BULLETIN

OF THE

ILLINOIS STATE LABORATORY

OF

NATURAL HISTORY

URBANA, ILLINOIS, U. S. A.

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DIRECTOR

VOL. IX. MARCH, 1913 ARTICLES VII-VIII

ART. VII. OBSERVATIONS ON THE BREEDING OF THE EUROPEAN CARP IN THE VICINITY OF HAVANA, ILLINOIS.

ART. VIII. OBSERVATIONS ON THE BREEDING HABITS OF FISHES AT HAVANA, ILLINOIS, 1910 AND 1911.

BY

R. E. RICHARDSON, A.M.

ERRATA AND ADDENDA

Page 54, lines 3 and 2 from bottom, and elsewhere in Article III, for *Cassia chamaechrista* read *Cassia chamaecrista*.
Page 62, between lines 4 and 5 from bottom of table insert *Erigeron annuus*.
Page 101, table, after *Croton glandulosus* read var. *septentrionalis;* and for *Equisetum laevigatum* read *Equisetum hyemale* var. *intermedium*.
Page 131, line 3, for *coerulea* read *caerulea*.
Page 138, last line, for *Ziza* read *Zizia*.
Page 141, line 21 from bottom, dele *Diodia teres*.
Page 169, between lines 3 and 4, insert as follows:
Erigeron annuus (L.) Pers. An interstitial in the bunch-grass association in the Hanover area.
Page 177, line 5, for *eastward* read *westward*.
Page 209, line 3 from bottom, for *copalina* read *copallina*.
Page 210, line 13 from bottom, for *Diospyrus* read *Diaspyros*.
Page 211, line 5, for *Foresteria* read *Forestiera*.
Page 256, line 3 of table, for Dr. H. *M*. Pepoon read H. *S*. Pepoon.
Page 278, line 16, the fifth word should be in Roman type.
Page 286, line 6 (second column), page 295, list of secondary species (second column), and page 353, line 8 from bottom, for *hiemalis* or *hiemale* read *hyemale*.
Page 313, line 4 from bottom (first column), for *pedicularis* read *pedicularia*.
Page 315, line 10, second column, for *Apocynum* read *Apocynum*.
Page 323, line 3 from bottom, for *Cyperus* read *Scirpus*.
Page 330, line 14, for *virginianum* read *virginicum*.
Page 336, lines 3 and 2 from bottom, for *virginicum* read *virginianum*.
Page 337, line 2 from bottom, for *philadelphicum* read *philadelphicus*.
Page 339, in first list of invading species, for *Rhus hirta* read *Rhus typhina*.
Page 351, line 4 from bottom, for *xerophtic* read *xerophytic*.
Page 355, above line 6 from bottom, insert *Scirpus heterochaetus* Chase.
Page 356, line 14 from bottom, for *Symlocarpus* read *Symplocarpus*.
Page 360, line 14, for *Pirus* read *Pyrus*.
Page 362, after line 7, insert *Acer saccharinum* L.
Page 363, line 2 from bottom, for *quadiflorum* read *quadriflorum*.
Page 365, line 14, for *thapus* read *thopsus*.
Page 369, last line, for *Tanecetum* read *Tanacetum*.
Page 417, line 1, dele *the*.
Page 497, line 9 from bottom, for *neglible* read *negligible*, and in foot-note, for *Austalt* read *Anstalt*.
Page 498, line 4 from bottom, for *Lockport* read *Chillicothe*.
Page 500, line 13 from bottom, after *up* insert *in*.
Page 501, line 2 from bottom, for *dissolving* read *dissolved*.
Page 504, line 23, for *gryina* read *gyrina;* line 17, for *dentata* read *knickerbockeri*.
Page 506, line 11, for *vernata* read *ternata*.
Page 507, line 3 from bottom, for *Mazon* read *wagon*.
Page 513, line 19, for *Nepa* read *Zaitha;* line 18, and page 517, line 13 from bottom, page 520, line 12 from bottom, and page 532, line 4, read *naid* or *naids* for *naiid* or *naiids*.
Page 517, line 6 from bottom, for *pondweed* read *pickerel-weed*.

Page 519, for first sentence of last paragraph read as follows:

We have no exactly comparable chemical data for July; but analyses for August give percentages of saturation for Morris and Marseilles as follows: 20.4 per cent. at Morris on the 11th and 11 per cent. at Marseilles on the 12th; 16.35 per cent. at Morris on the 22d and 23d and 7.4 per cent. at Marseilles on the 24th and 25th.

Page 521, line 6 from bottom, and page 529, line 9, for *chrysoleucas* read *crysoleucas.*

Page 525, line 22, and page 536, lines 21 and 24, for *Ekmann* read *Ekman.*

Page 532, line 1, for *Ancyclus* read *Ancylus.*

Page 551, line 7, for *00* read *512.*

Page 615, second line above foot-note, for *106* read 94.

Page 616, line 1, for the second *Bündeln* read *Bündel;* line 2, for *Bündeln* read *Bündels;* line 3, for *aussern* read *ausseren;* line 6, for *zwcierlie* read *zweierlei.*

Page 629, line 12, for *kein* read *keinen.*

Page 634, line 9, for *unternommen* read *unternommenen;* and in line 14 from bottom, after *575* insert *13 fig.*

Plate III, Fig. 1, after the word *mixed* in legend insert *consocies of the.*

Plate IX, Fig. 2, dele the legend and read instead: Root-system of *Tephrosia virginiana,* exposed by blowing of the sand.

Plate X, Fig. 2, dele the legend and read instead: A blowout almost stabilized by bunch-grasses, especially *Leptoloma cognatum.*

Plate XXXIX, for *Calamogrostis* read *Calamagrostis.*

Plate LIV, exchange places of cuts, but not the legends.

Plate LXXXV, for *7* read *7c.*

ARTICLE VIII.—*Observations on the Breeding Habits of Fishes at Havana, Illinois, 1910 and 1911.* By R. E. RICHARDSON.

In this paper is presented a summary of all our notes of the seasons of 1910 and 1911, concerning the breeding of fishes other than carp. They were made principally at Havana, Illinois, but include in a few cases observations made in the vicinity of Beardstown, Meredosia, and Grafton.

PADDLE-FISH (*Polyodon spathula*)

The paddle-fish is now rare at Havana, but it is considerably more abundant at Meredosia and other points below the La Grange dam. Meredosia fishermen believe that it spawns every year in Meredosia Bay. David McLean, an experienced and unusually intelligent fisherman there, says that paddle-fishes do a great deal of splashing in the middle of the bay in June of each year, and that they afterwards seem to leave the bay for the deep water of the Illinois and Mississippi.

SHORT-NOSED GAR (*Lepisosteus platostomus*)

Fifty eggs of short-nosed gar were found May 12, 1910, hanging to grass and smartweed in Schulte's field, Havana, very near or above the surface, where the depth of the water was one foot. Some of them were high and dry except for such moisture as they might get by capillarity. These eggs were taken into the laboratory, and all hatched at the end of eight days. Freshly spent females were taken with our trammel-net in the "Flag Pond" south of Lynch Slough, May 19, 1910. This marsh is thickly grown up with *Scirpus*. One female, 18 inches long, squirted eggs over the net, and they adhered to it firmly. We took this specimen to the laboratory and removed about 200 eggs from her. At 6 p. m. these eggs were sprinkled over the bottom of a white enameled pan, to which they adhered, and were washed with a little water containing milt squeezed from the rather hard testis of a large male taken that afternoon in the same place. At the end of twenty hours, examination showed that all these eggs were impregnated. They began to hatch May 27, toward evening, and by noon of May 28 were all hatched except for a loss of about five per cent. by fungus. Apparently fresh eggs were found May 8, 1911, on trash and vegetation on the bottom, in water

three feet deep, at the head of Flag Lake. These were brought to the laboratory, and hatched in from six to eight days. They were found in a locality frequented by spawning carp and black bass. Hundreds of short-nosed gar were seen spawning May 10, 1911, in shallow water, one to three feet deep, along the east shore of Meredosia Bay, half a mile above the Fish Hatchery, on ground on which carp had deposited great numbers of eggs only three or four days before. They were "running" in pairs, each female with a smaller male attending her, with nose held close under her belly, one or both occasionally flirting the tail or the whole body out of the water. Females full of nearly ripe eggs were taken in Quiver Marshes, Havana, in 1910, as late as June 30; but the great majority of the females taken in trammel-net drives at that date had spawned.

Fry hatched in the laboratory had the yolk sac absorbed at the end of seven days. At the age of ten days they were still observed to lie inert on their sides on the bottom of the aquarium, or to hang to the sides of it with their oral suckers. When between ten and sixteen days old they could not be seen to make any movement for securing food; but a sixteen-day specimen, ¾ inch long, was found on dissection to have eaten seventeen large specimens of a small crustacean, *Scapholeberis mucronata,* and nothing else. These *Entomostraca* were apparently selected separately from among a mixed plankton, and must have been taken by instantaneous movements, when no one was near to see what was happening.

Fry and fingerlings from ⅝ to 3½ inches long were taken in 1910 and 1911 at the following places and dates: May 10, 1911, ⅝ inch long, abundant in water 2 to 3 feet deep, among willows, full of weeds, at head of Meredosia Bay; May 25, 1911, ¾ inch to 2½ inches long, in shallow water, along shores of Dierker Lake; May 26, 1911, 2¼ inches long, Big Cove, Thompson's Lake; June 22, 1910, 1¾ inches long, Persimmon Point, near mouth of Quiver Creek; and July 7, 1910, 3½ inches long, head of Liverpool Lake.

The noticeable rarity of gar fingerlings and fry in collections is probably to be explained in part by their extreme slenderness, which permits them to escape through the meshes of ordinary minnow seines, but is perhaps due in greater measure to their solitary habit. All that we took in 1910 and 1911 were caught singly; and without exception, all young gars seen during these two seasons were floating at or very near the surface of the water, in the sun, sometimes with the back exposed. If disturbed, they dart downward in a flash; but usually return to the same place a few seconds or minutes later to take up their station. A second or third trial with a dip-net is often successful if the first is not.

Immediately after the close of the spawning season, or about May 25 to June 1, great numbers of adult short-nosed gars are to be seen in the river, swimming very near the surface and breaking water at short intervals to seize emerging gnats and Mayflies. This kind of activity is visible on sunny days at almost any time through June and most of July; but during the five or six weeks preceding its start, the river is nearly clear of gars, in consequence of their congregation for spawning purposes in the lakes and marshes. More than once between June 1 and July 15, both in 1910 and 1911, Allen and I had in sight at once as we went up the river in the launch as many as fifty large gar—at least twenty-five on each side of the boat. If we could have looked ahead also, we should doubtless have seen another twenty-five, making seventy-five in a radius of 60 feet. It has occurred to me that advantage might be taken of this habit of gars to destroy them. It is at least probable that very large numbers of them could be caught, without danger to other fishes worth mentioning, by hanging fine-meshed gill-nets so floated as to fish only the upper 18 inches to 2 feet of the river. Certainly if our commercial fisheries are to be properly conserved, stringent measures will have to be taken against these "weeds" and "wolves" among fishes.

Dogfish (*Amia calva*)

Dogfish nests with eggs nearly ready to hatch—the embryo turning inside the egg—were found April 20, 1911, in Weed Prairie, an overflowed flat south of Thompson's Lake, between Deep and Lynch sloughs. The nests were in water 2½ to 3 feet deep, choked with smartweed, "flag" (*Scirpus*), and *Cladophora*. They were about two and a half feet in diameter, and nearly round, and were excavated to a depth of about four inches, exposing grass roots, to which many of the eggs adhered. The nests contain from 2000 to 5000 eggs each. The male fish, about 20 inches long, could be seen hovering over each nest. One male allowed us to lower the water-glass to within six inches of his back. Eggs which were probably spawned about April 5 or 6 hatched in the nests between April 21 and 23, when the water temperature stood at about 60° Fahr. It was possible to determine only roughly the percentage of fungused eggs in the nests. They were probably less than fifty per cent.

Eggs brought to the laboratory hatched at the same time as those in the field and had the yolk sac absorbed by April 27. By April 29, the fry were swimming near the surface of the water in the aquarium, and when fed mixed small plankton, could be seen jumping, and opening and closing their mouths to catch the minute morsels.

Fry were still in nests, attended by males, in Weed Prairie, April 28; and the use of a thirty-inch pipette showed a rich plankton of small crustaceans in the very bottom of the nest. The most abundant forms were *Pleuroxus*, *Alona*, and *Chydorus*, possibly attracted there by decaying fungused eggs. On April 28, the temperature of the water was 61° Fahr. The fry left these nests at some time between May 4 and May 15.

Older fry and fingerlings were seen or captured on various dates between May 3 and May 23, 1911. May 3, a school of 500 to 600 fry, ½ inch long, was seen at the head of Flag Lake. May 5, a school of about 500 fry, ⅝ inch long, attended by a male 15 inches long, was seen in very shallow water among dead flag, at the head of Danhole's field. This male was not easily frightened, and moved away very leisurely, stopping only fifteen feet away, in full sight of us. These fry were probably considerably older than those in nests found in Weed Prairie. They must have hatched soon after April first, and were probably spawned soon after March 10, if not earlier. At this age the young swim low, about half way between the surface and bottom, in water 1½ to 2 feet deep, and if unattended by the male they might easily be mistaken for tadpoles.

Fingerlings 2 to 2¼ inches long were taken May 22, 1911, in the head of Danhole's field, in weeds, in water only 6 inches deep, and May 23, 1911, in Quiver Marshes, 150 yards above the mouth of the new dredge-ditch, in water of about the same depth, choked with weeds. The last school, of about 200, was still attended by the male. A dozen of these fingerlings were put into an aquarium in the laboratory, where they devoured in one night more than fifty minnows ½ to ¾ inch long. Fry, ⅜ inch long, from late-spawned eggs, and probably only a week or ten days out of the nest, were taken May 23, 1911, in open water 18 inches deep, in a still pocket opening from lower Quiver Creek. These fry were apparently unattended by a male, and were swimming just above the bottom.

Buffalo (*Ictiobus cyprinella* and *I. bubalus*)

In 1910 the condition of market specimens of both the red-mouth and quillback buffalo indicated that these species had spawned as early as April 15. May 15, 1911, males of the red-mouth buffalo kept several weeks in a crib belonging to the Havana Fishing Company, were spilling milt. There were no females in the crib, and the spawning of the males had probably been retarded somewhat by confinement. At Grafton, May 29, 1911, the condition of market

specimens indicated that about nine out of ten buffalo of all species had spawned.

A good deal of time was devoted in the spring and summer of 1910 and 1911 to the search for buffalo fry and fingerlings, though practically without success. Various reports of spawning of small bunches of buffalo proved, when followed up, to have referred to carp. Old spawning grounds, frequented by buffalo in thousands at breeding time some ten or fifteen years ago, do not now seem to be visited at all by buffalo. In fact the decrease of buffalo in the Illinois River seems to have been going on steadily during the last thirty years, and has been particularly noticeable since the completion of the lower locks and dams at La Grange (1889) and Kampsville (1893), the introduction and rapid increase of European carp, and the opening of the Chicago Drainage Canal. In 1881, Ira Sargent, an old fisherman still living in Havana, took 251,000 pounds of buffalo in Moscow Lake, below Bath, in a single haul with a 700-yard seine. Now the catch of buffalo at Havana and Beardstown probably runs on the average considerably less than 50 lbs. to 1000 lbs. of carp. The true reasons for this great decrease in buffalo are not at present wholly clear. That the construction of the lower Illinois river dams serves to some if not to a great extent to keep buffalo from coming up the river to spawn as formerly, is not unlikely, and seems to be indicated by such facts as the present rarity of observations of buffalo fry and fingerlings above the La Grange dam and their much greater abundance at points below La Grange, and more especially at points below Kampsville. The preference of buffalo for water of good depth and their timidity in the face of obstructions that carp would disregard, are pretty well established by the testimony of many observers, both fishermen and naturalists. That actual competition with the European carp for food may have a bearing on the decrease of buffalo is less certain, but is suggested by the steady change in the ratio of carp to buffalo in the catches at Grafton and Alton during the last seven or eight years. As late at 1904 and 1905, many more buffalo than carp were taken at these places. Now the ratio is reversed, Grafton fishermen informing me in 1911 that they got hardly more than 100 lbs. of buffalo to 1000 lbs. of carp. That the fouling of the bottom of the Illinois River in the last twenty years with city wastes may have something to do with the decrease is not out of the range of possibility. In this connection it is interesting to note the testimony of fishermen who have recently fished in both the Sangamon and the Illinois that at the present time buffalo are relatively more abundant and of finer quality in the Sangamon than in the Illinois River.

Chub-sucker (*Erimyzon sucetta oblongus*)

The fry of this species, ¾ to 1¼ inch long, were abundant in Quiver Marshes in late May and early June of 1910 and 1911. The fry swim in schools of fifty to a hundred or less, at about the same level as bass fry, and their coloration, owing particularly to the black side-stripe, is such that they are not always readily distinguished at the first glance from fry of large-mouthed bass.

Yellow Bullhead (*Ameiurus natalis*)

Examination of market specimens, May 19, 1910, showed the yellow bullhead well advanced—probably within less than a week of their spawning time. June 3, 1911, eggs ran from market specimens examined. That spawning was in progress was indicated also by a great decrease in the trot-line catch within the few days preceding.

Speckled Bullhead (*Ameiurus nebulosus*)

May 19, 1910, market specimens of the speckled bullhead uniformly appeared considerably less advanced than the yellow and black bullheads. May 27, 1910, a female brought in by Allen from Deep Slough May 23, spilled eggs in the tub in which she had been placed for observation.

May 28, 1910, trot-liners generally quit work because of failure of the bullheads to bite while spawning. May 31, 1910, we found a nest in Quiver Marshes containing a hundred or so recently hatched fry, probably not much more than three days old, the yolk sac still being large. This nest was in water 2½ feet deep, among *Ceratophyllum* and rushes. It was guarded by a 14-inch male, who allowed the water-glass to be pushed down almost in contact with his back.

In 1911 some specimens in market had eggs running as early as May 14. Between May 27 and June 3 they were reported by trot-liners generally as spawning. On July 2 we found two schools of 100 young each, 1¾ inch long, attended by the male, in Becks' ponds and Danhole's field.

Black Bullhead (*Ameiurus melas*)

May 19, 1910, market specimens of black bullheads were in about the same condition as the yellow bullhead already mentioned. They were apparently within less than a week of spawning.

Stone Cat (*Schilbeodes gyrinus*)

A female stone cat, full of nearly ripe eggs, was taken as late as July 1, 1910, near the head of Quiver Lake near the east shore.

Grass Pike (*Esox vermiculatus*)

Large numbers of grass-pike fingerlings are easily taken in May and June in Danhole's field. By the 25th of May, 1910, they had grown to a length of 2 to 2½ inches, and were doubtless, before that time, formidable enemies of the myriads of carp fry in the field, practically none of which were over ⅝ inch long on the first of June.

Top-minnows (*Fundulus notatus* and *F. dispar*)

On May 25, 1911, about two dozen *Fundulus notatus,* males and females, were observed swimming actively, pursuing one another, and occasionally jumping clear of the water, in weed-filled shallows toward the head of Dierker Lake. Two males at times pursued the same female, one trying hard to drive the other off. Examination of the females showed the ovaries full of eggs of large size and loosened from the membrane.

Gravid females of *Fundulus dispar,* on the point of spawning and attended by males, were taken May 23, 1911, in shallow water, full of weeds and algæ, just outside of Riley Smith's Marsh, above the head of Quiver Lake.

Silverside (*Labidesthes sicculus*)

During the second week of June, 1911, the fry of this species, ¼ to ⅜ inch long, were abundant, in schools, in water 2 to 3 feet deep, on the ridge between Flag and Thompson's lakes. They swim near the surface, with a very characteristic wriggling movement. They seem to keep to the open spaces between the clumps of smartweed and *Potamogeton.*

Speckled Crappie (*Pomoxis sparoides*)

May 2, 1911, a nest of this species was found in water 10 inches deep near the north end of Danhole's field. It was hollowed out under the leaves of a water-parsnip, and surrounded by smartweed and bog rush (*Juncus*). Some of the eggs were adhering to fine roots in the bottom of the nest, but most of them were on the leaves of the water-parsnip, at a level of 2 to 4 inches above the bottom of the nest.

The nest was guarded by a male 6 inches long, who was so gentle that we could reach out a hand to within three feet of him before he moved away. Eggs taken to the laboratory hatched May 3 and 4. Both eggs and newly hatched fry are even smaller than those of the blue-gill sunfish; and the great transparency of the new fry, along with their small size, makes it very difficult to see them in an aquarium.

Warmouth Bass* (*Chænobryttus gulosus*)

May 23, 1911, a dozen nests of this species were found in a circle of ten feet radius about the base of a large willow-tree in Deep Slough, in water 6 to 10 inches deep. The bottom was sand and mud, almost free of vegetation, but pretty well covered with fine dead twigs and dead leaves. The nests were very small, only 4 to 6 inches across in most cases, and of irregular shape; and all bore evidence of being very quickly and carelessly made, as compared with nests of bluegills and bass. Many of them would scarcely be recognized as nests if the male were not seen over them or a glimpse obtained of the white specks that indicate fungused eggs. There was practically no excavation of the soil of the bottom, merely the looser trash and leaves being brushed away, and not always all of that. Some of the males were exceedingly gentle, allowing us to touch them with a 30-inch pipette before moving away. We found no bluegill so gentle as this. Some of the nests contained new fry with yolk sac still large; others were full of eggs nearly ready to hatch. Eggs from these nests taken to the laboratory hatched during the night of May 23-24. Two nests containing fry with yolk sac nearly gone, were found in a similar situation in Lynch Slough May 26, 1911.

Orange-spotted Sunfish (*Lepomis humilis*)

A male and female of this species, in breeding color, were observed May 23, 1911, in Quiver Marshes over what appeared to be a freshly excavated nest in water 18 inches deep. They would occasionally swim a short distance off, but always returned to the same place.

Rather late spawning was indicated in 1910 by the taking, July 7, at the head of Liverpool Lake, of males in full color and females heavy with eggs.

*Called goggle-eye at Havana.

Blue-gill Sunfish (*Lepomis pallidus*)

We found more than fifty nests of this species May 16, 1911, on the west side of Deep Slough, among live willow timber, in water 1 foot to 18 inches deep. The nests were chiefly bunched about the bases of the willows, in some cases as many as a dozen about one tree, all in the shade, and many of them only 2 to 3 feet apart. This fish seems particular to select about the same sort of situation for all its nests,—a rather hard bottom of sand and mud, with little vegetation, but with some fine dead drift, grass, twigs, etc. The nests are 8 to 12 inches in diameter, usually quite round, and the excavation of the bottom soil is always well marked—usually to a depth of half an inch or an inch. All contained eggs nearly ready to hatch or newly hatched fry. The date of spawning was probably between May 1 and 5. The males are much more shy than males of the warmouth bass, but they can easily be seen and identified on nests by approaching quietly. Eggs taken to the laboratory hatched May 17, and by May 22 the yolk sac was wholly absorbed and the fry were swimming free in the aquarium.

May 22, 1911, we found twelve nests in Lynch Slough in similar situations, containing fry apparently 4 to 6 days old. May 26, 1911, we found about three dozen nests at the head of Liverpool Lake, along the west shore, in water 3 feet deep, offshore and outside of the "moss" zone, wholly unprotected by timber or vegetation. Some contained fresh-laid eggs, and others were just built or still unfinished, the progress of nest-building roiling the water in many places. Late-spawning bluegills built nests along the east shore of the Illinois River, less than a rod from the Biological Station, during the second week in August, 1911.

Examination of market specimens and catches from our own nets furnished the following records bearing on breeding dates during the seasons of 1910 and 1911:

May 19, 1910, one female with eggs running taken in Lynch Slough. May 23 to 26, 1910, large numbers of females taken in trammel-net in Deep and Lynch sloughs; eggs maturing, but none near ripe. June 30, 1910, females not yet having spawned taken in Quiver Marshes, though condition of market specimens indicated that spawning was finished before June 10, except for scattered stragglers. May 24, 1911, though nesting had been going on actively for about two weeks, a good many females could be found in the markets with ovaries still hard. Between May 27 and June 3, 1911, several fishermen reported that many females squirted eggs

over nets as these were lifted. June 3, 1911, many females with eggs running, were seen in markets.

Pumpkinseed Sunfish (*Eupomotis gibbosus*)

A ripe female pumpkinseed was taken in the "Flag Pond", south of Lynch Slough May 23, 1910. Eggs could be squeezed out in clouds, and adhered to the glass sides of the aquarium. In Lynch Slough, May 22, 1911, a male and female in high color were seen together over a round opening on the bottom, among moss in 2 feet of water. They went away and came back several times while we watched. Examination of the bottom of the nest showed that no eggs had yet been deposited.

Large-mouth Black Bass (*Micropterus salmoides*)

Between April 26 and May 4, 1911, more than thirty nests of this species were found in an area of about twenty-five acres in the northeast end of Danhole's field. Most of the nests were in 10 to 15 inches of water, but a few were found in water 2 feet deep, and some were in water as shallow as 6 inches. This 25-acre area is thickly grown up with flag and smartweed, among which is some bog-rush and a good deal of filamentous algæ (*Cladophora*). The nests are 12 to 18 inches across, usually nearly round, and well excavated, in most cases more than two inches at the center, and the bottom of most nests is at least partly formed of exposed grass roots, to which many of the eggs adhered. Hatching went on continuously in these nests between April 29 and May 5, under a water temperature of 60° to 65° Fahr. If we assume an incubation period of about fifteen days, the dates of spawning lay between April 15 and 20, when water temperatures stood between 58° and 60°. Eggs hatched in the laboratory April 28 had the yolk sac absorbed by the evening of May 1. The number of eggs in a nest seems to run usually between 2000 and 3000, though in a few cases the number was considerably higher. The males guarding the nests were as a rule under two pounds in weight. In most of the nests the percentage of fungused eggs was low, in some cases hardly more than five per cent. A few nests were found in which nearly all the eggs were fungused. One nest, which we boxed over with a cheese-cloth fry-retainer, contained more than a thousand active fry 3/16 inch long when we visited it May 6. The males are very timid, and usually dart away like a flash before one can even get the nest well in sight; but by using the greatest care to approach quietly we

were able in a few cases to get a good observation of the male over the nest, guarding the eggs.

Other observations on nesting bass in the vicinity of Havana, between May 3 and May 18, 1911, were made at places and dates as follows:

Head of Flag Lake, May 3-6, ten nests, one with eggs near hatching, others with eggs mostly fungused. Weed Prairie, May 4, one nest; eggs well advanced; male seen on nest. West shore of Thompson's Lake, ¼ mile above Warner's Cut, May 16, two nests containing newly hatched fry; 2-lb. male seen guarding one nest. Weed Prairie, May 5-17, twelve nests. Samples of eggs, about 200 each from several of these Weed Prairie nests, hatched with a loss of not more than five per cent. from fungus. These nests were in 2½ to 3 feet of water—considerably deeper than that in the breeding grounds at the head of Danhole's field (usually 10 to 15 in.)—and contained a moderate quantity of living smartweed and algæ. Eggs in most of the nests in Weed Prairie had hatched by May 17, though one nest found on this date contained eggs spawned hardly more than 24 hours.

Observations on advanced fry and fingerlings were made on various dates between May 17 and June 16, 1911, as follows:*

Weed Prairie, May 17, 1911, one school of more than 1000, three weeks old, largest nearly ½ inch long; one school of more than 2000, 24 days old; one school of more than 5000, 21 days old. Fry between two and three weeks old swim in very close schools, in some cases suggesting a swarm of bees. Their movement is very leisurely; it is in fact almost impossible to stampede them. The level kept is considerably below the surface, usually about two-thirds of the way up from the bottom. Most of these schools were found along the margins of the weed-filled breeding grounds—on which the water is now rapidly falling—within easy reach of moderately deep water. Weed Prairie, May 18, 1911, two schools, aggregating about 6000, 3½ weeks old. Lynch Slough, May 22, 1911, one school, several thousand, about 35 days old. These probably hatched before the end of the first week in April. Riley Smith's Marsh, May 23, 1911, several schools, 3 to 5 weeks old, at edges of marsh, in easy reach of

*In these notes all estimates of the age of fry are based on comparison with Reighard—Bull. Mich. Fish Comm., No. 7, in Sixteenth Report of State Board of Fish Commissioners.

creek and lake. Dierker Lake, May 25, 1911, four schools, 1000 each or less, 4 weeks old. The water here was very dirty. The small size of the schools may be due to fungusing of the eggs in the nests. Crabtree dredge-ditch, June 10, 1911, young bass are still in schools, but easily scattered; length 1½ to 2 inches. Head of Quiver Lake, June 16, 1911, scattered fry, no longer in schools; length 1½ to 2½ inches. A good many fry at this age seem to seek the protection afforded by the numerous schools of golden shiners (*Abramis*).