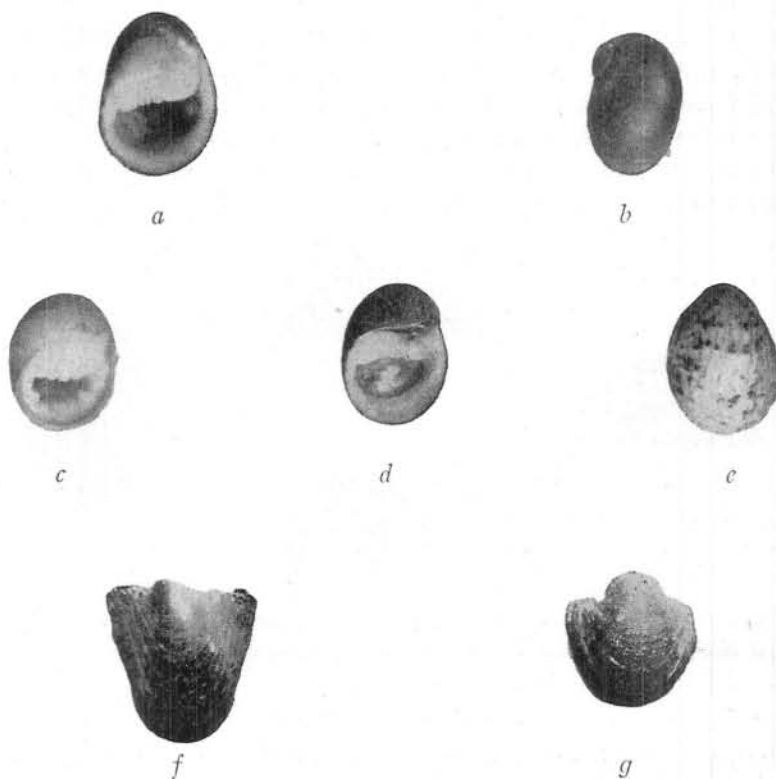


FIGURE 82.—Neritidae: *a*, *Nerita polita*; *b*, *Nerita picca*; *c*, *Nerita plicata*; *d*, *Nerita neglecta*; *e*, *Nerita albicilla*; *f*, *Neritina vespertina*; *g*, *Neritina cariosa*.

The fresh-water species, *N. granosa* Sowerby, is hoof shaped with the black upper surface covered with low, rounded granules. Large specimens are 2 inches in diameter. This species is apparently not so plentiful on Oahu as on some of the other islands, where it is found clinging to stones in rivers far from the sea. It is occasionally sold in the Honolulu fish market.

FAMILY PHENACOLEPIDIDAE

Mollusks with oval, caplike shells represent this family. The apex, which is without a perforation, is strongly curved backward. At least three species of *Phenacolepas* have been recorded from Hawaiian waters. In *P. cancellatus* (Pease) (fig. 83, *a*) the surface is marked by fine radiating ribs and concentric striae. The apex curves backward even with the posterior margin. A specimen from the rocks near shore at Kahala, Oahu, is pale brown and slightly exceeds 8 mm. in length. Another species, *P. granocostatus* (Pease) differs from *P. cancellatus* in having the radiating ribs covered with rounded granules. In *P. aculeatus* (Pease) the surface of the shell is covered with small sharp nodules and fine striae. The reddish apex does not extend to the posterior margin.

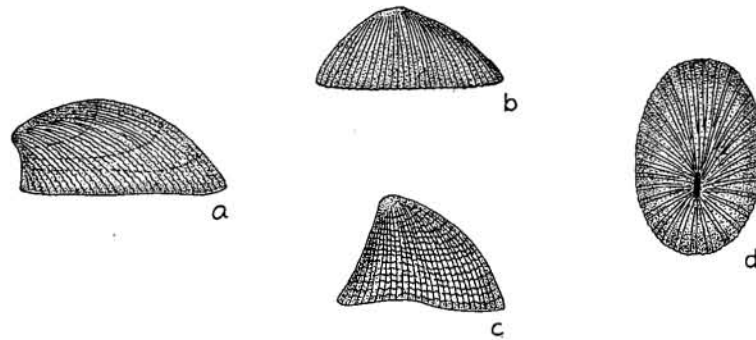


FIGURE 83.—Prosobranchia: *a*, *Phenacolepas cancellatus*; *b*, *Diadora granifera*, lateral view; *c*, *Diadora* species; *d*, *Diadora granifera*, apical view.

FAMILY FISSURELLIDAE

The keyhole limpets resemble, in general form of shell, those of the family Patellidae (p. 162) but differ from them in having a perforation in the apex or in the front margin of the shell. The Hawaiian species are few in number and small in size.

A common local form is *Diadora granifera* Pease (fig. 83, *b, d*), which has a conical shell oval in outline with the apex in front of the middle. The surface is marked by numerous radiating ribs crossed by concentric lines resulting in a beaded appearance. Some of the ribs are green and give that color to the shell. The apex has an elongated perforation. Large specimens are 5 mm. long. Another common but undetermined form of *Diadora* (fig. 83, *c*) has a tall yellowish or light brown conical shell. It is

ornamented by numerous radiating ribs and the apex is perforated. Its diameter is about 10 mm.

The species *Hemitoma oblonga* Pease has an elongated shell with a low dome. The apex is perforated and the surface is radially striated. Its greatest length is about 10 mm.

ORDER OPISTHOBRANCHIA

Key to Suborders of Order

- A. Shell usually present (may be rudimentary); gills covered by mantle..... **Tectibranchia.**
 AA. No shell present; gills absent or exposed.
 B. No gills (branchiae) or mantle cavity..... **Ascoglossa.**
 BB. Gills (branchiae) exposed..... **Nudibranchia.**

SUBORDER TECTIBRANCHIA

About 50 species of this suborder have been recorded from Hawaii. Some are known only from dredged material, and others have been taken but once or only occasionally about the shores. A few species are very common especially at certain times of the year.

FAMILY ACTAEONIDAE

Members of this family have a spirally coiled, ovate, or fusiform shell into which the animal is capable of completely retracting. A head shield is well developed. This is the only family of the order possessing an operculum in the adult stage.



FIGURE 84.—*Bullina scabra*.

Several species are known about the islands, but none are common in shallow water. A form occasionally observed near shore is *Bullina scabra* Gmelin (fig. 84). The ovate shell is white or rose colored, spirally grooved, encircled by two red lines, and marked longitudinally by

numerous zigzag lines of the same color. Its length is 12 mm. A Hawaiian subspecies, *Bullina scabra solida* Pilsbry, differs from the typical species in that the shell is more solid and the apex is thicker. Many years ago *Bullina vitrea* Pease was recorded from Hawaiian waters, but it has not been seen by recent collectors. The shell is said to be white, with or without fine transverse black lines on the body whorl. It is about the same size as *B. scabra*.

Species of *Pupa* are seldom taken near shore but are occasionally dredged from depths of 6 or 8 fathoms. A typical form is *P. thaanumi* Pilsbry. The elongated, spirally grooved shell is whitish, encircled by rows of pink spots. Its length is 8 mm.

FAMILY ACTEOCINIDAE

In this family the shells are spirally coiled, elongate-cylindrical, with a short spire and a knoblike apex. The aperture is long and narrow. The living animal has a short foot and a small, quadrangular head shield. Hawaiian species are very small. They seem to frequent depths of several fathoms, but their tiny shells may be found in the sand of reefs and beaches.

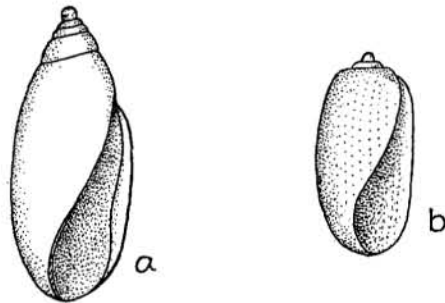


FIGURE 85.—Acteocinidae: a, *Acteocina honoluluensis*; b, *Acteocina hawaiiensis*.

Three Hawaiian species of *Acteocina* are known. In *A. honoluluensis* Pilsbry (fig. 85, a) the spire is elevated and the nipple-like first whorl is wholly exposed. In *A. sandwichensis* Pease the spire is more retracted and the first whorl is partly concealed. These two species are each slightly less than 5 mm. long. Another species, *A. hawaiiensis* Pilsbry, is characterized by a distinct shoulder between the spire and the body whorl. The last whorl is ornamented by spiral wrinkles. The species is about 2 mm. long. (See fig. 85, b.)

FAMILY SCAPHANDRIDAE

Mollusks of this family have spiral shells with sunken or concealed spires. A short foot, truncated or forked behind, and large lateral lobes characterize the living animal. The head shield does not bear tentacles.

The most familiar species in Hawaii is *Smaragdinella viridis* (Quoy and Gaimard). Specimens are abundant on rocky shores, where they may be found between tide marks clinging to the rocks in a contracted condition. The animal is truncated in front, and the shell is partially covered by thick lobes. Its color is dark gray or greenish black, speckled with white. When expanded the animal is about 1 inch long. The shell is oval, dark green, with the aperture occupying nearly the entire ventral aspect. It is 12 mm. long.

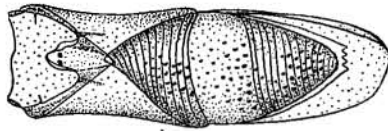


FIGURE 86.—*Atys semistriata* drawn from a living specimen by J. M. Ostergaard.

The genus *Atys* is represented by several species occasionally found in shallow water. Their shells are oval, spirally striated, with the aperture as long as the shell. The species most often seen is *A. semistriata* Pease (fig. 86), in which the thin shell is widest below the middle. Near the ends the bluish-white shell becomes opaque white. The upper part is encircled by about 12, the lower part by about 16, shallow grooves. The middle part is smooth. Large specimens slightly exceed 12 mm. in length. Two local subspecies have been recognized. In *A. semistriata mua* Pilsbry, taken at Honolulu, the shell is compressed at the summit, which is narrower than in the regular form. A subspecies with about 10 spiral grooves above and below the middle has been named *A. semistriata ford-insulae* Pilsbry, from Ford Island, Pearl Harbor, Oahu, where it was taken.

An elongated, cylindrical species, *A. cornuta* Pilsbry, is encircled by about six principal grooves, two or three smaller ones toward the upper end and numerous unequal grooves toward the lower end. A toothlike process at the upper end also characterizes this species. Its length is about 15 mm. In *A. costulosa* Pease the shell has the general shape of *A. cornuta* but is marked by longitudinal folds as well as by spiral grooves near each end. It is about 5 mm. long. Another species, *Atys debilis* Pease,

with a slender, elongated shell and narrow apex is accredited to Hawaii by its author but has not been seen recently. The shell is spirally grooved near both ends and has a projecting point at the summit. Its length is about 15 mm. The shell of the genus *Dimia* differs from the shell of *Atys* in having the columella abruptly truncate at the base and in lacking a spiral fold in the lip, ascending from the summit. The species *D. compitorum* Pilsbry has a white shell about 8 mm. long. It has been taken from shallow water and also from depths of 4 to 12 fathoms. Specimens of *Mnestia pusilla* (Pease) have been collected from about the shores and from depths of 10 fathoms. It is elongated, cylindrical in the middle, and whitish with a white band at the base and brownish markings above it. The entire surface is spirally striated. Its length is about 5 mm. Two species of *Scaphander* belonging to this family, *S. alatus* Dall and *S. pus-tulosus* Dall, have been described from deep water off Oahu.

FAMILY BULLARIIDAE

A representative of this family, well distributed throughout the islands, is *Bullaria peasiana* (Pilsbry) (fig. 87, *b*). The thin, oblong shell is brown blotched with white and finely striated spirally and longitudinally. Large specimens are 1 inch long.



FIGURE 87.—Opisthobranchia: *a*, *Haminoea aperta oahuensis*; *b*, *Bullaria peasiana*.

FAMILY AKERIDAE

Shells of this family are oval or cylindrical, very thin and fragile. The spire is retracted or concealed and the aperture extends the entire length of the shell. The shells are white, pale yellow, brown, or green. In the living animal the head shield is well developed, and most forms have broad lateral lobes reflected over the shell during activity.

Of the six or seven species of *Haminoea* recorded from Hawaii, *H. aperta oahuensis* Pilsbry (fig. 87, *a*) is the one most frequently observed. The shell is smooth, white, and somewhat swollen in the

middle. Large specimens are about 15 mm. long. The shells of *H. crocata* Pease and *H. galba* Pease are much alike. They differ from *H. aperta oahuensis* in having fine spiral striations and in being yellowish in color. In *H. crocata* the shell is more swollen than in *H. galba* and the outer lip rises higher from the summit. It is also slightly larger, being about 12 mm. long. Two species, *H. curta* A. Adams and *H. olopana* Pilsbry, resemble each other in being distinctly striated and more or less cylindrical in form, but the lateral outlines are straighter in *H. curta*. Known specimens of *H. olopana* are about 8 mm. long. Some shells of *H. curta* slightly exceed 12 mm. in length.

The species *H. tomaculum* Pilsbry, which resembles *H. curta*, but is narrower, is known only from dredged material taken off Honolulu in 6 to 8 fathoms. Another species, *H. sandwichensis* Sowerby, resembling *H. crocata*, but with more pointed ends, has not been seen by recent collectors. Many years ago *Valvatella fragilis* Pease was reported from Hawaii, but it has not been observed since. In this species the aperture of the shells is widely dilated at the base, but the lips meet near the middle and folding over each other form a posterior tube with a circular opening.

FAMILY HYDATINIDAE

Mollusks with thin, oval, or globular shells and nearly flattened spires are included in this family. The last whorl is large and distinctly marked with bands of color. In the living animal the foot is large and the head shield is divided behind into two lobes, which partly cover the shell.



FIGURE 88.—Hydatinidae: *a*, *Hydatina amplustre*; *b*, *Micromelo guamensis*.

The Hawaiian species of the family are easily distinguished. In *Hydatina amplustre* (Linnaeus) (fig. 88, *a*) the pink shell is encircled by white bands bordered with black. Large specimens slightly exceed 1 inch in length. The shell of *Hydatina physis staminea* (Menke) is white under a buff cuticle and is encircled by wavy lines of brown placed close together. It is about 1.3 inches long. Another species, *Hydatina albocincta* (Van

der Hoeven), has the shell marked by five white spiral bands and obliquely streaked with brown. It is about 1.4 inches long.

The species *Micromelo guamensis* (Quoy and Gaimard) (fig. 88, *b*), probably the same as *M. eximia* (Deshayes), is occasionally taken alive on the reefs. The ovate shell is marked by three black spiral lines and more numerous wavy longitudinal lines of the same color. Large specimens are about 10 mm. long.

FAMILY AGLAJIDAE

Representatives of this family have thick mantle lobes and an oblong head shield without tentacles. The shell is but slightly spiral and is completely inclosed by the mantle. Although several species have been described from Hawaii, apparently only the type specimen of each is known. These mollusks are very seclusive and are seldom seen by collectors.

The subspecies *Aglaja pilsbryi hawaiiensis* Pilsbry was described in 1910 from a specimen collected at Hilo, Hawaii. It is distinguished by the color markings, which consist of a black figure-of-eight on both head shield and mantle, and other black spots on the lateral borders. The animal is about 1 inch long. Other species, *Aglaja speciosa* (Pease), *Aglaja nigra* (Pease), and *Aglaja nuttalli* Pilsbry, were described from single specimens collected about the islands many years ago. None of these have been observed since.

FAMILY APLYSIIDAE

This family includes the sea hares, elongated mollusks with long necks, oral and dorsal tentacles, and in most species a thin, platelike shell beneath the mantle.

These animals are typical of the shallow water. They are found during the day concealed under stones or among seaweeds upon which they feed. Of the genus *Tethys*, two species are abundant about the shores. One of these, *T. bipes* (Pease) (fig. 89, *a*), may be readily distinguished by its double foot, the posterior part of which is circular, smooth, and projects laterally and posteriorly. The animal is olive-brown. A thin, flexible shell is concealed under the mantle. (See fig. 90, *a*.) Large specimens are 4 inches long. When disturbed this species has a tendency to roll itself up into a ball. Like other species of the family, *T. bipes* deposits eggs in long white tubes, looped and coiled in masses, which adhere to

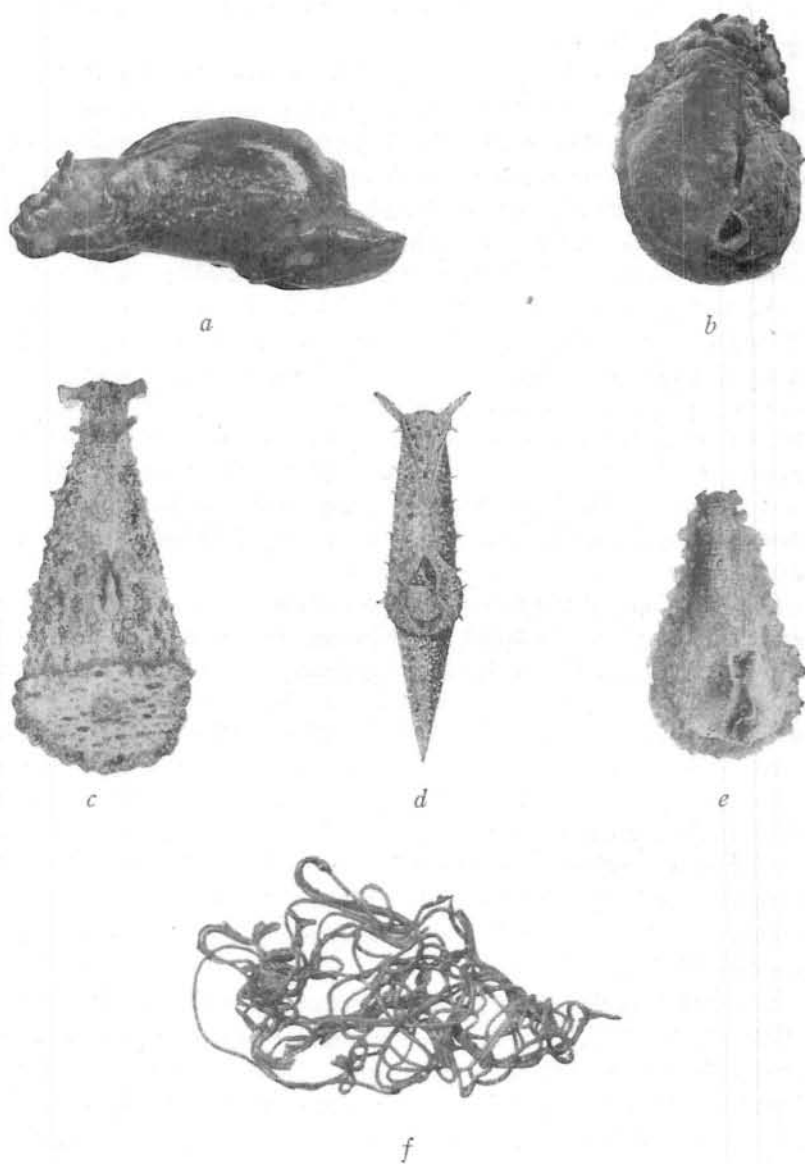


FIGURE 89.—Aplysiidae: *a*, *Tethys bipes*; *b*, *Dolabrifera* species; *c*, *Dolabella variegata* from a drawing by J. M. Ostergaard; *d*, *Notarchus lineolatus* from a drawing by J. M. Ostergaard; *e*, *Dolabrifera olivacea*; *f*, egg masses of *Tethys bipes*.

the under surface of stones. (See fig. 89, f.) Previous to hatching, the egg clusters turn brown.

The other common species, *T. grandis* (Pease), is purplish brown with whitish spots on the sides. The foot is long, narrow, corrugated, and undivided. A large, thin, flexible shell is partially concealed by the mantle. Large specimens may reach a length of 6 inches. In this species the mantle lobes are usually held erect and open during activity. Although the animal contracts under stimuli, it does not roll itself into a ball as does *T. bipes*. A purple fluid is discharged by the mollusk when it is disturbed.

A small species, probably *Tethys elongata* (Pease), is occasionally collected close to shore. The usual color is dark brown with the dorsal surface speckled with white. The species is about 1.5 inches long. Specimens of a purplish-black form, probably a color variety of *T. elongata*, have been collected on the reefs of Oahu. In respects other than color it corresponds well with the typical species. The back is considerably elevated, and the mantle lobes are held open exposing the shell which is very convex and quite solid. The foot is white and terminates in a point behind.

It is quite likely that a thorough survey of the reefs would reveal other species of the genus. An undetermined form about 2 inches long, bright green and finely speckled with white, has been observed at Kahala, Oahu.

Species of *Dolabrifera* are dorsoventrally flattened and have a broad foot and small mantle lobes. The shell is calcareous but not spiral and is entirely enclosed by the mantle. The most common species, found under stones near shore, is *D. olivacea* Pease (fig. 89, e). When extended, the animal is about 2 inches long, pyriform with the broad end behind. The rounded upper surface is ornamented with filaments. It is usually dark olive-green, mottled with white and dark brown. The shell, which varies in outline in different specimens, is narrow, oblong, with a thickened apex (fig. 90, b).

A doubtful species of the genus was collected at Maalaea Bay, Maui, in 1931 (fig. 89, b). It is a smooth, gray form, mottled with darker gray and light brown. The thick platelike shell is fanshaped with the borders folded longitudinally near the small end. The species was abundant under lava stones in shallow water. Large specimens expanded to a length of 3 inches.

Other species of *Dolabrifera* have been accredited to Hawaii but have not been recognized by recent collectors. In *D. oahuensis* (Souleyet) the body is said to be greatly swollen, smooth, and green, tinted with rose and

dark green. The length is given as about 3 inches. Another species, *D. marmorea* Pease, was described from the shell only. From the variations noticed in the shells of *D. olivacea* these structures do not seem to be safe features upon which to base species.

Species of *Notarchus* may be recognized by the fusiform body with a long, narrow foot tapering to a fine point. The shell, if present, is small and orbicular. The common Hawaiian species, *N. lineolatus* (Gould) (fig. 89, *d*), is green with longitudinal wavy lines and scattered spots (ocelli) of brown. The mantle is ornamented with branched papillae. This species, which is about 3.5 inches long, is abundant about the shores, in tide pools and among seaweeds, at certain times of the year, usually in the spring, which seems to be the spawning season. The egg case is a tubular cord looped and folded like that of *Tethys*. A less familiar species, *N. arcola* (Pease), is said to be greenish ash in color, about 2 inches long, striped longitudinally and speckled with white. It is covered with small branchial filaments.

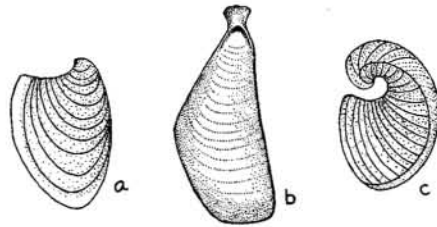


FIGURE 90.—Aplysiidae: *a*, shell of *Tethys bipes*; *b*, shell of *Dolabrifera olivacea*; *c*, shell of *Dolabella variegata*.

The largest representative of the family in Hawaii is *Dolabella variegata* Pease (fig. 89, *c*), which may reach a length of 10 inches. The animal is cone shaped, wider behind, greenish, variegated with brown and white and roughened by small tubercles and ridges. The mantle lobes are almost completely united and form a large gill chamber behind. The siphon is near the center of the obliquely truncated posterior end. A calcareous, hatchet-shaped shell is concealed by the mantle (fig. 90, *c*).

FAMILY PLEUROBRANCHIDAE

Mollusks of this family have the dorsal region covered by a broad mantle with free borders and entirely concealing the shell, if one is present. A large plumate gill is on the right side under the mantle. There are two prominent dorsal tentacles.

Species of *Pleurobranchus* are generally white, yellow, brown, or red. A common local species, probably *P. delicatus* Pease, is orange-yellow, oval in outline, and about 1.5 inches long. The concealed shell is narrow posteriorly, slightly convex, and marked with lines of growth. Its color above is iridescent violet, below dull violet. (See fig. 91, a.) Another species, probably *P. violaceus* Pease (*Oscanius violaceus* Pease)

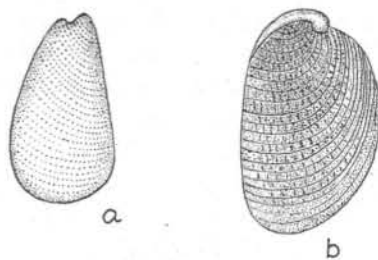


FIGURE 91.—Pleurobranchidae: a, shell of *Pleurobranchus delicatus*; b, shell of *Pleurobranchus violaceus*.



FIGURE 92.—*Pleurobranchus violaceus*.

(fig. 92), has occasionally been taken in Hawaii. The mantle is notched in front, and the convex upper surface is covered with purple polygonal areas which give it a reticulate appearance. Its length is 1.5 inches. The minute shell is pale brown, slightly concave, and marked with concentric and longitudinal lines. (See fig. 91, b.) Other species of *Pleurobranchus* have been recorded from Hawaii. In *P. pellucidus* Pease the animal is whitish with the mantle reticulated on its upper surface. It is about 10 mm. long. The species *P. rufus* Pease is vermilion and 1 inch long. In *P. varians* Pease the color is said to be red, yellow, brown, or variegated

with white, and the color of *P. marginatus* Pease is given as pale lemon-yellow, flecked with white and margined with light red.

FAMILY UMBRACULIDAE

The widely distributed species *Umbraculum sinicum* (Gmelin) (*U. aurantium* Pease) is occasionally collected in shallow water on Hawaiian reefs. The broadly oval animal (fig. 93) has a thick foot, and the upper surface is partially covered by a depressed, conical shell from which the name of the mollusk, "Chinese umbrella", is derived. The surface between the edge of the shell and the border of the foot is covered with rounded tubercles. In life the animal is yellowish gray, the calcified shell yellowish white with its under surface radially striated with brown. Large specimens are 5 inches long. The shell is about 3 inches across.

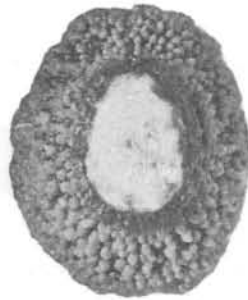


FIGURE 93.—*Umbraculum sinicum*.

SUBORDER ASCOGLOSSA

Typical forms of this group are without branchiae, mantle cavities, or shells. According to some authorities they supply a link between tectibranchiate and nudibranchiate mollusks.

FAMILY PLACOBANCHIDAE

A common representative of this family, a species of *Placobranchus* (fig. 94, *a*), is found in shallow water, where it creeps about on a sandy or muddy bottom or on dead coral rocks. It is recognized by the broad extensions of the body which fold upward and touch in the midline giving the animal a tubular appearance. The dorsal surface of the body proper has longitudinal folds inclosing green algae. Externally the color is grayish green, mottled with white and marked by circular spots (ocelli),

the larger ones of which have blue centers and are encircled by narrow zones of black or orange and white. When expanded the animal is about 2 inches long.

FAMILY ELYSIIDAE

Undetermined forms, probably of the genus *Elysia*, are occasionally taken among seaweeds and on stones in shallow water. The wings of the sides of the body inclose branches of the liver, and the entire outer surface acts as a respiratory organ. The animals are brilliantly colored and of small size. Hawaiian forms observed are less than 1 inch long. (See fig. 94, *b*.)



FIGURE 94.—Ascoglossa: *a*, *Placobranchus* species from a drawing by J. M. Ostergaard; *b*, *Elysia* species.

SUBORDER NUDIBRANCHIA

Nudibranchs are mollusks without shells in the adult stage. The larvae, however, possess coiled shells which disappear before the mature state is reached. Among nudibranchs are some of the most attractive of marine organisms, presenting a marvelous variety of tints and color patterns which probably serve to protect the animals in their environment.

Gills such as are possessed by tectibranch mollusks are lacking in nudibranchs, respiration taking place through the body wall or by means of papilla-like processes (cerata) of the dorsal surface. In some forms the papillae inclose branches of the liver and represent offshoots of the digestive tract. Spicules are present in some nudibranchs (fig. 95, *a*).

For the taxonomist this group is a perplexing one because of the multitude of variations existing and the difficulty of preserving the soft-

bodied animals in their natural form and color. The jaws and radula when present serve as important features in classification.

Although Hawaiian nudibranchs comprise a rich fauna, few local species have, as yet, been described or identified. It is only possible, therefore, to mention and illustrate some common forms without specific determination.

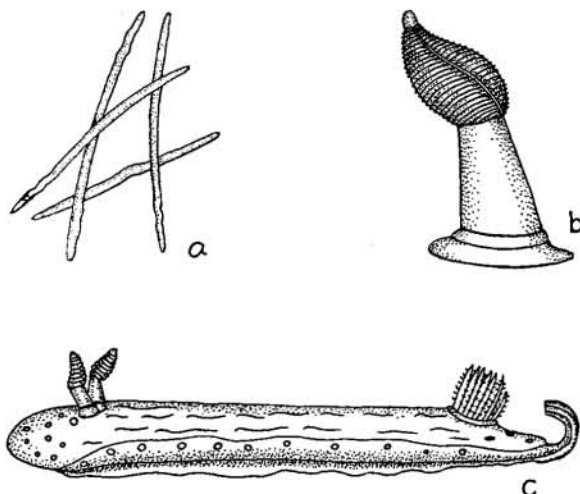


FIGURE 95.—Holohepatica: *a*, spicules of a nudibranch; *b*, tentacle of *Hexabranchnus* species from a drawing by J. M. Ostergaard; *c*, *Glossodoris* species from a drawing by J. M. Ostergaard.

TRIBE HOLOHEPATICA

In nudibranchs of this division the branchial papillae do not inclose branches of the liver but in many forms are arranged on the dorsal surface in a group about the anal opening and, with some exceptions, are retractile into pockets. In typical representatives the posterior pair of tentacles are clubbed, marked by spiral or oblique ridges, and retractile into pits (fig. 95, *b*).

Numerous families are recognized in this group, but as the Hawaiian species are undetermined, only a few common forms are here considered and briefly described without family assignments.

One of the most attractive nudibranchs is the swimming form, *Hexabranchnus* species (fig. 96, *a*), which may be recognized by its brilliant color and large size. The general color is bright red, mottled with white. It swims gracefully by undulating movements of the thin margins. A

specimen taken from Kaneohe Bay, Oahu, slightly exceeded 7 inches in length, but most specimens are smaller. Another swimming form, dull brown with irregular patches of white, is less common than the preceding species but about the same size.

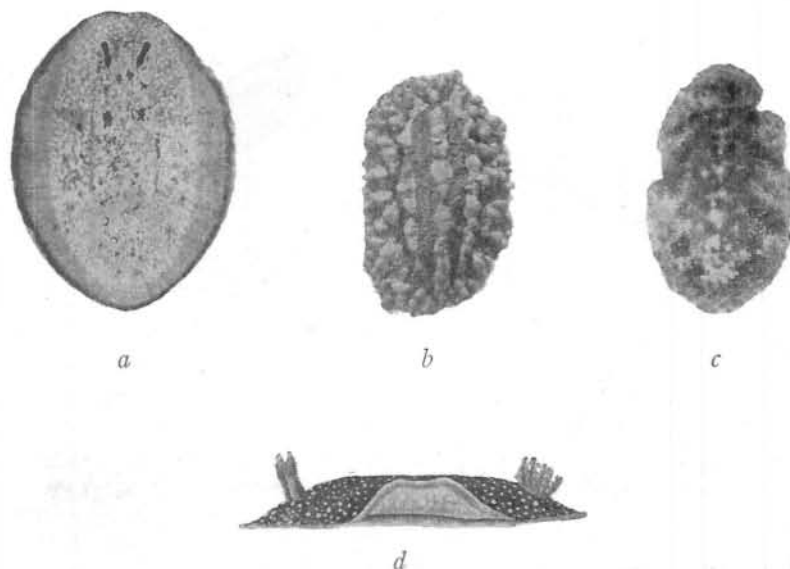


FIGURE 96.—Holohepatica: *a*, *Hexabranhus* species from a drawing by J. M. Ostergaard; *b*, *Phyllidia trilineata*; *c*, a spicule-bearing form; *d*, a common undetermined form from a drawing by J. M. Ostergaard.

A black species with a dorsal surface covered with white spots is common in shallow water. It is 1.5 inches long (fig. 96, *d*). Several rigid, spicule-bearing forms are found near shore. The most common of these is grayish, speckled with white. It is 1.5 inches long (figs. 95, *a*; 96, *c*). A less common species is pure white with black tentacles. It is 1.5 inches long.

Another rigid species with broad thin margins and mottled with gray, brown, and white occurs in shallow water. Large specimens are 2.5 inches long. A small, uniformly blue species with an operculum-like flap closing over the gills when they are retracted, has been collected at Kahala, Oahu. It is 10 mm. long.

In the genus *Glossodoris* (*Chromodoris* of some authors) the body is elongated, narrow, and the mantle does not cover the posterior extremity of the foot. A form occasionally observed is brightly marked by interrupted lines of blue and dots of brown and blue. The retractile gills are pinnate. Specimens are about 15 mm. long (fig. 95, *c*).

In species of *Phyllidia* a thick, tuberculated mantle covers the dorsal surface of the body. The gills consist of a series of lamellae between the under surface of the mantle and the foot. A specimen collected on the shore of Maui probably represents *Phyllidia trilineata* Cuvier. It is black with the tubercles of the mantle in three prominent longitudinal rows. Its length is 2.5 inches (fig. 96, *b*).

TRIBE CLADOHEPATICA

This group includes nudibranchs usually provided with elongated, simple or branched papillae on the dorsal surface. Branches of the liver usually extend into the papillae which probably serve as organs of respiration as well as inclosing the ramifications of the digestive tract. At the same time the papillae doubtless render the animal less conspicuous among seaweeds or corals.

Although specific determination of Hawaiian forms of this division is wanting, some of the common representatives can be tentatively assigned to more or less well-established families.



FIGURE 97.—Nudibranchia: *a*, *Tritonia* species; *b*, an orange-colored nudibranch associated with the coral *Dendrophyllia mami*.

FAMILY TRITONIDAE

An undetermined species, probably of the genus *Tritonia*, is occasionally observed in shallow water. It has a thick body and is grayish green. The dorsal papillae are branched, nonretractile, and arranged in a longitudinal row on each side of the body. The posterior tentacles are also branched. Specimens are about 1 inch long (fig. 97, *a*).

FAMILY AEOLIDIIDAE

This large family is represented in Hawaiian waters by numerous undetermined species. They are sluglike nudibranchs with dorsal papillae arranged in rows. Stinging cells (nematocysts) have been detected in the tips of the papillae in some species but are probably derived from coelenterates upon which the mollusks feed.

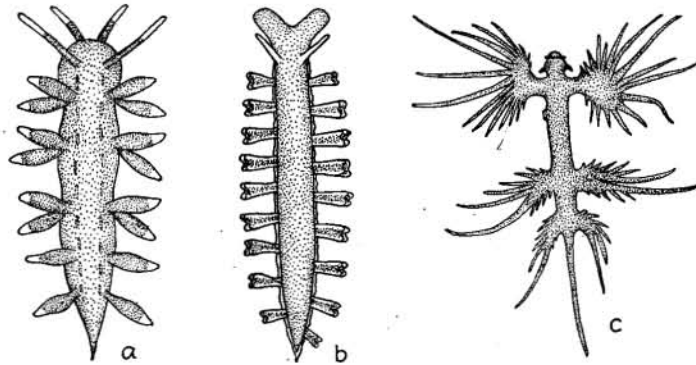


FIGURE 98.—Cladohepatica: *a*, *b*, undetermined species of nudibranchs; *c*, *Glaucus longicirrus* (?).

Among forms commonly observed is a dark brown species with long tapering papillae arranged in transverse rows and diminishing in length toward the posterior tip of the body. Its length is about 1 inch. A species usually associated with the living coral *Porites evermanni* has the dorsal surface densely covered with cylindrical papillae in transverse rows. The animal is pale green, mottled and spotted with white. Large specimens are 1.5 inches long. Evidences of the activity of this mollusk are seen in smooth patches on the coral heads where it has destroyed the polyps of the coral. Another species showing remarkable adaptation in color is associated with the coral *Dendrophyllia manni* upon which it feeds. The nudibranch is covered with long papillae and is uniformly bright orange in color harmonizing perfectly with the color of the polyps of the coral (fig. 97, *b*). Its length is 1.5 inches. A bluish-black species (fig. 98, *a*) with fusiform papillae in transverse rows is occasionally observed creeping over rocks or among seaweeds. It is about 1 inch long. A small form having thick papillae, bifid or quadrifid at the tips, is found on seaweeds. It is white, and the specimens observed are about 10 mm. long. They may be immature individuals. (See fig. 98, *b*.)

FAMILY GLAUCIDAE

Representatives of this family are slender, elongated nudibranchs with the papillae supported on three pairs of lateral lobes. They are pelagic forms occasionally found floating near shore, and often washed up on the beaches during storms. A bluish-black species taken about Oahu, probably *Glaucus longicirrus* Reinhardt (fig. 98, c), is characterized by a very long posterior extremity of the body and also long tapering papillae. It is about 20 mm. in length. A dark blue form less than 12 mm. long, with short papillae and a short posterior extremity, is occasionally seen near shore.

Associated
with papillae
illustration
in expedition
report, 1930
(VAN COILLIE)



FIGURE 99.—*Melibe* species.

FAMILY FIMBRIIDAE

The family name Fimbriidae was proposed by O'Donoghue to replace Tethymelibidae, incorrectly used by some authors.

A species of *Melibe* (fig. 99) is not uncommon in shallow water. It is found under stones, though it is capable of floating. The animal presents a remarkable expansion of the head to form a hood used in collecting small organisms upon which it feeds. Dorsal papillae are leaflike processes capable of some inflation and are easily detached. The color of the animal is pale yellow or brown and variegated. Large specimens are 2.5 inches long. The eggs of the species are deposited in thin, white spiral plates attached to stones by a stalk about 1 inch high.

Another form occasionally observed has the entire dorsal surface covered with flattened, leaflike papillae which are readily released from the body when the animal is stimulated. It is greenish, speckled and mottled with white and brown. Specimens slightly exceed 1 inch in length.

ORDER PULMONATA

Pulmonate mollusks are air breathers provided with lung sacs for respiration. Included in this group are land and fresh-water snails without opercula and certain sluglike forms which seem to be transitional between marine and terrestrial habitats. The quasi-marine species inhabit brackish water or frequent the shore line near the high tide mark, where they are out of water much of the time. Some of the common forms found about the shores are considered here.

FAMILY AURICULIDAE

Although representatives of this family are not strictly marine, some are typical inhabitants of the shore line and are found under stones at the water's edge and on walls and piling, where they are washed by the waves at high tide. Several genera and species are recognized among the Hawaiian fauna.

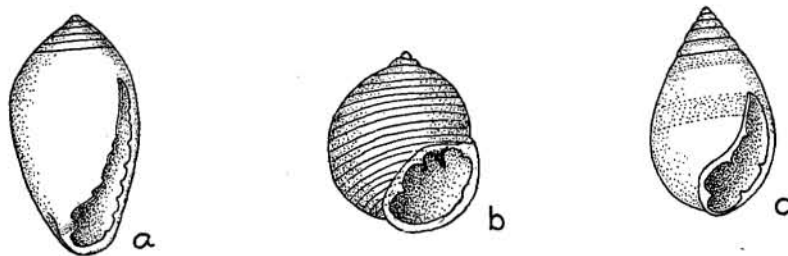


FIGURE 100.—Auriculidae: a, *Melampus castaneus*; b, *Pedipes sandwichensis*; c, *Laimodonta* species (?).

A very common form, *Melampus castaneus* (Muhlfeld) (fig. 100, a), has a smooth, brown, polished shell with a short conical spire. Both lips of the narrow aperture are toothed. Large specimens are nearly 12 mm. long. In *Melampus semiplicata* Pease the reddish-brown shell has the spire and upper part of the body whorl longitudinally plicated. There are folds on both lips. Specimens are less than 12 mm. long. Another species, probably *Plecotrema striata* (Philippi), is very common in certain localities of the East Loch of Pearl Harbor, Oahu, and has also been taken elsewhere about the islands. The shell is oval, dark brown, with a sharp conical spire. The entire surface is spirally ribbed. There are three folds on the columella and two or three teeth on the interior of the outer lip. Large specimens are 5 mm. long. (See fig. 101.)

A small species, *Pedipes sandwichensis* Pease (fig. 100, *b*), is globular, with a very short spire and a large body whorl. The brown shell is spirally striated. Three prominent folds, the first of which is spiral, are borne on the columella. Specimens are about 3 mm. across. In 1931 the species was abundant on the lava rocks bordering the shore at Makena, Maui. Often associated with *Plecotrema striata* is an undetermined form, *Laimodonta* species (?) (fig. 100, *c*). The smooth oval shell is brown encircled by paler bands. There are three teeth on the inner lip and an internal rib on the outer one. The length is 8 mm.



FIGURE 101.—*Plecotrema striata* (?).

FAMILY SIPHONARIIDAE

Some authorities believe this family supplies a link between land pulmonate mollusks and marine forms.

The shell of *Siphonaria* bears some resemblance to a small specimen of the limpet, *Helcioniscus exaratus*, in its general shape and the ribbed character of the surface. It differs from that species, however, in that the apex is posterior to the middle, and that on the right side of the inner surface there is a groove for the siphon of the animal which causes a projection on the margin of the shell.

These mollusks are very common along the shore and cling to rocks about the high tide mark, where they are exposed to the air most of the time.



FIGURE 102.—Siphonariidae: *a*, *Siphonaria normalis*, dorsal and lateral views; *b*, *Siphonaria normalis* form *chirura*.

Some authorities consider the Hawaiian representatives under one variable species, *Siphonaria normalis* Gould. Large specimens are about 1 inch long and have prominent ribs. (See fig. 102, *a*.) Other authorities give at least a subspecific rank to a smaller form with finer ribs and designate it as *Siphonaria normalis omara* Reeve.

A variety with several very strong ribs (fig. 102, *b*) has been called *Siphonaria normalis* form *chirura* Pilsbry. It has been collected on the island of Kahoolawe and is a typical form on the north shore of Maui.

FAMILY ONCHIDIIDAE

Sluglike, air-breathing mollusks without shells but with thick mantles frequently covered with wartlike tubercles are included in this family. In some species the tubercles bear eyes.

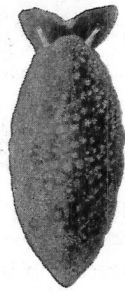


FIGURE 103.—*Peronia* species, from a drawing by J. M. Ostergaard.

A representative of the family, *Peronia* species (fig. 103), may be found creeping about on rocky shores at high tide mark. It is elongate-oval and black. The tubercles which cover the mantle are without eyes. Large specimens are 1.5 inches long. Some authorities consider this pulmonate group of mollusks to consist of those reverting to marine habits.

CLASS SCAPHOPODA

Mollusks known as "tooth shells" are characterized by wormlike bodies inclosed by tubular shells that are open at both ends. The shells are larger at one end than at the other and are curved like the tusk of an elephant. These mollusks, which are comparatively simple in organization, inhabit the bottom of the ocean ranging from shallow water to great depths. By means of a long pointed foot which extends from the larger

aperture of the shell, the animal moves about in the sand and mud in which it lives.

Few families and genera of scaphopods are recognized, and apparently none are represented on the reefs or in the shallow water about Hawaii. Of the genus *Dentalium* two species, *D. complexum* Dall and *D. phaneum* Dall, were taken by the *Albatross* off Honolulu at depths of 295 to 351 fathoms. Another form, *Cadulus honoluluensis* (Watson), was dredged by the *Challenger* off Honolulu in 40 fathoms.

CLASS PELECYPODA

Bivalve mollusks, such as clams and oysters, comprise this class. Each has a shell made of two parts (valves) which are hinged together. The body of the animal is enclosed in a two-lobed mantle, and there is a hatchet-shaped foot.

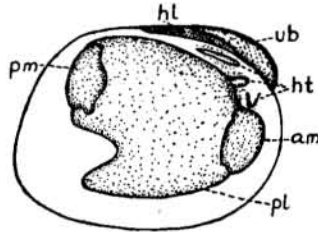


FIGURE 104.—Inner surface of left valve of a typical bivalve mollusk (*am*, anterior adductor muscle scar; *hl*, hinge ligament; *ht*, hinge teeth; *pl*, pallial line; *pm*, posterior adductor muscle scar; *ub*, umbo).

For general determination of species, the characters of the shell may be used. Externally the features of the shell of a typical bivalve include the anterior and posterior ends or borders corresponding to the mouth and siphon ends respectively of the body of the animal; the dorsal border along which the valves are hinged; the umbo, a dorsal prominence representing the original center of growth of the shell; and the ventral border or free edge of the shell opposite the hinge. The valves are usually sculptured externally by concentric ridges, more or less pronounced, which represent lines of growth. Radial sculpturing, tubercles, and spines may also be included in the external ornamentation of shells.

An internal view of the valve shows: the hinge ligament and hinge teeth, if present; muscle scars for attachment of adductor muscles used in closing the valves, and retractor and protractor muscles useful in movements of the foot; and the pallial line along which the mantle is attached. (See fig. 104.)

The bivalve mollusks of the shallow water about Hawaii comprise a small group. Of the known forms there are probably about 30 families represented in the near-shore areas, but the number of species of each family is not large. Some are apparently localized in their distribution; others are seldom seen alive, but their empty shells are often washed ashore.

The shoal water species considered in this class are included under four orders.

Key to Orders of the Class

- A. Hinge of shell with many similar teeth.....**Taxodonta.**
- AA. Hinge of shell with few teeth or none.
 - B. No siphons and no true teeth.....**Dysodonta.**
 - BB. Siphons usually well developed; teeth few, or reduced, or absent.
 - C. Both lateral and cardinal teeth usually present.....**Heterodonta.**
 - CC. No lateral teeth; cardinals may be reduced or absent.....**Desmodonta.**

ORDER TAXODONTA

FAMILY NUCULIDAE

Mollusks of this family are small forms and apparently seldom seen about the shores. The outer surface of the shell may be smooth or marked by radial or concentric lines. The hinge is bent in the middle, where there is a depression, and bears numerous transverse teeth. The species, *Nucula hawaiiensis* Pilsbry, was described from a shell taken at Haleiwa, Oahu. It is white, oval and more broadly rounded at the anterior end than at the posterior end. The surface is marked by concentric striae. There are 10 teeth behind the hinge depression and 5 in front. The type specimen is 2.8 mm. long. The species has also been collected near Koko Head and on the northeastern shore of Oahu.

FAMILY ARCIDAE

Members of this family are recognized by the trapezoid form of shell, which is strongly ribbed in some species. The hinge bears numerous comblike teeth.

Specimens of several genera have been taken about the islands, some in shoal water, others dredged. The largest Hawaiian species, *Navicula ventricosa* Lamarck, has a shell much deeper at the anterior than the posterior end. Apparently it is plentiful among the leeward islands. It has

been taken from Honolulu Harbor, but is not often seen in a living state on the reefs of the larger islands. Its shells are found as fossils in emerged reefs about Oahu. Length of shells may be nearly 3 inches.

Another species, *Acar hawaiiensis* Dall, Bartsch, and Rehder (fig. 105, *a*), is occasionally taken near shore. The surface of the shell is roughened by concentric and radial ridges. It is about 1.5 inches long. The shell of *Calloarca* (*Barbarca*) *hua* Dall, Bartsch, and Rehder is thinner and smoother than that of the preceding species. The surface is marked by fine radial ribs and delicate concentric lines. The anterior edge of the shell is denticulated, and hairlike projections are developed from a thin periostracum which covers the surface. Specimens may be about 1 inch long (fig. 105, *b*).

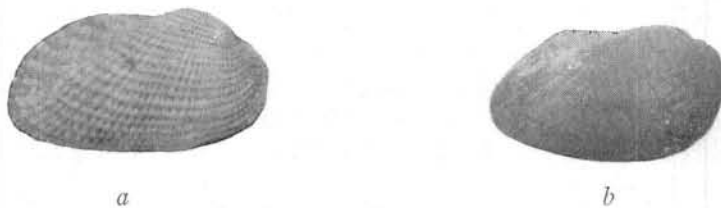


FIGURE 105.—Arcidae: *a*, *Acar hawaiiensis*; *b*, *Calloarca* (*Barbarca*) *hua*.

At least five species of *Barbatia*, subgenus *Abarbatia*, have been described from Hawaii by Dall, Bartsch, and Rehder. In this genus the almost straight hinge bears many teeth, the central ones being small or obliterated. Three species have been collected occasionally in shoal water, *Barbatia* (*Abarbatia*) *oahua*, *B. (A.) hawaia*, and *B. (A.) hiloa*.

ORDER DYSODONTA

FAMILY MYTILIDAE

Attached to reef rocks and to piling and other supports in shallow water is the common mussel, *Brachidontes cerebristriatus* Conrad (fig. 106, *a*). The species grows in clusters, each individual attached by a strong byssus. The valves are equal in form and size with the umbo at the pointed end of the shell. The species seems to grow larger in shallow bays or at the mouths of streams where the sea water is slightly dilute. A black or brown horny layer forms the outer surface of the shell. Large specimens are 1.5 inches long. A small form, *Brachidontes cerebristriatus*

maritimus Pilsbry, is characteristic of open reefs but is often found near shore. In some localities it covers large areas of the flat reef platform. It slightly exceeds 12 mm. in length. It is marked by fewer ribs and is more concave ventrally than the typical species.

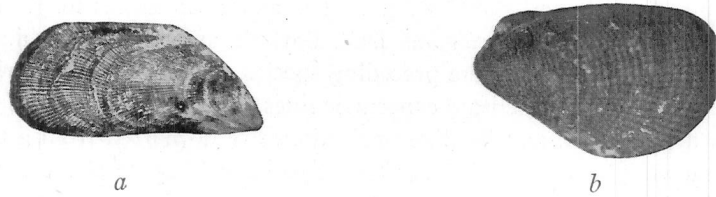


FIGURE 106.—Mytilidae: *a*, *Brachidontes cerebristriatus*; *b*, *Septifer bryanae*.

In the genus *Volsella* the shell is inflated anteriorly, more arched than in *Brachidontes*, and the umbone is subterminal. There are no teeth on the hinge. The Hawaiian shore species, *Volsella matris* Pilsbry (fig. 107, *a*), has a thin shell brightly colored with tints of rose and yellow within and without. Large specimens are about 12 mm. long. A larger species, *V. peasei* Newcomb, has been dredged in offshore water about the islands.

The species *Septifer bryanae* Pilsbry (fig. 106, *b*) is occasionally taken about the shores. The ventral border is concave, cut out for the passage of the byssus, and the shell spreads out in a fanlike manner. The hinge has no teeth but is provided with a narrow shelf (septum), which is typical of the genus. Most specimens are less than 12 mm. long.

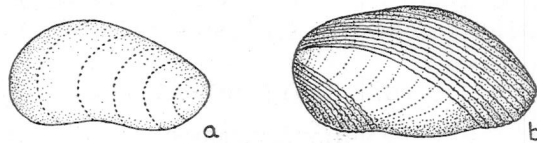


FIGURE 107.—Mytilidae: *a*, *Volsella matris*; *b*, *Musculus oahuus*.

Large ascidians (p. 318) of Hawaiian waters are sometimes parasitized by a bivalve, *Musculus oahuus* Dall, Bartsch, and Rehder (fig. 107, *b*), which is attached to or embedded in the tough tunic. The shell is marked by fine radial lines anteriorly and posteriorly, with a smooth area between. It is about 10 mm. long. Large numbers of the mollusks have been taken from ascidians on piling in Kaneohe Bay, Oahu.

FAMILY ISOGNOMONIDAE

Representatives of the family have flattened shells, the right valve smaller than the left one. They are attached to some support by a tuft of strong filaments (byssus) which develops from the foot of the animal.

Examples of the genus *Isognomon* (*Pedalion* or *Melina* of some authors) are common about local shores, attached to the under surface of stones in shallow water. The species *Isognomon* (*Melina*) *costellatum* Conrad (fig. 108, *a*) may be recognized by the yellowish-white shell, which usually is a little longer than broad. Radiating striae mark the surface. Internal surface light in color. Large specimens are 2.5 inches across. Another common form, *I. (M.) incisum* Conrad (fig. 108, *b*), is distinguished from the preceding species by the dark internal surface of the shell. Its form varies considerably but old specimens are usually thick and heavy with the outer surface worn and corroded. Large specimens are 2 inches across.



FIGURE 108.—Isognomonidae: *a*, *Isognomon* (*Melina*) *costellatum*; *b*, *Isognomon* (*Melina*) *incisum*; *c*, *Isognomon* (*Melina*) *californicum*.

In *I. (M.) californicum* Conrad (fig. 108, *c*) the shell is somewhat rhomboidal in form, with outer surface covered by imbricating lamellae and a dark periostracum. The inner surface is gray with a black border. In this species the beak at the hinge line is only slightly hooked. The height of the shell may slightly exceed 1.5 inches.

FAMILY PTERIIDAE

Widely distributed about the islands and abundant in Pearl Harbor, Oahu, is the small pearl oyster, *Pinctada nebulosa* Conrad (fig. 109, *a*). The shell is quadrate in outline, compressed, with a long hinge line and small wings. The left valve is somewhat more inflated than the right one.

Concentric wrinkles with serrated margins mark the surface of the shell. It is yellowish white with broad radiating bands of brown. Large specimens are 3 inches across. Some persons find this mollusk palatable.

The black-lipped pearl oyster, *Pinctada galtsoffi* Bartsch (fig. 109, *b*), seems to be widely distributed about the islands at depths of a few fathoms. It occurs in Pearl Harbor, Honolulu Harbor, and Kaneohe Bay, Oahu, and is known from Maui. Large specimens reach a diameter of about 8 inches. Many of the immature individuals which are occasionally taken in shallow water near shore have the outer surface of the valves covered with thin scales which also form a fringe about the margin of the shell. As the shell grows, the scales gradually disappear, and the valves of most large specimens are quite smooth.

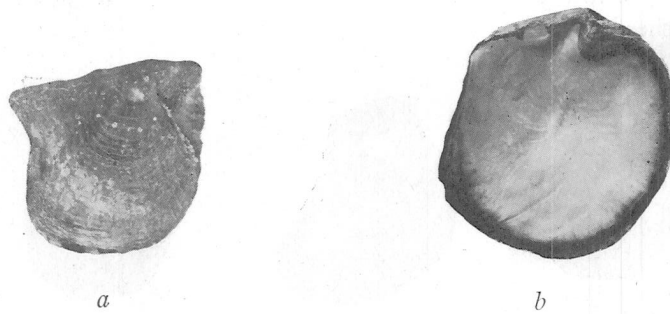


FIGURE 109.—Pteriidae: *a*, *Pinctada nebulosa*; *b*, *Pinctada galtsoffi*.

Extensive beds of the species were located at Pearl and Hermes Reef. Transplantings from that locality to Kaneohe Bay, Oahu, were made by a representative of the United States Bureau of Fisheries during the summer of 1930 in an attempt to populate Hawaiian waters more extensively. Although this species is not a popular food, pearls of excellent quality are occasionally taken from it and the shell is a product of some commercial value.

Studies of the rate of growth of the pearl oyster in Kaneohe Bay, Oahu, show that 10 young specimens, ranging from 2 to 3 inches across, made an average increase in diameter of 79 percent in six months' time. During the same period 12 larger specimens, ranging from 3 to 6.5 inches across, made an average increase in diameter of 13 percent.

FAMILY PINNIDAE

Thin, wedge-shaped shells characterize mollusks of this family. They rest vertically with the pointed end down, firmly anchored by a strong byssus, and usually almost buried in the sand and mud.

Species of two genera occur in Hawaiian waters. In *Pinna*, represented by *P. semicostata* Conrad (fig. 110, *a*), the elongated triangular shell is regular in outline. There is a specimen 8 inches long in Bishop Museum from Hilo, Hawaii. The species often grows much larger.



FIGURE 110.—Pinnidae: *a*, *Pinna semicostata*; *b*, *Atrina (Streptopinna) nuttalli*.

In species of *Atrina*, the shell is more irregular in outline and does not taper so gradually to a point. The valves are united on the dorsal side for their entire length. A widely distributed form *A. (Streptopinna) nuttalli* Conrad (fig. 110, *b*), is occasionally taken in shallow bays about the larger islands and is known from the leeward islands as far as Kuré. Specimens observed are about 8 inches long.

FAMILY PECTINIDAE

Pectens, or scallops, as they are called, have circular, more or less symmetrically shaped shells with wings (auricles) at the hinged border. The external surface of the valves is usually radially ridged and often tinted with bright colors. Pectens may swim rapidly through the water by clapping the valves of the shell together.

In Hawaii living pectens are seldom seen on the reefs or in the near-shore water. Most of the local forms have been recovered from dredged material or are known from empty shells washed up on the beaches. The shells of some are found in emerged reefs. On sandy shores of the north coast of Kauai immense quantities of pecten shells are sometimes deposited indicating that the mollusks are living in the bordering waters.

Among the more common of the pecten shells to be picked up on sandy beaches are those of *Haumea juddi* Dall, Bartsch, and Rehder. One valve of this species is white, the other is mottled and banded in an irregular manner with reddish brown. The wings are subequal. The surface is marked by strong radiating ribs which are somewhat sharp in the middle area but rounded toward each extremity of the shell. Fine, more or less interrupted lines cross the ribs. Specimens are less than 1 inch across (fig. 111, *a*).

Another species, usually dredged or the shells taken from raised reefs, is *Chlamys cookei* Dall, Bartsch, and Rehder (fig. 111, *b*). The height of the shell is greater than the length and the anterior wing is larger than the posterior one. Externally, the pale brown shell is blotched and spotted with red and marked by strong radiating ribs with smaller ones between. Internally, the valves are rose colored. Large specimens are about 35 mm. in height.

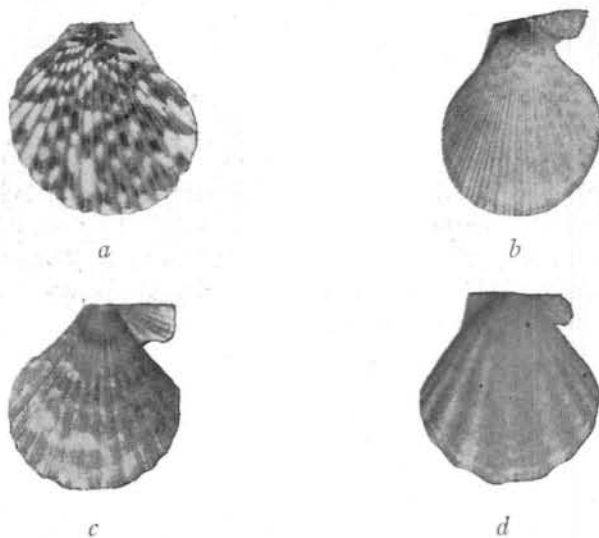


FIGURE 111.—Pectinidae: *a*, *Haumea juddi*; *b*, *Chlamys cookei*; *c*, *Chlamys hawaiiensis*; *d*, *Nodipecten langfordi*.

In another species widely distributed among the islands, *C. hawaiiensis* Dall, Bartsch, and Rehder (fig. 111, *c*), the anterior wing is strongly developed but the posterior one reduced. The prominent radial folds of the surface are marked by ribs. Its color is red or white. Specimens are about 12 mm. high.

Specimens of the genus *Nodipecten* have been dredged about the islands, and empty shells are occasionally picked up on the beaches. The heavy valves are reddish, yellow, or orange in color and marked externally by strong radial ridges with smaller ribs between. The heavy ridges often bear nodules. The local species, *N. langfordi* Dall, Bartsch, and Rehder (fig. 111, *d*), is about 1.5 mm. in height.

Numerous other pectens have been dredged at various depths about Hawaii. If empty shells are found on the beaches or in elevated reefs, a monograph on the group should be consulted for their determination.

FAMILY SPONDYLIDAE

One representative of the family, *Spondylus hawaiiensis* Dall, Bartsch, and Rehder (fig. 112, *a*), is found on rocky shores. It is somewhat like a pecten, but the shell is much thicker and is firmly attached to stones by the right valve, which is larger than the left one. Each valve has two strong interlocking teeth. Large specimens are 4 inches across.

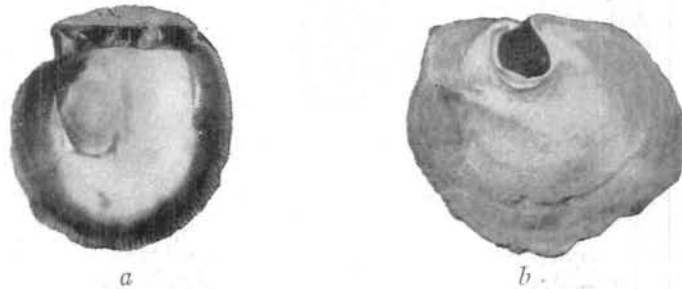


FIGURE 112.—Pelecypoda: *a*, *Spondylus hawaiiensis*; *b*, *Anomia nobilis*.

FAMILY ANOMIIDAE

An oysterlike species, *Anomia nobilis* Reeve (fig. 112, *b*), has two thin valves, irregular in outline, but tending to be circular. The lower or right valve is pierced by a round hole, through which a byssus extends, attaching the shell to a support. The shell is often bent or contorted, and assumes the form of the surface with which it is in contact. It may be found clinging to the under surface of stones in shallow water. Large specimens are 3 inches across. The bottoms of ships anchored in Pearl Harbor for a few months are sometimes badly fouled by this species.

FAMILY OSTREIDAE

Oysters have shells with unequal valves and no hinge. There is no byssus, the shell being attached to some support by the left valve.

The native Hawaiian oyster, *Ostrea sandvichensis* Sowerby (fig. 113), is recognized by the rough and ridged character of the upper valve of the shell. It attains a height of nearly 2 inches and grows in clusters attached to stones or other supports. It is widely distributed about the islands and is plentiful in Pearl Harbor, Oahu. Although it is an edible oyster, it is not used as food to any great extent at the present time.

Another small species, of little or no economic value as food, is *Ostrea thaanumi* Dall, Bartsch, and Rehder. The shell is rounded or oval in outline, very smooth and flat with only traces of fluting. It is usually white without and within, sometimes marked externally by reddish rays. It is about 2 inches in length.



FIGURE 113.—*Ostrea sandvichensis*.

On the shores of Pearl Harbor, Oahu, in elevated reefs, are extensive beds of an extinct oyster, *Ostrea retusa* "Pease" Sowerby. Some shells are 6 inches long, and it is obvious that the species lived under favorable conditions when the reef was submerged. A few specimens of a huge fossil oyster, *Ostrea kamehameha* Pilsbry, have been taken from elevated reefs on Oahu. The shells are thick and heavy, nearly circular in outline. The longest dimension of the largest specimen is 9 inches.

Many attempts have been made to establish exotic species of oysters in Hawaii. Quantities of the eastern oyster, *Ostrea virginica*, have been planted about the islands at various times. Trial plantings were made at Kalihi Bay, Kaneohe Bay, Pearl Harbor, and other localities with a degree of success. Recently, an Australian oyster, *Ostrea cucullata*, was transplanted in Kaneohe Bay. For some time there were encouraging reports regarding its growth, but there was no conclusive proof that spawning occurred in local waters and the specimens finally disappeared. During March 1939, more than one million spat of the Japanese oyster, *Ostrea gigas*, were planted in Kaneohe Bay. Rapid growth took place

during the following four months but the oysters were almost totally destroyed within a year. This was attributed to infestation by a parasitic worm.

ORDER HETERODONTA

FAMILY CARDITIDAE

Small quadrate shells with the surface ornamented by strong radial ridges are found in shallow water clinging to the undersurface of stones or concealed in crevices of rocks.

The common representative of the family in shallow water is *Arcinella thaanumi* Dall, Bartsch, and Rehder (fig. 114, *a*). Strongly elevated radiating ribs mark the external surface of the shell. It is pale brown or yellowish in color. Specimens are 12 to 15 mm. in length. The species is gregarious.

FAMILY TRAPEZIIDAE

A typical sand dweller and representative of the family in local waters is *Trapezium californicum* Conrad (fig. 114, *b*). The solid, oblong shell is trapezoid in outline with the external surface radially and concentrically striated. Large specimens are 2.5 inches long.



FIGURE 114.—Pelecypoda: *a*, *Arcinella thaanumi*; *b*, *Trapezium californicum*.

FAMILY SPORTELLIDAE

Two species of *Anisodonta* have been described from the shoal waters of Oahu and Hawaii by Dall, Bartsch, and Rehder. The small shells are subquadrate or rhomboidal in shape, pale yellow or white in color. The umbones are anterior of the middle and the surface is marked by concentric lines of growth. In *A. angulata* the shell is strongly keeled from the umbo to the posterior ventral margin, and minute tubercles cover the sur-

face especially toward the anterior end. It has been collected at Koko Head, Oahu, and may exceed 8 mm. in length. In *A. lutea* (fig. 115, *a, b*) the shell lacks the strong keel and the tubercles. Specimens 5 to 6 mm. long have been taken at numerous localities about Oahu, and from Hilo and Honaunau, Hawaii, and also from Kauai.

FAMILY JULIIDAE

Many years ago a tiny representative of this family, *Julia exquisita* Gould, was described from Hawaiian waters. It apparently lives near shore, as shells are occasionally found in beach sand. The shell is ovate with a deep invagination in front of the umbo. Specimens from Waimanalo, Oahu, are white with the outer surface finely costate radially and concentrically and marked by minute, oval, translucent areas. Its length is about 5 mm. (fig. 115, *c*). Somewhat smaller specimens have been collected at Hilo, Hawaii.

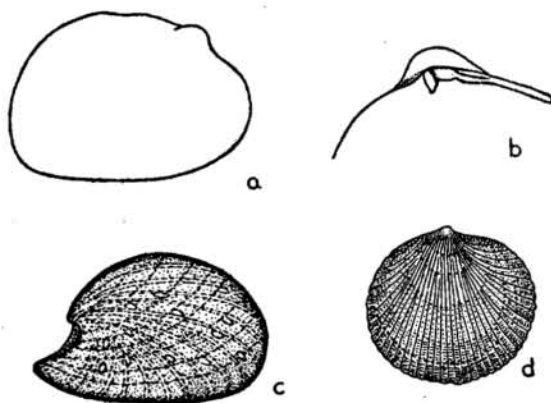


FIGURE 115.—Pelecypoda: *a*, *Anisodonta lutea*, outline of shell; *b*, *Anisodonta lutea*, hinge of right valve; *c*, *Julia exquisita*; *d*, *Ctena bella*.

FAMILY LUCINIDAE

The species *Ctena bella* Conrad (fig. 115, *d*) inhabits sandy bottoms of reefs and shallow bays. The white shell is nearly circular with the equal valves marked by fine, radiating, divergent ribs crossed by concentric lamellae which render the surface nodulose in appearance. Its diameter is about 1 inch. A larger species, *Codakia thaanumi* Pilsbry (fig. 116), is circular and ornamented with heavy radial ridges which are not

divaricate. Large specimens are nearly 3 inches in diameter. A small species, *Pillucina spaldingi* Pilsbry, has been collected at various localities about Oahu. It has a plump shell, suborbicular in form, slightly higher than long and marked by concentric wrinkles and radial lines. The umbo is prominent and median in position. The shell is white with grayish streaks. Its height is about 8 mm.



FIGURE 116.—*Codakia thaanumi*.

FAMILY KELLIIDAE

Representatives of this family have fragile little shells, mostly white and shiny, some with color. Some species may be recognized by the sculpture of the surface and others by the character of the hinge of the valves. A common form, *Nesobornia hawaiiensis* (Pilsbry) (fig. 117, *a, b*), is found in crevices of porous rocks and on the under surface of rough stones. It is gregarious in habits. The shiny white shell is almost evenly rounded at both ends and the ventral margin is quite straight. The outer surface is marked by fine concentric lines of growth. On the hinge of the left valve, under the umbo, are two divergent teeth with a triangular pit between, into which fits the large triangular tooth of the hinge of the right valve. Specimens are about 8 mm. long. A less common species, *Nesobornia ovata* Gould, has a single hooklike tooth on the hinge of the left valve, instead of two, as in the preceding species. It is also slightly larger than *N. hawaiiensis*.

In specimens of *Radobornia* the outer surface of the shell is covered by a fine network of punctae, the markings being much coarser near the ventral border. In *R. bryani* Pilsbry (fig. 117, *c-e*) the sculpturing is stronger than in *R. arafia* Dall, Bartsch, and Rehder. The former species is known from Oahu, the latter from Hilo, Hawaii.

Another member of the family, probably *Lasaea hawaiiensis* Dall, Bartsch, and Rehder (fig. 117, f), has a thin, oval, inequilateral shell with a reddish tint. In shallow water the mollusk clings to stones, walls or other supports. It is often associated with rock barnacles. Adult specimens are about 4 mm. long. Other species described by Dall, Bartsch, and Rehder include *Kaneooha rosea* and *Kellia hawaiiensis*. The former, taken in Kaneohe Bay, Oahu, has a rose-colored shell about 1.4 mm. long, the latter, taken at Fort Armstrong, Oahu, has a translucent, whitish shell about 4.4 mm. long. These tiny shells are specifically distinguished by the hinge teeth of the valves. For details of these characters the monograph by Dall, Bartsch, and Rehder should be consulted.

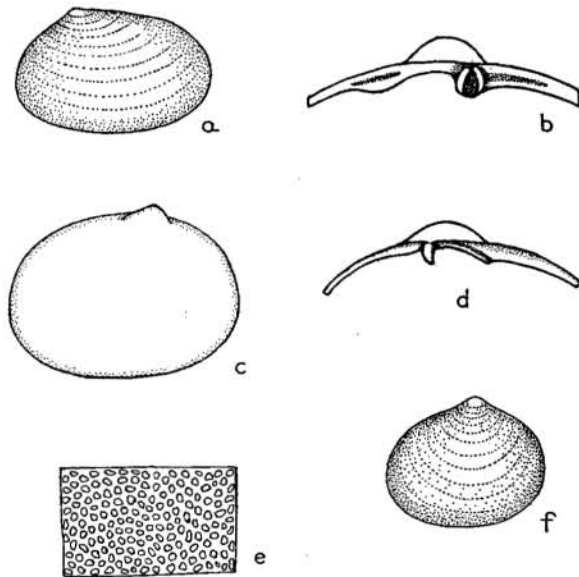


FIGURE 117.—Pelecypoda: a, *Nesobornia hawaiiensis*; b, *Nesobornia hawaiiensis*, hinge of left valve; c, *Radobornia bryani*, outer surface; d, *Radobornia bryani*, hinge of right valve; e, *Radobornia bryani*, outer surface near ventral border showing punctae (enlarged); f, *Lasaea hawaiiensis*.

FAMILY GALEOMMIDAE

Members of the family are characterized by small, oval shells, smooth, whitish and polished. The species *Scintillona stigmatica* Pilsbry is recognized by a reddish band crossing the shell from the umbones down toward the margin, often fading out before the edge is reached. There is a single

hinge tooth in each valve. Specimens are about 5 mm. long. In *Scintilla hiloa* Dall, Bartsch, and Rehder, the shell lacks the reddish band and there are several hinge teeth in each valve. Specimens are about 12 mm. long.

In the genus *Leiochasma* the hinge teeth are absent. The white, oblong shell of *L. (Achasmea) thaanumi* Pilsbry has the hinge margin straighter than the lower margin. Growth lines mark the surface. Its length is less than 8 mm. In *L. chascax* Pilsbry the white, translucent shell is very thin and fragile. The straight hinge margin has a minute nodule representing a tooth. Its length is about 8 mm.

FAMILY MONTACUTIDAE

Examples of this family are small, oval, white shells with the umbones near the posterior end. Two species are recognized. In *Kona bucki* Dall, Bartsch, and Rehder (fig. 118, *a*) the shell is thin and slightly inflated with the umbones directed posteriorly. Externally, the shell is marked by very fine lines of growth. In the hinge of each valve (fig. 118, *b*) is a prominent triangular tooth below the umbo. The species has been collected near Koko Head, Oahu, and at Hilo, Hawaii. It is about 4 mm. long. *Kona symmetrica* (Pilsbry) is known from a single valve collected on the beach at Haleiwa, Oahu. It is glassy white with the surface almost smooth. The length of the shell is 2.7 mm.

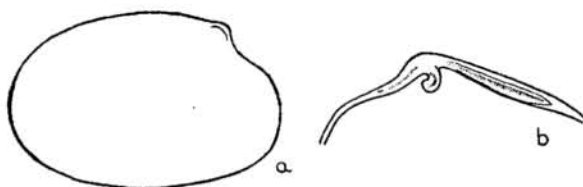


FIGURE 118.—*a*, *Kona bucki*, outline of shell; *b*, *Kona bucki*, hinge of left valve.

FAMILY CHAMIDAE

Rock oysters have thick, heavy shells and are firmly attached by the larger of the unequal valves. There are two hinge teeth on the attached valve and one on the other.

The most common Hawaiian species, *Chama iostoma* Conrad, inhabits rocky shores and the outer edge of the reef where the surf is strong. The outer border of the inner surface is edged with purple. Large specimens are 3 inches across. A smaller species, *C. hendersoni* Dall, Bartsch, and Rehder, has the larger valve twisted and the upper valve is sculptured by

radiating rows of folded lamellae. The inner surface lacks the colored border of *C. iostoma*. It has been taken in Pearl Harbor and Honolulu Harbor. Its diameter is about 15 mm.

FAMILY CARDIIDAE

The common representative of this family on sandy bottoms about the islands is *Trachycardium hawaiiensis* Dall, Bartsch, and Rehder (fig. 119, *a*). It has equal valves which are higher than long and are ornamented by strong radial ribs. Large shells are 3 inches high. A small species *Fragum thurstoni* Dall, Bartsch, and Rehder (fig. 119, *b*) has a thick shell, the posterior slope of each valve being depressed forming a flat dorsal area. The surface is radially ribbed. Its length is about 10 mm.

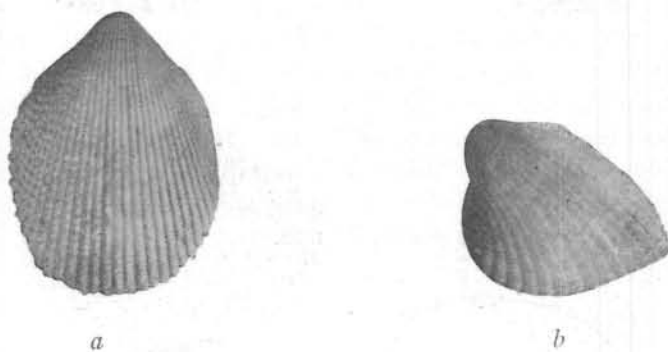


FIGURE 119.—Cardiidae: *a*, *Trachycardium hawaiiensis*; *b*, *Fragum thurstoni*.

FAMILY VENERIDAE

Mollusks of this family are sand dwellers and frequent habitats in common with those of the family Cardiidae. Several genera are represented in Hawaii.

A widely distributed species, *Periglypta edmondsoni* Dall, Bartsch, and Rehder (fig. 120, *a*), has an asymmetrical shell with the surface reticulated with radial and concentric ridges. Large specimens are slightly more than 2 inches long. Another well recognized species, *Lioconcha hieroglyphica* Conrad (fig. 120, *b*), is more plentiful at depths of a few fathoms than on shallow reefs. The smooth white shell is spotted with brown. Large specimens are 2 inches long.

The common clam of the Honolulu markets is an introduced form, *Venerupis (Ruditapes) philippinarum* Adams and Reeve (fig. 120, *c*). The brown shell is marked by fine radiating and concentric lines. Large specimens are 2 inches long. The species is native to the Philippine Islands and probably came to Hawaii by way of Japan. Since its introduction it has multiplied rapidly in shallow bays about Oahu and is now used extensively as food.

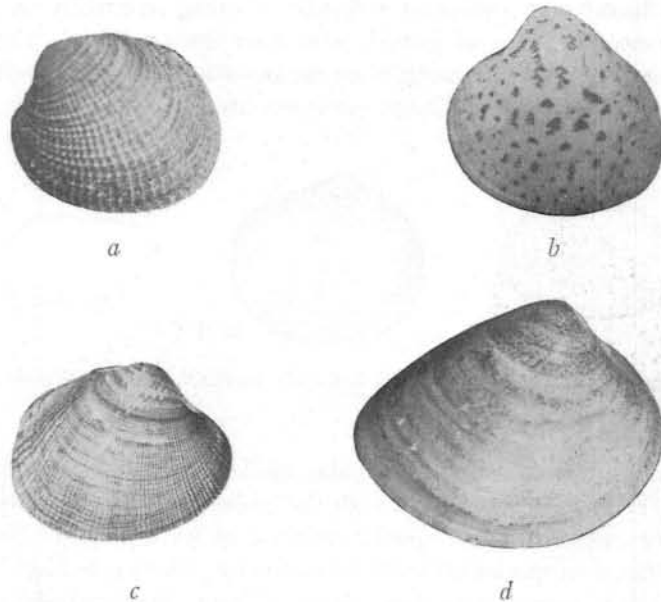


FIGURE 120.—Veneridae: *a*, *Periglypta edmondsoni*; *b*, *Lioconcha hieroglyphica*; *c*, *Venerupis (Ruditapes) philippinarum*; *d*, *Cytherea (Meretrix) meretrix*.

A species introduced into Hawaii from Japan and occasionally seen in local waters is *Cytherea (Meretrix) meretrix* Linnaeus (fig. 120, *d*). The shell is quite smooth, reddish brown, and marked by faint concentric lines of growth. Large specimens are 3 inches long. The species apparently finds a habitat in muddy bottoms. Many empty shells are to be found in certain localities along the south shore of Kaneohe Bay, Oahu.

FAMILY MESODESMATIDAE

A small species, probably *Rochefortina sandwicensis* Smith (fig. 121, *a*) is occasionally taken about the shores, and empty shells of the

form are found in the sand. The shell is oblong, white, marked by fine radial and concentric lines. Each valve has two divergent teeth. It is about 3 mm. long.

FAMILY SEMELIDAE

The most familiar representative of this family in shallow water is *Semele tita* Dall, Bartsch, and Rehder (fig. 121, *b*). Its shell is subcircular in broad view, white or yellowish, marked externally by rather strong concentric lines of growth with finer lines between. Very fine radial lines are present, especially on the posterior half of the shell. It is found on sandy bottoms. Large specimens are about 1 inch long.

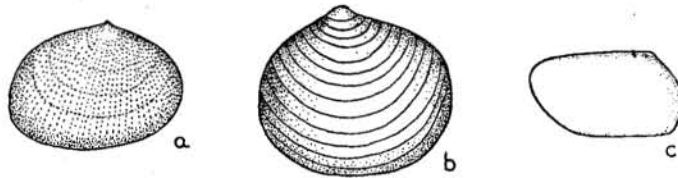


FIGURE 121.—Pelecypoda: *a*, *Rochefortina sandwichensis*; *b*, *Semele tita*; *c*, *Semelangulus* species.

A beach-worn shell of *Semelangulus* species (fig. 121, *c*) was taken on Oahu. The wedge-shaped shell with the umbone near the posterior end cannot be identified as to species, because of its condition. Shells of known Hawaiian species are usually marked by yellow or reddish tints or spots. Three species have been dredged from comparatively shallow water about the island and one was taken from Midway Island. The left valve of the shell figured is 10 mm. in length.

FAMILY TELLINIDAE

Mollusks of this family have compressed shells usually ornamented by concentric ridges or fine lines. They are sand dwellers and are found near shore and at moderate depths. Several genera are represented about the islands.

The most common species in shoal water is *Quidnipagus palatam* Iredale (fig. 122, *a*). Its shell is slightly elongated and bent to the right at the siphon end. The external surface is roughened by irregular concentric ridges. Large specimens are 2.5 mm. long. In *Scissulina dispar* Conrad (fig. 122, *b*) the shell is elongate-oval, bluish white, more sym-

metrical and smoother than in the preceding species. In the right valve the concentric lines become wavy and diagonal in the middle area. In the left valve the concentric lines are normal. Specimens may exceed 30 mm. in length. The species is seldom seen on the reefs, but living specimens are dredged in comparatively shallow water and empty shells are washed up on the beaches.

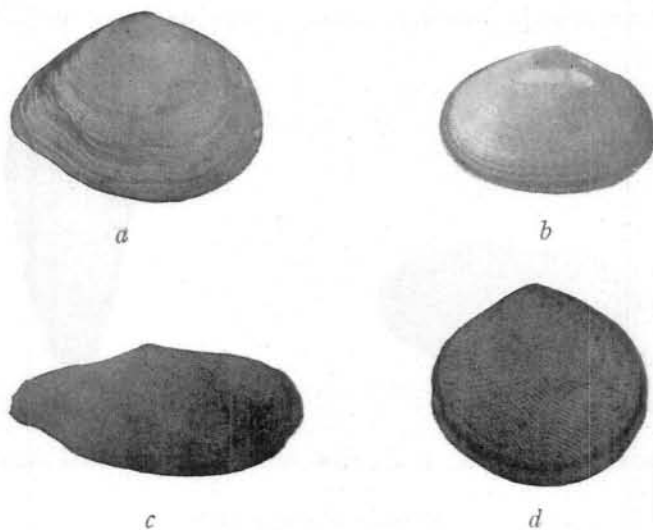


FIGURE 122.—Tellinidae: *a*, *Quidnipagus palatam*; *b*, *Scissulina dispar*; *c*, *Pharaonella venusta*; *d*, *Scutarcopagia scobinata elizabethae*.

About the leeward islands *Pharaonella venusta* Deshayes (fig. 122, *c*) seems to be a common species. It has a shiny white shell, narrow and beaked posteriorly, about 3 inches long. About the larger islands it is known from dredged material. Another species occasionally taken in shallow water and frequently found as a fossil in elevated reefs is *Scutarcopagia scobinata elizabethae* Pilsbry (fig. 122, *d*). The nearly circular shell is ornamented by minute blunt processes formed by interrupted crossed ridges. It is 2.5 mm. long. An elongated oval species, *Tellinella crassiplicata* Sowerby, has been recorded from Kuré and Midway Islands as well as from the larger islands of the Hawaiian group. Most specimens have been dredged. The shell is slightly bent at the siphon end and is yellowish in color, with radiating bands of reddish brown. It slightly exceeds 2 inches in length.

ORDER DESMODONTA

FAMILY GASTROCHAENIDAE

Rock-boring mollusks are placed in this family. The common species in Hawaii, *Rocellaria hawaiiensis* Dall, Bartsch, and Rehder (fig. 123, *a*), has a thin, elongated shell, gaping and slightly twisted at the narrow end. It is yellowish white in color. It burrows in dead coral blocks where it hollows out straight, tubelike cavities. Large specimens are 1.5 inches long.

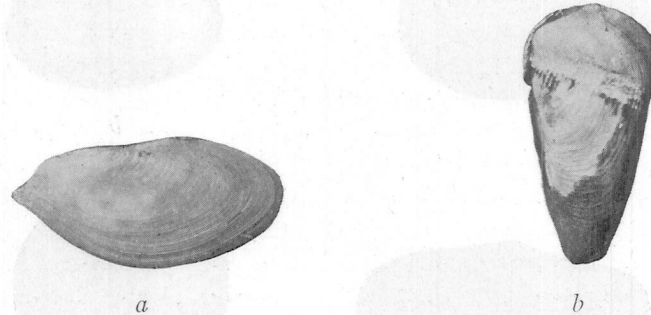


FIGURE 123.—Pelecypoda: *a*, *Rocellaria hawaiiensis*; *b*, *Martesia hawaiiensis*.

FAMILY PHOLADIDAE

Mollusks of this family are typically woodborers. They have elongated, cylindrical shells armed in front with file-like ridges, by means of which they are capable of cutting their way into even very hard timbers. The burrows formed are straight and increase in diameter from the surface of the wood inward as the mollusk grows in size. The species, *Martesia hawaiiensis* Dall, Bartsch, and Rehder (fig. 123, *b*), is more active in Pearl Harbor than in other localities examined about Oahu. Its shell is strengthened by five accessory plates, two over the front end, a large circular one on the dorsal border followed by a long narrow plate binding the valves together, and a similar one on the ventral border. Large specimens slightly exceed 1 inch in length.

After exposure to the water for a few years, algaroba piles supporting small piers in Pearl Harbor are destroyed by this mollusk. Experiments have shown that many kinds of timbers are damaged by *Martesia* in Pearl Harbor, California redwood being especially susceptible to its attacks.

FAMILY TEREDINIDAE

This family comprises the so-called shipworms, which are bivalve mollusks, mostly marine, habitually boring in wood. The mollusk has a short gaping shell, the anterior portion of which has rows of denticulated ridges, and a greatly elongated body. The posterior extremity terminates in two slender tubes (siphons), at the base of which is a pair of calcareous structures known as pallets. This extremity of the mollusk remains at the surface of the wood, and when the siphons are withdrawn into the burrow the pallets close the opening.

As the tortuous burrow is formed it is lined by a thin, shell-like layer secreted by the mantle of the animal. When the animal is feeding, the siphons are protruded from the burrow, one drawing in water and food, which consists of minute organisms, and the other discharging waste matter, including the wood pulp which has passed through the body. Investigators have shown that the animal derives some nourishment from the eroded particles of wood as they pass along the digestive tract.

Some species of shipworms, if not all, present a reversal of sex (protandry) during their lifetime. Usually individuals are males at first then become females then males again. Larvae with bivalve shells are developed within the body of the mature shipworm and are extruded through the exhalent siphon. The larvae are free-swimming for a short time and some eventually attach themselves to a wood surface and begin to work their way into it. The shell gradually changes shape, and the body becomes elongated.

A general substitution of concrete for wooden construction coming in contact with sea water has rendered the ravages of these mollusks less conspicuous. Their activities, however, may be observed by examining wooden piling that has stood in the sea for a few months, the unprotected bottoms of wooden boats or drift timbers about the shores. By anchoring test blocks in shallow water the larvae may be trapped and, on examining the blocks at intervals, the rate of development of the mollusk may be determined. (See fig. 124.)

A recent survey of shipworms in Hawaii indicates that representatives of two genera of the family Teredinidae are active about the islands.

Key to Genera of the Family

- A. Pallets typically paddle shaped, the calcareous portion of one piece..... **Teredo.**
 AA. Pallets not paddle shaped, the calcareous portion composed of separate units, or cone-in-cone elements..... **Bankia.**



FIGURE 124.—Teredinidae: Douglas fir wood attacked by *Teredo parksi*.

About a dozen species of the genus *Teredo* have been recognized in Hawaiian waters. One of the most common species widely distributed among the islands is *T. milleri* Dall, Bartsch, and Rehder (fig. 125, *a*). It has a peculiar pallet with four distal points (fig. 125, *b*), the middle pair being the longer. It is a very destructive species, and reaches a length of about 12 inches. A smaller form, *T. medilobata* Edmondson, is common in Honolulu Harbor and at Waikiki, Oahu. Its pallet is characterized by a median lobe on the distal margin (fig. 125, *c*). In *T. triangularis* Edmondson the pallet has a heavy, triangular blade (fig. 125, *d*). The species is common in Kahului Harbor, Maui, and elsewhere about the islands. Drift logs washed ashore about the islands are often honeycombed by the large species, *T. gregoryi* Dall, Bartsch, and Rehder, which has a very distinctive shell and pallet (fig. 125, *e*). Although full grown living specimens have not been recovered, the size of the burrows may reach a diameter of 18 mm. and a length of about 2 feet.

Other more or less common species of *Teredo* taken in Hawaiian waters in recent years include *T. parksi* Bartsch, *T. bartschi* Clapp, *T. trulliformis* Miller, *T. fulleri* Clapp, *T. hiloensis* Edmondson, and *T. diegensis* Bartsch. Some of these are localized, others are widely dispersed.

Few species of *Bankia* have been observed in Hawaii. A rare form, *B. oahuensis* Edmondson, was found only in Kalihi Entrance, Oahu, where the shore waters are considerably diluted. It is characterized by a

fusion of the elements of the pallet. A very common form in Honolulu Harbor and found elsewhere about the islands is *B. hawaiiensis* Edmondson (fig. 125, *f*). It probably attains a length of nearly 2 feet, although living specimens that large have not been taken. Another species, *B. konaensis* Edmondson, was recovered in Kealakekua Bay, Hawaii. It has a pallet in which the new elements or cups of the blade are formed at the basal end instead of at the apex as in *B. hawaiiensis*.

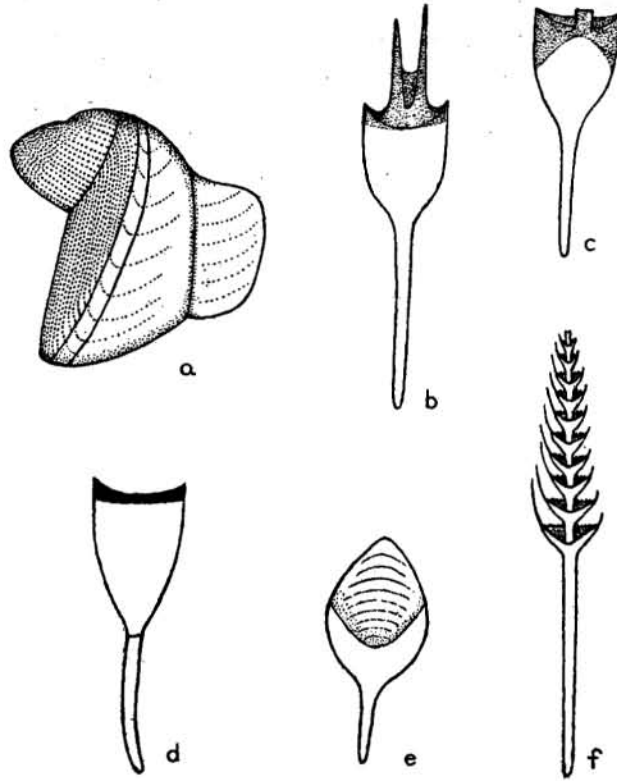


FIGURE 125.—Teredinidae: *a*, shell of *Teredo milleri*; *b*, pallet of the same species; *c*, pallet of *Teredo medilobata*; *d*, pallet of *Teredo triangularis*; *e*, pallet of *Teredo gregoryi*; *f*, pallet of *Bankia hawaiiensis*.

Several species of shipworms in Hawaii are infested by a parasitic copepod, *Teredicola typica* Wilson. It is carried in the infra-branchial chamber of the mollusk. The female is about 5 millimeters long, and the male is much smaller (fig. 130, *a*, *b*). The detrimental effect on the host

is problematic. A polyclad worm seems to be destructive of shipworms in some localities about Oahu (p. 52).

For a more complete discussion of the shipworms of Hawaii the paper entitled "Teredinidae of Hawaii" by Edmondson may be consulted.

CLASS CEPHALOPODA

Living representatives of this highly specialized class of mollusks include the octopus, squid, argonaut (paper nautilus), pearly nautilus, and spirula. In Paleozoic seas numerous other forms of cephalopods, relatives of the pearly nautilus, flourished, and some developed large and massive shells.

Recent cephalopods present many specialized features sharply distinguishing them from other groups of mollusks. Some grow to a large size. Giant squids 45 feet long, including the arms, have been reported. The eyes of some cephalopods are highly specialized, approaching those of vertebrates in structure and perhaps in function. Unlike most other mollusks, cephalopods are capable of rapid movement through the water. Many are provided with an internal sac (ink sac) from which an inklike fluid may suddenly be discharged into the water, discoloring it and thereby enabling the mollusks to glide away and escape.

A cephalopod consists of a head and body. The eyes are situated on the head, to which are attached the eight or ten tentacles or arms which represent the foot of the mollusk. Rows of suckers on the inner surface render these arms prehensile. The mouth is at the base of the arms and has a strong pair of horny jaws like the inverted beak of a parrot, the upper jaw fitting inside the lower one when closed.

The body is a rounded or elongated saclike structure enclosing the visceral organs. It is covered by a tough mantle which in some species is developed into lateral fins for purposes of locomotion. On the ventral surface at the anterior end of the body is the funnel through which are discharged waste products from the digestive tract, fluid from the ink sac, and the reproductive elements. Water may be forced out of the funnel in jets, and in this way the animal is enabled to move backward with great rapidity.

In some cephalopods (female argonaut and pearly nautilus) an external shell is developed. In some squids an internal shell (gladius) consisting of a thin leaflike plate of chitinous and calcareous composition is formed within the dorsal body wall. Other cephalopods (octopods and some squids) have no shell of any kind.

The sexes are separated in cephalopods. In most species one or more of the arms of the male become modified (hectocotylized) for sexual purposes. Such a specialized arm has the suckers reduced in size, crowded together, or otherwise altered. By means of this modified organ the sperm is believed to be transferred to the ova of the female.

Little is known of the egg-laying habits and early development of cephalopods. Species of octopods spawning in the Honolulu Aquarium lay masses of eggs attached to cords 4 to 6 inches long which become fixed to the walls of the aquarium tanks. One animal may produce many such clusters. Each cord supports 500 to 800 eggs. Young have hatched from these eggs, but attempts to raise them to the adult stage have met with no success. On escaping from the egg the free-swimming larva has the general appearance of the adult, though immature. (See fig. 126.)

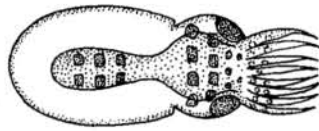


FIGURE 126.—A larval octopus just after escaping from the egg.

In a collection of 210 specimens of cephalopods taken in the vicinity of the islands by the *Albatross* in 1902, 36 different forms were recognized, about a dozen of which were not specifically determined. Many were taken from the surface of the ocean, others from depths down to 733 fathoms, but comparatively few came from the reefs or shallow water. The cephalopod fauna of the shore waters of Hawaii is restricted in number of species. In the following discussion only those species are mentioned which are typical or occasional residents of the reefs, or those whose shells have been or are likely to be picked up along the shore.

ORDER DIBRANCHIATA

All living cephalopods except the pearly nautilus belong to this order. They have two gills and eight or ten arms. A few forms produce an external shell, some develop an internal one (gladius), and others are without shells.

SUBORDER OCTOPODA

The octopus and argonaut are included in this group. They have eight arms, the sessile suckers of which are without horny rims. The octopus and male argonaut are without shells.

FAMILY ARGONAUTIDAE

In species of the genus *Argonauta* the sexes are diverse in form. The female is much larger than the male and develops an external shell, which is secreted from expansions of the two dorsal arms instead of from the mantle lobes, as in most mollusks.

The term "paper nautilus" is applied to representatives of this group. As they are pelagic and typical inhabitants of the open ocean, it is unlikely that living specimens will be seen in near-shore waters. Empty shells, however, are occasionally washed ashore. There are two shells in Bishop Museum, both of which were collected on the shore of the island of Lanai. The largest is 6 inches long. (See fig. 127, *b*.) They probably represent the widely distributed species *Argonauta argo* Linnaeus.

FAMILY POLYPODIDAE

This family includes the common octopods of the Hawaiian reefs. The term "squid" generally applied locally by fishermen and others to the octopus is a misnomer. The squid, although related to the octopus, is quite a different animal. (See p. 216.)

In general appearance the sexes of the octopus are very similar. The specialized arm of the male, for the reproductive function, is the third right one numbered from the dorsal side, in the two common local species.

One of the common Hawaiian species, *Polypus marmoratus* (Hoyle) (fig. 127, *a*), may be distinguished by the color and ornamentations. The general body color is some shade of gray or brown, although the active pigment cells make a rapid change of color possible. Below and in front of each eye is a large oval or round black spot surrounded by a narrow zone of light brown. In most specimens there is a blunt tubercle at the base of each dorsal arm and one in the mid-line in front of the head. A small ridge of skin in front of each eye and a large tubercle and a ridge behind each eye are also typical features. The web of skin (umbrella) which incloses the basal portions of the arms extends as a narrow band along their margins.

The reproductive arm of the male (third on right side) is shorter than the corresponding one on the left side, and its tip is slightly grooved. Large specimens reach a length of about 24 inches, including the arms. This species is the common one sold in the fish markets and is used extensively as food.

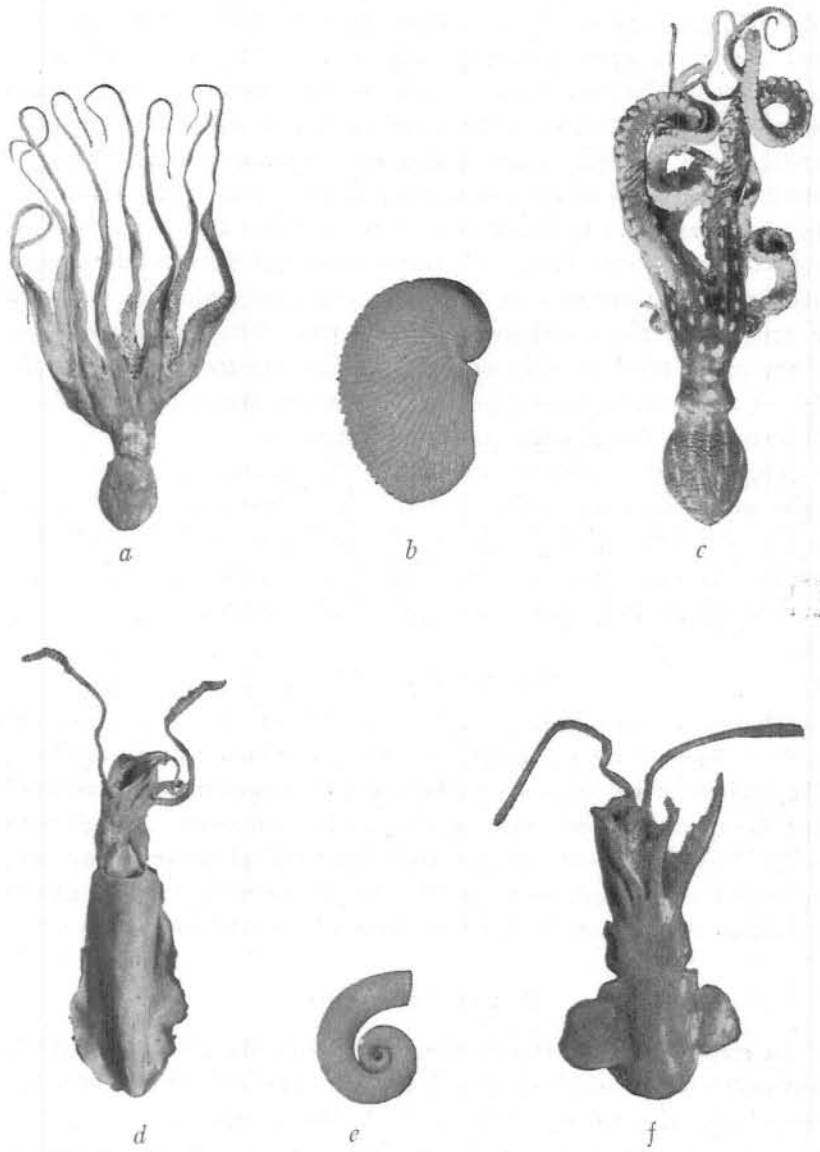


FIGURE 127.—Dibranchiata: a, *Polypus marmoratus*; b, shell of *Argonauta argo* (?); c, *Polypus ornatus*; d, *Sepioteuthis arctipinnis*; e, *Spirula peronii*; f, *Euprymna scolopes*.

Another species inhabiting Hawaiian reefs, *Polypus ornatus* (Gould) (fig. 127, c), is apparently less numerous than *P. marmoratus* and differs from that species in color markings as well as in structural features of the arms. The general color of the species is reddish brown or deep orange with the tubercles of the dorsal surface arranged in longitudinal series. Each tubercle is surrounded by a narrow elongated zone of white, these dashes of pale color extending along the outer surface of the dorsal arms in a double row. The posterior tip of the body is usually more pointed than in *P. marmoratus* and the arms are longer, tapering to filamentous tips. There is a gradual reduction in length of arms from the dorsal to the ventral pair. The reproductive arm of the male (third on right side) is flattened and spoon shaped at the tip. A preserved specimen in Bishop Museum has a total length of 45 inches; the dorsal right arm is 36 inches long.

This species is seldom seen during the day but is very active at night and is the common form taken by torch fishermen. It is known in Hawaii as the "night squid" and is considered excellent food. The species seems to be confined to the Hawaiian Islands but is closely related to one ranging through the Indian and western Pacific oceans.

SUBORDER DECAPODA

The squids and spirula belong to this suborder. There are ten arms; those of the fourth pair (tentacles) are usually longer than the others. The suckers of the arms are stalked, and their apertures are bordered with horny or chitinous rims which may be dentate or provided with hooks. In the squid the elongate body has terminal or lateral fins, and an internal shell (gladius or "pen") is usually present. In spirula there is a coiled shell. Some species have special light-producing organs.

FAMILY LOLIGINIDAE

In species of squid representing this family the elongated body is provided with terminal or marginal fins. The suckers of the arms have horny rims, usually toothed. A gladius is present.

Squids are much less common than octopods in the near-shore waters of Hawaii. They are more or less gregarious, and small schools are occasionally seen on the reefs.

The species *Sepioteuthis arctipinnis* Gould (fig. 127, d) has a dorso-ventrally compressed body which tapers to a posterior blunt point. The marginal fins are broad and extend nearly the entire length of the mantle. In the male the reproductive arm is the left ventral one, in which the suckers near the tip are crowded together and have reduced apertures. A horny gladius lies along the mid-dorsal line within the body wall. It has a heavy midrib with thinner, bladelike wings. Large specimens are from 8 to 10 inches long, including the longest arms.

FAMILY SEPIOLIDAE

Small squids with short, thick bodies belong to this family. The fins are rounded lobes attached about the middle of the body, and the gladius, when present, is rudimentary. Some species have light-producing glands.

The species *Euprymna scolopes* Berry (fig. 127, f) is a common one about the islands, both on the surface of the ocean and at moderate depths, and occasionally is seen in shallow water near shore. Nearly one third of all cephalopods collected by the *Albatross* in the vicinity of Hawaii in 1902 were of this species. It is easily distinguished by the semicircular fins. The left dorsal arm of the male is specialized for the reproductive function. No gladius is developed in this species. The species is believed to be luminous, as photogenic (light-producing) glands are found in the mantle cavity. Preserved specimens in Bishop Museum are yellowish or pale brown, dotted with small dark spots. The largest of these has a total length of about 4 inches.

FAMILY OMMASTREPHIDAE

Although not likely to be seen in shallow water, the species *Ommastrephes hawaiiensis* Berry is one of the common squids about the islands at the surface of the ocean and at considerable depths. It is important economically, as it serves as food for the larger sea birds and fishes and is frequently sold in the Honolulu fish market for human consumption. In this species the acutely pointed posterior end of the body extends between the broad fins. The head is broader than the body, flattened above and below, and the arms are stout and squarish in cross section. Large specimens are 10 to 12 inches long.

FAMILY SPIRULIDAE

Species of *Spirula* are squidlike mollusks with a loosely spiral, chambered shell partially inclosed in the lobes of the mantle. These little-

known cephalopods live in fairly deep water, and few living specimens have been seen. An empty shell, probably of *Spirula peronii* Lamarck (fig. 127, *e*), was collected on Waikiki beach, Honolulu. The spiral tube increases in diameter toward the aperture, producing a coil 18 mm. across. Of the three or four species of the genus which have been described, *S. peronii* is a widely distributed representative.

ORDER TETRABRANCHIATA

All known living species of this order belong to one family, Nautilidae, and to one genus, *Nautilus*. The animal occupies the last chamber of a coiled shell and is held in place by a hollow, membranous stalk (siphuncle) which penetrates the septa of the proximal chambers. The pearly nautilus, *Nautilus pompilius* Lamarck, and five other species of the genus have been recorded from tropical seas, where they live on the surface or at considerable depths.

There are no reports at hand that species of *Nautilus* have been seen in the shallow waters about the Hawaiian Islands or that empty shells have been taken on any of the beaches.

PHYLUM ARTHROPODA

Members of this phylum are characterized by elongated, bilaterally symmetrical and segmented bodies, some or all of the segments of which bear jointed appendages. Familiar examples of land arthropods are insects, centipedes, spiders, and scorpions. Marine representatives in shallow water about the islands include crabs, shrimps, and barnacles, together with many minute and less well-known forms.

Among marine invertebrates of Hawaii this phylum is exceeded in number of known species only by mollusks. Although about 400 species of marine arthropods, chiefly crustaceans, have been recorded from Hawaii, numerous subgroups, for the most part comprising minute forms, have been given but little or no taxonomic consideration. Much systematic work needs to be done, especially with the ostracods, copepods, amphipods, and schizopods, some of which are apparently well represented in species, but have been neglected because of their small size.

CLASS CRUSTACEA

Most marine arthropods are included in this class. The body of a crustacean is covered by a chitinous exoskeleton and three divisions, head, thorax, and abdomen, are usually recognized. The head and thorax, however, are often united into a cephalothorax, the covering of which is known as the carapace. Paired appendages of the head are specialized as sense organs and mouthparts. Those of the thorax and abdomen are usually modified for walking, creeping, or swimming.

Crustaceans vary greatly in size and form. Some are microscopic. Some are parasitic, and by this mode of life have become greatly modified in structure and habits. Among the free-living forms are to be seen some remarkable adaptations and strange relationships.

As a result of the efforts of investigators, the crabs, shrimps, and a few other groups of Hawaiian crustaceans are fairly well known. The evidence seems to indicate that the shallow-water crustaceans are largely Indo-Pacific in their relationships. Many of the common crabs and shrimps range from Madagascar and the Red Sea through the Indian and Pacific Oceans to Japan, Hawaii, and the Tuamotus. Few shore species found in Hawaii range into the Atlantic Ocean or reach the western American coast. Some deep-water forms are, however, quite cosmopolitan in distribution.

Key to Subclasses of Class

- A. Crustacea with body segments variable, never 19; usually of small size and simple organization.
- B. Body enclosed in a bivalve, hinged shell.....**Ostracoda.** *p. 220*
- BB. Body not enclosed in a hinged shell.
- C. Free-swimming or parasitic in adult stage; segments in typical free forms usually about 16; no abdominal appendages.....**Copepoda.** *p. 223*
- CC. Fixed or parasitic in adult stage; segments few, abdomen reduced; metamorphic changes remarkable.....**Cirripedia.** *p. 224*
- AA. Crustacea with body segments typically 19 in number; usually of large size and complex organization; stomach with gastric mill.....**Malacostraca.** *p. 232*

SUBCLASS OSTRACODA

Ostracods have the body inclosed in a hinged bivalve shell resembling in form that of a minute clam. There are a number of paired appendages (commonly seven pairs) which protrude between the edges of the shell. By means of the appendages the animal creeps about over water plants, or swims. In the dorsal anterior region of the living animal is a prominent eye spot.

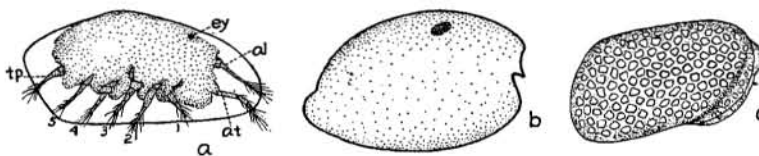


FIGURE 128.—Ostracoda: *a*, a common ostracod; *b*, an ostracod, *Pyrocypris* species; *c*, an ostracod, *Cythere* species. (*al*, antennule; *at*, antenna; *ey*, eye; *tp*, tail piece; 1-5, thoracic appendages.)

Hawaiian species are found among seaweeds near shore and may be taken in a tow net from the surface of the water. Several genera are apparently represented, but the species have not been determined. A common form living among sea lettuce (*Ulva*) and other seaweeds has a smooth, elongated shell. It is about 1 mm. long (fig. 128, *a*). In a larger form, *Pyrocypris* species (fig. 128, *b*), the smooth shell has a beak and a notch at the anterior end, and the posterior extremity is extended as a small rounded lobe. It is a swimming form and can be taken at the surface of the water. Specimens are 3 mm. long. Representatives of the genus *Cythere* have dense shells the surface of which is commonly sculptured by pits, rugae, spines, and tubercles. Empty shells are abundant in shallow water, but living specimens are seldom seen about Hawaiian shores. A common form is irregularly pitted; the thin anterior border

bears a few spines. It is about 1 mm. long (fig. 128, *c*). A large proportion of the marine ostracods collected by the *Challenger* Expedition was assigned to the genus *Cythere*.

SUBCLASS COPEPODA

Marine copepods are mostly minute crustaceans, free-living or parasitic. Typical free-living forms have elongated bodies with four or five pairs of biramous thoracic appendages. There are usually five abdominal segments.

Free-living copepods may be collected with sea lettuce (*Ulva*) and other seaweeds near shore or by pulling a fine-meshed tow net through the water so that the minute organisms concentrate in a small bottle fastened at the end of the net. Most copepods are barely visible to the unaided eye as they dart about when confined in a small container of sea water.

Six species of copepods from Oahu and the leeward islands were described by Otto Pesta in 1932, but there are many others in the near-shore waters of Hawaii. They differ in shape of body, length of antennae, in appendages, abdomen, and other details. A form which is closely associated with seaweeds (fig. 129, *a*) and apparently does not circulate widely through the water has short antennae. The female carries 12 to 15 eggs in a circular, flattened case attached to the under surface of the abdomen. Like many other copepods this species has a single median eye spot. The animals creep about over the seaweeds apparently feeding upon diatoms and other minute plant cells while they themselves furnish the chief source of food for some other creatures of this environment.

Among copepods which circulate freely through the water, the commonest ones are quite transparent and have long setose antennae. Some of the less common forms are red or bluish. Representatives of the genus *Pontella* (fig. 129, *b*) have a pair of dorsal eyes and a single median eye which projects as a papilla on the ventral surface of the head. The abdomen is commonly asymmetrical in these forms. They are large copepods, about 3 mm. long, and bluish. A curious form, *Peltidium* species, resembles a minute isopod in being dorso-ventrally compressed and in the tendency to curl up. It is colored brick-red and has anastomosing chitinous bands traversing the segments of the body. Specimens taken in shallow water are 2 mm. long. (See fig. 129, *c*.) Species of the genus *Macrosetella* have long slender bodies and very long caudal setae. There is a single eye spot. Specimens taken in the tow net on Hawaiian reefs are 2 mm. in body length.

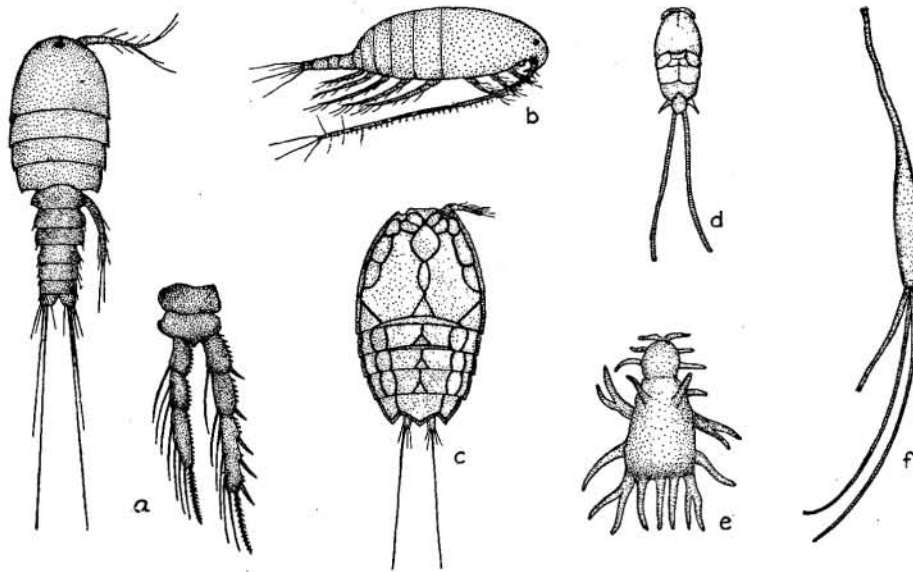


FIGURE 129.—Copepoda: *a*, a common copepod from *Ulva*, dorsal view of female and typical biramous appendage; *b*, *Pontella* species with three eyes; *c*, *Pelididium* species, dorsoventrally compressed, brick-red in color; *d*, *Pandarus* species, parasitic on sharks; *e*, *Lernanthopus* species (?) from the gills of a fish; *f*, *Lernaeenicus* species, parasitic, from the dolphin (*mahimahi*).

Free-swimming copepods are of great importance in the economy of the sea, furnishing food for many other animals. They are usually found in the surface water in greater numbers at night than during the day. Being positively phototropic to weak light they sink into deeper water during the hours of sunlight and probably for the same reason rise to the surface at night.

The relative abundance of copepods seems to be correlated with the growth of other marine organisms. In Kaneohe Bay, Oahu, the number of copepods may approximate 1,000 per liter of sea water, or 50 to 100 times more than is usual for the open leeward reefs of the island. Corals, hydroids, and other animals which probably feed primarily on these minute crustaceans grow luxuriantly in certain parts of Kaneohe Bay but appear more stunted and starved on the leeward shores.

Parasitic copepods, commonly known as fish lice, cling to the fins, gills, or other body parts of both fresh-water and marine fishes. They assume remarkable forms due to their mode of life, and some of them look

very unlike typical crustaceans. In mature females the eggs are carried in a pair of tubular filaments (egg strings) extending from the posterior end of the body. Species taken from local marine fishes have not been specifically determined, but the genera of some of them are recognized. Members of the genus *Pandarus* are typical ectoparasites of sharks. A common local form (fig. 129, *d*) has a body length of 10 mm., exclusive of the egg strings. Another species with smooth tapering appendages, probably of the genus *Lernanithopus*, was taken from the gills of a fish at the Honolulu market. The parasite is 5 mm. long (fig. 129, *e*). The largest parasitic copepods are of the family Lernaeidae, some of them reaching a length of 10 inches. Numerous specimens of the genus *Lernaeenicus* have been found attached to the fin of a large "dolphin" (*mahi-mahi*) in the Honolulu fish market. The parasite has a long, cylindrical, and unsegmented body with a slightly swollen trunk. The head and neck are deeply buried in the tissues of the fish. The length is 2 inches, exclusive of the slender egg strings (fig. 129, *f*).

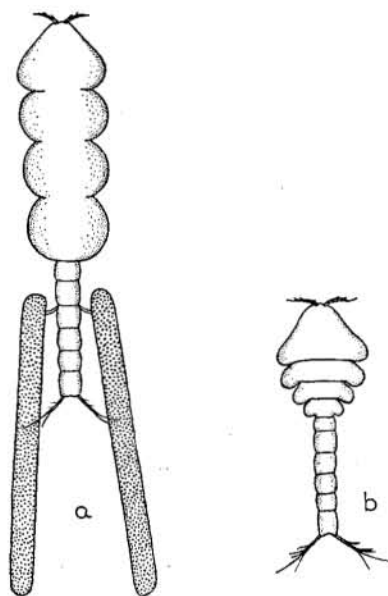


FIGURE 130.—*Teredicola typica*: *a*, female; *b*, male.

An internal copepod parasite of shipworms, *Teredicola typica* Wilson (fig. 130, *a*, *b*), infests at least five species of *Teredo* and one of *Bankia* in Hawaiian waters. The female, which is about 5 mm. in length,

has the head and first three thoracic segments greatly inflated and closely fused; the remaining segments are narrow. When fertile, the female may bear a pair of cylindrical egg strings as long as the animal itself. The male, which is smaller than the female, has the anterior portion of the body somewhat flattened. The parasites occupy the infrabranchial chamber of the shipworm, sometimes two or three occupying one host. There seems to be slight detrimental effect, if any, on the shipworm by the presence of the parasite. Parasitized shipworms have been taken in a number of localities about Oahu, in Hilo Harbor, Hawaii, and at Kahului, Maui.

SUBCLASS CIRRIPEDIA

Barnacles are highly specialized and strangely modified crustaceans. They are attached during adult life, and some are parasitic in habit. The more familiar nonparasitic forms are of two general kinds, commonly known as "goose barnacles" and "rock barnacles."

Goose barnacles are stalked forms usually characterized by having the chief part of the body, in the adult stage, protected by a calcareous shell somewhat resembling that of a bivalve mollusk, except that each valve is composed of a number of plates. (See fig. 131, *a*.) The plates (terga) at the tip of the shell are paired, as are those (scuta) at the basal region; a single narrow plate (carina) extends along the dorsal border.

A fleshy stalk attaches the animal to some support. The body of the barnacle is attached to the stalk by its anterior extremity so that the animal is standing on its head. Six pairs of long biramous appendages project from between the ventral edges of the shell and literally kick food into the mouth.

Like many other fixed forms of animals, barnacles are monoecious or hermaphroditic, both ova and sperm being developed in the same individual. The microscopic larvae which exhibit structural characteristics of typical crustaceans are free-swimming for some time, and then settle down and are transformed into the fixed adult phase. (See fig. 131, *b*.)

The term "goose barnacle" is derived from the ancient, fabulous belief that geese were developed from these crustaceans. Early works on natural history pictured the imaginary avian offspring escaping from the shells of stalked barnacles.

Rock barnacles (acorn barnacles) are without stalks and are closely attached to some support. The soft parts of the animal are similar to

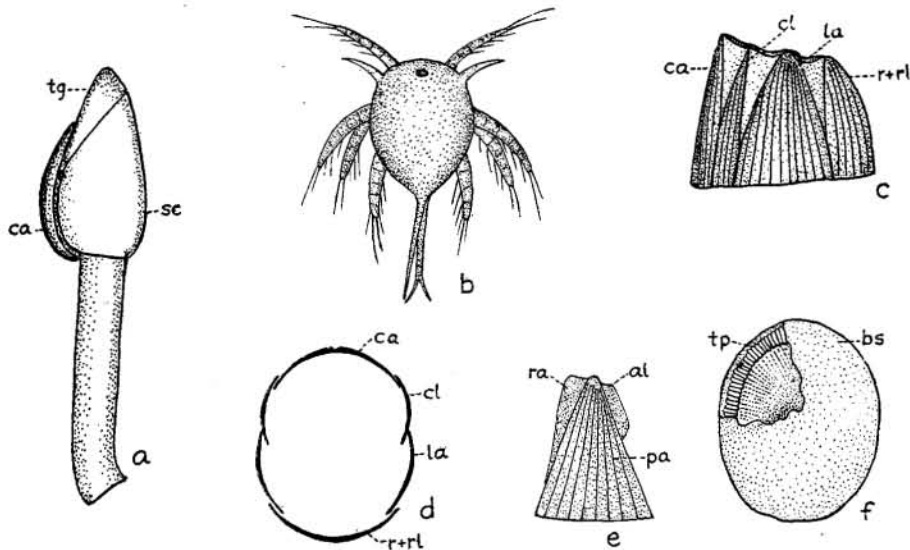


FIGURE 131.—Cirripedia: *a*, a typical "goose" barnacle showing plates of the shell (*ca*, carina; *sc*, scutum; *tg*, tergum); *b*, a barnacle larva; *c*, lateral view of a typical rock barnacle showing the plates composing the shell (*ca*, carina; *cl*, carinolateral; *la*, lateral; *r + rl*, fusion of rostrum and rostromedial); *d*, diagram showing the overlapping plates of a rock barnacle, *Balanus* species (lettering as in *c*); *e*, a single plate (compartment) of *Balanus* species (*al*, ala; *pa*, paries; *ra*, radius); *f*, basis of a rock barnacle, *Balanus* species (*bs*, basis; *tp*, tubules of parietes).

those of the stalked barnacle, but the body is inclosed by a series of calcareous plates forming a cup. Two hinged plates, each paired, form an operculum which may close the aperture of the shell when the animal is inactive or open it to permit the extension of the appendages while the animal is feeding.

The plates composing the wall of the shell are called compartments and are joined together by overlapping borders. The number of compartments varies with different genera, there being in some a fusion of adjacent plates. In the common genus *Balanus* the compartments consist of carina (single), carinolaterals (paired), laterals (paired), and a single plate representing a fusion of rostromedials and the rostrum (fig. 131, *c*, *d*). In a compartment the thickened, triangular central region (paries) is bordered by thin, winglike areas which overlap or are overlapped by adjacent plates. The overlapping wing is the radius. That which is overlapped is known as the ala. (See fig. 131, *e*.)

The operculum of the shell is composed of paired plates (tergum and scutum) which are comparable to those of the same names in the goose barnacle. The basal plate (basis) of the rock barnacle is usually calcareous. On its removal the structure of the wall of the compartments, of value in determining species, is revealed. (See fig. 131, f.)

Stalked barnacles are not numerous about Hawaii. Those found represent, for the most part, cosmopolitan species which have reached the shores on floating logs or by other means. Rock barnacles are common about the islands in shallow water. Some find attachment high up on pilings, rocks, and walls where they are completely exposed to the air except at extreme high tide. Others are found only below the low-tide mark.

Some cirripeds are parasitic. The adults are degenerate, and have lost evidences of segmentation and all appendages. They cling to the animal upon which they feed by tubular stalks through which fluids of the host are drawn into their bodies. Species of *Sacculina* and allied genera appear as inflated saclike bodies attached to the under surface of crabs and other crustaceans. The common little crab, *Pachycheles pisoides*, is occasionally found parasitized by a *Sacculina*-like form which is attached to the ventral surface of the abdomen.

FAMILY LEPADIDAE

Of the Hawaiian stalked barnacles the most familiar belong to the genus *Lepas*. Two widely distributed species are sometimes attached to drift logs washed ashore. Of these *L. anatifera* Lamarck (fig. 132, a) differs from *L. anserifera* Lamarck (fig. 132, b) in having a straighter ventral border, a smoother shell, and a longer stalk. The ventral border of *L. anserifera* is strongly arched and the surface is radially grooved. Its stalk is very short. Large specimens of *L. anatifera* have shells 1 inch long and stalks 3 to 4 inches long. Shells of *L. anserifera* are about 1 inch long, and the stalks are generally less than 1 inch long.

A pelagic species, *Lepas fascicularis* Ellis and Solander (fig. 133, a), has been taken attached to the shell of the floating mollusk *Ianthina fragilis*. The barnacle has a thin, paperlike shell, the carina of which is abruptly bent to form a prominent elbow. The largest Hawaiian specimen observed has a shell and stalk, each about 12 mm. long.

From the mouth parts of a sponge crab, *Dromidiopsis dormia*, has been taken a small stalked barnacle, *Trilasmis fissum hawaiiense* Pilsbry. The scutum is divided down to the base and the surface is faintly

striated. The largest specimen has a shell 2.5 mm. long and a stalk of about the same length. (See fig. 133, *b*.)

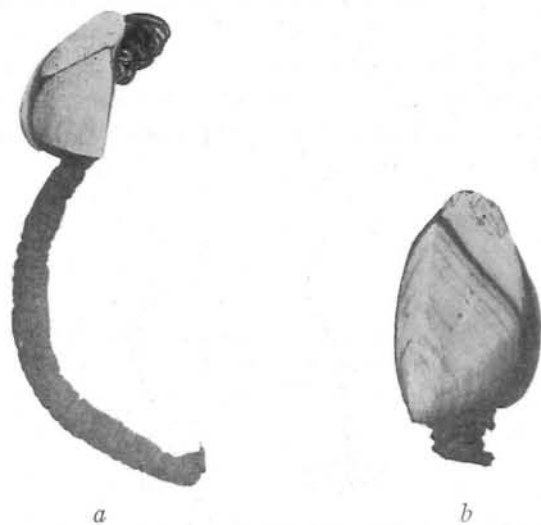


FIGURE 132.—Lepadidae: *a*, *Lepas anatifera*; *b*, *Lepas anserifera*.

In some stalked barnacles the plates of the shell have entirely disappeared. One such form, probably of the genus *Heteralepas* (fig. 134, *a*), has been taken from the appendages of a spiny lobster in the Honolulu Aquarium. The stout stalk is as long as the body, which is keeled along the dorsal border. The cirri extend from an elongated opening in the body near the distal extremity. Length 11.5 mm.

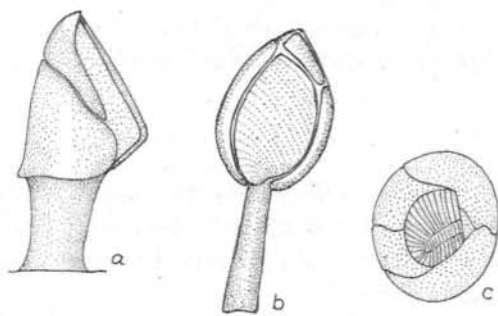


FIGURE 133.—Cirripedia: *a*, *Lepas fascicularis*; *b*, *Trilasmis fissum hawaiiense*; *c*, *Verruca cooki*.

In the genus *Conchoderma* the valves are small and remotely separated from each other. Specimens probably representing *C. virgatum hunteri* (R. Owen) (fig. 134, *b*) were taken from a submerged buoy off the coast of Oahu at a depth of 15 feet. The scuta are 3-lobed and the terga and carina are narrow and nearly straight. In life, three reddish-brown bands mark the sides of the capitulum, two of them extending to the base of the stalk. The largest specimen taken is 16 mm. in height.

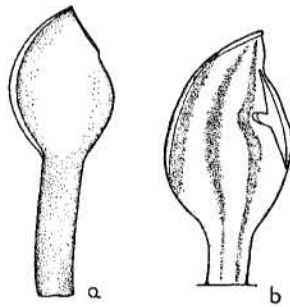


FIGURE 134.—*a*, *Heteralepas* species; *b*, *Conchoderma virgatum hunteri*.

FAMILY VERRUCIDAE

Among sessile barnacles, representatives of this family are the most primitive. They are small forms with asymmetrical shells, the lateral walls of which are formed of four plates fused together. The operculum consists of one scutum and one tergum which form a movable lid.

The species *Verruca cookei* Pilsbry (fig. 133, *c*) is subcircular in outline and greatly depressed. It is pale brown in color and about 2.5 mm. in diameter. It has been taken at Laie Point, Oahu, where it was found attached to another barnacle, *Chthamalus hembeli*.

FAMILY CHTHAMALIDAE

In the sessile barnacles of this family the rostrum has winglike lateral projections (alae) which are wanting in the rostrilaterals, but if these plates are fused with the rostrum the united plate overlaps the laterals. There are no pores in the walls.

The largest known Hawaiian barnacle is *Chthamalus hembeli* (Conrad). The aperture of the shell is large, quadrangular. It has been

recorded from Maui, Molokai, and Oahu. Some fine specimens have been taken from the rocks between tides at Laie Point, Oahu. Large specimens are 2.5 inches in diameter at the base and 2 inches high. (See fig. 135, *a*.)

A smaller species, *Chthamalus intertextus* Darwin, is common on shore rocks and concrete piers between tide marks. The purple or violet shell is commonly ribbed and wrinkled at the base. Specimens measure about 5 mm. across the base (fig. 135, *b*).

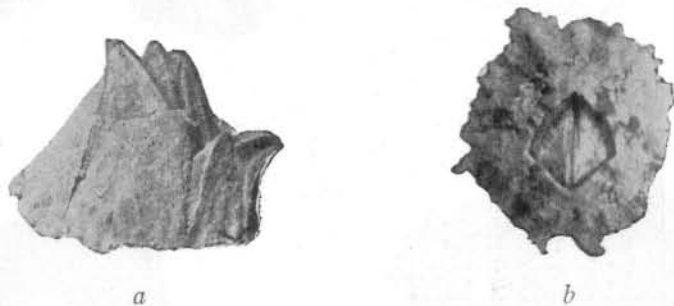


FIGURE 135.—Chthamalidae: *a*, *Chthamalus hembeli*; *b*, *Chthamalus intertextus*.

FAMILY BALANIDAE

Barnacles of this family are characterized by the overlapping rostrum which is fused with the rostrolateral plates. Some genera have the wall plates reduced to four or calcified into one piece.

The genus *Balanus* has six wall plates or compartments. The opercular valve composed of solidly interlocked tergum and scutum is as wide as the aperture of the shell. Several species of this genus are recorded from Hawaii. In *B. amphitrite* Darwin the shell, which is about 15 mm. across, is smooth or slightly striated longitudinally and may be purple, pink, or white. The base is porous and the aperture angular. It is a widely distributed barnacle found on rocks, shells, reeds, piling, or other supports in shallow water. (See fig. 136, *a*.) The species is quite variable, and numerous subspecies have been described. A form very common in Pearl Harbor, Oahu, attached to piling and shore rocks has been recognized as the subspecies *B. amphitrite hawaiiensis* Brock. The plates are smooth or ribbed longitudinally, dark gray or brown on the outer surface, purplish within. The diameter is about 20 mm. at the base.

Another form, *Balanus tintinnabulum tanagrae* Pilsbry, was collected by the *Tanager* Expedition from the leeward Hawaiian Islands from

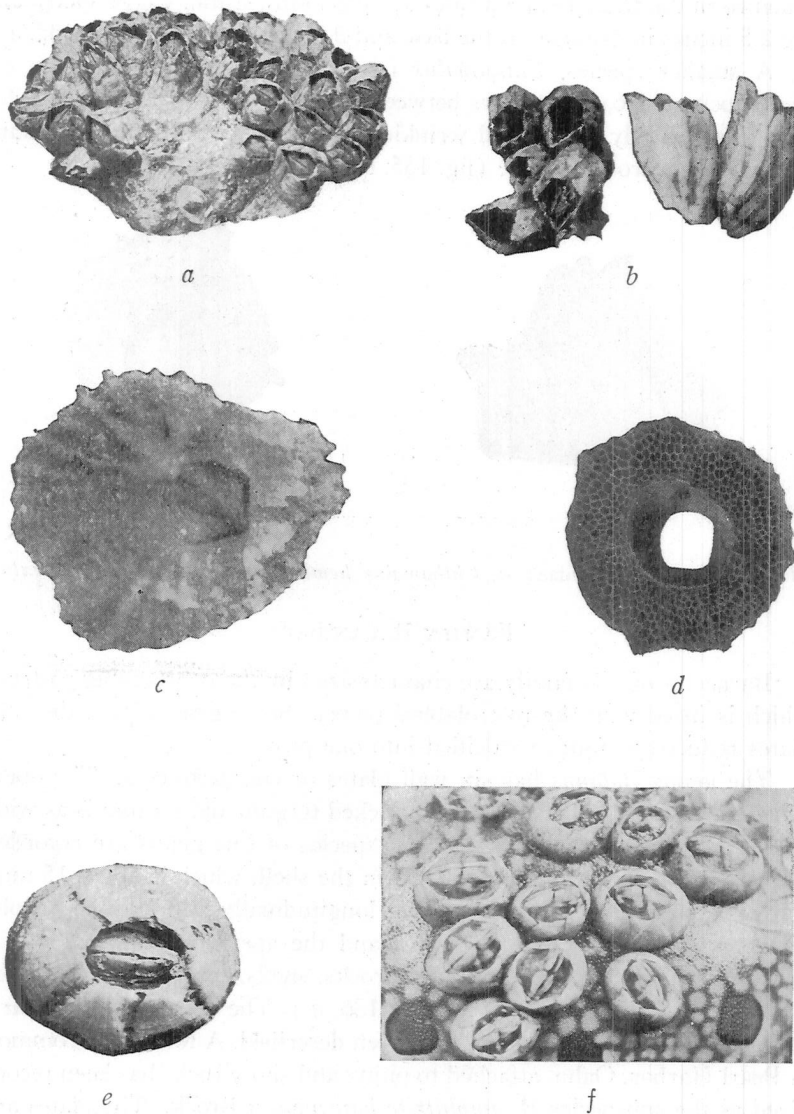


FIGURE 136.—Balanidae: *a*, *Balamus amphitrite*; *b*, *Balamus eburneus* (?); *c*, *Tetraclita purpurascens* viewed from above; *d*, *Tetraclita purpurascens*, basal view; *e*, *Chelonibia testudinaria*; *f*, *Chelonibia patula* attached to carapace of *Portunus sanguinolentus*.

Necker Island to Kuré. The subspecies grows tall and straight, and the diameter at the base is not much greater than at the aperture. The aperture is quadrangular and fine longitudinal furrows line the surface of the shell. Some specimens are pink, others gray or white. Large specimens are about 1.5 inches in diameter. The type species *B. tintinnabulum* (Linnaeus) has not been observed in Hawaii. It is widely distributed in warm seas, however, and readily carried about on the bottom of ships.

In Pearl Harbor, Oahu, attached to buoys, floats, and oyster shells, is a barnacle which closely resembles *Balanus eburneus* Gould (fig. 136, *b*). It is tall, slender and slightly curved. Its surface is smooth. The scutum is longitudinally striated and the tergum is three-pronged. On the east coast of the United States *B. eburneus* is a common species in brackish and even quite fresh water.

Species of *Tetraclita* have but four wall plates, and these are sometimes fused together. The walls have irregular rows of pores. A subspecies, *Tetraclita wireni pacifica* Pilsbry, collected at Necker Island, was attached to *Balanus tintinnabulum tanagrae*. The shell of this specimen is conical with the wall finely ribbed or granulated. Its diameter is about 8 mm.

Another species, *Tetraclita purpurascens* (Wood) (fig. 136, *c, d*), may be recognized by the membranous basis and the numerous rows of tubes which form the parietes. It is sometimes attached to the large barnacle, *Chthamalus hembeli* and is also found on stones near shore. It is especially abundant on the lava rocks on the west shore of Maalaea Bay, Maui. Large specimens are 12 mm. in diameter.

In the genus *Chelonibia* there are six wall plates, a membranous basis, and opercular valves much smaller than the aperture. A widely distributed species, *C. testudinaria* (Linnaeus) (fig. 136, *e*), is commonly found on turtles. The shell is low, flattened, and has thick, porous wall plates. Numerous specimens have been taken from the carapace of the green turtle in Hawaiian waters. Large specimens exceed 1 inch across. Another species, *C. patula* (Ranzani) (fig. 136, *f*), also widely dispersed in warm seas, is usually attached to the shells of crabs. In Hawaii it is frequently seen on the backs and appendages of the swimming crabs, *Podophthalmus vigil* and *Portunus sanguinolentus*. A specimen of *P. sanguinolentus* had 11 barnacles on the carapace and 2 on the chelipeds. The largest of these was 15 mm. across. In this species the wall plates are very thin.

SUBCLASS MALACOSTRACA

All crustaceans of a high degree of organization are included in this group. In nearly all representatives the thorax has eight, the abdomen six, segments. The modification of appendages for special purposes is well illustrated in these forms. Most of them are free-swimming, and a few parasitic.

Key to Orders of Subclass

- A. Cephalothorax incomplete or absent, carapace never covering all thoracic segments.
 - B. No movable segments in front of the head proper.
 - C. Carapace partially covering the thoracic segments; eyes on movable stalks; thoracic appendages biramous.....**Mysidacea**. p. 232
 - CC. No true carapace; head fused with one or two thoracic segments; eyes not on movable stalks; thoracic appendages not biramous (rudiments of exopodites in some tanaids).
 - D. Body usually dorsoventrally compressed.....**Isopoda**. p. 233
 - DD. Body usually laterally compressed.....**Amphipoda**. p. 239
 - BB. Two movable segments in front of the head, bearing eyes and antennules; cephalothorax short; branchiae on abdominal segments.....**Stomatopoda**. p. 241
- AA. Cephalothorax complete, carapace covering all thoracic segments.....**Decapoda**. p. 244

ORDER MYSIDACEA

Members of this order are commonly known as schizopods because of the biramous character of the thoracic appendages. The carapace partially covers the thorax and the eyes are stalked and prominent. No true gills are developed. The pleopods of the female are rudimentary, but in the male they are well developed. An auditory vesicle is borne in the endopodites of the uropods. These minute shrimplike forms inhabit the sea from the surface to great depths. They are transparent, and some, if not all, are capable of producing phosphorescent light.

The *Albatross* collected numerous species of schizopods about the islands ranging from the surface to nearly 1,000 fathoms. None are new to science and most of them are of wide distribution.

On Waikiki reef, Oahu, myriads of an undetermined species of Mysidacea sometimes make their appearance in the surface waters near shore. They occasionally swarm the shallow areas during the day but usually are more abundant at night. The species is without a rostrum and has very large eyes. Its thoracic appendages are biramous, and the posterior margin of the telson is deeply notched. The auditory vesicle of the endopodite of the uropod is large and oval. Large specimens are 3 mm. long. (See fig. 137.)

ORDER ISOPODA

Isopods are typically dorsoventrally compressed, usually with seven thoracic and six abdominal segments. The eyes when present are sessile and consist of a single pair. The branchiae are modified abdominal appendages.

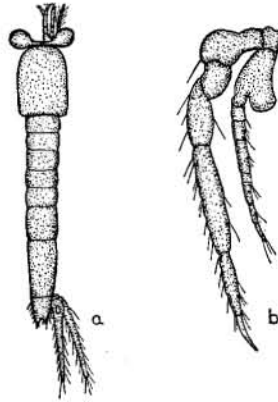


FIGURE 137.—Mysidacea: *a*, body of an undetermined schizopod of the genus *Mysis*; *b*, thoracic appendage.

Terrestrial, fresh-water, and marine isopods are known. Most of them are free living, but some are parasitic. A familiar terrestrial isopod is the sow bug found under boards and stones in moist places. Marine isopods are numerous and the group is a rather difficult one for the taxonomist. A partial survey of the shoal water marine isopods of Hawaii has recently been made by M. A. Miller, but some groups are still incompletely known.

Key to the Superfamilies of the Order

ADAPTED FROM REPORTS OF M. A. MILLER

- A. First pair of legs chelate; uropods terminal.....**Tanaioidea.**
- AA. First pair of legs without chelae; uropods lateral or terminal,
 - B. Uropods lateral.
 - C. Uropods visible dorsally, forming a caudal fin with the telson**Cymothoidea.**
 - CC. Uropods not visible dorsally, forming opercular plates hinged laterally and covering the pleopods.....**Idotheoidea.**
 - BB. Uropods terminal.
 - C. Terrestrial forms; pleopods adapted for air breathing..**Oniscoidea.**
 - CC. Aquatic forms; pleopods bearing branchiae.
 - D. Free living forms; symmetrical; abdominal appendages usually covered by opercular plates.....**Aselloidea.**
 - DD. Ectoparasites; females usually asymmetrical; pleopods not covered by plates.....**Epicaridea.**

SUPERFAMILY TANAIOIDEA

FAMILY TANAIDAE

FAMILY APSEUDIDAE

Among the seaweeds along the shore, live minute isopods with narrow elongated bodies which have the first legs chelate, like those of a crab. They are commonly known as tanaiids. Miller recorded three species of the family Tanaiidae from local waters, two of them new, and five species

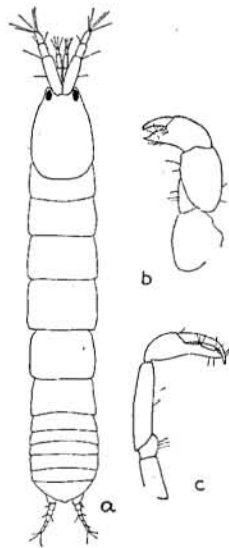


FIGURE 138.—Body and appendages of *Leptochelia dubia*: *a*, dorsal view of female; *b*, cheliped of female; *c*, cheliped of male. (After Miller.)

of the family Apseudidae, all new. In examples of Tanaiidae the body does not become greatly narrowed posteriorly, but in Apseudidae there is a decided narrowing of the body toward the posterior extremity. The Hawaiian species seem to be widely dispersed among the larger islands. One of the common local species, *Leptochelia dubia* (Krøyer) (fig. 138), is almost world wide in its distribution. All of the determined Hawaiian species are small, the largest being about 3 mm. long.

SUPERFAMILY CYMOTHOIDEA

FAMILY ANTHURIDAE

Isopods of this family may be recognized by the long, slender, nearly cylindrical body. The thoracic segments are distinct, the anterior segments of the abdomen are commonly fused, and the outer branch of the uropod folds over the last segment of the abdomen. These forms are associated with tanaids. The one illustrated (fig. 139, *a*) is 8 mm. long.

FAMILY CIROLANIDAE

Species of *Cirolana* are common isopods about Hawaiian shores. A familiar one is white, about 2.5 mm. long, and may be found creeping about on the under surface of stones in shallow water (fig. 139, *b*). Other common forms are dark brown or black and range in length up to about 12 mm. Members of the genus are elongate-oval in outline, with the six segments of the abdomen distinct.

FAMILY LIMNORIIDAE

Some isopods are destructive of wood exposed to sea water. The effect of their action is somewhat like that of *Teredo* (p. 210), except that their burrows are smaller, more numerous, and more superficial. (See fig. 140, *b*.)

Two widely distributed species of *Limnoria* have been recognized in Hawaiian waters. In *L. lignorum* Rathke (fig. 139, *d*) the telson is broadly and evenly rounded and the peduncle of the uropod is longer than the exopodite of that appendage. In *L. andrewsi* Calman the telson is not so evenly rounded and the peduncle of the uropod is about as long as the exopodite. Both species are about 2.5 mm. long.

FAMILY CYMOTHOIDAE

Some of the larger forms of isopods are parasitic, and members of several genera of this family are found attached to the skin, fins, gills, or the inside of the mouths of Hawaiian fishes. In the genus *Nerocila* the posterior border of the head has three lobes and the posterolateral angles of the thoracic segments increase in length posteriorly. The specimen illustrated (fig. 139, *c*) was taken from the ulua. It is 18 mm. long. In the genus *Cymothoa* the head is deeply set in the first thoracic segment. There are six distinct segments in the abdomen, which is embedded in the

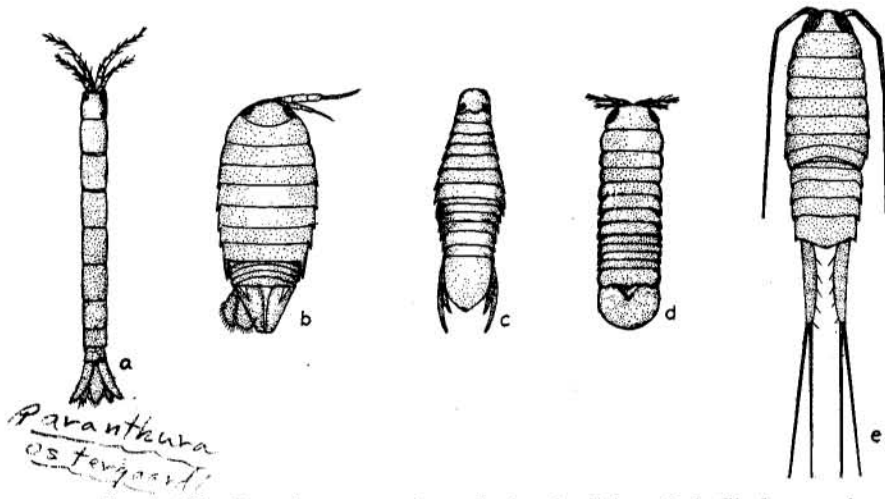


FIGURE 139.—Isopoda: *a*, an undetermined anthurid isopod; *b*, *Cirolana* species; *c*, *Nerocila* species, parasitic, from the *ulua*; *d*, *Limnoria lignorum*; *e*, *Ligia kawaiensis*.

thorax. The last abdominal segment is broad. No eyes are in the species illustrated (fig. 140, *a*), which was taken from the tongue of the *moi*. Large specimens are 1.4 inches long.

The species *Cymothoa recta* Dana has been reported from Hilo, Hawaii, without a record of the host. It is recognized by the parallel sides of the body and the narrow basal segments of the abdomen. Its length is about 1 inch.

Species of *Cymothoa* frequently have been taken about Oahu from the branchial chambers of eels.

FAMILY SPHAEROMIDAE

A probable representative of this family, *Dynamenella* species, has occasionally been observed among seaweeds along the shore. It is recognized by a deep notch in the posterior border of the terminal segment. Local specimens observed are less than 5 mm. long.

SUPERFAMILY IDOTHEOIDEA

FAMILY IDOTHEIDAE

Members of this family are recognized by the hinging of the uropods to the lateral borders of the last segment of the abdomen so that they close

ventrally like double doors. The species *Colidotea edmondsoni* Miller (fig. 140, c), has been collected on the shores of Maui, Molokai, and Oahu. In color, specimens are usually brown, harmonizing with the brown seaweeds among which they live. The type specimen is 7 mm. long.



FIGURE 140.—Isopoda: a, *Cymothoa* species, a parasitic isopod from the tongue of the *moi*; b, burrows of *Limnoria lignorum* in wood; c, *Colidotea edmondsoni*.

SUPERFAMILY ONISCOIDEA

FAMILY LIGIIDAE

Although members of this group of isopods are terrestrial forms, they are mentioned here because of their habitat. Species of the genus *Ligia* are typical of stony beaches and also are found about wharfs and on piling at the water's edge. The widely distributed species, *Ligia exotica* (Roux), is abundant among the lava blocks of the shore at Makena, Maui, and is also recorded from Honolulu.

The body is elongate oval with the second pair of antennae very long. The uropods are terminal, the peduncle bearing two long branches. Its color is dark brown or almost black. The body proper may reach a length of 1.2 inches.

Another species, *Ligia kauaiensis* (Edmondson) (fig. 139, e), described from the shore of Kalihiwai Bay, Kauai, is dark green. The second antennae, which are almost as long as the body, have flagella with 33 segments. The uropods also are very long. The species, *Ligia hawaiiensis* (Dana) differs from *L. kauaiensis* in having but 27 or 28 segments in the antenna, and a more pointed posterior margin of the terminal segment of the abdomen. It is recorded from both Oahu and Kauai.

SUPERFAMILY ASELOIDEA

Isopods of this group are usually elongated, narrow, and depressed. The segments of the thorax are more or less loosely articulated so that adjoining segments are somewhat separated from each other laterally. There usually is a fusion of the abdominal segments and the uropods are terminal or subterminal, sometimes rudimentary.

Examples of these isopods may be found among algae close to shore but are easily overlooked, as the largest form observed in local waters is less than 4 mm. long. Four new species, included under four genera and three families, have been described from Hawaii by Miller. They differ from each other in shape of body, antennae, eyes, uropods, and other structural features. The largest species, *Stenotrium medipacificum*

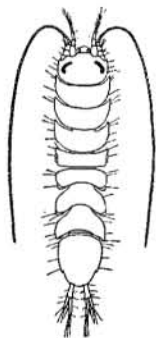


FIGURE 141.—*Stenotrium medipacificum*, female (after Miller).

Miller (fig. 141) is recognized by a narrow elongated body, very long antennae, crescent-shaped eyes, an oval abdomen with a notch on each side, and terminal uropods more than half as long as the abdomen. The type specimen is 3.6 mm. long. It has been collected at several localities on Oahu and also on Maui. Miller's paper should be consulted for a complete description of the Hawaiian species.

SUPERFAMILY EPICARIDEA

The epicarids are parasitic on other crustaceans. In extremely specialized forms the body may lose the crustacean appearance, becoming saclike, filled with developing larvae. The larvae indicate the relationship of the organism. In every major group of crustaceans, hosts of these parasites are recognized. Sometimes they parasitize parasites which in turn are attached to the crustacean host.

A species designated as *Faba glabra* Nierstrasz and Brender à Brandis (fig. 142), has been collected about Oahu, attached to snapping shrimps. The authors of the species believe it to be an epicarid, but its complete life history is unknown. Because its systematic position is somewhat doubtful no family assignment has been made. The adult female is bean shaped and is attached to the host by teeth which terminate a tube-like trunk. When mature, the body is filled with embryos and is eventually ruptured, releasing a swarm of free-swimming larvae. Nothing further is known of the larval phase, and males of the species have not been recognized. Some shrimps carry as many as five parasites in various stages of development. Large females are 8 mm. long.



FIGURE 142.—*Faba glabra*, parasitic epicarids attached to a snapping shrimp.

Although epicarids of the family Bopyridae have not been recorded from the shoal waters of Hawaii they probably occur here. Their presence may be recognized by abnormal swellings on the side of the carapace of crustaceans (*Macrura* and *Anomura*). Protandry is shown in the life cycle of the parasite, it being a functional male first, then a female. Pressure in the gill chamber of the host distorts the parasite, especially in the female stage.

ORDER AMPHIPODA

Crustaceans with laterally compressed bodies and without a carapace are known as amphipods. In some the first, in others the first and second segments, are united with the head. The gills are attached to the thoracic appendages.

Sandhoppers or beach fleas are common representatives of the order. They live among seaweeds, under stones at the water's edge, or in other places of concealment. Some form membranous tubes for protection. The last three pairs of abdominal appendages or "tail feet" are turned back and aid the animal in springing. Many of the sandhoppers are beach scavengers, destroying decaying animal and vegetable matter.

Others serve as food for fishes. When in very shallow water the sandhoppers tend to move about in circles because of the shape of the body. Large Hawaiian forms are about 12 mm. long (fig. 143, *a*). General observation suggests that there are numerous species in local waters. Although no systematic survey of the group has been made in Hawaii and few species have been determined, representatives of the genera *Lembos*, *Elasmopus*, *Amphithoe*, *Erichthonius*, *Chelura*, and *Caprella* are frequently seen.

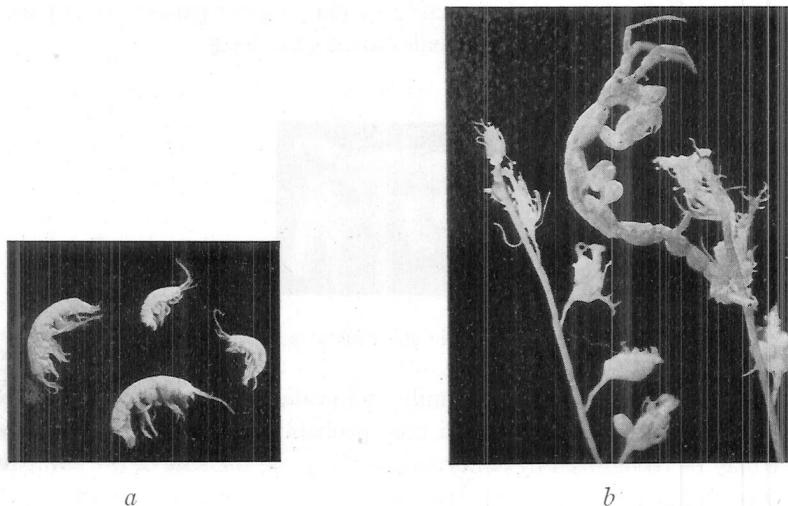


FIGURE 143.—Amphipoda: *a*, “sandhoppers”; *b*, *Caprella acutifrons* (?), parasitic on a hydroid colony.

Some amphipods produce membranous tubes, which are attached singly or in masses to supports in the water in which the animals live. Two species have been recognized locally, *Erichthonius disjunctus* Stout and *Lembos concavus* Stout, which were described from the waters of southern California. In Hawaii, they have been collected on wooden panels suspended in Kaneohe Bay and Pearl Harbor, Oahu.

A few amphipods are woodborers, cutting tunnels in timbers submerged in sea water. One species, *Chelura insulae* Calman, has been recorded from Hawaii. The antennae and antennules are long, and the first leg (gnathopod) has a large, broad palm. A large specimen is about 8 mm. long. This form is usually associated with the woodboring

isopod, *Limnoria* (p. 235), which it follows up, enlarging the burrows already made.

Other amphipods known as caprellids are typically parasitic in habits. They have slender, elongated bodies with three pairs of hook-like appendages toward the posterior extremity by means of which they cling to seaweeds or colonies of hydroids or bryozoans. Two pairs of grasping appendages (gnathopods) assist the animal in getting food. Some forms are very destructive of hydroids, a few specimens being capable of completely stripping a colony of polyps in a short time (fig. 143, *b*). Few caprellids observed in Hawaii are more than 12 mm. long. Although local species have not been determined, the most common one seems to be *Caprella acutifrons* Latreille, a cosmopolitan form in temperate and tropical waters.

ORDER STOMATOPODA

Members of this order have elongated, narrow bodies with a carapace which does not cover the last three or four segments. The eyes are stalked. The first five pairs of thoracic appendages, which represent maxillipeds, are leglike, with the last segment folding back against the one with which it articulates, like the blade of a jackknife. Of these maxillipeds the second pair is greatly enlarged and provides very efficient organs of offense and defense. To each of the three posterior thoracic segments is attached a pair of slender legs bearing exopodites. Gills are carried on the swimmerets.

Most authorities include all representatives of the order under one family.

FAMILY SQUILLIDAE

The most common species about local shores is *Pseudosquilla ciliata* Miers (fig. 144, *a*), which is typically dark greenish or brown, and is found in shallow water under stones or in holes in dead coral blocks. The front border of the rostrum is broadly rounded and spineless. Large specimens are about 4 inches long. Several bright orange specimens, which in all structural features seem to be identical with this species, have been taken on Waikiki reef, Oahu.

The species *Pseudosquilla oculata* (Brullé) may be distinguished from *P. ciliata* by the short spine at the middle of the anterior border of the rostrum and a round black spot on each side of the mid-dorsal line of

the carapace. Its habitat is similar to that of *P. ciliata*, but it seems to be less numerous and slightly smaller than that species, especially about the larger islands. It was found to be very abundant among the leeward islands.

An easily recognized species, *Squilla oratoria* De Haan, frequents bays at depths of a few fathoms, but is seldom seen on the reefs. Longitudinal sharp ridges (carinae) ornament the dorsal surface. The species is variable in color, but commonly reddish brown with black spots on the uropods. Large specimens are 8 inches long. Fishermen take this species in traps and it is frequently seen in the Honolulu fish market.

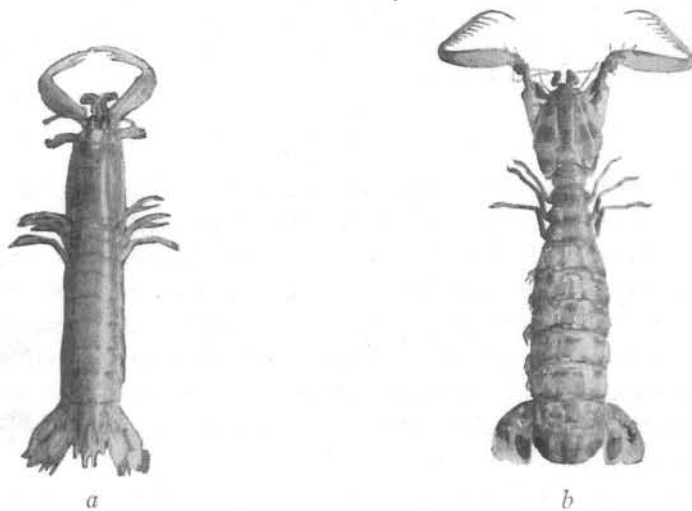


FIGURE 144.—Squillidae: *a*, *Pseudosquilla ciliata*; *b*, *Lysiosquilla maculata*.

Another species, *Squilla mauiana* Bigelow, was taken by the *Albatross* in 1902 between Maui and Lanai in 28 to 43 fathoms. The rostrum is about as broad as long, with a rounded front border. Although mutilated, the left raptorial leg apparently has five teeth, including the terminal one, on the dactylus. The right claw is destroyed. The telson has numerous marginal teeth and there is another row of teeth on the dorsal surface of the telson nearly parallel with the posterior border and a little distance from it. The specimen is slightly less than 1 inch long.

A specimen, white all over except for the pale yellow eyes, was collected in shallow water on Waikiki reef, Oahu. It was identified as *Squilla alba* Bigelow, described from the Bahama Islands. Longitudinal ridges ornament the carapace and abdomen, and there is a median, longi-

tudinal carina on the telson ending in a spine. The claw of each large pincer has five spines. Its length is 1.9 inches.

The largest species of the family in Hawaii is *Lysiosquilla maculata* (Fabricius) (fig. 144, *b*), which is occasionally taken in local waters. It is strikingly colored with broad, transverse bands of black on a pale yellow ground color. Large black spots mark the uropods. It lives in vertical burrows in mud or sand in shallow water. Large specimens are 10 inches long. The species is highly prized as food and brings a good price on the Honolulu fish market.

A minute white form, *Coronida sinuosa* Edmondson, was described from Waikiki reef, Oahu. The telson is ornamented with carinae in a sinuous and scroll-like pattern. Two specimens have been observed, each about 20 mm. long.

Other representatives of the family have been dredged about the islands but are not likely to be found on the shallow reef. In the genus *Odontodactylus* the dactylus of the large claw is thickened at its base, and a row of fine teeth is borne on its inner border. Two species, *O. japonicus* (De Haan) and *O. hansenii* (Pocock), have been taken at depths ranging from 27 to 240 fathoms. In *O. japonicus* the rostrum is broader than long, subtriangular, the pointed apex strongly deflexed. There are five to seven teeth on the dactylus of the large claw. Specimens may slightly exceed 5 inches in length. In *O. hansenii* the dactylus of the large claw bears six to 11 teeth and the telson is provided with six prominent spines on the posterior and lateral borders and bears a series of longitudinal keels on the dorsal surface. It is slightly more than 3 inches long. Specimens apparently identical with *Odontodactylus brevirostris* (Miers) were taken from the stomach of a fish (*aku*) purchased in the Honolulu fish market. This crustacean is characterized by a short, broad rostrum. The dactylus of the large claw usually bears eight teeth. The largest of three specimens is 1.2 inches long.

In the genus *Gonodactylus* the dactylus of the large claw is thickened at the base but lacks teeth on its inner border. One species, *G. guerinii* White, has been taken in Hawaiian waters, but only among dredged material. It may be recognized by the sixth abdominal segment and the telson which are armed with numerous spines from the ends of which fleshy processes extend. Four spinelike processes with secondary spines extend from the posterior margin of the telson. The species ranges from Mauritius to Hawaii and the Marquesas. Six specimens are known from Hawaiian waters. Three were taken by the *Albatross* in 1902, one by the

Challenger, and two specimens, in B. P. Bishop Museum, were dredged from 50 fathoms off Waikiki reef, Oahu, in 1916. The larger of the Waikiki specimens is 1.6 inches long.

ORDER DECAPODA

Shrimps and crabs are typical representatives of the order. They have five pairs of thoracic walking legs, some of which are, in most forms, provided with pincers (chelae). The head and thorax are united into a cephalothorax which is covered by a carapace.

Nearly 400 known species, including both shallow- and deep-water forms, occur about Hawaii, and it is safe to say that 150 species could be collected on the reefs of the several islands without much effort. During the day most of the species are concealed among living corals, in crevices of rocks, under stones, and in the sand. Dead, porous coral blocks, if broken into pieces, will yield large numbers of decapods as well as other invertebrates.

No attempt is made here to describe or mention all of the known Hawaiian shrimps and crabs. Illustrations of the more common shore forms, however, are presented, and brief descriptive comments are introduced to assist those interested in the determination of species. The decapod crustaceans are classified under two suborders, Natantia and Reptantia.

SUBORDER NATANTIA

Decapods of this group are shrimplike, usually laterally compressed, with the abdomen extended and not concealed by the cephalothorax. In

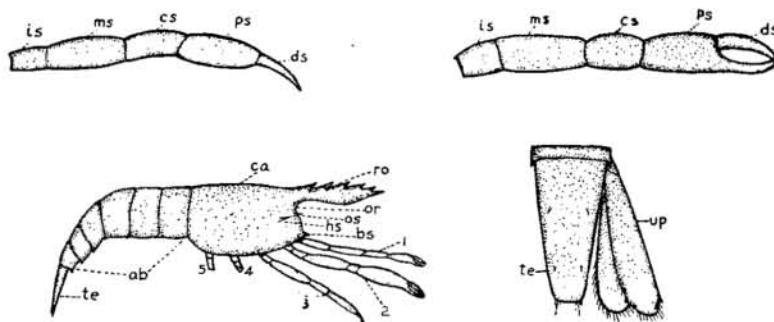


FIGURE 145.—Carapace and appendages of a typical shrimp showing structural features (*ab*, abdomen; *bs*, pterygostomial spine; *ca*, carapace; *cs*, carpus; *ds*, dactylus; *hs*, hepatic spine; *is*, ischium; *ms*, merus; *or*, orbit; *os*, ocular or antennal spine; *ps*, propodus; *ro*, rostrum; *te*, telson; *up*, uropod); 1-5, walking legs.

most forms the carapace projects forward between the eyes into a pointed process (rostrum). The appendages (pleopods) on the ventral surface of the first five abdominal segments are modified into swimming organs, as are the fanlike appendages (uropods) attached to the sixth abdominal segment. The terminal abdominal segment (telson) is without appendages. Important characters for ready determination of members of this suborder are the rostrum and the legs. (See fig. 145.)

Key to Tribes of Suborder

- A. First three pairs of legs chelate; abdomen usually curved but not bent, pleura of first abdominal segment not overlapped by those of second.
- B. Third pair of legs not stouter than the first two pairs.....**Penaeidea**. p. 245
- BB. One or both legs of third pair stouter than those of the first two pairs **Stenopidea**. p. 246
- AA. Third pair of legs not chelate; abdomen usually bent; pleura of first abdominal segment overlapped by those of second.....**Caridea**. p. 247

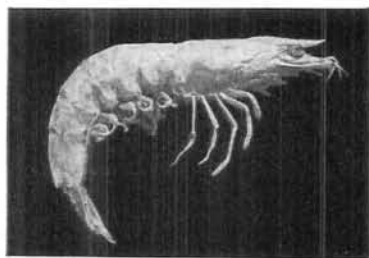


FIGURE 146.—*Penaeus marginatus*.

TRIBE PENAEIDEA

FAMILY PENAEIDAE

Of the 18 species of this family dredged by the *Albatross* about Hawaii, only two or three may be considered among the shallow-water fauna. The species *Penaeus marginatus* Randall (fig. 146) is taken at the surface of the ocean, on the reefs, and in deep water. Large forms, which may exceed 6 inches in length, are usually found at considerable depths, but smaller specimens inhabit shallow water or live at the surface.

The rostrum is long, slightly turned up, and armed with nine or ten teeth above and two or three below. The keel of the rostrum extends backward almost to the posterior border of the carapace and has a broad groove on each side.

The species is one of the larger Hawaiian shrimps and is of considerable importance as a food.

A small species, *Metapenaeus richtersii* (Miers), has been collected in shallow water at Pearl and Hermes Reef and is also reported from moderate depths off Oahu. The rostrum is shorter than the eyes and has five teeth on the upper margin with a gastric tooth farther back on the carapace. The fourth and fifth segments of the abdomen are carinate, and there is a median spine on the posterior border of the sixth segment. Specimens 1.7 inches long are known.

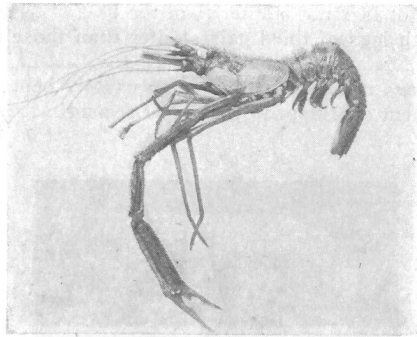


FIGURE 147.—*Stenopus hispidus*.

TRIBE STENOPIDEA

FAMILY STENOPIDAE

The species *Stenopus hispidus* (Olivier) (fig. 147), sometimes called the "bandana prawn", frequently seen near shore, is one of the most brilliantly colored crustaceans in Hawaiian waters. It is recognized by three broad, transverse bands of scarlet marking the anterior, middle, and posterior portions of the body, which otherwise is nearly white. The long and chelate third pair of legs has four transverse bands of scarlet. The upper surfaces of the body and the legs are covered by hooked spines, those on the front part of the body bending forward and those on the posterior portion bending backward. By means of these the animal is protected from attacks from the front or rear. The sexes are very much alike and are almost always found together. Large specimens exceed 2 inches in length.

TRIBE CARIDEA

Members of this tribe usually have the first two pairs of legs chelate and the abdomen sharply bent. Most of the shrimps of the shallow waters are included in this group.

Key to Families of Tribe

- A. One or both legs of first pair simple; carpus of second pair of legs segmented.
 - B. One leg of first pair simple; rostrum small, short, not toothed except at tip (bifid).....**Lyssmatidae (=Processidae).**
 - BB. Both legs of first pair usually simple; rostrum large, toothed (no Hawaiian records in shoal water).....**Pandalidae.**
- AA. Both legs of first pair chelate; carpus of second pair segmented or not.
 - B. Carpus of second legs not segmented.
 - C. Rostrum short, with or without teeth; one or both legs of second pair large.
 - D. Rostrum depressed, bent down, without teeth; one leg of second pair large.....**Pontoniidae.**
 - DD. Rostrum laterally compressed, upper border near tip sloping and toothed; both legs of second pair large.....**Gnathophyllidae.**
 - CC. Rostrum long, laterally compressed, toothed; neither leg of second pair large.....**Rhynchocinetidae.**
 - BB. Carpus of second legs segmented.
 - C. Eyes free; rostrum usually well developed.
 - D. Second pair of legs usually stouter than first.....**Palaemonidae.**
 - DD. First pair of legs stouter than second.....**Hippolytidae.**
 - CC. Eyes usually covered by carapace; rostrum small or absent; carpus of second legs with five segments.....**Crangonidae.**

FAMILY LYSSMATIDAE

Members of this family have but one of the first pair of legs chelate, and the carpus of the second leg is composed of numerous segments. The rostrum is short. These are very small shrimps and apparently not numerous about Hawaiian shores.

A widely distributed species, *Processa processa* (Bate), has been dredged from moderate depths about the islands and also taken on the reefs. The rostrum is as long as the eye and usually bispinous at the tip. The carpus of the second leg on the right side has 65 joints, and the corresponding segment on the left side has 30 joints. Large specimens are 1 inch long.

Another form, *Processa hawaiiensis* (Dana), was described from Hawaiian waters, probably from Maui. Its rostrum is shorter than the eye and broader than long. The carpi of the second legs have 11 joints. The species is about 18 mm. long. It has not been seen in recent years.

The species *Processa paucirostris* Edmondson (fig. 148, *b*), taken from Kahana Bay, Oahu, has a straight, smooth rostrum shorter than the eyes. The carpus of the second leg on the right side has 18 joints, and the merus also shows evidences of segmentation. The second leg on the left side was not observed. Specimens are 18 mm. long.

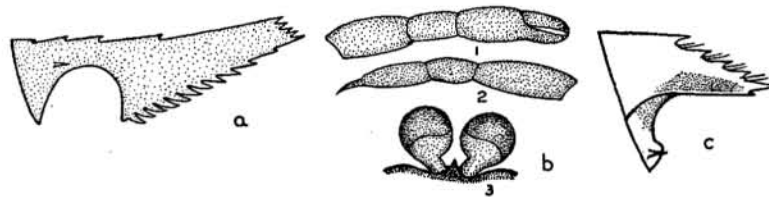


FIGURE 148.—Caridea: *a*, rostrum of *Rhynchocinetes rugulosus*; *b*, rostrum and eyes of *Processa paucirostris* (1, first right leg; 2, first left leg; 3, eyes); *c*, rostrum of *Gnathophyllum fasciolatum*.

Another form of *Processa*, undetermined but apparently distinct from any known species, was taken at Pearl and Hermes Reef. The rostrum is short and bears a short spine at some distance from the sharp extremity. There are 45 joints in the carpus of the second leg on the right side. Specimens are 20 mm. long.

FAMILY PANDALIDAE

No representative of this family has so far been recorded from the reefs or shallow water about the islands, although 11 species are known from moderate depths. All are characterized by a long, compressed rostrum armed with teeth. The first pair of legs is slender, without chelae or with very minute ones, and the second pair is long, slender, and chelate with the carpus composed of three or more segments.

FAMILY PONTONIIDAE

Species of several genera differing in size and general appearance represent the family in Hawaiian waters. In all, however, one or both of the second pair of legs are longer or stouter than the first.

The genus *Harpilius* (*Harpiliopsis* of some authors) is characterized by the outer maxilliped, of which the third segment from the last (antepenult) is broader than the following ones and shorter than the combined length of the last two. The most familiar species is *Harpilius depressus* Stimpson which lives among the branches of living

corals of the genus *Pocillopora*. The rostrum is deep, usually with six teeth above and four below. It is pale green and slightly less than 1 inch long. (See fig. 149.) Another species, *H. beaupresi* Audouin, recorded from French Frigate Shoal, differs from *H. depressus* in having a broader third maxilliped.



FIGURE 149.—*Harpilius depressus*.

Species of ^{*Peridimmaralas*} *Coralliocaris* are characterized by the approximate equality in width of the segments of the outer maxillipeds and by the large basal protuberance on each of the dactyli of the last three pairs of legs. One form, *C. tridentata* Miers, 9 mm. long, has been taken in shallow water at Pearl and Hermes Reef. Its nearly straight rostrum has three teeth on the upper margin. (See fig. 150, *a*.) In *C. quadridentata* Rathbun the rostrum curves down and bears four teeth above. One of the legs of the second pair has a very large chela. It occurs among dead coral heads near shore and is also known from deeper water. (See fig. 150, *b*.) Its length is 10 mm.

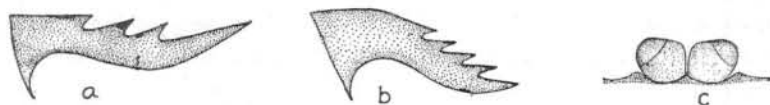


FIGURE 150.—Pontoniidae: *a*, rostrum of *Coralliocaris tridentata*; *b*, rostrum of *Coralliocaris quadridentata*; *c*, eye stalks of *Pontonia quadratophthalma*.

Associated with the large red sea urchin, *Heterocentrotus mammillatus*, is a form described as *Coralliocaris mammillata* Edmondson. It clings to the spines of the echinoid and harmonizes with its color. The very broad rostrum bears four small teeth above. Specimens about 12 mm. long have been observed. Other species of the genus have been dredged about the islands. All are small, less than 1 inch long.

In the genus *Pontonia* the rostrum is short, bent downward, and unarmed. The dactylus has no basal protuberance but bears a supplementary tooth near the tip. The species *P. quadratophthalma* Balss is concealed in tubular sponges which are attached to the under surfaces of stones in shallow water. It is recognized by the quadrate form of the eye stalks (fig. 150, c). Both of the second legs are stout, one somewhat larger than the other. Large specimens are 10 mm. long. The species is common in Hanauma Bay, Oahu, and has been taken at Pearl and Hermes Reef.

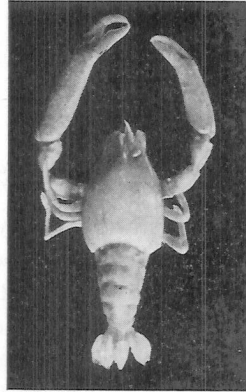


FIGURE 151.—*Conchodytes meleagrinae*.

Living in the mantle of the pearl oyster, *Pinctada galtsoffi*, is the shrimp *Conchodytes meleagrinae* Peters (fig. 151). It has a stout, somewhat compressed body and a short, blunt rostrum which is bent down and unarmed. The second pair of legs is large and the dactyli of the last three pairs have basal protuberances. Large specimens are 1.2 inches long.

FAMILY GNATHOPHYLLIDAE

A stout little species, *Gnathophyllum fasciolatum* Stimpson, is the only representative of this family in Hawaii. It has a short, obliquely truncate rostrum with five or six teeth on the dorsal sloping border and one below (fig. 148, c). Transverse lines of dark purple conspicuously mark the carapace and abdomen. The first and second pairs of legs are chelate, and the second are the larger and longer. There is an accessory tooth on each dactylus of the last three pairs of legs. Adult specimens are about 12 mm. long.

FAMILY RHYNCHOCINETIDAE

A specimen taken from shallow water at Laysan Island probably represents a young individual of *Rhynchocinetes rugulosus* Stimpson. The rostrum is long, laterally compressed, with four teeth above on the basal half and four minute ones near the tip. There are 11 teeth on the ventral border (fig. 148, a). The length slightly exceeds 1 inch. A specimen 18 mm. long, dredged by the *Albatross* near French Frigate Shoal, was tentatively assigned to this species. The type specimen described from Australia was 2 inches long.

FAMILY PALAEMONIDAE

This family is represented on local reefs by two genera, *Leander* and *Palaemonella*. In members of both genera the rostrum is long, compressed, and armed with teeth above and below.

In *Leander* (*Palaemon* of some authors) there is a spine on the front border of the carapace just below the orbit (antennal) and usually one on the lower front border of the carapace (branchiostegal). In *Palaemonella* there is no branchiostegal spine but there is one (hepatic) just behind and below the antennal spine.

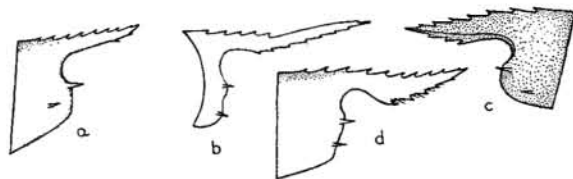


FIGURE 152.—Palaemonidae: a, rostrum of *Palaemonella tenuipes*; b, rostrum of *Leander debilis*; c, rostrum of *Palaemonella orientalis*; d, rostrum of *Leander pacificus*.

These small shrimps are sometimes found in considerable numbers under or about large stones near the shore. They are usually greenish in color, sometimes quite transparent. They may be collected by a small dip net.

A very common species is *L. debilis* (Dana). It is recognized by the rostrum (fig. 152, b), which is curved upward and armed with a variable number of teeth, often six above and seven below. The distal half of the rostrum above is free of teeth, except for one near the tip. Large specimens are 1.25 mm. long. A less abundant species, *L. pacificus* Stimpson (fig. 152, d), has the rostrum slightly curved upward and is armed with

eight to ten teeth above and four or five below. The species reaches 2 inches in length.

Two species of *Palaemonella*, sometimes taken on the reefs, differ from each other chiefly in the dactyli of the last three pairs of legs. These are simple in *P. tenuipes* Dana, but in *P. orientalis* Dana they have a tooth on the side (biunguiculata). In *P. tenuipes* there are usually eight teeth on the upper border of the rostrum and two or three below (fig. 152, a). Specimens are about 15 mm. long. In *P. orientalis* there are seven or eight teeth on the upper border of the rostrum and usually three below (fig. 152, c). Large specimens exceed 1 inch in length.

FAMILY HIPPOLYTIDAE

In this group the first and second pairs of legs are chelate, the first shorter and stouter than the second. The carpus of the second pair is segmented.

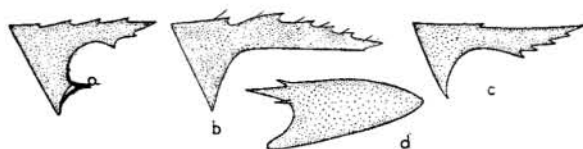


FIGURE 153.—Hippolytidae: a, rostrum of *Hippolysmata paucidens*; b, rostrum of *Hippolysmata kükenthali*; c, rostrum of *Hippolyte acuta*; d, rostrum of *Thor maldivensis*.

L. S. RATHBUN

A common species in shallow water is *Hippolysmata paucidens* Rathbun (fig. 153, a). The rostrum is short, usually armed with four teeth above and two below. There are 23 to 25 segments in the carpus of the second pair of legs. Large specimens are 20 mm. long. Another species, *Hippolysmata acicula* Rathbun, has the rostrum armed above with five or six teeth and below with two to five. The carpus of the second pair of legs has 29 segments. There are no records of this species from the reefs, but it was taken from the bottom of a tugboat at Honolulu and also dredged near Kauai. The species *Hippolysmata kükenthali* (de Man) is found under stones near shore. Numerous specimens have been taken in Hanauma Bay, and the species has been found at other localities about Oahu. Its rostrum has five or six teeth on the upper border and usually one or two on the lower border. The posterior one on the superior border is separated from the next in front by a wide space and a deep groove. (See fig. 153, b.) There is no spine on the antero-lateral border of the

carapace. The carpus of the second leg has 14 joints. Specimens are about 20 mm. long.

In the genus *Hippolyte* there is a spine above the orbit (supraorbital), and the carpus of the second pair of legs has three segments. Associated with seaweeds near shore is *H. acuta* (Stimpson). It has a straight rostrum nearly as long as the carapace with one tooth above and four below (fig. 153, *c*). Its length is about 20 mm.

The largest and most brilliantly colored representative of the family in Hawaii is *Spirontocaris* ^{SAVOH} *marmoratus* (Olivier) (fig. 154). Adult male specimens, which are larger than females, slightly exceed 3 inches in length. The rostrum is compressed and turned upward. The teeth of the upper border are continued on the dorsal crest of the carapace almost to the posterior border and become progressively smaller. There are usually nine teeth on the ventral border of the rostrum.

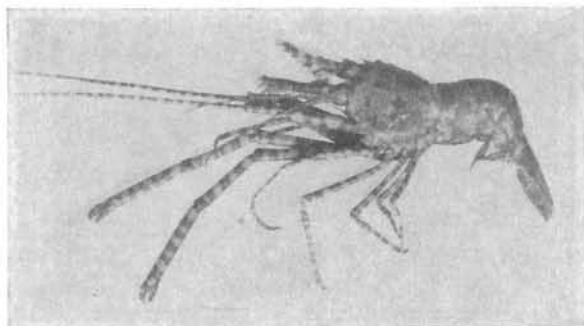


FIGURE 154.—*Spirontocaris* ^{SAVOH} *marmoratus*, a male specimen.

The species is mottled with gray, brown, red, and black. The first pair of legs of the male are banded with red and gray. Tufts of brightly colored hairs adorn the carapace and abdomen. In the male the first pair of legs may exceed the body in length. In old specimens they are stout. The species occurs in shallow water and is found under stones or concealed in crevices of rocks.

A small form, *Thor maldivensis* Borradaile, about 15 mm. long, is common among brown seaweeds near the shore. It is brown with a very short rostrum that has one tooth on its upper border and none below (fig. 153, *d*). In the male the first pair of legs is long and stout; the hand is as long as the arm but has very short fingers. The carpus of the second pair of legs has five segments.

FAMILY CRANGONIDAE

Snapping shrimps are to be found everywhere about the islands in shallow water, under stones, among seaweeds and living corals, and in crevices of rocks. The common name comes from the sharp snapping note the animal makes by the movements of the large chela. These sharp notes can be heard on an exposed reef at low tide, or to better advantage by placing the shrimp in a glass dish of water permitting it to strike the side of the container with its pincer.

Members of the family have a short rostrum or none at all. In some genera the front border of the carapace covers the eyes, and supraocular spines are sometimes present on each side of the rostrum. One chela of the first pair of legs is usually larger than that of the opposite appendage. The legs of the second pair are slender, chelate, with the carpus segmented.

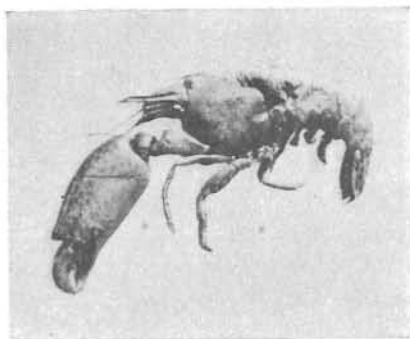


FIGURE 155.—*Crangon ventrosus*.

=Alpheus

About 20 species have so far been determined from Hawaiian waters. Most of the common forms are of the genus *Crangon*. Species of *Synalpheus*, *Jousseaumea* and *Alpheopsis* are occasionally observed. Characteristics determining genera and species include the rostrum, chelipeds, carpus of the second pair of legs, dactyli of the last three pairs of legs, telson, and so forth. A low-power microscope is necessary in order to observe these structural features clearly.

In the genus *Crangon* the lower front border of the carapace is without a spine and the thoracic legs are provided with epipodites. Some species lack supraocular spines, and in some the dactyli of the last three pairs of legs have double claws. More than a dozen known species of the genus occur close to shore, and doubtless there are others not yet recog-

nized. Only a few of the more common forms will be mentioned here.

One of the well-known species, *Crangon ventrosus* (Milne Edwards) (fig. 155), lives among colonies of the coral *Pocillopora*. It is red, and the large pincers are marked with spots of deeper red. The larger chela is smooth without notches or grooves and the dactyli of the last three pairs of legs are thick and blunt. Large specimens are 2 inches long.

Another common species, living under stones and in porous rocks, is *Crangon pacificus* Dana. The upper and lower margins of the large chela are deeply notched and there is a triangular groove on its inner surface near the upper border. Large specimens may reach 2 inches in length. In *Crangon paragracilis* (Coutière) the large chela is compressed laterally, with a longitudinal furrow on the outer face and the inner surface marked by fine red dots. Its length is about 15 mm.

Other common species are *Crangon insignis* Heller and *Crangon clypeatus* Coutière. In each, the large chela is cylindrical; that of *C. insignis* has a transverse groove behind the articulation of the dactylus, whereas the chela of *C. clypeatus* is without such a groove. Each of these species is about 1 inch long.

The fingers in the large chela of *Crangon collumianus* (Stimpson) are twisted and bent out of the usual plane, and in *Crangon deuteropus* (Hilgendorf) the upper borders of both chelipeds are densely fringed with long hairs. Of these two species *C. deuteropus*, about 1.5 inches long, is the larger.

The genus *Synalpheus* differs from *Crangon* in having a spine at the lower front border of the carapace and thoracic legs without epipodites. In *Synalpheus* the dactyli of the last three pairs of legs always have double claws. Two species of this genus are frequently observed about the shores. The most common one, *S. paraneomeris* Coutière, has a sharp, conical hook on the ventral side of the dactylus of the third pair of legs. In *S. charon* (Heller) the hook is spoon shaped and obtuse. In both species the large chela is without grooves or fissures. Each species is about 1 inch long. Another species, *S. macromanus* Edmondson, in which the large chela is enormously developed, was described from Lisiansky Island. Its length is 15 mm.

Species of *Jousseaumea* have a rostrum and supraocular spines. The large chela is bent under the body when not in use. Two species, *J. mauiensis* Edmondson and *J. brevirostris* Edmondson, have been described from Hawaiian shores. They differ chiefly in the character of the rostrum (fig. 156, *a*, *b*). Both are bright orange, when living, and slightly more

than 12 mm. long. They are found concealed in crevices of dead coral blocks, and *J. mauiensis* is almost always associated with a large flesh-colored polychaete worm. (See p. 109.)

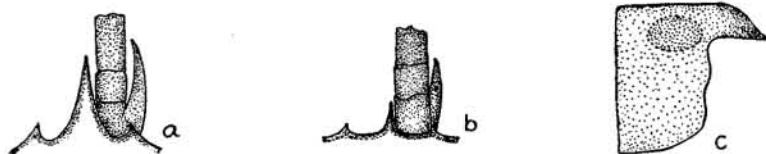


FIGURE 156.—Crangonidae: *a*, front border of carapace and base of antennule of *Jousseaua mauiensis*; *b*, front border of carapace and base of antennule of *Jousseaua brevirostris*; *c*, rostrum and front border of carapace of *Alpheopsis aequalis*.

In *Alpheopsis aequalis* Coutière (fig. 156, *c*) the short, high rostrum ends in an acute point and there are no supraocular spines. The chelae of the first pair of legs are smooth, and the carpus of the second pair is five-jointed. The dactyli of the three posterior legs are simple. Specimens from Maui and Oahu are 10 mm. long.

SUBORDER REPTANTIA

To this group belong the true crabs, the hermit crabs and their allies, and some lobsterlike forms. In most representatives of the suborder, the body is dorsoventrally compressed and the first pair of legs is stouter than the others. In true crabs the abdomen is turned under the body and although the swimmerets (pleopods) are retained for holding the eggs they are not used for swimming.

Three tribes of the suborder—Macrura, Anomura, and Brachyura—are here recognized.

TRIBE MACRURA

Under this tribe are listed a few shrimplike forms which have the abdomen strongly developed and not turned under the body. They include some of the largest of the shallow water crustaceans about the shores of Hawaii.

Key to Families of Tribe

- A. Cephalothorax not depressed; rostrum small; eyes not enclosed in separate orbits; antennae with flagella.
 - B. Rostrum small; first pair of legs not chelate, all legs about equally developed **Palinuridae.**
 - BB. Rostrum well developed; first pair of legs large, chelate.....**Homaridae.**
- AA. Cephalothorax depressed; eyes enclosed in separate orbits by the edge of the carapace; antennae with flat scales instead of flagellae.....**Scyllaridae.**

FAMILY PALINURIDAE

The so-called "spiny lobsters" are common examples of this family. These large, brilliantly colored crustaceans frequent rocky shores and reefs and conceal themselves in holes and crevices.

There are two species about Hawaii, *Panulirus japonicus* (De Siebold) and *Panulirus penicillatus* (Olivier). They look very much alike, but may be distinguished by the spines of the antennular segment. In *P. japonicus* this segment bears two strong spines on the dorsal surface. In *P. penicillatus* there are four such spines merged at the base. Large specimens of either species are about 15 inches long. Many years ago another species, *P. marginatus* (Quoy and Gaimard), was reported from Hawaii, but it has not been seen in recent years. It differs from *P. penicillatus* in that four spines of the antennular segment are arranged in a square, but not merged at the base.

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Holthuis
1945

These crustaceans differ from most others in that none of the legs end in pincers and the five pairs of walking legs are about equally developed. The sharp spines by which the surface of the body and appendages is covered probably are efficient in protecting the animals against most natural enemies. The mingled colors of red, violet, and yellow also doubtless render them more or less inconspicuous in their native habitats.

Young "lobsters" are sometimes hatched in the Honolulu Aquarium. They resemble, in the early stages, minute spiders, except that the long appendages are branched (biramous), an ancestral character.

FAMILY HOMARIDAE

The only representative of this family in Hawaii is *Enoplometopus occidentalis* (Randall). The triangular rostrum is broadly concave above, and its lateral margins are armed with strong spines which continue backward more than half the length of the carapace. A middorsal series of spines extends almost the entire length of the carapace. The first pair of legs are stout, chelate, and spinous. Numerous long yellow hairs ornament much of the exposed surface of the body. A specimen in Bishop Museum is 8 inches long. The species occurs on the reefs and at depths of a few fathoms.

FAMILY SCYLLARIDAE

Members of this family have the carapace greatly compressed dorso-ventrally. The antennae are reduced to flat scales, and the eyes are set in

depressions in the edge of the carapace. These strange-looking forms are protected by their general shape and their brown and mottled colors, which blend with the rocks and sand of their environment.

Three species are found about the islands. The one most likely to be seen in shallow water is *Paribaccus antarcticus* (Lund) (fig. 157). It is broad and stout, and large specimens reach a length of 8 inches. A much larger form, *Scyllarides squammosus* (Milne Edwards), is occasionally seen on the reefs but is more often taken by fishermen from depths of a few fathoms. It is more elongated and more quadrangular in form than is *Paribaccus*. Large specimens are 12 inches long.

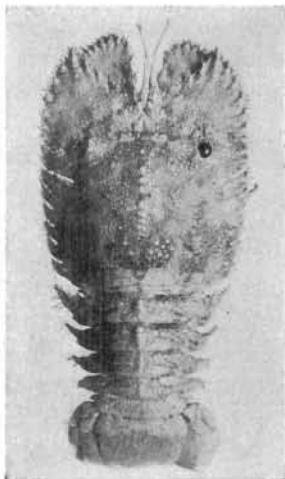


FIGURE 157.—*Paribaccus antarcticus*.

Of the genus *Scyllarus*, but one species, *S. martensii* Pfeffer, has been reported from Hawaiian waters and that from depths of not less than 32 fathoms. The flattened antennae are toothed on the margin and there are three teeth in a median line on the carapace. A specimen in Bishop Museum is 4 inches long. The locality from which it was taken is not known.

TRIBE ANOMURA

Crustaceans of this group include a variety of forms, some of which are shrimplike with the abdomen well developed and extended; others more closely approach the crablike form with the abdomen reduced. In all the first pair of legs is unlike the third.

Key to Families of Tribe

- A. Body shrimplike, first pair of legs chelate or subchelate; abdomen extended or bent upon itself but not folded against the thorax; with or without abdominal pleura.
 - B. Carapace equally firm throughout; abdomen distinctly segmented; tail fin well developed.
 - C. Body compressed; abdomen extended.
 - D. First pair of legs chelate, subequal, second pair chelate, equal; abdominal pleura well developed.....**Axiidae.**
 - DD. First pair of legs chelate or subchelate, usually unequal; second pair small, chelate or subchelate, subequal; abdominal pleura small or absent.....**Callianassidae.**
 - CC. Body depressed; abdomen bent upon itself but not folded against the thorax; first pair of legs chelate.....**Galatheidae.**
 - BB. Carapace firm in front, membranous behind; abdomen without distinct segments, often twisted with appendages reduced; last thoracic appendages much smaller than first ones.....**Paguridae.**
- AA. Body crablike, abdomen folded against the thorax; first pair of legs simple, subchelate or chelate.
 - B. First pair of legs simple or subchelate; legs adapted for burrowing in sand.
 - C. First pair of legs simple.....**Hippidae.**
 - CC. First pair of legs subchelate.....**Albuneidae.**
 - BB. First pair of legs chelate; legs not adapted for burrowing.....**Porcellanidae.**

FAMILY AXIIDAE

Several species of shrimplike forms included in this family have been taken in dredged material about the islands, but they are not often seen in shallow water or on the reefs. The species *Axiopsis* (*Axiopsis*) *spinossissima* (Rathbun) was taken from the stomach of an *opakapaka*, a surface-feeding fish, and also dredged in about 24 fathoms of water off the southern coast of Molokai. It has five longitudinal rows of spines on the dorsal border of the carapace and three spines on each lateral border of the rostrum. The cervical groove also bears spines along its posterior border. The large chelipeds are subequal, and the hand and wrist are densely covered with long yellow hairs. Its length is 1 inch.

Another species, *Axiopsis* (*Axiopsis*) *serratifrons* (Milne Edwards), was recorded from Hawaii in 1873 but apparently has not been observed there since. It has numerous spines between the main carinae on the gastric region of the carapace. There are specimens in Bishop Museum from Christmas (Pacific Ocean), Fanning, and Howland Islands. The largest is 1.8 inches long.

From the shallow water about Pearl and Hermes Reef a species, *Axiopsis* (*Axiopsis*) *irregularis* Edmondson (fig. 158), was collected in 1927. There are five rows of spines on the gastric region of the carapace, the median one extending onto the rostrum. The cervical groove is without spines. The largest specimen observed is 1.3 inches long.

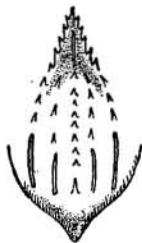


FIGURE 158.—Frontal area of carapace and rostrum of *Axiopsis* (*Axiopsis*) *irregularis* viewed from above.

FAMILY CALLIANASSIDAE

So-called mud shrimps are plentiful in certain localities about Oahu, and probably about others of the Hawaiian Islands as well. Some live in burrows in sandy and muddy shores and others have been taken from crevices of porous rocks on the reefs. Several species live in the sand and mud of Hanauma Bay, Oahu, others have been collected in Kahana Bay and on various reefs about the island. (See fig. 159.)

Two genera, *Callianassa* and *Upogebia*, have been recognized among the shore fauna. In *Callianassa* the first and second pairs of legs are chelate, the first pair much larger than the second pair, and unequal. In *Upogebia* the first pair of legs is subequal and subchelate, while none of the other legs is chelate.

A small species, *Callianassa articulata* Rathbun (fig. 159, *a*), was described from dredged material and has also been taken on the reefs about Oahu. The median, rostral spine of the anterior border of the carapace is almost as long as the eye stalks; the lateral spines of the anterior border are short and articulated at the base. The eye stalks are short, thick, the cornea round, large, covering more than one half of the peduncle. The first pair of legs (chelipeds) are large, subequal. The telson is shorter than broad, concave on the posterior border. Specimens are about 1 inch long.

The largest and most abundant species of the genus observed about Oahu is *C. variabilis* Edmondson (fig. 159, *b*, *c*), many specimens of

which have been taken from gravel beds in the intertidal zone in Hanauma Bay. The anterior border of the carapace bears three low, rounded teeth, the median one slightly the longer, but concealing little of the eye stalks. One of the first legs (chelipeds) is stout. The telson is a little broader than long, the posterior border rounded and slightly concave in the middle. The uropods are broad. Large specimens may exceed 3 inches in length.

The smallest species observed in local waters, *C. parva* Edmondson (fig. 159, *d, e*), lives in burrows in the sand under shallow water in Hanauma Bay. The anterior border of the carapace bears three short, sharp teeth, the median one slightly the longest. The first legs (chelipeds) are subequal in length. The telson is as long as broad, narrower

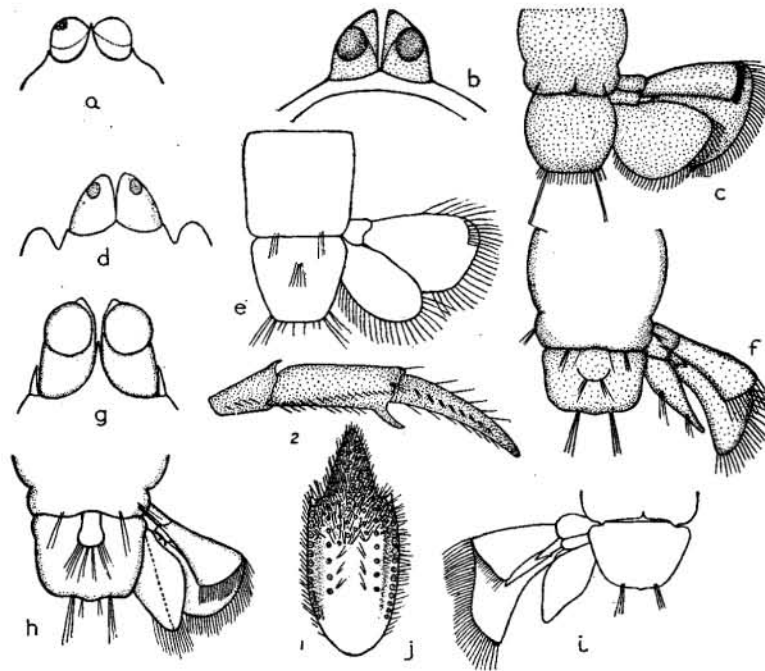


FIGURE 159.—Callianassidae: *a*, rostrum and eyes of *Callianassa articulata*; *b*, rostrum and eyes of *Callianassa variabilis*; *c*, telson and uropod of *Callianassa variabilis*; *d*, rostrum and eyes of *Callianassa parva*; *e*, telson and uropod of *Callianassa parva*; *f*, telson and uropod of *Callianassa lanceolata*; *g*, rostrum and eyes of *Callianassa oahuensis*; *h*, telson and uropod of *Callianassa oahuensis*; *i*, telson and uropod of *Callianassa winslowi*; *j*, carapace, rostrum (1), and right cheliped (2) of *Upogebia* sp.

behind, truncate on the posterior border. Specimens taken range in length up to about 16 mm.

Other Hawaiian species of *Callianassa* include *C. lanceolata* Edmondson (fig. 159, *f*), in which the inner branch of the uropod of the telson is narrow, lanceolate in shape; *C. oahuensis* Edmondson (fig. 159, *g, h*), in which the front bears three long spines, the lateral ones being articulated at the base; and *C. winslowi* Edmondson (fig. 159, *i*), the telson of which is broader than long, the sides sharply converging toward the posterior margin which bears a sharp point in the middle. Specimens of *C. lanceolata* and *C. oahuensis* may be taken in Hanauma Bay, Oahu, whereas *C. winslowi* is believed to have been collected on Maui. Specimens of the latter species are in the United States National Museum.

One specimen of an undetermined species of *Upogebia* was taken on Waikiki reef many years ago. It is 3 inches long. The front part of the carapace, including the large triangular rostrum, has the dorsal surface armed with longitudinal rows of spines and is very hairy. In both chelipeds the immovable finger (pollex) is shorter than the dactylus (fig. 159, *j*). The right cheliped is slightly smaller than the left, in this specimen.

FAMILY GALATHEIDAE

Representatives of this family are small shrimplike forms with the first pair of legs long, slender, and chelate. The abdomen is capable of being bent under the body, and most species creep about instead of swimming freely. More than 250 species are known. They are widely distributed in the seas and range from the shore line to great depths.

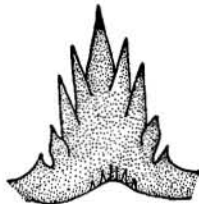


FIGURE 160.—Rostrum of *Galathea spinosorostris*.

Only two species have been recorded from the shallow waters of Hawaii, both of the genus *Galathea*. The most common one, *Galathea spinosorostris* Dana, occurs on the reefs and also at moderate depths.

The triangular rostrum has four spines on each lateral margin. (See fig. 160.) In *Galathca integrirostris* Dana the rostrum lacks the lateral spines, but there is a small spine above each eye. This species is probably confined to the Hawaiian Islands. It has been dredged at Lahaina, Maui, and collected in shallow water at Laysan Island. Each species has a cephalothorax approximately 8 mm. long.

FAMILY PAGURIDAE

Hermit crabs are easily recognized by their mode of life. They are adapted for living in mollusk shells or other hollow objects which they are able to drag about. The abdomen is soft, without apparent segments, and modified for holding the animal in its house. One cheliped is often much larger than the other and serves as a barrier to the aperture of the shell when the crab withdraws into its protecting shelter.

Several genera of hermit crabs are represented in the shallow waters about the islands. The most common are species of *Calcinus*, of which *C. herbstii* De Man is the most abundant. The left cheliped, which is the larger, has a short, circular palm, smooth and white in young specimens. In old animals the basal half of the palm is commonly black. Large specimens are 2 to 3 inches long. (See fig. 161, a.)

Another species of the genus, *C. elegans* (Milne Edwards) (fig. 161, b) has bright crimson markings on the carapace and appendages. Tufts of long red hairs are borne on the second pair of legs near the tips. The outer face of the palm of the left cheliped, which is the larger, is roughened by tubercles, and its crest is toothed. Large specimens are about 2 inches long. In *C. latens* Randall the legs are banded with blue and the large (left) cheliped is smooth. The length is about 1.5 inches.

Of the genus *Aniculus* one species, *A. strigatus* Herbst (fig. 161, c), is occasionally seen near shore. It usually occupies the shell of a species of *Conus*; this is possible because of the dorsoventral compression of the crab. Red and white bands mark the chelipeds and walking legs. The species is about 1 inch long.

The larger hermit crabs of Hawaii belong to the genus *Dardanus* of which there are several species. Two of these, *D. asper* (De Haan) and *D. deformis* (Milne Edwards), are light brown or yellowish, each 4 to 6 inches long. In *D. deformis* the outer surface of the large cheliped is smooth, in *D. asper* it is covered with tubercles. Both occupy shells

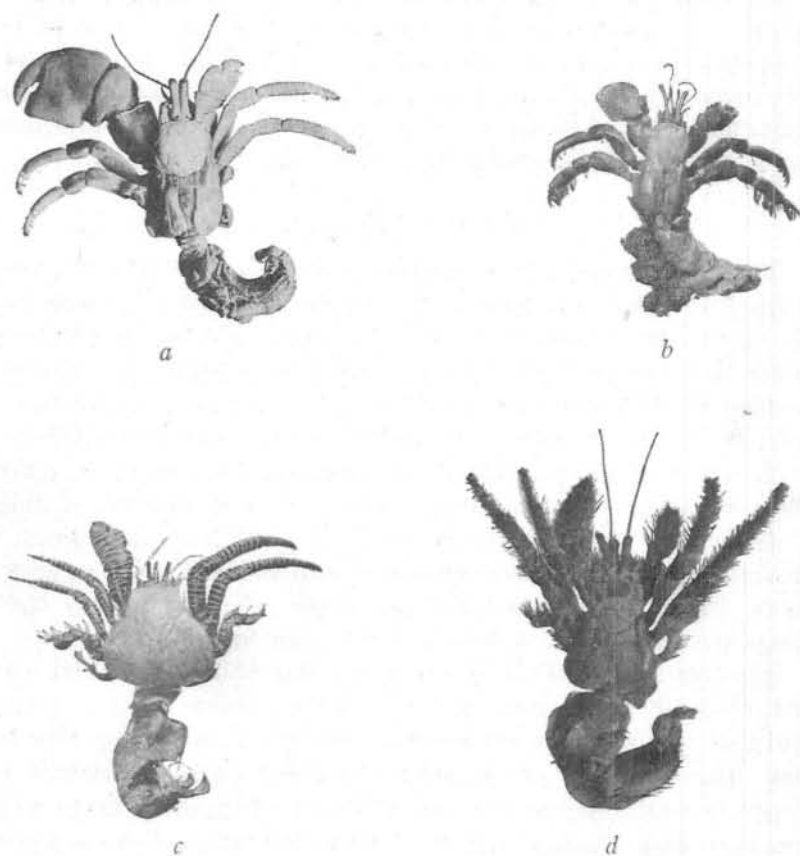


FIGURE 161.—Paguridae: a, *Calcinus herbstii*; b, *Calcinus elegans*; c, *Aniculus strigatus*; d, *Dardanus punctulatus*.

of *Turbo intercostalis* or species of *Tonna* which frequently bear specimens of the actinian, *Calliactis armillatas*. An easily distinguished species, *D. sanguinocarpus* Degener, has the lower border of the left cheliped curved outward. The outer surface of the palm of the large cheliped is armed with black-tipped spines. Other segments of both chelipeds and the second and third pairs of legs are spinous. The carapace and legs are mottled with red, purple, gray, and white, and support tufts of long yellow bristles. The crab commonly occupies the shell of *Turbo intercostalis*. It is about 3 inches long.

The largest hermit crab of Hawaii is *Dardanus punctulatus* (Olivier) (fig. 161, *d*), which may reach a length of 12 inches. It is reddish, the carapace being covered with white spots. Long yellow bristles cover the legs and anterior part of the carapace. Small specimens are occasionally seen on the reefs, but large forms are taken at a depth of a few fathoms and are usually found occupying shells of the large triton, *Charonia tritonis*.

A small species, *Dardanus sulcatus* Edmondson, about 1.5 inches long, has been taken only at French Frigate Shoal. The chelipeds are similar in form, the left slightly larger than the right. The last two joints of the left leg are deeply furrowed on the posterior surface and crossed by numerous transverse grooves. Yellow and red bristles cover the chelipeds and legs and conceal the armature of spines.

Of the genus *Clibinarius*, the species *C. zebra* Dana is found about the shores. It is dark reddish brown with the second and third legs longitudinally striped with a deeper tint of the same color. Its length is about 1 inch.

Another form, probably *Pagurus zebra* (Henderson), was collected at French Frigate Shoal. As in other members of this genus, the right cheliped is larger than the left. Red parallel lines mark both surfaces of the second and third legs, left cheliped, merus of right cheliped, and sides of the carapace. The length is 12 mm.

A careful study of the minute hermit crabs occupying small mollusk shells under stones and among seaweeds along the shore would doubtless reveal other and undescribed forms. One small, undetermined species, 5 mm. long, is a common inhabitant of mollusk shells of the genus *Vanikoro* on Kahala reef, Oahu.

FAMILY HIPPIDAE

Crustaceans of this family are very common on sandy beaches at the water line, where they are found just beneath the surface of the wet sand. They are highly specialized for burrowing, the body being oval and convex above. The first pair of legs is without chelae and the others have flattened dactyli for scooping out the sand as the animal buries itself backward. There is probably but one species, *Emerita pacifica* (Dana), in Hawaii. The front of the carapace is cut into four small teeth of about equal size with no median tooth. Large specimens are 1.5 inches long. (See fig. 162, *a*.)

FAMILY ALBUNEIDAE

A curious little form, *Albunea speciosa* Dana, not adapted for swimming but for burrowing in the sand, is occasionally seen in shallow water and also occurs at depths of several fathoms. It is dorsoventrally compressed and has the first pair of legs chelate and the dactyli of the others flattened. The carapace, which is almost as broad as long, has 10 small teeth on the anterior margin lateral to each eye. Its length is slightly less than 1 inch.

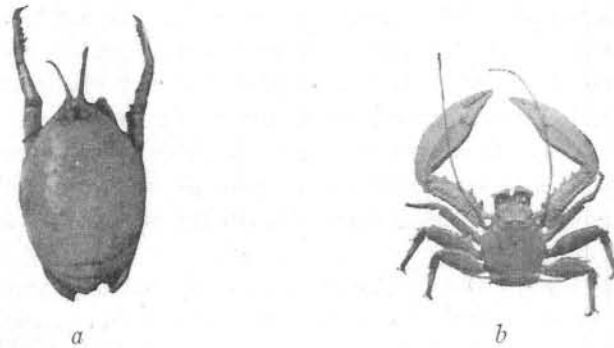


FIGURE 162.—Anomura: a, *Emerita pacifica*; b, *Petrolisthes coccineus*.

FAMILY PORCELLANIDAE

The crablike forms of this family have the first pair of legs stout and chelate but the last pair slender and turned up on the dorsal surface of the carapace. The abdomen is bent under as in typical crabs.

The most common species in local waters is *Pachycheles pisoides* (Heller). It has a smooth, almost circular carapace about 5 mm. across. The chelipeds are broad, unequal, and coated with hair. The slender fifth leg rests on the posterolateral edge of the carapace. This flattened species is usually concealed in crevices of dead coral heads. Its larva has a slender rostral process many times the length of the body proper, and a pair of long filaments are developed from the posterior border of the carapace.

A larger species, *Petrolisthes coccineus* (Owen) (fig. 162, b), is occasionally taken on the reefs in dead coral heads or in crevices of rocks. The carapace is a little longer than broad, and the flattened chelipeds are nearly equal. The fifth leg is slender and rests on the carapace. Its color is red. Large specimens are 12 mm. long.

TRIBE BRACHYURA

This large division includes the typical crabs in which the abdomen is turned under the cephalothorax and not used for swimming. All have the antennae median to the eyes. The shallow-water Brachyura of Hawaii comprise more than 150 species and represent more than a dozen families.

In distinguishing species of crabs reference is repeatedly made to the areas and borders of the carapace as well as to the character of the chelipeds and walking legs. That allusion to these features in the following discussion may be made clear, consult figure 163.

To facilitate classification, taxonomists usually subdivide this large group of decapod crustaceans into subtribes and superfamilies, making more simplified keys of lesser divisions.

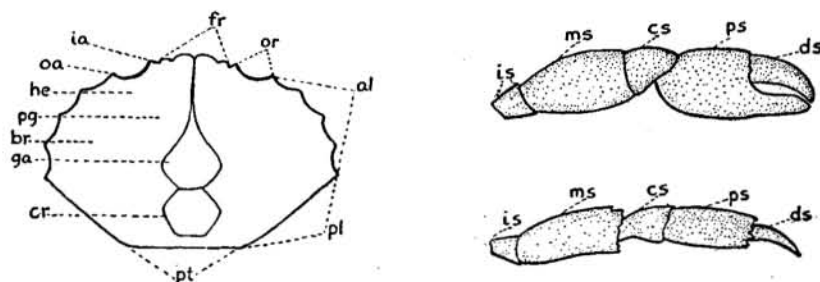


FIGURE 163.—Carapace and appendages of a typical crab showing structural features (*al*, anterolateral border; *br*, branchial region; *cr*, cardiac region; *cs*, carpus; *ds*, dactylus; *fr*, front; *ga*, gastric area; *he*, hepatic area; *ia*, inner orbital angle; *is*, ischium; *ms*, merus; *oa*, outer orbital angle; *or*, orbit; *pg*, protogastric area; *pl*, posterolateral border; *ps*, propodus; *pt*, posterior border).

Key to Subtribes of Tribe

- A. Mouth area (endostome) triangular, narrow in front and produced; carapace usually more or less circular.....**Oxystomata**. p. 264
- AA. Mouth area (endostome) squarish.
 - B. Fifth and usually fourth pairs of legs small, subdorsal in position; antennae long**Dromiacea**. p. 267
 - BB. Fifth pair of legs normal, seldom reduced; antennae short.....**Brachygnatha**. p. 268

SUBTRIBE DROMIACEA

Key to Families of Subtribe

- A. Fourth and fifth pairs of legs subdorsal or dorsal in position and adapted for holding sponges over the carapace.....**Dromiidae**.
- AA. Fifth pair of legs subdorsal in position, not adapted for holding sponges**Dynomenidae**.

FAMILY DROMIIDAE

Among the most primitive of the Brachyura are the "sponge crabs", so called because of their habit of carrying sponges over their backs. The carapace is strongly convex, and the fourth and fifth pairs of legs are held dorsally and by means of pincers grasp the under side of the sponge and keep it in place.

One of the smaller species, *Cryptodromiopsis tridens* Borradaile, is common near shore under stones and in the crevices of rocks. There is an oval, pearl-white boss, or smooth elevation, near each postero-lateral border of the carapace. It is light brown, and the sponge carried is usually of the same color. The length of the carapace is about 6 mm. and the breadth about 8 mm.

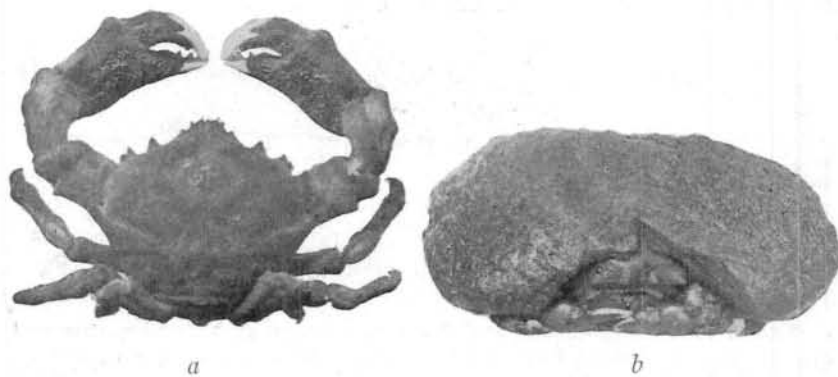


FIGURE 164.—*Dromidiopsis dormia*: *a*, with sponge removed; *b*, carrying a block of wood.

A subspecies, *Dromidia unidentata hawaiiensis* Edmondson, was described from Waikiki reef, Oahu. It is orange with 53 pearl-white spots on the carapace and first abdominal segment. The spots fade, however, in alcoholic specimens. The species is about 6 mm. long.

The largest sponge crab about the islands is *Dromidiopsis dormia* (Linnaeus) (fig. 164, *a*). It is seldom seen on the reefs but is typical of depths of a few fathoms. Large specimens often reach 5 inches in length of carapace. Objects other than sponges are sometimes held over the back of this species. A specimen was taken in a fishtrap off Waikiki reef, Oahu, carrying a block of wood nicely hollowed out to fit the convexity of the carapace (fig. 164, *b*). Another specimen taken was adorned by an old shoe sole instead of a sponge.

An undetermined species, about 1 inch long, is occasionally seen near shore. It is light brown. The sponges carried vary in form, size, and color. This species sometimes substitutes a group of soft corals, *Zoanthus confertus*, for a sponge.

FAMILY DYNOMENIDAE

Members of this family are closely allied to sponge crabs but do not carry sponges. The common representative in Hawaiian waters is *Dynomene hispida* Desmarest (fig. 165), which has a very convex



FIGURE 165.—*Dynomene hispida*.

carapace densely coated with short hairs. The front is broadly triangular and turned down. The chelipeds are slightly stouter than the three following pairs of legs, and the fifth pair is short and slender and lies against the posterolateral border of the carapace. On some reefs the species is very abundant in crevices of porous rocks. Large specimens are 12 mm. long.

SUBTRIBE OXYSTOMATA

Key to Families of Subtribe

- A. Crabs not adapted to living in cavities or galls in coral colonies.
 - B. Carapace short, rounded or squarish; last two segments of legs not broad.
 - C. Carapace rounded; hand of cheliped not broadly expanded..... **Leucosiidae.**
 - CC. Carapace rounded; hand of cheliped broadly expanded..... **Calappidae.**
 - BB. Carapace elongated; last two segments of legs usually broad..... **Raninidae.**
- AA. Crabs adapted to living in cavities or galls in coral colonies..... **Hapalocarcinidae.**

FAMILY LEUCOSIIDAE

The crabs representing this family are small with a rounded or oval carapace. The dorsal surface of the carapace is commonly roughened by humps or tubercles.

None of the shallow-water species are common in Hawaii. The one most frequently seen is *Nucia speciosa* Dana (fig. 166, *a*). The rounded, finely granulated carapace is marked by a row of tubercles along each lateral border and another on each side of the median line. The carapace and the short, stout legs are blotched with red. A large specimen is 12 mm. long. The species is usually concealed in dead coral heads.

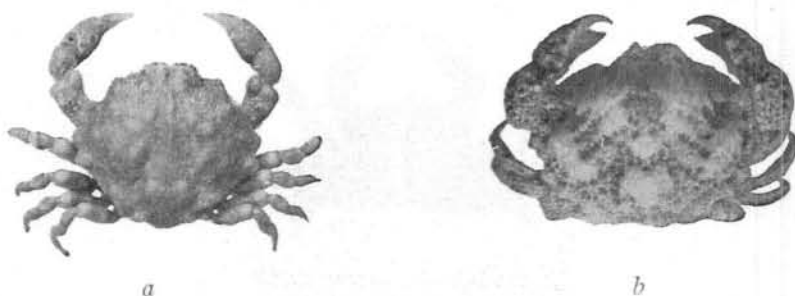


FIGURE 166.—Leucosiidae: *a*, *Nucia speciosa*; *b*, *Actaeomorpha erosa*.

In *Oreophorus (Tlos) latus* (Borradaile) the carapace is broader than long and can almost conceal all of the appendages. There are two humps on the posterior region of the carapace and a broad depression median of each lateral border. The granular surface is also pitted and roughened by grooves. Its width is about 10 mm.

A species corresponding closely with *Actaeomorpha erosa* Miers, which was described from Port Curtis, Australia, has been collected on the shores of Molokai, Oahu, and Laysan Island. The carapace and appendages are deeply eroded and pitted (fig. 166, *b*). Its breadth is about 10 mm. At least six other species of this family have been dredged in off-shore water about Hawaii but apparently do not inhabit the shallow reefs.

FAMILY CALAPPIDAE

These crabs are typical of sandy bottoms and habitually bury themselves just beneath the surface of the sand. The carapace is convex, commonly broader than long, and the expanded palms of the chelipeds cover the anteroventral region like a shield.

Species of *Calappa* are recognized by the winglike expansion of the posterolateral regions of the carapace under which the four posterior pairs of walking legs are concealed. The hands are greatly expanded with high, toothed crests. Three species are known in Hawaii. The largest of these, *C. calappa* (Linnaeus), has the carapace about twice as broad as long. Its surface is marked by wavy, transverse lines. The winglike expansions of the carapace have entire margins. Large specimens are 6 inches broad.

The most common species in Hawaii is *C. hepatica* (Linnaeus) (fig. 167). Its carapace is ornamented by numerous tubercles and is not quite twice as broad as long. The front borders of the winglike expansions of the carapace are serrated. Large specimens are 4 inches broad.



FIGURE 167.—*Calappa hepatica*.

In *C. gallus* (Herbst) the carapace is as long as broad and the front more pointed than in the other species. It is about 2 inches long. Like most crabs, species of *Calappa* are more active at night, when they come out of the sand in search of food.

Cryptosoma The genus *Cycloes* is represented in Hawaii by at least one species, *C. granulosa* De Haan. The carapace is longer than broad and there are no winglike expansions. Its surface is ornamented by granules and tubercles. The chelipeds are quite like those of *Calappa*. It has been collected in shallow water in Pearl Harbor, Oahu, and dredged off Waikiki, Honolulu, in 30 to 50 fathoms. The Pearl Harbor specimen is 2 inches long.

Two species of *Mursia* were described from dredged material taken by the *Albatross* about Hawaii. None have been recorded from Hawaiian reefs. Species of this genus have a carapace broader than long with a long spine on each lateral border.

FAMILY RANINIDAE

There seems to be but one representative of this family about Hawaii. Although not frequenting shallow water, the species *Ranina serrata* Lamarck (fig. 168) is mentioned because of the attention it

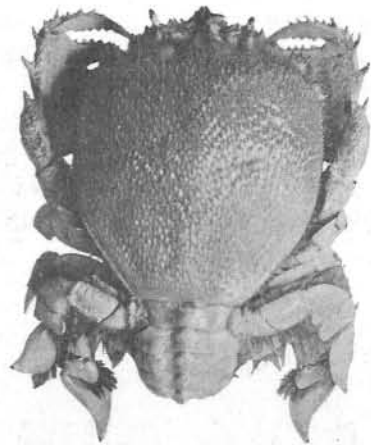


FIGURE 168.—*Ranina serrata*.

attracts when captured. The carapace is longer than broad, strongly convex from side to side, granular, and ornamented by smooth, elongated tubercles. The abdomen is small and the segments diminish in size from the first to the seventh. The last pair of legs is held in a dorsal position. Broad, flat hands characterize the chelipeds; the fingers are almost at right angles to the axis of the appendage. Long hairs form a dense coat under the lateral borders of the carapace and fringe more or less completely the front, legs, and abdomen. The largest specimen in Bishop Museum was taken near Nihoa Island in 30 fathoms of water. Its carapace is 7 inches long and 6 inches broad. The species is occasionally seen in the Honolulu fish markets.

FAMILY HALALOCARCINIDAE

On certain species of branching corals may be found inflated gall-like enlargements which contain a small crab, *Hapalocarcinus marsupialis* Stimpson (fig. 169). In Hawaii the galls are commonly formed on *Pocillopora damicornis*, rarely on other species of that genus. The crab within the gall is a female which, according to some authorities, settles in a crotch on the coral when young and by rapid movements

of the appendages accelerates growth of the skeletal material of the coral so that she is inclosed in a limestone prison for life. Small openings, through which food is admitted, remain in the crest of the gall. It is believed that the male, a tiny form and seldom seen, enters the gall through the minute pores to fertilize the eggs, and that the larvae escape by way of the same openings. The abdomen of the female is an inflated pouch in which eggs are carried, hence the specific name *marsupialis*. A full grown female crab is dark gray or black and about 12 mm. long.

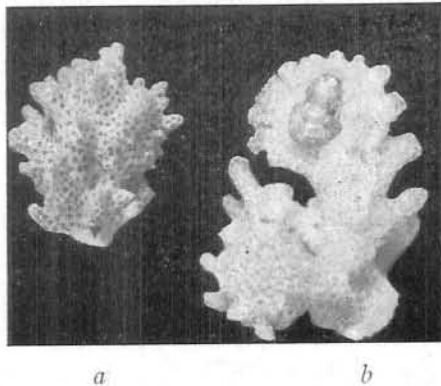


FIGURE 169.—Gall on coral (*Pocillopora damicornis*): *a*, inclosing the crab *Hapalocarcinus marsupialis*; *b*, broken open exposing the crab.

Other members of this family do not form galls but inhabit pits in living coral heads of the massive type. At least two species of *Cryptochirus*, having such adaptations, occur in Hawaii. One of these, *C. crescentus* Edmondson, was described from Johnston Island where it was found in crescent-shaped pits in the coral *Pavona explanulata*. This crab also inhabits the same species of coral in Hawaii. It has a broad, flattened carapace.

In *Cryptochirus* the front portion of the carapace is bent at an angle and serves to close the opening of the pit. Both sexes may occupy a pit, the male being much smaller than the female. Large females slightly exceed 2.5 mm. in length of carapace.

The species, *Cryptochirus minutus* Edmondson is very common in colonies of *Cyphastrea ocellina* in the shallow waters of Hawaii. It is about 2.5 mm. long. The carapace is more cylindrical than in *C. crescentus* and the pit in which it lives is nearly circular at the aperture.

It is believed that the crabs of the genus *Cryptochirus*, when young, settle in the calices of the coral, which builds its skeleton around them as it grows. The depth of the pit, therefore, indicates the amount of coral growth since the crab came to rest in the calice.

The Indo-Pacific species of *Cryptochirus*, *C. corallodytes* Heller and *C. dimorphus* Henderson, are apparently quite distinct from the Hawaiian forms and have not been observed about any of the islands.

SUBTRIBE BRACHYGNATHA

Key to Superfamilies of Subtribe

- A. Body pyriform in shape, rostrum drawn out into a point, sometimes bifid; orbits usually incomplete.....**Oxyrhyncha**. p. 274
 AA. Body usually oval, rounded or squarish, rostrum reduced or wanting; orbits usually complete**Brachyrhyncha**. p. 276

SUPERFAMILY OXYRHYNCHA

Representatives of two families of this group are found in shallow water about the islands. They are easily distinguished.

FAMILY PARTHENOPIDAE

The representative of the family in Hawaii most frequently seen is *Parthenope horrida* Fabricius (fig. 170), which occurs about the shores

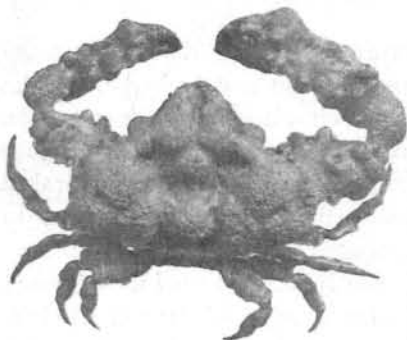


FIGURE 170.—*Parthenope horrida*.

and also at moderate depths. Its pentagonal carapace is marked by deep depressions and tubercles. The chelipeds are long, unequal in size, and covered with coarse spines. The breadth is about 1.5 inches.

Several species of *Parthenope* and one of *Harrovia* are known to occur about the islands at moderate depths, but are not likely to be seen on the reefs or close to shore. A specimen of *Parthenope* (*Rhinolambrus*) *lamelligera* (White) with a carapace 2 inches across was taken near Lihue, Kauai, in about 6 fathoms of water.

FAMILY MAIIDAE

This family includes an assortment of crabs resembling each other in having the fused second and third joints of the antennae so well developed that they occupy most of the space between the eyes.

There are four very common species, representing as many genera, about Hawaiian shores. Of these *Simocarcinus simplex* (Dana), *Trigonothir simplex* of some authors, (fig. 171, *a*) is abundant on the brown seaweeds (*Sargassum* species) growing near shore. The crab is the color of the weeds. The sexes of the crab differ in the form of carapace and chelipeds. In the male the carapace is triangular, with the front drawn between the eyes as the apex. In the female the carapace is more rectangular, the rostrum shorter, and the chelipeds more slender than in the male. Seaweeds often adorn the rostrum of the species. Large specimens of either sex are about 1 inch long.

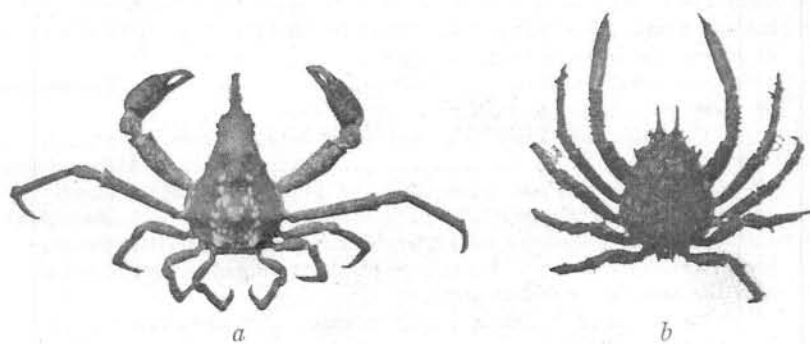


FIGURE 171.—Maiidae: *a*, *Simocarcinus simplex*, male specimen; *b*, *Schizophrys hilensis*.

In *Schizophrys hilensis* Rathbun (fig. 171, *b*) the carapace is oval, longer than broad; the front is drawn out between the eyes into two divergent horns. The lateral and posterior borders are spinous. The animal is often covered by sponges, seaweeds, and other growths, so that

it is inconspicuous as it clings to the under surface of stones. Large specimens are 1 inch long.

A species much smaller than the preceding one, but having similar habits, is *Menaethius monoceros* (Latreille). The rostrum is a long slender spine and is flanked on either side by a shorter spine. Tubercles mark the surface of the carapace. It is 12 mm. long.

Concealed in crevices of porous rocks is found a small crab, *Perinea tumida* Dana, which has a thick, triangular carapace with tuberculate surface. The legs are short and rough. In the male the chelipeds are stouter than in the female. Large specimens are 12 mm. long.

At least 16 other species of the family, representing 12 genera, have been recorded from Hawaii. Most of them, however, inhabit moderate depths and are not likely to be seen in shallow water.

SUPERFAMILY BRACHYRHYNCHA

By far the greater number of the true crabs to be found about the shores and on the shallow reefs of the islands belong to this superfamily. Those mentioned in the following pages are listed under seven families.

Key to Families of Superfamily

- A. Carapace usually rounded or transversely oval; frontal and lateral borders usually with teeth or spines; palp of third maxilliped articulates at or near the inner angle of the merus.
 - B. Legs usually adapted to swimming.....Portunidae p. 277
 - BB. Legs not adapted to swimming.
 - C. Antennules folded longitudinally; carapace subcircular.....Atelecyclidae p. 283
 - CC. Antennules fold transversely or obliquely; carapace usually transversely ovalXanthidae p. 284
- AA. Carapace usually squarish with lateral borders nearly parallel; frontal border usually without teeth; palp of third maxilliped not articulating near the inner angle of the merus.
 - B. Commensal or symbiotic crabs; carapace often membranous, oval or roundedPinnotheridae p. 302
 - BB. Free-living crabs; carapace hard and firm, lateral borders nearly straight or arched.
 - C. Carapace with lateral borders arched and toothed; last legs very smallPalicidae.
 - CC. Carapace squarish with lateral borders only slightly arched.
 - D. Front usually wide; third maxillipeds separated by a gap; eye stalks of moderate length.....Grapsidae. p. 303
 - DD. Front narrow; third maxillipeds close together; eye stalks usually very long.....Ocypodidae.

FAMILY PORTUNIDAE

Key to Hawaiian Genera of Family

- A. Front broad; eye stalks normal; fifth pair of legs flattened for swimming (except in *Catoptrus*); anterolateral border toothed.
- B. Antenna with flagellum in the orbit.
- C. Legs not adapted to swimming; anterolateral border with 6 teeth, including the external orbital one.....**Catoptrus.**
- CC. Legs adapted to swimming; last two segments of fifth leg flattened.
- D. Anterolateral border with not more than 7 teeth, including the external orbital one.
- E. Carapace broader than long; seven irregular teeth on the anterolateral border.....**Carupa.**
- EE. Carapace circular.
- F. Front not prominent; last two segments of fifth leg flat but not circular.....**Lissocracinus.**
- FF. Front prominent; last two segments of fifth leg, flat, circular plates.....**Coelocarcinus.**
- DD. Anterolateral border with 9 teeth, including the external orbital one.
- E. Hand of cheliped smooth, swollen.....**Scylla.**
- EE. Hand of cheliped longitudinally costate.....**Portunus.**
- BB. Antenna with flagellum excluded from the orbit.
- C. Anterolateral teeth 6.....**Charybdis.**
- CC. Anterolateral teeth 5 (or 4).....**Thalamita.**
- AA. Front narrow; eye stalks long; fifth pair of legs flattened for swimming**Podophthalmus.**

Although nearly 20 species of portunids are known to inhabit the reefs about the islands, few may be considered common forms. Some are rarely seen because they bury themselves in the sand; others have various means of concealment. Doubtless some are actually scarce because of disadvantageous competition.

The smallest of the near-shore forms is *Catoptrus inaequalis* (Rathbun). This small, smooth, white crab has an oval carapace with the front slightly concave in the middle, and six minute teeth on the anterolateral border, the last being the larger. The walking legs are long and more slender than the chelipeds. Adults are about 10 mm. wide. A larger species, *Catoptrus nitidus* A. Milne Edwards, has been taken at Pearl and Hermes Reef. The smooth carapace has a notch in the middle of the front border and six anterolateral teeth, the last of which is spinelike and curved forward. The chelipeds are unequal, smooth and unarmed. The fingers of the small hand are about as long as the palm, slender and finely toothed. Fingers of the larger hand are shorter and more coarsely toothed. A large specimen is 20 mm. wide.

About thirty years ago *Libystes nitidus* A. Milne Edwards was recorded from Honolulu. It has not appeared in Hawaiian waters since. The carapace is oval, broader than long, with smooth surface and arched, entire lateral borders. The chelipeds are stout, smooth, with long pointed fingers. It is nearly 1 inch broad. Until recently the genus *Libystes* was assigned to the family Ocypodidae, but is now generally recognized to be close to *Catoptrus*. In one species, *L. edwardsi* Alcock, the last walking legs are flattened as in a typical portunid.

The species *Carupa laeviuscula* Heller (fig. 173, a) is reddish and purple about the front of the carapace and on the chelipeds. Of the seven teeth on the anterolateral border the fifth is the smallest and the sixth is the largest. Large specimens are 1 inch across the carapace.

A conspicuously marked little crab, *Lissocarcinus orbicularis* Dana, has a nearly circular carapace with the anterolateral borders thin and cut into five shallow lobes. Black spots mark the carapace and legs. It is about 12 mm. across. The crab lives among the tentacles of holothurians, especially *Holothuria atra*. Another small form, *Coelocarcinus foliatus* Edmondson (fig. 172), has been taken on Waikiki reef. The subcircular

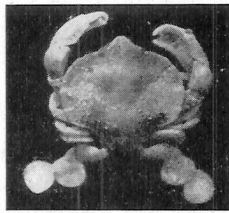


FIGURE 172.—*Coelocarcinus foliatus*.

carapace is deeply concave in the branchial regions and elevated in the median area. The front is produced into a blunt point and four low lobes, separated by slight incisions, mark the anterolateral border. In the fifth leg, the propodus and dactylus are expanded into thin, circular lobes.

An introduced crab, *Scylla serrata* (Forskål) (fig. 174, c), has apparently become well established in Hawaiian waters. It is the common edible crab of India and is widely distributed in other parts of the world, thriving in estuaries, mouths of rivers, and shallow bays. It is the largest portunid in local waters, some specimens exceeding 8 inches in width of carapace. The carapace of the species is smooth, the front bearing four blunt teeth and the anterolateral border nine sharp ones of about equal

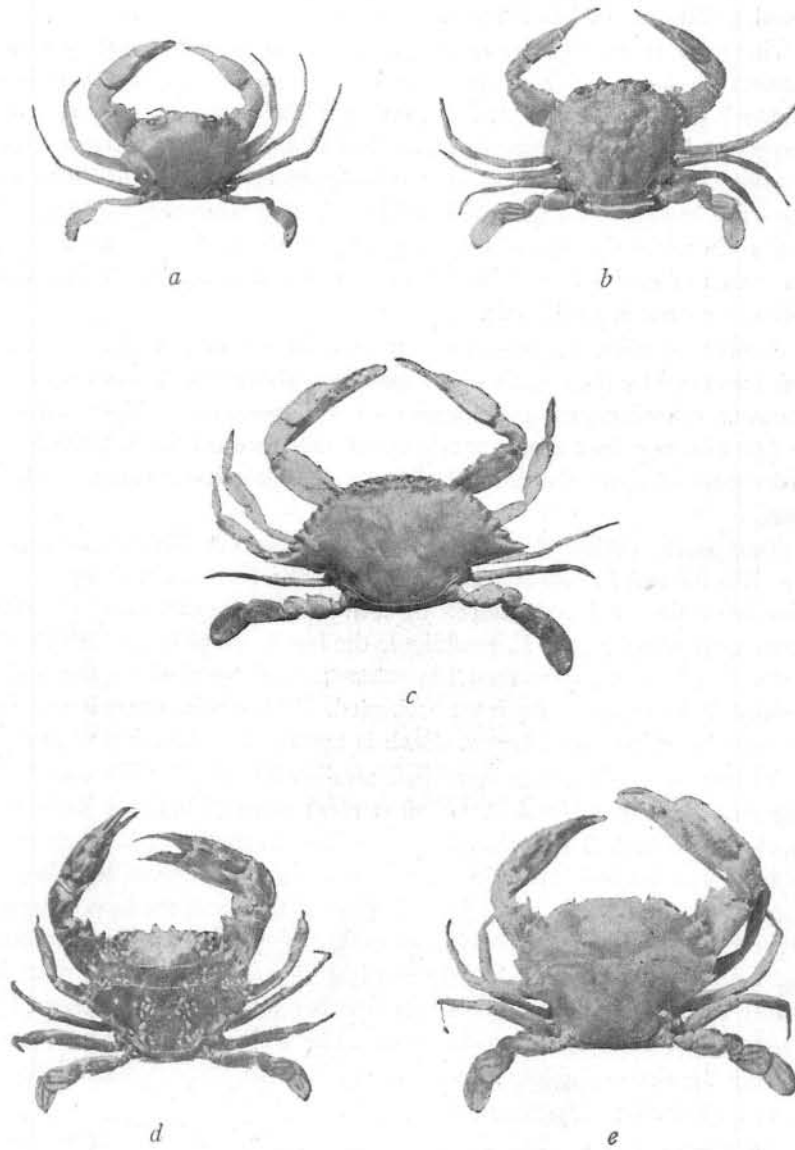


FIGURE 173.—Portunidae: *a*, *Carupa laeviuscula*; *b*, *Portunus* (*Achelous*) *granulatus*; *c*, *Portunus sanguinolentus*; *d*, *Charybdis erythrodactyla*; *e*, *Charybdis orientalis*.

size. In males the chelipeds become very large. The crab is now of considerable value as food in Hawaii.

There are several species of the genus *Portunus* (*Neptunus* of some authors) in local waters. The largest of these is *P. sanguinolentus* (Herbst) (fig. 173, c) which has a broad, slightly convex surface. The anterolateral border has nine teeth, the last of which is much larger than the others. Three large red spots mark the posterior region of the carapace. The last pair of legs is paddle-like. A large specimen may exceed 7 inches between the tips of the long, lateral spines. Large numbers of this crab are sold as food in the Honolulu fish markets. It inhabits shallow bays about the islands.

Another species, *P. pubescens* (Dana), lives on the reefs, where it buries itself under the surface of the sand in shallow water. The carapace is convex, granular, and sparsely covered with short hairs. There are on the front border four small, nearly equal teeth and on the anterolateral border nine, of which the last is the largest. Large specimens are 2 inches broad.

Two small species, *P. (Achelous) granulatus* (A. Milne Edwards) (fig. 173, b) and *P. (Achelous) orbicularis* (Richters), are occasionally taken from the sand near shore. In both species the carapace is suborbicular and flattened. In *P. granulatus* the last tooth of the anterolateral border is slightly larger than the others; in *P. orbicularis* the teeth diminish in length from the front backward. Both species are colored like the sand in which they burrow. Each is usually less than 1 inch broad.

Two other small species found in Hawaiian waters, *P. (Xiphonectes) longispinosus* (Dana) and *P. (Xiphonectes) macrophthalmus* Rathbun, are closely related. The former, however, lives in shallow water, whereas the latter has not been taken in Hawaii from depths less than 23 fathoms. In both species the last anterolateral spine of the carapace is very long. However, in *P. macrophthalmus* the number of spines preceding the long one is usually but four or five, whereas in *P. longispinosus* the number is usually six or seven in two series, the first two spines being separated by a wide space from the posterior ones. The width of *P. longispinosus* between the tips of the long, lateral spines is about 1.5 inches and that of *P. macrophthalmus* less than 1 inch.

Another small species, *P. (Achelous) argentatus* (A. Milne Edwards), was reported from Hawaii many years ago, but no recent records are known unless two young specimens taken by the *Albatross* from the surface on the north coast of Molokai represent it. It is said to have a

silvery or coppery sheen on the crest of the palm and dactylus of the chelipeds and on the third abdominal segment.

Three species of *Charybdis* have been recorded from Hawaii. One of the most brilliantly colored crabs is *C. erythroactyla* (Lamarck) (fig. 173, *d*). Although it presents almost every color of the rainbow, it may be recognized by the irregular spots of blue distributed over the carapace. The propodi and dactyli of the swimming legs are bright blue with longitudinal brown stripes. There are six bluntly rounded teeth on the front besides the supraorbital angles. On the anterolateral border are five large teeth which curve forward. At the base of the first and second there is a smaller tooth and a notch at the base of the third. Large specimens exceed 6 inches in breadth.

In *Charybdis orientalis* Dana (fig. 173, *e*), the front has six truncated teeth and the carapace is crossed by four series of granular ridges, the fourth connecting the last pair of lateral teeth. There are five large teeth on the anterolateral margin with a rudimentary one between the first and second. The general color of the crab is red, and the fingers are partly black. Large specimens slightly exceed 3 inches in breadth. A few specimens of *C. japonica* (A. Milne Edwards) have been recorded from Hawaiian waters, but apparently none have been observed in recent years. The six teeth of the front are more acute than in *C. orientalis*, and there are six large teeth on the anterolateral border. The species is the size of *C. orientalis*.

Of the swimming crabs about the shores of Hawaii, those of the genus *Thalamita* are the most familiar. They are recognized by the broad front which consists of well-developed supraorbital angles and two to six lobes or teeth. The anterolateral borders are cut into five teeth of which the fourth is often rudimentary. The chelipeds are stouter than the other legs, and the hand has longitudinal crests or series of definitely placed spines.

Species of *Thalamita* are very agile animals, capable of running swiftly as well as swimming. The shore forms are found under loose stones. They have a pugnacious disposition and can give one a severe pinch with their sharp chelipeds.

The most common of the reef-dwelling forms is *Thalamita edwardsi* Borradaile (fig. 174, *a*). The front of the carapace has two broad lobes in addition to the supraorbital angles, and there is a row of teeth on the basal segment of the antenna. Of the five longitudinal crests on the outer surface of the hand, the first two (upper) are granulated and each has two

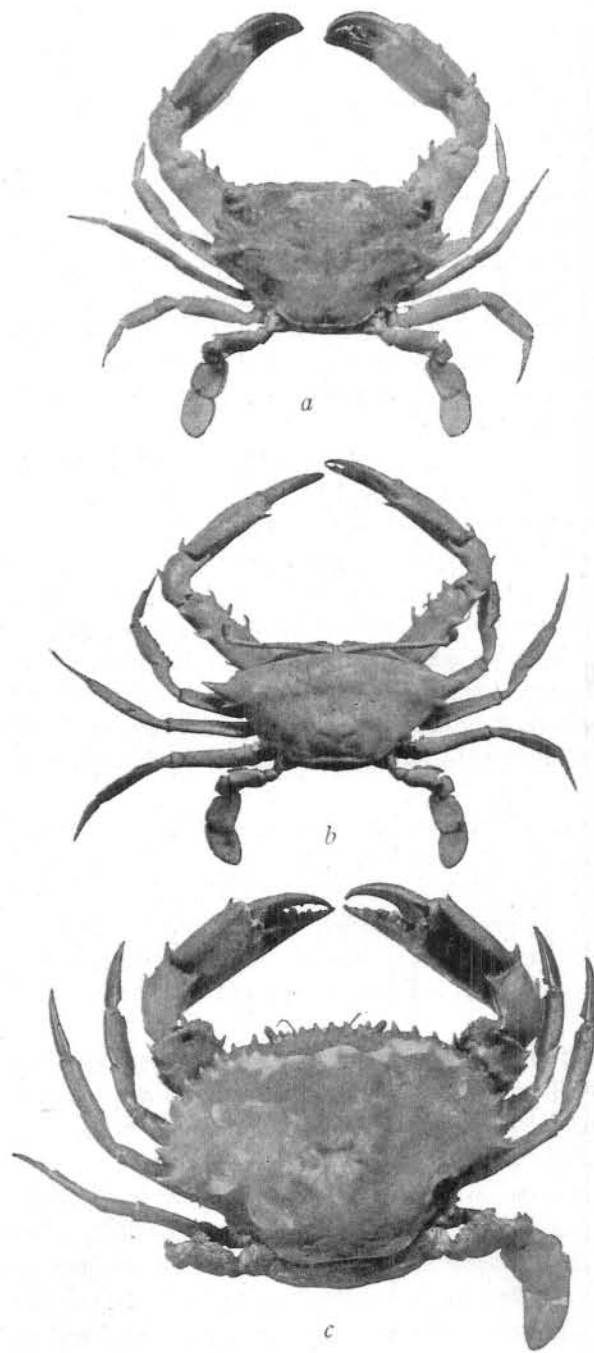


FIGURE 174.—Portunidae: *a*, *Thalamita edwardsi*; *b*, *Podophthalmus vigil*; *c*, *Scylla serrata*.

spines in addition to a blunt tooth at the front end. The fourth crest is interrupted in the middle of the palm. The fifth is smooth. Large specimens are 1.5 inches broad.

The species *T. integra* Dana is distinguished from *T. edwardsi* by the smooth crest of the basal segment of the antenna. It is about the size of *T. edwardsi* but is not so common on the reefs as that species, at least about Oahu. It seems to be the most abundant species, however, in Pearl Harbor, Oahu. In *T. picta* Stimpson the front is cut into six nearly equal lobes, in addition to the supraorbital angles. Large specimens slightly exceed 1 inch in breadth.

A form corresponding to *T. admete* (Herbst) is occasionally seen in shallow water. The five crests of the hand are granular, the granules diminishing in size from the third to the fifth crest. The fourth tooth of the anterolateral border is well developed but smaller than the others. Specimens are about 1 inch broad. Other species, *T. coeruleipes* Jacquinet, which has a rimmed lobe at the posterolateral angle of the carapace, and *T. sima* Milne Edwards, the hand of which is covered with squamiform markings, were reported from Hawaii many years ago but apparently have not been seen since.

Four other species of *Thalamita*, and *Thalamonyx gracillipes* A. Milne Edwards were dredged by the *Albatross* from moderate depths about the islands. None of these are likely to be seen near the shore.

One of the largest swimming crabs in Hawaii is *Podophthalmus vigil* (Fabricius) (fig. 174, *b*). The long eye stalks, which almost join medially, are protected by grooves which extend along the anterolateral borders of the carapace and end in large spines. A smaller spine is behind the large one. The chelipeds are much stouter than the other legs, and the hand has three longitudinal costae on the outer surface and a spine at the distal extremity of the dorsal crest. This crab has considerable economic importance as it is used extensively as food. Large numbers are sold in the Honolulu fish markets, along with *Portunus sanguinolentus*. It lives in shallow bays but does not frequent the reefs. Large specimens are 5 inches broad.

FAMILY ATELECYCLIDAE

The single representative of this family, *Kraussia rugulosa* Krauss (fig. 175), is recorded from the reefs of Hawaii. The carapace is subcircular with two broad, slightly concave lobes forming the front. Each lobe is edged with small teeth and long hairs. The anterolateral border bears

five teeth of good size with small teeth between them. Transverse, wavy rugae mark the dorsal surface of the carapace. The chelipeds are stout, the palm covered with smooth transverse rugae and the fingers deeply hollowed out at the tips. The length of the carapace is about 20 mm. Two other species of the genus are known to occur at moderate depths about the islands.



FIGURE 175.—*Kraussia rugulosa*.

FAMILY XANTHIDAE

Fully 100 known species of Hawaiian crabs are included in this family. More than one half of these inhabit the reefs and shallow water. Among them are most of the common and familiar crabs which find concealment under stones, in crevices of rocks near shore, and among the branches of living corals.

In typical representatives of this family the carapace is transversely oval with a fairly broad front notched in the middle. The legs are adapted for running.

Keys have, at times, been constructed for the genera of the xanthid crabs but they are more or less artificial and, at best, are very complicated. In the following treatment the determination of genera and species can, I believe, be accomplished by the brief diagnoses given, together with the supplemental figures.

The genus *Carpilius* includes some of the medium-sized crabs to be found under stones on the reef, or more frequently in crevices of porous rocks. They have a smooth, strongly convex carapace, the lateral borders of which are entire. The chelipeds are unequal and very stout. There are two well-known local species. The most common, *C. convexus* (Forskål) (fig. 176, a), is dark red, commonly mottled with white and gray in the middle of the carapace. Large specimens are 3 inches broad. The other species, *C. maculatus* (Linnaeus), is conspicuously marked by 11 dark

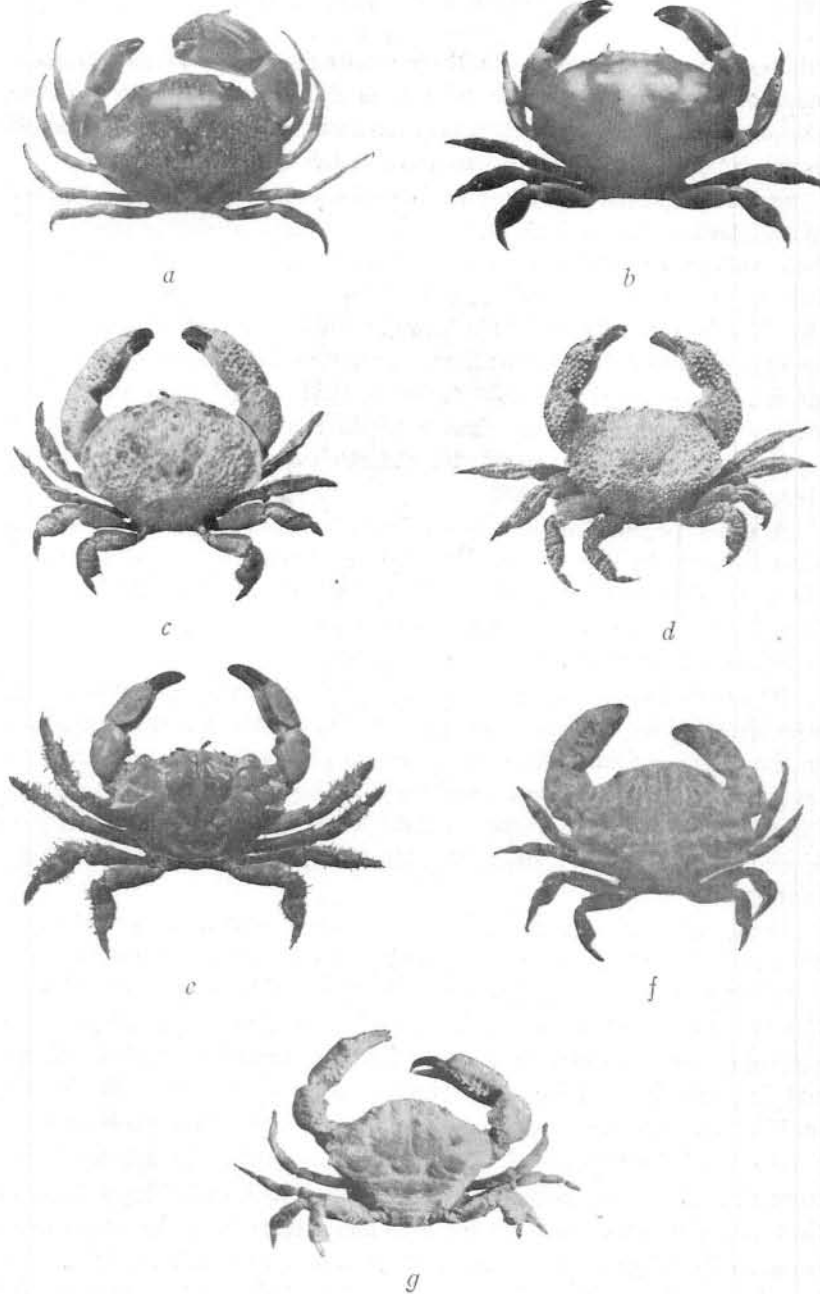


FIGURE 176.—Xanthidae: a, *Carpilius convexus*; b, *Atergatis floridus*; c, *Platypodia eydouxi*; d, *Platypodia fissa*; e, *Lophozozymus intonsus*; f, *Cyclozanthops cavatus*; g, *Medaenus simplex*.

red spots, two behind each eye, three across the middle of the carapace, and four in a transverse row in front of the posterior border. Young specimens less than 1 inch across may have as many as 28 round red spots on the carapace. Large specimens are 6 inches broad.

In the genus *Atergatis* the smooth, oval carapace has the areas marked off by shallow depressions and the anterolateral border is sharp with slight indications of lobes or teeth. The chelipeds and legs are crested on their upper borders. A widely distributed species, *A. floridus* (Linnaeus) (fig. 176, *b*) was collected from Oahu in 1864 by H. Mann, but it is not common locally at the present time. A young specimen, probably of this species, was collected at Kahala, Oahu, in 1931. It is 15 mm. across. The species is recognized by a tubercle which terminates the anterolateral border of the carapace posteriorly. Adult Samoan specimens in Bishop Museum are 1.5 inches broad.

A small specimen of an undetermined *Atergatis* was taken in shallow water in Kaneohe Bay, Oahu. The sharp anterolateral border is undulating with evidence of three teeth. The chelipeds are crested above and their outer surface is ornamented by rounded tubercles. The specimen doubtless is young, as it is but 5 mm. broad.

So far as known, no specimen of *Zozymus aeneus* (Linnaeus) has been observed in Hawaiian waters since 1864 when H. Mann took one on the shore of Oahu. The carapace and chelipeds are rough and traversed by numerous furrows, and the walking legs are flat and crested. Large specimens are 4 inches broad. There are specimens in Bishop Museum from Tahiti, Tonga, the Marianas, and Howland and Wake Islands.

Some other Hawaiian crabs with distinctly flattened legs belong to the genus *Platypodia* of which four species have been recorded. The most common one is *P. eydouxii* (A. Milne Edwards) (fig. 176, *c*). Conical granules ornament the lobules of the oval carapace and the outer surface of the wrist and hand. Four lobes separated by shallow notches and lines mark the thin anterolateral border. Wide crests border the walking legs and there is a low, granular crest on the upper border of the hand. It is 1.5 inches broad. The species *P. granulosa* (Rüppell) differs from *P. eydouxii* in being more strongly lobulated, in lacking a crest on the hand, and in the narrower crests of the walking legs. Another species occasionally taken on the reefs is *P. semigranosa* (Heller). The carapace is smoother than in *P. eydouxii*, and the lateral lobes are separated by deeper notches. It is about 1 inch broad. An easily distinguished

species is *P. actoeoides* (A. Milne Edwards). The front is deeply incised in the middle by a groove which runs back on the carapace. Parallel with the front are two transverse grooves with overhanging, imbricated lobes, the front margins of which are granulated. The anterolateral margin has four lobes, the last toothlike. A granulated crest marks the upper border of the hand and its outer surface is roughened by an irregular, longitudinal ridge near the upper margin and by scattered tubercles below. The walking legs are flattened, sharp above, and a longitudinal groove traverses the outer surface of the carpus and propodus near the upper border. Yellow bristles cover the carapace and fringe the legs. Large specimens are 1.6 inches broad. It has been taken on the reefs of Molokai and Oahu and seems to be common among nearly all of the low leeward Hawaiian Islands.

Another species occasionally taken on the reefs is *Platypodia fissa* (Henderson) (fig. 176, *d*), which may be recognized by the spiniform granules on the anterolateral borders of the carapace and on the surface near the borders. There are three fissures in the anterolateral border, two close together anteriorly and one posteriorly. The chelipeds are tuberculated externally. The legs are slightly flattened. Long yellow hairs cover the surface of the carapace, chelipeds, and legs. The species is 1 inch broad.

Crabs of the genus *Lophozozymus* also have crested legs, but the carapace does not bear coarse granules and the anterolateral border, although sharp, is more deeply incised than in *Platypodia*, and in some species is broken into teeth.

The most common species of *Lophozozymus* in shallow water about Hawaii is *L. dodone* (Herbst). It has a smooth, polished carapace with shallow furrows bounding the area. Four shallow scallops mark the thin anterolateral border. The upper border of the hand and the walking legs are crested. The width is about 20 mm. A large but less common species is *L. intonsus* Rathbun (fig. 176, *e*). Of the four lobes of the anterolateral border, the last two are toothlike. The stout chelipeds have a blunt crest on the upper border of the hand and four low longitudinal ridges on the outer surface; the two upper ones are broad. The walking legs are bordered with long, yellow bristles. Large specimens are 2.5 inches broad. A distinctly marked species, *L. pulchellus* A. Milne Edwards, is occasionally seen on the reefs. The carapace is finely granular and covered with a network of red lines. Three teeth, exclusive of the outer orbital angle, are on the anterolateral border. The crab is about 18 mm. broad.

There is an early report of *L. incisus* (Milne Edwards) from Laysan Island, but no other Hawaiian record is known. It has a rough carapace with the furrows filled with hair. Large granules and long hairs cover the outer surface of the hands, which are crested above. The legs also are crested and fringed with hair. The species is reported to be 1 inch broad.

A probable representative of the genus *Cycloxanthops* was recorded from Hawaii as *Megametope sulcatus* Edmondson, but tentatively should be called *C. cavatus* Rathbun. It has been taken at Makena, Maui, and Kahala, Oahu. The anterior half of the carapace is furrowed longitudinally and two shallow grooves extend medially from the lateral borders toward the gastric and cardiac regions. Externally the palms of the unequal chelipeds are reticulated with raised lines of granules and traversed longitudinally by ridges which are more numerous on the small hand. Specimens are about 8 mm. broad (fig. 176, f).

In 1864 specimens of *Daira perlata* (Herbst) were collected on the shore of Oahu by H. Mann. The species apparently has not been observed in Hawaii since. It is characterized by large rounded tubercles which cover the carapace and chelipeds. Large specimens are 3 inches broad. It is a very widely distributed species. There are specimens in Bishop Museum from the Line Islands, Wake Island, and Samoa.

In the genus *Medaesus* the anterolateral borders of the carapace extend below the orbits toward the angles of the mouth. Two species are common on Hawaiian reefs, and a third is occasionally seen. In *M. simplex* A. Milne Edwards the carapace has a smooth appearance and a shallow, longitudinal furrow traverses the upper border of the palm, which is finely granulate on the upper and outer surface and bears larger granules on the upper part of the inner surface. The species is 20 mm. broad. (See fig. 176, g.) The carapace of *M. elegans* A. Milne Edwards is lobulated and granulated and has a rough appearance. The wrist and hand also are roughened by rounded granulated nodules. The species is a little larger than *M. simplex*. A third species, *M. ornatus* Dana, is less common than the other two in shallow water. The carapace is rough, the convexities are covered with sharp granules. Rough, granulated tubercles cover the wrist and the upper part of the palm. Large specimens are 20 mm. broad.

One of the most common crabs in Hawaii, typical of the near-shore area, is *Leptodius sanguineus* (A. Milne Edwards) (fig. 177, a). Areas of the carapace are well marked and there are five teeth on the anterolateral border, including the external orbital angle, and a small accessory one behind the fifth. The outer surface of the wrist and upper border of

the palm are roughened by wavy ridges. The fingers are hollowed at the tips, and the legs are hairy on the margins. Adults are brown or grayish and may reach 1.6 inches in width. Some young specimens are mottled or spotted with red. These crabs are abundant under stones near the water's edge. Another species, *L. gracilis* (Dana) was collected in Hawaiian waters many years ago, but there are no recent records from this locality. In this species the carapace and chelipeds have a smooth appearance and the five anterolateral teeth are broad and thin. Its width is about 15 mm.

In *L. waialuanus* Rathbun, which is not common on the reefs, the carapace is narrow and there is a granulated ridge and groove behind the fifth tooth of the anterolateral border. Specimens are 15 mm. broad.

The chief difference between xanthids of the genera *Leptodius* and *Xantho* is that in the latter group the crabs have sharper and less hollowed out fingers than those of the former genus. The distinction is often very slight and some authors would reduce the term *Leptodius* to a subgenus. A form called *Xantho (Leptodius) exaratus* (Milne Edwards), is associated with *Leptodius sanguineus* but is less common than that species and differs from it in having sharper fingers and in the absence of the accessory tooth behind the fifth on the lateral border of the carapace.

Another species which closely resembles the common *Leptodius* is *Xantho crassimanus* A. Milne Edwards (fig. 177, *b*). It has a narrower front, however; the fingers are sharper, and the carapace is pitted. Specimens are 1.5 inches broad. *X. lacunosus* Rathbun was dredged between Maui and Lanai but has not been recorded from shallow water. A small specimen, probably an example of *X. quinquedentatus* Krauss, was taken on Waikiki reef, Oahu. The lobules of the carapace are pitted, the front is projecting, and there are granules between the five anterolateral teeth. The chelipeds are unequal with the outer surface wrinkled and pitted. The fingers are narrow and slightly hollowed at the tips. Adults of the species are said to reach a width of about 18 mm. Another species, *Xantho danae* Odhner, was recorded from Hawaii many years ago but has not been seen here recently. It has eight to 11 teeth of unequal size on the anterolateral border. It is about 20 mm. broad.

A small species, *Zoozymodes biunguis* (Rathbun) (fig. 177, *c*), is often abundant in shallow water. Fine granules cover the carapace and most of the surface of the chelipeds. A coating of hair partially conceals the carapace and appendages. The fingers of the unequal chelipeds are hollowed at the tips and are very black in color. The species is about 8 mm. in width.

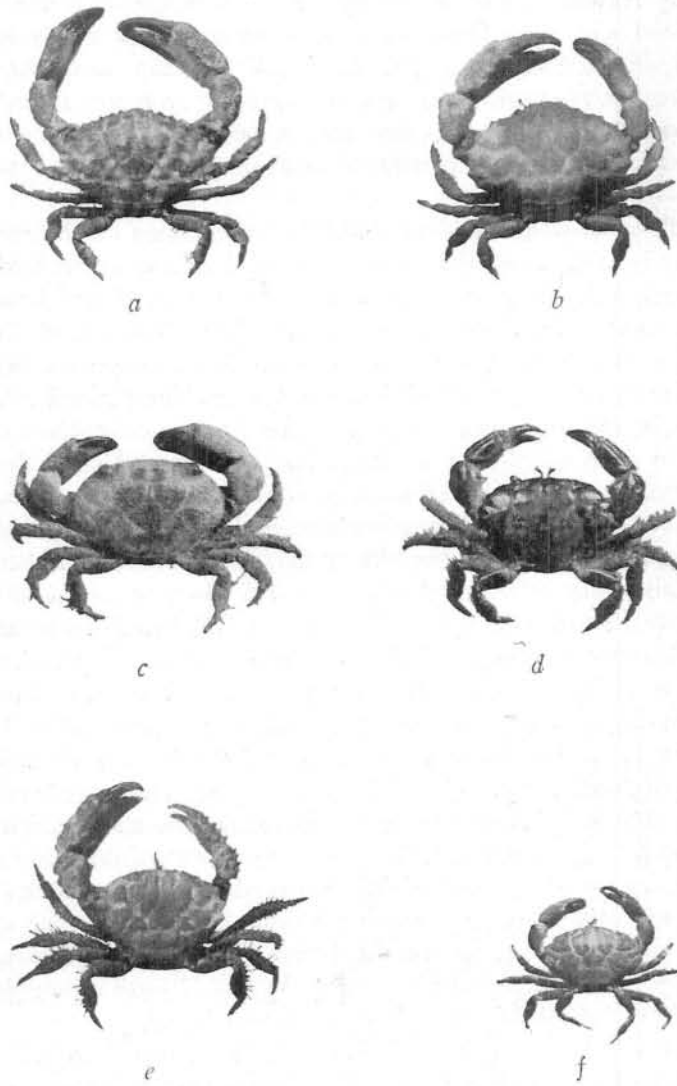


FIGURE 177.—Xanthidae: *a*, *Leptodius sanguineus*; *b*, *Xantho crassimanus*; *c*, *Zoozymodes biunguis*; *d*, *Xanthias canaliculatus*; *e*, *Paraxanthias notatus*; *f*, *Carpilodes bellus*.

In the genus *Xanthias* the carapace may be smooth or granular but the fingers are always narrow and sharp. Only one species, *Xanthias canaliculatus* Rathbun (fig. 177, *d*), is likely to be seen in local waters. It may be recognized by the smooth and shiny surface of the carapace, and by the chelipeds which are short and equal, each palm being traversed on its outer surface by three longitudinal grooves. Large specimens are 1 inch broad. It is frequently taken from crevices of rocks in shallow water. The species *X. lamarckii* (Milne Edwards) has not been taken in Hawaii for many years. Granules cover the anterior portion of the carapace, the four lobes of the anterolateral border, and the chelipeds. Three longitudinal furrows traverse the outer surface of the palm. The species is 15 mm. broad. It has a wide distribution, and is common at Wake and Palmyra Islands.

A very common crab in shallow water is *Paraxanthias notatus* (Dana) (fig. 177, *e*). Deep grooves divide the carapace into areas, and the chelipeds are unequal with sharp fingers. The upper and outer surfaces of the wrists and palms are covered with tubercles which are sharp in the small cheliped and blunt in the large one. Large specimens are 20 mm. broad.

To the genus *Carpilodes* belong a number of local crabs, some of which are common, others of which are seldom seen. The carapace is transversely oval, smooth or granular, with the areas well marked off. The four anterolateral lobes are rounded and the fingers are slightly hollowed out. One of the most common species is *C. bellus* (Dana) (fig. 177, *f*). The posterior part of the carapace is quite smooth but the anterior and anterolateral areas are furrowed and granular. Local specimens are usually pale brown or yellow. Large ones are 20 mm. broad.

Another familiar species is *C. rugatus* (A. Milne Edwards). The last anterolateral lobe has a transverse furrow which does not reach the border. The crab is red in color, and large specimens are about 1 inch broad. The easily recognized species, *C. supernodosus* Rathbun (fig. 178, *a*), is occasionally taken on local reefs but seems to be the most common representative of the genus among the leeward islands. The carapace has prominent, transverse lobules which are distinctly pitted. Its color is yellowish brown. A large specimen may exceed 1 inch in width.

Two other species, *C. ruber* A. Milne Edwards and *C. virgatus* Rathbun, have been dredged about the islands, and the former has occasionally been taken on the reefs of Oahu. It is red in color, and the surface of

the carapace, except the grooves, is covered with granules. Each of the lobes (protogastric), lateral to the median line just anterior to the gastric area, is completely divided by a longitudinal furrow. The chelipeds are granular. A low, longitudinal ridge crosses the palm near the middle and there is a groove close to the upper border. The crab is less than 1 inch broad. So far as known, *C. virgatus* has not been observed on the reefs. It is scarlet, with spots of buff on the carapace and bands of buff on the legs. Granules of the carapace occupy the grooves as well as the lobules. Specimens are about 18 mm. broad. Early authorities reported *C. tristis* Dana from Hawaii but apparently the species has not been observed recently in local waters.

The genus *Neoliomera* differs from *Carpilodes* in that the broad carapace has few grooves and lobules. Three species are known from Hawaii. In *N. pubescens* (A. Milne Edwards) (fig. 178, *b*), which occurs in shallow water near shore and also at depths of 2 or 3 fathoms, the color is pink, and the carapace is marked with scattered white spots and covered with short yellow hairs. Large specimens slightly exceed 1 inch in breadth. A somewhat smaller species, *N. praetexta* (Rathbun), was dredged in Auau Channel between Maui and Lanai at depths of 28 to 65 fathoms. The granules of the carapace bear tufts of long yellow hairs. The thin anterolateral border has four teeth, the first of which is broad and united with the outer orbital angle. The slender chelipeds and broad legs are granular and hairy. A fine specimen of *N. richtersi* (De Man) in Bishop Museum was collected near shore on the Kona coast of Hawaii. The carapace is broad, granular, and sparsely hairy. Two short, transverse grooves extend inward from the posterolateral border. The chelipeds are slender and granulated. The breadth is 1.5 inches. There is also a specimen in Bishop Museum from Pearl and Hermes Reef.

Typical representatives of the genus *Actaea* have the carapace divided into many convex lobules which are covered with granules or tubercles. The chelipeds and legs are usually ornamented in a similar way, and some species are more or less covered with hair.

A species frequently found in crevices of rocks near shore is *A. speciosa* (Dana) (fig. 178, *c*). It has a smooth appearance, the lobules being closely covered with small round tubercles. The usual color is brown, mottled with red or yellow. Specimens are about 15 mm. broad.

Other members of the genus occasionally taken on the reefs are *A. superciliaris* Odhner and *A. rufopunctata* (Milne Edwards). In the carapace of *A. superciliaris* the grooves are free from hair but the granu-

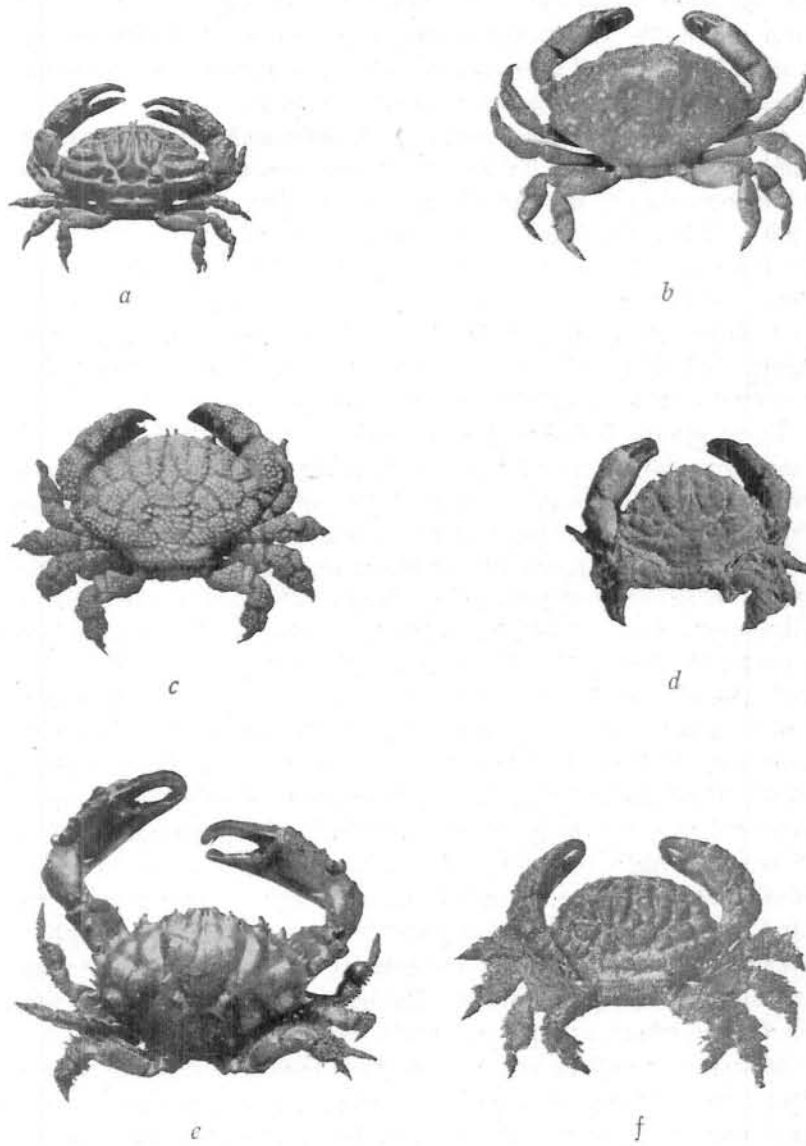


FIGURE 178.—Xanthidae: a, *Carpilodes supernodosus*; b, *Neoliomera pubescens*; c, *Actaea speciosa*; d, *Etisus electra*; e, *Etisus splendidus*; f, *Chlorodopsis areolata*.

lated lobules are hairy. A distinctive feature is a halfmoon-shaped granulated tuberosity ventrolateral to the orbit. The species slightly exceeds 1 inch in breadth. In *A. rufopunctata* the prominent lobules are separated by deep furrows filled with short hairs. Some of the lobules of the carapace and legs are red. Specimens are 1 inch broad.

A very distinctly marked species is *A. nodulosa* White, which has the carapace and legs covered with tall tubercles ornamented with granules. It has been taken on the reefs but is more common in off-shore waters at depths of 30 to 50 fathoms. It is about 18 mm. broad.

A species collected at Laysan Island, *A. variolosa* Borradaile, has the convex carapace and the legs covered with rounded granules and short, stout bristles. The chelipeds have large inflated palms and short, round fingers. It is 12 mm. broad. This species was dredged by the *Albatross* from moderate depths at three stations about the islands.

Early records included *Actaea tomentosa* (Milne Edwards) among Hawaiian shallow-water fauna but, so far as is known, the species has not been observed in Hawaii recently. A coat of short, black hair densely covers the carapace and legs. Large specimens are 1.5 inches broad.

The species *Actaea remota* Rathbun, described from Easter Island, has also been recorded from Hilo, Hawaii. The carapace is broad and covered with low, flat lobules which bear small pearly granules interspersed with short hairs. The smooth grooves between the lobules are filled with short hairs. The chelipeds and legs are granulated, and the white fingers are hollowed out at the tips. The species is 8 mm. broad. Uncommon in Hawaii, *Actaea parvula* (Krauss) has been collected at Laysan Island and at Kahala, Oahu. The lobules of the carapace and the outer surface of the chelipeds are covered with fine granules.

An undetermined species of *Actaea* has been collected on the reefs of Oahu. The carapace and legs are covered with a dense coat of long, coarse hair. The chelipeds are granular but the carapace is comparatively smooth under the mat of hair. The breadth is 15 mm. This form apparently differs from *Actaea villosa* (Rathbun), described from deep water near Laysan Island, as *Banareia villosa*.

Most recent authors have reduced the genus *Etisodes* to a subgenus under *Etisus* or combined it entirely with the latter. Crabs of this group range from small to large. The carapace is granular or smooth; the front is relatively narrow and the fingers are deeply hollowed out at the tips. Among the smaller forms occasionally taken near shore is *Etisus electra* (Herbst) (fig. 178, *d*). The carapace is longer than broad and the

lobules of the surface and of the chelipeds are granular. The front has four teeth of nearly equal size, and the legs are hairy. Specimens are 1 inch long. *E. demani* Odhner (*Leptodius molokaiensis* Rathbun) was dredged off Molokai, but young specimens are sometimes collected in shallow water. The carapace and chelipeds are very rough, and the five teeth of the anterolateral border are strong, acuminate and granular. Large specimens are 15 mm. broad.

Among the larger Hawaiian species is *E. splendidus* Rathbun (fig. 178, *e*) which is brilliantly red. There are nine to 13 teeth of unequal size and position on the anterolateral border. The chelipeds are long and stout, and the fingers are arched and broadly hollowed at the tips. Specimens are 6 to 8 inches broad. A smaller species, *E. laevimanus* Randall, is occasionally taken on the reefs. Four broad teeth mark the anterolateral border of the smooth carapace, the last with point turned forward. Specimens are 2 to 3 inches broad. A specimen of *E. dentatus* (Herbst) was collected on the shore of Oahu in 1864, but there are no recent records. The species has a smooth carapace with seven or eight clawlike teeth on the border. Its width is 4 to 5 inches.

A small crab, now known as *Liocarpilodes integerrimus* (Dana), is occasionally seen in shallow water. The thick, convex carapace is not much broader than long, with lateral borders granulate with faint traces of one or two teeth. The surface of the carapace is quite smooth and bears a few scattered hairs. Its unequal chelipeds are roughened by sharp granules. The carapace is less than 5 mm. across.

In the genus *Chlorodopsis* the regions of the carapace are well defined. Its surface is covered with tubercles or spines and sometimes is hairy. The chelipeds and legs are usually armed with spines. Four teeth, in addition to the outer orbital angle, occupy the anterolateral border. Of the species of this genus recorded from Hawaii, *C. aberrans* Rathbun was described from dredged material. The front portion of the carapace and the chelipeds are covered with sharp tubercles. Granules ornament the posterior region of the carapace. The species is about 12 mm. broad. It has apparently not been observed on reefs of the main islands, though it quite likely occurs there.

The species *C. scabricula* (Dana) was taken in Hawaiian waters many years ago, but it has not been seen about the islands recently. The carapace is roughened and granular in the frontal and lateral regions and the upper borders of the unequal chelipeds are covered with sharp tubercles. The species is about 12 mm. broad.

The carapace of the familiar crab, *Chlorodopsis areolata* (Milne Edwards) (fig. 178, f), is divided into numerous convex lobules bearing rounded granules. The hands are spinous and the legs are flattened and very hairy. Large specimens are 1 inch broad. The species is typical of shallow water and is one of the most abundant forms under stones and in the crevices of rocks near shore.

An undetermined species, resembling in some degree *Chlorodopsis melanochira* Borradaile, has been collected in shallow water near Wai-anae, Oahu. The lobules of the carapace are finely granular and covered with a dense coat of short, yellow hairs. The unequal chelipeds and the legs are covered with granules and a coat of hairs, like that of the carapace, and also bear some long yellow hairs. The fingers are toothed and hollow at the tips. In this species the granules are not so spinelike as in *C. melanochira*, and the brown color of the fingers does not extend back on the hand. The largest specimen observed is 10 mm. broad.

Two small crabs called *Chlorodiella nigra* (Forskål), and *Chlorodiella laevissima* (Dana) are very difficult to distinguish from each other, if they are separate species. Some authorities consider those forms in which the carapace is microscopically granulate throughout as *C. nigra*, those *C. laevissima* in which the central region of the carapace is smooth. In each the carapace is flat with little indication of areas. The chelipeds are long and smooth. Specimens range in color from light to dark brown or bluish black. Large specimens are 15 mm. wide (fig. 179, a). These species—if there are two—are among the most abundant shallow-water crabs in Hawaii. They are usually concealed in crevices of rocks.

Species of *Phymodius* are familiar shallow-water forms. The carapace is smooth or granular and divided into numerous lobules by well-defined grooves. Four lobes mark the anterolateral border. The chelipeds are long with broad fingers hollow at the tips, and the upper margins of the legs are spinous or granulose. The most common species is *P. nitidus* (Dana) (fig. 179, b), which is brown and has the palms covered with sharp spinules. Large specimens are 1 inch broad. In *P. unguulatus* (Milne Edwards) the upper border of the palm is covered with low, blunt tubercles. It resembles *P. nitidus* in color but is usually a little larger. (See fig. 179, c.) A species called *P. obscurus* (Lucas) resembles *P. unguulatus* and may be identical with it, but the carapace seems to be more convex and the hands less rough than in that species. A smaller form, *P. laysani* Rathbun (fig. 179, d), was described from Laysan Island but is common throughout the islands. It differs from other species in having

a granular carapace and in having the legs densely fringed with long yellow hairs. An unusually large specimen from Waikiki reef, Oahu, is 18 mm. broad.

The *Tanager* Expedition collected many specimens of *Phymodius* from the leeward Hawaiian Islands and from Wake and Johnston Islands.

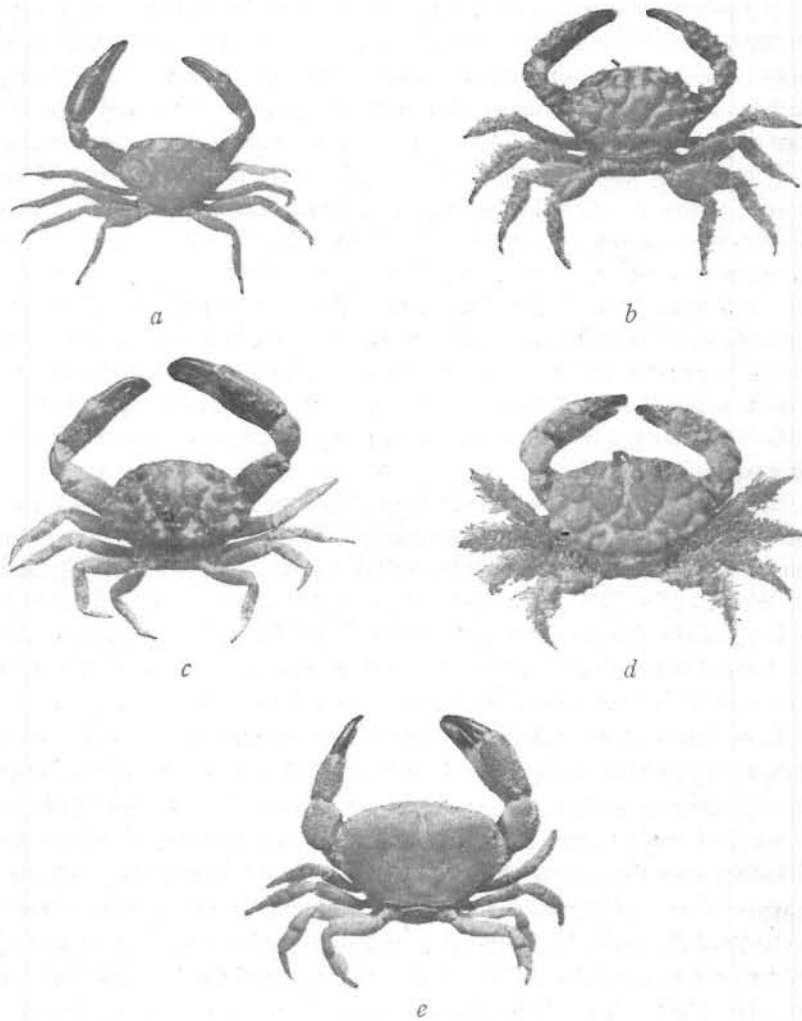


FIGURE 179.—Xanthidae: *a*, *Chlorodiella nigra*; *b*, *Phymodius nitidus*; *c*, *Phymodius unguatus*; *d*, *Phymodius laysani*; *e*, *Pseudozius caystrus*.

The species *P. nitidus* was most abundant in the Hawaiian Islands, *P. unguulatus* at Wake Island, and *P. laysani* at Johnston Island.

In 1864 Mann collected *Lydia annulipes* (Milne Edwards) on Oahu, but so far as is known it has not been recorded from Hawaii since. There are specimens in Bishop Museum from Fanning, Palmyra, Wake, and Marcus Islands. The front portion of the carapace is furrowed and granular, the posterior region smoother. Four low teeth form the front, and five are borne on the anterolateral border. The chelipeds are unequal and smooth except the upper portions of the hands, which have some minute tubercles and ridges. Fingers of the small hand are long and slender, those of the large hand stout. The species slightly exceeds 1 inch in width.

The species *Ozius hawaiiensis* Rathbun was described from Hilo, Hawaii, where it was collected under stones at high-water mark. It is apparently not common or widely distributed about the islands. The transversely oval carapace is roughened in the anterior one third by depressed granules and pits. The front is deflexed, four-lobed; the inner two lobes are larger than the outer ones. Of the four anterolateral teeth, the first is merged with the outer orbital angle. The chelipeds are unequal, at least in the female. The outer surface of the wrist and upper portion of the hand are roughened by pits and ridges. Large specimens slightly exceed 1 inch in width.

In the genus *Pseudozius* the transversely oval carapace is smooth and flat. The chelipeds are large and unequal. Two Hawaiian species occur along the shores under stones between tide lines. In *P. caystrus* (Adams and White) (fig. 179, *e*) the carapace is deflexed and finely granular in the fronto-orbital region but smooth elsewhere. In *P. inornatus* Dana the area behind the orbit is rougher and thicker than in *P. caystrus*. The two species are about the same size, 1 to 1.5 inches in width.

Two closely allied crabs, associated with *Pilumnus oahuensis* in Pearl Harbor, Oahu, are probably undetermined species of *Epixanthus* (fig. 180, *a*). One was described as *Panopeus pacificus* Edmondson and the other was thought to be a member of the genus *Neopanope*. Further consideration has thrown doubt upon these identifications. In each the carapace is crossed transversely by a few broken lines of granules. Of the five teeth of the anterolateral border, including the outer orbital angle, the first two are separated only by a shallow groove and the last is straighter than the others. The chelipeds are unequal, granular, and a shallow, longitudinal groove marks the dorsal border of each palm. In one species, the fingers are rather short and there is a strong basal tooth on the dac-

tylus of the larger hand. In the other species, the fingers are longer and thinner, and there is no basal tooth on the dactylus. Adult specimens of the form with the basal tooth are about 12 mm. broad, of the other form about 20 mm.

A crab seldom seen on the reefs but easily recognized, is *Pilodius flavus* Rathbun (fig. 180, *b*). Some or all of the five anterolateral spines have accessory spinules at their bases, and the margins of the legs are spinous. Long yellow hairs cover the carapace and legs. Large specimens are 15 mm. broad. It has been taken in Pearl Harbor, Oahu, among sponges and ascidians on floats. In this genus the fingers of the chelipeds are broad at the tips instead of sharp as in *Pilumnus*.

A small crab, *Actumnus obesus* Dana, is occasionally seen on the reefs but seems to be more abundant at depths of several fathoms. It has an oval, convex carapace covered with granules and a dense coat of short, yellow hair. Three broad lobes on the anterolateral border are edged with spinules and separated by shallow notches. The chelipeds are stout with thick palms and very short fingers. The width is about 12 mm.

In the genus *Pilumnus* the carapace and legs are covered with a more or less dense coat of hair. Spinelike teeth arm the anterolateral borders, and the fingers are sharply pointed. Few species are seen on the reefs of Hawaii or in shallow water near shore.

The convex, relatively smooth carapace of *Pilumnus oahuensis* Edmondson (fig. 180, *c*) is covered with short and long hairs; some of the short hairs in tufts. Three sharp teeth are borne on the anterolateral border as well as the outer orbital angle, which is not acutely pointed. The chelipeds are unequal. The palm of the larger one is in males quite free from hairs and granules, whereas in females it is more hairy and granular. In both sexes the palms of the smaller chelipeds are densely coated on the outer surface with spinules and hairs. Large specimens are 12 mm. broad. The species lives in Pearl Harbor, Oahu, among sponges, barnacles and tunicates attached to floats, buoys, and piling.

Another species, *Pilumnus planus* Edmondson (fig. 180, *d*), is recognized by the flat carapace, which is thickened and turned down in front and along the anterolateral borders. The declivitous regions are rough, tuberculate, and spinous. Tubercles and stiff hairs cover the outer surface of the chelipeds. The species lives under stones at the edge of the water and is often associated with species of *Pseudozius* (p. 298). It has been taken at Hana and Maalaea bays, Maui, and several localities on Oahu. Large specimens are 24 mm. broad.

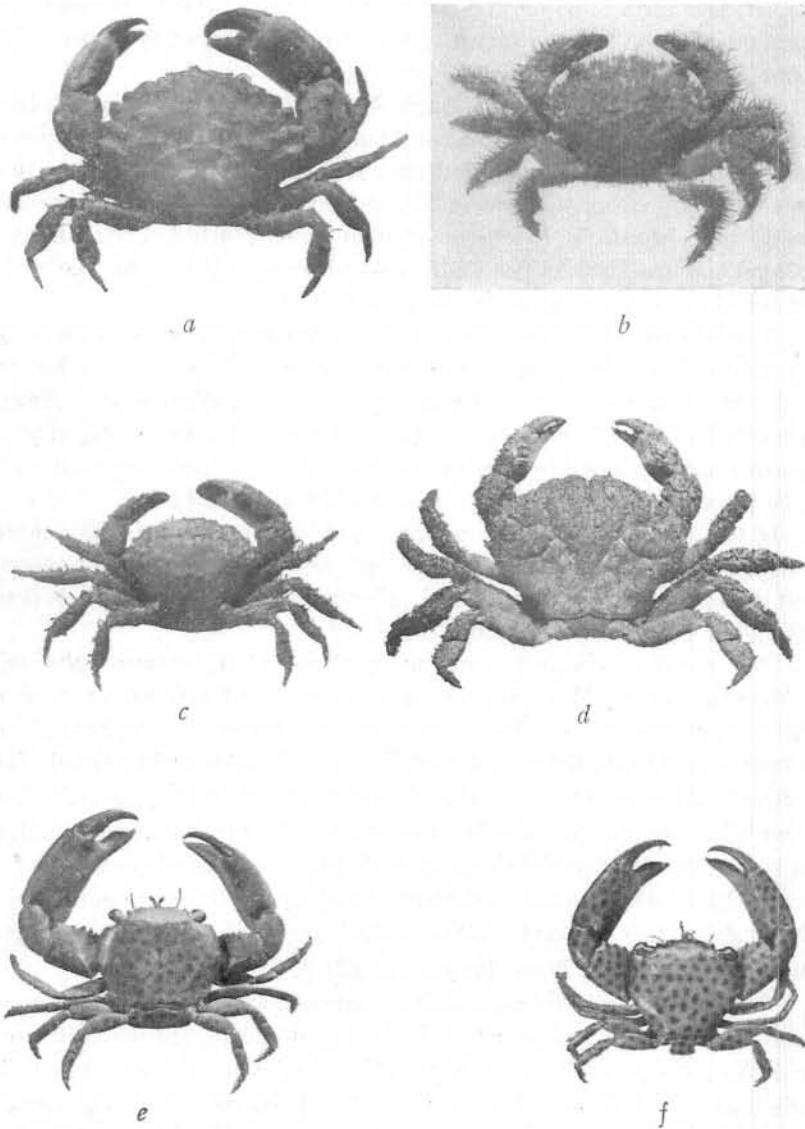


FIGURE 180.—Xanthidae: a, *Epixanthus* species; b, *Pilodius flavus*; c, *Pilumnus oahuensis*; d, *Pilumnus planus*; e, *Trapezia cymodoce intermedia*; f, *Trapezia maculata*.

Two species, *Pilumnus vespertilio* (Fabricius) and *Pilumnus ovalis* (A. Milne Edwards), were recorded from Hawaii many years ago but, so far as is known, have not been observed since. At least four other species of the genus were dredged from moderate depths about the islands by the *Albatross*. Apparently none of these occur on the reefs.

Among crabs associated with living corals on the reefs, the most familiar ones are members of the genus *Trapezia* (*Grapsillus* of some authors). These crabs habitually conceal themselves among the branches of coral colonies of the genus *Pocillopora*. The carapace is slightly convex, smooth and shiny. The color ranges from yellowish to dark brown, with special markings in some species.

The most familiar form is *Trapezia cymodoce intermedia* Miers (fig. 180, e) in which the carapace is covered with faint brown spots and the upper surface of the hands with a network of brown lines. *Trapezia cymodoce ferruginea* Latreille is plain yellowish or reddish brown, and in *Trapezia maculata* (Macleay) (fig. 180, f) the carapace and legs are covered with round red spots. The species *Trapezia rufopunctata* (Herbst) differs from *T. maculata* in having the lower border of the hand serrate or granular instead of smooth. Another species, *Trapezia cymodoce* (Herbst), plain yellowish or reddish brown, has the upper part of the outer surface of the hand covered with a mass of downy hairs. *Trapezia digitalis* (Latreille) is dark brown, almost black. The chelipeds are shorter than in other species. The species of *Trapezia* usually range from 15 to 20 mm. in width of carapace. They are vicious little crabs and some of them are capable of giving a severe pinch with their chelipeds.

Many years ago the species *Trapezia flavopunctata* Eydoux and Souleyet was reported from Hawaii, but apparently it has not been observed recently. It differs from other species in the triangular form of the carapace, the broad front forming the base of the triangle. Large red spots cover the carapace and legs.

Another small crab living among the branches of living corals is *Domecia hispida* Eydoux and Souleyet (fig. 181, a). It has a flat carapace, mottled with yellow and brown, covered with light colored hairs, and armed with short, sharp spines especially on the anterior and lateral margins. The chelipeds also are spinous. It is about 10 mm. broad.

There are two species of small crabs in Hawaiian waters which have the peculiar habit of holding sea anemones in their pincers. One of these, *Polydectus cupulifer* (Latreille), is recognized by the dense coat of long yellow hairs which covers the carapace and legs. The sea anemones are grasped tightly about the middle of the column by the chelipeds of the

crab. They are probably thus carried for defensive purposes, as the actinian is provided with stinging cells which may be feared by enemies of the crab. The sea anemone selected by the crab has been described as *Sagartia pugnax* Verrill. Other species of actinians, however, are readily accepted by the crab after *Sagartia* has been forcibly removed from its claws. Specimens of the sea anemone *Tealiopsis nigrescens*, nearly as large as the crab itself, are grasped and carried about when experimentally substituted for *Sagartia*. In picking up a sea anemone, the crab backs up to it and by the activity of its legs rolls the actinian forward under its body, taking hold of it only when it comes in contact with the chelipeds. Large specimens of *Polydectus* are 1 inch wide. The species is found under stones or in crevices of rocks near shore and also occurs at depths of a few fathoms.



FIGURE 181.—Xanthidae: a, *Domecia hispida*; b, *Lybia tessellata*.

Another species, *Lybia tessellata* (Latreille) (fig. 181, b), also carries sea anemones in its claws. This graceful little crab has a smooth carapace bearing scattered tufts of long hairs and is marked by polygonal color patterns of pink, brown, or yellow. The long, slender legs are ringed with dark purple. It is 15 mm. wide. The species is usually found in porous rocks near shore.

FAMILY PINNOTHERIDAE

Representatives of this family are commensal crabs living in the shells of bivalve mollusks, in worm tubes, in the tunnels of burrowing crustaceans, or associated with sea cucumbers and ascidians. The carapace is rounded or transversely oval and often is soft and membranous. In some forms the walking legs diminish in size from the first to the fourth.

Few species of the family have been reported from Hawaii, probably because of their efficient methods of concealment. One local form,

Aphanodactylus edmondsoni Rathbun (fig. 182), lives in the shelly tube of a large terebellid worm (p. 113). The carapace of the white crab is ovate, smooth, and somewhat membranous. A male and female were found in the same worm tube. The female, which is larger than the male, had a carapace slightly more than 16 mm. broad.

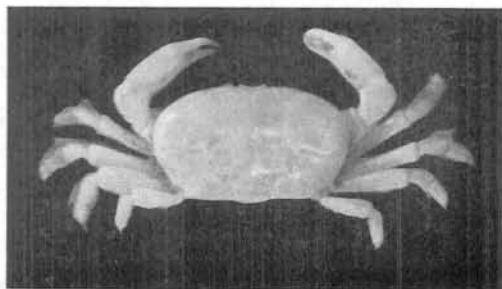


FIGURE 182.—*Aphanodactylus edmondsoni*.

FAMILY GRAPSIDAE

Representatives of this family of crabs are typical of rocky shores, where they may be found during the day under stones in shallow water or between tide marks. Some frequently leave the water and clamber over the rocks, scurrying into places of concealment when disturbed. A few species seem to have taken on terrestrial habits and may be found at considerable distances from the sea shore. Other forms are typically open ocean species, often observed clinging to floating logs or other supports on the surface.

In outline the carapace of grapsids ranges from almost square to nearly circular. It is depressed and flattened in some species but quite thick in others. The chelipeds are usually stout, especially in the male, and in some the fingers are deeply hollowed out.

Key to Subfamilies of Family

- A. Front not divided into lobes or teeth.
 - B. No oblique hairy crest on the ischium of the external maxillipeds.
 - C. Front broad, deflexed; flagellum of antenna short; a rhomboidal gap between the external maxillipeds.....**Grapsinae.**
 - CC. Front broad, not usually deflexed; flagellum of antenna long; no gap between the external maxillipeds.....**Varuninae.**
 - BB. An oblique hairy crest on the ischium of the external maxillipeds.
 -**Sesarminae.**
- AA. Front divided into lobes or teeth.....**Plagusinae.**

SUBFAMILY GRAPSINAE

Key to Genera of Subfamily

- A. Front less than half the total width of carapace; merus of external maxillipeds longer than broad.
 - B. Fingers of chelipeds hollowed out at tip; external maxillipeds with well-developed flagellum **Grapsus.**
 - BB. Fingers not hollowed out at tip; external maxillipeds without flagellum **Geograpsus.**
- AA. Front more than half the total width of carapace; merus of external maxillipeds broader than long.
 - B. Antenna excluded from the orbit..... **Metopograpsus.**
 - BB. Antenna resting in the orbit..... **Pachygrapsus.**

One of the familiar grapsid crabs in Hawaii is the subspecies, *Grapsus grapsus tenuicrustatus* (Herbst) (fig. 183, d). The carapace is about 3 inches across in large specimens, strongly arched on the lateral borders and marked dorsally by oblique and transverse ridges. The front is sharply turned down and the fingers of the stout chelipeds are deeply hollowed out at the tips. Its color is greenish to black with some red about it. The crab is commonly seen clambering about on the rocks near the water's edge. Two smaller species of the genus have been reported from Hawaii but are seldom seen. One, *G. strigosus* (Herbst), has a less deflexed front than *G. tenuicrustatus*, and the spine at the inner angle of the wrist of the cheliped is more slender and straighter than in that species. It is less than 2 inches across. In *G. longitarsus* Dana the carapace is more quadrate than the other species, the front is less deflexed and the merus of the walking legs is very broad but shorter than the propodus and carpus together. Its width is about 1 inch.

In the genus *Geograpsus* the carapace is squarish with the lateral borders nearly parallel. *G. crinipes* (Dana) has the lateral borders slightly divergent behind. The carapace is depressed, red in color and marked dorsally by nearly transverse ridges. It may be 2 inches across. Another species, *G. lividus* (Milne Edwards), was collected in Hawaii by Garrett about 50 years ago but apparently has not been seen locally since.

One of the most common species of the family in Hawaii is *Metopograpsus messor* (Forskål) (fig. 183, b). Transverse lines mark the front region of the carapace, oblique lines the posterolateral areas. The lateral borders converge posteriorly. The chelipeds are unequal, and the upper and lower borders of the palm are roughened by granules

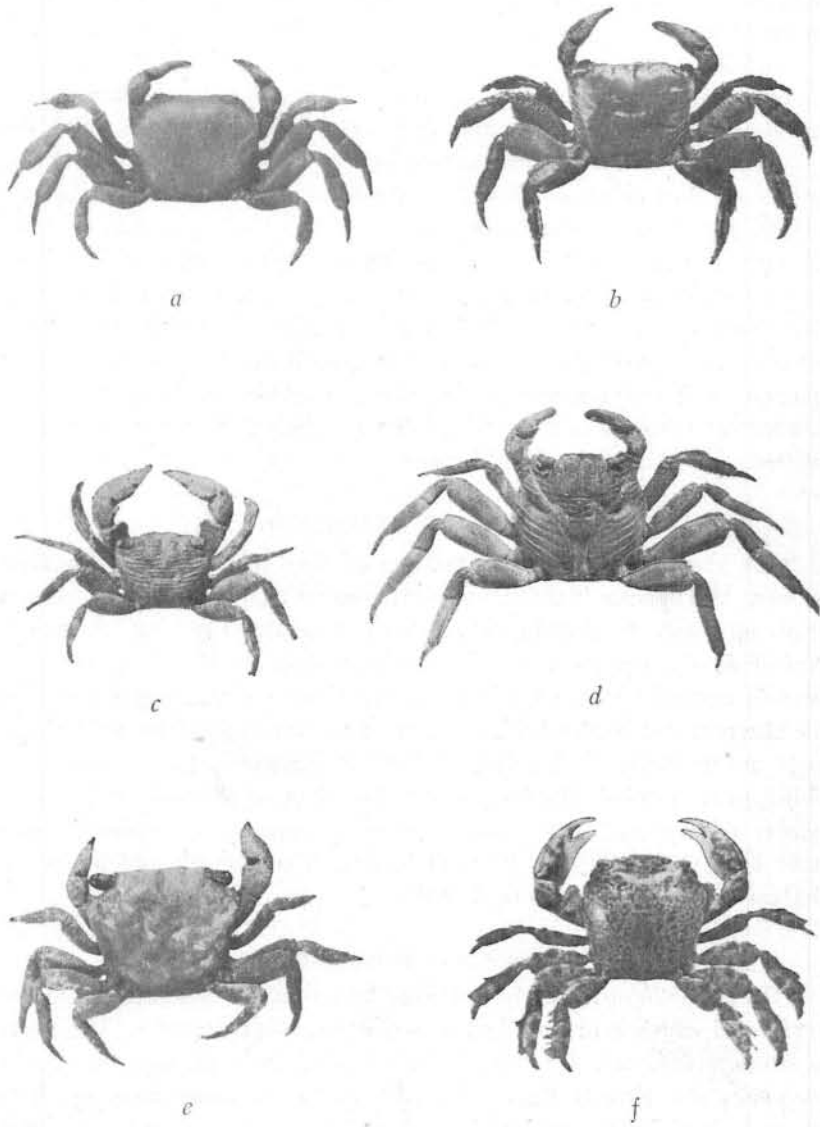


FIGURE 183.—Grapsidae: *a*, *Cyclograpsus henshawi*; *b*, *Metopograpsus messor*; *c*, *Pachygrapsus plicatus*; *d*, *Grapsus grapsus tenuicrustatus*; *e*, *Sesarma obtusifrons*; *f*, *Planes minutus*.

and wrinkles. Large specimens are about 1.5 inches broad. The color ranges from gray to dark green or black. This crab is common under stones on muddy flat reefs near the mouths of rivers. It is quite resistant to brackish water.

A common species living on rocky shores and often temporarily leaving the water is *Pachygrapsus plicatus* (Milne Edwards) (fig. 183, c). The squarish carapace is marked by transverse ridges. The anterior border of each ridge is fringed by a row of short, stiff hairs. Longitudinal lines traverse the outer surface of the palm. The crab is about 20 mm. broad. A smaller species, *Pachygrapsus minutus* A. Milne Edwards, is also found near the water's edge. The carapace is broader than long, strongly convergent behind, and marked by very fine transverse and oblique lines. Its greatest breadth is about 10 mm. Another species, *Pachygrapsus longipes* Rathbun, resembles *P. plicatus* but has a smoother carapace and is without the stiff hairs. The palm is sharply crested. Its breadth is about 8 mm.

SUBFAMILY VARUNINAE

One species only is representative of this subfamily in Hawaiian waters. The species *Planes minutus* (Linnaeus) (fig. 183, f) is a pelagic form supported by floating seaweeds, logs, or other objects. Although typical of the open ocean it occasionally drifts close to shore. The smooth carapace is convex in both directions and there is a notch in the anterolateral border behind the outer orbital angle. The stout chelipeds are smooth. A specimen taken at Hanauma Bay, Oahu, was bluish gray, mottled with brown, and the fringe of hairs on the anterior border of the legs was yellow. Other specimens taken about Oahu have been yellowish, clouded with brown. The breadth and length of the carapace are each about 1 inch.

SUBFAMILY SESARMINAE

The genus *Sesarma* is characterized by a squarish carapace, the under surface of which is marked by a reticulation of fine granules. The front is strongly deflexed. Of the species recorded from Hawaii, *S. (Holo-metopus) obtusifrons* Dana (fig. 183, e) is the most common. The carapace is slightly narrower behind, and its surface is evenly covered with granules. A line curves obliquely inward from the anterolateral border. The front is strongly curved downward. Large specimens are 20 mm. broad.

Two other species of the genus, *S. (Holometopus) trapezium* Dana and *S. (Sesarma) angustifrons* A. Milne Edwards, have been collected in Hawaii but are apparently not common forms. The carapace of the former is quadrate, somewhat narrower behind, and the lateral regions are marked by raised lines. Granules cover the outer and upper surface of the hands and there is a dense hairy spot on the inner movable finger near the base. The breadth of the species is 15 mm. In *S. angustifrons* there are tufts of short hairs on the frontal and lateral regions of the carapace, and the anterolateral border bears a small tooth behind the orbital angle. A strong transverse ridge marks the inner surface of the palm. Long, slender legs also characterize the species. Its width is about 12 mm.

Specimens of *Sesarma (Sesarma) rotundata* Hess were collected on Oahu in 1864 by H. Mann, but the species has not been taken in Hawaii since. The anterior part of the carapace is coarsely granular and the posterior part is marked by irregular, confluent grooves and pits. The chelipeds are equal and the hands are covered on outer and inner surfaces with sharp granules. Large specimens are 1.7 inches broad.

In Hawaiian species of *Cyclograpsus* the front is about half as wide as the entire carapace and is less sharply deflexed than in *Sesarma*. They are to be found under stones at high-water mark. In *C. henshawi* Rathbun (fig. 183, *a*) the carapace is smooth with the lateral borders parallel, granular, and entire. Six small white spots mark the front half of the carapace, one on either side of the gastric area and two on each side farther forward in a transverse line. Large specimens are 20 mm. broad. In *C. granulatus* Dana the anterior half of the carapace is granulated and the lateral borders are somewhat arcuate. The orbit is incomplete below. Of the exposed surface of the outer maxilliped only the crest is hairy. The species is about 10 mm. broad. Although neither of these two species is widely distributed about the islands, they are both found in considerable numbers in certain localities. The larger one, *C. henshawi*, was originally observed near Hilo, Hawaii, and has been collected at Kahana Bay and Kahala, Oahu, and Kalihiwai Bay, Kauai. The type locality of *C. granulatus* is Maui, where it was first collected more than 90 years ago. In 1931 it was abundant on the shore at Makena, Maui.

Another species of the genus *Cyclograpsus*, *C. cinereus* Dana, has been accredited to Hawaii as well as to South America. There are

no recent records of it from Hawaiian shores. It is slightly larger than *C. granulatus* and is further distinguished from that species by having a smooth carapace, a more complete orbit, and a hairy maxilliped.

SUBFAMILY PLAGUSIINAE

Members of two genera represent this subfamily in the Hawaiian reef fauna. Species of *Plagusia* have a subcircular carapace with the anterolateral borders toothed. The antennules fold in deep notches in the front border of the carapace. A subspecies, *P. depressa tuberculata* (Lamarck) (fig. 184, *d*), is associated with other Grapsidae about the shores of Hawaii. Its carapace is covered with flat, pearly tubercles each fringed in front with short, stiff hairs of equal length. Four teeth, including the outer orbital angle, arm the anterolateral border. The teeth decrease in length from the anterior to the posterior one. Large specimens are 2 inches broad. Another species, *P. immaculata* Lamarck, was collected at Honolulu by the *Challenger* Expedition but has not been observed in Hawaii since. It is said to be smaller, more convex, smoother, and more glabrous than *P. depressa tuberculata*. The specimen taken by the *Challenger* was 20 mm. broad.

On the under surface of flat stones in shallow water may be found very flat and exceedingly active little crabs of the genus *Percnon*. The most common one is *P. planissimum* (Herbst) (fig. 184, *a*), which is bright green with lighter stripes and streaks, a prominent one being in the mid-dorsal line. The front of the carapace, anterior border of the walking legs, arm, and wrist of the chelipeds are spinous. In the male the chelipeds are stouter than in the female. Large specimens are 1 inch broad. A slightly smaller species, *P. abbreviatum* (Dana), differs from *P. planissimum* in having a more quadrate carapace. It is commonly more brownish in color. Of the four teeth on the anterolateral border, the second is very small and placed close in front of the third, by which it is overshadowed. The palm is grooved longitudinally on the upper border.

Some early writers credited *Percnon pilimanus* (A. Milne Edwards) to Hawaii, but, so far as is known, the species has not been seen about the islands in recent years.

FAMILY PALICIDAE

Genus Cypripoda

In crabs of this family the carapace is ornamented by granules or tubercles and the last pair of legs is short and filiform. Few species

Cypridina
Cypridina
Cypridina
Cypridina

have been observed in shallow water about the islands. One of them, *Palicus oahuensis* Rathbun, was taken on the reef at Honolulu and also off the south coast of Oahu at a depth of more than 200 fathoms. The carapace is high in the middle and covered with tubercles and granules of unequal size. Of the four teeth, besides the orbital angle, on the

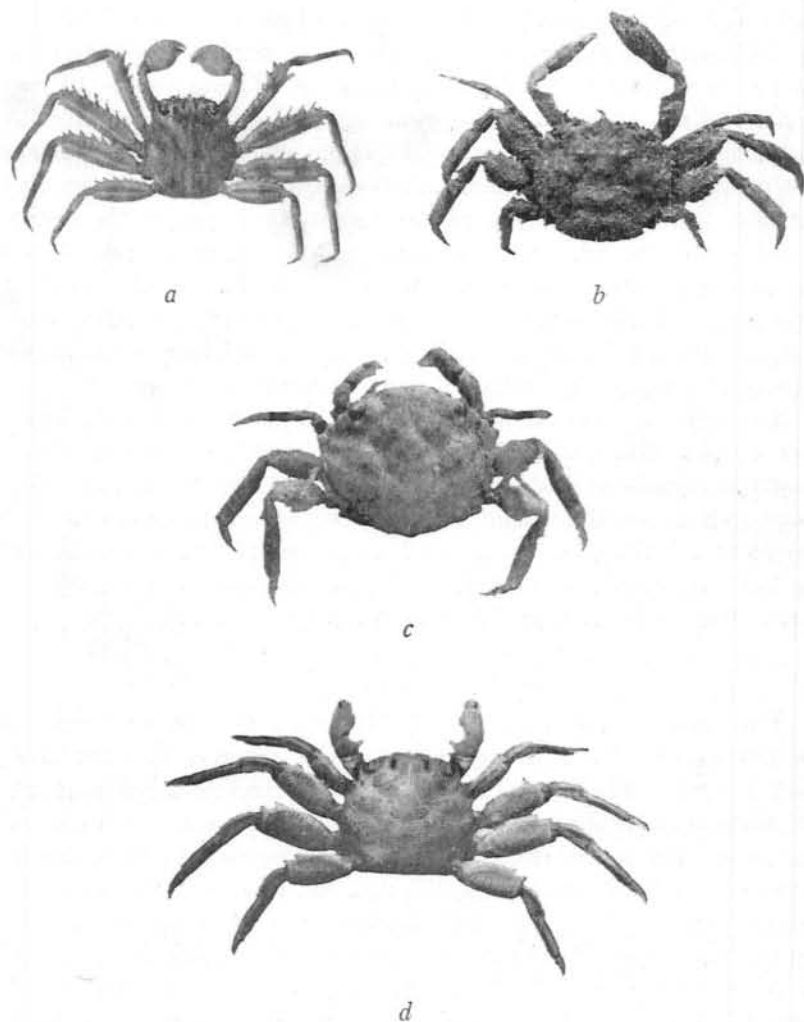


FIGURE 184.—Brachyura: a, *Percnon planissimum*; b, *Manella spinipes*; c, *Palicus maculatus*; d, *Plagusia depressa tuberculata*.

anterolateral border the second and third are large, being about equal, and the last is very small. The species is 12 mm. broad.

Specimens of *Palicus tuberculatus* Edmondson have been collected in shallow water at Kuré (Ocean Island), Molokai, and Waikiki reef, Oahu. Three ridges cross the carapace transversely, and the entire surface, except the grooves, is covered with tubercles of unequal size. Short hairs fill the grooves and are dispersed among the tubercles. Of the four teeth on the anterolateral border the third is the largest and the last is as long as the third but narrower. The species is 12 mm. broad. *Palicus maculatus* Edmondson (fig. 184, c) was taken on Waikiki reef, Oahu. The convex carapace is broken into irregular, inflated lobules, and the whole surface, including the furrows, is covered with granules. Of the four teeth, besides the orbital angle, on the anterolateral border, the third is the largest, being broadly triangular, and the last is included in a short crest posterior to the base of the third. A large oval red spot marks a depression behind each eye, the gastric region is splotched with the same color, and a red band encircles the propodi of the legs. The crab is about 8 mm. broad.

Two other species of the family, *Palicus fisheri* Rathbun and *Manella spinipes* (De Man), were dredged by the *Albatross* at several stations about the islands at moderate depths. *Manella spinipes* has also been taken in Kaneohe Bay, Oahu, in 10 feet of water. In general form it resembles a *Palicus*, but the lateral borders are spinous throughout and the last legs, though smaller than the preceding ones, are like them in form. The species is about 15 mm. broad. (See fig. 184, b).

FAMILY OCYPODIDAE

The most familiar members of this family are the sand crabs of the genus *Ocypode*. In these the carapace is squarish with the lateral borders entire. There is no gap between the external maxillipeds, and the chelipeds in both sexes are unequal. These crabs are sand burrowing forms, and at low tide one may see the openings of their tunnels. Adults are seldom seen during the day, but as dusk approaches they become active, digging out their burrows and throwing the sand up around the openings. The larger burrows extend down into the sand in an irregular course for 1 to 2 feet. These active crustaceans are termed "ghost crabs" because of their grayish color and nocturnal habits.

In the most common species, *Ocypode ceratophthalma* (Pallas) (fig. 185, b), the thick carapace is little broader than long and the lateral

edges are nearly parallel. The whole surface is finely granulate. In old specimens the long eye stalks may reach beyond the cornea of the eye. The chelipeds are stout, unequal, the palm being short and high in the larger appendage. On the inner surface of the palm of the large cheliped is a low, transverse ridge of comblike teeth (stridulating organ) that can be scraped against the ischium resulting in a grating sound. Some investigators believe the rasping note made by the male crab represents a mating call to the opposite sex. Others suggest it may be a warning sound given by the crab indicating to possible intruders that the burrow is occupied, "no trespassing allowed." Large individuals of this species are nearly 2 inches broad.

A less common species, *Ocypode laevis* Dana, is recognized by the great height and smooth appearance of the palm of the large cheliped. The propodi and dactyli of the second and third legs are scabrous and more hairy than corresponding segments of the last two legs. The species is about 1 inch broad.

Fiddler crabs, belonging to the genus *Uca* (*Gelasimus* of some authors), are gregarious in habit. They live in burrows on muddy flats exposed at low tide. They are characterized by a thick, smooth carapace which is broader than long and converges posteriorly. Long eye stalks are protected by grooves. In the male, one cheliped is of enormous size and the other is small, like both chelipeds in the female.

Two species, *Uca minor* (Owen) and *Uca tetragonon* (Herbst), were recorded from Oahu many years ago but, so far as is known, neither has been observed in Hawaii recently. In *U. minor*, which is about one half the size of *U. tetragonon*, the front (between the bases of the eye stalks) is one fifth the breadth of the carapace. In *Uca tetragonon* the front is one tenth the breadth of the carapace, which slightly exceeds 1 inch. The species are mentioned here in anticipation that they may be recognized and again reported from some Hawaiian locality.

In *Macrophthalmus telescopicus* (Owen) (fig. 185, a) the carapace is about twice as broad as long, with a narrow front and three teeth on the anterolateral border. Long, slender eye stalks, extending beyond the lateral borders of the carapace, are protected by broad grooves. The palms of the chelipeds are elongated, granular on the outer surface, hairy on the upper, inner surface, and bear a row of granules on the lower border terminating posteriorly in a sharp spinule. The fingers are thin, curve inward, and are widely separated at the base. The species

is apparently a burrowing form. Numerous dead specimens were collected on the muddy shores of the Middle Loch of Pearl Harbor, Oahu, a few days after a heavy rainfall. They were probably driven from their burrows and drowned by the excessive fresh water. Large specimens are 1.5 inches broad.

Another species, *Macrophthalmus inermis* A. Milne Edwards, was reported from Hawaii by its author, but no other record for this locality is known. The eye stalks do not extend beyond the border of the carapace. There is one small tooth behind the sharp outer orbital angle, and the chelipeds and legs are smooth. The width is about 1 inch.

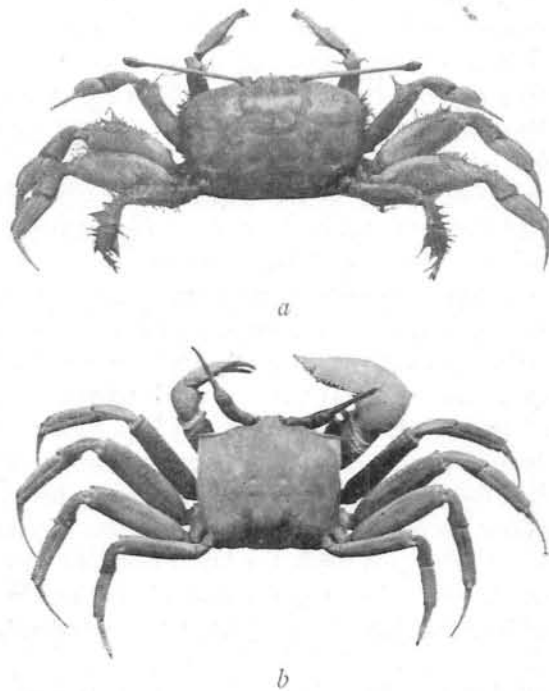


FIGURE 185.—Ocypodidae: *a*, *Macrophthalmus telescopicus*; *b*, *Ocypode ceratophthalma*.

CLASS INSECTA

A number of insects are known to have become adapted to marine environments, some of them inhabiting brackish water near the beaches, others frequenting the intertidal zones, and still others passing their life

cycle submerged in splash pools or shoal water close to shore. One group is specialized for life on the surface of the sea and may range far from shore.

ORDER HEMIPTERA

FAMILY GERRIDAE

The short-bodied water striders representing this family have lost their wings, but they show remarkable specialization in their legs for running and skipping on the surface of the ocean. The body is covered with a dense coat of fine hairs (pubescence) which protects the insect if it becomes submerged. At least 25 species have been described from the oceans of the world, but apparently only two species approach the shores of Hawaii.

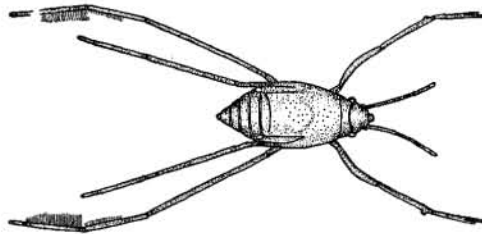


FIGURE 186.—*Halobates sericeus*.

One species, *Halobates sericeus* Eschscholtz (fig. 186), inhabits the Atlantic and Pacific Oceans, including the off-shore waters of Hawaii. Its body is ovate, ashy gray in color with some reddish marks on the posterior margin of the head. Adult specimens are 3 to 4 mm. in length. In Hawaii the species typically lives oceanward of the reefs, but storms often drive specimens ashore where they may be picked up on the beaches.

A recently described species, *Halobates hawaiiensis* Usinger, is typical of the near-shore waters of the islands. It is blue-black in color with fine gray pubescence, and stiff black bristles on the thoracic disk and posterior acetabula. Adults are nearly 5 mm. in length. Both nymphs

and adults frequently swarm the surface of the water at Waikiki within a few yards of the shore.

FAMILY CORIXIDAE

The water boatman, *Arctocorixa blackburni* (White), although usually considered a fresh water insect, may inhabit pools near the sea shore where the water is as salty as the ocean itself. The species is known to exist in sea water for a long time. A specimen was reported swimming and diving in shallow water about 130 feet off shore at Waikiki.

ORDER DIPTERA

Other maritime insects, mostly true flies, have been recognized about local shores. They are typical of saline flats and intertidal zones, or are found submerged in shallow water near shore. All are minute forms, representatives of the carnivorous family Dolichopodidae, species of the heterogeneous family Ephydriidae, at least one example of the biting midges, Ceratopogonidae, and several of the non-biting midges, Chironomidae.

Perhaps the most completely marine forms are non-biting midges, known to be represented locally by two genera, *Telmatogeton* and *Clunio*. In the genus *Clunio* the females are without wings and rest in shallow water or on rocks exposed at low tide. The adult male, about 2 mm. in length, possesses wings and may be seen running about over the wet rocks as the water recedes. The shore at Hanauma Bay, Oahu, is a favorable locality for the observation of some of the marine flies.

The contributions of F. X. Williams have greatly increased the knowledge of maritime insects of Hawaii. His papers should be consulted for detailed information on the species.

CLASS PYCNOGONIDA

This group of peculiar marine arthropods is treated by some authorities as a subdivision of the class Arachnida (spiders, scorpions, ticks). Others give it the rank of a class.

Pycnogonids are spiderlike forms which inhabit the sea from the shore line to great depths. Shallow-water forms may be found on seaweeds, hydroids, bryozoans, sponges and in sediment on the surface of stones. A typical pycnogonid has a short, narrow body with a proboscis, at the

free end of which is the mouth, and a rudimentary abdomen with the anal opening at its extremity. There are usually seven pairs of appendages. The first two pairs are short, the first typically chelate. The third pair (ovigera), if present, is slender and directed ventrally. Then follow four pairs of long, stout walking legs used in locomotion as the animal creeps about. Eyes, when present, are borne on a tubercle on the dorsal surface of the cephalothorax. They usually consist of two or four simple, pigmented areas.

In both sexes the reproductive glands extend into the basal segments of the legs. During the period of incubation the eggs are carried in masses on the ovigerous appendages, usually of the male. These appendages are absent in females of some genera.

Nine species of pycnogonids described from Hawaii have not, so far, been observed elsewhere. One Hawaiian form is a variety of a species known from the Bay of Naples and the California coast. The species,

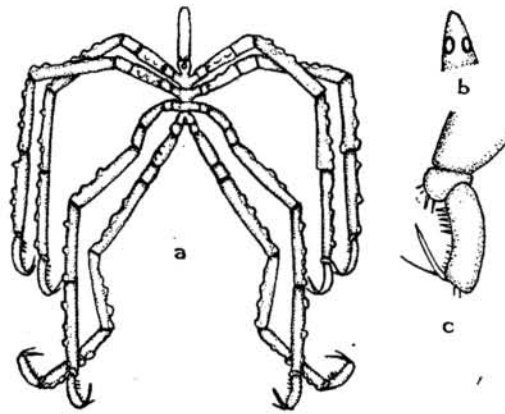


FIGURE 187.—*Endeis (Phoxichilus) nodosa*: a, adult; b, eye tubercle; c, foot (after Hilton).

Endeis (Phoxichilus) nodosa Hilton (fig. 187), apparently the most common Hawaiian form, was collected in large numbers from hydroid colonies in Kaneohe Bay, Oahu. It is characterized by nodules on the walking legs. The larger Hawaiian forms are less than 4 mm. in total body length. For a fuller account of the Hawaiian species Hilton's paper should be consulted. (See bibliography.)

PHYLUM CHORDATA

All animals of higher organization than invertebrates are included in this phylum. Three structural features characterize a chordate; first, a longitudinal supporting axis (notochord), dorsal in position between the digestive tract and the nerve cord; second, a series of branchial clefts (gill slits) perforating the wall of the pharynx; and third, a hollow, central nerve cord dorsal to the notochord.

Although these features indicate fundamental similarities, the chordates show wide diversities of form. Some have not advanced beyond the notochordal stage and retain this supporting tissue throughout life; in others it is present during the larval phase only, disappearing as the adult form is reached. Such primitive chordates are sometimes known as "provertebrates."

In the larger number of chordates, however, the notochord is more or less completely supplanted by a vertebral column composed of cartilaginous or bony segments. By reason of this and other specialized features these higher forms of animals are known as vertebrates.

The groups of provertebrates are few and, though representatives of some of them are common about Hawaiian shores, they are generally unrecognized as such by the casual observer. A few forms are here considered.

Key to Subphyla of Chordata

- A. Anterior end of central nervous axis not terminating in a brain; no skull developed.
 - B. Notochord not extending throughout the length of the body.
 - C. Notochord confined to anterior end of body; wormlike in appearance **Enteropneusta.**
 - CC. Notochord confined to the tail, and usually in larval form only; not wormlike in appearance..... **Tunicata.**
 - BB. Notochord extending the length of the body; fishlike in appearance; fins rudimentary **Cephalochorda.**
- AA. Anterior end of central nervous axis terminating in a brain; a skull developed **Vertebrata.**

SUBPHYLUM ENTEROPNEUSTA

Most known members of this group live in shallow water along shores, where they burrow just beneath the surface of the sand. These have many branchial clefts, though a few which inhabit the deep sea lack branchial clefts or have them reduced to one pair.

In Hawaii a subspecies, *Ptychodera flava laysanica* Spengel (fig. 188, *a*), is common on sand-covered reefs, where it may be found under stones near shore or collected by scooping up the surface sand. It is elongated, wormlike, and yellow. Three regions of the body, proboscis, collar, and long trunk-abdominal portion, are recognized. Posterior to the collar is a series of numerous paired branchial clefts occupying the entire pharyngeal region, which is exposed dorsally by a longitudinal cleft of the body wall resulting in two flaps (genital lobes) in which the sex products are developed. (See fig. 188, *b*.) Behind the pharynx is a series of dark

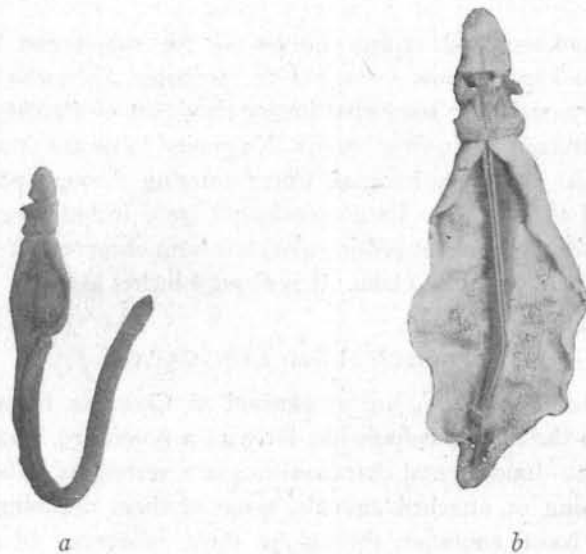


FIGURE 188.—Enteropneusta: *a*, *Ptychodera flava laysanica*; *b*, *Ptychodera flava laysanica* showing proboscis, collar, and branchial region, the genital lobes filled with ova.

brown, paired liver pouches, dorsal in position. These are followed by the abdominal region. The digestive tract extends from the mouth, beneath the front margin of the collar, to the anal opening at the posterior end of the body. That which seems to correspond to the notochord in the animal is a short offshoot of the digestive tract near its front end, extending forward into the proboscis.

The subspecies was described from Laysan Island but is widely distributed throughout Hawaii. Most specimens do not exceed 8 inches in length when fully expanded, but some giant forms have been collected which have a length of 18 inches and a diameter of 1 inch. When stimulated the animal secretes mucus having the characteristic odor of iodoform. The mucus, which is slightly luminous, emits faint flashes of light when the animal or the water surrounding it is agitated in the dark.

Ptychodera must be collected carefully if entire specimens are to be procured, as the soft body is readily ruptured. Regeneration, however, is carried on to such an extent that if the body is severed transversely into several parts each segment will, in course of time, develop into a new animal.

Two undetermined representatives of the subphylum have been observed in local shallow waters. One, probably *Spengelia* species, is white with a proboscis somewhat longer than that of *Ptychodera*. It is much less common than *Ptychodera*. No genital lobes are developed and the branchial clefts are internal, water entering through pores in the dorsal wall of the body. Large specimens are 6 inches long. Another undetermined form, violet-red in color, has been observed far out on the reef platform at Waikiki, Oahu. It is about 4 inches long.

SUBPHYLUM TUNICATA

Tunicates (ascidians) are recognized as Chordata because of the presence in the typical tadpole-like larva of a notochord, a neural tube, and gill slits—fundamental characteristics of a vertebrate. The tunicates are free-living or attached animals, some of them retaining the free-swimming larval condition throughout their existence. In others the larva passes through a retrogressive metamorphosis and becomes a fixed organism with no remaining trace of a notochord or neural tube. The group is represented by simple (solitary) and compound (colonial) forms.

A typical adult simple tunicate is pouchlike and may be sessile or attached by a stalk. The tough outer coat (tunic) has two openings (siphons). The terminal siphon is the mouth through which water and food enter the animal; the other, subterminal, is the atrial opening by means of which water and waste material leave the body. Inclosed by the tunic is the saclike pharynx with its wall perforated by branchial clefts, followed by the tubular portion of the digestive tract which is bent on

itself and leads to the atrial cavity. There is a circulatory system with a reversal flow of blood. A remnant of the nerve cord lies between the siphons. Although tunicates are hermaphroditic the typical method of reproduction in some forms is budding.

As no systematic treatise on Hawaiian tunicates has been published, it is not possible to designate the forms in a specific way. Van Name, however, has placed some of the local species in their generic positions. Simple tunicates are common about the islands, attached to the under surface of stones, to pilings, buoys, the bottoms of boats, and to other supports. A common example, *Microcosmus* sp. (fig. 189) has a tough,

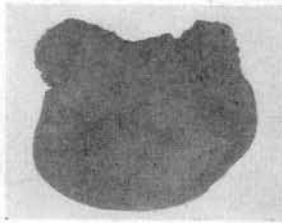


FIGURE 189.—Tunicata: *Microcosmus* species.

thick tunic, smooth or rough, whitish in color. Large specimens exceed 2 inches in height.

Another common form, *Ascidia* species (fig. 190, *a*) with a translucent

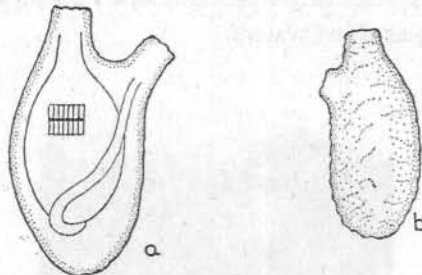


FIGURE 190.—Tunicata: *a*, *Ascidia* species; *b*, *Styela* species.

tunic, often fouls the bottoms of boats in local waters but is also attached to stones and pilings. Specimens 3 or 4 inches long are not unusual. Examples of *Styela* species (fig. 190, *b*) about 1 inch tall with a tough, brown tunic, usually wrinkled, are abundant in Pearl Harbor. It grows in aggregations but does not form colonies.

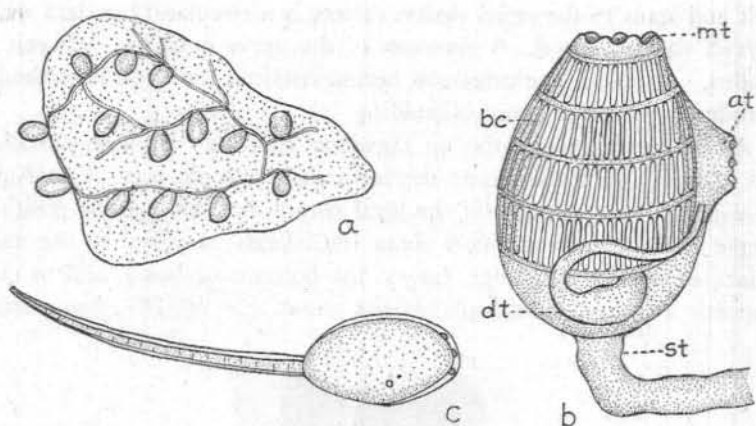


FIGURE 191.—Tunicata: *a*, *Perophora* species, a tiny bulbous tunicate attached by stolons to the under surface of stones; *b*, *Perophora* species showing structural features (*at*, atrial opening; *bc*, branchial clefts; *dt*, digestive tract; *mt*, mouth; *st*, stolon); *c*, larva of a tunicate.

A tiny bulbous tunicate, *Perophora* species (fig. 191), with a transparent coat is to be found on the under sides of stones near shore. The individuals are attached by rootlike stolons which form a network on the surface of the stone. Specimens are about 2.5 mm. in diameter. Numerous undetermined species of simple tunicates, varying in size, form, and color, inhabit the near-shore waters.



FIGURE 192.—Compound tunicates.

Compound tunicates also are familiar animals about Hawaiian shores. They are attached to stones or other supports and consist of spherical, fingerlike or irregular masses in which are embedded small individual tunicates with the siphons opening on the surface. The colonies may be black, yellow, purple, or red in color. Some have a diameter or length of several inches (fig. 192). Among them examples of *Symplegma* sp. have been recognized, but doubtless other genera are represented.

SUBPHYLUM CEPHALOCHORDA

Members of this group are somewhat fishlike in appearance but lack a distinct head and have no lateral fins. A persistent notochord extends the length of the body. A dozen or more species are known throughout the world. Most are typical of sandy beaches where during the day they burrow vertically with the anterior extremity exposed. At night they swim about actively. The term *Amphioxus*, or lancelet, is generally applied to well-known representatives of the group.

No member of the subphylum has been observed on the sandy beaches of Hawaii, although there are many localities about the islands which would seem to be ideal habitats for these primitive chordates. Specimens of an apparently pelagic form, *Amphioxides pelagica* (Gunther), however, were taken by the *Challenger* in 1875 and by the *Albatross* in 1902 a few degrees north of Oahu near the surface of the ocean. The form differs from typical members of the group in lacking tentacle-like processes (cirri) about the oral cavity. Specimens are 2 inches long.

Recent observations show *Amphioxides* to be widely distributed. It has been suggested that *Amphioxus* may have two types of larvae, one developing about sandy shores and another representing *Amphioxides*, having a prolonged pelagic life with a much later metamorphosis.

Careful observations of sand-covered reefs and flat beaches of Hawaii may yet reveal the presence of a lancelet-like form.

SUBPHYLUM VERTEBRATA

Key to Classes of Subphylum here Considered

- A. Skeleton cartilaginous; gill clefts not covered by an operculum; skin provided with placoid scales.....**Elasmobranchii.**
- AA. Skeleton more or less completely ossified; gill clefts usually covered by a well-developed operculum; skin usually provided with scales or bony plates, but scales never placoid.....**Pisces.**

CLASS ELASMOBRANCHII (SHARKS AND RAYS)

The elasmobranchs comprise a very old and successful group, the sharks especially having roamed the seas since early geologic times, prevailing by force and aggressiveness. Representatives of the group still present many primitive features in their morphology and anatomy. The slender, elongated body of the shark is indicative of an alert, predaceous type; the broad, flat form of the ray is adapted for more sluggish, bottom-feeding habits. The shark is characterized by the lateral position of the gill clefts; whereas in the ray, greatly broadened by an expansion of the pectoral fins, the gill clefts are on the ventral surface.

Although more than a dozen species of sharks and at least five species of rays have been reported from the Hawaiian area, they are not typical of near-shore waters. Of those recorded locally, some were taken from considerable depths and others were obtained through the fish markets.

The natural bathing beaches of Hawaii, usually located within protective reefs, are reputedly free of danger from roaming sharks. No doubt, however, they often approach shores unprotected by reefs, as they are known to enter local bays and harbors. Although many species probably are harmless, it is wise, if swimming beyond the reefs or in open water, to keep in mind the potential danger of sharks.

Since elasmobranchs are not likely to be seen on the shoal reefs, they are not treated systematically in this work. A monograph on the group should be consulted for details of species reported from Hawaiian waters.

CLASS PISCES (TRUE FISHES)

Among islands bordered by coral reefs the student of ichthyology finds delight and satisfaction in the many types of highly adapted fishes, unique in form and gorgeous in color. Not only are Hawaiian fishes attractive by reason of their odd shapes and rainbow tints, but almost every known species of fish in local waters is utilized as food in some manner.

To the student of reef and shore fishes in Hawaii, many favorable opportunities present themselves. On the shallow reefs are natural aquaria, where one may study fishes in their native haunts among rugged coral heads at low tide. A good exhibition of some of the most interesting reef forms usually is found in the public aquarium in Honolulu. Here close views of the fishes are possible and their movements and habits can be observed. When fishing boats are active, a remarkable display of both

reef and off-shore species is seen in the fish markets. Bishop Museum has a collection of preserved specimens available for study, and also a large series of casts of Hawaiian fishes in natural colors.

In Jordan and Evermann's monograph on Hawaiian shore fishes, 441 species are listed, including those taken from deep water and the open sea. Fowler, in a later work on the fishes of Oceania, has increased the number of known Hawaiian species, from all sources, to about 500. A useful handbook on Hawaiian fishes has been compiled by Spencer Tinker. These publications should be consulted by every student of Hawaiian fishes.

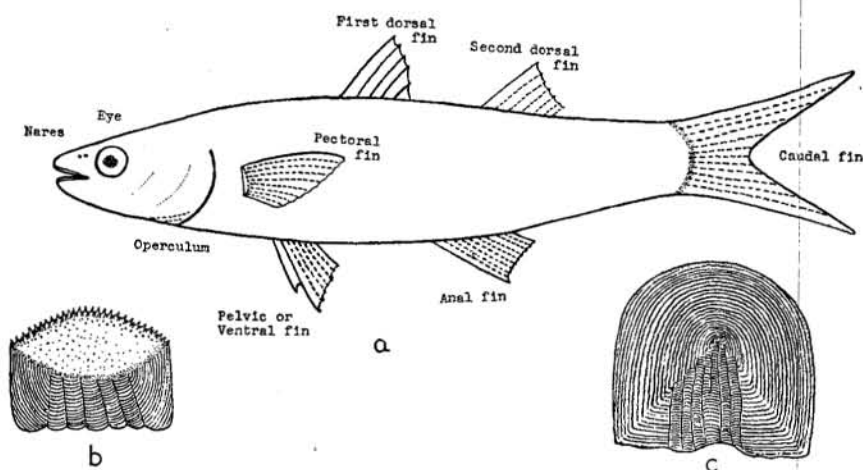


FIGURE 193.—Some features of a typical fish: *a*, position of fins and other structures; *b*, ctenoid scale from a demoselle; *c*, cycloid scale from mullet.

The following systematic treatment is an attempt to acquaint the reader with a few of the more common forms of fishes of the reefs and near-shore areas. Omitted are those groups which, for the most part, comprise typical off-shore species and those groups of which few representatives have been taken.

Fowler's monograph has been followed for the arrangement of families and for nomenclature. The figures are my drawings or photographs of preserved specimens or casts in Bishop Museum. Refer to figure 193 for the general external features of a typical fish and diagrams of two types of scales characteristic of true fishes. The 41 families here considered are included under one subclass.

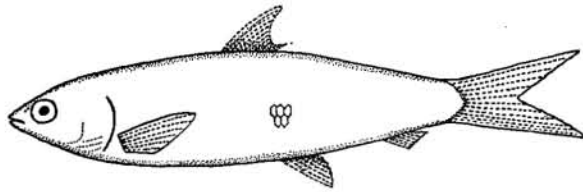


FIGURE 194.—*Chanos chanos*, milk fish (*awa*).

SUBCLASS TELEOSTOMI

FAMILY CHANIDAE (MILK FISH)

A silvery-white fish, *Chanos chanos* (Forskål), is often seen on the reefs or near shore with schools of mullet. It is elongate, compressed, with a single dorsal fin and the pelvic fins almost opposite, near the middle of the body (fig. 194). Very large specimens are about 2 feet in length, but most specimens taken are much smaller. It is considered an excellent food fish. The native name of the milk fish is *awa*.

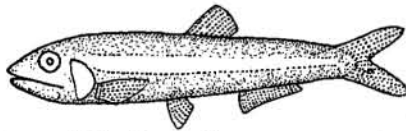


FIGURE 195.—*Engraulis purpureus*, anchovy.

FAMILY ENGRAULIDAE (ANCHOVIES)

The anchovy, *Engraulis purpureus* (Fowler) locally known as *nehu*, runs in large schools along the shores or on the reefs. It is an elongated fish with a large mouth, and marked on the side by a longitudinal, silver band about the width of the eye (fig. 195). Large specimens may slightly exceed 3 inches in length. Quantities of the *nehu* are used by fishermen as bait.

FAMILY CONGRIDAE

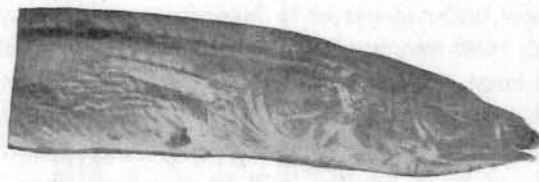
Eels are elongated, slender fishes with reduced scales or with none, without pelvic fins, and without spines in the fins. The gill openings are very small. Eels are numerous on Hawaiian reefs, and about 30 species have been recorded from local waters. During the day they

find concealment under stones or in holes in coral blocks. It is unwise to extend one's hand into crevices in the rocks or to place a hand under the edge of a large stone. Small eels can do little damage to a person but some of the morays 4 or 5 feet long are capable of inflicting a severe wound. Local species are included in several families but only a few, representatives of three families, will be mentioned here.

Conger eels are scaleless forms with well-developed pectoral fins. The colors are plain, usually gray or brown above, paler below. During development, a curious metamorphosis takes place. A young conger eel is transparent and bandlike in form with a very small head. Some larval forms have been described under distinct generic terms. Adult conger eels of Hawaii are included in the genus *Conger*. The distinct species are very much alike in appearance but differ in the form of the jaws and in the dentition. In *C. bowersi* (Jenkins) the jaws are equal in length (fig. 196, a). The color is pale brown above, lighter below. Its length is about 1 foot. In *C. cinereus* Rüppell the snout projects beyond the lower jaw. The teeth are subequal and somewhat truncate. Its length may exceed 3 feet. A larger species, *C. wilsoni* (Schneider), has the lower jaw only slightly shorter than the upper. The teeth are compressed and rounded at the ends. It is dark brown in color above, lighter below. Some specimens are 4 to 5 feet in length. Usually, conger eels may be seen in the Honolulu Aquarium.

FAMILY OPHICHTHYIDAE

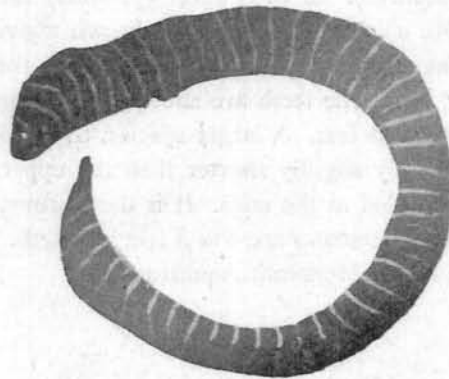
Snake eels are not common about the Hawaiian Islands, but are occasionally taken near shore. They are small, scaleless forms with sharp snouts. The anterior opening of the nares terminates a lobelike projection on the upper lip. Some species have no traces of fins. The species most likely to be seen locally is *Leiuranus semicinctus* (Lay and Bennett) (fig. 196, b), which has minute pectoral, dorsal, and anal fins. There is no caudal fin, the tail terminating in a conical point. The color is whitish with 24 to 27 brown patches saddled across the dorsal border. Toward the tail the patches encircle the body. A specimen about 15 inches long was taken at night on the surface of the water off Kewalo, Oahu.



a



b



c

FIGURE 196.—a, *Conger bowersi*, anterior extremity, conger eel; b, *Leiuranus semicinctus*, anterior extremity, snake eel; c, *Echidna zebra*, moray.

FAMILY ECHIDNIDAE

The morays are scaleless eels without pectoral fins. The gill openings are small round apertures. In this family are to be found some of the largest and most pugnacious eels of the reefs. At least 18 species, included in five genera, have been recorded locally. Most of them have distinctive color patterns by which they may be recognized. A whitish species, *Echidna nebulosa* (Ahl), is marked by irregular brown patches which are dotted with yellow spots. There are gray and brown bars

between the patches, and the tip of the snout is orange color. Its length is about 2 feet. *Echidna polyzona* (Richardson) is whitish with numerous vertical dark bands, and is 2 to 3 feet long. In *Echidna zebra* (Shaw) the reddish-brown body is encircled by numerous white rings (fig. 196, c), some of which are interrupted or branched. Its length is between 2 and 3 feet.

Most of the eels of this family to be found on the local reefs are included in the genus *Lycodontis*. Some of them are very large and pugnacious. In *L. picta* (Ahl) the general color is light olive, spotted and mottled with black posteriorly, paler below. It sometimes exceeds 5 feet in length. Another large species, *L. meleagris* (Shaw and Nodder), is brown in color, marked by large rounded black spots between which are smaller white spots (fig. 197, a). Large specimens are about 4 feet long. The general color of *L. petelli* (Bleeker) is purplish brown with numerous darker cross bands, some of which encircle the body

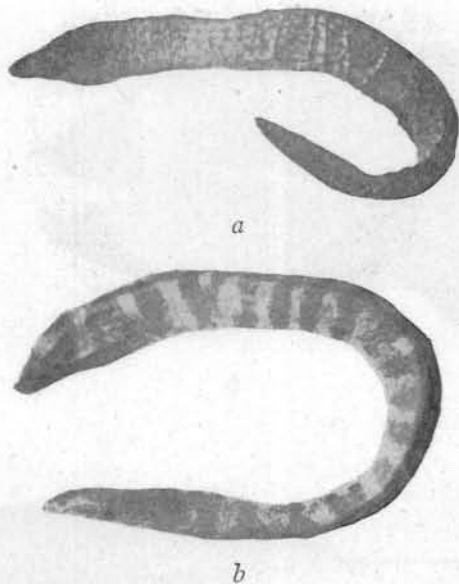


FIGURE 197.—a, *Lycodontis meleagris*, moray; b, *Lycodontis petelli*, moray.

(fig. 197, b). The edge of the dorsal fin is black and white alternately. Its length is about 3 feet. Perhaps the most abundant species is *L. undulata* (Lacépède), which is dark brown in color covered with white reticulations. Its length is about 3 feet.

FAMILY SYNODONTIDAE (LIZARD FISH)

Elongate cylindrical fishes with scaly heads and large mouths suggest the resemblance to lizards. The second dorsal fin is a small lobe far back on the body. They are alert, carnivorous fishes, their jaws provided with numerous needle-like teeth.

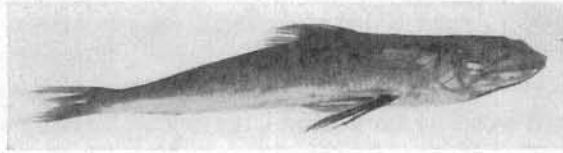
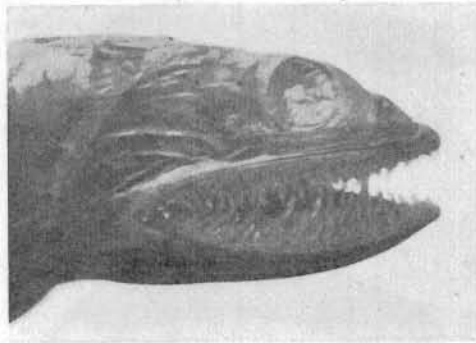
*a**b**c*

FIGURE 198.—*a*, *Synodus japonicus*, lizard fish; *b*, *Saurida gracilis*, head showing teeth; *c*, *Hemiramphus brasiliensis*, anterior extremity.

In *Trachinocephalus myops* (Schneider) the head is blunt, depressed. It is pale gray, silvery below, with a series of dull yellow cross bars on the sides. Its length is about 8 inches. In *Synodus japonicus* (Houttuyn) the head is pointed (fig. 198, *a*). Some specimens are greenish, some reddish, all with transverse bands across the body. Length about 10 inches. In *Saurida gracilis* (Quoy and Gaimard) the head is elongate, depressed, broad in front of the eyes (fig. 198, *b*). The color is brownish above, white below, with black blotches on the sides. The length is about 6 inches.

FAMILY HEMIRAMPHIDAE (HALF-BEAKS)

Half-beaks are elongate, slender fishes with a long lower jaw, and a very short upper one. Pelvic fins are inserted far back on the body. These fishes are not typical reef forms, although young specimens are occasionally seen near shore. The species most likely to appear locally is *Hemiramphus brasiliensis* (Linnaeus) (fig. 198, *c*). It is greenish brown on the back, silvery on the sides and below, with a dark longitudinal line from the gill opening to the caudal fin. Large specimens are about 18 inches long. *Me'eme'e* is the native name.

FAMILY PLEURONECTIDAE (FLOUNDERS AND SOLES)

Fishes of this family show a curious structural change in the course of development. When small they swim vertically, like ordinary fishes; later they begin to rest at the bottom on one side, while the bones of the head become distorted and one eye passes around coming to rest on the upper side. Thereafter one side becomes the lower surface and is normally free of pigment, and the other side becomes the upper surface with both eyes directed upward. The pigmented upper surface may present remarkable changes of color depending upon the background on which the fish is resting. While swimming in graceful undulating movements they are readily seen, but when they come to rest on the sand they become almost invisible, usually only the eyes being detected. The common local species, *Platophrys pantherinus* (Rüppell) is usually less than 8 inches long (fig. 199, *a*). The native name is *paki'i*.

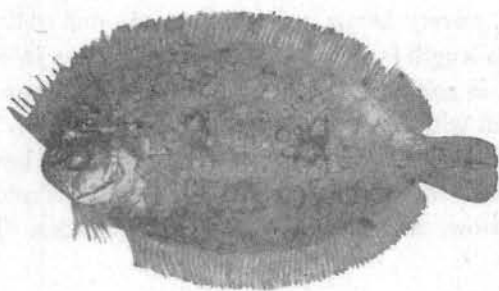
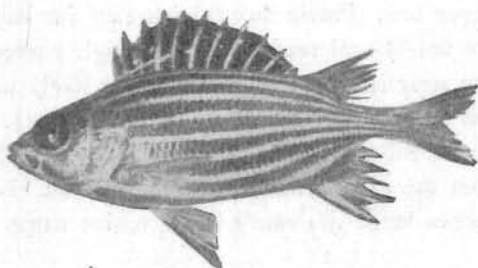
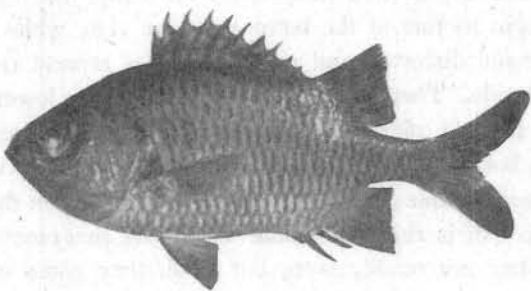
*a**b**c*

FIGURE 199.—*a*, *Platophrys pantherinus*, sole; *b*, *Holocentrus diadema*, squirrel fish; *c*, *Myripristis murdjan*, squirrel fish.

FAMILY HOLOCENTRIDAE (SQUIRREL FISH)

This family includes small to medium-sized fishes familiar about coral reefs. The scales are rough or spiny, and the colors are usually some shade of red. Their eyes are large, indicating nocturnal habits. Observations made on the fishes in the Honolulu Aquarium during the night reveal that the squirrel fishes are actively swimming about all night long. The name "squirrel fishes" is applied to these forms because they make a noise like the bark of a squirrel when they are taken out of water.

Fifteen or more species of the family are known in local waters. Most of them belong to the genus *Holocentrus*, which is characterized by a strong spine on the lower border of the operculum, or to the genus *Myripristis* which lacks such a spine. Only a few species will be mentioned here. In *Holocentrus diadema* Lacépède (native name, *ala'ihī kalaloa*) the color is dark red with the sides marked with 11 longitudinal white lines (fig. 199, *b*). It may exceed 6 inches in length. In *H. lacteoguttatus* Cuvier the color is rosy red with a silvery tint. Length about 1 foot.

Of the genus *Myripristis*, *M. murdjan* (Forskål), known locally as 'u'u, is a red species with a pale center in each scale (fig. 199, *c*). A black bar crosses the operculum diagonally. It is about 1 foot long. In *M. multiradiatus* Günther the color is rosy red, paler below. The reddish brown edge of the operculum extends as a bar down to and including the base of the pectoral fin. Its length ranges up to about 8 inches. In *Holotrachys lima* (Valenciennes) there is no spine on the operculum. The lower lip protrudes beyond the upper one. The color is red, with the edges of the scales darker. It is about 8 inches long.

Many of the squirrel fishes are food fishes and are seen in the fish markets.

FAMILY SYNGNATHIDAE (PIPE FISH AND SEA HORSES)

Pipe fish and sea horses are mostly small forms with the body covered by bony plates. They lack pelvic fins and are not strong swimmers. Pipe fish are elongated, slender forms with a long snout. The head of the sea horse is bent at an angle with the body which terminates in a prehensile tail. In swimming, the sea horse maintains a vertical position, and at rest it normally clings by its tail to sea weeds or other supports. In both groups of fishes the male carries the eggs in a ventral pouch during incubation.

Few species of the family are known in Hawaiian waters, and pipe fish are not likely to be found on the reefs. One specimen of *Doryrhamphus melanopleura* (Bleeker) was taken by the *Albatross* off Honolulu in 18 fathoms of water. Sea horses, however, are occasionally seen in shallow water, and may be found among sea weeds. The local form is *Hippocampus kuda* Bleeker (fig. 200), which reaches a length of about 4 inches.



FIGURE 200.—*Hippocampus kuda*, sea horse.

FAMILY AULOSTOMIDAE (TRUMPET FISH)

These fish are elongated forms with long snouts which terminate in a small mouth with a barbel at the symphysis of the lower jaw. They are not typical reef fishes, but occur in off-shore waters. The species occasionally taken about the islands is *Aulostomus chinensis* (Linnaeus) (native name, *nunu*). It is characterized by a long caudal peduncle. The posterior dorsal and anal fins are similar and opposite in position. It varies greatly in color and may reach a length of 2 or 3 feet.

FAMILY FISTULARIIDAE

A slender, long-snouted fish occasionally seen near shore is the cornet fish, *Fistularia petimba* Lacépède (fig. 201). The body is scaleless and

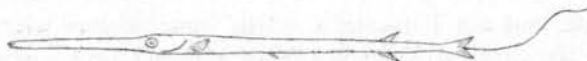


FIGURE 201.—*Fistularia petimba*, cornet fish.

more flexible than the pipe fish, and a long filament is developed from the caudal fin. Adults may reach a length of several feet. Young specimens a few inches long have been taken on Waikiki reef, but the fish is typical of more open water.

FAMILY MUGILIDAE (MULLETS)

The mullet is an oblong, somewhat compressed, rather blunt-headed fish that has, for a very long time, served as a common food fish in Hawaii. The body is covered with cycloid scales. There are two dorsal fins. The second dorsal and anal fins are concave, and the caudal fin is deeply notched. The dentation is weak, adults being largely vegetarian in habits. Two species of the family, which closely resemble each other, occur in local waters. *Mugil cephalus* Linnaeus (native name, 'ama'ama) is a common fish of the shore waters, appearing in schools on the reefs, and also thrives in fish ponds connected with the sea. It is bluish gray in color becoming white below. Large specimens are about 1 foot in length. (See fig. 202.) Another species, *Neomyxus*

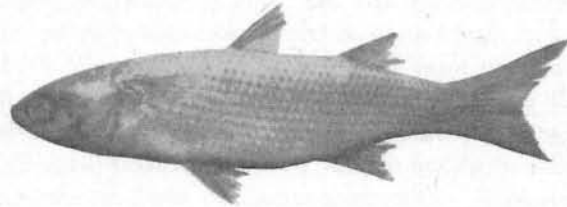


FIGURE 202.—*Mugil cephalus*, mullet ('ama'ama).

chaptalii (Eydoux and Souleyet) closely resembles *Mugil cephalus* but has a slightly more pointed head. The color of preserved specimens is dull olivaceous above, somewhat silvery, becoming white below. The tip of the head, or snout, is brown. The lower lobe of the forked tail is the longer and heavier, whereas in *Mugil cephalus* the upper lobe is the longer. Specimens exceeding 12 inches in length are known.

FAMILY SPHYRAENIDAE (BARRACUDAS)

Barracudas have elongated bodies with long pointed heads, the lower jaw projecting beyond the upper one. The teeth are very sharp, unequal in size in both jaws. Two short dorsal fins are widely separated, the anterior one over the ventrals, the posterior one over the anal fin.

A small species, *Sphyraena japonica* (Cuvier) (fig. 203), frequents the near-shore waters and is often found in mullet ponds where it is destructive of the mullet. Large specimens are about 2 feet long. The large barracuda, *S. barracuda* (Walbaum), which may exceed 6 feet in length is a ferocious fish typical of off-shore waters and the open sea.

Like the shark, it is a potential danger to swimmers who go beyond the reef.



FIGURE 203.—*Sphyraena japonica*, barracuda.

FAMILY POLYNEMIDAE (THREADFINS)

The threadfin fish is oblong, compressed, covered with large ctenoid scales. The head is scaly and the snout is broad and blunt. They are typical of sandy shores and estuaries, sometimes entering the mouths of rivers. A common local species, *Polydactylus sexfilis* (Valenciennes), known locally as *moi*, is grayish in color with silvery tints (fig. 204). It may be recognized by the pectoral fin, which is low on the side, and by its ventral portion which consists of a number of long filaments suggesting the name "threadfin." The young are silvery white in color. Adults attain a length of about 1 foot.

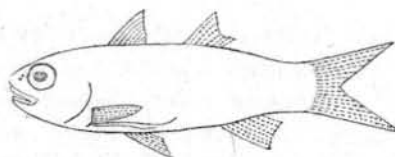


FIGURE 204.—*Polydactylus sexfilis*, threadfin (*moi*).

FAMILY CARANGIDAE (POMPANOS)

This family includes a large number of excellent food fishes, most of which are silvery colored. They resemble mackerels in general appearance but may be recognized by the presence of two spines in front of the anal fin and a series of bony plates along the posterior part of the lateral line. Some of the species run in schools and may approach the shore, but most of them are typical of the open ocean or waters beyond the reef. Among the well-known Hawaiian species are the *ulua*, *opelu*, *akule*, and the *ulua kihikihi* or threadfin, so called because of long filaments on the fins like those on the moorish idol (*kihikihi*). At least 25 species of the family, including representatives of the genera *Caranx*, *Selar*, *Caran-*

goides, *Blepharis*, *Decapterus*, and others, are sold in the local fish markets. The species are separated chiefly by characters of the dentition and the fins.

The *ulua*, which is one of the most important food fishes of the islands, is often fished for by hook and line from rocky shores. The name *ulua* has been applied to more than one species, *Caranx ignobilis* (Forskål) and *Caranx sexfasciatus* Quoy and Gaimard, and different Hawaiian names are applied to the same species depending upon age or size of the fish. For an analysis of this large family a monograph on fishes should be consulted.

FAMILY CHEILODIPTERIDAE (CARDINAL FISH)

Cardinal fish are small, scarlet or coppery forms, some marked with longitudinal stripes, others with black spots or bands. Most of the species belong to the genus *Amia* and are elongate, compressed fishes with large eyes and mouths. The scales are large, ctenoid. A common species is *Amia frenata* (Valenciennes), which is pale red with a dark longitudinal band about the middle of the body (fig. 205). Specimens reach nearly 6

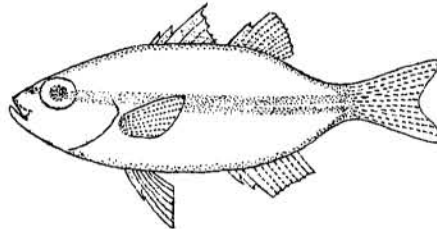


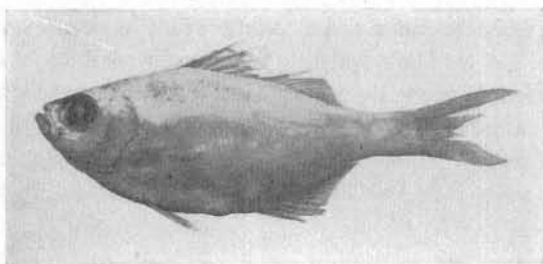
FIGURE 205.—*Amia frenata*, cardinal fish.

inches in length. Young specimens have often been taken from the body cavity of a large jelly fish in Pearl Harbor where they seem to live as commensals. Species of other genera, *Synagrops*, *Hymnodus*, and *Ariomma* have rarely been taken in Hawaiian waters.

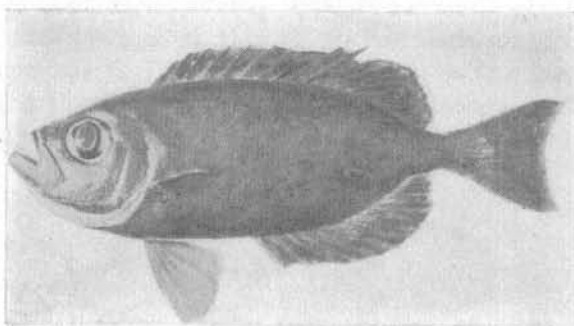
FAMILY KUHLIIDAE

The most familiar species of the family known locally is *Kuhlia marginata* (Cuvier), known as *aholehole* (fig. 206, *a*). It is elongated, compressed, with a short, oblique mouth, and reaches a length of 10 inches. The single dorsal fin is deeply divided. Its color is light brown on the back, silvery below. The species, which is adapted to brackish water and frequents the mouths of streams, is a good food fish. Two other species,

Kuhlia rupestris (Lacépède) and *K. sandvicensis* (Steindachner), are not so well known in Hawaiian waters.



a



b

FIGURE 206.—a, *Kuhlia marginata*, *aholehole*; b, *Priacanthus cruentatus*, *catalufa*.

FAMILY PRIACANTHIDAE (CATALUFAS)

The brightly colored catalufas are represented by a few species in Hawaii. They have elongate-oval, compressed bodies, large eyes, and very oblique mouths. The scales are small and rough, and the long dorsal fin is entire. They are red or blotched with red. A common species, known in Hawaii as *'āweoweo*, is *Priacanthus cruentatus* (Lacépède) (fig. 206, b), which is mottled with red and white on body and fins. Length about 1 foot. There are past records of immense schools of the young of this species, known as "red fish", entering Hawaiian harbors. Another species, *P. hamrur* (Forskål) is light olive, mottled with red. The fins are without spots. The young usually show no red color. Adults may exceed 1 foot in length.

FAMILY LUTJANIDAE (SNAPPERS)

Members of this family are important food fishes. They are active, carnivorous forms inhabiting the outer reefs or the open sea, where some run in large schools on the surface. Some species exceed 3 feet in length. The bodies of snappers are oblong, of moderate depth, covered (including the side of the head) with ctenoid scales. The mouth is low in position and only slightly oblique. The dorsal fin is continuous, deeply notched or subdivided. Colors among the species vary greatly, shades of gray, blue, brown, and red prevailing. The principal market fishes of this family include the *opaka*, *Pristipomoides sieboldii* (Bleeker), which is reddish olive above with violet shades, paler below; and the *uku*, *Aprion virescens* Valenciennes, which can be recognized by the very short pectoral and entire dorsal fins, and by its bluish-gray color, lighter below. Other familiar fishes are the rosy-red species of *Etelis*, *E. marshi* (Jenkins) with the caudal fin evenly notched, and *E. carbunculus* Cuvier which has the upper lobe of the caudal fin very long. Both species are known as 'ula'ula. Members of this family usually can be seen in the fish markets.

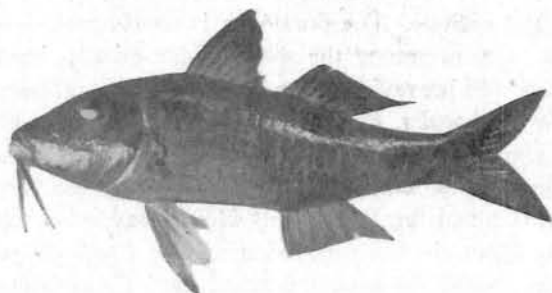
FAMILY MULLIDAE (SUR-MULLETS)

Red mullets or sur-mullets, also known as goat fishes, may be recognized by a pair of strong chin barbels, and two dorsal fins. The colors usually are brilliant. The fishes are also characteristic in their movements. They swim close to the bottom stirring up the sand with the barbels, which are held below and in front of them. The dentition of these fishes is weak, their food consisting of organic material stirred up by the barbels.

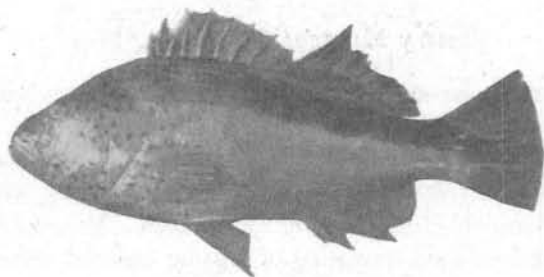
One species, *Mulloidés auriflamma* (Forskål) (native name, *weke 'ula*), varies in color but often is rosy red on the back, paler below, with a narrow yellow band from eye to caudal fin. It may reach 1 foot in length. In *M. samoensis* Günther (fig. 207, a) the body is greenish olive with a broad yellow stripe from eye to caudal fin. It is about 1 foot in length. This species is known locally as *weke 'a'a*. Another common species, *Upeneus multifasciatus* (Quoy and Gaimard), is transversely banded with alternating shades of bright and dark red. The pelvic, anal, and second dorsal fins are black. The length is nearly 1 foot. The native name is *moano*. Several other species of this genus are more or less common locally.

FAMILY CIRRHITIDAE

This family consists mostly of small, brilliantly marked fishes, often with distinctive blotches of color on the body and head. They are characterized by strong spines in the fins. Several species of the genus *Paracirrhites* are found locally. In *P. forsteri* (Schneider) there are deep red spots on the head and front part of the body (fig. 207, *b*). In *P. arcatus*



a



b

FIGURE 207.—*a*, *Mulloides samoensis*, sur-mullet; *b*, *Paracirrhites forsteri*.

(Cuvier) the color is pale red without spots, and in *P. cinctus* (Günther) there are four or five transverse red bands on the body and pearly and olive spots on the head. These species, called *pilikoa*, are up to about 6 inches in length. Other genera, *Cirrhitoidea* and *Cirrhitus* are represented locally. Species of *Cirrhitoidea* have pointed snouts. In *Cirrhitus pinnulatus* (Schneider) the body is marked by brownish and white blotches and the head by alternating longitudinal bands of the same tints. It is about 10 inches in length.

FAMILY CHAETODONTIDAE (BUTTERFLY FISH)

The chaetodons, among the most conspicuous of the reef fishes, are remarkable for their form and color. They are strongly compressed, short, and deep. The soft parts of the fins are covered with scales. The small mouth bears brushlike teeth. All are carnivorous, feeding on small

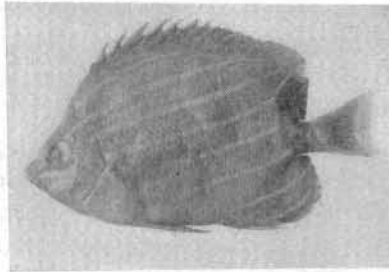
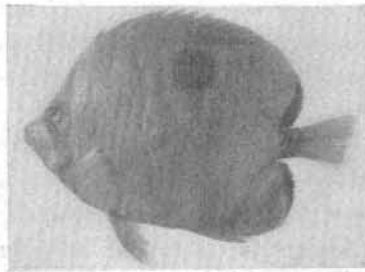
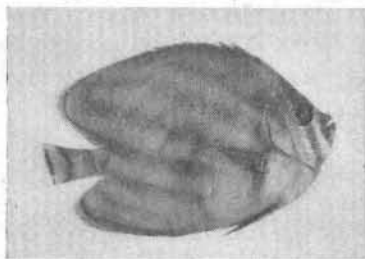
*a**b**c*

FIGURE 208.—*a*, *Chaetodon fremblii*, chaetodon (butterfly fish); *b*, *Chaetodon unimaculatus*, chaetodon (butterfly fish); *c*, *Chaetodon ornatissimus*, chaetodon (butterfly fish).

organisms found on and about coral colonies. Few of the species are much over 6 inches in length. There are more than a dozen common species of the genus *Chaetodon* found on the reefs. All have a short snout, lack spines on the operculum, and have a continuous dorsal fin without filaments. Many of them are marked by a black band through the eye. Only a few species will be mentioned here.

In *C. fremblii* Bennett (fig. 208, *a*) the body is ornamented by oblique stripes of blue, ascending posteriorly. There is no ocular band, but a black patch is saddled across the back above the eye; and there is a black spot at the base of the tail. In *C. miliaris* Quoy and Gaimard the sides are marked by vertical rows of blue spots. There is a vertical band of black through the eye. The general color of *C. unimaculatus* Bloch (fig. 208, *b*) is golden in the upper portion, grayish below. The broad ocular band meets the opposite one on the ventral surface, and there is a large black spot on the side. In *C. quadrimaculatus* Gray the upper part of the body is black with two white spots, the remainder of the body yellowish. There is an ocular band. Living specimens of *C. ornatissimus* (Cuvier) are whitish, marked on the side by 7 orange-brown bands. There are several vertical black stripes on the head, the broadest one through the eye. (See fig. 208, *c*.)

The genus *Holacanthus* is characterized by a strong spine and serrations on the operculum. Several species are found on local reefs. In *H. arcuatus* Gray the ground color is pale or whitish with a broad, dark band extending from the eye to the caudal fin. The anterior portion of the body of *H. bicolor* (Bloch) is white, sharply contrasted with the black posterior portion (fig. 209, *a*). A dark band is saddled across the back from eye to eye. The species *Forcipiger longirostris* (Broussonet) has a long protruding snout, is yellowish orange, and has a black patch on the upper part of the head. The lower front portion of the body and lower beak are white. (See fig. 209, *b*.)

FAMILY ZANCLIDAE (MOORISH IDOL)

The family is represented by a single species, *Zanclus canescens* Linnaeus, which is one of the most attractive of local reef fishes (fig. 209, *c*). The body is greatly compressed and very deep. A small mouth terminates the protruding snout. The anal fin is drawn out into a point and the dorsal one into a long filament. Three broad black bands cross the body vertically. The anterior and broader band includes the eye and the pectoral

and pelvic fins, the second band parallels the posterior border of the fish and extends into both anal and dorsal fins, and the third band crosses the caudal fin. Specimens may exceed seven inches in length, not including the dorsal filament. The Hawaiian name is *kihikihī*.

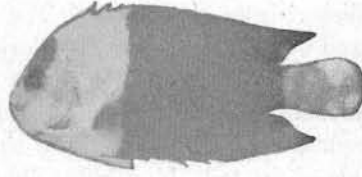
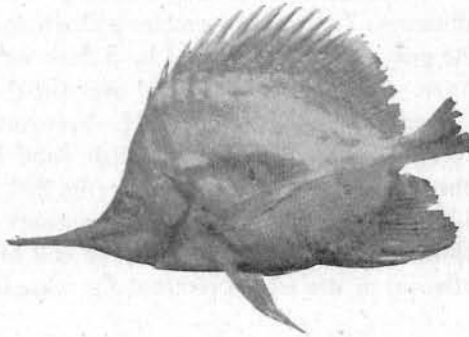
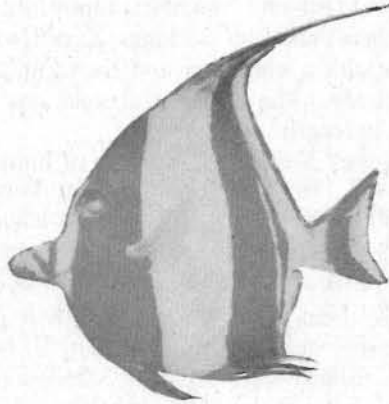
*a**b**c*

FIGURE 209.—*a*, *Holacanthus bicolor*, butterfly fish; *b*, *Forcipiger longirostris*, butterfly fish; *c*, *Zanclus canescens*, Moorish idol.

FAMILY HEPATIDAE (SURGEON FISH)

Fishes of this large group, many common on the reefs, are designated as surgeon fish because of the spines or knifelike plates on either side of the base of the tail. These structures serve as efficient weapons when the tail is suddenly flipped from side to side. The fishes have compressed, deep bodies, covered with small scales. The dorsal and anal fins are long and continuous. The colors are usually shades of brown, olive, or red, often with special markings. In the genus *Hepatus*, of which about a dozen species frequent local reefs, there is a single, movable, lancetlike spine on either side of the tail. *H. achilles* Shaw (native name, *paku'iku'i*) is black, marked by a diamond-shaped orange spot, which encloses the caudal spine. Specimens are nearly 1 foot long. The very common *H. triostegus* (Linnaeus) (*manini*) resembles a chaetodon in appearance (fig. 210, *a*). The grayish body is crossed by 5 dark vertical bands, the first through the eye. A dark spot is saddled over the dorsal side of the caudal pedicle. Length about 6 inches. *H. leucopareius* (Jenkins) (*maikoiko*) is recognized by a vertical whitish band behind the eye extending from the dorsal fin to the operculum (fig. 210, *b*). Length up to about 8 inches. In *H. olivaceus* (Schneider) (*naenae*) there is a broad band of color, whitish or orange, from the upper end of the operculum straight back to the tip of the folded pectoral fin. Specimens are about 10 inches long.

In another genus, also with a single spine on each side of the tail, is *Zebрасoma flavescens* (Bennett) (*laipala*), uniformly yellow with a protruding snout. It is less than 4 inches long. *Z. veliferum* (Bloch) (*kikihi*) is almost black with a white face and six additional whitish vertical bands crossing the body. The dorsal and anal fins are very high. It reaches about 1 foot in length.

In fishes of the genus *Naso* there is a pair of immovable sharp plates on each side of the tail. In some species a bony horn projects forward between the eyes. The development of both the horn and plates apparently progresses with age. In *Naso unicornis* (Forskål) (*kala*) the adult develops a horn (fig. 210, *c*). The color varies; it is often gray or olive, the dorsal fin usually blue. Specimens more than 20 inches long are known. Another species which develops a horn, *N. brevirostris* (Valenciennes) (*kala lolo*), usually shows spots or splashes of color. It is about 15 inches long. In *N. hexacanthus* (Bleeker) the color is usually grayish brown. No horn is developed. Specimens over 2 feet long are known. Members of this genus are taken in traps at the outer edge of the reefs but seldom are seen near shore.

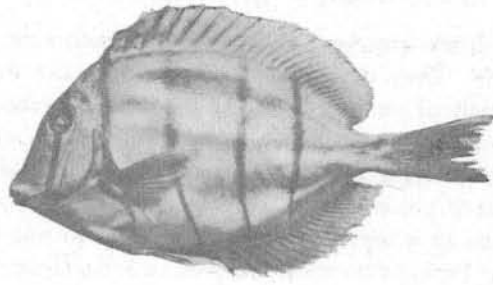
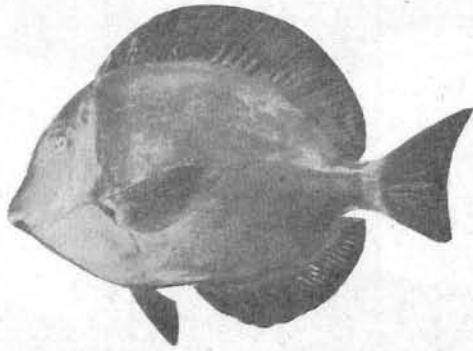
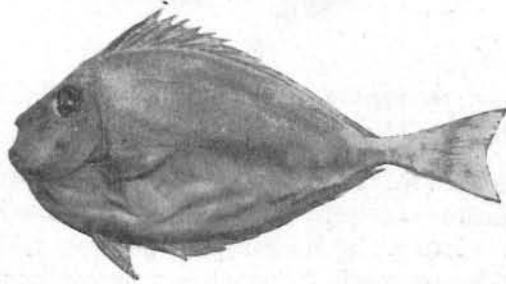
*a**b**c*

FIGURE 210.—*a*, *Hepatus triostegus*, surgeon fish (*manini*); *b*, *Hepatus leucopareius*, surgeon fish; *c*, *Naso unicornis*, young surgeon fish.

FAMILY SCORPAENIDAE (SCORPION FISH)

Scorpion fish are grotesque in appearance, with enlarged, distorted, and spiny heads. They are mottled or blotched with many colors, or provided with dermal processes making them inconspicuous as they rest on the bottom among stones. The pectoral fins are large and fanlike, with the under surface brightly colored. Strong spines of the dorsal fins of some species have poison sacs at the base. Many species included in numerous genera have been recognized in Hawaiian waters, but few are seen near shore. Perhaps the most common is *Sebastapistes albobrunneus*

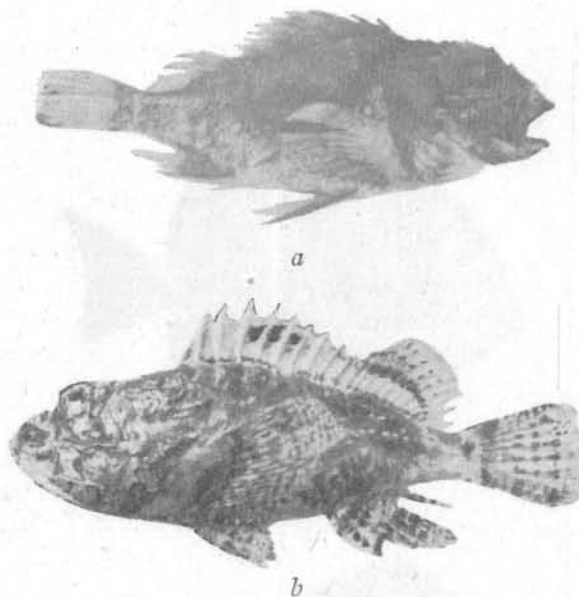


FIGURE 211.—*a*, *Sebastapistes albobrunneus*, scorpion fish; *b*, *Scorpaenopsis cacopsis*, scorpion fish.

(Günther) (fig. 211, *a*). It is light olive, mottled with dark brown and covered with small brown spots. The tip of the caudal fin is red. Length is up to about 4 inches. In *Scorpaenopsis gibbosus* (Schneider) (the *nohu*) the head is very rough, the mouth large and oblique, and the back arched. It is mottled in coloration. The pectoral fins have a large black spot at the base on the under side, with orange and yellow completing the marking. Specimens 8 inches long may be seen on the reefs. A larger species, *Scorpaenopsis cacopsis* Jenkins (fig. 211, *b*), is reddish brown,

blotched with darker and lighter shades of similar color. There are spines on the side and upper surface of the head. Specimens may exceed 1 foot in length. Species of the genera *Taenianotus*, *Pterois*, and *Dendrochirus* have also been taken locally. In the *Pterois* and *Dendrochirus* the pectoral fins are very long.

FAMILY CARACANTHIDAE

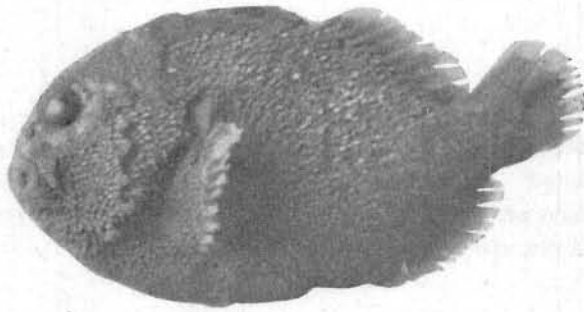
In this family are included small fishes with compressed, scaleless bodies, covered with minute papillae. The fins are small and weak. A common local species, *Caracanthus maculatus* (Gray), is often found among coral heads. It is reddish brown in color and covered with minute fleshy papillae and dotted with red spots. The dorsal fin is deeply notched. Specimens are about 2 inches long. (See fig. 212, a.)

FAMILY POMACENTRIDAE (DEMOSELLES)

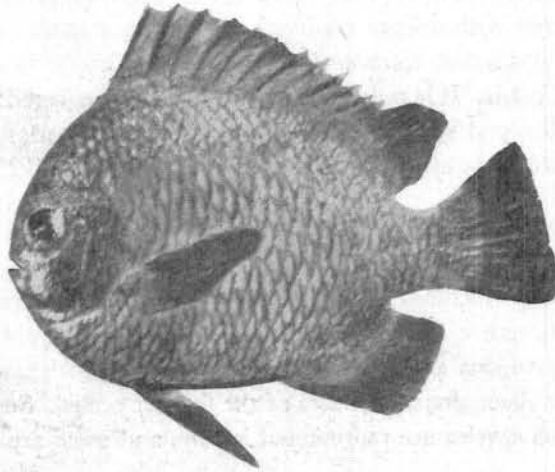
This family includes small fishes with deep, compressed bodies covered with rather large ctenoid scales. In general appearance they resemble chaetodons and some have color markings suggestive of that group. As in chaetodons, the bases of the fins are scaled. Several genera and numerous species are represented locally, and some are common on coral reefs.

In *Dascyllus trimaculatus* (Rüppell) (fig. 212, b) the general color is whitish, the scales having black borders except in the middle of the dorsal area where there is a white blotch. Fins are bluish black. Specimens are 4 or 5 inches long. Specimens of *Pomacentrus inornatus* De Vis are dark drab in color with an olive tint and have blackish fins. This fish is up to 6 inches in length.

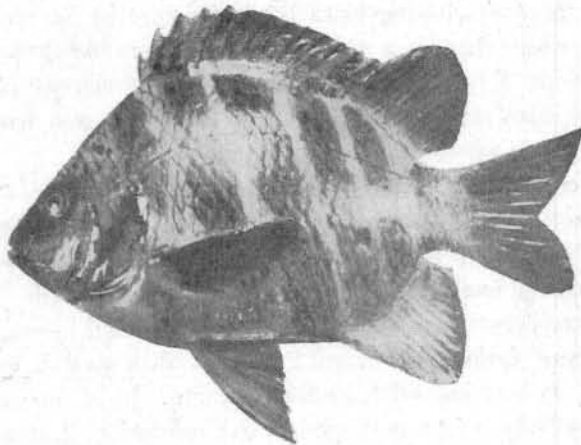
Fishes of the genus *Abudefduf* are usually brightly colored. In *A. abdominalis* (Quoy and Gaimard) (the *ma'oma'o*) the green color is marked by 5 bluish-black vertical bars, the last represented by spots on the dorsal and anal fins. It may reach 9 inches in length. The brown color of *A. sordidus* (Forskål) (fig. 212, c) is marked by six incomplete vertical bars of darker brown, and there is a black spot on the peduncle of the tail. It may exceed 8 inches in length. In *A. melas* (Cuvier) (*kupipi*) the body is of a uniform blackish coloration. Large specimens may slightly exceed 6 inches in length.



a



b



c

FIGURE 212.—a, *Caracanthus maculatus*; b, *Dascyllus trimaculatus*, demoselle;
c, *Abudefduf sordidus*, demoselle.

FAMILY LABRIDAE (WRASSE FISH)

Wrasse fish comprise a very large group of Hawaiian forms, being represented by more than 20 genera, and are typical of coral reefs. Their bodies are oblong in shape and are covered with cycloid scales. In many, the head is somewhat pointed; in some, drawn out into a tubelike snout. They are carnivorous in habits, having strong dentition. Apparently, some wrasses are long-lived, specimens having survived for many years in the Honolulu Aquarium, where they are among the most attractive fishes.

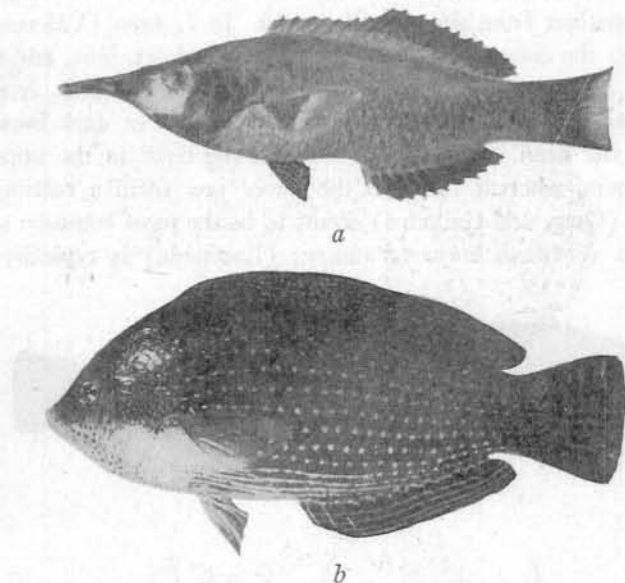


FIGURE 213.—*a*, *Gomphosus tricolor*, wrasse fish; *b*, *Anampses cuvier*, wrasse fish.

A bluish-green species, *Gomphosus tricolor* Quoy and Gaimard (*hinalea 'i'iwi*), is a familiar reef fish having a long snout (fig. 213, *a*). It attracts attention in the aquarium, because of its odd shape and nocturnal habits. As darkness approaches, it ceases swimming and finds a resting place among the rocks, often lying in grotesque positions where it remains throughout the night. This species, may reach a length of 10 or 12 inches. In *Thalassoma duperrey* (Quoy and Gaimard) (*hinalea lauwiki*) the color varies greatly. Green may predominate with a broad vertical band of orange or brown behind the head. Specimens may exceed

10 inches in length. Another distinctively colored species is *Anampses cuvier* Quoy and Gaimard ('*opule*') which is brownish with a round white spot on each scale (fig. 213, *b*). It is nearly 1 foot long.

Other genera including more or less common species are *Cheilio*, *Iniistius*, *Stethojulis*, and *Novaculichthys*. *Cheilio inermis* (Forskål) (*kupou pou*) is a slender, elongated fish with a projecting snout (fig. 214, *a*). Its color varies, but it is usually greenish or yellowish with shades and tints of other colors. Many specimens have a dark spot on the side at the tip of the pectoral fin. Its length may reach 18 inches. It is a common market fish. In the genus *Iniistius* the first two dorsal spines are distinct from the rest of the fin. In *I. pavo* (Valenciennes) (fig. 214, *b*) the color usually is greenish with violet, blue, and orange tints about the head and fins. It exceeds 1 foot in length. A smaller species, *I. niger* (Steindachner), is uniformly black or dark brown. In *Stethojulis* the head is without scales, and the teeth in the upper jaw are very short, whereas those in the lower jaw form a cutting edge. *S. axillaris* (Quoy and Gaimard) seems to be the most common species. The species, *Novaculichthys taeniourus* (Lacépède) is typically olive-

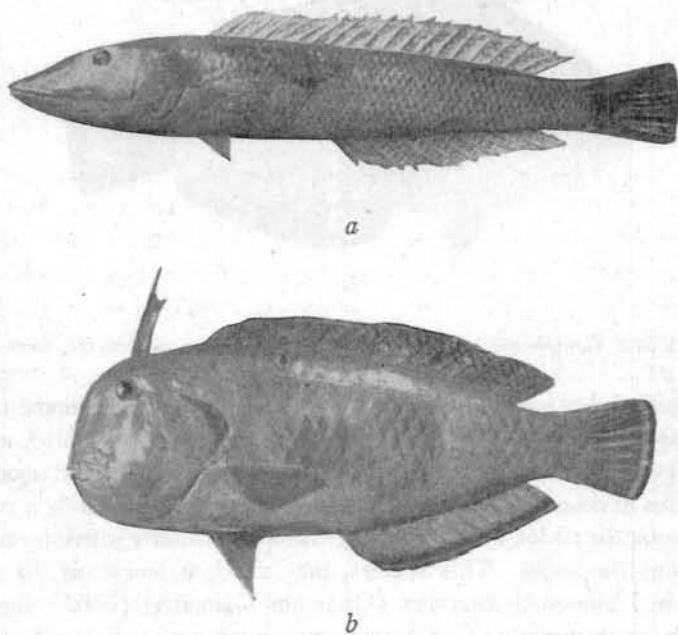


FIGURE 214.—*a*, *Cheilio inermis*, wrasse fish; *b*, *Iniistius pavo*, wrasse fish.

brown in color, each scale having a white edge. Usually four olive bands radiate from the eye, and two golden spots mark the membrane of the dorsal fin toward its anterior extremity. Other spots cover the dorsal, the anal, and the tip of the caudal fins. Specimens are about 10 inches long.

FAMILY CALLYODONTIDAE (PARROT FISH)

Parrot fish have rather short, compressed, but deep bodies covered with large cycloid scales. The dorsal fin is large and entire. The dentition varies, in some the teeth being fused. Colors also vary greatly, but shades of brown, blue, and green are common. Parrot fish are attractive in the aquarium but are not highly regarded as food, for the flesh is rather soft.

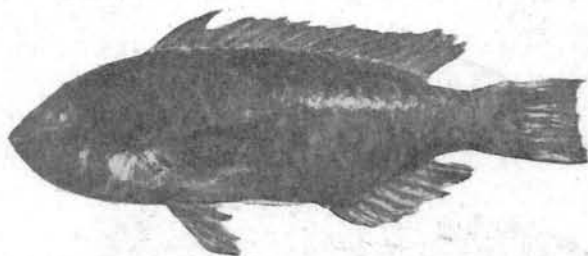


FIGURE 215.—*Callyodon forsteri*, parrot fish.

At least 15 species of the family have been recorded from local waters, mostly of two genera, *Leptoscarus* and *Callyodon*. Species are distinguished from each other chiefly by the dentition and coloration. Only a few species will be mentioned. Of the genus *Leptoscarus*, *L. viridescens* (Rüppell), known locally as *panuhunuhu*, is fairly common. The front teeth are imbricated, incisor-like, and the color of the fish is mottled gray and brown. It may exceed 8 inches in length. In *L. vaigiensis* (Quoy and Gaimard) the front teeth are imbricated in three series above and in four or five series in the lower jaw. The general color is blue with a pink vertical line on each scale. Specimens 20 inches long are known.

The genus *Callyodon* includes about a dozen local species. In these the teeth are fused into dental plates. In *C. ahula* (Jenkins) (native name, *panuhunuhu*) the color is dull red, lighter ventrally. Specimens 19 inches long are known. *C. brunneus* (Jenkins) is gray, mottled with brown. There are some red and blue markings but none of the colors

is bright. It is about 9 inches long. In *C. forsteri* (Valenciennes) the color is greenish or bluish purple with lines of green and blue on the head. The length is about 14 inches. (See fig. 215.)

FAMILY ELEOTRIDAE

In this family are small fishes, some of which inhabit reefs and shore waters whereas others are adapted to fresh water streams. Few species are known in Hawaii. A species not uncommon on some local reefs, *Eviota epiphanes* Jenkins (fig. 216, a), is less than 1 inch long. It is bluish in color, with brown spots. The sides of the head are without scales, and there are no spines on the preoperculum. Another species, *Asterropterix semipunctatus* Rüppell, is uniformly dark brown, sometimes marked by small bluish spots or dusky vertical bars (fig. 216, b).

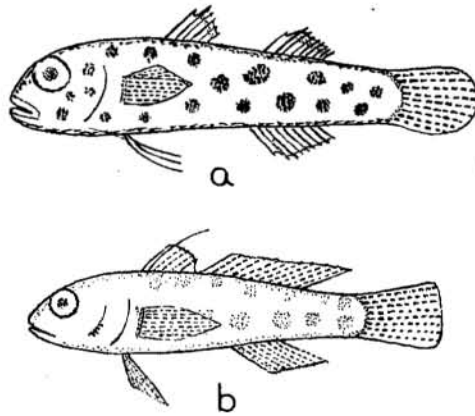


FIGURE 216.—a, *Eviota epiphanes*; b, *Asterropterix semipunctatus*.

The sides of the head are scaly and the preoperculum bears 4 or 5 small spines. The second spine of the first dorsal fin is produced into a long filament. Adults are about 2 inches in length. A robust little fish, *Gobiomorphus eugenius* (Jordan and Evermann), is brown with about 10 vertical bands of dark brown. There are no spines on the preoperculum and the sides of the head are scaly and also marked by several rows of papillae. Adults are less than 2 inches long.

Another member of this family, *Eleotris fusca* (Schneider), is typical of the fresh-water streams of the islands. Usually it is dark brown variously marked with spots of black, brown, or blue. Unlike the preceding species of the family mentioned, in *Eleotris fusca* the pelvic

fins are more or less united. The side of the head is without scales. Adults are up to about 9 inches in length.

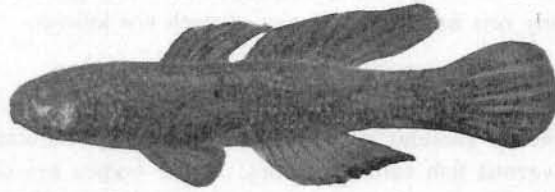


FIGURE 217.—*Bathygobius fuscus*, goby.

FAMILY GOBIIDAE (GOBIES)

Gobies are small to medium-sized fish, some confined to fresh-water streams whereas others are found on the reefs and in the tide pools along the shores. The ventral fins are united, forming suctorial organs by which the fishes can cling to stones. They often lie on the bottom in tide pools and suddenly dart about with great agility. During Gordon Mainland's recent survey of this group about Oahu, four or five species were reported to be more or less common in shallow marine habitats. The most abundant species of Hawaiian reefs is *Bathygobius fuscus* (Rüppell), known as 'o'opu. Jordan and Evermann describe some specimens as "very dark with black marblings and brown edges to the scales", and others as "marked with pearly blue spots on a ground of mottled light and dark olive and reddish olive." The species may reach a length of 6 inches but most specimens are smaller. (See fig. 217.)

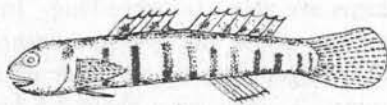


FIGURE 218.—*Kelloggella oligolepis*, goby.

Chlamydes cotticeps (Steindachner), a uniformly brown species about 1.5 inches long, is common among loose rocks near shore. A rather abundant species, *Kelloggella oligolepis* (Jenkins) (fig. 218), is found in tide pools on rocky shores. It is brownish marked by minute black spots and about 12 dark brown vertical bands on the side. Adults are less than 1 inch long. Another small form, believed by Mainland to be a new species, was given a manuscript name, *Paraxyurichthys*

edmondsoni, by him. It is abundant in shrimp burrows in the mud flats of Kaneohe Bay.

Four or five other species belonging to as many genera occur about Oahu, but only one or two specimens of each are known.

FAMILY BLENNIDAE (BLENNIES)

Tide pools or shallow shore waters are typical habitats of small, active, carnivorous fish called blennies. Their bodies are elongate and somewhat cylindrical, with long dorsal and anal fins. The ventral fins are not united as in gobies but are narrow and are used like feet as the fish moves about on the bottom of tide pools. The large eyes are high in position, and in many species the front of the head is blunt. The lips are thick and fleshy, covering the teeth. A familiar species, *Salarias zebra* Valliant and Sauvage (fig. 219), has the long dorsal fin

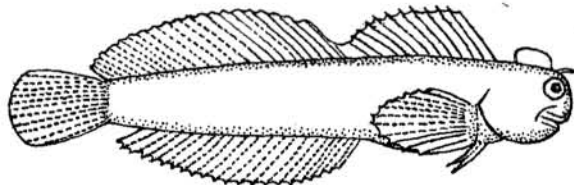


FIGURE 219.—*Salarias zebra*, blenny.

which is partially divided, connected posteriorly with the caudal. There is a flexible tentacle above each eye, and a median dorsal membranous flap. The color usually is dark brown with a series of darker transverse bands. Large specimens are about 6 inches long. In *Salarias meleagris* Valenciennes the tentacles above the eyes are branched and the upper lip is crenulated on the edge. The brown color of the body is broken by numerous light spots. A small form about 1.5 inches long, *Enneapterygius hemimelas* (Kner and Steindachner), is recognized from three dorsal fins and threadlike pelvic fins. There are no supraocular tentacles. The color is light brown with pale fins. In *Cirripectes variolosus* (Valenciennes) the head is vertical in front and the mouth is low, directed downward (fig. 220, a). There is a narrow fringed flap above each eye. The dorsal fin is continuous and the ventral ones are filament-like. It is brown with an orange tint on top of the head. A specimen from the reef at Waikiki, Oahu, is 60 mm. long. A number of other species of the family have occasionally been taken in local waters.

FAMILY CARAPIDAE (PEARL FISH)

Pearl fish are small, eel-like forms, the body tapering to a long slender tail. They lack pelvic fins and are scaleless. The dorsal and anal fins are narrow and long. The best known Hawaiian species is *Jordanicus gracilis* (Bleeker) (fig. 220, *b*) which usually is olive-brown in color, vari-

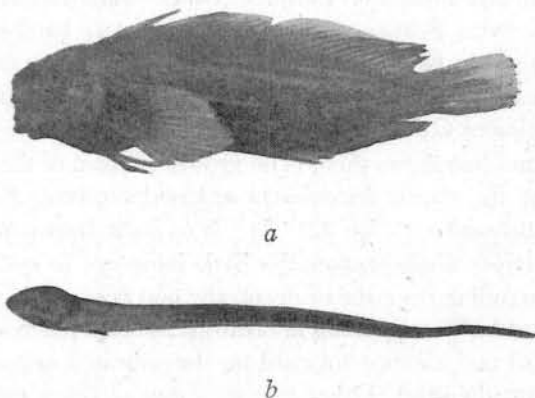


FIGURE 220.—*a*, *Cirripectes variolosus*, blenny; *b*, *Jordanicus gracilis*, pearl fish.

ously marked by spots and dots of other colors. It is a common commensal of holothurians in Hawaii, and it has been found in the starfish, *Asterope carinifera*. About Oahu, among holothurians, species of *Actinopyga* and *Stichopus* have frequently been found to harbor this fish. Large specimens may exceed five inches in length. Another pearl fish, *Carapus homei* (Richardson) has been reported from Hawaii, being found in a holothurian. The head is compressed, flattened, and the lower jaw is shorter than the upper one. Specimens 5 inches long are known, but apparently it has seldom been seen. An undetermined pearl fish was recovered from the starfish *Linckia multifora* in Kaneohe Bay, Oahu.

FAMILY BALISTIDAE (TRIGGER FISH)

The term "trigger fish" is applied to members of this family because of the character of the dorsal fin. The first dorsal fin has two or three spines, the anterior one very stout, and, when erected, is locked in position by the second spine which serves as the "trigger." The head and snout are somewhat protruded, placing the eye at a considerable distance from the small mouth. The skin is leathery with rough scales. Some species also have a few bony plates behind the gill opening. The pelvic

fins are modified into a single ventral spinous process. Nearly a dozen species are known locally, some of them common reef forms. In the genus *Balistes* there is a groove in front of the eye. The species *B. capistratus* Shaw (*humuhumu mimi*) is light brown in color and marked by a red longitudinal band on the head, formed just behind the mouth by lines from the chin and upper lip. Large specimens may exceed 15 inches in length. In *B. bursa* Schneider (fig. 221, *a*) a white band extends from the mouth to below the pectoral fin. There are also two darker streaks above and in front of the pectoral. The anterior streak curves through the eye. Specimens are about 10 inches long.

In the genus *Balistapus* there is no groove in front of the eye. To this genus belongs the classic *humuhumu-nukunuku-apua'a*, *B. rectangulus* (Bloch and Schneider) (fig. 221, *b*). It is light brown in color, with three black stripes arched across the back from eye to eye and a broad black band extending from the eye ventrally and posteriorly to the base of the anal fin, gradually expanding in breadth. A black patch surrounds the base of the tail and extends forward on the side in a triangle, the apex directed toward the head. Other narrow bands of color, usually of blue, yellow or violet bound the black patches. Specimens may reach a length of 9 inches.

Numerous other trigger fishes, including representatives of the genera *Canthidermis* and *Melichthys*, are occasionally seen about local reefs. Usually some of them may be seen in the Honolulu Aquarium.

FAMILY MONOCANTHIDAE

Members of this family are not often observed on the reefs or in shallow water. These fishes resemble the Balistidae but have only one spine in the first dorsal fin, usually with a rudimentary one behind it. Few Hawaiian species are known. Probably the most common local species is *Cantherines sandwichiensis* (Quoy and Gaimard) ('*ohua*). It is brownish in color, and some specimens have small scattered black dots. The large spine of the first dorsal is serrated and has a very small spine behind it (fig. 221, *c*). Large specimens are 12 to 14 inches long. In *Alutera scripta* (Osbeck) ('*ohua*) there is a single dorsal spine and the tail is very long.

FAMILY OSTRACIIDAE (TRUNK FISH)

Trunk fish are protected by a coat of armor, in the form of a bony case consisting of six-sided plates. Openings are provided in the armor

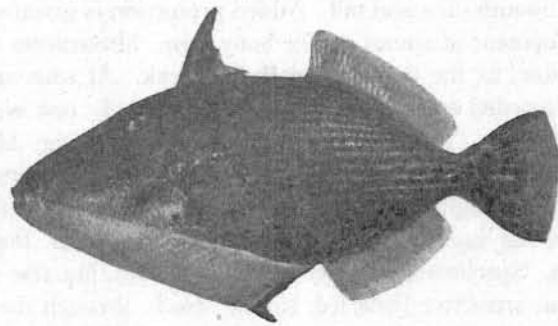
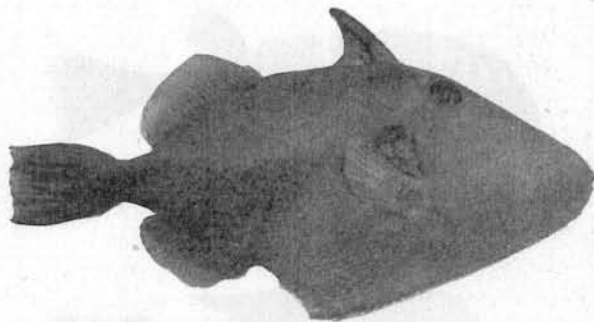
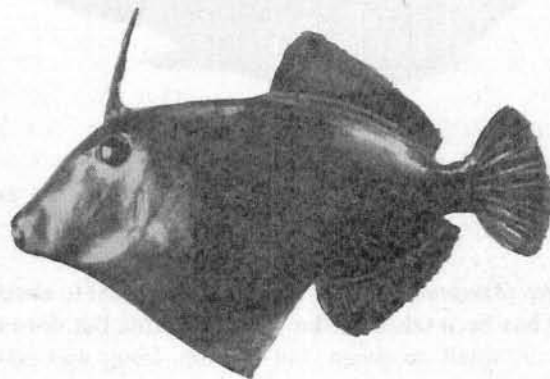
*a**b**c*

FIGURE 221.—*a*, *Balistes bursa*, trigger fish; *b*, *Balistapus rectangulus*, trigger fish (*humuhumu-nukunuku-apua'a*); *c*, *Cantherines sandwichiensis* ('*ohua*).

for the eyes, mouth, fins and tail. Added protection is given some species by the development of spines on the bony case. Movements of the fishes are rather slow, as the fins are small and weak. At least seven species have been recorded from Hawaiian waters but only one is likely to be seen close to shore. This is *Ostracion sebae* Bleeker (fig. 222, a) which is not uncommon on the reefs. The body is four-sided, with dorsal and ventral surfaces slightly convex, sides slightly concave. The color is bluish black, the back covered with small white spots, the sides with golden spots. Specimens 6 inches long are known, but few so large are seen. It is an attractive little fish sailing slowly through the water by a rapid movement of the fins, especially the anal and dorsal ones. The native name is *moa*.

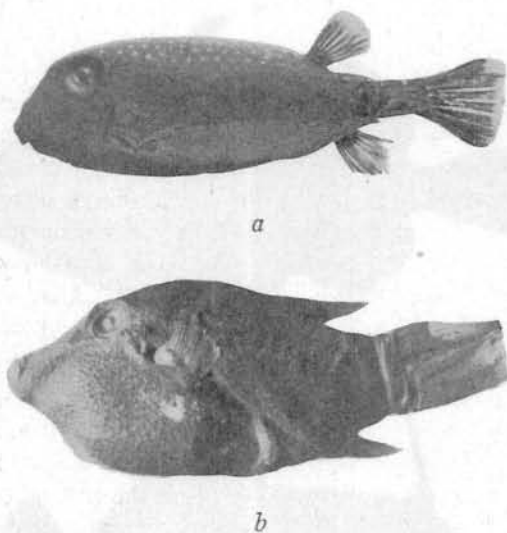


FIGURE 222.—a, *Ostracion sebae*, trunk fish; b, *Conthigaster jactator*, sharp-nosed puffer.

The species *Ostracion cubicus* Linnaeus is known to exceed 15 inches in length. It has been taken in the Hawaiian area but does not frequent shoal water. A small specimen, but 16 mm. long, was taken from the stomach of the dolphin (*mahimahi*). It probably is *Ostracion fornasini* Bianconi (*makukana*). There is a spine in front of each eye, one at each lower posterior corner, and a median dorsal spine. The species reaches a length of about 3 inches and inhabits off-shore waters.

FAMILY CANTHIGASTERIDAE (SHARP-NOSED PUFFERS)

These small puffers are much like the Tetrodontidae, but they have a pointed snout and a somewhat ridged back. In some forms the body is smooth, in others it is covered with short spines. Most of the species are brown, marked with spots of various colors. At least six species of the genus *Canthigaster* have been taken about Hawaii, but apparently none is common. In *C. rivulatus* (Schlegel) a broad dark band extends forward from the base of the tail, curves around the pectoral fin and straight back to the tail as a narrower band. It exceeds 4 inches in length. *C. jactator* (Jenkins) (fig. 222, b) is covered by light blue spots about the size of the eye. Specimens about 3 inches long are known. Fowler lists four other Hawaiian species.

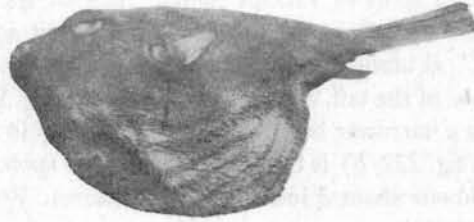
FAMILY TETRODONTIDAE (PUFFERS)

Puffers have short, plump bodies and broad heads. They are scaleless but the skin usually bears spines without roots and sometimes is provided with small bony plates. The teeth are fused plates of parallel layers, the beak having a median suture. Puffers are capable of inflating the body into a spherical form. In this condition the fishes float upside down on the surface and, no doubt, are thus protected from enemies. A familiar local species is *Tetrodon hispidus* Linnaeus (fig. 223, a) which is olive-green in color, usually marked with white or bluish spots. The under surface is often striped longitudinally by yellow or light olive. Elements of the skin vary from scattered prickles to well developed spines. Specimens may exceed 1 foot in length. This puffer is highly regarded as food but is believed to have been responsible for several recorded deaths of people in Hawaii. Some think the poison is in the gall, others believe the skin or eggs to be toxic. In 1925, members of the staff of the Queen's Hospital, Honolulu, tested the effect of extracts of various tissues of the fish on laboratory animals with varied results. The conclusions were that the six fishes used in the experiments were not poisonous. Two theories were suggested: first, that there may be a poisonous variety of the species, not readily distinguished from the normal; second, that the fish may at times eat a poisonous seaweed in sufficient quantity to render all the tissues toxic.* It is now unlawful in Hawaii to sell the fish for food.

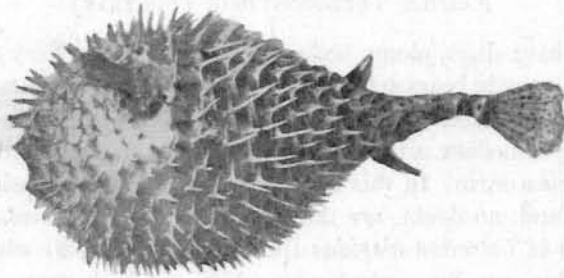
In another species, *Tetrodon meleagris* Schneider, the body is covered with small setae-like spines. The color markings consist of minute

* Later, Dr. Nils P. Larsen found toxic substances in tissues of the fish, especially the eggs. (See *Tetrodon* poisoning in Hawaii, Sixth Pac. Sci. Congress, Proc. 5: 417-421, 1942.)

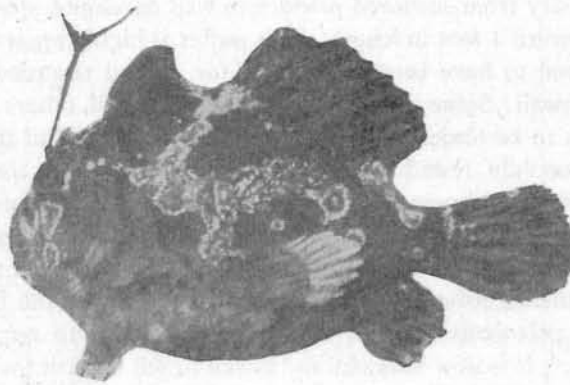
white spots distributed over the entire body. Specimens about 1 foot long are known. Two or three other species of puffers have been taken in Hawaiian waters but are not likely to be seen on the reefs. None of the representatives of the family is common in shoal water.



a



b



c

FIGURE 223.—a, *Tetrodon hispidus*, puffer; b, *Diodon hystrix*, porcupine fish; c, *Antennarius commersonii*, angler fish.

FAMILY DIODONTIDAE (PORCUPINE FISH)

Porcupine fish are similar to puffers in form and habits. The body, however, is covered with long quill-like spines. Most of the spines are two-rooted and movable, capable of lying down flat or being erected. The few three-rooted spines are immovable. When the fish inflate themselves with air and water, the spines stand erect and are effective armor as the fish floats about upside down on the surface.

In *Diodon hystrix* Linnaeus (fig. 223, b) the frontal spines are about equal in length to those behind the pectoral fins, whereas in *D. holocanthus* Linnaeus they are much longer. Both species are covered with black spots which are larger and fewer in *D. holocanthus*.

Another species, *Chilomycterus affinis* Günther ('o'opu-hue), is characterized by short, blunt spines increasing in length posteriorly along the sides. Each of the species mentioned here may exceed 2 feet in length. Although porcupine fishes are not typical of the shallow reefs, young specimens may be seen near shore.

FAMILY ANTENNARIIDAE (ANGLER FISH)

To this family belong strange-looking fish with short, compressed bodies and dorsal fins of separate portions, the anterior spine usually modified into a fleshy tentacle. This tentacle waves about as "bait" above the mouth, which is obliquely placed, opening upward. The pectoral fins are bent like an elbow and the fish is effectively camouflaged to resemble seaweeds or coral rocks. They are voracious, carnivorous fish. Some are found among seaweeds floating in the open sea, others are seen on the shallow reefs. Those likely to be near shore in Hawaii belong to the genus *Antennarius*.

In *A. hispidus* (Schneider) the skin is set with minute sharp spines and bears small, scattered dermal filaments. The "bait" is long and slender. Preserved specimens are yellowish white with dark blotches. Specimens exceeding 6 inches in length are known. *A. commersonii* (Shaw) is usually dark brown or black and the skin is comparatively smooth (fig. 223, c). The "bait" is long and slender. Specimens may reach 1 foot in length. Another species, *A. mummifer* Cuvier, is pale brown with darker brown spots. Specimens about 3 inches long have been taken on Waikiki reef. The "bait" is relatively short. Two or three other species of the genus have been taken but rarely in local waters.

GLOSSARY

- Abdominal: referring to the section of the body behind the thorax in an arthropod and in some other animals.
- Aboral: opposite the mouth.
- Ambulacral: pertaining to areas, plates, grooves, etc., containing tube feet in an echinoderm.
- Ampullae: the inner, dilated ends of tube feet in echinoderms.
- Anastomosing: fusing or running together to form a network.
- Annulations: rings forming segments of a worm, etc.
- Arborescent: branching like a tree.
- Arcuate: curved as a bow.
- Aristotle's lantern: jaws and teeth of a sea urchin.
- Asexual reproduction: reproduction without ova and sperm.
- Auditory vesicle: an organ of balancing or equilibrium.
- Axial: referring to the axis or central line of a body.
- Bifid: divided into two branches.
- Bifurcated: separated into two parts.
- Bilateral symmetry: similar arrangement of organs on two sides of a body.
- Biramous: referring to appendages of a crustacean with two branches.
- Biserial: in two rows.
- Biunguiculate: pertaining to a double claw on the end of the leg of a crustacean.
- Bivalve: a mollusk with a shell of two parts (valves).
- Budding: a method of reproduction in which there is a separation from a body of a small portion of it which develops into a new individual.
- Bulbous: inflated or swollen.
- Calice: the cup or depression of the skeleton of a coral colony in which a polyp rests.
- Capitate: provided with a knob at the end.
- Capsule: a sheath inclosing eggs, etc.
- Carapace: the chitinous covering of the back of a crab, shrimp, etc.
- Carina: a ridge.
- Carpus: referring to the wrist joint of the appendage of a crustacean, the segment immediately behind the hand (propodus).
- Cephalothorax: the union of head and thorax as in some crustaceans.
- Chelae: pincers of an arthropod.
- Chelate: referring to chelae.
- Cheliped: the appendage bearing a pincer in a crustacean.
- Chitinous: referring to chitin, a hard substance forming the exoskeleton of an arthropod.
- Coelomic cavity: the body cavity.
- Columella: an upright pillar as the axis of the shell of a univalve mollusk and the central portion of the calice of a coral.
- Commensal: the association of two organisms in which there is a one-sided benefit, but not amounting to parasitism.
- Concentric: referring to lines, ridges, etc., curving about a center.
- Confluent: running together.
- Costae: riblike ridges.
- Crenulated: scalloped on the margin.
- Dactylus: referring to the terminal segment of the appendage of an arthropod.
- Decadent: in the process of decay.
- Declivitous: sloping downward.
- Deflexed: bent abruptly downward.
- Dental papillae: a cluster of small, blunt granules associated with the oral plates of a brittle star.
- Denticles: minute teeth.
- Dextral: referring to a mollusk shell that is twisted to the right.
- Dorso-ventral: from the dorsal to the ventral surface of an animal.
- Ectoderm: the outer layer of a developing animal.
- Ectoparasites: referring to external parasites of an animal.
- Ellipsoids: pertaining to the elliptical shape of calcareous deposits in the skin of some holothurians.
- Endoparasite: an internal parasite.

- Endopodite: the inner branch of the uropod of a crustacean.
- Epipodites: membranes attached to the basal segment of the legs of a crustacean.
- Excentric: to one side of the center.
- Exoskeleton: referring to the chitinous covering of a crustacean.
- Eye spot: a mass of pigment cells serving as a sensory organ.
- Filiform: slender, threadlike.
- Fission: a breaking into parts.
- Foliaceous: flattened, leaflike.
- Foramina: small openings, especially in shells of Foraminifera.
- Fusiform: tapering toward each end.
- Girdle: referring to the muscular border of a chiton.
- Gregarious: having a tendency to live in groups. Several individuals near together.
- Hermaphrodite: an animal having both ova and sperm. (See monoecious.)
- Hexagonal: six-sided.
- Horny: having the character of horn.
- Host: the individual upon which or in which a parasite lives.
- Imbricated: having scales overlapping one another.
- Incised: having deep notches.
- Inferomarginal: referring to spines or plates of a starfish ventral to the marginal ones.
- Infradental papillae: certain of the oral papillae in a brittle star.
- Interambulacral: in position between the ambulacral areas, plates, etc., in an echinoderm.
- Lamellae: thin plates of hard or soft tissue.
- Larval: pertaining to a larva or immature form.
- Leeward islands: referring to the islands of the Hawaiian group lying northwest of Kauai.
- Leis: ornamental garlands of flowers, shells, etc., typical of Hawaii.
- Littoral: the seashore between high and low tide lines.
- Madreporite: the perforated plate of an echinoderm which admits water into the water-vascular system.
- Mantle: folds from the sides of the body of a mollusk.
- Maxillipeds: the anterior thoracic appendages of a crustacean, used in feeding.
- Merus: the arm segment of the appendage of a crustacean just proximal to the carpus.
- Moniliform: like a string of beads.
- Monoecious: an animal having both ova and sperm. (See hermaphrodite.)
- Mottled: spotted with different colors.
- Mucus: a sticky fluid secreted by the skin or other membranes of animals.
- Narcotizing: producing numbness or stupor.
- Nautiloid: referring to a coiled shell like that of *Nautilus*.
- Nocturnal: active at night.
- Nodular: in the form of knots or nodules.
- Nodulose: having small knots or nodules.
- Nuclear: referring to the tip or earliest part of the shell of a gastropod mollusk.
- Obtuse: blunt.
- Ochraceous: pale yellow.
- Operculum: a plate on the foot of a gastropod mollusk closing the aperture of the shell.
- Oral papillae: ossicles of a brittle star associated with the dental papillae and projecting into the buccal fissure.
- Orbit: the cavity in which the eye rests.
- Papillae: small soft projections.
- Papular: referring to soft, conical elevations of the body of a starfish.
- Parapodium: a flat organ projecting from the segments of a marine worm and used for swimming and respiration.
- Parietes: the middle portion of a section of the shell of a rock barnacle.
- Paxillae: groups of minute spines arranged around a column on the surface of some starfishes.
- Pedicle: a stalk or stem; tubefoot of a holothurian.
- Pedicellariae: small defensive bodies with jaws on the surface of a starfish and sea urchin.

- Peduncle: a slender stem or stalk.
- Pelagic: referring to animals living at the surface of the ocean.
- Pentagonal: five-sided.
- Pentamerous: divided into five parts.
- Periproct: the area about the anal opening in the shell of a sea urchin.
- Peristome: a membrane about the mouth of a sea urchin.
- "Persons": pertaining to feeding, defensive and reproductive bodies of a Portuguese man-of-war.
- Petals: referring to the ambulacral areas on the dorsal surface of certain echinoids.
- Pharynx: the anterior part of the digestive tract just behind the mouth.
- Photogenic: having light-producing properties.
- Phototropic: responding to the stimulus of light.
- Phylum: a large division of the animal kingdom.
- Pilose: covered with hair.
- Pinnate: resembling a feather.
- Planula: a free-swimming pre-polyp stage of a coral.
- Pleopods: appendages (swimmerets) of the abdominal segments of a crustacean.
- Plicated: provided with folds.
- Plumate: like a feather.
- Polygonal: many-sided.
- Polyps: the feeding individuals of a hydroid or coral colony.
- Proboscis: the anterior end of some animals.
- Propodus: the segment next to the terminal one in the leg of a crustacean.
- Prostomium: the first segment in the body of an annelid worm.
- Punctate: filled with minute pits.
- Quadrifid: divided into four branches.
- Radial shields: paired plates on the disk of a brittle star, one on either side of an arm.
- Radial symmetry: the parts of the body arranged about a central point or axis like the spokes of a wheel.
- Radula: a plate bearing fine teeth in the floor of the mouth of a mollusk.
- Raptorial: capable of grasping.
- Reticulate: forming a network.
- Rhomboidal: referring to the form of a parallelogram with unequal adjoining sides.
- Rostrum: the dorso-medial extension of the anterior border of the carapace.
- Rugose: rough.
- Sculpturing: referring to the surface markings of the shell of a mollusk.
- Scuta: referring to paired plates in the shell of a barnacle.
- Segmented: composed of segments or divisions.
- Septa: partitions; hard, calcareous in corals or mollusks; soft in worms, etc.
- Sessile: without a stalk.
- Setae: bristles in the parapodium.
- Sexual reproduction: reproduction by means of ova and sperm.
- Sinistral: twisting to the left as in some mollusk shells.
- Sinuose: winding and turning in an irregular course.
- Siphon: tubular folds of the mantle or body of a mollusk for conveying water in or out of the gill chamber; also in tunicates.
- Sphaeridia: small round bodies, probably sensory organs, among the spines of a sea urchin.
- Spire: the whorls of a gastropod mollusk shell preceding the body whorl.
- Squamiform: flattened, platelike.
- Stellate: shaped like a star.
- Stolon: a rootlike growth that gives rise to some tunicates by budding.
- Stone canal: a water canal in echinoderms leading from the madreporite to the ring canal.
- Striae: narrow lines.
- Suborbicular: nearly circular.
- Suctorial: having the power of clinging by suction.
- Supraorbital: above the eyes.
- Suture: the line of union between the chambers in the shell of a gastropod mollusk.
- Swimmerets: biramous abdominal appendages of a crustacean used in swimming.

- Symbiosis:** the association of two species of organisms from which mutual benefit results.
- Taxonomic:** referring to the classification of organisms.
- Telson:** the terminal segment at the end of the abdomen of a crustacean.
- Tentacular cirri:** slender, tentacle-like processes on the head of a marine worm.
- Terga:** referring to paired plates in the shell of a barnacle.
- Test:** the shell of a foraminiferon or a sea urchin.
- Thorax:** the section of an arthropod's body just behind the head.
- Tow net:** a fine meshed net for collecting microscopic animals in water.
- Translucent:** clear, semitransparent.
- Trapezoid:** four-sided with no two sides parallel.
- Triserial:** in three rows.
- Tuberosity:** a rough elevation.
- Turbinate:** cone-shaped with a round base.
- Turreted:** pertaining to gastropod shells with long spires.
- Umbilicus:** a depression in the base of the shell of a gastropod mollusk.
- Uniserial:** in a single row.
- Uropods:** biramous appendages of a crustacean attached to the sixth or last abdominal segment; in some isopods the last three pairs of abdominal appendages.
- Varices:** longitudinal ridges on the shell of a gastropod mollusk.
- Variegated:** marked by different colors.
- Verrucae:** wartlike elevations on a sea anemone.
- Water-vascular system:** referring to the canal system of an echinoderm through which water passes to inflate the tube feet.

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