BULLETIN

OF THE

ILLINOIS STATE LABORATORY

OF

NATURAL HISTORY

URBANA, ILLINOIS, U. S. A.

STEPHEN A. FORBES, PH.D., LL.D.,
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 VII.—*Observations on the Breeding of the European Carp in the Vicinity of Havana, Illinois.* BY R. E. RICHARDSON.

Observations on the breeding habits of the European carp were begun at the opening of the Illinois Biological Station in late April, 1910, and carried on throughout the remainder of the spawning season; while the search for fry and fingerlings, with the object of ascertaining their habits, habitat, local preferences, etc., was continued until the Station closed in September. In the season of 1911 similar observations were in progress, practically continuously, from April 15 to June 8.

LOCALITIES

The localities within five miles of Havana that have been most frequented by carp for spawning since 1900, are chiefly the shallow overflowed fields and marshes along the Thompson's Lake bottom between Flag Lake and the west bluff and the region about the mouth of Spoon River. All of the places described in the list following are within this radius except the last two.

1. *Danhole's Field.*—This is a 600-acre tract, formerly a cultivated field, lying between the south end of Thompson's Lake and the west bluff, and immediately north of Lynch Slough. Except for two small "guts" at the south end, leading into Lynch Slough, a lotus pond of about one acre in the middle of the east side of the field, and a few narrow ridges toward the north end, the contour of the bottom of this marsh does not show great variation. The entire field is normally overflowed in April and May to a depth of one to three feet. Over almost the entire field is scattered a more or less dense growth of "flag" (*Scirpus fluviatilis*), while beneath and between the flags, and entirely covered by water through April and May, is usually to be found a carpet of short bog-rush (*Juncus*). With less uniformity of distribution but in places covering several acres continuously, are to be seen thick beds of smartweed, and mere scattering patches of cut-grass (*Leersia*), arrowhead (*Sagittaria*), and pickerel weed (*Pontederia*).

2. *Spoon River "Horseshoes" and adjacent Flats.*—Here are included several hundred acres of overflowed flats, largely timbered, lying between Spoon River and Deep and Lynch sloughs, and between the C., B. & Q. R. R. and the Illinois River. In summer these flats

are, as a rule, dried up to a considerable extent, or completely so except for the "horseshoe ponds," which are remnants of an old bed of Spoon River.

3. *Beck's Swale and connecting Ponds.*—This small swale and connecting marsh-land parallels the river in a narrow strip for most of the distance between the Isabelle Township ditch and the C., B. & Q. R. R. Station at West Havana. The ponds on Beck's land, just south of the old Illinois Central bridge, are all small, the largest not over 100 ft.×30 ft. They are connected with the township ditch by the swale at high water.

4. *Schulte's Field and neighboring Marshes.*—An overflowed field of about 50 acres, owned by J. C. Schulte, lying between the Isabelle Township ditch and the C., B. & Q. tracks, about half a mile west of the river. This area was cultivated previous to 1900, and even now crops of grass are taken from it in late summers of moderately dry years. In April and May the water is one to two feet deep over the field. Similar land in the immediate vicinity brings the total acreage available here as spawning grounds in normal seasons up to approximately 200 acres.

Many of these marshes are newly made—the result of rise in river levels due to drainage canal water—these bottoms having been cultivated fields previous to 1900. They are now overflowed throughout the spring season and usually till the first or middle of June to a depth of six inches to three feet or more. During this period there are usually large variations in water levels in the marshes; and towards the close of the spring freshet season, there are likely to be rather wide and sometimes sudden fluctuations in water levels and temperatures.

5. *Head of Flag Lake, northwest Shore.*—One hundred acres or more of "flag", smartweed, and willows. Bottom generally rather sandy; depth of water, 1 to 3 feet, April and May, 1910 and 1911.

6. *West Shore of Thompson's Lake, Warner's Cut to Big Cove.*—A narrow strip, several hundred acres in extent, of shallow water, 1 to 3 feet deep. Smartweed, pondweed, willows, and button-bush; the bottom mostly soft black mud, but in places there is considerable sand.

7. *Dierker Lake.*—A small lake, about half a mile long, just below Matanzas Lake. Smartweed and willows along shores; mud bottom, little sand.

8. *Sangamon Lake.*—At the south end of this lake or "bay", which is six miles north of Beardstown, are extensive mud flats, several hundred acres in extent, covered with willows, cut-grass, smartweed, and pondweed (*Potamogeton*); also considerable hornwort (*Ceratophyllum*). Depth of water, May, 1911, 1 to 3 feet.

Equipment

The equipment used in making the field observations was extremely simple, and for the most part was as follows:

1. A flat-bottom skiff of light draught, with wide stern.

2. A black calico-covered sun-hood, so constructed that it could be easily set up, clamped, and disconnected from the stern of the skiff.

3. A small, hand water-glass, for close observation of the bottom. This glass, cemented into the end of a 40-inch tube, 6×6 inches in section, could be lowered to or very near bottom in as much as three feet of water.

4. A garden rake for lifting bog rush, smartweed, sodden drift, etc., on which eggs were seen, by use of the sun-hood or water-glass, to have been deposited.

5. The ordinary field collecting utensils employed in collecting and preserving zoological material.

We had also as field helper, at the oars and in every service in which help was needed, an experienced, intelligent, and interested fisherman and mechanic*, to whom is due no small part of the credit for whatever success attended the season's operations.

Journal of Field Observations, 1910-1911

nineteen hundred and ten

March. Although the month of March was exceptionally dry and warm throughout, no reports of spawning of carp came in from fishermen. The Illinois River gage stood at 14.1 ft. March 15, and fell gradually to 12.9 ft. by the end of the month. Between March 18 and April 1 the surface temperature of the water in the channel of the river, at our regular plankton station, rose from 44° to 60° Fahr., and in Thompson's Lake, at the regular plankton station, it rose from 40° to 60°. The plankton (silk-net catches) in Thompson's Lake was nearly quadrupled in the week between March 18 and 25, and by April 1 had increased to nearly nineteen times the amount present on March 18.

April. During the first half of April moderate weather prevailed, water temperatures in the river and Thompson's Lake remaining between 60° and 64° Fahr. The river gage declined gradually through the month, from 12.8 ft. to 10.2 ft. Between April 8 and 20, large numbers of carp were reported to have been heard and seen "splash-

*Henry C. Allen, of Havana.

ing"* at various points in the vicinity of Havana. If any judgment is possible from a comparison of the frequency of these reports with those that came in later, it seems probable that the majority of the carp at Havana spawned between April 10 and 25. A cold spell between April 20 and 25 resulted in a drop of water temperature to 46° by April 25. No reports of spawning activity were received between this date and the beginning of the second week in May. The warmer days, preferably when a light south wind is blowing, seem usually to be chosen by the carp for spawning.

May. The first week in May was cool and rainy, and no spawning movement was reported. The weather cleared and moderated after May 7. The surface temperature of the water in Thompson's Lake rose from 46° to 62° Fahr. between April 25 and May 2, and increased gradually thereafter, the maximum air temperature reaching 72° on May 9. Numerous reports of spawning activity of carp came in between May 7 and 9, and on the last-named date the greater part of the day was spent by Allen and myself in making observations on the breeding grounds in Danhole's field.

May 9. Went with Allen and outfit to Danhole's field morning and afternoon. Carp splashing in south end of field all day—two or three or half a dozen in one place. Giggers (farmers), with pitchforks, wading about. In the part of the field in which carp are now spawning the water is from 1 to 3 ft. deep. The bottom is for the most part thickly covered with a fine short bog-rush, cut-grass, and smartweed. At the surface a good deal of loose drift—dead twigs, etc.—is floating. Examination of the bottom with the water-glass shows eggs in large numbers attached to the submerged vegetation and drift—green bog-rush and grass and dead grass and brush. Most of the eggs are in water 2 ft. or more in depth, and in such places as are most densely covered by floating drift. They are clearly seen with the water-glass in two feet of water, and easily lifted to the surface, with the bog rush and drift to which they are attached, by the use of a common garden rake. The floating trash is also very generally sprinkled with eggs, doubtless thrown out of the water into the air by the carp as they crowded and turned or were thrust on their sides in the act of spawning. Large numbers of eggs are fungused, indicating that they have been spawned some days, but presumably during the first week of May. Several hundreds of eggs were taken into the laboratory and put into aquaria for observation.

In the south hundred acres of the field, counts were made in vari-

*"Splashing," "rolling," "fluttering," etc., are terms used by fishermen to describe movements of carp in the act of spawning.

ous places of the number of eggs over a square yard or less of bottom. These counts varied from a minimum of 100 to a maximum of 2500 per square yard. It was difficult to find anywhere an area of bottom, however small, within the entire southern third of the field—the only part examined—on which at least some eggs had not been deposited. If we assume that the field has, as reported, an area of 600 acres (2,903,617 square yards), and that the eggs are distributed over the whole area at the same rate as in the south third*, that is, at the rate of 500 per square yard, which is probably a conservative estimate considering the very high density of distribution in those portions where most splashing has been done, we have for the field a total of 1,451,818,500 eggs. At the average rate of 500,000 eggs apiece (the number estimated by Cole and others for 5- to 6- lb. carp), it would take 2903 females of five to six pounds' weight to furnish these eggs. This is equivalent to saying that at various times and places in the field between May 1 and May 9, *29* lots of *100* females each, spawned in the whole field. Looked at in this light our estimate is, indeed, in all probability too low†, and is so considered by the best-informed and most observing fishermen, to whom it is no uncommon experience to see *several hundred* carp splashing at one time in a space of less than an acre.

May 12. Eggs in Danhole's field are advancing rapidly towards hatching (embryo turning inside egg), but the number of fungused eggs has increased greatly since May 9. After making test counts in various places, it was estimated that in the neighborhood of ten per cent. of the eggs have eye-spots, the rest being fungused. This gives a total hatch of 145,181,850 out of the 1,451,818,000 eggs present May 9. In the south end of the field some fresh eggs, spawned in the past three days, were found. Several lots of eggs of various ages again taken to laboratory for observation. A few of these hatched on the way in. These eggs are evidently somewhat further advanced than those from same lot brought in to the laboratory on May 9.

In afternoon, visited Beck's Swale and ponds, between river and C., B. & Q. Station at West Havana. Mr. Beck says that a hundred or more large carp were rolling yesterday (May 11) in the swale behind his house. They come up by way of the township ditch. The

*Note that we got several reports of carp splashing in the upper part of the field, behind the club house, between April 15 and May 15.

†Additions should also probably be made to these numbers to allow for eggs spawned before and after the estimates were made, as these refer only to eggs in field between May 9 and 12, *and not to the total spawned during the whole spring season.*

wind was in the south on May 11. We found large quantities of carp eggs in the swale—on the bottom and on floating drift. About half of them were quite fresh in appearance and showed no fungus; the rest were older and largely fungused. They probably belonged to a lot spawned before or on May 9, about which dates also carp were splashing here, according to Beck and J. C. Schulte.

May 13. The water in Schulte's field is now 12 to 18 inches deep. Many carp eggs were found in grass and leaves, both submerged and floating, chiefly in water about 6 inches deep.

May 13. Eggs brought in from Danhole's field May 9 are beginning to hatch.

May 14. Visited Danhole's field in afternoon. Few carp eggs to be seen. About the last of the eggs on which observations were made May 9 and 12, have hatched or disintegrated. Tried pumping up newly hatched fry from the bottom with a small bilge-pump, with coarse silk-net over spout, but got none.

May 15. The last of the eggs brought into the laboratory from Danhole's field May 9, hatched today. The loss by fungus has amounted to about 70 per cent. The smaller percentage of fungused eggs than the 90 per cent. found in the field is doubtless due to the fact that the fungused eggs were carefully picked out and thrown away every day in the laboratory.

May 18. Carp fry in Danhole's field have been hatched a week. They were easily taken today in large numbers with a small cheesecloth seine. The largest numbers of fry are found in about 2 ft. of water, where the bottom is thickly covered with bog rush and scattering flag and smartweed. No fry can be seen anywhere near the surface. They are probably swimming and feeding near the bottom. The water at all levels, in a depth of only 1 to 2 ft., is swarming with a rich entomostracan plankton.

May 19. Carp eggs brought into laboratory from Danhole's field May 12, are all hatched and doing well. These eggs were probably spawned between May 9 and 12 (see above).

May 21. Took large numbers of carp fry half an inch long in Schulte's field, in the shallower portions, where water was only 6 to 12 inches deep, with weedy or grassy bottom. In the deeper parts of the field—18 inches and over—with open mud bottom and no vegetation but scattering smartweeds, no fry were found. Tests with silk net showed that there was much less plankton over soft mud in this open water, which is apt to be roiled by wind because of shallowness, than in the shallower vegetation-filled portions of the field, where there was instead a very rich entomostracan plankton.

The water has fallen in this field about 6 inches since May 12, and the gage is still on the decline. At this rate it may not be many days till the water in the field will be so low that the fry will be scalded or left high and dry.

Water in Danhole's field 8 to 18 inches deep, and going down at rate of 1 inch a day.

Carp fry ¼ to ½ inch long are abundant, and easily taken with cheese-cloth seine.

June 3. Carp coming into market include a good many females full of eggs, some dressing only half their round weight; but most have evidently spawned.

[*June 3-22.* This interval was taken up by the Rock Island plankton trip and preparations for the opening of the University Summer School.]

June 23. Water has fallen about 1.8 ft. since the first of June. Depth of water 4 to 6 inches in south end of Danhole's field. Temperature of water 85° Fahr. Rushes (*Scirpus*), as high as a man's shoulders, choking up the marsh almost completely except for scattering small open spaces 10 to 30 feet across. In these openings we found small fry, ½ inch to 1 inch long, of bass, bluegill, and crappie, but no carp. Have all the carp gone out of the field? If so, where are they? We searched for them in the deeper water of Lynch Slough, just outside of the field, but could find no trace of them.

June 23-30. Tried repeatedly to get carp fry in waters adjacent to Danhole's field,—Lynch Slough, Crabtree dredge ditch, Thompson's Lake, west shore, between dredge ditch and club house, etc. No trace of them found.

July 1. Visited Beck's ponds. They are now very low and all shut off from connection with the township ditch and the river, some being dried up completely. If dry weather continues a few weeks, all will be dry. In one of the largest ponds, 30×100 ft., just dried up, several hundred dead carp, 1 to 2 inches long, were found.

In small pitlike depressions (cow tracks?) in the bottom of this pond, holding from a quart to a gallon of water, with a temperature of 92° Fahr., we found half a dozen carp, ¾ inch long, well-fed and lively, although all about them were skeletons and decaying bodies of hundreds of others.

July 5. Visited Danhole's field. Most of the field has gone dry except for small areas in the middle of the densest flag patches, where water from 2 to 6 inches is present, and the two lotus ponds, which have 2 to 3 feet of water. We searched high and low for young carp, but found none, alive or dead. In the lotus ponds, found

an abundance of large-mouth black bass (1 inch to 2½ inches), young black bullheads, and various minnows (*Cyprinidæ*). In the flags in the south end of the field, found sunfish and crappie fry in water 2 to 4 inches deep. They are shut off now from any connection with Lynch Slough or Thompson's Lake, making it practically certain that they will perish with further drying.

In the soft mud of the nearly dried-up bottom of the two "guts" in the south end of the field, draining the field southward into Lynch Slough, we found numerous dead crayfish and snails, but no carp. It is through these two "guts" that the fry seem most likely to have gone out of the field—if they went out at all—as the water receded between June 5 and 20.

July 7. Took 200 specimens of young carp, 1 to 2 inches long, at the head of Liverpool Lake, west shore, with one haul of the 120-ft. minnow seine. They were taken in water 1 to 3 feet deep, moderately clear of vegetation, but with a thick fringe of *Ceratophyllum* and *Spirogyra* along shore. The bottom is mixed hard clay and black mud, with some vegetation as far as 100 feet out from shore; the water is slightly turbid, from the strong current flowing in from the river through the inlet ditch opposite Liverpool.

Among the specimens taken were a good many of the mirror and leather varieties. The large number saved in the haul with ¼ inch mesh, through which many probably escaped, suggests the probability that there were in all several thousand in the shallow water at the northwest end of the lake, below the inlet ditch.

July 12. Took four specimens of young carp (1 to 2 in. long) in one haul of a 15-ft. seine, on the gravel point below Sam Bishop's, on the west shore of Quiver Lake, in *Ceratophyllum*.

July 24-31. Took a few young carp, 1 to 2 in. long, on the west shore of Illinois River, opposite Quiver Beach, along the edge of the muddy bank, in *Ceratophyllum*.

August 3. Allen tried the haul at head of Liverpool Lake, where 200 carp were taken July 7. No young carp obtained. Water has fallen 2 feet, and the vegetation zone is nearly all out of water.

August 9. Tried the west shore of Illinois River, opposite Quiver Beach, where we took a few young carp July 24-31, but got none. Water has gone down one foot, and left most of the *Ceratophyllum* high and dry.

August 10. Tried the head of Liverpool Lake again. No trace of young carp. The water has receded, leaving the vegetation zone dry.

August 11. Tried half a dozen hauls with 120-ft. seine in Clear and Mud lakes and Courtwright Slough, but got no carp, young or old.

August 10-12. Tried various hauls in Shepard Island Slough and Bath Lake, but found no trace of young carp.

August 25. Half a dozen specimens of young carp, 2 to 3 inches long, taken by Mr. Hart in a slough below the Chautauqua barns when the slough was drained in the course of mosquito work. The slough contains some smartweed and *Ceratophyllum*.

September 7. One young carp 6 inches long (1909 spawning?) taken from "Black Bill" Shafer's seine, head of Thompson's Lake.

NINETEEN HUNDRED AND ELEVEN

Field work began April 15. Weather generally chilly between April 15 and 30, cloudiness and winds not favoring spawning activity and interfering a good deal with field observations under water. Water temperatures on spawning grounds reached 60° to 66° Fahr. between April 20 and 25, and dropped back to 58° as a result of a heavy frost at the end of the month. The river rose from 10.2 to 10.6 feet between April 15 and May 1.

April 25. Carp are on the spawning grounds at head of Flag Lake, and giggers are at work. (A boat-load of gigged carp were brought to Havana the next day.) No eggs found today.

May. The weather was fair and dry throughout the month of May, with the river gradually falling from 10.6 feet on the first to about 9 feet on the last of the month. The first ten days were rather chilly to moderate, with water temperatures increasing from 58° to 74° Fahr. Temperatures mounted rapidly between May 10 and 18, the air touching 90° and the water 81° on the last date. By May 22, water temperatures on the spawning grounds had reached 86°.

May 3. A few carp eggs were found today in the north end of Danhole's field, in water 10 inches deep, on bog rush. Also a few found at the northeast end of Flag Lake, attached to dead flag at and below the surface in 2 feet of water. The indications are, however, that only a few carp have spawned, and that the greatest spawning activity is yet to come, with warmer weather.

May 5. The river gage is nearly two feet lower than on the same date last year, and falling. Danhole's field is under water only at the north and south ends, about 100 acres in all—a sixth of the total area—being flooded. Carp eggs are thick on live bog-rush and dead grass and drift in the north end of the field, but 98 or 99 per cent. are fungused. The water is 6 to 10 inches deep, with a temperature of 62°.

Several large carp were seen splashing this afternoon on the west shore of Thompson's Lake, just below the Thompson's Lake Club

House. They occasionally jump clear of the water, with body vertical, head up, "treading water with the tail." It is a warm, sunny afternoon.

May 6. Visited the lower end of Sangamon Bay, six miles north of Beardstown, today. Towards noon the mud flats here and at the head of Pluckimen's Slough, several hundred acres in extent, were alive with spawning carp. Probably not less than a thousand fish were spawning. The water is shallow, 1 to 3 feet deep, and pretty well filled with smartweed, *Ceratophyllum,* and *Potamogeton;* also a good deal of live willow. Spawning females, with eggs running, are easily taken with a dip-net. The "coursing" of the pairs and trios (one female and one male, or one female and two males) is easily observed, the fish sometimes passing close enough to rub one's boots. The males are always smaller than the female, and swim a little lower, with the nose under her belly, pressed close up against her. The grass and water-weeds are hung with myriads of eggs, from freshly spawned ones to those nearly ready to hatch. Spawning must have been in progress here for several days. Of the older eggs, it is noted that the per cent. fungused is very small, probably not over 10 per cent. This may be connected with the freshness of the vegetation among which the eggs were spawned.

May 8. About a hundred carp were seen spawning at the head of Danhole's field today, in water 8 to 10 inches deep, and another hundred on the west side of Thompson's Lake, a quarter of a mile above Warner's Cut, in water 2 to 3 feet deep, full of smartweed and "blanket-moss" (*Spirogyra* and *Cladophora*). Small numbers were seen spawning at the head of Flag Lake and on the west shore of Thompson's Lake, below the club house.

May 16-17. The river has fallen a foot since May 1, and is now two feet below the level of this date last year. Danhole's field is rapidly drying up. The north end is padded down with a blanket of rotting weeds and pond scum. The only egress for the carp fry is through a small opening into the Crabtree ditch, a quarter of a mile south of the northeast corner of the field. The temperature of water 2 to 6 inches deep is 89° to 92° Fahr.

May 22. Visited Danhole's field to search for carp fry. The field is now almost wholly without water, with the bottom a soft muck, except for small depressions, 1 to 3 feet in diameter and occasionally larger, in which water ½ inch to 4 inches deep is still standing. The temperature of the water in these holes is 92°. There are thousands of dead carp fry in recently dried-up holes. In some of the holes with water ½ inch to 3 inches deep we found apparently healthy carp, ½

to ¾ inch long, in a water temperature of 92°. In a single depression one foot in diameter, with water only ½ inch deep, there were fifty fry, some dead, some nearly dead, and others flopping about wildly. It is impossible to estimate with any accuracy the number of fry that have already perished. It is surely hundreds of thousands, possibly millions.

May 25. Saw several carp spawning this morning in the head of Dierker Lake. Fresh eggs, and those nearly ready to hatch, are abundant on *Ceratophyllum* and dead drift.

May 26. Carp fry ½ to ¾ inch long are abundant today in the head of Liverpool Lake, west shore, just below the inlet ditch, in 2 to 6 inches of water, in vegetation. They are feeding at and very near the bottom. A cheese-cloth seine used in water 1 to 2 feet deep, away from the shore and out of the vegetation zone, does not get them.

May 26. Searched for carp fry today along the west shore of Thompson's Lake, from half a mile below the club house to Big Cove. Found them abundant in "blanket-moss" zone, along the edge of the lake, in water 4 to 8 inches deep. By lifting up "moss" we can see them feeding on the bottom. Some also are feeding in the moss near the surface. The temperature of the water is 89° to 90° Fahr. in the upper two inches; 81° to 83° in the lower two inches. In a brush patch just above the Big Cove, fry are abundant in moss-choked water 3 feet deep. Picked them up with a tin cup from surface moss, and got large numbers with Ekman dredge from the bottom, under the moss.

June. The month of June was unusually hot and dry, air temperatures ranging from 85° to 98° except for a short cool spell June 12 and 13. The river gage was at 8.4 feet on June 15, fully three feet lower than on the same date last year, and had dropped to 7.9 feet by June 21. Danhole's field is all dry except the lotus pond. The lakes are so low and choked with vegetation as to make navigation difficult with either skiffs or launches. Heavy rains June 25 caused a temporary rise of a few inches. Field operations of the month included some search for carp fry, but without success in any instance. Actual observation of carp spawning was made as late as June 2, and reports of spawning as late as June 8 were received from fishermen.

June 2. A dozen or so carp spawned about a drift pile in Flag Lake Swale this morning, in water 5½ feet deep. Went to the spot immediately with William Selby, fisherman, who brought in the report, and got an abundance of fresh eggs. Hatched these in the laboratory, and kept them until a satisfactory determination of the species was possible. While buffalo are believed to spawn frequently in water as deep as this, carp certainly do not do it often.

June 5-8. James Trent, fisherman, reports carp spawning in considerable numbers in Clear Lake, on the "Middle Ground"—a brush-covered ridge under shallow water.

SEARCH FOR YOUNG CARP, SEASON OF 1909

Young carp under six inches seem very rare about Havana. From July 1 to December 31 we succeeded in finding them only twice, and in very small numbers: once in one of the mud-bottom "horseshoe" ponds north of Spoon River bridge (C., B. & Q.); and once in a small pond along the Crabtree dredge ditch opposite the foot of Thompson's Lake.

FEEDING HABITS OF YOUNG CARP IN FIELD, AND IN LABORATORY AQUARIA, 1910

May 25. Young carp ½ to ¾ in. long observed to snap at and swallow large *Entomostraca* (*Cladocera* and *Copepoda*), in laboratory aquarium.

July 14. Specimens 1 to 1½ in. long, observed to attack and swallow, with difficulty, full-sized specimens of a small amphipod crustacean (*Hyalella knickerbockeri*), 3 to 5 mm. long, in laboratory aquarium.

August 19. In a laboratory feeding experiment made August 19, young carp 1 to 2 inches long were fed mixtures of coarse plankton—*Entomostraca, Hyalella,* small insect larvæ, *Wolffia,* etc.—and killed after thirty minutes. One specimen 1⅝ in. long was examined, and had eaten several *Hyalella* and one *Cyclops,* but no *Wolffia* or other vegetation.

Acc. No. 28551. The food of two specimens of this collection, made in Danhole's field June 3, 1910, was as follows: One (½ in. long) had eaten nothing but three large *Cyclops;* the other (⅝ in. long) had eaten 1 *Cyclops,* 1 *Alona,* 4 ostracods (*Cypris?*), and a trace of *Spirogyra.* It was noted that *Cladocera, Copepoda,* and *Ostracoda* were very abundant June 3 in cheese-cloth seine-haul.

Acc. No. 28569. A specimen 1¼ in. long taken from the head of Liverpool Lake in July, 1910, had gorged itself with about a dozen *Cyclops.* No vegetation had been eaten except a trace of *Spirogyra.* Nothing of the nature of mud was to be seen in the stomach.

Is it possible that the reason for the sudden disappearance of the carp fry from this place between July 7 and August 11 was that they had exhausted the supply of *Entomostraca*—to which they had accustomed themselves for some weeks—and that they left to find new feeding grounds?

SPAWNING DATES, HAVANA AND VICINITY, 1910 AND 1911

1910

April 8-20. Vicinity of Havana (reported by fishermen; localities various).

May 1-10. Danhole's field. Large numbers spawned between these dates. Eggs found.

May 10. Schulte's field. Eggs found.

May 10-11. Beck's Swale and ponds. Eggs found.

1911

April 25 Head of Flag Lake. Breeding males and females on spawning grounds. Giggers at work. No eggs could be found.

May 2-3. Danhole's field. Fresh eggs found.

May 2-3. Head of Flag Lake. A few dozen observed spawning. Eggs found.

May 6. More than 1000 seen spawning in Sangamon Bay. Many fresh eggs taken. Spawning females taken with dip-net.

May 8. About a hundred seen spawning on the west side of Thompson's Lake; a few at head of Flag Lake; and a hundred in Danhole's field.

May 25. Dierker Lake. A few dozen seen spawning.

June 2. Flag Lake Swale. About a dozen spawned. Eggs taken and hatched.

June 5-8. "Middle Ground", Clear Lake. Fishermen report considerable numbers spawning.

SITUATIONS SELECTED FOR SPAWNING

1. Overflowed fields and marshes (cultivated previous to opening of the Drainage Canal in 1900) grown up with bog rush, smartweed, cut-grass, and "flag" (*Scirpus*); depth of water (April and May, 1910 and 1911) 1 to 2 feet. Danhole's and Schulte's fields.

2. Shallow ditches and ponds, mud bottom and smartweed; water 1 to 2 feet deep, 1910. Beck's ponds.

3. Shores of open lakes, in vegetation zone; flag, smartweed, *Potamogeton,* and *Ceratophyllum;* water 1 to 2 feet deep, 1911. Northwest shore of Flag Lake; west shore of Thompson's Lake; head of Dierker Lake.

4. Overflowed mud flats, grown over with willows, grass, and *Ceratophyllum;* water 1 to 3 feet deep, 1911. Flats at south end of Sangamon Bay and head of Pluckimen's Slough.

5. Swales, among willows and "buck brush"; water 4 to 5 feet, 1911; too deep for rooted aquatics; occasional *Ceratophyllum*. Flag Lake Swale.

ESTIMATED NUMBERS SPAWNED, HATCHED, FUNGUSED, AND MATURING, DANHOLE'S FIELD (600 ACRES), 1910

Number of eggs present May 9, 1,451,818,500.

Per cent. of eggs with eye-spots May 12, ten.

Per cent. of fungused eggs in field (to beginning of hatching), ninety.

Number of eggs hatched, 145,181,850.

The percentage of eggs fungused in the north end of Danhole's field in May, 1911, was much greater than in 1910, probably equaling 98 or 99 per cent. This high ratio was probably due largely to the abnormal lowness of the water and unseasonable warm weather. Both in 1910 and 1911, Danhole's field contained a great deal of rotting dead grass and flag. In laboratory lots it was noted that eggs hatched better in jars containing fresh living algæ and *Ceratophyllum*, and free from dead grass and trash. Eggs spawned in *Ceratophyllum* in Sangamon Bay, May, 1911, showed a relatively small ratio of fungus, probably less than 25 per cent.

H. M. Smith (quoted in *Fishing Gazette*, June, 1910), has expressed the opinion that one out of a thousand salmon hatched comes to maturity. On this basis, out of 145,181,000 carp hatched in Danhole's field in May, 1910, 145,181 would reach maturity, and it would take only 28 times this number to replace the annual take-out of carp from the river by fishermen (about 20,000,000 lbs. for the whole state in 1908, at an average weight of 5 lbs. each, equivalent to 4,000,000 adult carp). In other words, it would take only 28 marshes the size of Danhole's field to replace the present annual catch on the basis of one out of a thousand hatched reaching maturity. The ratios actually realized in seasons of favorable water-levels are probably much better than this, both in *per cent. hatched* (after deducting for fungus) and in *per cent. of fry that reach maturity.*

HABITS AND LOCAL PREFERENCES OF FRY AND FINGERLINGS

1. *Marked preference of fry for animal food.*—Specimens ½ to ⅝ inch long from Danhole's field, June 3, 1910, had eaten large quantities of *Cyclops, Alona,* and an ostracod, with a trace in some cases of *Spirogyra*. One had eaten nothing but large *Cyclops*. A specimen 1¼ inch long from the head of Liverpool Lake, July, 1910, had

gorged itself with *Cyclops*. It had taken no vegetation except a trace of *Spirogyra*, and nothing of the nature of mud was to be seen in its stomach. In the laboratory, young carp ½ to ¾ inch long were observed to snap at and swallow large *Cladocera* and *Copepoda*, and specimens 1 to 1½ inch long were seen to attack and swallow, with difficulty, full-sized specimens of *Hyalella knickerbockeri*, 3 to 5 mm. long. In August, 1910, several young carp 1 to 2 inches long were fed in the laboratory a mixture of coarse plankton, including *Entomostraca*, *Wolffia*, etc., and killed after thirty minutes. Specimens examined had eaten greedily of the *Entomostraca*, but had taken no *Wolffia* or other vegetation.

2. *Apparent preference of fry and fingerlings for feeding grounds with some bottom-covering of vegetation (presumably because of the animal organisms living among the vegetation)*.—Work with the cheese-cloth seine in Danhole's and Schulte's fields in May, 1910, indicated that fry ⅜ to ¾ inch long feed by preference very near the bottom. The situations studied were all shallow, 1 to 2 feet deep, more or less densely filled with short bog-rush, among which was a rich entomostracan plankton. Fry were *never* observed *swimming at or near the surface, in open water*, as do the fry of bass, sunfish, and various native *Cyprinidæ*. In May and June, 1911, likewise, it was our experience that the fry were most likely to be found along the very edges of lakes such as Thompson's, Liverpool Lake, etc., in water 6 inches to 1 foot deep, choked with bog rush, algæ, or other vegetation. Large numbers were observed feeding on the bottom under veritable blankets of algæ, which had to be lifted before the fry could be seen. At no time did we find carp fry in open water with mud or sand bottom. We found them in Thompson's Lake, May, 1911, in water as deep as 4 feet, but only where there was a rich growth of vegetation. In Thompson's Lake, May, 1911, in intertangled algæ and *Potamogeton*, reaching from bottom to surface in 4 feet of water, we found them at various levels, from bottom to surface, but those at and near the surface were held up to a great extent by the algæ, and were not swimming free. In the search for fingerlings in July and August, 1910, when we could find them nowhere else, we were pretty sure of getting them in the narrow *Ceratophyllum* zone on the west shore of the Illinois River, opposite Quiver Beach. This *Ceratophyllum*, rolling against a mud bank in 1 to 2 feet of water, was swarming with a small amphipod, *Hyalella knickerbockeri*, on which the young carp were feeding.

THE FRY'S STRUGGLE FOR EXISTENCE FROM HATCHING TO FINGERLING STAGE

1. *Natural enemies.*—Large numbers of gar, bass, and pickerel (grass pike) frequent the marshes used by carp for spawning grounds and themselves spawn there. The pickerel are in the fingerling stage by the time the carp are ½ to ¾ inch long. The bass and gar spawn at about the same time as the carp, in general, but the large size of the mouth of these species and their well-known predaceous tendency, doubtless make them destructive enemies of at least the later-spawned carp fry.

2. *High temperatures on the spawning grounds.*—By May 22, 1911, water temperatures in the marshes and overflowed flats about Havana had reached 86° Fahr.; but some fry were found still alive at that time in drying-up holes in Danhole's field, in water registering 92°, as likewise in small puddles left from the drying-up of Beck's ponds, July 1, 1910.

3. *Landlocking and drying up of spawning grounds before fry are old enough to escape.*—Large numbers of fry perished from these causes in May, 1911, (Danhole's field,) and in June and July, 1910, (Beck's ponds). To what extent their instincts protect young carp of proper age from the danger of falling water is not altogether certain. The bottom- and vegetation-loving habit of the fry, from hatching to the fingerling stage, is probably always a source of danger. That great numbers of them fail to take care of themselves when 4 to 6 weeks old and from ½ to ¾ inch long, is apparently proven by the observations made in Danhole's field in May, 1911. The slightly greater age of the fry when first critical levels were reached in the last week of June, 1910, was probably the only thing that prevented even greater destruction then.

There are also indications of a general nature that conditions in the lakes and sloughs about Havana, and perhaps at other points along the river, are now less favorable to the development and maturity of carp fry than they were previous to the opening of the Chicago Drainage Canal in 1900. Previous to 1900 there was much vegetation in what is now open water. The shallower lakes then offered excellent opportunities for spawning, many of them over considerable areas well away from shore, and in all cases with deeper water always within easy reach. Now in most of the lakes the vegetation is reduced to a narrow zone along portions of the shores, and the newly formed marshes due to the temporary overflow of the old lake-banks offer the most extensive and suitable territory available in April and May for spawning purposes; but the flatness and shallowness and im-

permanency of these new marshes is likely, except in spring seasons of more than average water levels, to be a source of serious danger to the fry before the fingerling stage is reached. In Danhole's field the critical range of river levels for the young carp lies between 9.6 and 9.0 feet (Havana gage). At 9.6 feet this 600-acre tract is practically landlocked except for a single small opening into the Crabtree dredge ditch, toward the northeast corner of the field; and between that level and 9.0 feet destruction of fry under six weeks old is known to proceed on a large scale, as perhaps also some destruction of fry still older. The stage of 9.6 feet was reached on May 17 in 1911, and great destruction resulted in the week following. The same level was not reached till the last of June in 1910, when the greater age and size of the fry seems to have permitted most if not all of them to escape; but it should be noted here that the field observations of the spring and summer of 1910 were broken off from June 3 to June 23, and that our history of the fate of the fry that season is consequently incomplete.

A full list of dates follows, on which critical river levels for the fry in Danhole's field were reached from 1900 to 1911 inclusive. It should be noted in this connection that at 9.6 feet the field is practically landlocked, and that at 9.0 feet the destruction of fry by drying is about completed. The unmarked years are those in which it is certain, on evidence of the observations of 1910 and 1911, that more or less extensive destruction of fry went on in such areas as Danhole's field. The interrogation points indicate seasons in which the amount of destruction that occurred is uncertain, depending very probably on the date of spawning of the various broods and their size at the time the critical level was reached. The years preceded by an asterisk are those in which it is reasonably certain that the fry escaped, the number of these years being only three out of a total of twelve.

Dates of Critical River Levels for Fry in Danhole's Field, 1900-1911
(Havana gage)

Year	Date of fall to 9 6 ft.	Date of fall to 9.0 ft.
1900	May 12	May 23
1901	May 9	May 13
1902	April 17	April 23
?1903	July 3	July 7
1904	June 9	June 23
?1905	July 11	July 15
1906	May 18	May 22
*1907	Nov. 1	Nov. 10
*1908	July 23	July 27
*1909	Aug. 4	Aug. 9
?1910	June 29	July 4
1911	May 17	Before May 31

POSSIBLE REMEDIAL MEASURES

1. *Artificial regulation of water levels on the most important breeding grounds, especially during the critical period of such seasons as* 1900, 1901, 1902, 1904, 1906, and 1911; *and provision of better means of escape for the fry at the beginning of the critical period, by ditching.* It is possible that something could be accomplished in both these directions by cooperation of the Fish Commission with some of the better-situated agricultural drainage districts.

2. *Protection of growing fry against enemies, particularly bass, gar, and pike.* The State Fish Commission has already taken up the question of gar extermination; but until some suitable method of segregation in the Illinois river backwaters of the angling (bass) and commercial (carp and buffalo) interests is adopted, the bass will continue to be a very destructive enemy of the fry of the two commercial species—carp and buffalo.

3. *Protection of eggs against destruction by fungus.* Our observations show clearly that destruction by fungus is least among eggs spawned in clean water, bearing a naturalized growing aquatic or semi-aquatic vegetation. As a result of the higher water-levels since the opening of the Chicago Drainage Canal, in 1900, the breeding grounds of the carp have been pushed back, to a great extent, into newly made marshes, not yet adapted to submergence, and still choked every spring with dead and rotting land plants. It is possible that in time this matter will adjust itself to a certain extent. Such a readjustment would be assisted by any measures taken to insure, artificially, greater permanence of levels in these areas.

On the Breeding Grounds, watching Movements of Fish, and searching for Fish Nests and Fry.