

THE HABITS AND CULTURE OF THE BLACK BASS.^a

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This paper sets forth the experiences of nine seasons, beginning with 1894, during which I have had charge of the black-bass work of the Michigan Fish Commission. The work was begun at Cascade, Mich., and after four seasons was transferred to Mill Creek, where it is now carried on. The methods of pond culture finally adopted are based on a knowledge of the breeding habits of the fish under natural conditions. The account has reference to the small-mouthed bass, unless the large-mouthed is specified.

In studying the habits of the bass, it is necessary to distinguish the males from the females; ordinarily this is not possible except by dissection, but at spawning time the female is distinguishable, even at a distance of 10 or 20 feet, on account of her distension with eggs, and this makes it possible to determine the part taken by each sex in nest-building and the rearing of young.

The nests of the black bass are built by the male fish working alone. The small-mouthed bass prefers a bottom of mixed sand and gravel, in which the stone ranges from about the size of a pea to that of one's fist. As the spawning season approaches the males are seen moving about in water of 2 or 3 feet depth seeking a suitable resting-place. Each male tests the bottom in several places by rooting into it with his snout and fanning away the overlying mud or sand with his tail. If he does not find gravel after going down 3 or 4 inches, he seeks another place. Having found a suitable place, he cleans the sand and mud from the gravel by sweeping it with his tail. He then turns over the stones with his snout and continues sweeping until the gravel over a circular spot some 2 feet in diameter is clean. The sand is swept toward the edge of the nest and there forms a few inches high, leaving the center of the nest concave like a saucer. The nest is usually located near a log or large rock so as to be shielded from one side. If the bank is sheer and the water deep enough, the nest may be built directly against the bank. If possible, it is placed so that the fish can reach deep water quickly at any time.

During nest-building no females are in sight, but when the nest is done—and this takes from 4 to 48 hours—the male goes out into deep water and soon returns with a female. Then for a time—it may be for several hours—the male exerts himself to get the female into the nest and to bring her into that state of excitement in which she will lay her eggs. If she lies quiet, he turns on his side and passes beneath her in such a way as to stroke her belly in passing. If she delays too long, he urges her ahead by biting her on the head or near the vent. If she attempts to escape, he heads her off and turns her back toward the nest. If, after all, she will not stay in the nest, he drives her roughly away and brings another female.

^a Read at the thirty-first annual meeting of the American Fisheries Society.

Some 15 to 30 minutes before the female is ready to enter the nest and spawn, her excitement is made evident by a change of color. Ordinarily she appears to be of a uniform dark olive or brown above, changing to a light green below. The only markings readily seen are four stripes on each cheek; but in reality the sides of the fish are mottled with still darker spots on the dark-olive background. The spots are arranged so as to form irregular, vertical bands like those on the perch, but these are not usually visible. Now, as the excitement of the female increases the background becomes paler and finally changes to a light-green or yellowish hue, so that the spots and bands stand out in strong relief. The whole surface of the fish becomes thus strongly mottled. This is a visible sign that the female will soon spawn. The male undergoes a similar but less pronounced change of color.

Soon after this the female enters the nest and the male continues to circle about her, glide beneath her, and to bite her gently on the head and sides. At times he seizes her vent in his mouth and shakes it. When this has continued for a time spawning takes place. The two fish turn so as to lie partly on their sides with their vents together and undergo a convulsive fluttering movement lasting 3 to 5 seconds. During this time the eggs and milt are extruded. The circling movements are then resumed to be interrupted after a few seconds by spawning. This alternate circling and spawning continue for about 10 minutes. The male then drives the female away, biting her and showing great ferocity. She does not return.

The male, and the male only, now continues to guard the nest, fanning sediment from the eggs and repelling enemies. At 66° F. the eggs hatch in 5 days and the young fish swarm up from the bottom in 12 to 13 days from the time of hatching.

Henshall in his "More About the Black Bass," published in 1898, quotes, with approval, Arnold's observations to the effect that the nests are built and then guarded by the female. The Manual of Fish Culture, published in 1897 by the United States Fish Commission, speaks of the nests as being built by the mated fish, sometimes working together, sometimes separately. These seem to be the latest published observations, and are not at all in accord with my observations in Michigan.

Shortly after the young small-mouthed bass rise from the nest they scatter out over a space 4 or 5 rods across—not in a definite school with all the fish moving together, but as a loose swarm, moving independently or in small groups. This makes it impossible to seine the young fry, as upon the approach of the seine, instead of keeping together, they at once scatter and escape the seine. The fry may be at the surface or on the bottom in weeds or clear water and are attended by the male until they are 1½ inches long. The swarm then gradually disperses and the young fry, which were previously black, take on the color of the old fish.

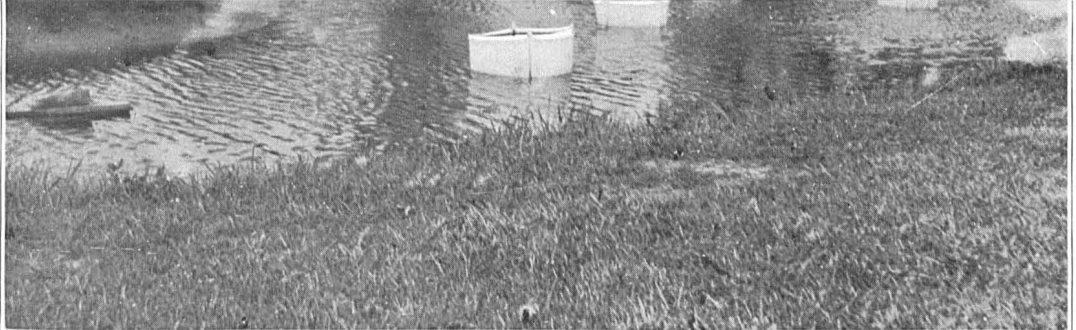
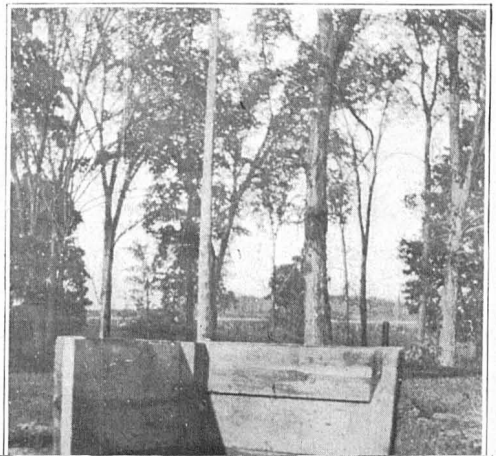
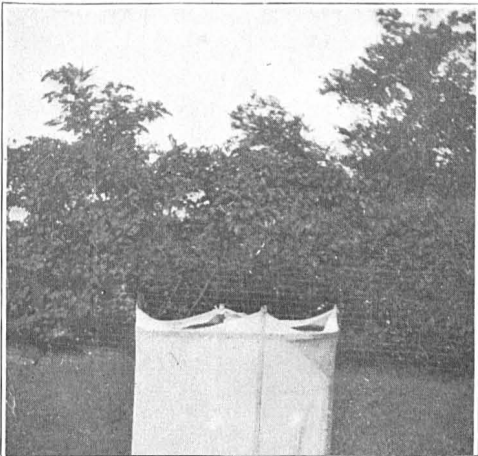
The breeding habits of the large-mouthed black bass are similar to those of the small-mouthed, but differ in some respects, which are of importance in pond culture.

1. The nests of the large-mouthed are not made on gravel, but by preference on the roots of water plants. These are cleaned of mud over a circular area, and on them the eggs are laid. As the eggs of the large-mouthed bass are smaller and more adhesive than those of the small-mouthed they are apt, when laid on gravel, to become lodged between the stones and to stick together in masses, and are then likely to be smothered. When laid on fibrous roots of water plants this does not occur.

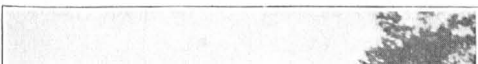
2. The young large-mouthed bass remain together in a compact school very much smaller than that of the small-mouthed, and the fry usually move all in the same direction. This makes it easy to seine the large-mouthed fry when wanted.



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CULTURE OF BLACK BASS.

Ponds and stock fish.—After some experimenting all our ponds, both for stock fish and fry, are built on the model of a natural pond. There is a central deeper portion or kettle about 6 feet deep, and around the shore a shallow area where the water is about 2 feet deep. The bottom is the natural sand, and water plants are allowed to grow up in the ponds. All ponds are supplied with brook water, and silt from this furnishes a rich soil for the aquatic plants. The water of these ponds contains *Daphnia*, *Bosmina*, *Corix*, and other small aquatic forms in great numbers. These furnish food for the bass fry. The ponds run in size from 120 feet by 190 feet to 100 feet by 100 feet.

At first we were unable to feed the stock fish on liver, but after a time we found that by cutting the liver into strips about the size and shape of a large angleworm and by throwing the strips into the water with the motion that one uses in skipping stones they wriggle like a worm in sinking and are then readily taken. The liver must be fresh. If bass are fed on liver alone they do not come out of winter quarters in good condition. Of eleven nests made by bass thus fed only three produced fry. Although eggs were laid in all, they seemed to lack vitality, owing to the poor condition of the parent fish, and in eight of the nests the eggs died.

In order to bring the fish through the winter in good condition it is necessary to begin feeding minnows in September and to continue this until the fish go into winter quarters. The bass eat minnows until they go into winter quarters, after which they take no food until spring. The minnows are left in the ponds over winter, so that the bass, when they come out of winter quarters, find a plentiful supply, which lasts them until the spawning season. At this time the minnows are seined from the pond, as their presence interferes with the spawning. Before this, however, some of the minnows have spawned, and their fry later serve the young bass as food. Bass fed in this way come out of winter quarters in fine condition and their eggs are found to be hardy.

Artificial fertilization.—During the first two or three seasons of our work numerous attempts were made at artificial fertilization, but only twice with success. On one occasion the female was seined from the nest after she had begun to spawn. She could then be readily stripped. The male was cut open and the eggs were fertilized with the crushed testes. About 75 per cent of the eggs hatched on a wire tray in running water, the eggs being fanned clean every day with a feather.

In the second case the fish were seined while spawning, and it was found that in the case of one female pressure on the abdomen caused a reddish papilla to protrude from the vent. This had the appearance of a membrane closing the vent. It was pinched off, and the female was then stripped readily and the eggs fertilized and hatched.

Pond culture.—Having abandoned artificial fertilization, our attention was turned to pond culture, and this we have carried on for about six years. Our earlier ponds not furnishing natural spawning-grounds, we constructed alongside each of the large ponds six smaller ponds for use as spawning-ponds, each about 16 by 24 feet, 16 inches deep, with gravel bottom, and connected to the central pond by a 4-foot channel.

The fish entered these and spawned. In one case we had eight nests in a single pond of this sort. Where so many nests were made, usually but one or two of them

came to any good, the others being destroyed by the fighting of the males. Ordinarily but one or two nests were built in each spawning pond. The male first to enter and begin the construction of a nest generally regarded the whole pond as his property and held it against those that tried to enter after him. On one occasion the male thus holding the pond was attacked by 10 or 20 other males at one time and after a long struggle was killed and his nest destroyed.

The attempt to use small spawning-ponds was then abandoned and all the ponds were made of good size and with a central kettle and shallow shore area, as already described. The problem now was to prevent the fighting of the male fish and the consequent destruction of nest and eggs. I finally hit upon remedies for what seemed to be the two chief causes of this fighting. I had noticed that in the natural water the nests of the small-mouthed bass were frequently built against a stone or log, so as to be shielded on one side. When so built the nests might be quite close together, as near as 4 feet, and the fish did not fight, because they did not see one another when on the nest. On the other hand, if a bass nest was built where it was not shielded the bass on that nest would prevent any other bass from building within 25 or 30 feet of him. It occurred to me to try to construct artificial nests and shield them so that the fish on the nests could not see one another, placing the nests so near together as to fully utilize the pond area.

In the spring, before the spawning season opened, the ponds were drawn down so as to expose the shallow terrace along the shore. The terrace was then cleaned to a depth of about 2 inches of sediment and vegetation which had accumulated since the previous summer. Rectangular nest frames of inch board were made 2 feet square and without bottoms. On two adjacent sides these frames were 4 inches high, while on the other sides they were 16 inches high. They were set where there would be about 2 feet of water when the pond was filled, and so placed that the corner formed by the junction of the two lower sides pointed to the center of the pond, while the opposite corner, formed by the higher sides, pointed toward shore. The frames were set directly on the bottom, not in excavations, and each was filled with gravel containing sand suitable for nest-building. A board was laid diagonally across the two higher sides and a heavy stone laid on this to keep the frame in place. The two higher sides form a shield on two sides of the nest, while the board across the top affords shade. The frames were set in two rows about the pond, parallel to the shore line.

The rows were about 6 feet apart and the nests in each row about 25 feet apart, alternating with those in the other row. There was thus about one nest to each 100 square feet of suitable bottom, or in each area of 10 by 10 feet. When the bass were on the nests no one was able to see any other and the fighting from this cause was practically eliminated. The number of rows of nests may be increased to three or four, or more where the area of shallow water is wide enough.

The bass selected these nests in preference to any other spawning-ground. They cleaned up the gravel and behaved in the nests in every particular as they would on natural spawning-grounds. The first time we tried these shielded nests not a single bass made a nest outside of them, though there was plenty of good gravel bottom available for this purpose.

As to the second cause of fighting: In 1900, when these nests were first tried, from 475 stock fish we obtained 315,000 fry and 750 fingerlings. In the season of 1891 the output was very much less and there was considerable fighting among the

fish. This remained unexplained till the ponds were drawn down after the spawning season, when it appeared that although the fish had been sorted, the number of male fish was considerably in excess of the number of females, and these excess males, banding together, went about breaking up the nests of their more fortunate brothers. It is now the practice when setting the nests to seine out the stock fish and sort them, putting about 40 males to 60 females, thus removing the second source of fighting.

During the present season from 493 adult fish we had produced 430,000 fry up to May 26, and we believe that we can do as well every year.

Up to the present year there have been two sources of loss incident to the water supply. The supply is a spring-fed brook, which runs over an open country before it reaches us. The water in this brook becomes quite warm on a hot, sunny day and cools off at night. The temperature thus falls at night sometimes as much as 13° F. and becomes as low as 46° F. This is disastrous, since when the temperature gets below 50° F. the adult fish desert the nests and the eggs or young fry are killed by the sediment. By watching the temperature of the water and, when it approaches 50° F., shutting off the supply until the water warms up, this difficulty is obviated. Since the ponds are well stocked with water plants the fish do not suffer from lack of oxygen when the water is shut off. Indeed, if the water did not leak out of the ponds, I doubt if it would be necessary to introduce any running water into them during the breeding season.

The second difficulty with the water supply is from sediment brought down by the brook after heavy rains. This sometimes accumulates over the nests so thick as to smother the eggs and drive away the parent fish. By shutting off the water supply whenever the water is much roiled this trouble is avoided.

The water supply, however, must be kept fairly constant. If the level lowers more than about 6 inches the fish leave their nests and the eggs die. For the purpose of maintaining a constant water level it would probably be best to have the ponds made with clay bottoms. The difficulties arising from roily water of variable temperature are, however, local, and would probably not be usually encountered.

Handling the fry after they rise from the nest.—The small-mouthed fry have the habit of scattering into a large swarm when they leave the nest and it is consequently difficult to seine them when wanted. It is therefore desirable, just before the fry rise from the bottom, to set over each nest a cylindrical screen of cheesecloth supported on a frame of band iron, first removing the wooden nest frame. The screen keeps the fry together. They thrive and grow within it and may be left there until one desires to ship them. The old fish stays outside and watches the screen. When this supply is gone other crustacea may be taken from the pond with a tow net and placed inside the screen. The fry are removed from these screens directly to the shipping cans, as wanted.

Raising the fingerlings.—The water in one of the ponds is lowered, the old fish seined out of the kettle and transferred to another pond; the pond is then refilled, and the fry, now about one-half to three-fourths of an inch long, are put in. The water in the pond is thick with *Daphnia* and other crustacea, and these do not get out when the water is drawn off. The fry feed on them and the supply is usually sufficient; but if it gives out, a fresh supply may be gathered from another pond and placed in the nursery pond. As the young bass grow they eat not only the *Daphnia* but young *Corixa*, and doubtless other aquatic animals.

In 1901, fry one-half to three-fourths inch long were introduced into the nursery pond on July 12; on August 5 they were seined out and shipped, and were then 2 or 3 inches long. They had had none but the natural food. In three months these fish, under the same conditions, are 4 to 6 inches long.

I have spoken so far of the small-mouthed bass, and it remains to say something of the large-mouthed, with which my experience is more limited. It is less necessary to resort to pond culture with them since, owing to the habit of the fry of keeping in a close swarm, they may be readily seined from their natural waters shortly after they have left the nests. In cultivating them in ponds I use the shielded nests already described, but make the bottom of some fiber, preferably Spanish moss bedded in cement, as has been suggested by Mr. Stranahan. This imitates the natural nest bottom and gives better results in our locality than the gravel nest. I do not place screens about the nests, since the young fry are so small that it is difficult to hold them with a screen, and since they may be readily taken with a seine when wanted. I allow the large-mouthed fry to leave the nests with the parent fish and seine them when wanted.

Finally, I will sum up what seem to me to be important points in pond culture of small-mouthed black bass, the ponds being constructed, as is usual, on the model of a natural pond with a central kettle and shallow shore region, well grown up with water plants, and supplied with lake or brook water:

1. Fish should be so fed (with minnows) as to be in good condition in the spring.
2. They should be sorted into the ponds in the spring in about the proportion of 4 males to 6 females.
3. Shielded nests should be used, arranged as already described—about 1 to each 100 square feet of shallow water.
4. The gravel in the nests should be carefully selected; it should contain sand and plenty of small stones.
5. Water on the nesting-grounds should be kept constantly at a level between 18 inches and 2 feet.
6. The water temperature should be kept constantly between 66° and 75° F. (in our locality).
7. Roily water should be, as far as possible, kept out of the ponds during the spawning season.
8. Fish should not be disturbed until the eggs are hatched.
9. The nests of the small-mouthed bass should be screened just before the fry rise from the bottom.
10. The water should contain an abundance of natural food for the fry.

The processes described are perhaps susceptible of improvements, viz:

1. Special nursery ponds might be provided for rearing fingerlings.
2. It is perhaps desirable to have the nest frames shielded on three sides instead of two sides, and made with a bottom; then when the fry rise from the nest, close the fourth side of the nest frame by sliding a screen into it. In this way it would not be necessary to remove the nest frame and put a screen over it, but the frame could be left in place and the open side closed with a screen.
3. If the ponds were made with clay bottoms, the water supply could be entirely shut off during the breeding season, if necessary.