COMMON PARASITES OF FISHES

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Glenn L. Hoffman, Bureau of Sport Fisheries and Wildlife, Leetown, W. Va.
and
Carl J. Sindermann, Bureau of Commercial Fisheries, Boothbay Harbor, Maine

Fish taken commercially, for sport, or raised by fish fanciers are sometimes found to be abnormal due to injury, deformity, disease, or the presence of parasites. This paper is concerned with common parasites of fishes and their recognition. Life cycles and biology are mentioned briefly, and references to more detailed literature are included.

Parasites may be defined as "animals that live on or in another animal, the host, at the expense of that animal." There are many kinds of parasites which may be found on the surfaces of fish, including the gills, as well as in the flesh and internal organs (fig. 1). Those on the surface are known as *external parasites,* and those that live inside are called *internal parasites.* Several types may occur together in a single fish. Some parasites are fairly large (up to several inches) and can be seen easily, but many are microscopic. Scientists who work on parasites describe the organisms, study the life cycles (some have several intermediate hosts), survey the kinds and numbers found in fish, study damage done to fish, and attempt to control them. Research is carried on by the U. S. Fish and Wildlife Service and some colleges and universities.

Under natural conditions in both fresh and salt water, most of the parasites produced are lost to enemies or to the expanse of water before they can infect fish. Apparently a light parasitic infection does little harm to the host. Under crowded conditions or inadequate water and oxygen supply, however, fish may become heavily parasitized; in such cases, more damage is done and the fish may even die. Such conditions sometimes occur in hatcheries, causing heavy loss of fish.

Much of the damage to fish appears to be mechanical. Parasites may injure tissues and blood vessels by their burrowing, or block blood vessels entirely with their bodies or their eggs. Some actually eat skin, other tissues, mucus, or body fluids. Some parasites are known to release toxic materials in other hosts, but this has never been demonstrated in fish. Probably fish weakened by parasites are easily captured by predators.

Fishermen who find parasites when they clean their catch frequently discard the fish. This is an unnecessary waste. Although worms and other parasitic forms are unsightly, none of them can possibly harm humans if the fish is thoroughly cooked. Freezing and hot smoking of the fish will also kill most parasites, but some may remain alive in brine for a month. A few parasites may develop in man if the fish containing them is eaten raw. Best known in this category is the broad fish tapeworm *(Diphyllobothrium latum),* whose larvae may be found in the muscles and among the viscera of pike and perch, particularly in our northern lakes. Most fish parasites will not live in man.

The commercial fishing industry suffers great losses each year because of parasitized fish which are condemned for human consumption and can be sold only for animal feed at reduced price. In Minnesota, for example, tullibees (ciscos) are infected with tapeworm cysts *(Triaenophorus)* which do not infect humans but are unsightly. The annual catch of 2-1/2 to 3 million pounds, if uninfected, would find ready markets for human use, but as much as 1,500,000 pounds have been condemned by governmental agencies. Similar losses occur in marine fisheries.

At present there is no known control for most parasites except in relatively small bodies of water such as fish hatcheries, small ponds, and aquaria. References to the methods of treatment of fish parasites may be found in Hoffman (1959).

The major parasite groups discussed in this report are listed and explained below:

Protozoa - single-celled animals, usually microscopic. Parasitic groups of protozoa important to fishes include Ciliata, Flagellata, Myxosporidia, and Microsporidia; may be either external or internal parasites. While the individual protozoan is usually microscopic, aggregations may cause effects recognizable by the naked eye.

Monogenetic trematodes - External flatworms, usually small, commonly called flukes, often found on the gills; are called monogenetic because they complete their life-cycle on one host (mono = single, genetic = origin). Posterior organ of attachment (haptor) well developed with chitinous clamps and hooks.

Digenetic trematodes - Internal flatworms, often very small, but occasionally large enough to be seen easily; are called digenetic because at least two hosts are needed for their life-cycle (di = two, genetic = origin). Larva (metacercaria) or adult may be found in fish, first intermediate host is snail or clam; possess oral and ventral suckers; eggs present in adults which may be found in alimentary tract, occasionally elsewhere; metacercariae in various organs (skin, muscle, mesenteries, etc.).

Cestodes - Tapeworms, are also flatworms, but are distinct from "flukes" in that the adult worm is usually composed of a head (scolex) and many egg-producing segments. Found as adults or larvae in fish; intermediate stages in "water fleas".

Nematodes - Unsegmented roundworms (actually cylindrical) which occur as larvae in tissues, and as adults in the alimentary tract, occasionally elsewhere. Adult female contains eggs, larva does not.

Acanthocephala - "thorny-headed" worms, which occur as larvae or adults in fishes.

Parasitic copepods - Small highly specialized crustaceans related to crayfish and crabs, often called "fish lice," usually found on external surfaces; sometimes embedded, sometimes loosely attached; shape may be louse-like to wormlike.

Leeches - External worms recognizable by their external segmented appearance, frequently bright coloration, and a large sucker at the posterior end.

Glochidia - Fresh-water clam larvae in cysts on gills or fins of fish.

Lampreys - Primitive fishlike vertebrates and the largest of the fish parasites, ranging up to 3 feet in length. They may be recognized by the large circular mouth containing many rows of thornlike teeth.

In most instances marine and freshwater fish have different parasites, therefore, they are discussed separately under FRESH-WATER PARASITES and SALT-WATER PARASITES.

The following plan of organization is followed under each category:

(1) Parasites of the body surfaces and gills

(2) Parasites of the body muscles

(3) Parasites of the viscera

A simplified drawing (fig. 1) of an opened fish is included to show the various organs.

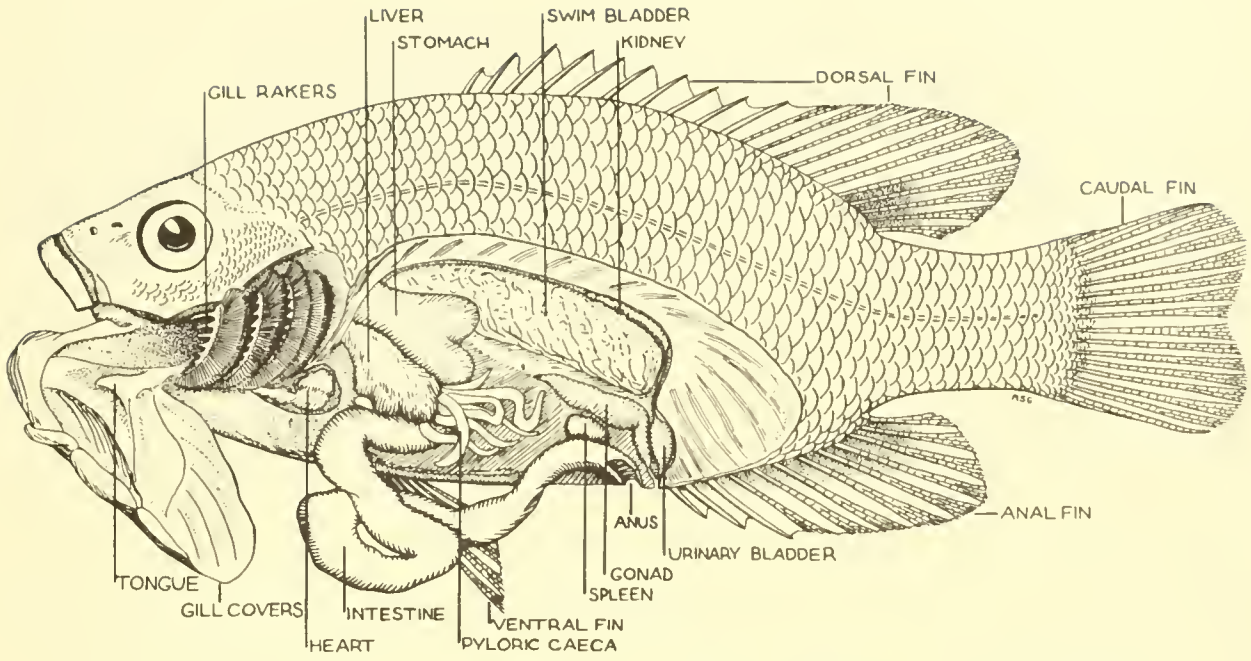


Figure 1.--Drawing of *Lepomis cyanellus*, (from Hile, 1960, U. S. Fish and Wildlife Service, Fishery Leaflet 132).

FRESH-WATER PARASITES

Parasites of the Body Surfaces and Gills

1. *Fungi*. White cottony growths on wounds or ulcerations are usually fungi of the genera *Saprolegnia* and *Achlya*. The filaments can be seen easily under the microscope. The fungus often develops as a secondary infection following wounding or ulceration due to other agents.

2. *Protozoa*. These are the smallest animals. They consist of a single cell, and nearly all are too small to be seen without a microscope. Some protozoa form whitish cysts containing many spores. Such cysts are large enough to resemble worm larvae superficially. They may be found in many organs including the skin and gills.

Often in aquaria and fish hatcheries, a condition develops which is known as "Ich" or "white spot." The fish are seriously affected, and many little white spots can be seen - some of them moving slowly over the fish. These are individual protozoa, *Ichthyophthirius multifilis*, the largest protozoan to be found on fish. Under the microscope the most striking characteristics that can be seen are the constantly beating hair-like cilia, which completely cover the parasite (fig. 2).

All other protozoa that live on the skin of fish are very small in comparison to *Ichthyophthirius*. Although some of them are serious fish disease agents, none is harmful to man.

Myxosporidian cysts containing many spores (fig. 3) are whitish and usually large enough to be seen easily. They are found in many organs including the skin and gills.

3. *Internal flukes* (digenetic trematodes). These small worms are flat, leaflike forms from 1/250- to 1/8-inch long with two suckers. The trematodes most frequently seen are larvae ("grubs") encysted in the skin or flesh. The largest of these larvae is the yellow grub, *Clinostomum marginatum* (fig. 4). The cyst is yellowish, about 1/8 inch in diameter, and is usually seen in the gills and at the bases of the fins but may

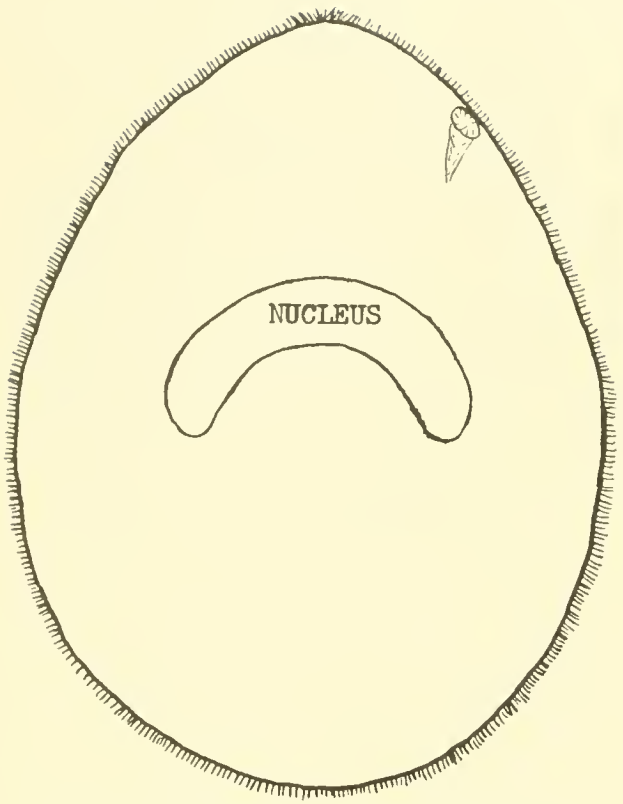


Figure 2.-- *Ichthyophthirius multifilis*, ciliated protozoan, the "Ich" of aquarium and fish hatchery fish.

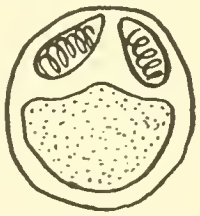


Figure 3.--*Myxobolus* spore from white cysts.

occur almost anywhere, including internally. If the cyst is removed and opened, the larva can be seen. The life history (fig. 5) is typical for the group. When the fish is eaten by a heron the larva is digested free from the cyst and continues development in the intestine of the bird. Most trematodes develop to maturity in the intestine of the host, but the "yellow grub" migrates to the esophagus where it matures. The adult

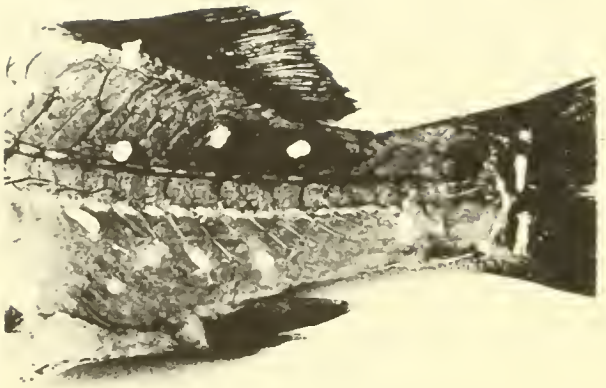


Figure 17.—Yellow grubs in flesh of yellow perch. (Courtesy of the New York Conservation Department.)

Figure 4.-- *Clinostomum marginatum* "yellow grubs" in the flesh of yellow perch. (Courtesy of the New York Conservation Department).

produces eggs which pass out in the feces into the water. After a suitable period, these hatch into a microscopic free-swimming larva (miracidium) which has about 8 hours to find the right kind of snail. If it succeeds, it burrows in and continues to develop. It produces many of the next stage larvae (cercariae) which burrow out of the snail. To survive, cercariae have about a day in which to contact a fish and burrow into the tissue. In the fish, the worms may migrate a short distance before reaching their final site where they secrete a cyst wall about themselves and become the "yellow grubs", completing the cycle.

Another type of fluke that is often noticed is the "black grub" (fig. 6), a very small larva enclosed in a black cyst about 1/16 inch in diameter. These may be the larvae of any one of many trematodes but the most common is known as *Neascus*. The life cycles are similar to that of the "yellow grub." Different fish, birds, and snails may be involved.

4. *Gill flukes* (monogenetic trematodes). Most of these are microscopic, but one of the larger ones, *Discocotyle salmonis* (fig. 7) often occurs on the gills of trout and salmon. It is about 1/4 inch long and attaches by its large rear suckerlike attachment organ to the gill of the fish. Sometimes these flukes become so numerous that the fish are seriously affected. Another very common monogenetic trematode, *Gyrodactylus*,

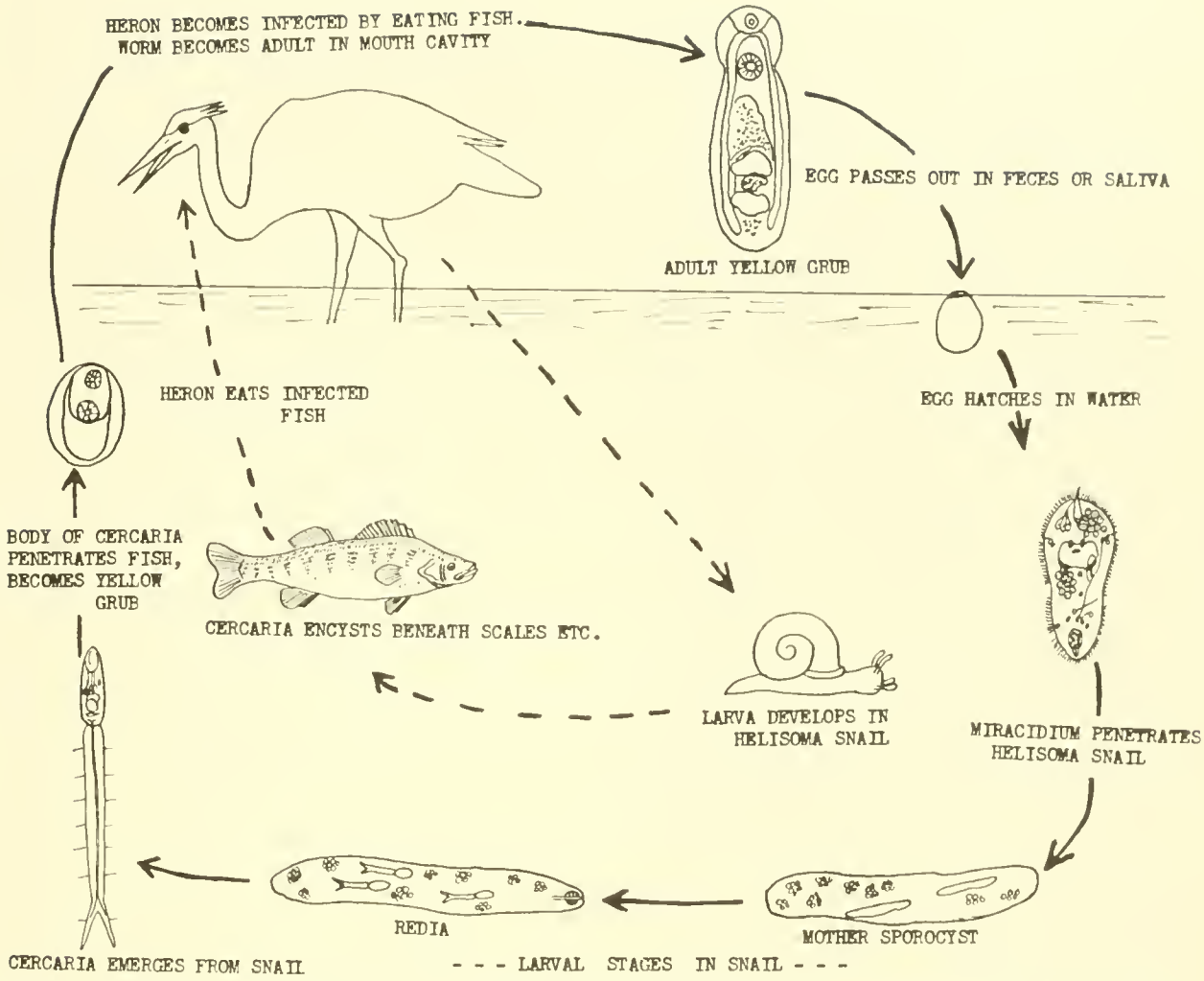


Figure 5.--Life cycle of the "yellow grub," *Clinostomum marginatum*. Outer circle (solid line) includes the worm stages. Inner circle (broken line) includes the hosts.

is usually found in greater numbers on the body than on the gills; most of the others occur on the gills only.

5. *Parasitic copepods.* In some ponds and hatcheries, the "anchor worm" copepod *(Lernaea)* flourishes. It protrudes wormlike from the fish, usually at the base of a fin, with its head buried in the fish. The visible portion is cylindrical, whitish, and about 1/2 inch long (fig. 8). There are often two egg sacs extending from the end of the creature. With care, the head can be dissected out of the fish, and one can then see that some of the forward appendages have become modified into a very efficient "anchor." This parasite goes through several microscopic developmental stages usually on the gills of fish other than the one on which it finally matures. Because it can do considerable damage to fish if present in large numbers, it should be eradicated from fish rearing ponds and hatcheries, and parasitized fish should not be used for stocking.

Sometimes "fish lice" *(Argulus)* may be seen crawling over a fish. They are among the largest of external parasites and can be seen easily. They are round to oval when

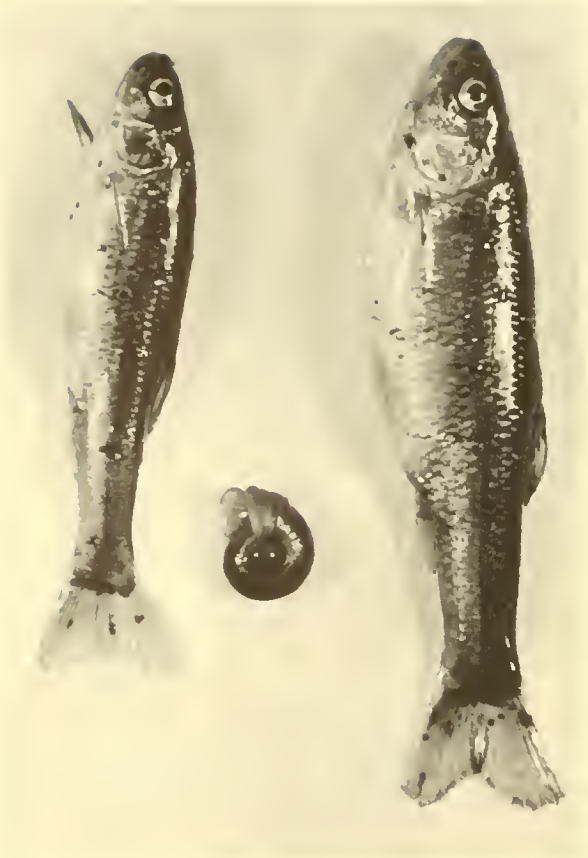


Figure 6.--*Crassiphiala bulboglossa*, a *Neascus* metacercaria of one of the several "black spot grubs" of fish in the fathead minnow, *Pimephales promelas*.

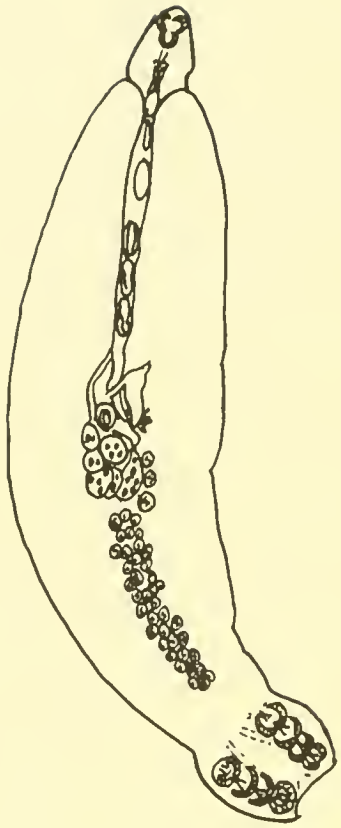


Figure 7.-- *Discocotyle salmonis*, an ectoparasitic trematode from the gills of trout (after Price).

seen from above and are flattened from top to bottom. Four pairs of swimming legs extend from their sides (fig. 9). The eggs are borne in sacs at the end of the female. The eggs drop off when developed, hatch, and the larvae must eventually find a fish or perish. There are several larval stages which precede final development of the adult. Other forms, *Ergasilus, Achtheres,* and *Salmincola,* are usually found attached to the gills.

6. *Glochidia.* These small larvae of some of the large fresh-water clams clamp onto the gills or fins of fish where they remain for 10 to 20 days. Some of the fish tissue grows up and over the glochidium (larva) forming a small translucent cyst about 1/8 inch in diameter. If numerous, they cause considerable damage to the fish.

7. *Blood suckers* (leeches). Except for lampreys, these are the largest external parasites, sometimes reaching an inch in length. There are suckers at each end of the flattened, segmented body. The front sucker contains the mouth with which the parasite rasps a small hole in the fish skin to obtain its meal of blood (fig. 10). Leeches often attach near the bases of or on the fins. They transmit certain protozoan parasites from fish to fish through their feeding. The kinds of leeches that parasitize fish do not attack humans.

Parasites of the Body Muscles

1. *Protozoa.* Myxosporidian cysts containing many spores (fig. 3) are whitish and

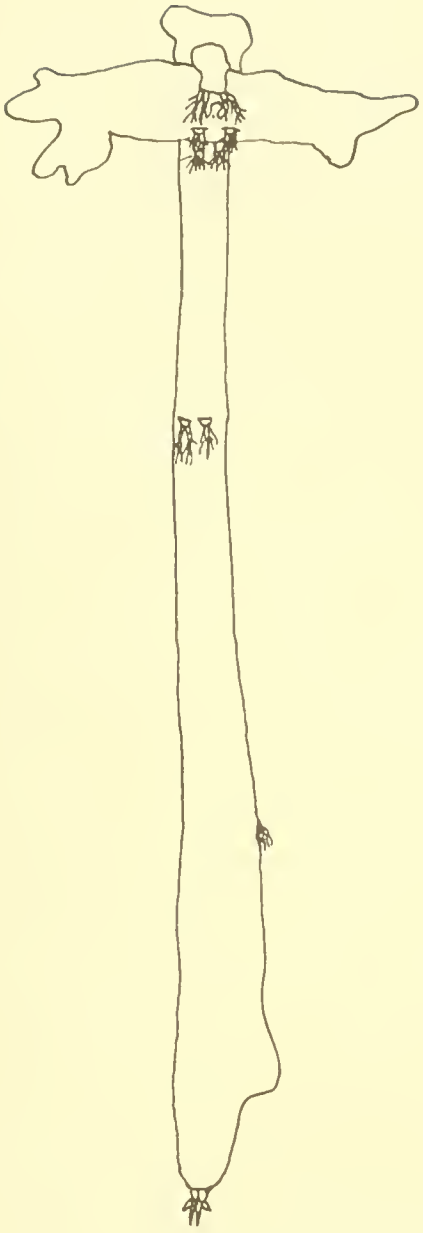


Figure 8.-- *Lernaea tortua*, the "anchor worm" of fish (after Wilson).

large enough to be seen easily. They are found in many organs but some species found in the muscle produce a large ugly-looking "boil." These are not infective for man.

2. *Flukes*. Some of the "grubs" discussed in the previous section may be found in the muscle.

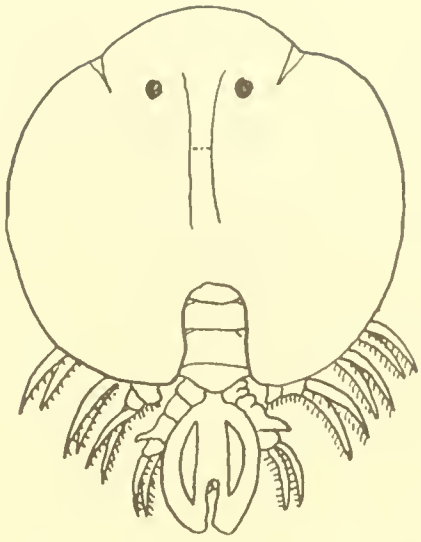


Figure 9.--*Argulus trilineatus*, the "fish louse" (after Guberlet).

3. *Tapeworms*. A tapeworm that is considered important because it may infect man through eating improperly cooked infected fresh-water fish is the broad fish tapeworm, *Diphyllobothrium latum*. The white larva (plerocercoid) may be found among the viscera as well as in the flesh, and may be up to an inch in length, but has no other outstanding characteristics. Normally the parasite will attain maturity in the intestine of bears, man, dogs, and perhaps other animals if they eat infected fish (fig. 11). It grows into a large worm - up to 30 feet in length - and produces millions of eggs which pass out with the feces of the animal. If the eggs fall or are washed into the lake, a small swimming larva (coracidium) hatches out. This very active creature develops into the next larval stage (procercoid) when eaten by certain species of "water fleas" (copepods). Small fish feed on the infected copepods, and if a pike or perch eats such fish, the larva will continue to develop. Humans become infected by eating raw fish containing the larval stages.

4. *Roundworms* (nematodes). The largest one seen in muscle is *Eustrongylides* (fig. 12). It is a red worm coiled up in a cyst about 1/4 inch in diameter and is sometimes seen while dressing a fish. It may also be found in the body cavity. The life cycle is not entirely known, but it is probable that a bird is the final host.

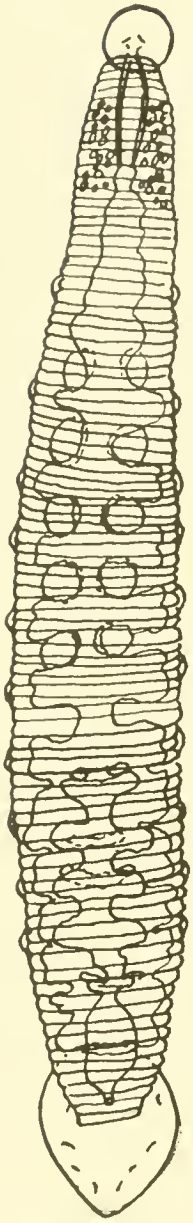


Figure 10.-- *Piscicola salmositica*, a leech or "blood-sucker" (after Meyer).

Parasites of the Viscera

1. *Protozoa.* Internal fish protozoa are usually not seen by the casual observer except for the myxosporidian cysts discussed in previous sections.

2. *Flukes.* "White grubs" are sometimes found in the visceral organs. These are somewhat similar to the "yellow grubs" discussed previously, and are not harmful to man. Adult flukes of fish occur in the intestine and stomach, but are usually small and not seen.

3. *Tapeworms* (cestodes). Two forms of these are seen in fish. One, the adult, lives in the intestine of fish. It is flat like a tape, and often several inches long. It is this stage that is seen when the intestine is accidentally cut or torn during cleaning of the fish. The other form is the larva (plerocercoid), which may or may not be the same species as the adult seen in the fish. Larvae are smaller, nonsegmented, and may occur among the internal organs as well as in the flesh of the fish. Calcareous corpuscles (round concretions of lime) can be seen microscopically in all tapeworm larvae; this is sometimes a very helpful characteristic for identifying a larval tapeworm parasite. The adult from fish is never harmful to man, but some of the larvae, if eaten raw, can develop in man. We have previously discussed the best known one in this group, the broad fish tapeworm (p. 7).

One of the most noteworthy fish tapeworms is the bass tapeworm, *Proteocephalus ambloplitis* (fig. 13). The larvae (plerocercoids) often cause sterility in black bass. The adult lives in the intestine of black bass and produces large numbers of eggs which pass out with the feces of the fish into the water. The small larva in the egg will develop to the next stage larva (procercoid) if eaten by the proper kind of copepod. After development in the copepod, this larva invades small fish which eat the infected copepods. The larva is freed in the intestine of the small fish, burrows through the intestinal wall, and wanders among the internal organs. When large numbers of these larvae (plerocercoids) are present they cause considerable damage to the fish. Small bass, once infected, will retain the larvae for a long period of time. Larger bass accumulate larvae by eating small fish that have recently fed on infected copepods. Larvae, if still in the stomach or intestine of the small fish when eaten by the larger fish, will migrate through the intestinal wall and into the visceral cavity of

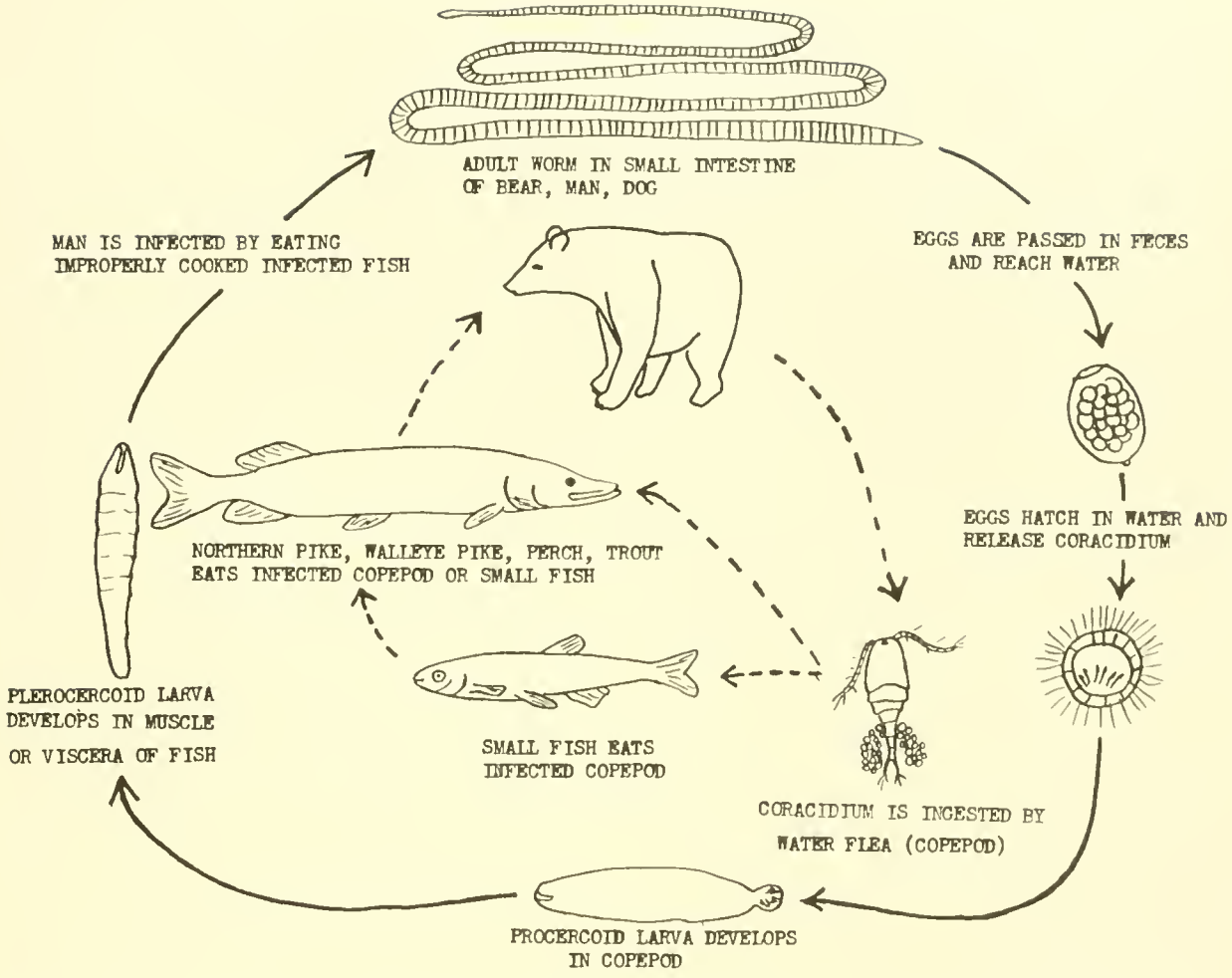


Figure 11.--Life cycle of the broad fish tapeworm, *Diphyllobothrium latum*. Outer circle (solid line) includes the worm stages. Inner circle (broken line) includes the hosts.

the larger fish. The damage done by the larvae moving among the reproductive organs may render the fish sterile. The life cycle is completed when a larger bass eats an infected smaller fish in which the larvae have had time to become established in the visceral cavity. The larva is then freed in the intestine of the larger bass and grows into the adult tapeworm.

The large larva of another tapeworm, *Ligula intestinalis*, is often seen in the body cavity of minnows and suckers (fig. 14). Sometimes it becomes so large in small fish that it causes the body wall to burst, releasing the worm. This worm develops into an adult in the intestine of fish-eating birds.

4. *Roundworms* (nematodes). The red worm, *Eustrongylides* (fig. 12 and p. 7) may occur among the viscera. Some smaller larval nematodes may also be present. A very long, thin nematode, *Philonema*, causes serious damage to the reproductive organs of salmonid fish. Usually the adult nematodes in the intestine are not noticed because of their small size. None of these is harmful to man.

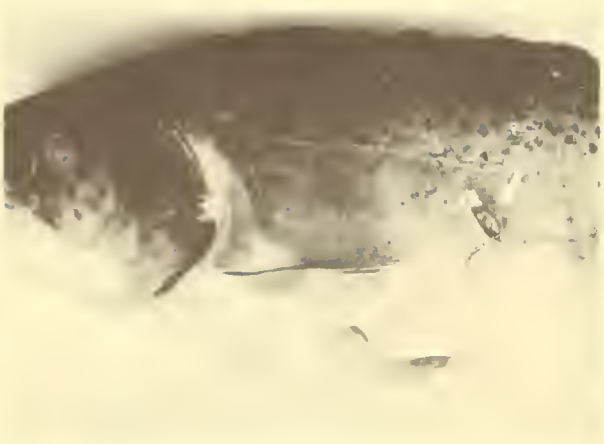


Figure 12.--The "red worm," larval nematode, *Eustrongylides*, from the flesh of fish.

5. *Thorny-headed worms* (Acanthocephala). These cylindrical worms have rows of hooks on their heads which become embedded in the intestinal wall of the fish. Unless large numbers are present no harm is apparent.

SALT-WATER PARASITES

Parasites of the Body Surfaces and Gills

When a fish is first taken from the water it may be carrying a variety of external parasites or external evidences of disease. The mouth and gill chambers are favored sites for certain parasites because these areas afford protection and are in close proximity to the host's blood supply.

1. *Fungi and protozoa* ulcerations of the skin may be due to underlying protozoan or fungus infection of the flesh (as in young sea herring). Such infections kill tissues and cause the skin to slough, creating the external ulcers. Two groups of the protozoa (Myxosporidia and Microsporidia) may invade the muscles, producing ulcers of the skin (fig. 15). Fungus organisms, such as *Ichthyosporidium hoferi,* may also cause ulcers.

2. *Trematodes* or flukes may be found on the body surfaces of the larger marine fishes such as halibut, sharks, skates, and ocean sunfish. These worms may be leaf- or disc-shaped and characteristically possess a conspicuous attachment organ of hooks and/or suckers. Trematodes are also common on the gill bars and filaments of marine fishes, but are usually quite small and not easily observed, unless the fish is heavily parasitized.

3. *Grubs* of marine fishes--larval trematodes that localize beneath the skin or in the fins--are common in inshore waters. So-called "pigment spot" of cunner, herring, mackerel, butterfish, and other fish is caused by encystment of such larvae beneath the skin. The life cycle of the worm *(Cryptocotyle)* that is responsible involves successively a snail, a fish, and a sea gull (fig. 16a, 16b). The adult fluke inhabits the bird's digestive tract and sheds its eggs with the droppings of the host. Snails become infected by eating the worm eggs. After a period of larval development in the tissues of the snail, an infective stage, known as the cercaria, emerges from infected snails and is free-swimming until it contacts the fish host, where it penetrates the skin and encysts. The cycle is completed when fish carrying encysted larval worms are eaten by the bird. Other larval trematodes may also cause "pigment spot" of marine fish, but they are not as well understood, except that a fish-eating bird and a snail are usually necessary for completion of the life cycle. Flounders are often invaded by larval flukes which do not cause pigment accumulation. Encysted larval worms appear as tiny opaque white patches in the fins and on the light undersurface of the fish.

4. *Parasitic copepods* --fish lice--may be found on external surfaces of many species of marine fishes. These may be of various forms. Some are temporary and retain their mobility, moving freely from fish to fish, while others, such as *Sphyrion* on the ocean perch (redfish), are permanent tissue invaders (fig. 17). Anchorlike projections of the head of this particular copepod grow into the flesh, often causing an unsightly ulcer. This projection persists as a brownish mass in the flesh after the parasite dies.

Copepods may also be found attached to the gills and gill regions of marine fishes. An

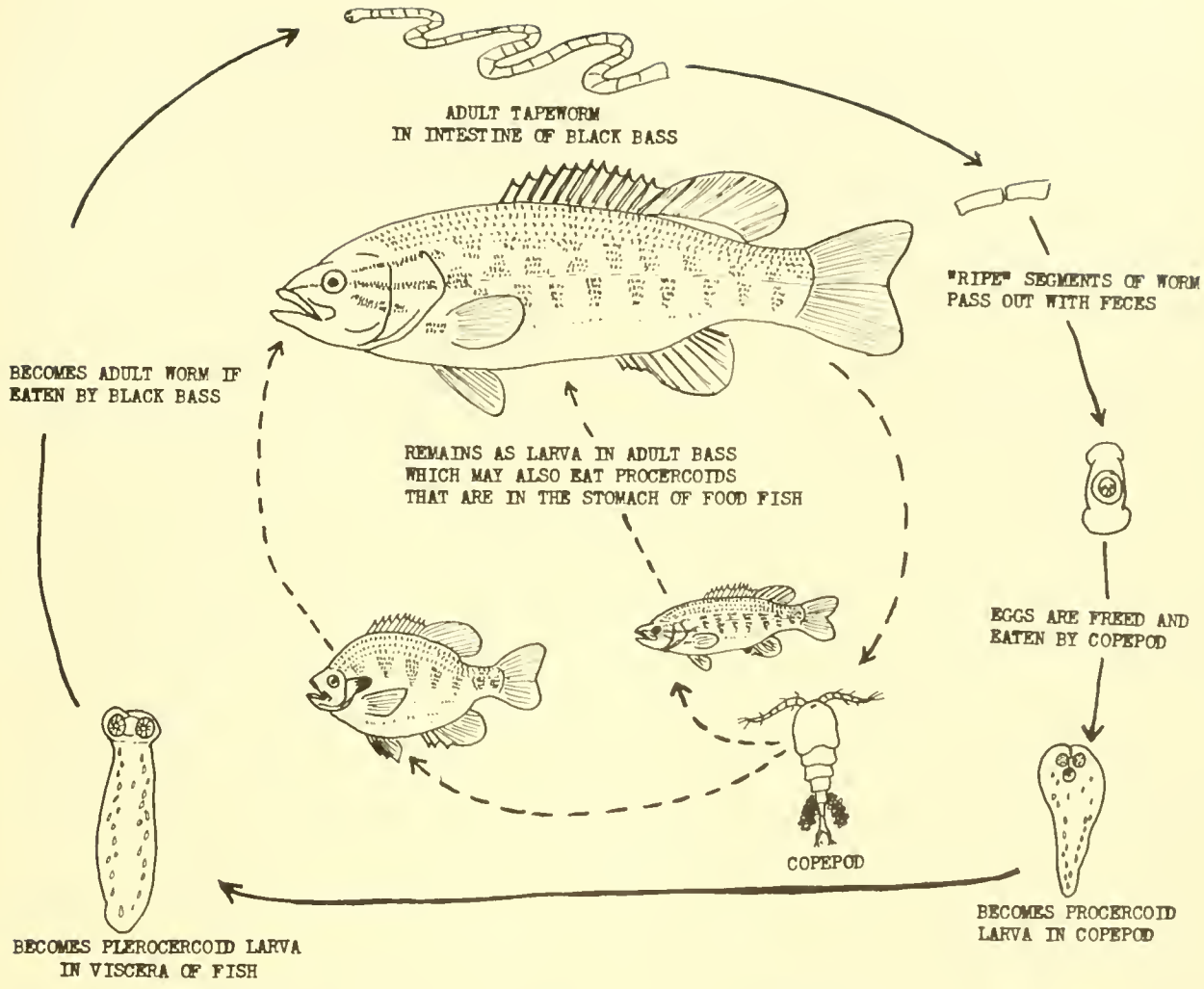


Figure 13.--Life cycle of the bass tapeworm, *Proteocephalus ambloplitis*. Outer circle (solid line) includes the worm stages. Inner circle (broken line) includes the hosts.

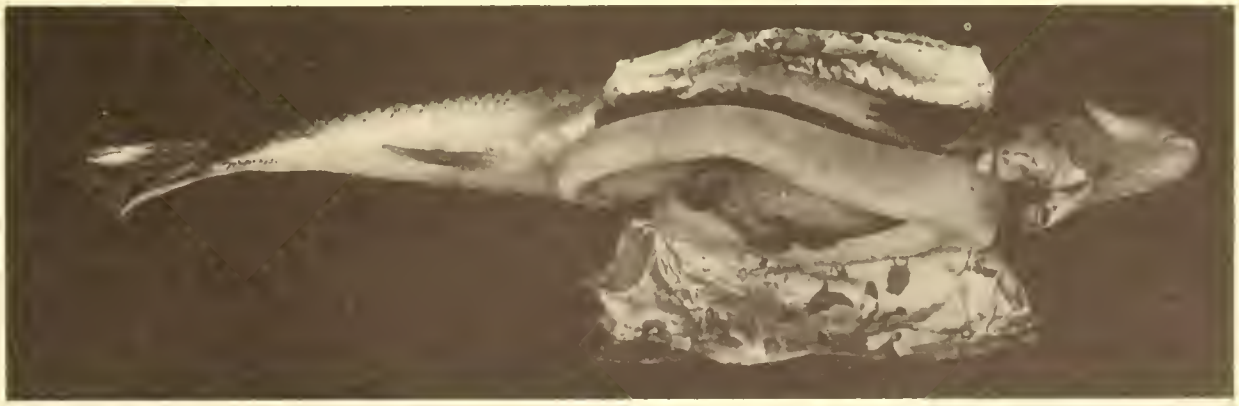
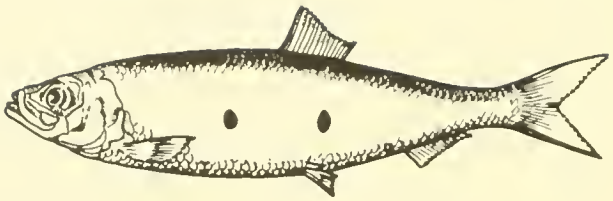


Figure 14.--*Ligula intestinolis* (tapeworm larva) in the chub, *Couesius plumbeus*. (Courtesy of the New York Conservation Department).

Figure 15.--Skin ulcers in young herring caused by underlying muscle infection with the myxosporidian, *Kudoa clupeidae*.



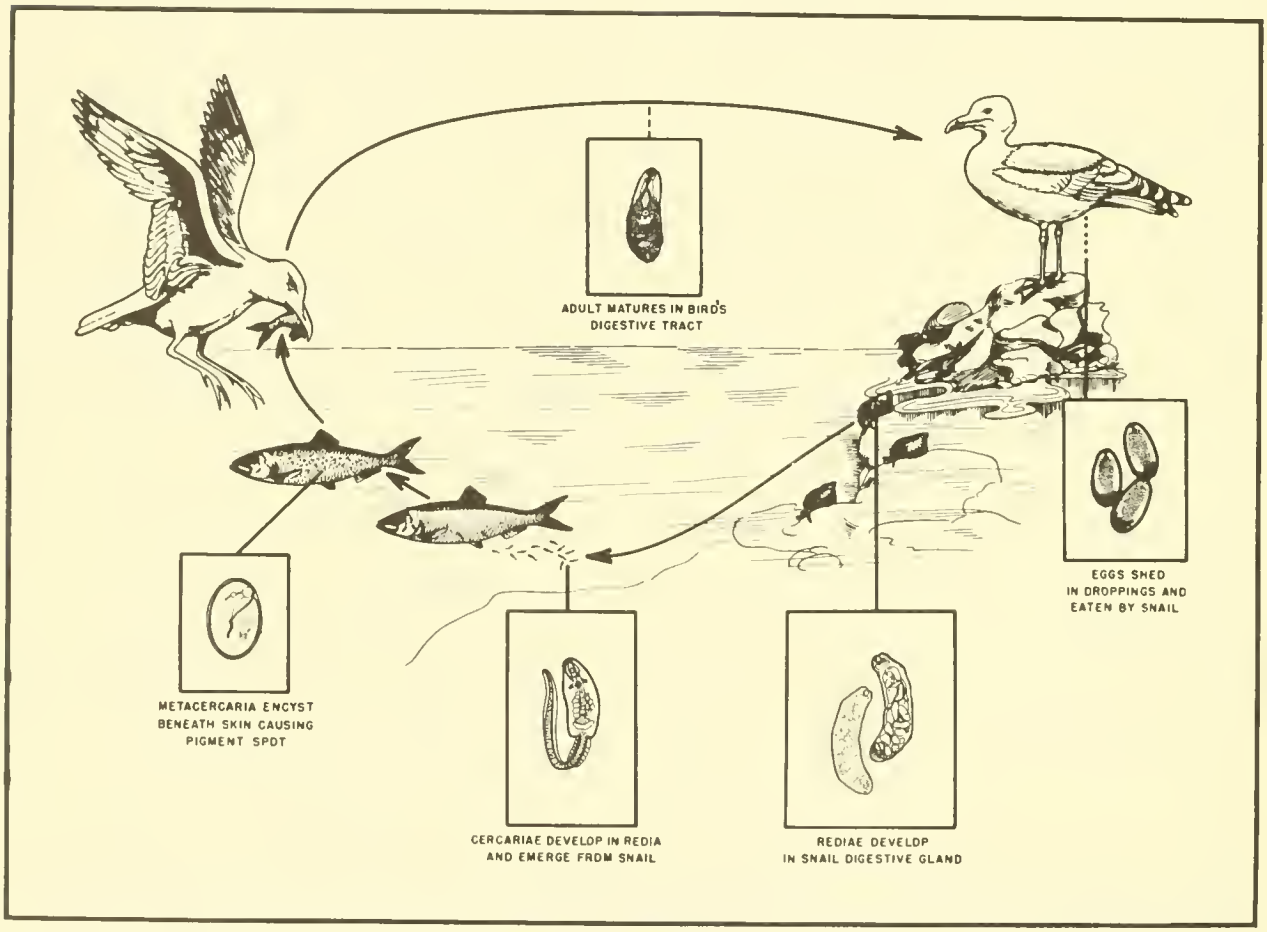


Figure 16a.--Life cycle of *Cryptocotyle lingua*, the worm whose larvae cause "pigment spot" of herring and other fish.

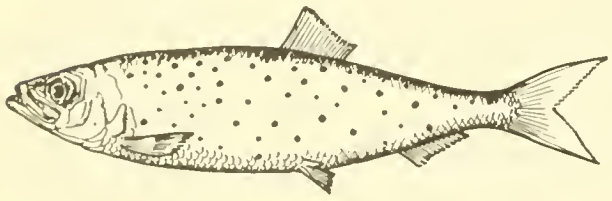


Figure 16b.--Pigment spot of herring caused by *Cryptocotyle lingun*.

extreme example is *Lernaeocera branchialis* found on cod and some other species (fig. 18). The copepod is located in the gill chamber, but roots formed by extensions of the body extend into the host, eventually penetrating to the heart region. The life cycle includes lumpfish, flatfish, and possibly others as intermediate hosts.

Parasites of the Body Muscles

Because the flesh of fish is the part that is usually consumed by man, parasites and diseases affecting the body muscles of fish are of primary concern. Though parasites are killed by proper cooking, the presence of worms or other abnormal conditions in the flesh of food fish is esthetically and phychologically disturbing, and many fish thus affected are discarded unnecessarily.

1. *Protozoa* are significant and sometimes conspicuous parasites. Myxosporidia form either spindle-shaped white nodules up to 1/2 inch in length or so-called "pus pockets" in the flesh of small herring, alewives, and menhaden from the east coast. Myxosporidia are also responsible for the conditions known as "jellied swordfish" on the Atlantic coast and "wormy halibut" on the Pacific coast. Both are characterized by progressive destruction and liquefaction of the muscles, producing unsightly areas in the flesh that must be cut out and discarded, or else the entire fish may be discarded.

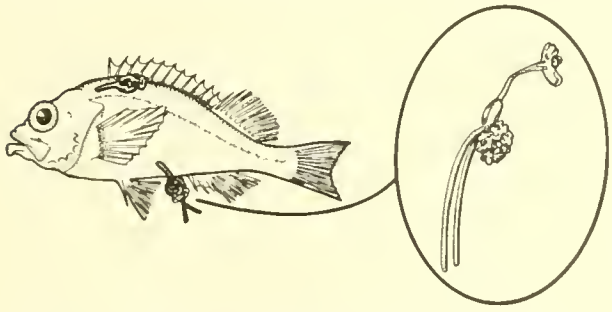


Figure 17.--Parasitic copepods *(Sphyrion lumpi)* embedded in redfish. Dissected copepod is shown at right.

Figure 18.-- *Lernaeocera branchialis* from cod. Note the "antlers"--anterior projections of the copepod that anchor it in the flesh of the host.

2. *Fungus infections* may produce muscle abnormalities. A fungus infection of herring on the east coast of North America produces small yellow-white nodules. Advanced infections result in extensive degeneration of muscles, and diseased fish are difficult to salt or smoke (fig. 19). Another symptom of this fungus infection is the accumulation of black pigment around spores in the flesh, making the fish less desirable for filleting and pickling.

3. *Larval trematodes* occur commonly in the flesh of many coastal marine fishes. Conspicuous in this respect are young Atlantic herring, in which larvae of the fluke *Cryptocotyle* frequently localize in the muscles as well as underneath the skin, causing black pigment accumulation and the formation of a conspicuous "pigment spot." Flounders are frequently invaded by another larval trematode which appears as a small opaque white cyst in the flesh although there is no pigment response.

4. *Larval nematodes* in the flesh of marine fishes best fulfill the popular conception of "worms." They may occur free or encysted in the muscles, and may become very active when released. The so-called "codworm" *Porocaecum* has received particular attention, especially on the Canadian east coast. This larval roundworm encysts, sometimes in great numbers, in the flesh of cod, smelt, and other fishes (fig. 20). Its life cycle is not completely understood, but it involves a succession of fish hosts, with the seal as the final host for the adult worm. Other kinds of larval roundworms may be found in haddock and other commercial marine fish, occasionally in great numbers, but usually only a few in any single fish.

Usually they are cooked, eaten and never noticed, but occasionally they may be seen and may result in unnecessary waste of the fillet or the fish. None has been demonstrated to be harmful to humans. Usually a fish-eating bird or mammal serves as host for the adult worms.

5. *Larval cestodes* may localize in the flesh of marine fishes, although this condition seems less frequent than in fresh water. Butterfish of the U. S. east coast frequently have tapeworm larvae in small (less than 1/25-inch) white to yellow cysts in the body muscles. Occasionally enormous numbers of such cysts may be found in individual fish (fig. 21). Other tapeworms may occur as contorted opaque white ribbons in the flesh of fish, often in sufficient numbers to require discarding the fish.

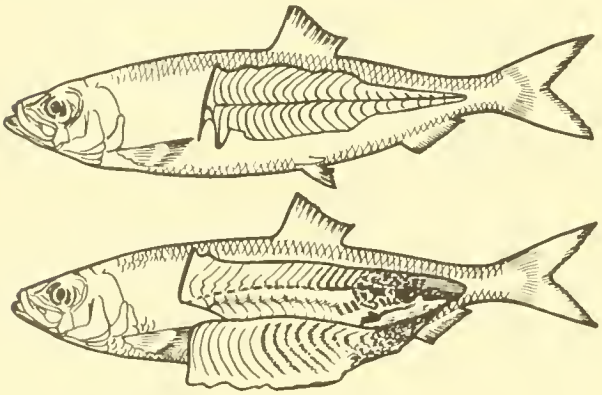


Figure 19.--Adult herring infected with fungus. Top--skin has been sliced away to show normal muscle. Lower--shows advanced decay of muscles.

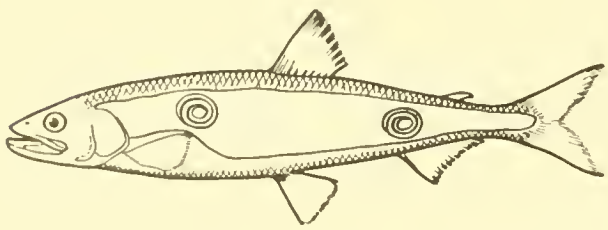


Figure 20.--Smelt with codworms encysted in flesh.

Parasites of the Viscera

Inhabitants of the visceral mass of fishes are many, and are often apparent when fish are dressed. Adult worms--cestodes, trematodes, nematodes, and acanthocephala--usually occupy the digestive tract, while larval stages of members of these groups may be found, usually encysted, in the gut wall, the liver, or the supporting membranes. In addition to worm parasites, there may be protozoan and fungus infections.

1. *Protozoa* may occur in nodules or cysts on and in the viscera of fish. These are actually masses of thousands of spores, much like the nodules or cysts in the flesh. Conspicuous in this respect are such forms as *Glugea hertwigi*, a microsporidian that produces white cysts in the viscera of eastern smelt (fig. 22). This parasite may occasionally be sufficiently abundant to interfere with reproduction. It varies in abundance geographically, and may occur in over one-quarter of all fish sampled in particular areas.

2. *Fungus infections* and resulting involvement of the viscera are found in such marine fishes as the Atlantic herring, mackerel, and flounder. A fungus disease

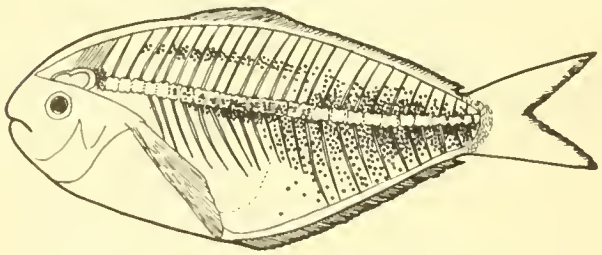


Figure 21.--Larval tapeworms in the flesh of butterfish.

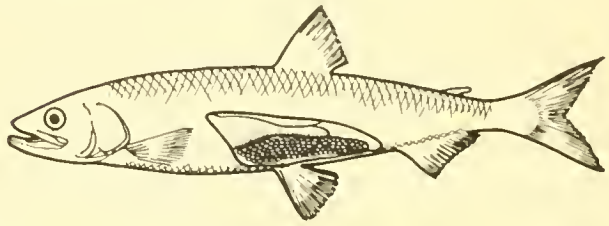


Figure 22.--Visceral cysts of the microsporidian *Glugea hertwigi* in a smelt.

of marine fishes, caused by *Ichthyosporidium hoferi*, has received some attention in recent years, especially in North America, where it has periodically assumed epidemic proportions in the Atlantic herring. Visceral symptoms often include extensive white nodules on and in the heart, liver, gonads, and mesenteries (fig. 23).

3. *Adult trematodes* are common, but their small size and location within the gut make them inconspicuous. Occasionally hundreds or even thousands of these small adult worms may be found in the digestive tract of a single fish. They are usually less than 1/4 inch long, opaque white, with a brownish patch of eggs near the center or posterior part of the body.

4. *Larval nematodes* may localize in the viscera, particularly in the mesenteries adjacent to the digestive tract. They are often found encysted in tightly coiled spirals in the Atlantic and Pacific herrings, redfish, and many other species, and may become very active when released--moving in a typical whiplike manner. Numbers per fish range from a few to many hundreds.

5. *Adult nematodes* may also be found in the digestive tract, but as a rule are not conspicuous.

6. *Larval cestodes* may be regionally abundant in the viscera of many fish species. Frequently these are larvae of tapeworms which mature in sharks and skates or in fish-eating birds. The larvae encyst in the mesenteries or wall of the digestive tract as white ovoid or club-shaped nodules, frequently 1/8 to 1/2 inch in length.

7. *Adult cestodes* inhabit the digestive tract of fish, and may be recognized by their extended white ribbonlike appearance--the ribbon being composed of many egg-producing segments. Such worms may occasionally be found extruded from the vent of the fish after death (this often happens with smelt, for example). Worms are usually few in number in any single host, but may occupy the entire length of the intestine.

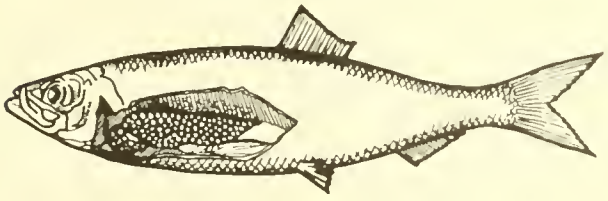


Figure 23.--Visceral nodules in herring caused by the fungus *Ichthyosporidium hoferi*.

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