cycles, the relationship between environmental conditions and degree of infection.

Disease associated with *Haplosporidium*

Excessive mortality of oysters in Delaware Bay in a 6-week period of April and May 1957 wiped out from 35 to 85 percent of planted oysters and almost completely ruined the oyster industry of the State. A microorganism consistently found in tissues of infected oysters was designated by the code name MSX and later on was tentatively identified by Mackin as one of the Haplosporidia. The organism invades the connective tissue surrounding the intestine and digestive diverticula. Early plasmodial stages and ensuing stages of development are shown in two illustrations (figs. 375 and 376) made in the laboratory from a preparation kindly supplied by Haskin.

Mortality of oysters on the eastern shore of Virginia near Seaside was investigated from 1959 to 1961 by the Virginia Institute of Marine Science. Tbe microorganism causing the disease and first designated as SSO was described by Wood and Andrews (1962) as a sporozoan, *Haplosporidium costale*, n. sp., infecting connective tissues of oysters and producing a truncate spore encased in an operculum with a lid. An early plasmodium with 6 to 12 nuclei is from 6 to 8μ in size (fig. 377). *Haplosporidium* has been found in live oysters as early as February, and in mid-May to June the infection may cause high mortality. How the parasite infects the oysters is not known, and its life history is not fully understood (Andrews, Wood, and Hoese, 1962).

Shell disease

This disease, which is probably associated with an unidentified fungal infection of oyster shell, is not particularly serious in *C. virginica*, but has been reported to cause catastrophic mortalities in the population of *O. edulis* in Oosterschelde, Holland. The disease can be recognized by bottle-green or orange-brown rubberlike warts and spots

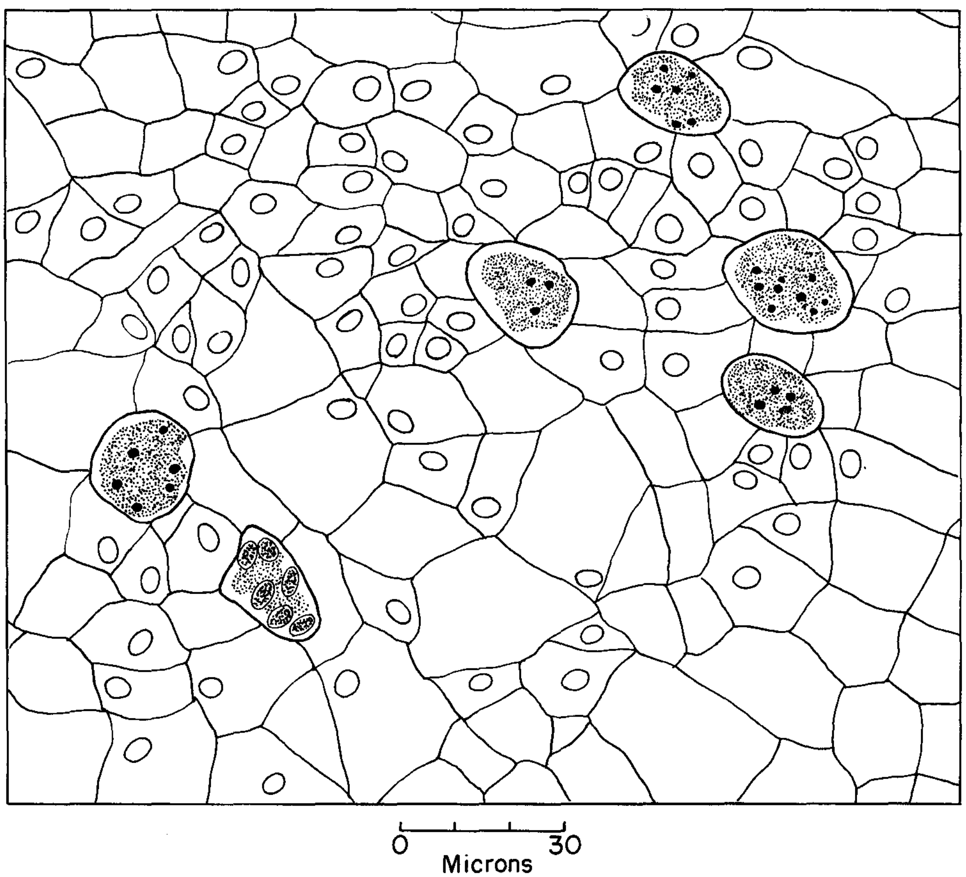

FIGURE 375.—Plasmodial stage of MSX in the connective tissue of heavily infected *C. virginica* from Delaware Bay. Bouin, hematoxylin-eosin.

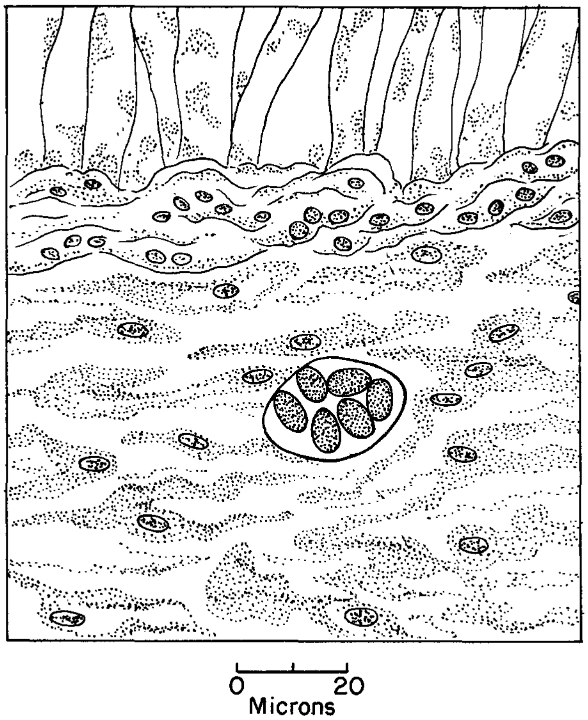

FIGURE 376.—Later stage of development of MSX in the connective tissue of heavily infected *C. virginica* from Delaware Bay. Formalin 10 percent, iron hematoxylin.

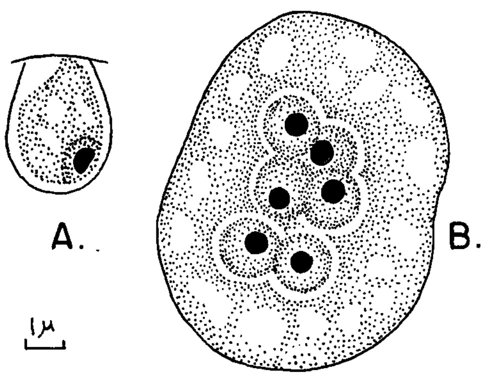

FIGURE 377.—*Haplosporidium costale.* A—mature spore; B—early plasmodium. From Wood and Andrews, fig. 1, Science, vol. 136, 1962, p. 711.

on the inner surfaces of the shell and, in more advanced cases, by deformation of the shell edges and hinge. Examination of thin slides of shell show abundantly branching fungus. The shell disease in Oosterschelde was studied by Korringa (1951a), who discovered that it spreads at water temperatures above 19° C. and that the higher the temperature the more vigorous the attack. The fungus was not isolated from Dutch oysters and remains unidentified. Korringa believes that it survives in the old green cockle shells scattered as cultch over the bottom and that its spores are probably carried by the water currents. Wholesale cleaning, removal of old shells, and disinfecting of young infected oysters with a solution of "an organic salt of mercury" (not fully specified by Korringa) are recommended as control measures.

Shell disease in Dutch oysters has been known since 1902, but at that time occurred only in a limited percentage of oysters. Its rapid spread in the years following 1930 was probably due to the enormous quantities of old cockle shells, about 40,000 to 50,000 $m.^3$, scattered annually as spat collectors. This gave the fungus a chance to proliferate more rapidly and infect the oysters. Voisin (1931) describes the disease in oysters imported from Zeeland, Holland, for planting in the Marennes area on the west coast of France. He states that more than 40 percent of these oysters had shells infected by a fungus, probably belonging to the genus *Monilia.* The identification is merely a guess and cannot be verified.

Foot disease

Foot disease or "maladie du pied" of French oyster growers occurs in *O. edulis* and *C. angulata* in the waters of the western and southern coasts of Europe. Korringa suggests that it is probably identical with the shell disease. The name is an obvious misnomer because the foot is lacking in all adult oysters.

"Foot disease" has existed in the Arcachon region since 1877. Giard (1894) described its parasitic nature and attributed it to a schizomycete fungus *Myotomus ostrearum* Giard, a genus not listed in Johnson and Sparrow's treatise on fungi (1961).

The disease affects the area of the attachment of the adductor muscle, primarily on the lower, concave (left) valve, and in certain cases the upper, flat valve. The surface of the shell under the muscle is covered with small, rough dark green spots. In advanced cases the muscle becomes detached from the valve and forms irregular cysts of horny and slightly elastic material. Later on when the cyst extends beyond the area of the muscle attachment, the cyst walls become covered with calcareous shell deposit. According to Giard (1894) and Dollfus (1922), the parasitic fungus grows by utilizing the conchiolin of the shell and stimulates its secretion by tbe mantle.

The progress of the disease is slow. During the advanced stage shell movements are affected and the oyster has difficulty in closing its valves, thus becoming an easy prey for its enemies.

Foot disease is found in *C. virginica*, particularly in oysters inhabiting muddy waters of the southern States, but in my experience it never reaches epizootic proportions. The cysts of an affected oyster (fig. 378) contain a suspension of blood cells, debris, and numerous bacteria which probably represent secondary infection. The disease does not present a serious menace to the oyster fishery of the coastal states.

Hexamita

The flagellate *Hexamita inflata* was first found in the intestinal tract of *O. edulis* (Certes, 1882). It is present in *C. virginica* of Prince Edward Island, Canada, and southern Louisiana, and in *O. edulis* in Dutch waters (Mackin, Korringa, and Hopkins, 1952). Heavy infection with *Hexamita* causes breakdown of connective tissue cells, general inflammation, the appearance of many trophozoites in blood vessels, and necrosis of adjacent tissues. The early stages of the disease appear to be intracellular, and are usually found in the leucocytes of the blood vessels. The trophozoite is oblong and narrow at the anterior, with six anterior and two posterior flagella. Cysts found in advanced stages of the disease are small, about 5 μ in diameter; they contain two or four small nuclei and have no flagellar structure. The complete life cycle of the parasite has not been described. The method of infection appears to be by cysts liberated after the disintegration of an infected oyster body. Experimental studies by Stein, Denison, and Mackin (1961), who used diseased *O. lurida*, give no evidence that *Hexamita* is a highly pathogenic parasite because there was no significant difference in the mortality between the experimental and control specimens.

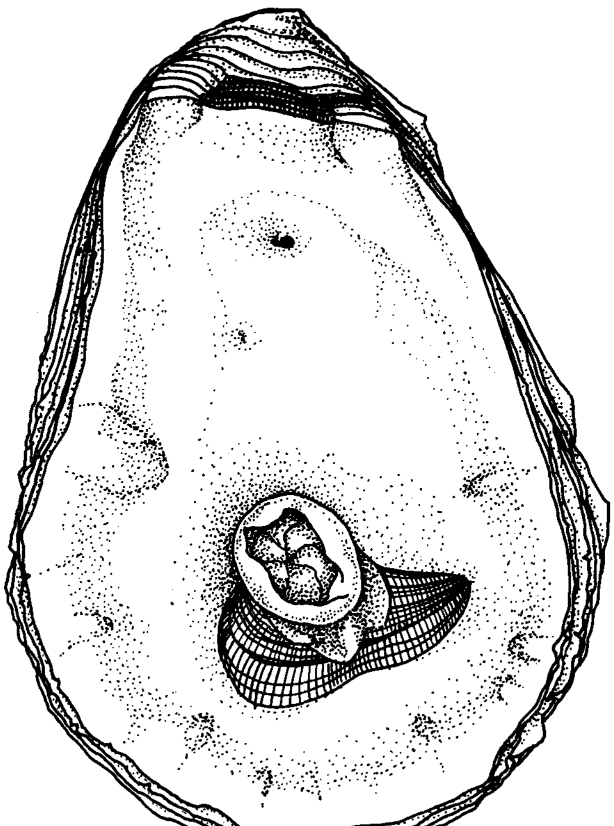

FIGURE 378.—Large cyst filled with blood cells, bacteria, and debris of muscle tissue in *C. virginica*.

Nematopsis

Cysts of the gregarine *Nematopsis* are frequently found in the tissues of several European bivalves including *O. edulis*, *Mytilus*, *Cardium*, *Donax*, *Tellina*, *Mactra*, *Solen*, and others (Dollfus, 1922). Observations by Louis Léger (quoted from Dollfus) showed that vegetative stages of the gregarine are often found in the kidneys and that the spores with sporozoites are usually located in the gills. Léger also showed that the intermediary hosts are the crabs *Carcinus moneas* and *Portunus depurator*. *Nematopsis* develops in the intestinal canal of the crab and forms cysts which are rejected into water and are transmitted with water currents. There was no evidence that *Nematopsis* is pathogenic.

The species *N. ostrearum* from *C. virginica* has been described by Prytherch (1940), who found the parasite in the oysters of Virginia, North Carolina, and Louisiana. He expressed the belief that mortality of oysters in Virginia and Louisiana was directly caused by this gregarine. *Nematopsis* is widely distributed throughout the waters from the Chesapeake Bay states to Louisiana. Its distribution indicates no correlation with oyster mortalities in that area (Landau and Galtsoff, 1951).

Trematodes and parasitic copepods

The trematode, *Bucephalus haimeanus* Lac. Duth., is occasionally found in *O. edulis* and *C. virginica*. According to Tennent (1906), who studied its life history, the worm thrives in oysters of brackish water and is inhibited by an increased salinity. In cases of heavy infestation, the gonads and digestive diverticula are almost completely replaced by cercariae and by the long germ tubes of the sporocysts, which after their liberation infest *Menidia*, other small fishes, and *Tylosurus marinus*. Destruction of the gonad is the most obvious pathological effect caused by *Bucephalus*. So far this trematode has not been suspected of causing mortalities in oyster populations.

The parasitic copepod *Mytilicola intestinalis* is common among mussels of the Mediterranean. Another species, *M. orientalis*, infests *C. gigas* and *Mytilus crassitesta* of the Inland Sea of Japan. The parasitic copepod is found in the intestinal tract of bivalves and is easily recognized by its red color and relatively large size which makes it visible to the naked eye. In the United States *Mytilicola orientalis* is widespread in lower Puget Sound, occurring in *O. lurida* and *C. gigas*, *Mytilus edulis*, *Paphia staminea*, and *Crepidula fornicata*. Infection is heaviest in the common mussels, often reaching 100 percent in some areas (Odlaug, 1946). A single specimen of *Mytilicola intestinalis* was found by Pearse and Wharton (1938) in *C. virginica* on the Gulf coast of Florida. The presence of *M. orientalis* in *O. lurida* in the lower Puget Sound area interferes with their fatness, but apparently inflicts no serious injuries to oyster stocks. In *C. gigas* the copepod produces metaplastic changes in the gut, completely destroys the ciliated epithelium, and penetrates the underlying connective tissue (Sparks, 1962).

The presence of parasites in adult oysters makes them unmarketable for esthetic reasons and, therefore, detracts from the commercial productivity of oyster bottoms.

Any disease factor, regardless of the identity of the pathogen, can be evaluated by determining the percentage of the infected oysters, the intensity of infection, the loss caused by the mortalities, and the decrease in yield of marketable oysters.

COMMENSALS AND COMPETITORS

The shell and body of the oyster are the natural abodes for many plants and sedentary animals which attach themselves to the shell surface or bore through it to make for themselves a well-protected residence; some settle on the soft body without penetrating its tissues while others invade the inner organs. The difference between the commensals, i.e., organisms which share the food gathered by the host, and the parasites, which live at the expense of their hosts and sometimes inflict serious injuries, is not very sharp. Some commensals may cause injury to the host and become parasites.

Competitors are those organisms which live in close proximity to each other and struggle for the space and food available in the habitat. Some appear to be innocuous while others by virtue of their habits and high reproductive capabilities are harmful.

Boring Sponges

Small round holes on the surface of mollusk shells indicate the presence of the most common animal associated with the oyster, the boring sponge. There are seven species of the genus *Cliona* along the Atlantic Coast of the United States. In a case of heavy infestation the shell becomes brittle, breaks under slight pressure, and reveals conspicuous tunnels and cavities filled with yellow sponge tissue. Microscopic examination shows a typical sponge structure with numerous siliceous spicules from 150 to 250 μ long, of the type called tylostyles, and small skeletal elements of different shapes and sizes known as microscleres. Species identification is based on the type of cavities or galleries made by the sponge and the shape and sizes of the spicules (Old, 1941). Small fragments of shell material at the holes by *Cliona* may suggest mechanical action of the sponge. Warburton (1958) found experimentally that sponge cells in contact with a surface of calcite form a reticulum of fine pseudopodia and filaments. A corresponding pattern of lines is etched into the mineral, and the marked areas are of the same size and shape as the fragments discharged by the sponge. Apparently the cytoplasmic filaments penetrate the calcite by secretion of minute amounts of acid and undercut fragments which are carried out by excurrent canals of the sponge.

It is not known whether boring sponges use the organic component (conchiolin) of the shell, but it is obvious that they do not draw their nutrients from the body of the oyster. The sponge touches the surface of the body only in cases of old, heavy infestation. In such instances the holes made by the sponge are rapidly covered by a deposition of conchiolin. The holes made by the sponge are clearly visible on the inner surface of the valve under a newly deposited layer of conchiolin (fig. 379). The race between the sponge and the oyster

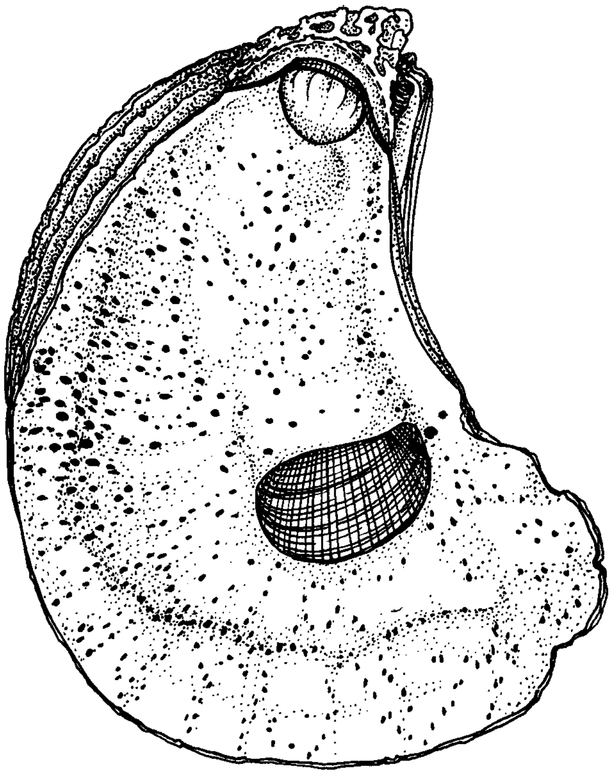

FIGURE 379.—Left valve of adult *Crassostrea virginica* heavily infested by boring sponge, *Cliona celata*. Woods Hole.

continues, and in most cases the oyster's protective measures prevent direct contact between the sponge and the mantle. However, should the deposition of shell material be delayed by adverse conditions, the sponge makes direct contact with the mantle and produces lysis of the epithelium and underlying connective tissue. Dark pigmented pustules form exactly opposite the holes in the shell. This extreme case observed in oysters kept for several months in the laboratory is shown in fig. 380. The tissue of these oysters is flabby, and the mantle is easily detached from the shell surface.

All oyster bottoms are, to a certain degree, infested by boring sponges which are found in both live oysters and empty shells. There are certain areas, however, where the infestation is particularly heavy and the growth of the sponge is very rapid. After the death of an oyster the sponge continues to grow on the shell, forming large, irregular masses 2 or more feet wide and several inches thick. About 30 years ago such large specimens were common in the bays and harbors of southern Cape Cod, but now they are found only in deep offshore waters. The effect of the boring sponge can be estimated by determining the percentage of oysters with heavily infested and brittle shells and by comparing their solid and glycogen contents with those of uninfested oysters.

Boring clam

Oyster shells in the south Atlantic are often infested with a boring clam, *Diplothyra smithii* Tryon of the family Pholadidae. Many papers on oyster biology refer to this clam as *Martesia* sp., but the taxonomy of the family revised by Turner (1955) corrects the nomenclature and restricts the name *Martesia* to wood-boring clams.

The boring clam *D. smithii* is about one-half inch long. It is usually found inside the shell material in a cavity which increases in size with the growth of the clam. The range of distribution extends from northern Cape Cod (Provincetown, Mass.) south to the east and west coasts of Florida, Louisiana, and Texas. I have found no live clams in oyster shells during my long-continued studies in New England waters, and only a few live specimens have been recovered from dead oyster shells around Tangier Sound in the Chesapeake Bay. In southern waters the boring clam is very common, particularly on some reefs on the Texas coast. In 1926 oysters from Matagorda Bay, Tex., were found to be so heavily infested by *Diplothyra* that over 200 clams of various sizes were found in a single adult (fig. 381). In order to make this count the shell was dissolved in hydrochloric acid and the bodies of the clams were collected.

As the cavity bored by the clam increases and approaches the inner shell surface, the oyster protects itself by depositing layers of conchiolin over the nearly perforated areas. Very rarely does one find an oyster in which there is a direct contact between the clam and oyster mantle. On the outer surface of the shell the presence of clams is indicated by small holes. The weakening of the shell structure is the main effect of the boring clam on the oyster.

Mud worms

Of the several species of Polydora found in the intertidal zone of the Atlantic and Pacific coasts of the United States, only two, *P. websteri* Hartman and *P. ligni* Webster, are important to oyster ecology. *P. websteri* is found in oyster shells and on the inner surfaces near the valve

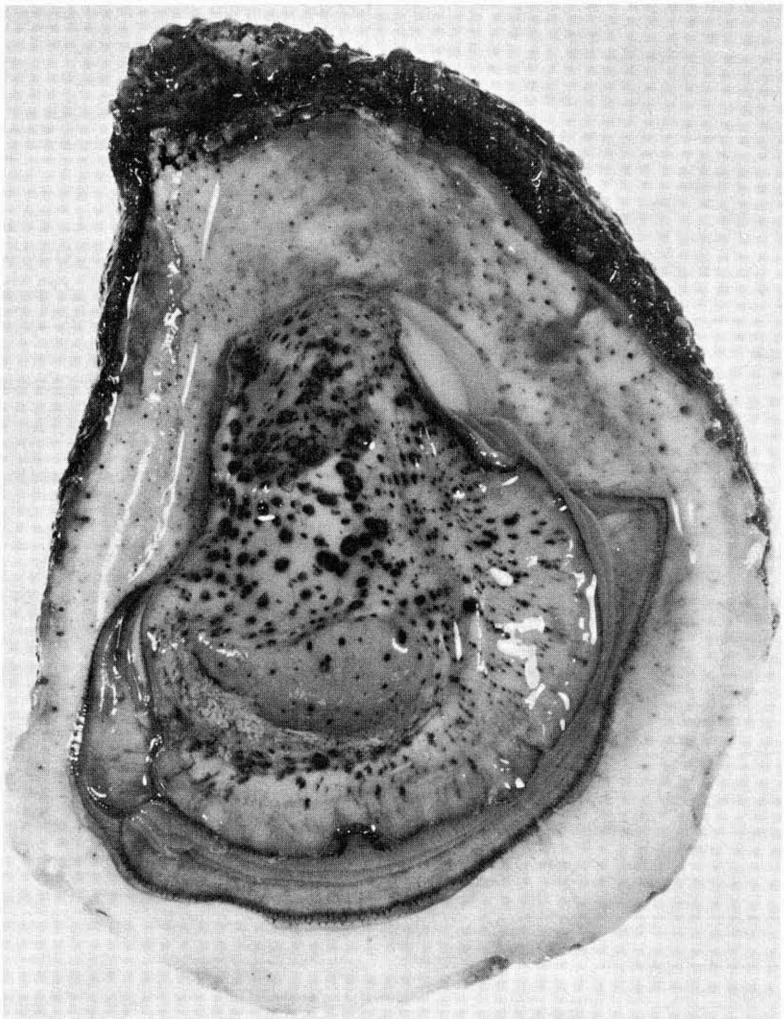

FIGURE 380.—Black pustules on the surface of the visceral mass and mantle of *C. virginica* caused by contact with boring sponge, *Cliona celata*. Photograph of an oyster kept in the laboratory tanks at Woods Hole.

edges. The worm accumulates mud and builds a U-shaped tube which is covered by semitransparent shell material secreted by the oyster. The formation is usually called a blister. *P. ligni* is abundant on tidal flats where it can be found living in small mud tubes or in crevices of waterlogged wood structures and other submerged objects. The mud worm may be indirectly destructive to oysters, for when many worms settle on shells they can smother an entire oyster population with their tubes. *P. ciliata* (Johnston) has been accused of extensive mortalities of oysters in New South Wales, Australia (Roughly, 1925). Frequent reports of finding this species on the coast of eastern America are based on erroneous identifications and probably should be referred to as *P. websteri* (Hartman, 1945). Korringa (1951b) finds no serious injuries by *P. ciliata* to oysters (*O. edulis*) in Dutch waters and thinks that in many areas the damages were caused by *P. websteri* and *P. hoplura*.

Knowledge of the life histories of *P. websteri* and *P. ligni* is incomplete. Both species lay eggs in capsules attached to the inner walls of the tube in which the animal lives. The egg-laying was noticed in the Woods Hole laboratory when *P. ligni* were placed in small glass tubing of appropriate length and diameter (fig. 382). The process of egg laying has never been observed in spite of frequent examination of several tubes during both day and night (Mortensen and Galtsoff, 1944). However, egg capsules were found attached to the walls of the tubes shortly after *Polydora* were left undisturbed in darkness.

The eggs develop within the capsule until the larvae have acquired three pairs of setiferous segments; then they leave the tube. At a temperature of 21° to 23° C. the development of *P. ligni* under laboratory conditions varied from 4 to 8 days. Larvae of *P. websteri* (fig. 383) also have three setiferous segments. According to Hopkins (1958), planktonic larvae, presumably *P. websteri*, occur in Louisiana waters throughout the year; eggs were found in the tubes when water temperature ranged between 12° and 18° C.

The duration of the pelagic life of either species of *Polydora* is not known. The planktonic larvae grow and develop additional segments before they settle on the substratum. Since the largest *P. websteri* worm found in plankton had 17 segments and the smallest found on oysters also had 17 segments, it is probable that this species settles at that age. The appearance of young *P. ligni* at an early bottom stage is shown in fig. 384.

The larvae of *P. websteri* settle on the rough exterior surface of young oysters and make shoe-shaped burrows near the extreme edge of the valves. As the worm grows it enlarges its burrow. The process of excavation is probably chemical, apparently similar to that described by Wilson (1928) for *P. hoplura* and by Hannerz (1956) for *P. ciliata*.

The tubes of *P. ligni* are made of mud particles held together by mucus secreted by the antennae and the body surface. Ciliary motion along the tentacle grooves serves as an efficient mud-gathering device. Experimental evidence shows that if the lumps of mud are too large or if particles consist of the finest sand or foreign materials such as corn starch or powdered glass, the ciliary motion is reversed and the material is rejected. These laboratory observations prove that the worm is capable of selecting the substances needed for the building of a soft tube.

The tube inhabited by the worm, whether U-shaped or straight, is lengthened by the worm at both ends. To accomplish this *P. ligni* reverses its position in the tube by folding itself halfway and sliding over its own ventral side. The process, frequently observed in the Woods Hole laboratory, is accomplished with great speed and remarkable ease.

The amount of mud which *P. ligni* can accumulate in the formation of their tubes is astonishing. A sample collected on June 8, 1944 from the tidal flats of Delaware Bay contained about 430 closely packed worm tubes per square inch of mud area. They all lay nearly perpendicular to the surface. A cubic inch of the washed and dried sample weighed 20 g., of which 12.8 g. consisted of mud with the balance made up of sand, empty shells, and organic matter. On this basis it is estimated that the worms gathered 4.9 pounds of dry mud

FIGURE 381.—Photograph of an adult *C. virginica* from Matagorda Bay, Tex., heavily infested with *D. smithii*. The outer layer of the shell was chiseled off to expose the cavities.

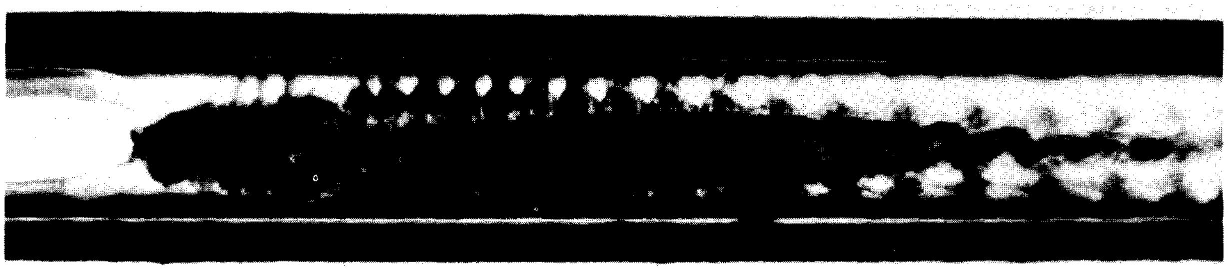

FIGURE 382.—Photograph of live *P. ligni* lying quiescent inside a glass tube. Dorsal view.

per layer of surface 1 square foot in area and 1 inch deep.

Since *P. websteri* is confined in oysters to mud blisters and does not come in direct contact with oyster tissues, it causes no visible injuries. This view is corroborated by the observations of Loosanoff and Engle (1943), who found that oysters heavily infested with *P. websteri* and grown in trays above the bottom were in excellent condition.

However, personal observations made in Seaside, Va. and in Texas bays convinced me that oysters heavily infested by mud worms (fig. 385) are usually in poor condition. This opinion is shared by Lunz (1940, 1941), who calls the mud worm a pest in South Carolina oysters. According to his

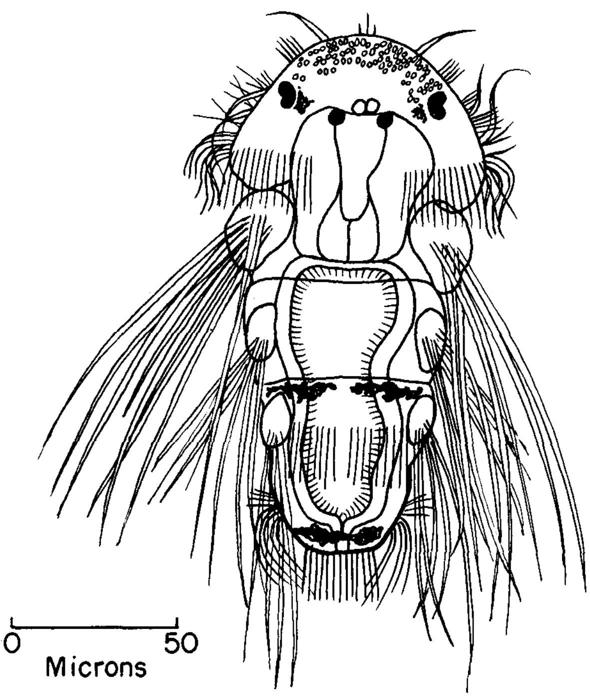

FIGURE 383.—Drawing of newly emerged larva of *P. websteri* viewed alive from the dorsal side. From Hopkins, 1958.

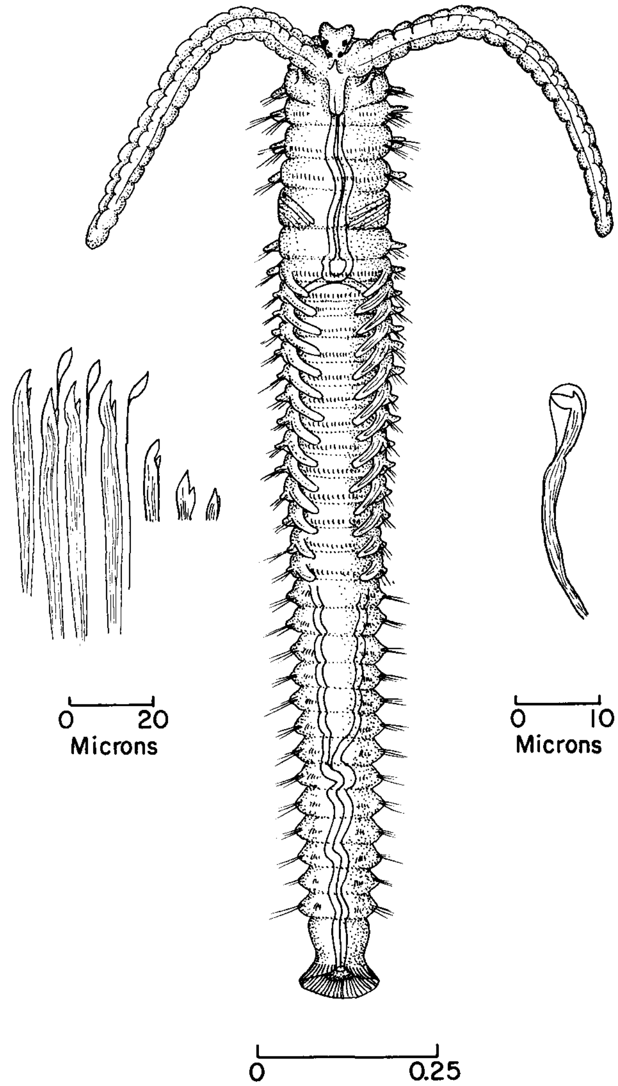

FIGURE 384.—Young "bottom stage" of *P. ligni* Webster. Modified bristles from fifth segment at left, and ventral hooded crochet at right. From Fauvel, 1927.

observations, 20.9 percent of the oysters growing on the hard surface of tidal flats are infected, and the percentage increases to 51.9 on soft, muddy bottoms above low-water mark. There is no

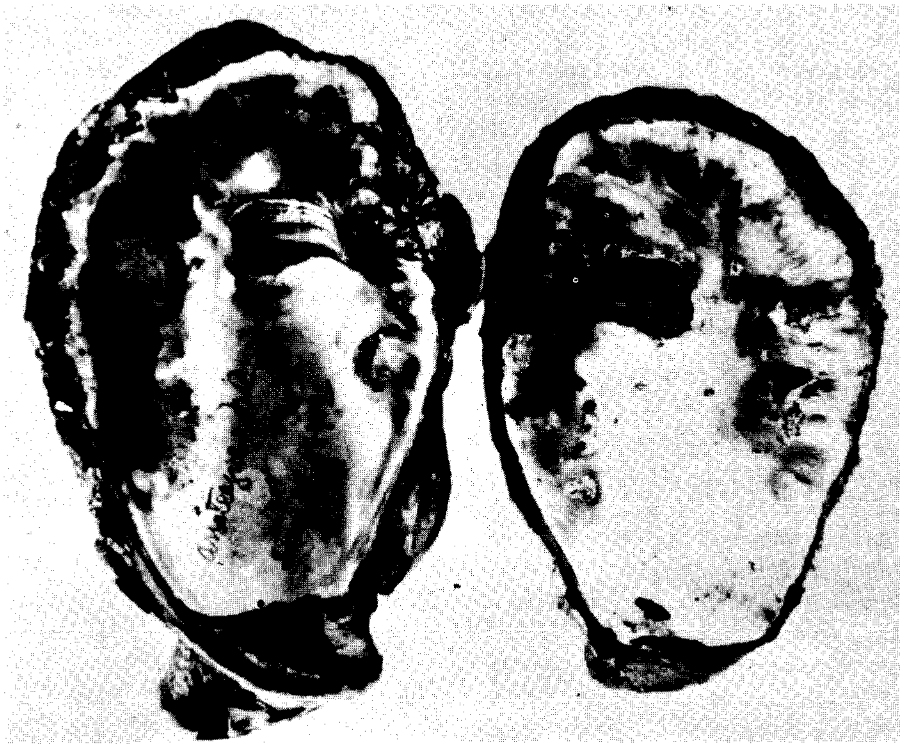

FIGURE 385.—Oyster shells with mud blisters made by *P. websteri* from the grounds at Assateague Island, Va.

evidence, however, that infestation by the mud worm constitutes a serious menace to the oyster population.

Oyster Crab

Several species of the large family Pinnotheridae, commonly called oyster or pea crabs, are associated with oysters, mussels, and other bivalves. The adult females have been known since ancient times and were first described by Aristotle. The males of the American species, *Pinnotheres ostreum* Say, are much smaller than the females and are rarely seen. Usually one or two adult crabs per oyster can be found, and the percentage of infestation varies from zero in some New England waters to about 77 percent in New Jersey. The latter figure, quoted from Christensen and McDermott (1958), refers to the "invasion" of the oyster crab on certain grounds of Delaware Bay. The oyster crab is also abundant in Virginia waters, where its life history has been studied by Sandoz and Hopkins (1947). Some oysters contain a surprisingly large number of these crabs; the maximum reported in a seed oyster was 262 (Stauber, 1945).

Larvae of the oyster crab are pelagic until late summer. At this time larval development is completed, the first crab stage is reached, and the small crabs invade the mantle cavities of oysters. At this time the carapace width of the young crabs ranges from 0.59 to 0.73 mm.

The female crab may be found in various parts of the water-conducting system of the oyster, but settles chiefly on the surface of the gills, in the promyal and suprabranchial chambers, and grows with the growth of the host. The males are not permanently attached to their host and may leave to enter other oysters for copulation.

For many years the oyster crab has been considered an innocuous commensal; however, the female crabs which have settled on the oyster erode its gills and impair their function. More serious lesions may develop and cause leakage of water from the water tubes, which further reduces the efficiency of the food collecting apparatus and of the gills. Rapid regeneration of the damaged gills probably saves many oysters from death, but interference with the normal gill functions causes a relatively poor condition in many infested oysters.

Spirochaetes

Tissues of oysters are often infected by spirochaetes which may be found in the stomach, crystalline style sac and in the gonads after spawning. Dimitroff (1926) identified 10 species and found that 91 percent of the oysters sold in Baltimore, Md. were infected. He reported the following species: *Saprospira grandis* Gross; *S. lepta*, *S. puncta; Cristispira balbiani* (Certes); *C. anodontae* Keysselitz; *C. spiculifera* Schellack; *C. modiola* Schellack; *C. mina; C. tena;* and *Spirillum ostrae* Noguchi. The species are harmless to oysters and man.

Perforating algae

The empty shells of oysters and other mollusks found on tidal flats and on the bottom are frequently perforated by various algae. Bornet and Flahault (1889) gave a detailed description and illustrations of several species, some of them also found in the carapaces of crabs. Live mollusks do not escape the attacks of perforating algae. *O. edulis* of various ages living in the channel of Saline de Cagliari, Italy, were found to be infested by three species: *Hyella caespitosa* Bornet and Flahault; *Mastigocoleus testarum* Lagerheim; and *Gomontia polyrrhiza* (Lagerheim) (Agostini, 1929). The algae penetrate the periostracum, then spread across the prismatic layer, and form branching threads in the inner layer of shell. Apparently the growing tips of the filaments dissolve the calcium carbonate of the shell and make possible the expansion of algae which, in severe cases of infestation, spread through the entire valve and become noticeable by the greenish color of the valve's inner surface. The color cannot be rubbed off the surface since the alga is separated from the oyster and does not come in direct contact with its body. The algal filaments can be studied on fragments of shell or after decalcification in acid.

Gomontia polyrrhiza, continuously distributed along the Atlantic coast, has been reported from North Carolina and Connecticut, to New Brunswick, Canada, growing in empty shells along the shores and occasionally found in live *Spirorbis* and barnacles (Taylor, 1937).

Live oysters infested with perforating algae are occasionally found in shallow bays and estuaries of Cape Cod. The inner surfaces of the valves are bluish-green. At Woods Hole I saw under a microscope a network of perforating algae resembling *Gomontia* and probably mixed with other species. The plants have not been positively identified.

Perforating algae do not appear to be harmful to oysters. Continuous growth in empty shells accelerates the disintegration of the shells and the return of calcium salts to the sea.

Fouling organisms

Many sedentary marine organisms use oyster shells as a convenient place to attach, either permanently or temporarily. They do not penetrate the shell nor do they inflict any direct injury on the oyster, but they do compete with it for food and space and sometimes smother the oyster by their accumulated mass. The most conspicuous among them is the American species of slipper shell, *Crepidula fornicata* (L.), which received international notoriety because of the havoc it caused for oyster growers in Europe.

Various species of *Crepidula* are very common gastropods found attached to hard objects near or below low water. *C. fornicata* does not present a problem to oyster growers in the United States, although sometimes in certain estuaries, as in Cotuit Bay, Mass., it becomes a nuisance because of its extraordinary abundance. Slipper shells settle on oyster shells and tend to form a spirally curved chain of individuals, the sexes of which change from female to male (fig. 386).

The lowest and, therefore, the oldest members of the chain are always females. The uppermost are males, and those between the two extremes are hermaphrodites, which undergo changes from female to male. To the biologist the species is of interest because the alteration of sex which takes place in this mollusk offers an excellent opportunity for experimentation. Grounds heavily infested with *Crepidula* are, therefore, of great value as a source of material for marine biological laboratories. Oyster growers do not share this enthusiasm because the presence of large numbers of unwanted slipper shells requires additional work in cleaning the oysters before delivery to market.

On many occasions *C. fornicata* has been introduced to Europe with the shipment of live oysters from the United States. It has established itself in Essex, Northumberland, Falmouth, England, and in South Wales. In 1929 the first specimens of *C. fornicata* were noticed in the Oosterschelde, Netherlands, and in 1932 to 1933, according to Korringa (1950), the situation became alarming. The mollusk spread to the German and Dutch