36.—RECENT EXPERIMENTS IN STURGEON HATCHING ON THE DELAWARE RIVER.

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The region of the Delaware River near its mouth has long been the seat of an extensive fishery for sturgeon (*Acipenser sturio*). At Delaware City, Del., the great number of fish brought in daily to the wharfs during spawning time provides an opportunity especially favorable for experiments in artificial propagation. The studies by Prof. Ryder (published in the U. S. F. C. Bulletin for 1888) were here carried on in 1888, and during the present season this station was again selected for experiments to be made in behalf of the U. S. Commission of Fisheries.

At the time of the writer's visit the fishermen were bringing daily to the slaughtering wharfs from 50 to 100 fish; and among these (May 16, 17, 18, 1893) a number of spawners were taken. There was thus abundant material for purposes of experiment. In the following paper the results of these test studies, in their bearing upon practical sturgeon-culture, are briefly reviewed.

Fertilization.—The fertilization of the eggs, as known from former experiments,* is easily accomplished. The milt and roe appear to even retain their capability of fertilization under conditions seemingly very unfavorable. Ripe fish when brought into the docks had been out of the water at least several hours; no precaution had been taken to insure their careful transportation, and they were usually near the point of death. In one case eggs were successfully fertilized which were taken from a fish apparently lifeless. The milt appears to remain active as long as a quarter of an hour after the fish had been slaughtered.

In the mode of fertilization care in details appears to be needless. Eggs from ripe fish are readily fertilized whether extruded by pressure or obtained by excision. In the latter case there is apparently no preference to be given to eggs from different ovarian regions. Excision is certainly the more speedy and convenient method. The eggs may be received with equal success in vessels earthen, metal, or wooden. Especial cleanliness is not vitally essential—in one case eggs were fertilized in an earthen bowl from which a fixing solution of concentrated acetic-sublimate had been hastily rinsed.

Milt may likewise be taken as well by excision as extrusion. In case the fish be not actually "ripe" sufficient milt for a fertilization may often be obtained in a

*In the United States those of Seth Green, 1875 (Fish Hatching and Fish Catching, Rochester, 1879); Prof. Ryder, 1888, and William Lanz, 1890 (Ohio F. C. Report).

pipette after repeated body pressure. Milt may be collected in vessels clean, soiled, or rusted, and will retain its activity (out of water) for at least six minutes. Obtained by excision the milt may be separated from the fragments of cut testes by coarsely straining through cloth. For convenience in handling, it was found that the milt might best be secured and retained in a long rubber-bulbed pipette.

If untouched by water the eggs remain capable of fertilization for several (five) minutes. Details in the mode of introducing the milt seem of but little importance. No better results followed the introduction of milt directly from the living fish than of that strained from cut testes and retained several minutes in pipette. A few drops of milt were found to fertilize about 2 liters of eggs.

In the experiments, running water was in some cases added to the egg mass at the time of fertilization, in others as long as ten minutes afterward; in all cases were results approximately the same. Within from twenty to thirty minutes the eggs have become viscid and "set."

Under conditions of natural spawning it seems probable that the eggs are fertilized at extrusion, since experiment failed to fertilize eggs that had been immersed in water about half a minute. This spawning condition is further attested by the scratches and abrasions noted on the abdomens of spent fish, both male and female.

Difficulties in sturgeon-culture have usually been reduced to three: (1) That of obtaining ripe eggs and milt simultaneously; (2) that of imperfect means of aëration of eggs, and (3) that of inroads of fungus. It is evident that by careful experimental study the dangers of malaëration and fungous growth might be reduced, if not largely obviated. To these problems the attention of the writer was especially directed.

Difficulty of aëration.—Sturgeon eggs have proven difficult to handle on account of their viscid character. Shortly after artificial fertilization the eggs stick together in a glue-like mass; this, speedily hardening, forms a compact egg mass, whose dense jelly-like matrix the culturist finds does not permit the inner and innermost eggs to be sufficiently aërated. Dying in consequence, these become the cause of the loss of the intimately connected surrounding although better aërated eggs.

On the natural spawning-grounds this harmful condition does not, apparently, maintain. The eggs, fertilized and becoming viscid, appear to be drawn out into stringy clusters or ribbons, attaching at all points to submerged objects. Sticks, water weeds, fish nets, and especially brush, spread over with a thin layer of sturgeon eggs, are well known to the fishermen. Egg-attached objects, moreover, it is generally noted, are found only in deeper, usually channel waters.

Favorable aëration, as suggested by natural conditions, seems accordingly to be insured by the disposition of the eggs in thin layers and by a plentiful water supply. To imitate these natural hatching conditions in a way practicable for large numbers of eggs is clearly the bourne of the culturist. To attain this end, however, is not his easiest task. The eggs, becoming viscid speedily, must be attached to the hatching devices with the greatest promptness. The hatching trays must be prepared for immediate use, and the eggs must simultaneously be spread over them in a single layer. Otherwise, all eggs becoming "set" at the same moment, those that remain unspread must, in their clustered condition, be inevitably lost.

Aëration seems to be especially concerned with three cultural details: (1) The character of the egg trays; (2) the mode of egg attachment, and (3) the means of securing water circulation.

1. The shallow trays to which the eggs are affixed have, as far as the writer can find, been constructed either of fine metal gauze* or of cheese cloth.† In the present experiments the use of a coarse-meshed "mosquito netting" was found to give most satisfactory results. Of a tray bottom of this material the perforations are sufficiently large to admit an egg, but not so large as to permit it to pass through; a tray properly prepared retains a single layer of eggs, which may be aërated as conveniently on the under as on the upper side.

2. In former experiments the eggs, becoming viscid, appear to have been lifted from the water, spread upon the trays, and retained thus until their attachment. In trials made at the suggestion of Mr. Pancost, of Delaware City, the eggs were spread upon immersed trays. Under water the eggs are easily handled, flowing smoothly over the netting tray, and by careful tapping of the tray frame may be made to assume a single layer. Placed on the tray ten minutes after fertilization they become firmly attached within twenty minutes.

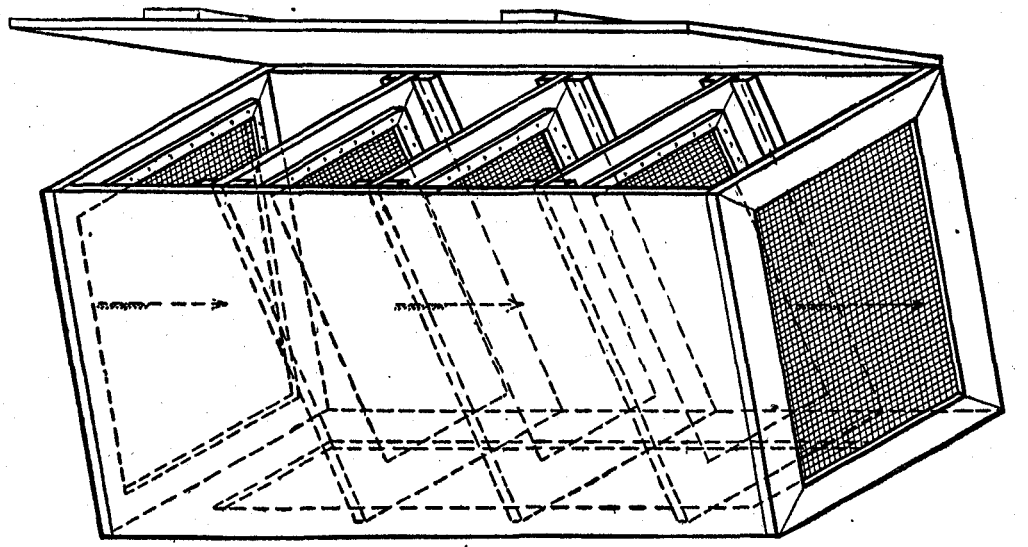

Diagram of floating case used in sturgeon hatching.

3. To secure the free circulation of water necessary to the hatching process, the egg trays are arranged in stout wooden cases, which float in the current or are sunk (Glückstadt, Elbe) in deep water. Bottom and two sides of the cases covered with metal gauze permit a free passage of water current. In the present experiments the floating hatching-case differed from any of which the writer is aware in the following regards: It was nearly as deep as wide. By this means the hatching-trays might be placed almost vertically, to thus take advantage of the water current and at the same time economize space. As many as four trays to a case were successfully employed; these, held in position by cleats, were directed slightly downward, to guard against deposits of sediment. The incoming current was directed against the under side of the tray.

*Experiments of Green and Lanz. †Prof. Ryder, U. S. F. C. Bulletin, 1888, p. 272.

The problems of aëration seem closely connected with those of fungous growth, as may be seen in the following paragraphs:

Inroads of fish fungus, Achlya.—The greatest difficulty encountered by Prof. Ryder in his experiments at Delaware City appeared to be due to fungous growth. This would be found to arise at various points of the hatching-tray during the first 48 hours of hatching, and would gradually spread its velvety encasing over and stifle the entire egg mass. For success in hatching, water sterilization was then suggested, the fungous spores to be removed by use of either filters or heat.

The effect upon fungous growth of more perfect aëration and increased salinity of water, however, had *not* been positively determined. And in the following experiment the writer aimed to reconsider these matters, hoping that favorable results might suggest a simpler and less costly means of evading fungous growth.

The results of Prof. Ryder had been obtained in a small fresh-water pond emptying through the river bank directly into the Delaware; the hatching-cases had been placed in a sluiceway through which water was constantly escaping; yet in spite of this current, fungous inroads had here destroyed all but a few of the fertilized eggs. It was the plan of the writer to array a line of hatching-cases from this shore point near the mark of low water out as far as the edge of the channel in deep water. By this means (the cases to contain eggs in every way similarly conditioned) the effects of differences of salinity, aëration, and silt deposit upon fungous growth seemed most likely to be understood. Surface waters of mid stream, stronger in current, would naturally be better aërated and more devoid of silt than marginal waters. In channel, moreover, the water density was noted at 1.007 (sp. gr.).

The success of the experiment seems clearly to indicate the means that may be here taken to obtain practical results. The eggs in strong current, in salter and less silty waters were practically exempt from attacks of fungus; those in marginal waters speedily perished (see table). It would in fact seem to the writer that the fungus is rather a consequent than a prime cause of egg destruction. That it is lacking under the natural conditions of sturgeon hatching is a fact not the most remarkable, and that it may be obviated in artificial processes by imitation of the natural hatching conditions seems the simplest plan of cultural procedure.

No. of case.	Location.	Percentage of eggs destroyed by fungus.			
		Second day.	Third day.	Fourth day.	Fifth day.
I	At outlet of fresh pond, as in experiments of Prof. Ryder	100	.....	.....	.....
II	At stake near line of low water	60	100	.....	.....
III	At wharf sluice a rod farther out	20	80	100	.....
IV	At wharf end a rod farther out	.....	20	50	60
V	In deep water in current at breakwater	.....	5	5	5

In the above results the problem of hatching sturgeon eggs is doubtless intimately conditioned by water current, by silt deposits, by salinity of water. To determine to what degree each of these factors is contributive to success would doubtless be very difficult. In the case of the common anadromous sturgeon (*Acipenser sturio*) a slight degree of brackishness of water might be regarded as a favorable, if not a necessary condition, were it not that the eggs of this species have been repeatedly hatched in

water that was absolutely fresh (New Hamburg, N. Y., Seth Green; Delaware City, Del., Prof. Ryder; the Elbe). Current, on the other hand, could not have been alone an essential condition, since in the fresh sluiceway at Delaware City, in the experiments of Prof. Ryder, a circulation maintained stronger undoubtedly than in channel waters. Nor could the effect of silt be regarded as alone the unfavorable element; quantitatively in mid stream—especially of sturgeon waters—an amount of sediment might be expected greater doubtless than a neighboring spring-fed pond. Mode of temperature variations might, again, be looked upon as of problematic value. To what degree, then, is the sum of all conditions to be regarded as essential for success in sturgeon hatching? In theory the problem is assuredly more troublesome than in practice.

As to obtaining simultaneously spawning fishes, male and female: In the event of extensive culture this difficulty is one that in the opinion of the writer could not be regarded as of serious weight. In a favorable locality each season brings a number of spawners to the wharfs of the fishermen, and with a regularity of occurrence that appears remarkable. In a letter to the writer, Mr. Reuben Anderson, of Delaware City, well known as a careful observer of the habits of the sturgeon, predicted *to a day* the appearance of spawners. He afterward stated that the "run" of fish,* though brief—often not longer than a single day—might, in his long experience, with every possibility be depended on.

* A breeding habit of the sturgeon Mr. Anderson discussed with the writer, seems for cultural purposes of the utmost significance. The earliest fish in their passage up the stream spawn farthest from the river mouth, the next school in a locality not as distant, and the later fish in the lower stream regions. This zonal distribution in spawning seems attested by the character of fish as taken in their journey past a single shore front; the earliest are uniformly "caviar fish" (i. e., of immature ovaries); later are taken "runners" (i.e., ripe fish); and at the close of the spawning season none but "slunkers" (i.e., those having spawned).