BREEDING HABITS OF THE YELLOW CAT-FISH.

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In view of the paucity of information in regard to the spawning habits of cat-fishes, and owing to the possible inauguration of cat-fish culture in response to a widespread demand, we think it worth while to present these observations on one of the most important members of the family. The notes may be taken in conjunction with Dr. Albert C. Eycleshymer's "Observations on the breeding habits of *Ameiurus nebulosus*," published in the *American Naturalist* for November, 1901.

On July 3, 1902, it was observed that among a lot of yellow cat-fish (*Ameiurus nebulosus*) from the Potomac River near Washington, which had been in the Fish Commission aquarium since May 19, 1902, two had paired and exhibited breeding tendencies. They had withdrawn to one end of the aquarium tank and maintained themselves there, the male driving away any others which approached. The other fish were thereupon removed and the two in question left unmolested. They were kept under daily observation, and their behavior furnished the principal data on which this paper is based. In the latter part of July another pair of fish in the same lot showed an inclination to spawn and afforded additional information, as did also a lot of eggs of the same species found in a pool in the Fish Commission grounds on June 16; these eggs, which were about ready to hatch, were removed to an aquarium, where two-thirds hatched the same night, the others being dead the next morning.

Nest-making.—The aquarium in which the fish were held was 5 feet long and 16 inches wide on the bottom and 18 inches high, the posterior wall inclining obliquely backward so that at the surface of the water the tank was 2 feet 4 inches wide. The front was of solid glass, and the sides, bottom, and back were of slate. The bottom was covered with gravel and a little sand to the depth of 1½ or 2 inches.

The nest-making, as modified by the artificial conditions of the aquarium, consisted in removing all the stones and sand from one end and keeping the slate bottom scrupulously clean from all foreign objects, even the smallest particles of food, sediment, etc. In moving the pebbles, which were mostly from one-half to three-fourths of an inch in diameter, the fish took a vertical or slightly oblique position and sucked a pebble into the mouth, usually beyond the lips and out of sight, then swam toward the other end of the tank and dropped it by an expulsive or blowing effort. Sometimes the gravels were carried only a few inches and sometimes the entire length of the aquarium. Usually the fish swam horizontally near the bottom when carrying a stone, but sometimes turned obliquely upward and dropped it from near the surface. Both fish participated in this operation. The removal of finer sediment was effected by a quick lateral movement of the body which caused a whirl that lifted and floated the particles beyond the limits of the nest.

The pair of fish more particularly under consideration, during the first night they were in the aquarium, removed all the gravel from over a space nearly 2 feet long and 1½ feet wide, upward of a gallon of stones being transferred as described. After

the second pair of fish had cleared a similar space, a pint or more of gravel was scattered on the nest; the fish immediately began to remove the stones, and in a few minutes had completely freed the nest from gravel. The gravel—regarded by bass and other fishes as desirable material for the bottom of nests—may be removed by the cat-fish for two reasons: (1) To have a clean place for the eggs and young, so that they may be better guarded and agitated as hereafter described; (2) to provide a smooth place on which to rest and against which to rub the abdomen.

Upward of twenty years ago the yellow cat-fish was much more abundant in the Potomac River than at present. The marshes in Piscataway Creek were a favorite place for the fish to spawn, and large quantities were there taken each season in spring and summer, mostly by colored people living near the river. The fish at that time of year were found in shallow water occupying depressions in the muddy bottom, with most or all of their bodies concealed in an excavation extending laterally from the rounded depression. The fishermen easily made large catches by wading and thrusting their hands into the depressions. An old colored man whom we knew used to refer to a marsh as his "meat market," and would often bring ashore a sackful of yellow cat-fish caught in this way. We are inclined to believe that these fish were brooding, but we have had no opportunity of late years to examine them critically.

Behavior of adult fish before spawning.—Two days intervened between the beginning of the nest-making and the laying of the eggs. As soon as the nest was made ready, the fish became very quiet. During most of the time they rested on the bottom, with practically no body or fin movement, except at intervals. The fish lay close together, often parallel, with their abdomens just clear of the bottom, their weight being borne on the anal and ventral fins. At frequent intervals the female compressed her distended abdomen against the smooth slate bottom with a quivering or convulsive movement, the male often accompanying or following the female in this action, which is obviously for the purpose of loosening the eggs.

The second pair remained on the nest from July 18 to September 30, when they were removed to make room for other species, as it was evident no eggs would be laid. During this time they behaved in the same way as the other pair and their failure to spawn can not be positively accounted for, though such an outcome has been the rule among fish retained in the Fish Commission aquarium. The enlargement of the abdomen and ripening of the eggs go on to a point when spawning seems imminent; the actions of the fish suggest the arrival of breeding time; but no eggs are laid. After a few weeks the enlargement of the abdomen subsides, and dissection has sometimes shown a liquefaction of the egg mass. It has been suggested that the presence of alum in the circulating water has an injurious astringent action on the mucous membrane of the vent, and it is a significant fact that the change from an open to a closed circulation, with consequent elimination of the alum filter, was soon followed by the spawning of the cat-fish first mentioned—an unprecedented occurrence at the Fish Commission aquarium. The second pair of fish had been in the alum-filtered water for a few days, some time before the spawning season.

Number, character, and incubation of eggs.—On July 5, between 10 and 11 a. m., the eggs were deposited in four separate agglutinated masses on the clean slate bottom. Unfortunately, the fish were not under observation at this time, although they were watched for about fifteen minutes after the extrusion of the first two lots of eggs, when it was supposed the spawning had been completed. The masses of eggs were of nearly uniform size, about 4 inches long, 2½ inches wide, and half an inch thick. The newly laid eggs are one-eighth of an inch in diameter, nearly transparent, and of

a pale yellow color. The number of eggs deposited was estimated at 2,000. The incubatory period was 5 days in a mean water temperature of 77° F., the lowest temperature being 75° and the highest 80°. About 12 hours intervened between the hatching of the first and last eggs. Active movement was observed in the embryos 40 hours after the eggs were laid. Fully 99 per cent of the eggs hatched into normal fry, a few weak and deformed fry and a few unfertilized or dead eggs being noticed.

Growth of young.—When the fry first emerged from the egg they were about one-quarter of an inch in length, and of a yellowish, transparent color. By the second day the skin of the back had begun to darken, and by the end of the fourth day the entire upper parts were uniformly bluish black and the under side had become whitish. On the third day the barbels at the angles of the mouth and the pectoral and dorsal spines were clearly visible through the glass front of the aquarium.

Until 6 days old they remained on the bottom in densely packed, wriggling masses, the largest lot in the nest and several smaller lots in other parts of the aquarium. On the sixth day they began to rise vertically a few inches above the bottom, at first falling back at once, but gradually remaining longer above the bottom. By the end of the seventh day they were swimming actively, and practically all collected in a school just beneath the surface, where they remained for two days. They then began to scatter, and subsequently did not school.

The relatively large yolk-sac had nearly disappeared by the sixth day, when they began to eat finely ground beef liver, and they were feeding ravenously by the eighth day. Between feeding times, they passed much of the time on the bottom of the aquarium in search of food, which they ate in an almost vertical position, head downward; they also browsed on the sunny side of the aquarium, where there was a short growth of algæ. The early growth was rapid, but not uniform; on the eleventh day their length varied from one-half to three-fourths of an inch. At the age of 2 months the average length was 2 inches; but after that time the growth was very slight, and in January, 1903, six months after hatching, the length of the survivors was only 2¼ to 2½ inches. The slow growth was undoubtedly due to the fact that the fry were retained in small troughs where the conditions were unnatural.

Care of eggs and young.—During the entire hatching period both parents were incessant in their efforts to prevent the smothering of the eggs, to keep them clean, and to guard against intruders. The eggs were kept constantly agitated and aerated by a gentle fanning motion of the lower fins, and foreign particles, either on the bottom of the nest or floating near the eggs, were removed in the mouth or by the fins. The most striking act in the care of the eggs was the sucking of the egg masses into the mouth and the blowing of them out, this being repeated several times with each cluster before another lot was treated.

The male was particularly active in watching for intruders, and savagely attacked the hands of the attendant who brought food, and also rushed at sticks or other objects introduced into the aquarium. Practically the entire work of defense was assumed by the male, although the female occasionally participated.

During the time the fry were on the bottom the attentions of the parents were unrelaxed, and, in fact, were increased, for the tendency of the different lots to become scattered had to be corrected, and the dense packing of the young in the corners seemed to occasion much concern. The masses of fry were constantly stirred as the eggs had been by a flirt of the fins, which often sent dozens of them 3 or 4 inches upward, to fall back on the pile.

The very young fry were also taken into the mouths of the parents and blown out, especially those which became separated from the main lot and were found in the sand and sediment. The old fish would take in a mouthful of fry and foreign particles, retain them for a moment, and expel them with some force. After the young began to swim and became scattered, the parents continued to suck them in and mouth them, and, as subsequently developed, did not always blow them out.

An interesting habit of the parents, more especially the male, observed during the first few days after hatching was the mixing and stirring of the masses of young by means of the barbels. With their chin on the bottom, the old fish approached the corners where the fry were banked, and with the barbels all directed forward and flexed where they touched the bottom, thoroughly agitated the mass of fry, bringing the deepest individuals to the surface. This act was usually repeated several times in quick succession. The care of the young may be said to have ceased when they began to swim freely, although both parents continued to show solicitude when the attendant approached the aquarium from the rear.

When 12 days old, about 1,500 of the fry were removed from the aquarium to relieve crowding, and placed in a hatching-trough such as is employed for salmon and trout. For some unknown cause, about 1,000 of these died during the first three days. The others survived with little or no loss, and are still on hand.

The fry which were left with their parents continued healthy, but their number steadily decreased. There being no way for them to escape, and a closely woven wire screen preventing inroads from the exterior, it was suspected that the old fish were eating their young, though they were liberally fed at suitable intervals. They were kept under close observation during the day, and were seen to be fond of mouthing the fry, more especially the weaker ones—a habit which at this stage seemed unnecessary. They were frequently seen to follow leisurely a fry, suck it in their mouth, retain it for a while, and then expel it, sometimes only to capture it again. There was no active pursuit of the fry, and the tendency seemed to be to spit them out. In one or two instances, however, it appeared that fry taken into the mouth were not liberated, the feeding instinct becoming paramount to the parental instinct. After all the fry which had been left with their parents had disappeared—in about 6 weeks after hatching—18 fry from the trough were placed in the aquarium one evening, and only 2 of these had survived on the following morning.

During the entire period covered by these observations liver and beef were fed regularly to the brood fishes, and at no time did their appetites fail. There was apparently no interference with deglutition, or closure of the œsophagus, such as has been observed in some other cat-fishes, as half-inch cubes of meat were readily ingested during the entire time the fish were under observation.

External sexual characters of adults.—Besides the fullness of abdomen which the mass of eggs gives to the female, there was in both pairs of fish under consideration another external feature by which the sexes could be distinguished. This was the shape of the snout and interorbital region, which in the males were noticeably flatter and broader than in the females. The males in both these cases were about 12 inches long and were an inch longer than their partners.