DISEASES AND PARASITES IN MICHIGAN FISH HATCHERIES

By

T.H. LANGLOIS

Numerous visits to the Michigan State fish hatcheries and trout-rearing ponds during 1928 provided the material for this paper, and my gratitude is extended to the Department of Conservation officials and hatchery overseers who have collaborated in this study. My thanks are also tendered the fish division of the University of Michigan Zoology Museum for laboratory facilities and other courtesies.

Considerable time was spent at each hatchery in turn, and more at certain ones during epidemics, discovering and identifying desease-causing organisms, noting their effects upon the fish, and experimenting with the control methods recommended by the U.S.Bureau of Fisheries, the Ohio Department of Conservation, the New York Conservation Commission, the University of Washington's College of Fisheries, and by Hofer's "Handbuch" and Plehn's "Praktikum der Fischkrankheiten". The complete records of disease-control experiments are not yet ready for publication, and this report presents mainly records of the prevalence of diseases and parasites in the various hatcheries. The study is being continued in 1929, and it is expected that further data, particularly on control methods, will be available for presentation at a later date.

There are seventeen state-owned fish hatcheries, and two of the trout rearing ponds developed in 1928 are of comparable importance, having numerous troughs and ponds, and, listed with the others, raise the total to nineteen. Fifteen of this number propagate brook, brown,

or rainbow trout, five of them produce bass, bluegills, or perch for stocking the inland lakes, and four hatch commercial species for the Great Lakes. Of the fifteen trout hatcheries, only eight maintain a stock of adults for brood- or exhibition purposes, the rest planting all of their produce at the fingerling stage. As noted on the accompanying tables, (II and III) the specific diseases and parasites are closely correlated with the type of hatchery products; so closely, in fact, that, with a few noteworthy exceptions, the diseases and parasites might be listed for the type of hatchery product , with the statement that where this occurs that also is to be found. However, it is the group of exceptions that make such a study as this worth while, as it may serve to prevent the spread of diseases into places where they do not already occur.

Trout Hatcheries:

Except for a few million eggs taken from the brood stock maintained at certain of the hatcheries, all of the brook trout hatched in Michigan are from eggs bought from hatcheries in other states, namely; Pennsylvania, Rhode Island, Massachusetts, Wisconsin, Colorado, and Montana. These eggs are at the "eyed" stage when they arrive, and if they were properly packed for shipment they will practically all hatch. This actually is true of shipments from certain companies, but it is not true of shipments from other companies, and eggs that look rather dry upon arrival yield a heavy first pick-off. Moreover, this does not appear to end the results of poor packing, as later pick-offs are also heavy, and the fry that hatch frequently show great losses in early stages, so that the final crop of fingerlings represents but a small

fraction of the original shipment of eggs. (See Table I)

In Michigan hatcheries the newly-hatched fry are kept in troughs for several weeks, and are feeding well before they are transferred to outdoor raceways or rearing ponds. Most of them are fed all summer in the raceways or ponds and planted as four to eight inch fingerlings, in September, October, and November, with only a few kept over for brood stock. Of the above periods, the trout appear to be most susceptible to diseases when in the troughs before transferring to ponds, and when kept for a prolonged period for brood stock. Most of the losses in the troughs have been ascribable indirectly to the lowered vitality caused by crowding in under-oxygenated water. More directly the causes noted have been :(1) elimination of monsters; (2) Octomitiasis;(3) Costiasis; (4) bacterial infection of the gills. Among the adults losses have been caused by: (1) ulcer disease; (2) furunculosis; (3) fungus; (4) Gyrodactyliasis; and (5) Cyclochaetiasis, and as Marsh pointed out in 1904, the lowered hemoglobin content of the blood of domesticated fish undoubtably makes them less resistant to all diseases.(See Table IV)

When the young trout are transferred to rearing ponds the weaklings are quickly eliminated, and thereafter the losses are ordinarily very slight. The heavy losses among young rainbow trout in the ponds at Baldwin in Lake County for a brief period in the summer of 1928, and its extraordinary cause makes a noteworthy exception. This site consists of a bend of the Baldwin River that has been made into an ox-bow by ditching, with the flow through the ox-bow controlled by two dams, one at the head of the ox-bow, the other at the head of the ditch. The

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ox-bow has been divided into three unit ponds, separated by screens and slash-boards, and in these three ponds rainbow, brook, and brown trout are raised during the summer to the fingerling size for planting in the fall. The brook and brown trout eggs hatch in Michigan from latter January to the end of February, while the rainbow eggs, taken in mid-April, hatch about the last of May. Because of this seasonal difference in the species spawning habits the brooks and browns have a considerable start on the young rainbows, and retain a greater average length throughout the season. In the middle of the summer of 1928, when the brook and brown trout were $2\frac{1}{2}$ to $3\frac{1}{2}$ inches long, growing fine and showing but light losses, the $1\frac{1}{4}$ to $1\frac{3}{4}$ inch rainbows, also looking fine, began dying in great numbers. Out of 300,000 in the pond about 125,000, according to an estimate by Mr. J. P. Marks, died within a very short period. This loss proved to be due to the fact the surface of the pond bore many floating "devil's pitchforks", the seeds of Bidens frondosa, and the surface-feeding young rainbows were getting these pitchforks lodged in their eyes, snout and mouth, and throat. The loss stopped abruptly when the weeds surrounding the ponds were mowed. The brook and brown trout were apparently not feeding at the surface at this time, and these ponds showed no losses attributable to this cause.

In hatchery ponds, trout with definitely margined areas of dark pigmentation are occasionally seen, in appearance quite similar to the Phoxinus which Frisch(1910) experimentally blotched by severing certain nerves. Such an individual, a brook trout about six inches long, was seen in a pond at Oden in October, 1928. At Wolverine, in February, 1929,

one fingerling brook trout in a raceway with many others exhibited a veritable piebald appearance, with irregular white and black blotches. The occurrence of this color peculiarity and its control by the nervous system as demonstrated by Frisch are significant only in that they may give some clue toward the cause of a peculiar malady that made serious inroads on the stock of brook trout at Wolverine and at one of the rearing ponds stocked with fish from Wolverine in the summer of 1928.

At both of these places, among the three to seven inch fish, individuals were noted who were much darker than their normal colored fellows, some of them nearly black, and it was presently also noted that these black individuals were the ones forming the major share of the dead fish collected each day at the foot of the pond. Microscopic examination of freshly dead and dying fish did not reveal bacterial, protozoan, or other causative agents, and it is suggested that the disease may have been one of the nervous system. The loss of control of chromatic expansion and contraction seems to indicate that such might have been the case, and the apparent absence of external cause strengthens the hypothesis, though there is, as yet, no confirmatory evidence.

Gyrodactyliasis at Oden: Fin worms were found on adult trout in all ponds at the Oden hatchery where adults are kept, and they appeared to be causing considerable losses in 1928. Every dead or dying fish that came from one particular pond bore numerous fin-worms, and since fish had been transferred from this pond to the other ponds where fin-worms were found it seemed not improbable that the heavily infected

pond was serving as a center of dispersal. Accordingly, all fish were removed from this pond and the pond allowed to stand empty for some time before new fish were introduced, and the next season will show whether or not this mild form of prophylaxis successfully interrupted the life-cycle of these Monogenes.

Costiasis at Hart: In the spring of 1928 the Baldwin and Pentwater rearing ponds, which were to receive the fry produced at Hart, were constructed, and unavoidable delays in their construction obligated the Hart troughs beyond their capacity to care for the young trout. Although the fry were repeatedly thinned out as their growth made the troughs too crowded, further growth again made the troughs.crowded before the ponds were ready to receive the excess number. This crowding in water of low oxygen content so reduced the vitality of the fry that when the fin-parasitic protozoan, Costia necatrix, became established, it quickly became abundant and caused the loss of many fish. Series of three or four 2.5% salt baths were given them, with some beneficial effect, as evidenced by the fact that following this treatment numerous frayed fins were found to be showing new tissue growth around the protruding ends of fin rays. However, control methods merely helped to limit the malady, and the epidemic really ended only when the fry were all out of the troughs and in their larger quarters. In the ponds individuals with frayed fins were seen for a week or two, and, hot weather coming during this period, heavy losses were noted in one of the ponds, but from then on no Costia were seen.

Ulcer Disease at Wolverine: The appearance of the ulcer disease at the Wolverine hatchery was coincident with the opening of the new ice pond, a boggy-bottomed small pond separated only by a cement wall from a pond of a different type. This second pond is, in size, 175 x 35 x 1½ feet, has a gravel bottom, and is fed by a combination of spring and creek water. Fish had been successfully raised here for anumber of years, and the infected fish were transferred to it with the hope thatthe disease would disappear. Instead of improving conditions grew worse, with losses as follows: Of the 1800 fish transferred in September, 1927,805 remained on May first, 1928, 508 on June 18, and only 150 on August 1. The 150 were transferred to the small pond in front of the hatchery, the lowest one in the series, on August 1,1928, and in February, 1929, about a half-dozen of these were still alive. This consistent loss, in spite of treatments with potassium permanganate and copper sulfate, practically eliminating the adult stock at this hatchery, is apparently typical of the ulcer disease and its course, as described by Calkins in 1898, and Marsh in 1904. The futility of persistent efforts at control in this case seems to indicate that the wholesale destruction of infected fish, as practised at Cold Springs Harbor in 1904, may be the only method of combatting this type of infection.

The ulcers were typically round or elliptical, dull-red and raw of the erodent type, and quickly becoming surrounded with fungus. There were one or more ulcers present on most of the fish examined, and they were located on the sides of the fish. In addition to the ulcers

practically every fish bore a whitish raw sore on the tip of its snout, and a few, but not a majority, showed an inflamed area around the lower end of the intestine.

Gas Disease in Rearing Ponds at Schuil Acres: In one of the rearing ponds at Schuil Acres on the outskirts of Grand Rapids there occurred an epidemic of the malady named by Marsh the "Gas Disease", characterized normally, and in this case, by protrusion of the eyeball, or pop-eyes. In September, 1927, there were 1800 fine yearling brook trout in this pond, and the over-winter loss was reported to be small, so it is assumed that nearly this number were present at the beginning of the epidemic. The loss started in early July, and by the twentieth of August only about 175 fish remained, and these were salvaged by a copper sulfate treatment and transference to another pond. Most of the dying fish showed great bulging eyeballs, and the protrusion was caused by an accumulation of gas in the orbit behind the conjunctiva. By puncturing this membrane it was possible to release this gas, and analyses of several samples by Mr. K. C. Kuster of the Zoology Department of the University of Michigan, using a Krogh micro-gas analysis apparatus, showed this gas to consist of about 2½% carbon dioxide, 11 to 12½% oxygen, and the remaining 85% presumably nitrogen but not identified. Marsh (1904) has published tables of water analyses showing that excessive amounts of nitrogen sometimes occur when dissolved carbon dioxide and oxygen are present in normal amounts, and Marsh cites cases when such an excess of nitrogen has apparently unquestionably been the cause of similar gas embolism with resulting pop-eyes and heavy losses of fis

In this pond at Schuil Acres analyses for dissolved gases by Mr.F.E. Eggleton showed that no excess of carbon dioxide or oxygen was present, and limitation of equipment prevented analysis for nitrogen, but in view of Marsh's findings it seems not improbable that this pond contained an excessive amount of nitrogen, and that this caused the trouble. This is further indicated by the characteristic that distinguishes this pond from its fellows where pop-eyes did not occur.

Of the five small ponds on Schuil Acres, three are supplied by creek water, and two are fed directly by springs. One of the spring-fed ponds is shallow, with gravel bottom throughout, and a drainage tap low enough to permit thorough cleaning of the bottom. The other spring-fed pond was built with the double purpose of raising fish and motivating a small hydraulic ram, and the outlet for the ram was placed about three feet above bottom in the six foot dam. This pond bottom could not be thoroughly drained and cleaned, and about two feet of soft black ooze had settled on top of the gravel bottom at the deeper end of the pond. This pond is the only one that had trouble and when the remaining 175 fish were transferred to another pond in latter August most of them survived, though some had one empty orbit whence the eyeball had gone completely. The attribution of the presumed excess of nitrogen to this black deposit on the pond bottom seems justifiable under the circumstances, and the pond bottom has been filled with gravel to the level of its outlet so it can hereafter be kept clean.

Losses due to excessive temperatures: Heavy losses occurred in all

three of the trout rearing ponds operated by the Oden Hatchery on July 8, 1928, an exceptionally hot day for northern Michigan. On this date the temperature of the creeks rose to 80 or 82°, and many fish died of suffocation. An estimate for the loss at one of the ponds was placed at 225,000 brook trout fingerlings by Mr. Guy Lincoln of the Oden hatchery who added his observation that little trout were not so severely affected as the bigger one, and brown trout not so badly as brooks. Such a catastrophe would not occur in normal years, as this extreme heat is very seldom reached in this northern region.

Lake fish Hatcheries:

The Michigan hatcheries handling large-mouth bass, small-mouth bass, bluegills, and perch operate upon the following bases: No brood stock of large-mouth bass is maintained, the fry being siphoned off the nests in public lakes near the hatcheries. The fry are raised to large fingerling size in hatchery ponds and then planted in other lakes. Adult small-mouth bass are maintained and provided with spawning facilities at the Lydell and Harrisivlle hatcheries, and their progeny is dispensed throughout the state. This brood stock is supplemented each year from adjacent streams and from commercial fishermen operating on the Great Lakes, but this latter stock has seldom justified its acquisition.

Wherever the basses occur in this region they appear to harbor the intestinal flukes Crepidosomum cornatum and Cryptogonimus, the spiny-headed worm, Echinorhynchus thecatus, and the cestode, Proteocephalus ambloplites; wherever bluegills occur they appear to contain the wee flukes, Neascus vancleavii, and almost wherever perch are found

they are to greater or lesser extent infected with Neascus cuticula, the cysts of which form the prominent small black spots in the skin. In general, the occurrence of minor infections with these parasites need not be viewed with alarm, though severe effects are known to accompany severe infections, and the desirability of trying to obtain clean stock cannot be questioned. (See Table IV)

Commercial Fish Hatcheries:

The hatcheries handling the commercial species, lake trout, whitefish and pike-perch, receiving all of their eggs from the fishermen, are uniformly successful with lake trout and whitefish, planting an average of 74% and 63% respectively of the eggs received of those species. They are also uniform in their failure to plant any respectable percentage of the pike-perch eggs received, and the precise reason for this remains to be determined. It has been variously blamed upon the quality of the hatchery water supplies, the methods of taking the eggs, injuries to the adults while holding for their eggs, low fertilization percentage, jarring the eggs during transportation, etc., and the spring of 1929 will see a renewal of the attempt to improve the situation.

TABLE II

Showing Kinds of fish Produced at Each Hatchery

HATCHERY	SPECIES OF FISH
Baldwin	brook, brown and rainbow trout
Bay City	whitefish, pike-perch
Bay Port	whitefish,pike-perch
Benton Harbor	brook,rainbow trout, large-mouth bass,bluegills, perch
Drayton Plains	large-mouth bass, bluegills,perch
Grayling	brook,brown rainbow trout
Harrietta	brook,brown,rainbow trout
Harrisville	brook,brown,rainbow trout
Hart	brook trout
Hastings	small-mouth bass, large-mouth bass, bluegills, perch
Lydell	brook trout,small-mouth bass, large-mouth bass, bluegills,perch
Marquette	brook trout
Oden	brook,brown,lake trout
Paris	brook,brown,rainbow trout
Sault Ste.Marie	brook,brown,lake trout,whitefish,perch
Sidnaw	brook trout,small-mouth bass
Thompson	brook,brown,lake trout,whitefish,pike-perch
Watersmeet	brook,brown,lake trout
Wolverine	brook trout

TABLE III

Showing Diseases and Parasites Occurring at Each Hatchery

HATCHERY	DISEASES AND PARASITES IN 1928
Baldwin	Costiasis
Bay City	Fungus
Bay Port	Fungus
Benton Harbor	Blue-sac
Drayton Plains	Fungus
Grayling	Fungus, blue-sac, Octomitiasis, furunculosis, Gyrodactyliasis, gill-lice, goitre, exophthalmia
Harrietta	Fungus, blue-sac, gill-lice
Harrisville	Fungus, blue-sac, Cyclochaetiasis, Echinorhynchus thecatus, Crepidostomum cornutum, Cryptogonimus
Hart	Blue-sac, Costiasis, exophthalmia
Hastings	Fungus, Proteocephalus ambloplites, Echinorhynchus thecatus, Crepidostomum cornutum, Cryptogonimus
Lydell	Fungus, Proteocephalus ambloplites, Echinorhynchus thecatus, Crepidostomum cornutum, Cryptogonimus
Marquette	Fungus, blue-sac, Octomitiasis, Gyrodactyliasis, gill-lice, exophthalmia
Oden	Fungus, blue-sac, Cyclochaetiasis, Myxosporidiosis, furunculosis, Gyrodactyliasis, gill-lice, Abothriocephalum crassum
Paris	Fungus, blue-sac, Myxosporidiosis, furunculosis, gill-lice, Ichthyonema
Sault Ste. Marie	Blue-sac, bacteria on gills of trout-fry
Sidnaw	Blue-sac, Octomitiasis
Thompson	Fungus, blue-sac, goitre
Watersmeet	Fungus, blue-sac, Octomitiasis, Myxosporidiosis, Gyrodactyliasis, goitre
Wolverine	Fungus, blue-sac, ulcer-disease, bacteria on gills of trout-fry, exophthalmia