ENTRANCE TO MARINE GROTTO.

1.—OBSERVATIONS ON THE AQUARIA OF THE U. S. FISH COMMISSION AT CENTRAL STATION, WASHINGTON, D. C

[Plates I to IV and two text figures.]

BY WILLIAM P. SEAL.

THE MARINE AQUARIA.

The establishment of a marine aquarium at Central Station for the purpose of demonstrating the possibility of keeping marine plants and animals at a distance from the sea, and consequently with the use of a very limited quantity of water, was entered upon at the beginning of the year 1889, and has resulted so favorably as to afford abundance of argument for an extension of the work as a means of practical observation and experiment.

The system of construction adopted is the most economical and favorable possible. The building is practically a greenhouse in style, 16½ feet wide and 64½ feet long, built against the west side of Central Station, with a small extension about 8 feet in length on the south side, sufficient to accommodate the pumping apparatus, filter, etc. This style of structure, whether simple or elaborate, is necessary to afford the light required to establish favorable conditions for plant life, and no doubt in as marked a degree for the health and happiness of animal life also.

The construction of both building and grotto will be understood by referring to the accompanying ground plan. (See plate III, at end of article, page 12.)

The central space or gallery for the observation of the aquaria is completely covered with imitation rock-work made of heavy paper applied in a soft or plastic condition and afterward painted, sanded, and frosted. No part of the aquarium tanks is allowed to show except the glass, which appears like so many holes or openings in the rocks. While all extravagance in the attempt to imitate natural rock is avoided, there is still afforded a very realistic representation of a natural grotto or cavern in which the observer appears to be beneath or surrounded by water.

The idea of constructing an aquarium in any imitation of a cavern or grotto has been very vigorously assailed by Mr. W. A. Lloyd, late superintendent of the Crystal Palace Aquarium, London, England, principally from an artistic or esthetic standpoint, the argument being in general that any attempt at ornament or idealization is unnecessary and inefficient for the object sought, and therefore wasteful and inartistic.

Not assuming to be competent to affirm or deny Mr. Lloyd's conclusions from his standpoint or to form an opinion concerning attempts of this nature in European capitals, which were altogether different from the skeleton framework and light paper shell of the Central Station Aquarium, they having been built of stone and cement at great cost, I commend the idea as here employed on the score of economy, cleanliness, and general effectiveness. To have produced equally good results with wood or metal would have cost very much more. The advantages of such an arrangement are that, while the aquaria are afforded the light necessary for their success, it is cut off from the eye of the observer, except as it reaches it softened and diminished in passing through the water. A further advantage is that the attendants can carry on their work undisturbed and without annoying or distracting the attention of the observer from the aquaria. It further prevents the introduction of food, or the interference of any kind, by visitors or those not properly authorized.

Some unavoidable use of brass piping in the beginning demonstrated beyond any further need of experiment the necessity for the entire absence of metals from the tanks, reservoirs, and circulatory apparatus, and consequently the materials now used in their construction are glass, slate, hard and soft rubber, and wood, nothing being used which is oxidizable or capable of exciting galvanic or chemical action.

The use of an awning covering the entire structure affords the necessary protection from excessive heat and sunlight in summer.

A gas engine with hard-rubber pump supplies the means of elevating the water to a sufficient height to give the pressure necessary for effective aëration.

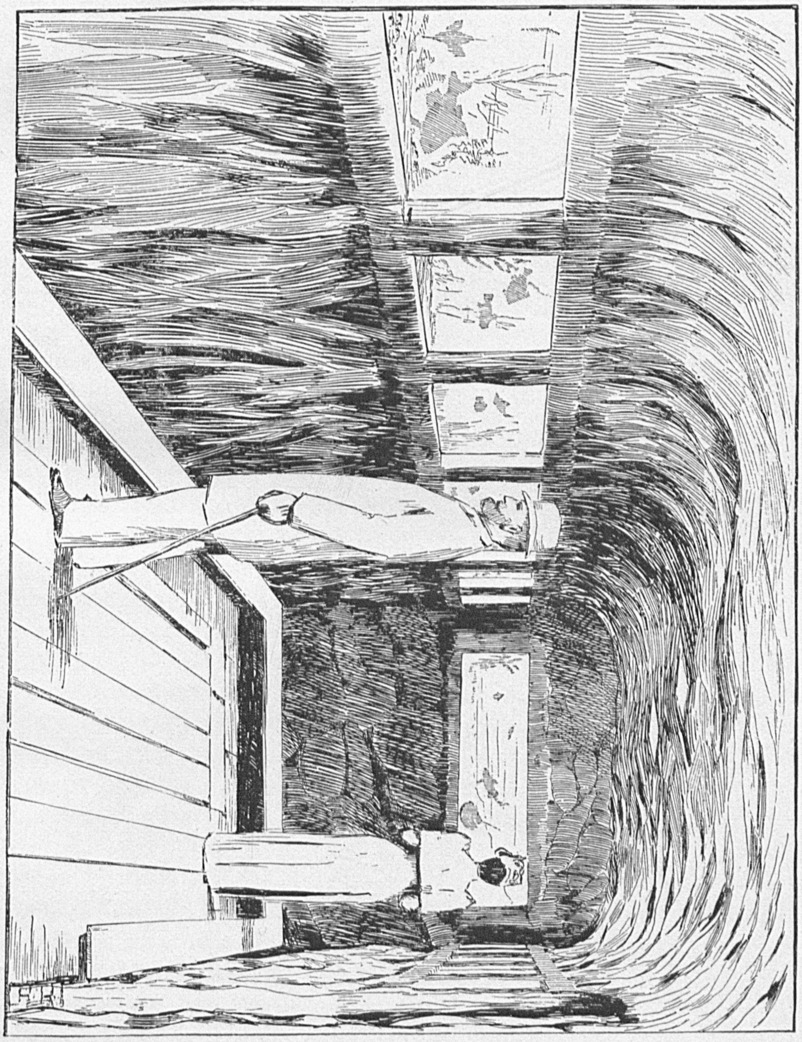
The number of aquaria in the marine grotto is twenty-four, having an aggregate capacity of about 1,800 gallons of water. The elevated tank holds something over 400 gallons. The reservoir, located in the yard of Central Station and inclosed with wood and glass, holds about 4,000 gallons of water, thus making a total of about 6,000 gallons in the circulation. The upper tank, being at an elevation of about 40 feet, gives a pressure of about 20 pounds to the water entering the aquaria.

By passing the water through very small glass nozzles (one thirty-second to one-eighth inch orifice, as required) at this pressure a small amount of water suffices, as a very large amount of air is drawn in with it and dispersed throughout the entire body of water in an aquarium in minute bubbles, thus affording efficient aëration.

In addition to this circulatory system, there is an auxiliary system of aëration, which is used in case of unavoidable suspension of the circulation, and is also valuable in special cases and in the aëration of water of other degrees of density than that in the main body of salt water.

This system, devised by Hon. Marshall McDonald, is a modification of the various air-pumps in use, which are operated by a fall of water through tubes, and is so simple and efficient as to be of very great value, and within the reach of all, for the aëration of a single aquarium kept for amusement or for the greater needs of institutions of learning. Artificial aëration, or change or circulation of water, is necessary where more than a certain proportion of aquatic animals are kept in a given amount of water. For the keeping of marine forms of life where the supply of salt water is necessarily limited and especially for the uses of biological laboratories, this device should prove of very great value.

To establish such a pump there must be first a fall of water. As but a small amount is necessary for the operation of a single pump, it may be carried up from a



INTERIOR VIEW OF MARINE GROTTO.

watercock, conveniently located, by means of small rubber tubing. The higher it can be carried, the greater will be the force created. The fall should be 8 or 10 feet at least, and 20 or more feet will make it much more efficient. The higher it is carried, however, the stronger the tubing must be. From this tube a small stream of water, cut down to a gentle flow, is allowed to drop into another tube having an enlarged mouth and of one-fourth to three-eighths inch bore, drawing in with it air, thus inducing capillarity, the air forming into globules or bubbles alternating with water spaces, as shown in fig. A 1, plate IV.

In the illustration the tube is shown as being attached directly to the cock and with a hole in the side for the induction of air. This method of attachment is probably the best, and might be made more effectual by the use of a metal supply-pipe.

Some provision is necessary for carrying off the water in case of any accidental stoppage of the pump, as when the water is prevented from passing down the tube it finds its way out of the air-hole at the top. A funnel-shaped receiver with a nipple inserted into the side, to which may be attached a piece of small rubber tubing leading to a sink or other exit, might be placed on the tube below the air-hole and would probably be as simple and effective as anything; but this can be left to individual ingenuity.

A small nozzle has been used through which to pass the water into the tube (A 1) with force, but it is probably no more efficient, while great strain is brought on the tubing attaching it, often causing it to burst, and it is also liable to become choked by small crustaceans, scale from the water-pipes, etc.

Through the tube (A 1), which is an enlarged sketch of what would be the top of the supply tube (A 2), the air and water pass into a jar, B, which has, in addition to the entrance or supply tube, two exit tubes, all passing through an air-tight cork or stopper, C. One of these tubes, D, merely passes through the stopper and is for the exit of the air, which of course remains in the upper part of the jar or above the water, while the longer one, extending to the bottom of the jar, is for the exit of the water.

A proper regulation of the height of the overflow-pipe outside the jar will regulate the flow of air into the aquarium. This regulation is necessary to equalize the pressure, as it will vary with the proportion of air and water passing into the jar, the depth of water in the aquarium, etc.

Several forms of liberators for the air passing into the aquaria have been devised. The difficulty in efficient aëration in this way has been in the tendency of the escaping globules of air to coalesce and form large bubbles. The more finely the air can be comminuted the more rapidly it will be absorbed by the water, and consequently the more perfect the aëration will be. Many kinds of dead wood, which are porous, such as grape-vine, have been found to liberate the air in very minute bubbles, and sponge properly inserted into the mouth of a glass tube bent in the shape of a hook so that the mouth will open upwards has worked well. It is probable that many other more satisfactory porous materials may be found.

The original supply of salt water was brought from Chesapeake Bay, and from time to time when the Commission's steamer, the *Fish Hawk*, returns to Washington an additional supply is obtained. This, however, does not supply all loss from various causes and artificial sea water has sometimes been used. This has been made by using a salt produced by evaporating sea water.

The usual method of preparing artificial sea-water for the aquarium is by use of one of the many formulas provided for the purpose. In the present case Turk's Island salt is used. The writer has used this salt for preparing salt water for small still-water aquaria with perfect success, and it has proven satisfactory in the present case. There was in the beginning some principle, apparently mildly acrid or astringent, affecting more or less unfavorably all of the lower forms of life, while it had but little noticeable effect on the fishes. Fishes having a slimy mucous coating, such as the toad-fish, appeared to lose it and the skin became shriveled in appearance, but their general health seemed unaffected.

It appeared probable that, as there is a considerable precipitate of lime from this salt in solution, some of it may have remained in suspension for a long time owing to the activity of the circulation. It was noticed at least that in the same water which is quiet and has stood for some time the low forms of life kept in much better condition, but without some form of aëration the amount of life so kept must be very limited. The result was all the more puzzling because of the fact that some fish usually very difficult to keep lived remarkably well. Among these was the gizzard shad, transferred from fresh water. It was finally found to be necessary to exercise more care in introducing the water into the reservoir so as to avoid stirring up the precipitate of lime formed at the bottom of the vessel in which the solution was made. After this precaution was taken the disturbing effect disappeared.

It appears, from a paper by R. S. Hoffmann in the Bulletin of the U. S. Fish Commission for 1884, that the Berlin, Hamburg, and Vienna aquaria encountered in the beginning numerous difficulties in the preparation of artificial sea-water, threatening failure for a considerable period.

The director of the "Zoophyte Aquaria" in the Zoological Garden in Regent's Park, London, declared some years ago that "artificial sea water, even if a chemical analysis can not discover the least difference between it and natural sea water, is never beneficial to animals and plants;" but this has been disproved by the success of the aquaria at Berlin, Hamburg, and Vienna. In 1884 the artificially made sea water of the Hamburg aquarium had not been changed for 15 years, and was then perfectly transparent and odorless, and in every way satisfactory.

A minute green organism which appeared in the water of the Washington aquarium during a long and unavoidable suspension of the circulation during the summer of 1889 in such numbers as to render the water opaque was finally eradicated by causing the water to pass through a filter composed of sand and gravel of graduated sizes on its way to the reservoir.

One of the interesting evidences of the advantages of the greenhouse system employed, affording abundance of light, is the beginning of the development of algæ directly from spores on the slate work of the aquaria and on the stones placed therein. There is apparent evidence that in time there will be a dense growth of algæ adapted to the changed conditions, just as on sea-walls, piles, etc. This is a matter of slow development in nature, so that some time will elapse, probably, before there is a very complete realization of this expectation.

The necessity for light is most effectually illustrated by the fact that this plant development is greatest in the aquaria at the southern end of the grotto, diminishing gradually towards the northern end, which does not receive so much sunlight.

The plant and animal life has been supplied by seining expeditions to Chesapeake Bay, and by several lots of specimens brought by the Commission's steamer *Fish Hawk* on her returns from work of investigation.

During the springs of 1889 and 1890 a number of the eggs of the horse-shoe crab (*Limulus*) were received by mail from Delaware Bay by Dr. Hugh M. Smith, of the Fisheries Division of the Commission. They were sent by Mr. E. S. Howell, of Dias Creek, New Jersey, packed in wet sand in small tin boxes. They hatched and developed until about three-eighths or one-half inch long, when they began to die off gradually, probably from lack of proper food. The adults in the aquarium feed on beef, clam, and fish.

A number of nests of the 2-spined stickleback (*Gasterosteus aculeatus*) were built, affording an opportunity for observation of the breeding habits of that species. The nest is composed of a mass of vegetable fiber and shreds of algæ, living and dead, deposited on the bottom of the aquarium or on the flat upper surface of a piece of rock. It is not so elaborate as that of the 4-spined species, but is bound together in the same manner by means of a thread spun by special secretive glands, as described by Prof. John A. Ryder, in the Bulletin of the Commission for 1881, in the case of the 4-spined species. The young are protected by the male after hatching by driving away other fish, and by giving them an education in self-protection. He will dart at the young as if about to devour them, causing them to take refuge among the plants and stones, to again emerge as he darts off in pursuit of fish venturing near. With a vigilance that is incessant and untiring they are thus guarded and driven under cover until finally they flee and hide at the passing of a shadow over the water.

During the spring and summer of 1889 four species of Cyprinodonts spawned in the aquaria and their spawning habits and sexual coloration were noted.

The readiness with which these small species spawn in captivity justifies the belief that when adequate conditions are afforded for our larger fishes similar results will be attained with them. Such a consummation would undoubtedly lead to the most practical advance possible in our knowledge of the habits of our fishes.

It was noticed, on transferring some white perch (*Roccus americanus*) suddenly from fresh to salt water, that they were so buoyant as to be unable to swim beneath the surface, the dorsal fin and part of the back being out of the water, and that it was only after some days that they acquired the proper specific gravity and could swim about normally. This probably explains the necessity for a gradual change from water of one density to another, they not appearing to suffer from the effects of the salinity.

In a similar experiment with some eels they were able to keep near the bottom, but had a tendency to stand on their heads.

A very interesting experiment has been made in confining fishes infected with fungus (generally as a result of injuries received in transportation) and such as are infested with parasites, in brackish water for a time. It is well known by all who handle live fish that they are very easily injured. The scales may be detached, the fins torn and abraded, the lips bruised and torn from knocking against the sides of the can or box, and the whole mucous coating and skin more or less scratched and bruised. Many of these injuries do not show for some days, and it is possible that where fish are speedily restored to natural conditions at the end of their journey they may find in the mud or in some other source a healing specific which will effect a cure. In the aquarium, however, they are soon attacked by fungus (*Saprolegnia*), and in their generally depressed condition, refusing food although undoubtedly slowly starving, they soon succumb. The usual method of treatment in such cases is to dip them frequently into salt water. While many other solutions, such as carbolic acid, washing soda, etc., are frequently used, it is quite probable that the salt water is as efficacious as any of them and much less liable to do harm. The labor involved, however, in treating a number of fish in this manner is very great, and the splashing and slopping occasioned by large fish is a further objection.

It is also a question as to whether the injuries inflicted upon fish by the frequent handling of them, especially in the common knot-woven net, are not as great as the benefits received from the treatment. However that may be, the experiment herein described seems to open up a very simple and efficacious treatment of fishes so injured. The water in the aquarium was brought to a density of 1.006. The fish experimented upon were large-mouthed black bass, white bass, red-eye or rock bass, crappie, yellow perch, white perch, eel, sunfish, carp, goldfish, and catfish. The under lips of the black bass were badly torn and completely covered with fungus. There is no question in the minds of any who saw them and understood their condition that they would have speedily died in a fresh-water aquarium. After a month's sojourn in the brackish water they were fully restored, with a new skin grown over what were ragged festering sores. While in the brackish water they commenced to feed upon small minnows given them, whereas in the fresh water they would not feed at all. In every repetition of this experiment the same favorable results were obtained.

The crappie is a timid and very delicate fish, easily injured by transportation. It is soon attacked by fungus. In every instance it has been speedily restored by the brackish-water treatment. All the other species mentioned were quickly cured of injuries or freed from fungus in the same way.

The goldfish and carp are frequently infested by a minute infusorian parasite, the identity of which is not yet certain, and the catfish, sunfish, white perch, trout, and others, are in winter infested by a parasite, *Chromatophagus parasiticus*, and all of these have yielded to the brackish-water treatment.

It seems assured also, from the experiments made, that any of our fresh-water fishes will live for an indefinite time in salt water about one-fourth the density of sea water; whether an artificial solution will answer as well as the sea water itself is yet to be determined. There is an interesting field for experiment and observation thus opened up in this direction. It has been found also that, to some extent at least, beneficial effects have followed the temporary transfer to brackish water of species supposed to live wholly in sea water.

All of the salmon and trout may be transferred suddenly from fresh water to water having a density of 1.010 without inconvenience to them, and the water can then be brought up to the full strength in the course of two or three days.

It should be stated that the density of the main body of water is kept at 1.020, as that has been found to be sufficiently saline for any species whatever, and also to be more generally favorable to all species.

The aquaria have proven to be very popular, and the expressions of wonder and delight are universal; and many zoölogists, and biologists in particular, are gratified that at last there is a possibility of the development of conditions affording the means for the study of marine as well as fresh-water forms in a living condition where access may be readily had to works of reference.

Of course it is not to be assumed that the ultimate measure of success will be suddenly attained. Much is yet to be learned regarding the requirements of all forms of life under artificial conditions. The temperature at one season is unfavorable for some species, and at another season for other species. There may be a necessity for a change of density of water at certain seasons for some species as well as the nearly uniform temperature which they find in nature by migration, and these are impossible to provide for under existing conditions. All of these and many other influences are matters well worthy of investigation in the general interests of science, to say nothing of the advance of knowledge necessary in the holding and handling of many of our fishes for the more practical purposes of propagation.

The realization of these objects must be accomplished through the medium of years of investigation and patient observation and experiment, based upon a knowledge of past progress in this direction, and a comprehensive idea of and faith in the possibilities of fish-cultural development. All the experiences of the past, successes and failures, point to the necessity of approximating natural conditions more closely in the keeping of living things in captivity.

Some fishes are less easily kept or transported than others, principally, it is believed, from mental effects alone. Many are physically much more tender and more easily injured than others. The young of a species will endure the conditions of captivity, while the adult will refuse food and pine and die.

In the future development of aquaria, and in all attempts to hold fish or other animals for purposes of study or propagation, all of these influences of environment must be considered. To ignore them is to limit the chances of success, or to invite absolute failure. All the advances made will be upon the lines of imitating nature more closely, so as to render animals measurably happy and contented by affording such conditions as will promote a normal and healthy physical condition and development.

THE FRESH-WATER AQUARIA.

There are twenty-five tanks devoted to fresh-water fishes; they vary in capacity from 10 gallons to almost 300 gallons. The conditions afforded are, as a rule, unfavorable, owing to the impossibility at present of having the proper amount of light for healthy plant growth, upon which depends the proper condition of the water as well as the health and happiness of the fishes. The prevalence of fungus is very great, leading to the conclusion that the conditions for its development are very favorable. There are animal parasites, also, which at times become veritable plagues, but which, under natural surroundings, do not appear to exert any injurious influence on fishes. Some means of controlling the temperature of the water in winter would be very desirable, as, when it approaches the freezing point, the fish generally refuse food, and not being afforded the opportunity for the semi-hibernation possible to them in nature, they soon succumb. These matters are mentioned not as difficulties which can not be overcome, but rather as the unavoidable results of an enforced economy.

One very persistent and troublesome form of parasite is described in the Report of the Commission for 1884, by Dr. S. Kerbert, as *Chromatophagus parasiticus*. This parasite is an infusorian which encysts itself in the skin of fishes and but few are exempt from its ravages. So completely will a fish become infested with them that it would be difficult to find a spot as big as a pin's head free from them. Many experiments have been made to find means of destroying it, but, until the efficacy of confinement in brackish water was noticed, it was impossible to restrict its ravages. When thus infested the fish will refuse food and by scratching themselves violently on the sand or stones will soon produce an inflamed condition of the skin and a rapid growth of fungus, to which influences they soon yield and die.

The necessity for a supply of brackish water in circulation, in addition to the salt and fresh water system, is thus demonstrated to be of the greatest importance, from a practical and economical standpoint.

The prevailing muddy character of Potomac River water renders it necessary to employ some means of filtration. The system now in use (the Loomis), although probably as good as any, if not the best of the same character in use, is open to serious objections from several points of view. It requires frequent cleaning to render constant good service. The use of alum as a coagulator involves the necessity of very great watchfulness on the part of those required to attend to the operation of the filter. The amount of alum dissolved, or necessary to take up the matter in suspension in the water, appears to vary somewhat with temperature. The muddying and clearing of the water must be closely watched and the alum feed regulated to correspond. A very slight amount of alum will affect fish, and accidents will occur with the most watchful under such circumstances.

There is a question also as to whether, although apparently having no direct injurious action on the fish, something in the character of the water after filtration by the alum process may not be, in part at least, the cause of the difficulties encountered from fungus. It is stated in the Report of Walpole and Huxley, inspectors of fisheries of England and Wales, for 1881 (See Bull. U. S. Fish Com. 1881), that—

> It is known with respect to many of the common molds such as *Penicillium* and *Mucor*, which are habitually saprophytes (that is to say, live on decaying organic matter as *Saprolegnia* does), that they flourish in certain artificial solutions containing salts of ammonia. It is quite possible, though whether the fact is so will have to be experimentally determined, that *Saprolegnia* is capable of living under the same conditions. Fungi are also extremely sensitive to slight differences in the acidity or alkalinity of water, so that even apparently insignificant changes in that respect may come into play as secondary conditions of salmon disease. * * * A factory for making a spirit from turnips was established near Schweidnitz, in Silesia, and the refuse was poured into an affluent of the river Westnitz, which runs by Schweidnitz. The result was such a prodigious growth of *Leptometus* that the fungus covered some 10,000 square feet of the bottom of the stream with a thick white layer compared to sheep's fleeces, choked up the pipes, and rendered the water of the town undrinkable.

The writer has noticed similar developments of fungus, possibly the same, in streams into which the refuse of creameries was allowed to drain. On the other hand, the presence of fungus in such quantities in the fresh-water tanks at Central Station may be due, to a great extent, to the lack of light afforded them and the consequent absence of growing aquatic plants, as in those tanks where there is an abundance of light and a healthy plant growth it gives no trouble, in fact is practically unknown.

The attempts to establish an exhibit of live fishes at the New Orleans Exhibition failed because of the use of alum in filtration. At the Ohio Valley Exposition, at Cincinnati, Ohio, in 1888, very great difficulties were encountered in establishing an exhibit of aquaria, owing to the muddy character of Ohio River water and the high pressure of the water supply there. Some accidents occurring threatened for a time a failure of the live-fish exhibit. The difficulties were finally overcome, but, together with the other experiences and observations herein recorded, point to the desirability of the development of some absolutely pure and automatic system of filtration for use in connection with the establishment of aquaria here and elsewhere.

It should be stated in explanation of the use of a filter of this character that it is the only system yet introduced which will afford a sufficient supply of water and deliver it with force so as to provide for the efficient aëration of the water.

The spawning of the yellow perch (*Perca flavescens*) in an aquarium in March and April of 1888, and again beginning as early as December of the same year and running through January, February, March, and up to April 10 of 1889, is further evidence of the possibilities of the natural spawning of fish in aquaria. Probably few fish of such size would spawn under such restricted conditions, much larger tanks and more natural surroundings being required. The smaller species of fish spawn more readily. The goldfish and the paradise fish (*Macropodus*) are hatched and reared in the tanks each season.

GENERAL OBSERVATIONS ON THE HABITS OF FISHES IN THE AQUARIA.

SPAWNING HABITS OF THE DARTERS.

During April and May of 1889 a number of spawnings of the "tessellated" darter (*Boleosoma olmstedi*) were observed. The eggs were deposited on the under surfaces of stones, or on the backs of them, where one leaned against the ends or back of the tank, or against another stone, in a single irregular layer over an area of about 1 by 3 inches. They were about the size and appearance of those of the common sunfish and were deposited in the same manner. The great activity and brilliant coloration of the male, which is ordinarily one of the most sober-hued of the darter family, differing but little from the female, were very conspicuous.

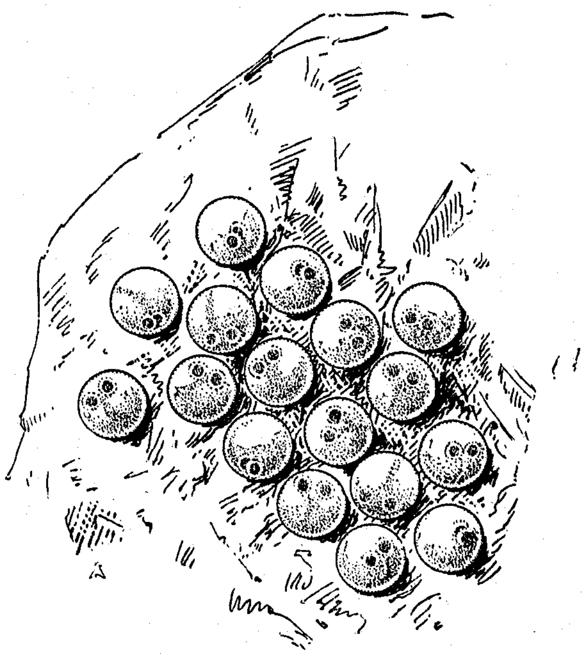


FIG. 1. Eggs of the Tessellated Darter (*Boleosoma olmstedi*) spawned in Aquaria.

The spawning was effected by passing up and down over the surface chosen until all the eggs were extruded and adhering to the stone. The fish undoubtedly pair, for, although all the males would be in a state of great excitement and would endeavor to join in the operation, they were invariably driven away by the successful male, who would dart at them furiously with open mouth and fins quivering with excitement, the colors glowing with increased brilliancy and intensity. The male guards the eggs incessantly and drives every fish from their vicinity during incubation, retaining the brilliant color until that duty is over.

The markings on the fins of the males become at this period very bright and distinct, and add more to its ornamental appearance than the brightest coloration does to other species. The colors assumed at this period are a mingling of delicate and indefinable shades of blue and green with bronze and iridescent reflections, which, with the striking effect produced by the markings, make it perhaps as beautiful as any of the family, if not so gorgeously colored.

The "rainbow darter," also called blue darter, soldier fish, etc., is probably not found east of the Allegheny Mountains. It is one of the most highly colored species of the family *Percidæ*. The prominent colors are red, yellow, orange, blue, and green, arranged in conspicuous patches, or regular patterns of the most striking character. The specimens in the aquaria are from the vicinity of Cincinnati, Ohio, and Neosho, Missouri, and correspond perfectly in color and markings.

The following probably inadequate description of the markings may give some idea of the gorgeous colors of the fish: Lower half of spinous dorsal deep brick-red with a line of lemon-color arranged in a series of arches on the membrane just above the back; a lemon-color line, composed of a series of arches also, at the upper margin of the dark brick-red, arranged in reverse order to the lower lemon line, that is, with the concavity of the arches turned upward; the upper half of the fin of a very deep indigo-blue. Soft dorsal, an artistically arranged pattern of green, blue, yellow, and light brick-red, difficult to describe except by diagram. Ventral and anal fins with broad band of pale-blue (becoming more intense at times of greatest excitement) at base and tips, with a broad central band of deepest indigo-blue; pectoral fins transparent, yellow at base; caudal transparent, bordered with dusky and pale blue; a blue blotch across the nape; breast with small orange spot; a lemon-yellow dash around the throat.

This species is more addicted to perching on aquatic plants near the top of the water; this habit, with its darting movements (which are analogous to the flight of birds), not having a swimming bladder, make it very bird-like in appearance.

At the spawning period a spot would at times be selected, apparently, among the plants as a place of deposit for the eggs, and, although in their active sexual demonstrations they would travel to every part of the tank, they would invariably return and perch in the same place. As with the tessellated darter, there was undoubtedly a mating, although usually two or three other males would hover very near and frequently make rushes to join the female, in which they were invariably defeated and driven away by the chosen male. At times the spawning would take place among the pebbles on the bottom of the tank, the female dragging herself along in a quivering manner, the male pressing closely alongside, and other males following closely in the rear, evidently bent on assisting in the fertilization of the eggs. All the fish not actually engaged in the spawning were evidently in a state of great excitement, and followed after, eating the eggs as fast as they were deposited. As the tessellated darters are much the larger, the eggs could hardly have been protected from them, although many smaller fish, notably the 4-spined stickleback, under like circumstances, would attack anything regardless of size.

It is probable that in a wholly natural condition the eggs are deposited on the under or protected sides of stones where they would be more easily guarded. In the limited space of an ordinary aquarium tank, well stocked for exhibition, there would hardly be a sufficiency of desirable spawning-places for all. In some cases the females would remove the sand from beneath a part of small stones by means of the fins and would remain ensconced in the shelter thus made, but no spawning was observed in such situations, the preference appearing to be for the denser masses of plants high up or among the pebbles on the bottom.

The spawning of the tessellated darter was wholly as described on the sheltered sides of stones, but their presence in the same tank may have interfered with the natural habits of the others.

The quick, jerky, energetic, climbing and darting movements of both species are much like those of the nut-hatches among birds.

BREEDING HABITS OF FRESH-WATER MUSSELS.

Three species of *Unionidæ* were under observation during the spring of 1890, which showed the manner of development and escape of the young. The accompanying sketches of two species are traced from water-color pictures by Mr. S. F. Denton.

The specimens were not positively identified by the conchologist who observed them. It will be seen that while the shells are outwardly very much alike the peculiar development of the mantle is very different in each and would afford a ready means of identification in the breeding-season.

The difference in color is also very great. In the one with the small tentacles the color of the mantle is white, tipped with pale yellow, with the gills, which also inclose the eggs and appear as the lobed central mass, a pale slate color. In the other the mantle is salmon color from pale to quite deep tints, while the egg-sack is purple.

In each of them the peculiar processes or tentacles were kept constantly in motion, in the one waving like cilia, while in the other they were constantly clasped and unclasped, crossing as a pair of arms.

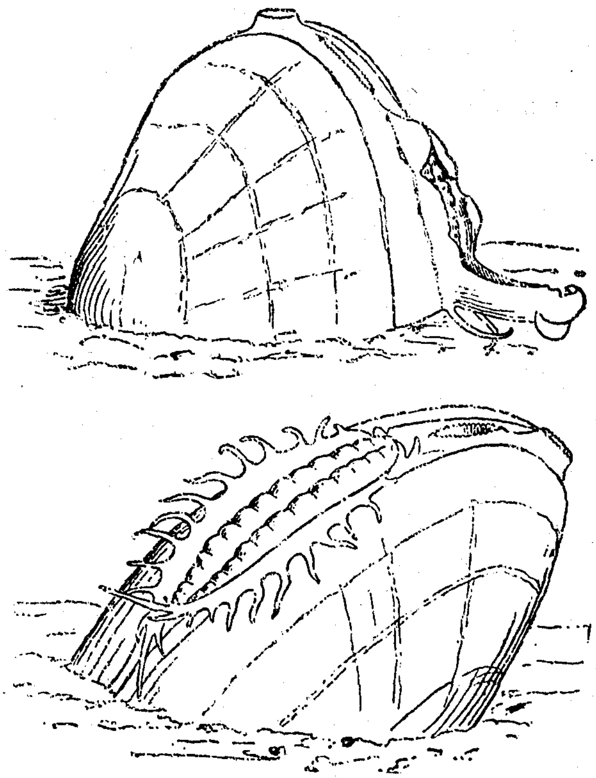


FIG. 2. Fresh water Mussel throwing off the young.

No sketch was made of the third species. There was no such extensive development, there being simply two rows of short tentacles of equal length, which were kept in constant wave-like motion after the manner of cilia.

The first two specimens were from ponds in which there is no current, and this probably accounts for the necessity of an extensive development of tentacles for the purpose of inducing circulation and providing food and fresh water. The third was taken from a rapid stream flowing into the Potomac and, having abundance of circulation through natural currents, did not need so elaborate a development of tentacles.

The authorities say of the generative habit that the eggs are fertilized in the fall of the year and are carried by the female through the winter, meanwhile undergoing development to the swimming stage. About March they make their escape and enter into the swimming stage, during which they are armed with hooks, by means of which they fasten themselves to aquatic animals, where they undergo further development, finally dropping off and sinking to the bottom as the fully developed mussel, but still very minute.

A PECULIAR HABIT OF A HOLOTHURIAN.

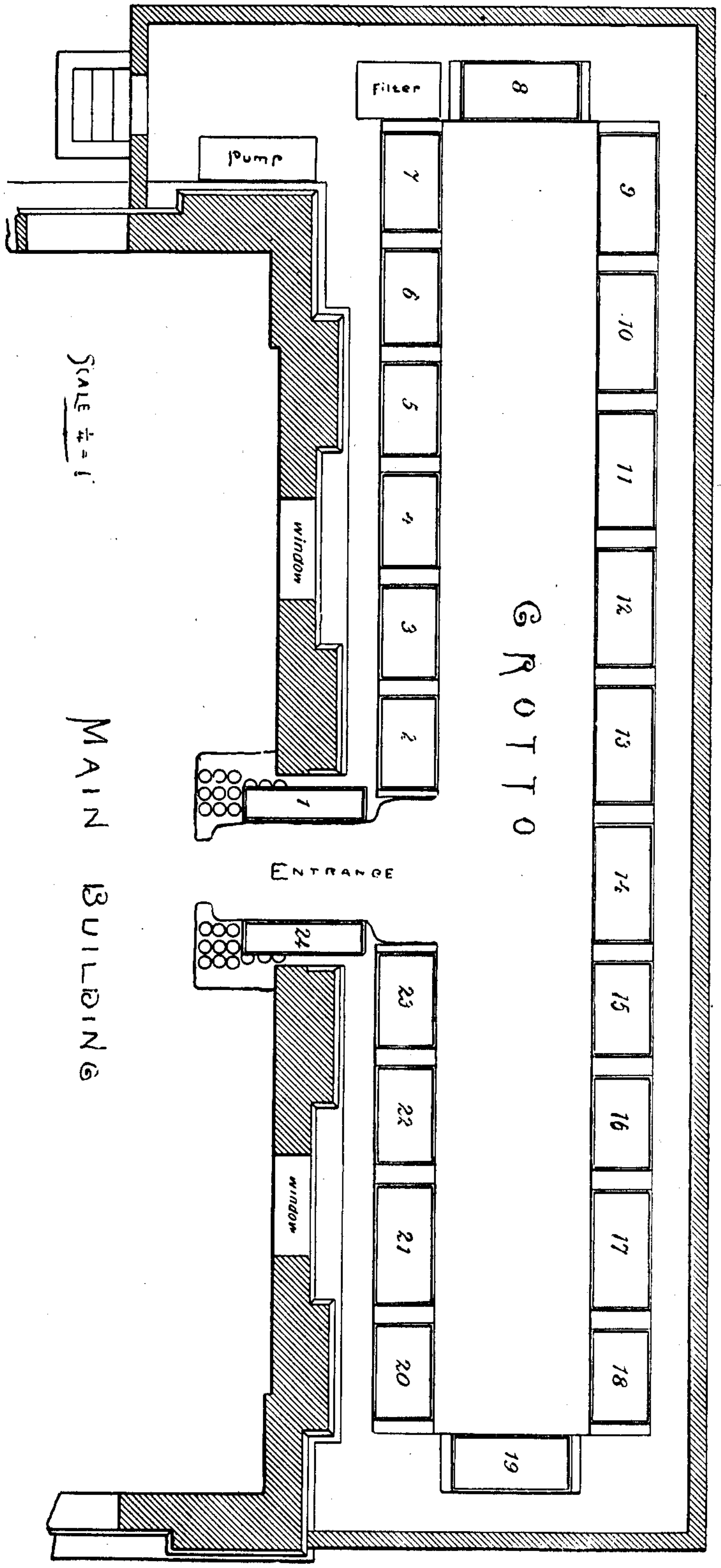
A holothurian, or so-called sea-cucumber, in one of the tanks was observed to eviscerate itself, as is their known habit. It immediately put forth a new set of branchiæ, very delicate and transparent, but somewhat smaller than usual. This would indicate that the new organs are developed before the old are thrown away. The branchiæ of this species of holothurian are ordinarily dark gray in color. The new ones were white, translucent, and beautifully lobed and branched, not having the usual fringed appearance given to them by the development of numbers of still more minute lobes. They were evidently only partly developed and looked like some of the small and delicate red algæ with all the coloring matter bleached out.

SPAWNING OF OVO-VIVIPAROUS FISH.

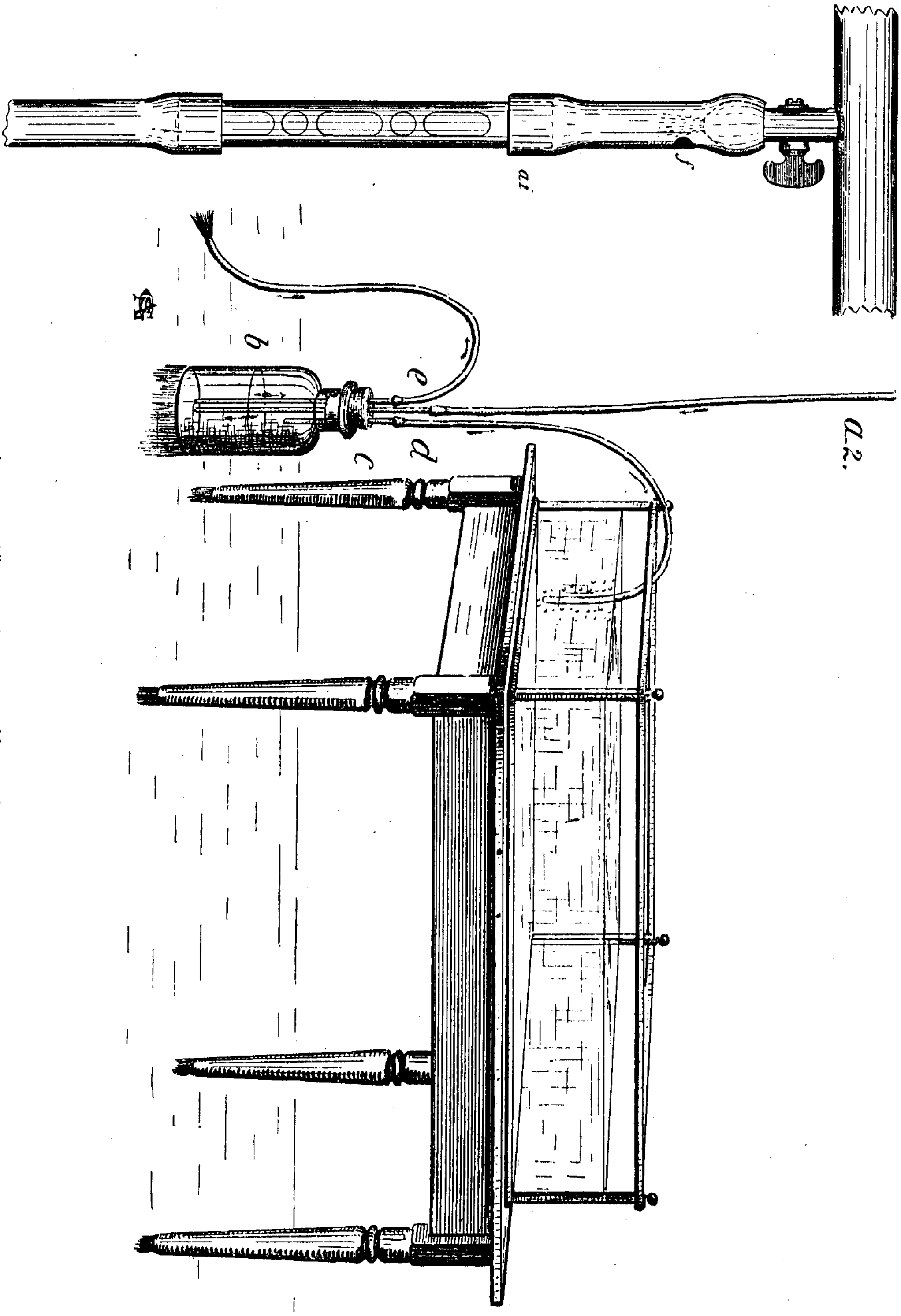
The top-minnows (*Gambusia patruelis*) have frequently brought forth their young in an aquarium and they have been reared to maturity, but all attempts to observe the method of fertilization or the extrusion of the young have failed.

In conclusion it may be said that many minor observations of more or less value to science or practical fish-culture have been made.

Altogether the results herein noted, while not extremely important, point to possibilities of great practical value when adequate facilities are afforded.



GROUND PLAN OF MARINE ANNEX



AUXILIARY AËRATING APPARATUS, MARINE AQUARIA.