15.—HISTORY OF THE EXPERIMENTS LEADING TO THE DEVELOPMENT OF THE AUTOMATIC FISH-HATCHING JAR.

By MARSHALL McDONALD.

The work of practical pisciculture was, until a comparatively recent period, confined for the most part to the hatching of the different species of the salmonidæ. The incubation of the eggs was at first effected in troughs having the bottoms covered with a layer of gravel, upon which the eggs were placed and over which a current of fresh water was allowed to flow.

In succession followed the "grill system" of M. Coste and the different devices of movable trays now in common use for handling this class of eggs. In all these various methods the separation of the dead eggs from the live ones was effected by means of hand-picking. The necessity for the separation, although not so urgent in the case of the eggs of the salmonidæ as in that of those eggs which develop in warmer waters and in much shorter periods of time, still entails a vast amount of labor in connection with the hatching operations.

Although the ingenuity of our fish-culturists has greatly improved the forms of hatching apparatus for these heavy eggs, yet up to a comparatively recent period no other effectual means of separation than that above indicated has been found practicable. The United States Fish Commission, in the development of its work, had presented to it the necessity of dealing with the eggs of the whitefish and the shad upon a scale unprecedented in the history of fish-culture. Millions of eggs were to be hatched where fish-culturists formerly handled only thousands, and the old methods of hand-picking were soon found to be impracticable.

In all of the forms of apparatus for bulk hatching no adequate means is employed for the separation of the dead eggs from the living. All, as they come from the fish, the unimpregnated as well as impregnated, are placed in the apparatus and remain together.

In the case of the whitefish, and more especially in the case of the shad eggs (which run through their period of incubation in a much shorter time), fungus rapidly develops among the dead eggs, communicates itself to the living, and large numbers of them, which would otherwise reach the period of hatching, are destroyed. The percentage of loss produced in this way is always considerable, and in many cases none of the eggs undergoing incubation are saved. The attention of fish-culturists was early directed to the serious losses thus arising, and various experiments have been made with a view of effecting the separation of the dead from the living eggs.

In 1878 Mr. F. N. Clark, the superintendent of the United States Hatchery at Northville, Mich., attempted to effect the separation by

introducing a gate into one side of the cone, through which the shells and fish and dead eggs might go out into appropriate receptacles. This device, so far as it served for the collection of the young fish, was quite successful; but it was not found capable of doing the work for which it was first planned by Mr. Clark, and was abandoned. Similar experiments, looking to the same result, were made by him with the Chase jar—the form of apparatus employed for the whitefish work at the Northville station. The result of these experiments, however, led Mr. Clark to the conclusion that an automatic or self-picking arrangement for effecting the complete separation of the dead from the live eggs was not practicable, and a paper to that effect was written and published by him in Vol. I, Bulletin of the United States Fish Commission (1881, p. 62). The present method employed by him for the separation of the dead whitefish eggs is to siphon off the dead eggs and such live eggs as are necessarily drawn over with them, and to transfer them to what he terms "hospital jars," the live eggs thus drawn over being left to take their chances with the dead ones.

This mode of treatment undoubtedly has served to diminish materially the percentage of loss in the eggs, thus treates by him, as in this way, by the sacrifice of a small proportion of the eggs, he secured the complete separation of all elements of contamination and disease from the great bulk of the eggs.

In 1881, while I was in charge of a shad-hatching station on the Potomac River, and in position to observe closely the performance of the hatching apparatus in use, the question of the separation of the dead from the living eggs was taken up systematically, with the view of devising a form of apparatus which would accomplish the purpose and which would be of such shape as to be of easy and convenient use in practice. Knowing that there was an apparent difference in the specific gravity of the living and the dead eggs I determined to see if I could not avail myself of this difference to effect the separation. The first form of apparatus employed is represented in Fig. 1.*

* This consists essentially of an oblong trough with wooden ends and sloping glass sides, glass being used in order to be able to observe the movement of the eggs under the influence of the currents. This trough rests upon a rectangular box made of boards, which serves at once as a firm base for the support of the trough, and as a chamber for the equable distribution of the water pressure. The water, which enters the rectangular box forming the base of the apparatus through the supply pipe I, passes to the trough proper through a slot extending the whole length. The influx of the water to the trough is regulated by the valve V V′, which, by means of the set rods S S, can be pushed down so as to cut off the flow of water entirely. By setting so as to have the opening between the valves and the glass sides about one thirty-second of an inch, the water enters the hatching trough in thin sheets which are directed up the glass sides of the trough. The effect of this is to give the eggs a continuous movement in the direction shown by the arrows. The water flows over the edges of the central trough, and escapes from the apparatus at O. The dead eggs in their circuit float higher than the living, and the force of the entering current may be so regulated that the former will be swept out by the escaping water.

In the use of this apparatus I found that a fair separation could be effected, but to accomplish this required perfect stability of the vessel

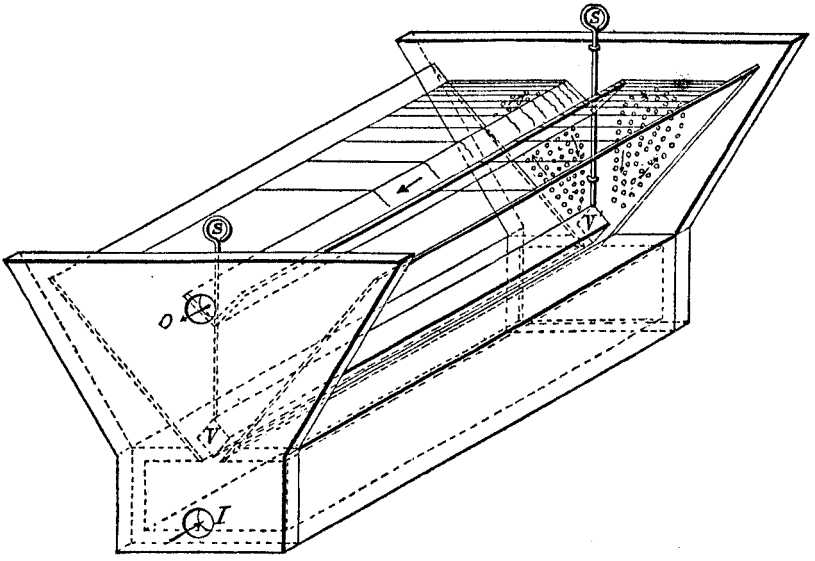

FIG. 1.—Original form of apparatus employed in the experiments. Used May, 1881, on the Potomac barges.

and careful manipulation. When the barges were lying quietly on the water, and there was no tide swell in the river, the separation went on perfectly, the dead eggs being continually thrown off from the mass of living eggs and swept by the current over into the exit trough and car-

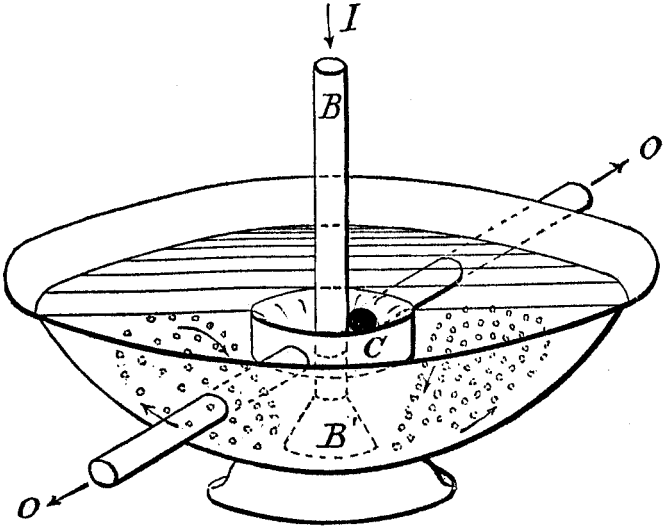

FIG. 2.—An alternate form, used in the spring of 1881.

ried off from the apparatus. The slightest oscillation, however, of the barge, produced by waves, would derange the orderly movements of the

eggs, and required continual watchfulness on the part of the attendant to prevent considerable losses of live eggs. A second form of apparatus, looking to the accomplishment of the same result, is shown in Fig. 2.

The results with these forms of apparatus were not satisfactory in developing a method which could be conveniently applied in practice, yet they pointed the way to it. Later in the spring, near the close of the hatching season, at the suggestion of Professor Baird, and in conjunction with Professor Ryder, we instituted, in the basement of the Smithsonian Institution, a series of experiments in order to determine the limit of healthy retardation of development that could be effected by lowering the temperature of the water employed. In order to subject the eggs conveniently to the action of the current of cold water

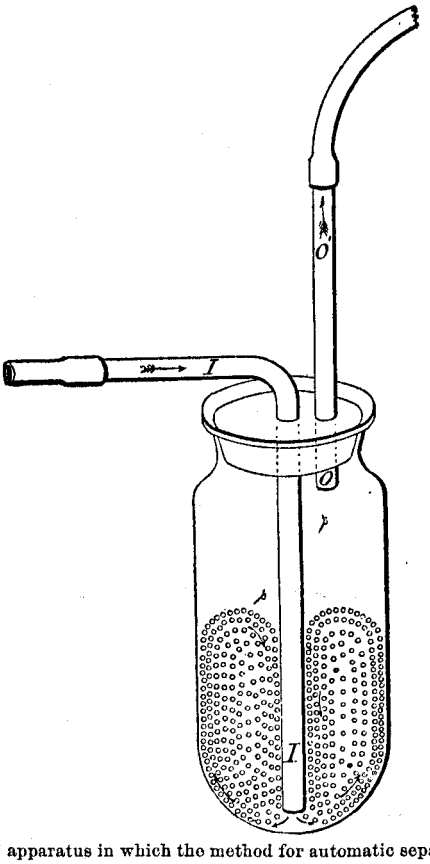

FIG. 3.—Original form of apparatus in which the method for automatic separation of dead from living eggs was demonstrated.

they were placed in small two-ounce laboratory flasks, closely corked. Through the center of the cork was passed a glass tube which descended to within a short distance of the bottom of the flask, and through which the current of water was admitted to the apparatus. This is shown in Fig. 3.

An exit tube, the lower extremity of which extends a short distance below the neck of the bottle, provided for the escape of the water. Whilst this form of apparatus had been devised by me in connection with the experiments on retardation above referred to, I had no sooner fixed upon the apparatus than I felt at once I had arrived at the solution of the question of automatic separation of the dead from the living eggs. An eight-ounce wide-mouthed glass jar, such as is used in the National Museum for holding alcoholic specimens, was fitted up as indicated (Fig. 3).

Six thousand shad eggs were placed in this apparatus and a current of water turned on and regulated. The movement of the current established a regular rolling, boiling motion on the eggs, which brought all in succession to the surface. The dead eggs remained there, forming as they were freed from the mass a layer upon the upper surface of the others. By pushing down the exit tube a suitable distance, I found that the dead eggs were taken up by the escaping current, were by degrees drifted under the lower end of the tube, lifted through it by the current, and swept out, leaving an absolutely clean mass of live eggs in the jar.

This lot of eggs was successfully hatched, and at the time of hatching not a dead egg was found in the bottle, nor do I think a live egg was lost in the whole course of the experiment.

The first experiments had been framed solely with reference to the assumed slight difference in the specific gravity of the living and the dead eggs. Attentive study of the movement of the eggs in the jar showed a still more potent influence for separation than the difference in the specific gravity. It is true there is a slight difference in this respect, but it is hardly appreciable. The more important difference, and that upon which the success of the apparatus depends, is the close adhesion which exists between the living eggs, the effect being that the live eggs rolling in mass are always in contact, even when they reach the surface, and are by this adhesion carried around in regular sequence. On the other hand, the dead eggs having once reached the surface, their adhesion to the underlying layer of eggs is not sufficient to draw them along with it in its regular movement; consequently when they once reach the surface of the mass they remain there until they are carried off by the exit tube. Several experiments made with different lots of eggs gave uniformly the same satisfactory results.

In May, 1881, the apparatus in actual operation was exhibited before a meeting of the Biological Society held in the basement of the Smithsonian Institution. These experiments were so decisive that I did not hesitate to recommend and urge the adoption of the new method in the work of the United States Fish Commission.

In the spring of 1882 it was determined to convert the old Armory building into what is now known as the Central Hatchery and Distributing Station. Prof. S. F. Baird was pleased to manifest his confi-

dence in the success of the new form of hatching apparatus by authorizing me to equip the station with them. The working form of apparatus not having been then even designed on paper, it was not possible

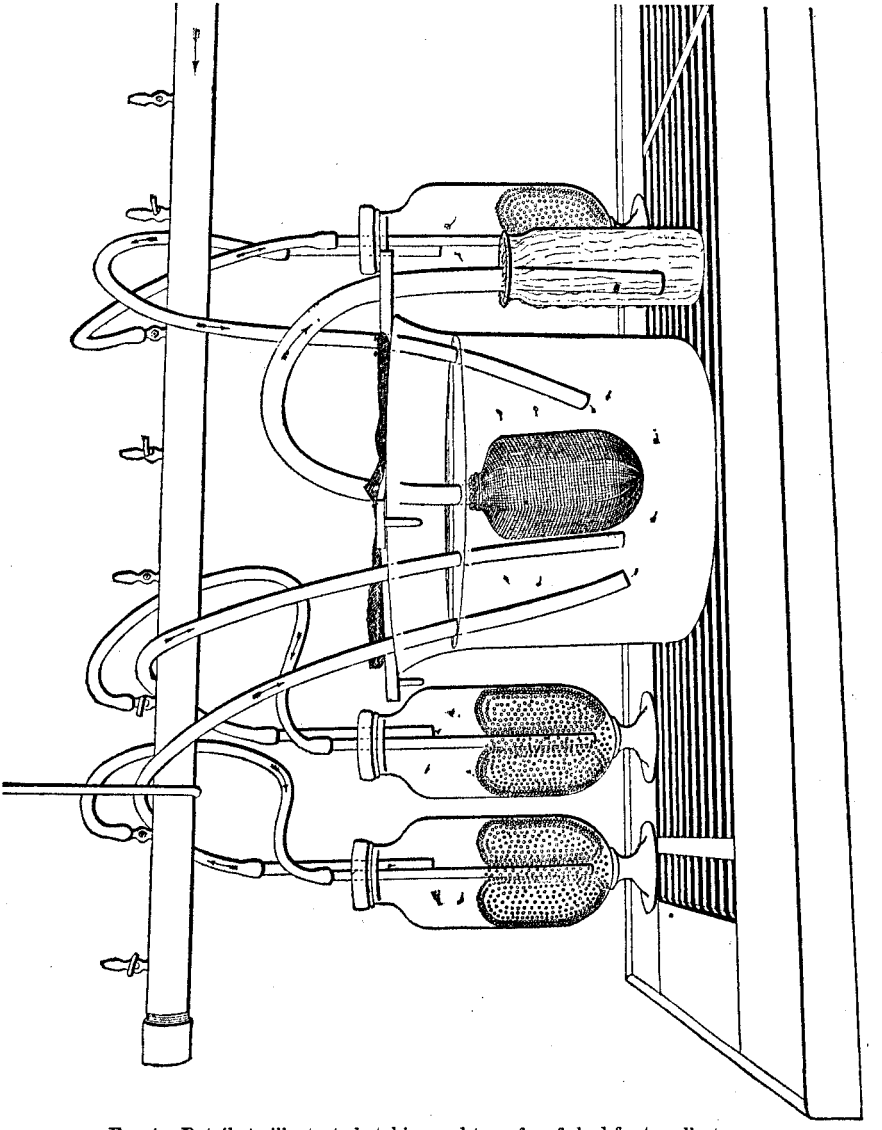

FIG. 4.—Details to illustrate hatching and transfer of shad fry to collectors.

to prepare the drawings and to have the jar complete in all details ready in time for the shad-hatching season. An improved form was devised in which cork stoppers were substituted for the screw cap and metal tops employed in the form now fixed upon. Ten tables suitably planned to receive the waste water from the jars and carry it off from the building were constructed, the pipes for the distribution of water supply to

the tables were introduced, and the station was equipped with 300 of the jars. Each jar having a capacity of 60,000 to 70,000 shad eggs gave a total hatching capacity to the station of 21,000,000 eggs at one time, or 900,000,000 for the entire shad-hatching season. This was, of course, in excess of any expected production; but in the organization of a shad station it is necessary to provide for the contingency of the great bulk of the eggs coming within an interval of a few days of each other. The form of hatching apparatus used during this season is shown in Fig. 4.

The general arrangement of a hatching table for the collection of the young fish as they hatch in appropriate receivers or aquaria is also shown in Fig. 4. The present form of apparatus and the form contemplated in the first design, but only completed recently, is indicated in Fig. 5.

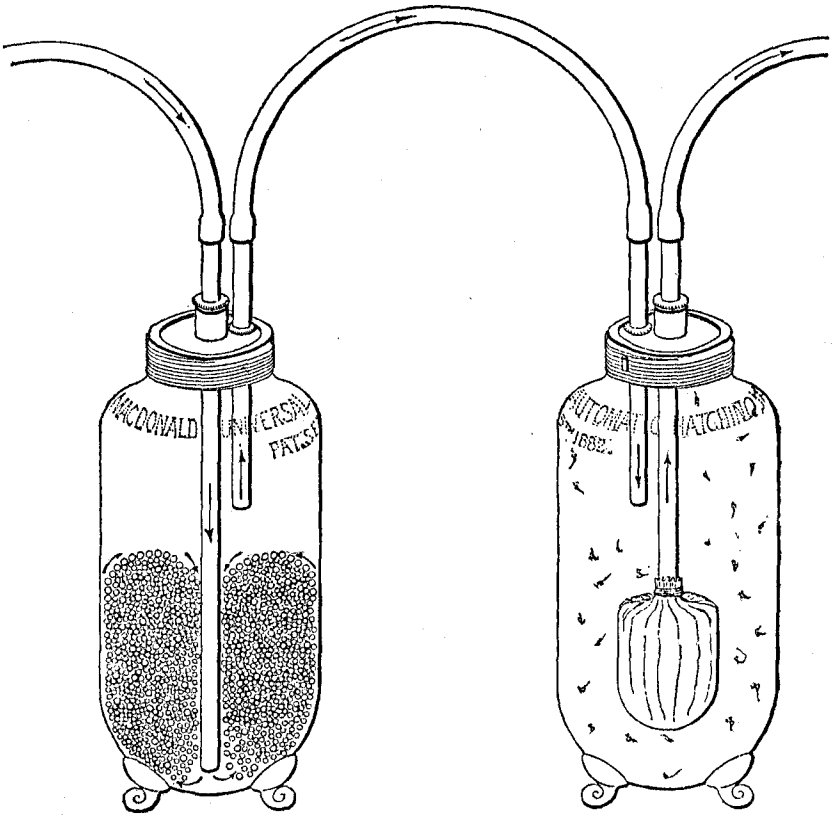

FIG. 5.—Arrangement of jars for hatching and collecting, as in use at present.

In this figure we have shown a pair of jars fitted up, one for the hatching of the eggs, the other for the collection of the young fish.

The jar consists essentially of a cylindrical glass vessel with hemispherical bottom. These are not blown, but pressed, in order to secure perfect regularity of the interior surface, upon which depends to some

extent the perfect working of the jar. The glass foot which is shown in the improvised form has been omitted in the form now in use, the jar being supported upon a tripod of three glass lugs; this form of attachment being adopted to prevent the distortion of the bottom of the jar, which would necessarily result from the attachment of a single foot to it.

The top of the jar is made with threads to receive a screw cap, and both the bottom and the top surfaces are ground so that the plane of each shall be perpendicular to the axis of the jar and so that when the jar is resting upon its feet its axis shall be perfectly vertical.

These are all-important considerations to secure the proper working. The top of the jar is closed by a metallic disk perforated with two ⅝-inch holes—one perfectly central, which admits the tube that introduces the water into the jar; the other equally distant from the central hole and from the edge of the plate. A groove in the inner surface of this metallic plate carries a rubber collar, and when the plate is in place the tightening of the metallic screw cap shown in the figure seals the opening hermetically. Both the inlet and outlet tubes pass through stuffing boxes, by which means the tubes can be slid up and down easily and tightened firmly in any desired position. The construction of the jar is such that when the metallic disk is in place the central tube takes the central position necessarily; by loosening the screw cap of the stuffing box the central tube can be slid up or down so as to produce just such movement of the eggs as is desired. If the quantity of water entering be small, or the head of water slight, without changing the feed of water we may vary at will the force and velocity with which it enters the jar. By pushing the tube down so as to be almost in contact with the bottom of the jar we make a relatively small quantity of water do the work of a larger quantity in producing motion. Moreover, as in the season of shad hatching, a full supply of water is needed and not a great deal of motion, this is arranged for by increasing the feed and raising the lower end of the central or supply tube, so that the delivery of the water from it will be under less pressure. This central tube is connected by a rubber pipe with the pet cock which furnishes a supply of water under a constant head.

The exit tube serves a double purpose—first, as an outlet for the water; and secondly, at our pleasure to remove the layer of dead eggs from the surface. This is accomplished at stated intervals, say once in twenty-four hours, by loosening the screw of the stuffing box so that the tube will slide readily, pushing it down until the dead eggs nearest to the lower end are seen to begin to pass off. By allowing it to remain in this position a few minutes the layer of dead eggs is swept off entirely. They may be either allowed to pass off in the waste, or better, collected by screens and fed to the fish in the aquaria, thus serving the double purpose of preventing the fouling of the water and furnishing a very appropriate food for many varieties of fish. When the period of hatch-

ing approaches, instead of allowing the water from the hatching jars to pass directly into the sinks, it is necessary to conduct it through the collecting jar. This is precisely similar in construction to the hatching jar. Indeed it is the hatching jar with some special arrangements to adapt it to its new purpose. The water passes from the hatching jar through the rubber tube into the eccentric opening of the receiving jar. The tube and opening then serve for the inlet instead of the outlet of the water. On the lower end of the central tube is placed a wire frame, over which is drawn a bag made of cheap cotton, the texture of which is such as to permit the water to strain through, but the meshes of which are so fine that the suction of the water will not hold the young fry against it as would be the case if a wire screen were used.

The surface of this strainer should be as large as is convenient. It is adjusted to the lower end of the central tube in such position that the end of the tube is in the center of the wire cage, or as nearly so as possible, the object of this being to make the draw of the water equal in all directions. The water is allowed to pass out of this second receiving jar out into the waste. The young fish, if they be whitefish or shad, as soon as they burst their shells begin to swim around vigorously in the hatching jar, drifting with the current. They pass into the exit tube and are carried over into the receiver, in which they may be collected to any number desired, being retained there without injury until it is convenient to make a shipment.

In extensive work in hatching I have found it more convenient to make use of large glass aquaria for receivers, four or five hatching jars being disposed around one, which serves as a common collector for the young fish from all. A siphon, arranged as shown in Fig. 4, with a wire cage and strainer on the shorter end, serves to give free discharge to the water while the strainer prevents any fish from passing out. I have found the hatching jars to be a very compact form of apparatus for handling the eggs of the salmonidæ. In this case it is not desired to nor do we give any motion to the eggs. The jar is filled with them from one-half to two-thirds full. The current of water being introduced at the bottom filters up through them, enveloping each egg in a stratum of fresh water, and placing each under the best possible conditions of development. From fifteen to eighteen thousand eggs may be readily placed in each jar. Of course, in the case of these eggs we must have recourse to hand-picking. This is readily accomplished by opening the jars, placing the hand over the mouth to prevent the escape of water, inverting and placing the mouth under water over a broad shallow tray. The eggs by gravity flow out and spread over the bottom of this, and when picked over are returned to the jar, the precaution being observed to have the jar full of water, and to use a broad flat funnel to return the eggs. They may be poured from the tray into the jar in bulk without any injury.

From the experience had during the winter of 1882 in hatching this

class of eggs at Central Station I am convinced that large numbers of eggs up to the very period of hatching can be handled in this jar.

The necessity of arriving at methods of hatching the light or floating eggs of many of our salt-water fishes has for several years impressed itself upon the United States Fish Commission. No form of apparatus heretofore devised has been satisfactorily operated to the accomplishment of this purpose. The experiments made during the summer of 1882 in the Chesapeake Bay with the eggs of the Spanish mackerel led to the hope that the hatching jar, fitted up as a receiver, may be with equal advantage employed in hatching this class of eggs. The number of eggs obtainable was not enough to give results sufficiently decisive to establish this assertion. But these eggs, being subjected under the conditions presented in the receiving jar to a current of salt water, being confined so as to prevent escape, and this confinement effected without the use of appliances that would injure the delicate membrane of the shell, there seems to be no reason why we may not use the jar as successfully with this class of eggs as with those of the whitefish and the shad.

UNITED STATES FISH COMMISSION,
Washington, D. C., April 6, 1883.

16.—THE SUCCESSFUL STOCKING OF STREAMS WITH TROUT.

By WAKEMAN HOLBERTON.

[From a letter to Prof. S. F. Baird.]

Near Cleveland, Ohio, is a stream, very much of the nature of Caledonia Creek, only finer and larger, which gushes from the earth in such volume as to turn a mill not far from its source. This stream never contained trout until 1872, when it was leased by a club and stocked with trout which, I think, were obtained from Lake Superior. Since then the trout have increased finely and the fishing is superb. It is not unusual for trout to be taken there of three or even four pounds weight. The members of the club are restricted to fifteen pounds a day, and only allowed to fish three days in a week. The fish are well fed and very lively.

The trout which were put into some streams near here two years ago are doing well. I noticed a marked increase in fishing last spring. The California trout that we put in in 1881 were doing finely last year, and had already grown to the size of four inches. I caught several of them but returned them to the water.

NEW YORK, *March* 9, 1883.