THE METHODS, LIMITATIONS, AND RESULTS OF WHITEFISH-CULTURE IN LAKE ERIE.

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In a paper of this character it will not be possible to go into details as to the methods pursued in whitefish-culture, nor do I deem it necessary, since the subject has been so often and so ably treated; but I will rather confine myself to what I conceive to be some comparatively new and interesting features of the work.

To summarize, it is only necessary to say that the mode pursued at the Put-in Bay station of the United States Fish Commission is the same as that generally followed, dry impregnation being the starting point—that is, the eggs and milt are brought into contact as they come from the fish and well mixed, after which water is added, the mass gently stirred and allowed to stand about 2 minutes, when the eggs are washed and placed in wooden kegs holding 15 gallons each.

In this connection it will be proper to state that a series of experiments made at Put-in Bay station the past season demonstrates that in water the milt loses much of its vitality at the close of 1 minute. In fact, at the close of ½ minute it has done its best work. In one test only 49 per cent of the eggs were impregnated by milt which had stood in water 1¼ minutes, and in another 47 per cent where it had been 1½ minutes in the water; while eggs from the same lot showed 98 per cent and 97 per cent impregnation, respectively, where milt was used from the same lot which had stood but ¼ minute in the water. It is therefore obvious that reliance should not be placed in milt which has stood over 1 minute in water, and it follows that eggs should be washed at the close of 2 minutes, as the longer they stand in the milt after impregnation has taken place the worse for the eggs, as shown by Professor Reighard and other writers.

After being brought to the station, some 2 to 10 hours after taking, the eggs are kept in the kegs in running water and carefully stirred once an hour until the next forenoon, it being our belief that while "harding"—that is, while the investing membranes are filling with water—they should not be submitted to even the gentle motion which they undergo in the jars.

It is evident to all observant fish-culturists that the eggs must be treated in the most gentle manner possible from the time they are taken up to the period when they are sufficiently cushioned by water to protect them from injury.

As is well known, many whitefish and lake-trout eggs are annually lost through lack of males at certain times, especially near the close of the season, when large numbers of ripe females are taken from the nets with very few or possibly no males. With this fact in view, experiments were made at Put-in Bay the past season to demonstrate practically how long the milt and eggs can be held separately and still

retain their fertility. It was shown beyond question that both may be held at least 48 hours, and practically as great a percentage of impregnation procured as if applied immediately after they are taken from the fish.

I will quote from the records of the station the results of a few experiments which will fairly illustrate the whole. One lot of eggs taken on December 6 was impregnated on December 7 with milt taken on December 4; percentage of impregnation, 98. A lot taken on the same day and impregnated immediately with milt just taken showed the same percentage of impregnation—a mere coincidence so far as exactness is concerned. Another lot, where the spawn and milt were both taken on December 6 and impregnated on the 7th, showed 97 per cent impregnated. Still another lot taken on the 7th and immediately impregnated with milt taken on the 4th showed 95 per cent impregnation. Fourteen tests were made, and it may be inferred from them that neither the eggs nor milt can be carried past the third day with good results. With all those carried past that time the percentage of impregnation ran from 0 up to 6.

In this work care was taken that the eggs and milt should be kept entirely free from water and other foreign substances. The eggs were held in pans and the milt in corked vials, both being kept in running water at the then prevailing temperature of the lake—about 35° F. One lot of milt, where a very small clot of excrement had entered the vial, was used as an experiment 48 hours after it was taken and failed to impregnate any eggs.

One of the important problems in whitefish-culture in Lake Erie has been the successful penning of adult fish in order to hold them until their eggs are sufficiently developed or ripe. Up to the past season this has been a failure so far as practical results are concerned, for the reasons that the pound nets are so scattered and so few fish are taken from each on each day that under the usual methods sufficient fish could not be procured, and that when penned in stationary inclosures in landlocked bays—the only place where the crates can be held during stormy weather—the water, during specially warm periods, gets so warm as to render the fishes unhealthy and the eggs become congested, or what is called "caked," in the abdomens of the females. Both these causes have been removed at Put-in Bay station the past season.

A supplemental net 3 feet in diameter and 7 feet long, held open at the top and bottom by iron rings, is placed at each pound net by fastening one side to the downhaul stake and the opposite to the rim line of the pot, thus holding the top about 3 feet above the surface of the water. When the pound is lifted all the whitefish are singled out and lifted by a net made of coarse, open cloth—an ordinary net is too harsh on the fish and injures their delicate scales and fins—and dropped into the supplemental net, from which they are taken and placed in special tanks on the deck of the station steamer and removed to the crates located near the station. It will be readily understood that by this means the fish can be procured from a large number of nets, while otherwise only such can be saved as are procured by one lifting boat, accompanied by the steamer, as all the boats in a given locality lift at about the same time, generally early in the morning. After the fish are in the supplemental nets they can be collected by the steamer at leisure, taking all day for it if necessary.

To avoid the danger of too warm water the pens or crates are secured between long pine-boom logs, the whole making a substantial raft, which can be towed outside and anchored where good currents and safe temperature can be procured until danger is past. The crates are surrounded on all sides by walks for convenience in sorting and handling fish. The compartments of the crates are 8 feet square and 7 feet deep,

with false bottoms guided by upright standards used in raising and lowering the false bottoms for the better examination of the fish. Each compartment will carry about 250 fish at a time, or about twice that number during the season, as the numbers are continually being added to and taken from, as new arrivals come in and the older ones are stripped and sent to market.

The fish are sorted into three classes, which are denominated soft, medium, and hard, and are handled as little as possible. The softs are examined the next day after being sorted, the ripe ones stripped, and the others reclassified if necessary—the mediums on the third day and the hards in about a week, it having been found by experience that very little spawn is lost by thus holding and very much unnecessary handling is obviated.

Although large numbers of fish were not penned at Put-in Bay the past season, owing to almost continuous gales, the experiment proved a complete success, as showing what can be done in an ordinary season. Over 10,000,000 eggs of good quality were taken, and it should be remembered that but for the penning the eggs would have gone to market in the abdomens of the fish and been lost. The fish, notwithstanding the adverse circumstances under which they were taken, did remarkably well, and only seven were lost because of becoming diseased, and they had been injured in the pound nets before coming to our hands. The last fish turned over to the fishermen were in as fine condition as if just taken from a pound, and some of them had been in confinement for a month.

As to the limitations and results, they must be largely a matter of speculation. With penning successfully carried out there would seem to be practically no limit to the number of fry which can be turned out, and then comes the question, To what extent is the hatching of whitefish beneficial? The statistics do not answer the question in a manner entirely encouraging to the fish-culturists, and yet I believe I am safe in saying that there is not a commercial fisherman on Lake Erie who does not think that the hatcheries have done much to increase the take of whitefish, many of them openly asserting that but for the work of artificial propagation whitefish would be practically extinct in the lake. They cite in proof of this that while the increase has not been what they might hope, the whitefish has reasonably held its own, while all other commercial fishes have rapidly fallen off.

There is another encouraging feature to be noted. If common report is to be taken for anything, the catch of whitefish has been greater in Lake Erie the past season than for several years past. This is especially the case with the gill nets in deep water, also with the pounds at the head of the lake, so the writer is informed on what seems to be trustworthy authority. Of course it is too early yet to have reliable statistics as to just what the catch was. The fish were small and of quite uniform size, which lead the fishermen to the conclusion that at least a considerable portion of them were the result of the large hatch of the season 1895-96, when 121,000,000 fry were planted in Lake Erie from Put-in Bay station, and when the Detroit hatchery of the Michigan Fish Commission and the Sandwich hatchery of the Dominion Government of Canada made specially large plants, all of which found their way into Lake Erie.

In common with other fish-culturists the writer believes that the work of artificially increasing the number of whitefish in Lake Erie and the other waters to which this fish is indigenous will be greatly improved when some practical way is

found for holding and feeding the fry, if only for a few weeks, or until they are large enough to care for themselves. Nor do we believe that such a hope is wholly illusory, for the experiments of Mr. Carl G. Thompson, of Warren, Ind., who succeeded in rearing this fish from the fry in considerable numbers in comparatively small ponds by feeding them on fine wheat middlings, at least gives encouragement that the problem will yet be solved. It is true that experiments at feeding whitefish fry at Put-in Bay the past season were not successful, but the work is new and it may yet be brought to a successful termination.

MORTALITY AMONG FISH EGGS.

As is well known to fish-culturists, there is a considerable mortality among fish eggs between the stage where the embryo is formed and the time of hatching. Can this be prevented? To answer this question intelligently we must first know the cause, and to this end I have carried on a series of investigations, making them as thorough as I could with my very limited knowledge of the several sciences called into action and the appliances at hand.

Dead and dying eyed eggs, generally easily detected by the naked eye, were examined from time to time, generally in hundred lots, and where the cause of loss could be determined the results were kept in memorandum. In many cases the cause is easily ascertained; in other cases, with my limited knowledge, it could not be determined at all. I should here state that, having no microtome, all the work was done in gross, simply by the aid of the microscope, and that without doubt one well versed in the work and with suitable instruments could determine the cause of death in a large percentage of those where I failed. I should also state that the percentages here given are not absolute, for the reason that with dead eggs considerable numbers were in such a condition that no opinion could be arrived at, although if examined a little earlier the cause might have been apparent, and in the case of aneurisms and ruptured blood vessels most of them were discovered while examining apparently healthy eggs, the embryo being not yet dead but dying, and the egg therefore not yet so changed as to be detected by the unassisted eye.

By far the greater loss of the whitefish eggs in embryo, the only ones examined, is caused by insufficient food supply, the yolk being undersized, and when the store is exhausted the embryo dies of starvation, this occurring at all stages from the early formation of the embryo up to the time of hatching, those with very small yolks dying first and others later on. Taking an average of all my data, this amounts to 31 per cent of the total loss of eyed eggs, but for reasons already stated this is not strictly accurate, and I am of the opinion that it is too low rather than too high.

The next greatest loss is caused by abnormal development, and here I am less certain of my percentage than in the former case, for the reason that the diagnosis is more difficult to the unscientific eye. It may, however, be safely stated that the loss is not far from 20 per cent, and extends over the whole period of incubation up to the time of hatching, and doubtless far beyond.

In some cases there is not the semblance of an embryo, and yet life goes on up to a certain stage. The cell mass spreads out over the yolk in an irregular way, perhaps a brain and a heart forming with a rudimentary spinal column, while in other cases the egg dies before any of the organs are discernible. I have never observed eyes in any of these more imperfect ones; in fact, the eyes are among the organs first to show abnormality, while crooked spines are well-nigh universal. Often one of the eyes is rudimentary or missing entirely, and sometimes both.

Twins and double-headed monsters, common with trout, are so rare with the whitefish that I have discovered but few, except in the case of the eggs of a single fish, where they amounted to over 10 per cent of the whole.

Next come aneurisms and ruptured blood-vessels, probably between 5 and 7 per cent. Aneurisms are much more common than ruptures, and, contrary to the rule with the higher animals, they cause death without the complete rupture of the artery. The red corpuscles form a clot in the enlargement, the serum filtering through the mass, and only a straggling red corpuscle being seen here and there coursing through the vessels of the body. The clot seems to collect them all. The heart beats feebly, and death ensues. Aneurisms are most common in the side of the embryo about the middle of the body, and it seems that most of them are on the right side.

In the earlier stages, that is, up to about two months from the taking of the egg, there is a small loss occasioned by the rupture of the yolk-sac. In these cases the embryo generally lives a few days after the rupture. I have not computed this loss very closely, but it does not probably exceed 1 or 2 per cent.

In all these cases, where the embryo is far enough advanced to show the pigment cells, or "color stars," and is approaching death, the branches of the cells become shortened, and usually at death only the nucleus remains.

For the remainder, I have not been able to determine what is the cause of death. In many cases I find what seem to be small patches of a fungoid growth on the body of the embryo. I can not see that they do any harm, and have not discovered them on the bodies of dying embryos more than those in an apparently healthy condition.

It seems to me that these deaths are the result of the natural weeding out of the weakly individuals, "the survival of the fittest," the same as in the higher forms of life, and that no amount of care on the part of the fish-culturist can prevent it, except, possibly, in reducing the number of abnormalities by exercising great care in the taking and handling of the eggs, eminent biologists holding that monstrosities are often caused by injuries sustained at certain stages in the development of the individual.

In this connection I would state that, so far as my observation goes, this loss of eggs after the embryo is formed varies greatly from year to year. It is also certain that eggs taken near the close of the season suffer a greater loss in this respect than those taken at the flood. With eggs taken near the close in small lots this loss may amount to a fourth of the whole, or even more.

PUT-IN BAY, OHIO.