

NOTES OF LIFE-HISTORIES OF ILLINOIS FISH.

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In the progress of the field studies being made of the animal life about Charleston, Illinois, data on the life-histories of twelve species of fish have been obtained, and these will be treated in this paper together with related data obtained from literature. Little appears to be known of the life-histories of the species of fish in the region, probably because most of them are small and of little economic value. Of the seventy-two species found there, there are thirty-eight have apparently nothing definite published on their life-histories. About three-fifths of the 150 or more species of fish found in the whole State have their breeding habits and breeding habitats almost unknown to ichthyologists, although Illinois has probably had its fish fauna more thoroughly studied than any other state.

Forbes and Richardson ('09) brought together the important facts on the life-histories of Illinois fish, but since this work was written there have been some published contributions to this subject by Richardson ('13) from the Havana region; by Bertram Smith ('08) from Lake Forest; by Shelford ('11; '11a; '11b) and Hubbs ('19) and Meek and Hildebrand ('10) from the region about Chicago; and by Hankinson ('10) from the Charleston region.

Besides these notes from observations and investigations in the State, species represented in Illinois have been studied outside of the State since Forbes and Richardson's writing as shown by the following publications:—

Reighard ('10) on the Horned Dace; (10a) on the pearl organs of minnows; ('13; '15) on the Log Perch and some other species; ('14) on the common Pike; ('20) on suckers.

Reeves ('07) on the Rainbow Darter.

Kendall and Goldsborough ('08) on the Common Sucker and on a number of other species.

Kendall ('10) on catfishes; ('17) on pikes; ('18) on several species represented in Illinois.

Fowler ('12; '17; '17a) on many species, mostly minnows and suckers.

Emboly ('14) growth data on several species.

Crevecoeur ('08) on *Campostoma*.

Barker ('18) on the Brook Stickleback.

Jaffa ('17) on the Iowa Darter.

Shira ('17; '17a) on the Channel Cat.

Pearse, A. S., ('19) on the Black Crappie.

Hankinson ('08; '20) on a number of fish in southern Michigan, also found in Illinois.

Wright and Allen ('13) give a table with the important facts concerning the life-histories of many common species; and Gill ('07) includes a few notes on breeding of species present in Illinois. Some life-history data is given by Johnston and Stapleton ('15). In many local lists notes of value on life-histories are published. Important among these from the standpoint of Illinois ichthyology are the lists by Bensley ('15), Nash ('08), Ellis ('14), and Smith ('07).

The twelve species of fish, upon the life-histories of which the writer has obtained data through field studies chiefly in the region about Charleston, Illinois, are as follows: Chub Sucker; Common Sucker; Common Redhorse; Hogsucker; Stone-roller; Blunt-nosed Minnow; Horned Dace; Silver-mouth Minnow; River Chub; Green Sunfish, Long-eared Sunfish; and Johnny Darter.

These fish all breed in shallow parts of streams in this locality and during the spring. The breeding season for the two sunfish, the darter, the Blunt-nosed Minnow, and the River Chub extends into the summer. The sunfish appear to nest chiefly at this time, breeding as late as August. The Common Sucker, Stone-roller, and Horned

Dace were found spawning in shallow water over gravelly bottoms, in or just above riffles and always with some good retreating place like a deep pool easily accessible. Blunt-nosed Minnows, River Chubs, the two sunfish, and the Johnny Darter breed in the less rapid stream water, commonly not far from a foot in depth, and on hard bottoms, usually stony or gravelly and with little sediment.

Breeding conditions for fish in the streams of the Charleston region are very uncertain. Hard rains raise the streams rapidly and give them an intense turbidity, which is prolonged, although the water goes down quickly and leaves them in their ordinary, sluggish condition. During one of these brief freshets, a breeding area may have its character completely changed by the deposition of sediment or rubbish, by the removal of stones, gravel, and other bottom material, and often by a marked change in depth. Many eggs of these stream breeding fish are undoubtedly destroyed, since changes of this nature frequently occur at the principal spawning time in the spring.

There is considerable difference among our fish as to the way the eggs are cared for after deposition. Some, like the Common Sucker and the Silver-mouthed Minnow, drop them on unprepared bottoms. Some spawn on selected though unprepared areas and guard the eggs there, as Miss Reeves ('07) found in the case of the Rainbow Darter, where males had "holdings" commonly about fifteen inches in diameter. Some fish, like the Stone-roller and the Horned Dace and the sunfish, make structures for their eggs, and these may be called nests. In Illinois there are at least twenty species of fish known to construct nests. Some use natural cavities and depressions for their eggs and appear to do little if any building; such is the case with the Blunt-nosed Minnow* and the Johnny Darter as far as observed and probably the Channel Catfish (Shira '17a) and the Tadpole Cat, *Shilbeodes gyrimus* (Hankinson '08, p. 208).

The streams (Map, Fig. 1) where most of the field work was done are in the southeastern part of Coles County, Illinois, and belong to the Wabash system. Some observations

*Professor Jacob Reighard writes that breeding Blunt-nosed Minnows observed by him usually excavate under stones.

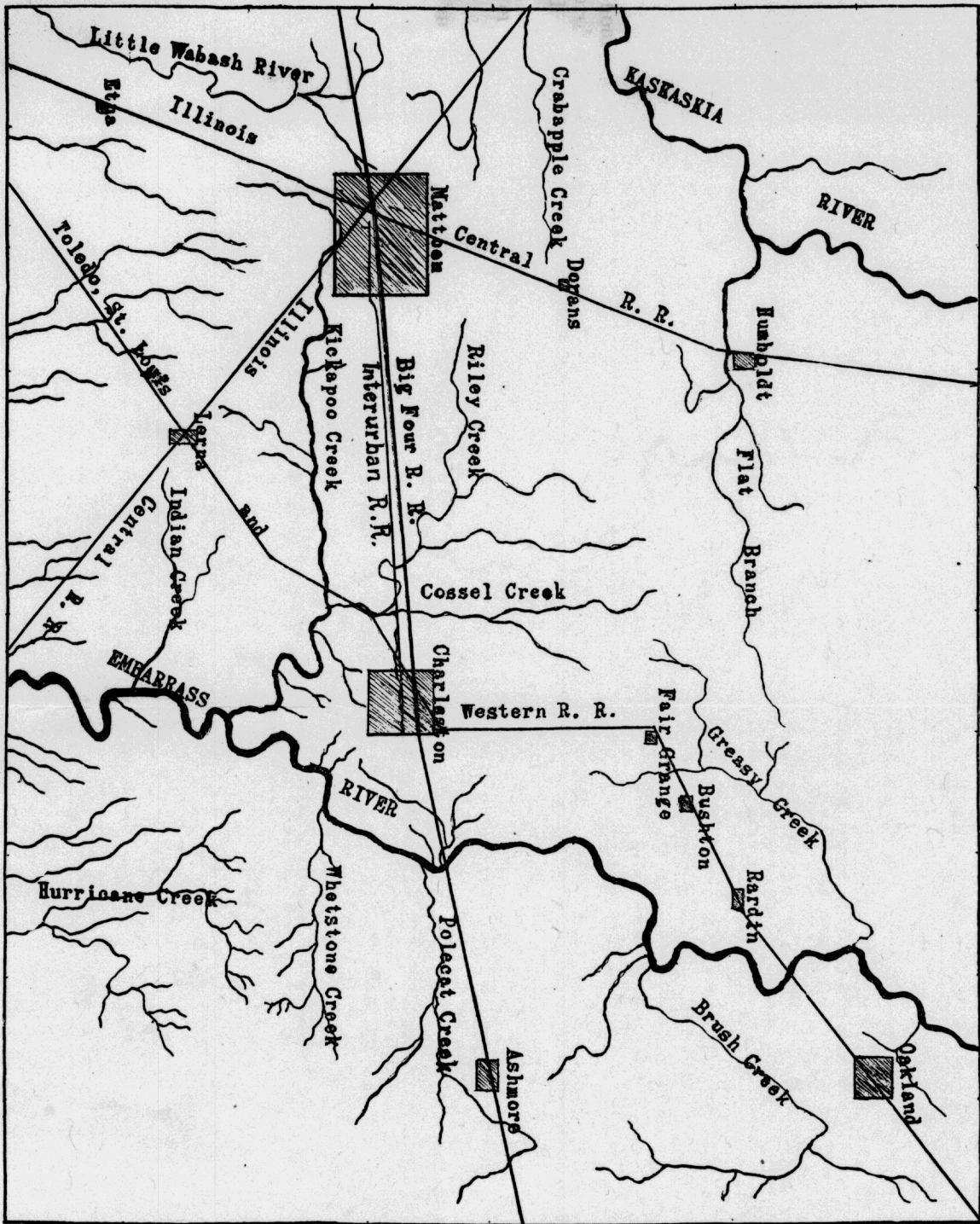


Fig. 1. Streams near Charleston, Illinois

were made in Flat Branch, near Humboldt, Illinois. This is a tributary of the Kaskaskia River and hence is in the Mississippi drainage.

Notes on each of the twelve species of fish upon which data concerning life-histories have been obtained through field studies in the region about Charleston and other parts of Coles County, Illinois, are here given. The distribution and relative abundance of these species in this region are treated by the writer in his paper on the Distribution of the Fish in the streams about Charleston, Illinois (Hankinson '13).

Erimyzon sucetta oblongus (Mitchell), Chub Sucker.

On April 10, 1910, in Cossel Creek near Mound Cemetery, two large Chub Suckers with tuberculate snouts were seen pulling at the stones of a piece of broad, gravelly shoal. At one time these two fishes, which were in all probability males, were seen to place themselves against the sides of one of the several smaller Chub Suckers, probably females, that were associated with them. The act was very similar to the spawning act of the Common Sucker.

Little appears to be known of the breeding of the Chub Sucker. It evidently spawns early in Illinois, in March and April according to Forbes and Richardson ('09, p. 82), who found fish ready to spawn at that time. Richardson ('13, p. 410) found young more than an inch long in early June at Havana. Meek and Hilderbrand ('10, p. 252) say that the Chub Sucker spawns in April. It evidently breeds in streams, up which it may run in spring (Fowler '06, p. 162; Wright and Allen '13, table).

Catostomus commersonii (Lacepede), Common Sucker.

In the early spring this species runs up small streams for spawning purposes, chiefly at night. In Kickapoo Creek, about three miles west of Charleston, I observed the spawning activities of this species on March 31, 1910. There were about twenty of these suckers poising over a clean gravelly bottom just above riffles near a deep pool (Fig. 2). Each fish was about ten inches long and very dark colored, almost black, dorsally; and the sides were jet black. They were very different in appearance from other Common Suckers associated with them on this shoal. These were probably all or mostly females and had the ordinary coloration of the species.

Now and then two fish, evidently males, would crowd on either side of a sombre fish, very probably a female, and there would follow much bodily agitation and water disturbance. This was undoubtedly the spawning act and is like that described by Culbertson ('04, p. 65) and by Reighard ('20, p. 10). A collection of these breeding fish was made by me, and I was interested to note that on capture they lost their intense black markings instantly. Small pearl organs were found on the males taken and on two of the females in this collection; both were spawning fish with eggs streaming from their bodies.

Reighard (l. c. '04, p. 212) notes the use of pearl organs in suckers for maintaining contact of the sexes during spawning and ('20, pp. 3-15) treats in detail the breeding behavior of the species as observed in southern Michigan. Fowler ('12, p. 474) notes the distribution of these tubercles in breeding fish examined by him, but he found none the females. Neither did Reighard ('20, p. 7).

Hypentelium nigricans (LeSueur), Hogsucker.

This species appeared to be breeding in Riley Cree. about two miles west of Charleston on April 11, 1910. In a broad expanse of shallow water where the stream was about twenty feet wide and but a few inches deep, two of these fish were seen, one chasing the other and finally settling with the sides of their bodies together. They remained quietly in this way for some minutes. At another time in this same stream in a similar place two Hogsuckers were seen to take this position, but this time there were active movements of the body as in the case of the spawning Common Suckers.

Little has been found in literature on the breeding of this species. Reighard ('04, p. 212) describes the spawning act of this fish, calling it the Black Sucker ('20, p. 20) and gives an account of the sexual difference in the species and the breeding activities as noted near Ann Arbor, Michigan. Meek and Hildebrand ('10, p. 257) say that it ascends streams in the spring to spawn. Wright and Allen ('13, table) note the Hogsucker as breeding in shallows of swifter brooks in April and May.



Fig. 2. Kickapoo Creek near Charleston, Illinois, showing breeding area of Common Sucker and Stone-roller



Fig. 3. Nest of the Horned Dace

Moxostoma aureolum (LeSuer), Common Redhorse.

These fishes run up the Embarrass River in large numbers in the early spring, commonly in late March or early April, probably impelled by the breeding instinct, but they do not appear to spawn till much later, for females caught and examined at this time do not have ova that are very near maturity. Local fishermen say that they spawn about May 1 and on riffles, where many of them are easily caught by dragging clusters of hooks over the spawning beds. This way of fishing is locally called "jigging." The Redhorse is known to breed on riffles in other regions, Reighard ('14, p. 100), Hay ('94, p. 185) and McCormick ('92, p. 15), say that the Redhorse (very probably this species) spawns at such places. Reigard ('20, p. 19) describes in detail the breeding of Common Redhorse near Ann Arbor, Michigan.

Campostoma anomalum (Rafinesque), Stone-roller.

During the first warm days of early spring, usually in March but sometimes as early as February, schools of these minnows begin to move up small creeks in the Charleston region. Large numbers sometimes collect in pools below barriers, like small water falls, and over these they endeavor to jump, frequently springing a foot or more out of the water (Hankinson '10, p. 28). Sometimes they go to the extreme headwaters of these creeks where there is barely enough water to cover them and where they may be picked up easily by hand. They begin breeding in late March or early April, often some weeks after the migrations started, in water temperatures ranging from about 65° F.—80° F., according to my observations. The spawning is usually over by the middle of May in this region; the latest date recorded being May 31. The favorite breeding area is swiftly flowing shallows over fine gravel above riffles, rarely in them, with a convenient deep pool or overhanging bank for hasty retreat (Fig. 2). The fish are usually very shy at this time, making it necessary for the observer to approach very slowly and carefully, keeping out of their sight as much as possible.

The males dig pits in the gravel by pulling and pushing away stones, and according to Crevecoeur ('08) by carrying pebbles up stream and dropping them. The small pearl organs that are numerous on the dorsal half of the body of

the male are used in this nest building according to Reighard ('03, p. 531). As a rule one male works at a single pit, but I have seen two digging at one and one working at two pits. The fish frequently give chase to each other, often with such heedlessness that they throw themselves out on shore and get back to water with some delay and considerable effort. They are sometimes found digging in the pit or gravel pile made by the Horned Dace. Reighard ('10, p. 1133) has also observed this, and he suspects that they eat the eggs of the Dace. Stone-rollers feed extensively and chiefly on the brown diatomaceous scum that usually covers the gravel of breeding streams, and one might easily mistake feeding for a breeding activity, but when the digging is being done by the adult males only, and Richardson '09, p. 110 and plate opp.), and when the fish without these markings associated with them are not taking part in the work, it is very likely that the operation is a breeding one. More certainty is given to the conclusion if the spawning act is observed. This takes place over a pit by a male applying himself to the side of a female or as observed in one case two males on either side of a female. The contact is maintained but for an instant. The pearl organs of the male enable him to maintain such contact, according to Reighard ('03, p. 531).

When the fish are working eggs are usually found among the stones in or about the pit by taking up a handful of the gravel and putting it in a shallow dish with a little water. The eggs sink but move about readily when the water is agitated. They are small, translucent spheres about a $\frac{1}{20}$ inch in diameter and non-adhesive. To make the identity of these more certain, I hatched some in my laboratory and got fish eleven days old and about $\frac{1}{3}$ inch long that showed the intestinal peculiarities of *Campos-toma*. Nest building in the Stone-roller appears to be a process of bringing gravel to the surface to make a clean, scum-free bed for the eggs. The advantages of nests of this type are discussed by Reighard ('10, p. 1132).

Pimephales notatus (Rafinesque), Blunt-nosed Minnow.

This species breeds abundantly in our larger streams and to some extent in the smaller ones, there being no evident general breeding migration in this region. The eggs are placed in patches similar to those of the Johnny Darter



Fig. 4. Flat Branch near Humboldt, Ill., Nesting place of River Chub.
Vertical stick marks a nest.

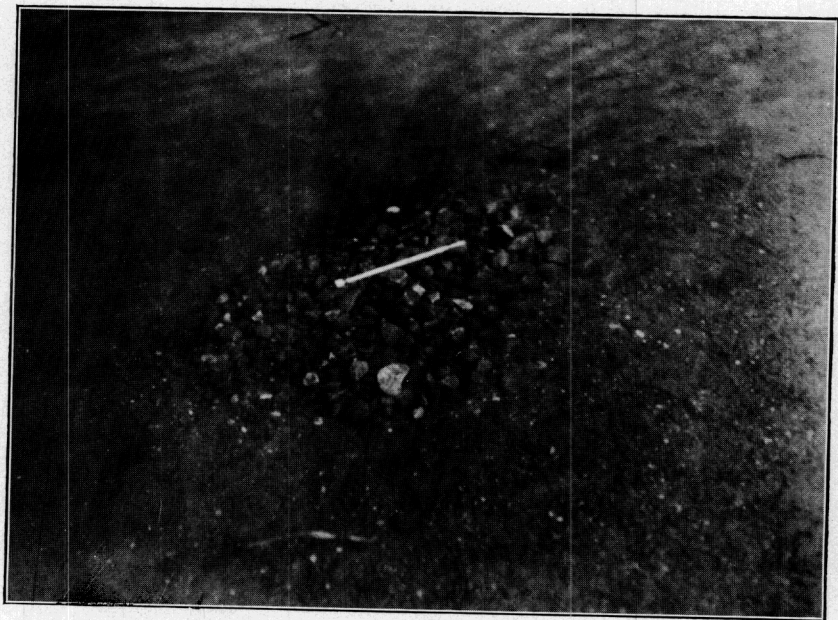


Fig. 5. Nest of River Chub. Thermometer five inches long used as scale.



Fig. 6. Eggs of Johnny Darter. Note: Circle used as a scale, size of a five-cent piece.

(Fig. 6) on the lower surfaces of stones or other objects that are not in close contact with the bottom giving space for the egg-laying process and for the attending male fish, that remains for the most part beneath the eggs and protects them. The breeding season appears to be a long one, my dates for finding eggs are from May 1 to August 26. Eigenmann ('96, p. 252) found eggs in Indiana during June and the greater part of July.

The eggs are most often found in shaded stretches of large creeks where the depth is about a foot and where there is a moderate current and where the bottom is rather solid with large stones on it, and these must not be firmly embedded or used as crayfish shelters. I have found eggs about Charleston in streams from 2½ to 40 feet wide, but most often where they were from 8 to 10 feet in width. Most of the stones with eggs have been in about a foot of water, but I have taken them in 18 inches. Voris ('99, p. 233) reports eggs from water as deep as two feet. My temperature readings for the breeding waters of this species have been from 70°F. to 79°F. When stones are absent or their lower surfaces unavailable, the eggs may be placed on lower sides of other objects. In this region, I have found them on tin cans, on a metal wash basin, on a half submerged barrel, on boards, pieces of bark, and once on a clod of hardpan clay. The eggs are usually placed very closely together in a roughly circular or oblong patch with longest diameter typically 4 or 5 inches; the largest observed was 10 by 4 inches. Possibly this was formed by the joining of two patches, since two or more fish frequently use the same stone. Once eight patches were found under one large broad flat stone, about four feet at its widest part. Ordinarily a surface six inches to a foot in diameter will harbor a single patch of eggs. I have found no evidence of nest building by the breeding Bluntnosed Minnows; any excavation found may have been made by a crayfish that formerly lived under the object later used to hold the minnow eggs. Eigenmann ('96, p. 252) says the fish keeps the vicinity of its nest clean, and Professor Rieghard has made similar observations as above noted.

The parent fish watching the eggs is very dark, sometimes almost black and possesses a number of prominent pearl organs on the snout (Forbes and Richardson '09, p. 121; Fowler '12, p. 471). The fish is very probably the

male in all cases. He remains by the eggs and appears to protect them well against their ordinary enemies, for when he is removed the eggs quickly disappear in a few cases observed. They are very probably eaten by crayfish and minnows. Once eight minnows from many that were swarming about the deserted eggs of this species were caught by me. Six were Blunt-nosed Minnows, and two Stone-rollers. No eggs could be found in the digestive tracts of these fish, however, but this may have been due to their complete mastication. At Walnut Lake, Blunt-nosed Minnows were found to be important destroyers of eggs of other species of fish (Hankinson '08, p. 204).

Semotilus atromaculatus (Mitchill). Horned Dace.

This abundant minnow in this region associates closely with the Stone-roller and like it prefers small creeks to large ones, and it breeds at about the same time and in the same kind of situation, which is a gravel shoal above riffles with a convenient place of refuge. They appear to have a breeding migration, for in the early spring, usually in late March, large individuals are abundant in the Embarrass River, and many are caught by hook then. At other times they are scarce in this stream. Shelford ('13, p. 90) notes a prominent up-stream movement for breeding. They usually spawn in April but spawning has been observed by me as late as May 15. The water in which the nests were found varied in depth from 3 to 12 inches (usually 5 or 6 inches), and its temperature ranged from 55°F. to 80°F.

The nest is made by the male fish, which is easily distinguished by the prominent pearl organs on the head and by the more or less intense flushing of red in the breast region. He is usually much larger than other fish of the species on the breeding shoal with him. In this region the nest-building males observed were from about 4 to 8 inches long. Stones are moved as in the case of the Stone-roller but in a more methodical way, since they are carried up stream and dropped in such a manner as to form a distinct ridge (Fig. 3 r.). There is a pit (Fig. 3, p.) below this ridge where the digging takes place, which forms further and further down stream as the ridge grows longer, the size of the pit remaining about the same. Reighard ('10, p. 1125) has found these ridges 16 or more feet long, but around Charleston they are seldom much more than two

feet in length. A large male eight inches long ordinarily makes ridges about two feet long and has a pit about eight inches in diameter and about two inches deep. The short ridges may be due to the swift currents produced by spring rains in the creeks where I have found the Horned Dace nests. Such currents often obliterate completely nests of this species and those of the Stone-roller, sometimes removing all the gravel there and leaving a bed of smooth clay or hardpan in its place.

As a rule, only one fish works on a piece of gravel shoal, but sometimes two are on one shoal but with nests not very near together. The nesting fish are ordinarily very wary and can be approached by taking the special precautions described in detail by Reighard ('10, p. 1113). The spawning act has been seen once by me. It was performed very quickly over the pit of the nest, and the positions of the two fish were apparently the same as those described by Reighard ('10, 1130). Eggs may be obtained and examined from the gravel of the pit or ridge by the same method suggested for the Stone-roller. Embury ('14, p. 170) advises lifting some of the gravel up in the water over the nest and allowing the eggs to be carried with the current into a fine mesh net.

Ericymba buccata Cope, Silver-mouthed Minnow.

Data on the breeding of this abundant species in this region has been obtained during one spring season, 1909, and in Campus Creek, a small stream about two miles long and draining perhaps two square miles of the region south and west of the Normal School at Charleston (Hankinson '10). They were abundant then in the stream but have been found scarce there at other times, so it is probable that they came into the creek for breeding purposes from the larger Kickapoo Creek, in which they are apparently numerous at all times. They remained in the lower half of Campus Creek and showed no tendency to go to the headwaters. Here they found a clean sandy and gravelly bottom for which they have preference (Forbes and Richardson '09, p. 158). A number of ripe fish of both sexes were caught here, April 24, 25, 26, and June 7. What appeared to be the spawning behavior was noted on April 25, 1909. A number of these Silver-mouthed Minnows were on a piece of sandy shallows where the stream was six or seven

feet wide and where the sand was thrown into many horizontal ridges or "ripple marks." Here in two or three inches of water a number of minnows of this species were chasing others of the species that were probably females. When one of these last would be overtaken it would be given a blow on the side by the pursuer. This may have effected spawning. Evidence of this was the finding of young in an aquarium over some sand gathered from beneath a place where I saw this apparent spawning take place. Evidently they hatched from eggs in this sand. Two of these fish were reared: one to a length of $\frac{3}{4}$ inch (August 5, '09) and one to $1\frac{1}{4}$ inches (December, 1909). Both were sufficiently large for positive determination.

None of the ripe fish, males or females, taken by me had pearl organs or special noticeable breeding markings of any kind. This is in accordance with the observation of Jordan ('82, p. 855), who says that the males do not undergo any special changes in color or form during the breeding season.

Hybopsis kentuckiensis (Rafinesque), River Chub.

Structures that were undoubtedly nests of this species were found in Flat Branch (Fig. 4), about two miles east of Humboldt, Illinois. These were low, round conical piles of small stones (Fig. 5), mostly from $\frac{1}{2}$ inch to $1\frac{1}{2}$ inches in diameter. The piles varied at their bases from about 6 by 8 inches to 10 by 20 inches and were from about 2 to 8 inches in height; this last dimension was evidently determined by the depth of the water. The fish appeared to build till the stones were near the water surface. The nests were found June 14, 1912; June 14, 1913, and May 14, 1914, but all had evidently been completed. Forbes and Richardson ('09, p. 169) give the breeding time of the species as late May and early June.

The part of the creek where the nests were found ran through a piece of pasture where there were cattle and hogs; the latter frequently roiled the water. The stream was here mostly about fifteen feet wide and shallow, almost everywhere under a foot in depth, but there were overhanging banks which gave good concealment for the nesting fish. The bottom was of firm, light-colored, mixed clay and gravel. The temperature readings made on the dates the nests were found were from 67°F. to 82°F.

Fish were not seen working on these piles, but in southern Michigan I have seen such structures constructed by large males of this species armed with pearl organs and having other breeding characteristics (Hankinson '20). There were many large male River Chubs in breeding dress in Flat Branch at the times these nests were found, and they were easily caught by scooping under the banks with a small net, and there were no other fish in the stream likely to make such stony structures. Once, one of these large male River Chubs came out to a stone pile and moved about over it, but I did not see him carry any stones. Fish eggs were found in one of the piles pulled to pieces. These were sticking to the stones and to each other in small masses. I could not be positive that these were eggs of the River Chub or some other fish that may have found such piles convenient places for eggs.

Very little has apparently been published on the life-history of this species. Reighard ('10, p. 1183) undoubtedly refers to *Hybopsis kentuckiensis* when he writes of *Hybopsis* carrying away materials from Horned Dace nests. Forbes and Richardson ('09, p. 169) say the nesting time is late May or early June 2 ('20, p. 9) describe the breeding activities of a male in southern Michigan.

This species thrives and breeds under a great variety of conditions in the Charleston region. It is abundant in large and small streams, but seems to prefer the latter, and there are large numbers in some artificial ponds including the one on the Normal School campus. It has a long breeding season here, my dates for finding nests with attending fish being from June 13 to August 23.

Two nests found in streams were in Indian Creek and Campus Creek; the first on July 1, 1907, and the other June 13, 1918. Both were shallow depressions in fine gravel; to which the eggs were attached. The nests were well out in unshaded parts of the streams conspicuously exposed without any vegetation or other concealing features near them. Each was about ten inches in diameter and in water a little less than a foot deep. This species has been found nesting in two ponds about Charleston, but in these ponds the nests were among clumps of partly submerged grass or other vegetation, and all were roughly

circular, cleaned areas about eight inches in diameter and all in a little less than a foot of water. The eggs were attached to gravel except in one case where they were on small, pea-size lumps of clay. I have found none on roots here as at Walnut Lake, in Michigan (Hankinson '08, p. 211). Hubbs ('19, p. 144), reports this species using willow roots for its eggs with no indication of a nest.

All nests found by me have been located by the presence of the attending fish over them. These have all been very similarly marked with dorsal, caudal and anal fins bordered with white and with the ventral fins nearly all white. All these nesting fish were very probably males. They stay close over the nest and show little shyness, and I have never found one defending eggs with much vigor. Hubbs ('19, p. 144) notes a nesting fish permitting itself to be handled and only gently biting at his fingers when he touched the eggs; and it took earthworms from his hands repeatedly. The sunfish that I have seen over eggs in lakes and ponds have been very well concealed by their markings. The light border of the dorsal fin is easily mistaken for a submerged grass blade or piece of rush and distracts attention from the sombre fish form below it. The spawning act was noted once and this at Indian Creek over the nest found on July 1, 1907. Here the male was about a third smaller than the female.

Very little appears to have been written on the life-history of this species. Dyche ('14, p. 115) gives a brief account of its spawning in hatchery ponds in the state of Kansas. The writer describes their nesting in Walnut Lake, Michigan (Hankinson, '08, p. 211).

Lepomis megalotis (Rafinesque), Long-eared Sunfish.

This sunfish in this region is confined almost entirely to the large streams, where it nests. Many are in the pond on the Normal School campus, and one season, 1907, they were seen nesting there, and they have undoubtedly bred there during other seasons. In the streams there is no evident migration, and the height of the breeding appears to be about the middle of June; my dates are May 25 to June 17, but they undoubtedly nest much later. In the Normal School pond, they were nesting in July and August, as late as August 23. In northern Indiana.

Kirsch ('95, p. 331) found the fish on spawning beds July 17. At Walnut Lake in Michigan, it is very certain that the fish did not begin to nest much before the middle of June in 1906.

All of the eggs of this species found in the Charleston region were attached to the stones of a gravelly nest bottom, but at Walnut Lake in Michigan rush roots were used for holding the eggs (Hankinson '08, p. 212). Broad, shaded, shallow parts of large creeks with gravelly bottom, depth under two feet and moderate current appear to be the conditions most favorable for the nesting of this species in this region. The width of the stream at the breeding site has usually been between 20 and 40 feet. In the Normal School pond nests were found a few feet out from shore in about a foot of water. Here the fish had cleaned away leaves and other bottom debris down to a gravel stratum. All nests found in the Charleston region were more or less circular areas, but they varied much in distinctness, some being almost perfectly circular and others irregular and difficult to discern and only found by the presence of the attending fish. In size they varied; some found at Polecat Creek on June 7, 1913, were about 30 inches in diameter, but ordinarily they were between a foot and two feet wide. All nests noted were very shallow depressions. The Long-eared Sunfish appears to nest always in small colonies in this region. From five to thirteen nests have been found together and from an inch or so to about a foot apart.

All nests have been located and identified by the presence of the attending fish. This was very probably the male in all cases since it always had the long opercular flap and high coloration of that sex. It appears to be especially active compared with other sunfish in protecting its eggs, especially when minnows or other creatures threaten them. I have seen the spawning act but once, and that was in the Normal School pond on July 27, 1907. Here the male and female were similar in size, each about five inches long. Forbes and Richardson ('09, p. 255) had not found a female of this species over three inches in length, and they note gravid females only $1\frac{5}{8}$ inches long. All attending fish noted by me were from three to five inches long.

On June 17, 1910, I watched a school of minnows in a nest of this sunfish where there were eggs and where my presence kept the sunfish away. The minnows were chiefly Blunt-nosed Minnows with a few Stone-rollers and Red-fins, *Notropis umbratilis atripes* (Jordan). All seemed to be devouring eggs, but observation sufficiently close to determine this was not possible except in the case of one fish, a Stone-roller, which I saw actually take in eggs.

There appears to have been very little written on the life-history of the Long-eared Sunfish. Jordan ('05, p. 15) gives a brief general account of the nesting behavior of the male, and Henshall ('03 p. 66) notes that its spawning is similar to that of the Bluegill, *Lepomis incisior* (Valenciennes).

Boleosoma nigrum (Rafinesque), Johnny Darter.

The breeding habits of this common darter are very similar to those of the Blunt-nosed Minnow in that the eggs are placed on flat under surfaces of stones (Fig. 6) or other objects, and a parent fish stays by them and protects them. Eggs have been found in both large and small streams, and it is the only darter in this region that frequents small creeks to any extent, but it appears to be in these streams in numbers only in the breeding season, so it probably has a breeding migration. I have found eggs in May and June (my dates: May 1 to June 17) in this region. Forbes and Richardson ('09, p. 295) give an earlier season, from the last of April to the first of June. At Walnut Lake, in southern Michigan, nests were found by me from May 16 to June 19 (Hankinson '08, p. 215).

All of the eggs that I have found in the Charleston region have been in shallow parts of streams with water under a foot in depth and where the current was moderate and the bottom gravelly with a few large stones or other objects for holding them. Four water temperature readings have been made close to nests, and these were from 66°F. to 77°F. At Walnut Lake, eggs were found under stones on soft white marl bottoms (Hankinson '08, p. 215). Eggs have been found on splinters, a piece of tile, and a mussel shell (l. c.). The stones used were all small, none with any diameter greater than ten inches. Beneath all these objects there has been space sufficient to permit a

free movement of the attending fish and this has been opened to the exterior, permitting the fish to move in and out. No evidence of any excavating or other nest building process by the species was obtained.

There were usually several hundred eggs packed in a layer (Fig. 6) close together in a patch, mostly in a single layer but in places in two layers. The patch is usually roughly oblong with no diameter exceeding five inches. The eggs are placed very similarly to those of the Blunt-nosed Minnow, but they are smaller and each has a conspicuous oil globule not found in the minnow's eggs. Identification has been made in every case by the presence of the attending fish, which has always been a large example of the species with much black pigment, showing especially on the dorsal part of the body and on the head, which is very dark. Jordan and Copeland ('96, p. 28) describe this pigmentation of the breeding male and say that it is a nuptial feature and disappears at the end of the breeding season. The fish watching eggs is very bold and behaves much as the Blunt-nosed Minnow does while guarding its eggs.

Forbes and Richardson ('09, p. 296) describe the spawning act in this species as it took place in an aquarium. Seal gives an account of the breeding in an aquarium of the closely related eastern form, *Boleosoma nigrum olmstedii* (Storer). He noted that the spawning was effected by the female passing up and down over the surface chosen until all the eggs were extruded and adhering to the stone. The writer made a number of observations on the nesting places and the breeding behavior of this species in Walnut Lake, Michigan (Hankinson '08, p. 215).

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