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PROTEOCEPHALUS AMBLOPLITIS, THE BASS TAPEWORM, ITS LIFE HISTORY, IMPORTANCE TO BASS CULTURE AND ITS CONTROL

by

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The study of *Proteocephalus ambloplitis* is of interest to the fish-culturist and the sportsman as well as to the scientist because of its damage to two important game fish, the smallmouth bass, *Micropterus dolomieu*, and the largemouth bass, *Huro salmoides*. It has been found widely distributed throughout lakes in eastern United States. No attempt to include all the minute details of its structure, development and experimental data will be made in this report. Rather it will concern only the salient features of the information set down by various investigators.

The adult of this tapeworm was first described by Joseph Leidy in 1887 as *Taenia ambloplitis* from the rock bass *Ambloplitis rupestris*, and in the same publication he described the plerocercoid (larva) as *Taenia micropteri* from the black bass *Micropterus nigricans*, the green or bayou bass now named *Huro salmoides*. Both stages have since been reported from other hosts mentioned later in this report.

In 1914, G. R. LaRue revised the family Proteocephalidae and included the synonyms of each species. For *Proteocephalus amboplitis* the synonyms are as follows:

1887:	Taenia amboplitis	Leidy (from rock bass)
1887:	Taenia micropteri	Leidy (from smallmouth bass plerocercoid)
1896:	Ichthyotaenia amboplitis ..	Riggenbach
1897:	Taenia ocellata	Linton
1900:	Proteocephalus amboplitis..	Benedict.

Marshall and Gilbert in 1905 and LaRue in 1909, 1911, and 1914 also used *Proteocephalus amboplitis*, and thus it stands today. P. H. Harwood (1933) discusses the characters of the Proteocephalidae and suggests that a revision is necessary.

The bass tapeworm is the largest species of *Proteocephalus* known from North America, reaching a length of 41 cm. (16.1 inches) and a width of 2.0 to 2.5 cm. (approximately 1 inch). The head is large and prominent, measuring 0.57 to 0.60 mm., has four suckers and a vestigial fifth sucker deep in the tissue, and has no rostellum. The vestigial sucker separates *Proteocephalus amboplitis* from all other species of *Proteocephalus*. Hunter (1928) says, "The only time at which the identification of the larva would be in doubt is during the first three days of development, i.e., from the time of ingestion by the Cyclops until ...."the formation of the invaginated scolex begins in the procercoid larva and the appearance of the vestigial fifth sucker, .."...so called by LaRue, 1914." No one has proven any definite function of this structure. LaRue suggests that it may be a sort of penetration gland. Since the plerocercoid migrates through the visceral tissues of the host for some time after infection takes place, it is reasonable to suspect that such might be the case.

LaRue (1914) says, "*Proteocephalus ambloplitis* may be further distinguished from all other known species of *Proteocephalus* by means of its extremely large sphincter vaginae which because of its length and its extraordinary development is remarkable. This species is also readily distinguishable from all other species of the genus by reason of the large number of coils of the ductus ejaculatorius."

A. R. Cooper in 1915, commenting on its probable life history, suggested that two intermediate hosts were necessary; one an aquatic arthropod and the second either minnows, small perch or the final host itself. His suspicions were confirmed by later workers.

In 1923 W. H. Rich described for the first time its pathogenic effects in the reports of the Division of Scientific Inquiry of the Bureau of Fisheries and shortly after this reports from various hatcheries of damage by this worm began to appear. Finally, in 1927, Ralph V. Bangham reported on the life history. His report mentioned only the hosts involved and the method of transfer, and again emphasized the damage caused by this worm. George W. Hunter III reported on the life history in greater detail the following year. Both of these accounts confirmed Cooper's assumptions.

Life History:

Mature proglottids (reproductive sacs) are passed by the bass and sink to the bottom, voiding eggs as they go. Thus the eggs are scattered over a wide area. The eggs appear dumb-bell shaped, although Cooper and Hunter have recorded other shapes; they are about 50 mu. long and each contains a 6-hooked oncosphere. Hunter and Hunter (1929) studied the viability of the eggs and found that the enclosed embryo began to disintegrate after 36 to 48 hours. So, to complete its cycle, the egg must be eaten within a relatively short time after it is liberated.

The first intermediate host becomes infected by eating the eggs, which hatch, burrow through the gut wall to the body cavity, and become the procercoid. *Cyclops leuckarti*, *C. vulgaris*, *C. prasinus*, *C. ablidus*, *Eucyclops agilis* and *Hyallela knickerbockeri* have been demonstrated carrying the procercoid infection. Hunter and Hunter (1930) state that, "The period of development of the procercoid in the first intermediate host has been found by the authors to vary from 9 to nearly 15 days, depending on temperature." They further state that, "This coincides rather closely with the period of time from the spawning act to the time the yolk sacs of the bass fry become resorbed and they rise to the surface and commence feeding upon the plankton. It is but a step farther to visualize the fry eating the infected plankton as they are slower of movement and consequently more easily caught."

The second intermediate host, a restricted group of fishes, eats an infected copepod, the procercoids burrow through the gut wall of the fish and normally locate at first in the mesenteries as plerocercoids. They tend to migrate to other parts of the viscera as the bass grows older, and to localize in tissues having a good blood supply, consequently well supplied with easily obtainable food. These organs are the gonads, liver, and spleen. Hunter and Hunninen (1934) comment that, "In heavy infestations the wanderings of these parasites are typically associated with a proliferation of connective tissue resulting in an indistinguishable tangle of organs and tissues. In cases of heavy infections the various organs themselves appear affected." This is the stage that fish-culturists are particularly interested in since the greatest damage is to the gonads, which are often sterilized by the plerocercoid. Bangham (1927) states that as high as 100 per cent of 150 brood stock bass were rendered sterile from this cause. Hunter and Hunninen (1934) have found that the plerocercoids found in the ovaries average nearly twice as large as those found in the testes. This was not true in bass less than four years old. It suggests two things--that the growth of the plerocercoid is favorably affected by the sexual activity of the female bass, and that the quantity of yolk produced probably is involved in the increased growth of the worm. Hunter and Hunter (1929) succeeded in experimentally infecting the rock bass (Ambloplitis rupestris), the yellow perch (Perca flavescens), and the top minnow (Fundulus diaphanus) with the plerocercoid stage. They obtained negative results with the spot-tailed minnow (Notropis hudsonius), the emerald minnow (N. atherinoides), and the blunt-nosed minnow (Hyborhynchus notatus). Emmeline Moore, (2) 1929, believes that all Centrarchids (sunfish family) are capable of carrying the plerocercoids. Hunter and Hunter (1929) report it from the chain pickerel (Esox reticulatus) as well as from various Centrarchids and it is quite probable that other fish will be found to serve as intermediate hosts.

The fish may become infected with the plerocercoid in two ways. First, it may eat a copepod carrying a procercoid or, secondly, it may eat a fish that has recently fed upon infected copepods. Hunter and Hunter (1929) state, "...infected liver and cysts attached to the mesentery were fed to the rock bass (Ambloplitis rupestris). The parasites were (also) recovered from these, some from the digestive tract and some from the body cavity where they had apparently re-encysted. No doubt re-encystment depends upon the developmental stage attained by the parasite before ingestion takes place."

Hunter and Hunninen (1934) found that up to nine years of age, the larger the fish the more heavily it was parasitized by plerocercoids, and that beyond that age the number of larvae decreased. This, they explain, is because after a fish is over nine years old his diet no longer includes many fish small enough to feed on plankton.

Proteocephalus amblopltis becomes an adult in the gut of certain fishes that feed on fish containing the plerocercoid stage. Rock bass, smallmouth bass, largemouth bass and the dogfish (Amia calva) are suitable final hosts. From here it migrates to the upper intestine, grows proglottids and becomes sexually mature. The time required for this development is not known but is thought to be not less than three weeks.

According to Hunter and Hunter (1929), the following distribution obtains--Lakes of Minnesota and Wisconsin, Ontario, Canada, Michigan, Connecticut, New Jersey, Ohio, New York, Kansas, and Neosho, Missouri. In as much as the four final hosts are common to both the Great Lakes drainage and the Mississippi River basin, there is great danger of spreading this disease through the planting of bass from an infected source. The variety of first and second intermediate hosts also enhance its chance of surviving ~~one~~ once it has been introduced to previously uninfected waters. Thus it deserves important consideration in hatchery policies.

Various types of habitats are shown by Hunter and Hunninen (1934) to contain fish supporting greater or lesser worm burdens. They divide the habitats into lake, flow (impounded waters), and river. The lake bass carry the heaviest load while river bass the lightest. Flow bass are intermediate.

Experiments concerning the control of Proteocephalus ambloplitis in hatcheries have been performed, some with reputed success. Since the life history is known, several methods of attack are evident. Perhaps the most positive method would be to use brood stock entirely free from adult tapeworms, either fish naturally free or stock from which the worms have been removed by drugs. Thus, regardless of the abundance of suitable first intermediate hosts, no fish in the waters planted could become infected. A second method would be to remove all first intermediate hosts (certain plankton organisms which carry the initial stages) from the ponds and prevent others from entering. By so doing, the cycle would be broken at this point.

The former method has been tried by Donald McKernan (1940) of the U. S. Bureau of Fisheries at Seattle, Washington. He concluded that 1 1/2 to 2 per cent Kamala, which is an anthelminthic used in human medicine, mixed with a standard diet and fed for approximately one or two weeks could be relied upon to eradicate Proteocephalus sp. from trout. Some modification of this method might be worked out to apply to Proteocephalus ambloplitis in black bass. Dr. LaRue has suggested that a period of starvation might be as effective as application of anthelmintics. It is hoped that both of these experiments may be tested out in the near future.

The latter method, the elimination of the first intermediate host, has been investigated by Hunter and Hunter (1930) with favorable results. They found that copepods (the plankton organisms referred to above) were unable to survive four hours of steady freezing. They also found that copepods could be killed by desiccation. Since copepods lay no winter eggs, either of these methods could be used for the elimination, providing conditions at the hatchery permitted the necessary operations to be carried out. The above authors tried infection experiments with Cladocera to determine whether they could be used with safety for bass food. These forms are easily raised artificially, make excellent food for young fish and can survive unfavorable periods by means of winter eggs. The Cladocerans, *Daphnia magna*, *D. longispinus*, and *D. pulex*, were exposed to the eggs of *P. ambloplitis* with negative results. As a result of these experiments Hunter and Hunter (1930) advise, "... that bass hatcheries not only adopt methods to destroy the copepods but also to propagate Cladocera as a substitute food for bass fry." In addition to the destruction of the copepods it is also necessary to be certain that no copepods can get into the ponds through water supply or by any other means. Where they are found to be entering through the water supply, sand filters should be established as a barrier to them.

Another method of control is used by the State Fish Hatchery at Constantia, New York. From Hunter and Hunter (1930) I quote, "Here the 'breeders' are netted from Lake Oneida at the time the bass begin 'schooling' which is prior to their coming in shore for spawning. The trap nets are set for the small-mouthed black bass (*Micropterus dolomieu*), the captured fish being paired off (as accurately as it is possible to determine by a superficial examination) and placed in the various hatchery ponds. Soon after the spawning the breeders are returned to the lake eliminating multiple infections.

"Early in the spring the bass ponds are stocked with the well known food for young bass, water fleas or Cladocera. Two genera produce excellent food, the so-called '*Daphnia magna*' and a species of the genus *Moina*. These may be raised artificially indoors or can be raised in quantity in small out-of-doors cement vats where they will winter by the production of winter eggs. These can be inoculated into the spawning ponds early in the spring and will be present in quantity by May or June as food for the young bass. If the ponds are 'wintered', i.e., drained during the winter months, the copepods which act as the first intermediate hosts will be destroyed if the weather is sufficiently cold or dry. The Cladocera present will survive through the formation of winter eggs (ephippia).

"An examination of fifteen adult bass taken as breeders for the Constantia Hatchery revealed the presence of the bass tapeworm (P. amblopitis) in the digestive tract in 4, or 26 per cent, of the cases (several being sexually mature) while the larvae were recovered from the body cavity in 11, or 73.3 per cent, of the cases. (Hunter and Hunter, 1929, described the life cycle.) This clearly indicates the existence of the parasite in Lake Oneida. However, an examination of 200 fry taken from the various hatchery ponds did not reveal a single infected specimen! ...."

"In summing up the situation we find that in the first place new adult small-mouthed black bass are secured each spring for breeding purposes. This does away with the evil of confining the same infected fish in close quarters year after year with the probability of adding smaller bass many of which would probably carry the plerocercoid of P. amblopitis in the body cavity. These smaller fish when eaten by the older adults would be the means of conveying the larval stage of the tapeworm to the digestive tract where it would develop to sexual maturity and serve as a means of dissemination of the parasite's eggs. In a relatively short time the breeders would show an 100 per cent infection. One record of this condition occurred in Ohio and is recorded by Bangham in a mimeographed report (Hunter, 1928). Therefore by following the policy of returning the 'breeders' to Lake Oneida the infection, although present, is kept from spreading in the hatchery ponds.

"Another factor in explaining the freedom of the fry from infection with the plerocercoid of the bass tapeworm (P. amboplitis) lies in the drainage of the spawning ponds which is accomplished at irregular intervals. Such a procedure tends to eliminate the copepods particularly if the ponds are left for the winter. As explained above it does not destroy the Cladocera.

"A third factor lies in the inoculation of the ponds in the spring with Cladocera. Naturally this tends to produce a preponderance of safe as well as excellent food for young bass."

Although much has been learned about Proteocephalus ambloplitis, the information is not complete and still needs rounding out. There is as yet no definite information on the time necessary for the plerocercoid to develop into a mature tapeworm or infective stage. In a hatchery, the offspring of infected fish could easily become infected with the plerocercoid by eating infected copepods and then become infected with the adult tapeworm through cannibalism. If the time necessary for the development of the plerocercoid to the adult or egg-laying stage were known, the fish could be removed from the pond before this latter stage was reached, thereby preventing a building up of the infection in the pond. As previously stated, this time is thought to be not less than three weeks. Methods of control of parasitized fish have been described, and some apparently successful, but none that could be applied to all hatcheries. Since freedom from the bass tapeworm is so important to successful bass culture, its study should be continued until complete data are secured. I have found no reference concerning the control of this parasite dating later than 1934. This indicates either that the control methods described are effective and usable or that most hatchery men are completely unaware of the damage that is sure to result from infected brood stock.

As stated above, this parasite has been successfully controlled at several hatcheries. It can be controlled at other hatcheries also either by modifications of known methods or by the development of new techniques.

Due to the variety of first and second intermediate hosts, great care should be exercised in transferring wild bass from one lake or stream to another because of the danger of establishing this parasite in previously uninfected lakes. This has probably been done many times under some transplanting methods now in use. It is only by transferring infected fish that the bass tapeworm can be spread.

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to the bass tapeworm, Proteocephalus ambloplitis.

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