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Parasitic fish diseases; advancements in prevention and treatment[1]

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[1] Contribution from the Michigan Institute for Fisheries Research

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Abstract

The most recent advancement in control of external organisms causing fish disease is the pond-treatment method. It is an improvement over the hand-dipping method because fish are not killed by handling, fewer men are needed to carry it out, and the pond itself is treated along with the fish. All external parasites are controlled by a treatment with formalin (diluted to 1 to 4000) for an exposure of one hour, except Ichthyophthirius multifiliis, parasitic copepods and Saprolegnia sp. I. multifiliis can be controlled by holding affected fish in swiftly running water for several weeks or by chemical treatment of the water for the duration of the life cycle

of the parasite. Free-swimming larvae of the copepod Salmincola edwardsii can be killed by chemicals added to the water; because of the long period of time required for the parasite's life cycle, treatment would hardly be feasible at large hatcheries. Saprolegnia sp. (fungus) can be killed readily by dipping fish in a 1 to 15,000 solution of malachite green ~~(oxalate crystals, zinc free)~~ for 10 to 30 seconds, or pond treating for 45 minutes with a dilution of 1 to 180,000. Eggs can be kept fungus-free by semi-weekly treatments with a 1 to 200,000 solution of malachite green.

There are comparatively few internal parasites that cause mortalities among fish. Octomitus salmonis, an intestinal protozoan, may cause high losses but can be controlled by adding 0.2 percent calomel or carbarsone to the food for four days. Carbarsone is safer to use since it is not toxic to fish. Adult tapeworms of the genus Proteocephalus can be purged from fish by feeding for one week food containing 1½ to 2 percent kamala. Fish can be protected from the eye fluke (metacercaria of Diplostomum flexicaudum) by killing all snails in the ponds and preventing entrance of infective cercariae with the supply water. Miller attempted to control infestation of whitefish by larvae of the tapeworm Triaenophorus crassus in certain Canadian lakes. No feasible method has been developed, and research on the problem is still in progress.

Introduction

The control of parasitic fish diseases is of prime importance if we are to successfully engage in raising fish. The search for more effective methods and drugs to combat fish parasites is, as it is in human medicine, a never-ending task. The purpose of this paper is to bring together advancements made since about 1940 in the use of new drugs and the methods of application. With one exception, the discussion will be confined to the control of parasites found in fish hatcheries, since control of fish parasites in nature is, with present knowledge, seldom possible or feasible.

Methods

The treatment of fish for external parasites is accomplished in two ways, hand dipping and pond treatment. In the former method, fish are taken from the trough or pond and dipped, a few at a time, in a solution of the chemical prescribed for the parasite present, and then returned to the trough or pond. There are many disadvantages to this method. Many man-hours are required to complete the treatment, weak fish are killed because of handling, and, since it is not always possible to sterilize the pond itself, fish are often returned to infested waters.

The most recent development is that of pond treatment, where chemicals are applied to the entire pond containing infested fish. In this method, fish are not killed by handling, one or two men can do the job, and the pond itself is treated along with the fish. In coldwater-fish culture, Kingsbury and Embody (1932) applied chemicals directly to the supply water of ponds, and Fish and Burrows (1939) reported success with recirculation of chemicals through ponds. Although these methods had definite advantages over the hand-dipping method, they were not generally used. One objection is that disinfectants do not penetrate the sediment in dirt ponds and may be neutralized by the organic matter present.

Fish (1944; 1947) described a method of prolonged treatment in a pond or trough, in which the weight of water is determined and the amount of chemical necessary for the desired dilution is added to the water. Common practice is to hold the water at a level below normal with inlet and outlet closed; less chemical is required and the treated water can be flushed more quickly after treatment. Very little labor is involved in the preparation and administration of this kind of a treatment and, because of its simplicity, it is well adapted to prophylactic treatments. Unfortunately, however, it is not possible to use the pond treatment in ponds where inflow and outflow of water cannot be effectively shut off.

Application of the treatment is made by spraying greatly diluted solutions of the chemicals onto the surface of trough or pond. Water sprinkling cans are satisfactory for treatment of fish in troughs but are not suitable for large ponds. In Michigan, we have used to advantage a small power sprayer mounted on wheels. The outfit consists of a 20 gallon tank, a gasoline motor and a coil of hose. This unit is economical in that it is also used for other purposes, such as spraying weed killing compounds and certain paints.

Ectoparasites

Most of the parasites that cause mortality among hatchery fish attack the fish externally. A list of those parasites commonly found is as follows:

Protozoa:

Costia necatrix	*Ichthyophthirius multifiliis*
Trichodina sp.	*Epistylis* sp.
Chilodon cyprini	*Scyphidia tholiformis*

Trematoda:
Gyrodactylus sp.

Dactylogyrus sp.

Copepoda:
Salmincola edwardsii

Fungi:
Saprolegnia sp.

With the exception of *I. multifiliis*, *S. edwardsii*, and *Saprolegnia* sp., all of these parasites can be eradicated by a pond treatment with formalin, used at a dilution of 1:4000 for an exposure of one hour (Fish and Burrows, 1939; Fish 1940a, 1940b, 1947). Fish (1947) recommended that the quantity of formalin needed for the treatment be diluted about one hundred times and sprayed over the surface of the entire pond to prevent formation of "hot spots" toxic to the fish. The formalin should be sprayed into the pond within a period of fifteen minutes. Since formalin is colorless, a small amount of oxalate crystals of malachite green is commonly added to the formalin in treatments given in Michigan, to serve as a "tracer" and show areas of high or low concentrations. L. E. Wolf (private communication) uses a 1:1,000 dilution of formalin for 20 minutes in a trough treatment, but reported that a considerable loss of fish was experienced when this dilution was used on rainbow trout fingerlings. Fischthal (1949) described Epistylus on brook trout and recommended a 1½- to 2-minute dip in a solution of salt (3 percent) and malachite green (1:15,000) to eradicate the parasite. In Michigan, we have used the formalin pond-treatment to successfully control this protozoan.

Ichthyophthirius multifiliis cannot be eradicated by one treatment because of its more complex life history. Since the stage on the fish is imbedded in the flesh and cannot be reached by chemicals, control methods must be aimed at killing the free-swimming young. The easiest and least expensive control measure is to hold the fish in swiftly running water until all encysted forms have left the fish. The water current carries away the young, or infective, stage before it can infest another fish. However, when it is not possible to do this, chemical control must be used.

Fish (1947) recommended daily pond treatments with formalin (1:5000 for one hour) for seven to fourteen days. Butcher (1947) found that daily pond treatments with salt solution of approximately two per cent dilution for the duration of the full period of the parasitic stage were effective. Wolf (1938) reported the parasitic stage to last from four to five weeks at a temperature of 52°F. Butcher (1941; 1947) found at the Ballarat fish hatchery in Victoria, Australia, that the life cycle of the parasite was from fourteen to sixteen days at water temperatures ranging from 60° to 62°F. According to these studies, a temperature variation of 8° to 10° F. alters the length of the life cycle by about three weeks. Since Wolf and Butcher have shown that the length of the parasitic stage is dependent upon water temperature, the length of the treatment should be judged accordingly.

Schaeperclaus (1941) recommends a prolonged treatment with quinine to eliminate Ichthyophthirius. The chloride, sulfate or "Chinin-Weil" may be used. He uses a dilution of 1:50,000 for the length of time necessary to effect control (from three to 20 days). He also used quinine in the same dilution to control Costia, Chilodonella and Cyclochaeta. At 15° C. he found that these three species were killed in 26, 18, and six hours, respectively.

No effective method suitable for large hatcheries has yet been proposed for the eradication of the copepod Salmincola edwardsii, infesting the gills of brook trout. Its tough, chitinous hide and its habit of burying its head in the flesh of the host protect the adult from chemical treatments. The free-swimming larvae are vulnerable to chemical control, but since the adult remains on the fish for at least two months, chemical control would have to be in effect for at least sixty days. Exposure to strong salt solutions, and to formalin in a dilution of 1:6000 for one hour will kill free-swimming larvae. Undoubtedly, other chemicals could be found that would be as effective. However, in most instances it would hardly be feasible to carry out such a program for sixty days in a hatchery as large as the average state fish hatchery. In states where there are a number of trout hatcheries, the problem could be solved by raising brook trout only in those stations free of the parasite, and other species of trout at stations having a contaminated water supply. However, the cost of transporting the fish to streams widely scattered over the state might be prohibitive.

In England, Hindle (1949) effectively controlled *Argulus* on carp in aquaria by an exposure of two or three days to a 1:10,000,000 dilution of "gammexane" (gamma isomer of hexa-shloro-cyclo-hexane) called lindane in the United States. Since this chemical is insoluable in water it must be dissolved in alcohol before it is mixed with the water to be treated. Hindle used a one percent alcoholic solution as a stock solution. He pointed out that with few exceptions, this treatment had been applied only to carp and that other species of fish may be less tolerant to the chemical.

The common species of fungus on fish is *Saprolegnia parasitica*. Other species of water mold may occasionally appear, but they need not be listed here since the same control measures apply to all species. In the past, solutions of common salt, copper sulphate, potassium permanganate, and possibly others, were used as control measures, but none gave completely satisfactory results and some were dangerous to use. Foster and Woodbury (1936) first used malachite green as a fungicide. Their experiments, however, involved only a special "lot" of trout. Although there are warnings in the literature that only the zinc-free salts should be used, L. E. Wolf (private communication) reported that he had always used the double zinc salt on fish and had uniformly good results. Wolf pointed out that it should be used with caution since direct experimental comparisons have not been made.

O'Donnel (1941) successfully eliminated fungus from eighteen species of fish (including trout) by dipping them for 10 to 30 seconds in a 1 to 15,000 solution of malachite green. In Michigan, the chemical is often used as a pond treatment, but the methods vary, according to the facilities at the different stations. The flush method is used at one location. Here, water in the pond is lowered to a minimum depth, and a strong solution of malachite is introduced at the head and allowed to progress through the pond in a dense cloud. The treatment lasts about half an hour. At most stations, a regular pond treatment with a dilution of 1:180,000 for an exposure of 45 minutes is used. Where some other external parasite, such as Gyrodactylus, is also present, both malachite green and formalin are used in one treatment.

Saprolegnia attacks both fish and fish eggs. In trout hatcheries, many man-hours are necessary in picking dead eggs from hatching trays to prevent the development of fungus, unless prophylactic measures are used. Burrows (1949) tested malachite green, formalin, roccal, and hyamine 1622 and concluded that malachite green in a dilution of 1:200,000 for an exposure of one hour was best for preventing development of fungus. Cost of the treatment was lower and the eggs had a wider tolerance to it.

Endoparasites

There are comparatively few internal parasites of fish that may cause mortalities and indicate control measures. Several that might warrant discussion here are as follows:

Protozoa:
- Octomitus salmonis

Cestoda:
- Proteocephalus sp.

Trematoda:
- Diplostomum flexicaudum

Octomitus salmonis is a protozoan parasite that occurs in the intestines of trout and salmon. Serious mortalities at hatcheries among fingerling trout up to three or four inches long have resulted from infestations by <u>Octomitus</u>. Davis (1946) reviewed the symptomology, life history, pathology and control measures. Only the control measures will be discussed here. Tunison and McCay (1933) successfully controlled <u>Octomitus</u> by adding 0.2 percent calomel (mercurous chloride) to the food for several days. Although calomel may be toxic to fish under certain circumstances, the chemical has been used commonly in this country for treatment of <u>Octomitus</u>. Another chemical, carbarsone, was found by Fish and McKernan (1940) and Nelson (1941) to be just as effective as calomel for control of <u>Octomitus</u>, and not toxic to fish. Treatment is made by thoroughly mixing 0.2 percent of carbarsone into food to be fed for four consecutive days. We have been using carbarsone successfully in Michigan for both therapeutic and prophylactic treatments. Prophylaxis is now used on rainbow and brook trout fingerlings at several hatcheries where <u>Octomitus</u> appeared occasionally among fish in the troughs and every year when they were transferred to outside ponds. Losses from <u>Octomitus</u> have been eliminated by four-day treatments each week for two weeks before the fish are moved from the troughs, and for one week after they are transferred to the ponds.

Davis (1946) suggests that there is evidence that immune races of trout might be developed. The breeding of trout immune to various diseases is a control measure that has not been fully explored. This phase of disease control will be discussed by Dr. L. E. Wolf in another paper on the program.

Although tapeworms rarely cause mortalities of fish at hatcheries, the stocking of infested fish is undesirable because of the possibility of introducing the parasite into waters where it does not occur and the possibility of maintaining or augmenting an established infestation. Adult tapeworms in the intestine of fish can be removed by the addition of kamala to the diet. McKernan (1940) found three-inch trout heavily infested with an undescribed species of *Proteocephalus*. He thoroughly mixed kamala with the food at the rate of one and one-half to two percent by weight, and after one week on this diet the trout were free of the infestation. He suggested that the treatment be continued for another week to insure complete elimination of the worms. This treatment can be used to free brood stock large- and smallmouth bass of the adult *Proteocephalus ambloplitis*, according to S. F. Snieszko (private communication). On his suggestion, Mr. Albert Powell, superintendent, State of Maryland fish hatcheries, treated largemouth bass with Kamala which was introduced into the stomach of the fish in capsules. A dose of about 180 to 220 milligrams of Kamala per pound of fish was given for three successive days. The results were excellent and great masses of tapeworms were eliminated from the fish.

The larvae (metacercariae) of several species of strigeid trematodes infest the eyes of fish, causing permanent blindness. Palmer (1939) first reported the infestation occurring in hatcheries. Van Haitsma (1930) traced the life history of the eye fluke, *Diplostomum flexicaudum*, and Ferguson and Hayford (1941) described the life history and control of this eye fluke at Hackettstown, New Jersey. Briefly, the adult of Diplostomum flexicaudum lives in the intestine of gulls; eggs pass into water; eggs hatch and miracidia infest snails of the genus Lymnea; cercariae leave the snail and burrow into fish, localizing in the crystalline lens of the eye; gull eats fish, and the adult worm develops in intestines of the bird. Infestations of this worm may cause high mortalities (starvation) among small fingerling trout, although hatchery trout from six to nine inches long, blinded by the disease, remain healthy when fed a diet that sinks to the bottom of the pond where they can find it, presumably by scent. Fish can be protected from the eye-fluke by elimination of snails from the pond, thus breaking a link in the life cycle.

The control of parasites of fish in lakes and streams is not feasible in most cases. However, an interesting study of the control of a fish parasite in nature was initiated in Alberta, Canada, by R. B. Miller (1945). In certain lakes in Canada, the plerocercoid of the tapeworm Triaenophorus crassus infests ciscoes and whitefish so heavily that the fish cannot be marketed. The parasite, therefore, is of considerable economic importance to the fishing industry. T. crassus lives as an adult in the intestines of northern pike (Esox lucius). The first intermediate host is the copepod, Cyclops bicuspidatus, and the second intermediate host a variety of salmonoid fishes, particularly the coregonids. Control methods were directed towards breaking the life cycle of the parasite. An unsuccessful attempt was made to kill free-swimming larvae (coracidia) by acidifying a lake (Miller and Watkins, 1946). Partial control was obtained by drastic reduction of the tullibee population (Miller, 1948) in Lesser Slave Lake, Alberta, Canada, but there is no assurance that the cure will be lasting or that it would be effective in other lakes. In Square Lake, Alberta, Canada, Miller (1950) succeeded in reducing the infestation in tullibee by 39 percent when he reduced the population of northern pike. He concluded that the method was not feasible because of the ability of northern pike to repopulate depleted areas very rapidly and because of the high cost of the operation. Control of the short-lived, free-swimming tapeworm larvae is now being studied in the labatory by Miller (1952), who stated that it is evident that a long period of research will be necessary to conquer the problem.

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