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STATE OF ILLINOIS
DEPARTMENT OF REGISTRATION AND EDUCATION
DIVISION OF THE
NATURAL HISTORY SURVEY
STEPHEN A. FORBES, Chief

Vol. XIV.

BULLETIN

Article IV.

Changes in the Bottom and Shore Fauna of
the Middle Illinois River and its Con-
necting Lakes since 1913—1915 as a
Result of the Increase, South-
ward, of Sewage Pollution

BY

ROBERT E. RICHARDSON



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ARTICLE IV.—*Changes in the Bottom and Shore Fauna of the Middle Illinois River and its Connecting Lakes since 1913—1915 as a Result of the Increase, Southward, of Sewage Pollution.* BY ROBERT E. RICHARDSON.

The following short account of the principal changes that have occurred both in the composition and abundance of the small bottom-invertebrate fauna of the Illinois River system between Chillicothe and Brown-ing since 1913—1915—these points being respectively 146.5 and 229.5 miles below the mouth of the Chicago River—is based on hauls made in July, August, and September, 1920, with the Petersen quantitative bottom-sampler at seventy-one stations in the river and Peoria Lake between Chillicothe and the head of Grand Island, and at twenty-five stations in five of the more important bottom-land lakes in the neighborhood of Havana. While the composition of the small bottom-fauna was apparently normal as far north as Chillicothe in 1915,* the 1920 data herein presented disclose conspicuous changes since that time both throughout the northernmost and southernmost portions of the section of river system studied, these including sweeping reductions in numbers and poundage of the still surviving groups of small bottom-animals, total obliteration of numerous families and species, and, in the range covered above Havana, the intrusion in large numbers of new pollutional or tolerant forms. If, as is approximately correct, we assume that Chillicothe marked about the upper limit of wholesome conditions in the bottom muds in 1915, then the added river mileage that is shown to have been more or less seriously damaged since that time figures out at not less than eighty, and represents an average southward encroachment of pollution amounting to fully sixteen miles per year for each year of the five.

Valuations of the small bottom-animals have been made in the same manner as for the 1915 material reported upon in the paper just cited. Valuable assistance in working up the Chironomidae of the collections of this year, as well as in the elucidation of older data for comparison, has been given by Dr. C. P. Alexander and Mr. J. R. Malloch.

* The Small Bottom and Shore Fauna of the Middle and Lower Illinois River and its Connecting Lakes, Chillicothe to Grafton: its valuation; its Sources of Food Supply; and its Relation to the Fishery. By R. E. Richardson. Bul. Nat. Hist. Survey, Vol. 13, Art. XVI. 1921.

SYNOPTIC LIST OF DREDGING STATIONS, ILLINOIS RIVER AND
CONNECTING LAKES, JULY—SEPTEMBER, 1920

1. ILLINOIS RIVER AND PEORIA LAKE, CHILLICOTHE TO WESLEY
MILE 146.5—MILE 167.8 BELOW LAKE MICHIGAN

	Channel	4—7 feet.	1—3 feet.	Total
Upper lake, Chillicothe to Spring Bay, Mile 146.5—153.2	3	4	1	8
Middle lake, Mossville to Al Fresco Park, Mile 154.9—159.3	3	4	1	8
Peoria Narrows, Mile 161.0	1	1	0	2
Lower lake, Straw-board Mill to Liberty St., Mile 161.7—164.2	8	3	4	15
Peoria and Pekin Union Railway Bridge, Mile 166.4	1	1	0	2
Total	16	13	6	35

2. ILLINOIS RIVER, LIVERPOOL TO 1.5 MILES BELOW HEAD OF GRAND ISLAND
MILE 199.0—MILE 215 BELOW LAKE MICHIGAN

	Channel	4—7 feet.	1—3 feet.	Total
Liverpool to Havana, Mile 199.0—207.0	7	7	0	14
2 miles below Havana to 1.5 miles below head of Grand Island, Mile 209.0—215.0	11	8	3	22
Total	18	15	3	36

3. ILLINOIS VALLEY LAKES, LIVERPOOL TO 3.5 MILES ABOVE BROWNING
MILE 199.0—MILE 226 BELOW LAKE MICHIGAN

Lakes north of Havana, Mile 199.0—207.0	All mud bottom, Depths, 2—6 ft.	
Liverpool Lake	5	15
Dogfish Lake	3	
Thompson Lake	3	
Quiver Lake	4*	
Lakes south of Havana, Mile 224.0—226.0		
Stewart Lake	5	

* In Quiver Lake five additional collections were made in the deep channel cut by the wash from Quiver Creek and in the sandy-muddy zone near the east beach.

The Illinois River and Peoria Lake, Chillicothe to Wesley
(Mile 146.5—167.8 below Lake Michigan)

At all of the thirty-five lake and river stations between Chillicothe and Wesley where bottom dredgings were made in 1920, there was evidence in some form or other of deteriorating change since 1915. The various tests and observations made both in 1920 and five to seven years earlier had regard chiefly to the physical condition, appearance, and odors of the muds; the composition and abundance of the small bottom- and shore-fauna; and the kinds, amount, and distribution of the coarse aquatic vegetation. While sharply drawn comparisons are not easy in the first group of items, bubbling and more or less foul odors having been noted at some stations between Peoria and Chillicothe in 1915, in the second itemization we have to do with the disappearance since that year of whole families and numerous genera and species of small bottom-animals, as well as with the entrance in their place, in several instances, of new pollutional forms; and in the last, with the practically complete disappearance of a rich aquatic vegetation which formerly covered several square miles of shallow-lake territory at low water, along with the similarly complete extinguishment of a previously very rich shore- and weed-fauna.

The muds taken at the eight stations in the "upper lake," between Chillicothe and Spring Bay, were all strong in odor, and bubbling was abundant, when the mud was stirred, in all depth-zones. Both in the channel at Rome and Spring Bay and in the open lake opposite Rome a peculiarly spongy and foul-smelling mud was lifted by the dredge. These samples showed a texture not unlike freshly risen bread, and gave out a distinct blubbery sound on being pressed with the hand as they lay

in the tray. Some improvement in odor and less bubbling was noted in samples taken well toward the east edge of the upper lake.

In the middle lake, opposite Mossville, the mud from the channel was spongy with gas, and in the channel of this lake as far south as Al Fresco Park, a mile and a half above Peoria Narrows, odors were foul and strong. Considerably less bubbling and milder odors were noted at the shallower-water stations in this section of Peoria Lake.

In the lower lake, opposite and below the principal sewers of the business and residence districts of the city of Peoria, all dredgings were made in the center or to the eastward of the steamboat channel and were for the most part out of the way of the worst of the local pollution. At our stations in the lake, neither in the main channel nor in the shallower water eastward were odors so bad as at upper-lake stations, although bubbling was abundant in whatever depth the dredge was let down. At all stations, both in this and in the upper and middle lake, it was noted that all dead shells of snails were badly blackened or otherwise discolored.

The principal changes in the bottom fauna in this 18-mile section since 1915 may be summarized under three heads: (1) disappearance of most species and genera and of several families of small Mollusca, along with important average decrease in numbers of the more tolerant forms still surviving; (2) enormous increase in larval midges (Chironomidae), with invasion of several more or less distinctly pollutional species, and similar or even greater increase in sludge-worms (Tubificidae); and (3) disappearance throughout Peoria Lake, except immediately along shore or in the short, half-mile, stretch of swifter water in Peoria Narrows, of all "other insects"* (Ephemeridae, Odonata, Phryganeidae, Corixidae, etc.), as well as of planarians and leeches, Amphipoda, Isopoda, sponges, and Bryozoa.

Although in 1913—1915 at least fifteen or sixteen species of snails, representing no less than eight families, were readily taken in the lake and river channel between Chillicothe and Peoria, but four species, representing three families, were found in the same range in July and August, 1920. The three principal surviving kinds (*Campeloma subsolidum*, Pleurocera species, and *Musculium transversum*) were those found by us farthest north—and hence most tolerant of foul water and bottom—in the upper Illinois in 1912, the first-named species occurring as far north that year as Starved Rock, and the last as far north as Marseilles. Two of the formerly abundant species of Viviparidae (*Vivipara contectoides* and *Lioplax subcarinata*), two species of Valvata, two Amnicolas, three or four species of Physidae and Planorbinae, a species of Ancyclus, and at least three species of Sphaeriidae seem to have disappeared altogether from the muds between 1915 and 1920.

* Understood in text and tables following to mean other insects than Chironomidae.

I. *Species surviving in 1920, and their distribution.*

1. Viviparidae.. 1. Campeloma subsolidum.....East side lake, opposite Rome; channel and 4—7 feet, lower lake.
2. Pleuroceridae 2. Pleurocera sp.....Channel of lower lake only.
3. Sphaeriidae.. 3. Musculium transversum.....Both zones, upper lake; shallower zone, middle lake; channel, lower lake.
- “ 4. Sphaerium stamineum.....Channel, lower lake, one occurrence.

II. *Species common or abundant in 1913—1915, but not found in 1920, and distribution in former period.*

1. Viviparidae.. 1. Vivipara subpurpurea.....Lower lake only.
- “ 2. V. contectoides.....Abundant in both zones, Chillicothe to Peoria.
- “ 3. Lioplax subcarinata.....Common to abundant, principally in channel.
2. Amnicolidae 4. Amnicola emarginata.....Common locally.
- “ 5. Somatogyrus sp.....Upper lake only.
3. Valvatidae... 6. Valvata bicarinata.....Common outside of channel.
- “ 7. V. tricarinata.....Common outside of channel.
4. Physidae.... 8—9. Physa spp.....Common in shallower zones.
5. Planorbinae 10—11. Planorbis spp.....Common in shallower zones.
6. Sphaeriidae 12. Sphaerium striatinum.....Lower lake only.
- “ 13. Musculium jayanum.....Scattered occurrences.
- “ 14. Pisidium sp.....Common.
7. Ancyliidae... 15. Ancyclus sp.....Common on shells of Unionidae.

* Nomenclature that of F. C. Baker, in "A Catalogue of the Mollusca of Illinois," Bul. Ill. State Lab. Nat. Hist., Vol. 7, Art. VII, Sept., 1906.

Even the surviving snails showed in 1920 great reduction in average numbers and weight since 1915 in nearly all portions of the area studied. The extent to which they had shrunk in the different depth-zones of the upper, middle, and lower lake is shown in the comparative valuation tables appended, and it will be sufficient here to note that whereas in 1915 the weight of the combined Gastropoda and Sphaeriidae in Peoria Lake collections made up from over 85 to over 99 per cent. of the total edible matter in the average haul, the snails in 1920, except in the short swift stretch through Peoria Narrows and in a few collections in the channel of the lower lake, weighed on the average less or only a little more than did the sludge-worms or midge larvae, and made up, in fact, only from 2 to 15 per cent. of the average catch under the new dispensation.

The Viviparidae and Pleuroceridae in 1920 were found only in the channel and 4—7-foot zone of the lower lake, opposite Peoria, and in the 1—3-foot zone, on the east side in the Rome—Mossville section. The single surviving species of Sphaeriidae (*Musculium transversum*) showed a visibly wider distribution than the large Gastropoda, and it was somewhat of a surprise to us to take the largest hauls of this stoutly tolerant little shell among the sludge-worms and larval midges of the filthy channel-bottom between Chillicothe and the foot of the upper lake.

SNAIL FAUNA OF BOTTOM MUDS, CHILLICOTHE TO FOOT OF PEORIA LAKE,
1915 AND 1920

1. Average number per square yard, main groups

		Channel		4-7-ft. zone		1-3-ft. zone	
		1915	1920	1915	1920	1915	1920
Viviparidae and Pleuroceridae	Upper lake	111	0	32	0	10	24
	Middle lake	19	0	28	0	7	0
	Lower lake	134	63	153	8	50	0
Sphaeriidae	Upper lake	152	112	204	24	12	24
	Middle lake	91	0	116	3	277	12
	Lower lake	5	6	97	0	30	0
Amnicolidae, Valvatidae, etc.	Upper lake	6	0	3	0	32	0
	Lower lake	0	0	12	0	12	0
	Middle lake	0	0	70	0	40	0

2. *Average weight, main groups, pounds per acre,
shells deducted*

		Channel		4-7-ft. zone		1-3-ft. zone	
		1915	1920	1915	1920	1915	1920
Viviparidae and Pleuroceridae	Upper lake	317	0	87	0	50	72
	Middle lake	26	0	57	0	18	0
	Lower lake	391	110	446	24	174	0
Sphaeriidae	Upper lake	76	56	88	12	6	12
	Middle lake	43	0	54	1	66	6
	Lower lake	3	3	28	0	1	0
Amnicolidae, Valvatidae, etc.	Upper lake	0.8	0	0.1	0	8.5	0
	Middle lake	0	0	1.7	0	0.6	0
	Lower lake	0	0	27.4	0	8.6	0

3. *Average weight of total snails
and per cent. decrease, 1915 to 1920*

		1915	1920	Per cent. decrease
Upper lake	Channel	394	56	85.7
	4-7 ft.	175	12	93.1
	1-3 ft.	64	84	31.2*
Middle lake	Channel	69	0	100.0
	4-7 ft.	113	1	99.1
	1-3 ft.	86	6	93.0
Lower lake	Channel	394	113	71.3
	4-7 ft.	501	24	95.2
	1-3 ft.	184	0	100.0

* Increase.

4. Percentage, by weight, of average total hauls
contributed by snails

	Channel		4-7-ft. zone		1-3-ft. zone	
	1915	1920	1915	1920	1915	1920
Upper lake	99.4	13.6	95.1	6.6	85.3	91.1
Middle lake	93.2	0	91.1	1.8	89.5	12.5
Lower lake	98.8	55.1	98.8	15.3	95.3	0

The changes in composition and abundance of the chironomid population of the bottom muds in this section of the river since 1915 are perhaps even more interesting and significant than those of the small Mollusca, including, as they do, the appearance of several new and more or less pollutorial species, the disappearance of a number of formerly common or abundant cleaner-water forms, and an almost sixty-fold multiplication in weight of the average chironomid contribution to hauls since 1915.

Unusually tolerant or pollutorial species that have come into Peoria Lake since 1915 seem to be several in number, and include *Chironomus plumosus* Linn., *C. maturus* Joh., *C. frequens* Joh., and a variety of the first-named species. *Chironomus plumosus* L. has before been recorded by writers in Europe as a species common in foul muds. It was taken by us in 1920 in large numbers all the way from Chillicothe to the foot of Peoria Lake, both in the channel and in the shallower zones, and also occurred in moderate numbers in the gassy river-muds eight miles above Havana. It was not found by Malloch in 1912 or 1913 collections from either above or below Peoria, but appears to have been present in the badly fouled bed of the Des Plaines River at Lockport in the autumn of 1911, as indicated by a provisional determination by Mr. Chas. A. Hart. *Chironomus maturus* Joh. and *C. frequens* Joh. are here listed as species capable of maintaining themselves in polluted muds because of their occurrence in 1920 in abundance in the Illinois River opposite Peoria, and because of the absence of definite records of them from clean muds elsewhere—either in the Illinois River or other waters.

Three more or less tolerant or pollutorial species, *Tanytus dyari* Coq., *Chironomus decorus* Joh., and *C. crassicaudatus* Mall., may be listed as hold-overs from 1913—1915, when, as in 1920, they were common in collections from some stations opposite or above Peoria. We note that *C. decorus* was the commonest species of this family found by Weston and Turner in the contaminated bottom of the Coweaset River in 1916, just below the drains of the city of Brockton, Mass. *Tanytus dyari* Coq. was found by Malloch some years ago to frequent a badly polluted local

ditch in Illinois, and was taken by us in 1912 in the worst fouled portions of the Illinois River between Morris and Marseilles, though not northward of those places. None of these three species was found by us either in 1920 or in 1913 south of Peoria; and the last one named, nowhere at all except at Peoria.

The list of larval midge-species that have dropped out of this section of the Illinois River since 1915 includes at least four, of which but one, *Chironomus tentans* F., is known definitely to do badly in the presence of pollution and to have been common in this section during or before 1915. This species was common to abundant in 1913—1915 both in the river and in the lakes all the way from Peoria Lake to Havana, but has now apparently disappeared altogether from the lakes and from the greater portion of its old river-range. Species of apparently rather indifferent habit as indicated by their distribution in this section and above and below six or seven years ago, but that failed to appear in Peoria Lake collections in 1920, are two in number—*C. lobiferus* Say and *C. viridicollis* v. d. W.

MIDGE LARVAE (CHIRONOMIDAE*) OF BOTTOM MUDDS OF ILLINOIS RIVER AND PEORIA LAKE,
CHILLICOTHE TO WESLEY, 1913—1914 TO 1920—JULY—OCTOBER

1. *Pollutional or tolerant species that have come in since 1913—14.*

Chironomus plumosus L....Des Plaines River, Lockport, 1911, Hart..Common, 1920, Chillicothe to Peoria, and Havana to Liverpool.

C. plumosus L., var.....Common, 1920, lower Peoria Lake, but not south of Peoria.

C. matorus Joh.....† Common, 1920, lower Peoria Lake, but not south of Peoria.

C. frequens Joh.....† Common, 1920, lower Peoria Lake, but not south of Peoria.

2. *Tolerant or indifferent species common both 1913—14 and 1920.*

Tanypus dyari Coq.....Peoria, 1913; Morris to Marseilles, 1912..Common, Chillicothe to Peoria Narrows, 1920.

Chironomus decorus Joh....Common at Peoria and present at Havana, 1913 Common at Chillicothe and in upper Peoria Lake, 1920.

C. crassicaudatus Mall.....Adults taken by Hart at Peoria, 1914....Common in lower Peoria Lake, 1920.

3. *Tolerant or indifferent species that have dropped out since 1913—14.*

Chironomus lobiferus Say....Common, 1912—13, Havana to Peoria and north to Depue.

C. viridicollis v. d. W.....Common, 1912—13, Havana to Peoria and north to Marseilles.

4. *Cleaner-water species, or species of doubtful position, that have dropped out since 1913—14.*

Chironomus nigricans Joh..Peoria Narrows, 1913.

C. tentans F.....Common, Havana to Peoria, 1913—15.

Cricotopus sp.....Peoria, 1913.

Orthocladius sp.....Peoria, 1913.

* It will be noted that this list and other lists of Chironomidae following are complete, either for 1920 or 1913—15, only so far as they concern more or less definitely determined species; several species of uncertain position, both periods, are omitted.

† Adults and pupal exuviae.

The vast increase in numbers and weight of midge larvae in the muds of Peoria Lake between 1915 and 1920, the comparison being of July—September collections for both periods, goes far in some portions of the range toward making up the losses in the small Mollusca. While the average number of young midges taken to the square yard between Chillicothe and the foot of the lake was less than 10 in the summer of 1915, in 1920 it had risen for the whole lake to 318; while in the channel and 4—7-ft. zone of the upper lake, between Chillicothe and Spring Bay, numbers per yard were 1216 and 554. Again, while in 1915 the greatest weight per acre figured for Chironomidae in a subdivision of Peoria Lake (the 4—7-ft. zone of the middle lake) was only 7 pounds, and the average for all zones and all subdivisions in 1915 was only 1.4 pounds, in 1920 the average weight had risen in the channel and 4—7-ft. zones of the upper lake to 182 and 128 pounds respectively, and for all subdivisions and all zones to 83.3 pounds, or 59.5 times the average valuation figure of 1915. When we compare the weight of the Chironomidae with the weight of the average total haul we find that the largest catches in Peoria Lake in 1915 ran less than 6 per cent. Chironomidae, most of the collections, in fact, running less than 3 per cent. In 1920, on the other hand, we find the Chironomidae making up from 21 to 42 per cent. of the average total weight of collections in the channel between Chillicothe and Peoria, and from 70 to 96 per cent. in the 1—3-ft. and 4—7-ft. zones.

MIDGE LARVAE (CHIRONOMIDAE) OF BOTTOM MUDS,
CHILLICOTHE TO FOOT OF PEORIA LAKE, 1915 AND 1920

1. Number and weight per unit of bottom area

		Channel		4—7-ft. zone		1—3-ft. zone	
		1915	1920	1915	1920	1915	1920
Average No. per sq. yard	Upper lake	2	1216	13	554	12	0
	Middle lake	10	36	21	201	5	84
	Lower lake	0	244	0	332	0	198
Average pounds per acre	Upper lake	0.2	182	4.2	128	2	0
	Middle lake	1.5	5	7	51	3	42
	Lower lake	0	86	0	132	0	24

Average weight per acre, all channel collections, 1920, 89.2 lbs.

“ “ “ “ all 4—7-ft.-zone collections, 1920, 101.0 lbs.

“ “ “ “ all 1—3-ft.-zone collections, 1920, 27.6 lbs.

Average weight per acre, all collections, all zones, 1920, 83.3 lbs.

Average weight per acre, all collections, all zones, 1915, 1.4 lbs.

2 Percentage, by weight, of average total hauls
contributed by Chironomidae

	Channel		4-7-ft. zone		1-3-ft. zone	
	1915	1920	1915	1920	1915	1920
Upper lake	0.08	44.2	2.2	71.1	2.6	0
Middle lake	2.0	20.8	5.7	96.2	3.4	87.5
Lower lake	0	41.9	0	84.7	0	82.7

Much as have the sludge-worms, the larvae of the midges have increased in the past five years in Peoria Lake from an average of half a pound per acre and a maximum of one pound—representing at the most less than 2 per cent. of the average total haul—to as much as 173 pounds per acre and 42 per cent. of the average haul in the river channel between Chillicothe and Spring Bay, and to a general average of 26.3 pounds per acre for all subdivisions and all zones collected from in the three lakes. The largest numbers reached—in the channel of the upper lake—amounted to 4960 per square yard, 4800 of these belonging apparently to a single species of *Tubifex*, and 160 to a species of an undetermined genus of *Tubificidae*. Both in the channel and in the shallower zones, sludge-worms became less abundant southward of the upper lake, though it is noted that in the channel of the lower lake the average number per square yard in 1920 (183) was more than sixteen times the average figure for the upper lake channel (11) in 1915 (table).

SLUDGE-WORMS (PRINCIPALLY TUBIFICIDAE),
CHILLICOTHE TO FOOT OF PEORIA LAKE, 1915 AND 1920
1. Number and weight per unit of bottom area

		Channel		4-7-ft. zone		1-3-ft. zone	
		1915	1920	1915	1920	1915	1920
Average No. per sq. yard	Upper lake	11	4960	26	1146	37	240
	Middle lake	0	540	0	36	0	12
	Lower lake	17	183	0	0	0	144
Average pounds per acre	Upper lake	0.3	173	1	40	1	8
	Middle lake	0	19	0	1	0	0.4
	Lower lake	0.6	6	0	0	0	5

Average weight per acre, all channel collections, 1920, 44.5 lbs.

“ “ “ “ all 4—7-ft.-zone collections, 1920, 14.0 lbs.

“ “ “ “ all 1—3-ft.-zone collections, 1920, 4.7 lbs.

“ “ “ “ all collections, 1920, all zones, 26.3 lbs.

“ “ “ “ “ “ 1915, “ “ 0.5 lbs.

2. Percentages, by weight, of average total hauls
contributed by sludge-worms

	Channel		4-7-ft. zone		1-3-ft. zone	
	1915	1920	1915	1920	1915	1920
Upper lake	0.07	42.0	0.4	22.0	1.7	8.7
Middle lake	0	79.0	0	2.0	0	trace
Lower lake	0.15	3.0	0	0	0	17.3

Out of a miscellaneous list of insects representing five or six families other than Chironomidae that were present or common in the bottom muds between Chillicothe and the foot of Peoria Lake in 1915, we found none at all surviving in the summer of 1920 at the thirty-one stations dredged in the sluggish waters of either the channel or shore zones of Peoria Lake proper or in the river at Chillicothe. At these same stations we failed also to find any isopods, the little amphipod *Hyaella*, any leeches or planarians, or any sponges or bryozoans. In the relatively much swifter water that continues for about a half mile through Peoria Narrows, however, and in the rapid portion of the river just below the lower outlet of the lake, large Viviparidae and Pleuroceridae were present in larger numbers than in the upper, middle, or lower lake, a bryozoan, *Fredricella* sp., was thriving on the shells of living snails, and the formerly common sand-case-building caddis larva (*Hydropsyche* sp.) was still present in considerable numbers. As the average valuation figures of this group of the bottom invertebrates ran only two to eight pounds per acre in Peoria Lake in 1915, it will be recognized that the decline is a small one compared with the losses since 1915 in Mollusca, and that it has been much more than made up in bulk and weight by the recent increases in the sludge-worms and the larvae of the midges.

OTHER INSECTS,* WORMS, CRUSTACEA, ETC. OF BOTTOM MUDS,
CHILLICOTHE TO FOOT OF PEORIA LAKE, 1915 AND 1920
NUMBER AND WEIGHT PER UNIT OF BOTTOM AREA

		Channel		4-7-ft. zone		1-3-ft. zone	
		1915	1920	1915	1920	1915	1920
Average No. per sq. yard	Upper lake	12	0	31	0	72	0
	Middle lake	23	0	12	0	42	0
	Lower lake	30	0	52	0	120	0
Average pounds per acre	Upper lake	2	0	4	0	8	0
	Middle lake	4	0	4	0	7	0
	Lower lake	5	0	6	0	7	0

* See foot-note p. 7.

The sum of the various changes that have taken place in the small bottom-fauna of Peoria Lake since 1915, as shown in the summary tables next following, have not apparently affected average total valuation figures in pounds per acre since 1915 nearly as much as they have changed the composition of the fauna. In the upper lake, in fact, it appears that the 1920 figures, for all zones—in consequence principally of the enormous increase of midge larvae and sludge-worms since 1915—indicate total stocks slightly heavier than five years before. In the middle and lower lakes, however, average figures for all zones seem to have been cut at least in two when not divided by three, and an estimate of an average reduction of around 50 per cent. in all zones of all three lakes combined would apparently be a fair approximation of the total change.

It is, we believe, the losses in the shore and weed fauna, rather than those in the bottom animals, that have bulked greatest in Peoria Lake in the past few years. The loss in this element of the small invertebrate fauna of the lake has without question been almost a total one since 1915. The luxuriant growths of coarse aquatic plants (*Potamogeton*, *Ceratophyllum*, *Scirpus*, *Vallisneria*, etc.) that covered several square miles of Peoria Lake at midsummer and autumn levels between 1910 and 1914, and their rich fauna of small invertebrates along with them have disappeared now altogether in the upper and middle lake except for an occasional scraggly clump at the very edge. In the lower lake, a thin patch of *Potamogeton* and *Ceratophyllum*, covering less than two acres, was still growing in the small springy slough on the east side, opposite the foot of Liberty St., in August, 1920—the sole more than negligible remnant of the several hundred acres of vegetation in this part of Peoria Lake at low water five to ten years ago.

ALL SMALL BOTTOM-ANIMALS, CHILLICOTHE TO WESLEY, 1915 AND 1920
AVERAGE VALUATIONS, POUNDS PER ACRE: SUMMARY

1. UPPER PEORIA LAKE, CHILLICOTHE TO SPRING BAY

	Channel		4-7-ft. zone		1-3-ft. zone	
	1915	1920	1915	1920	1915	1920
Viviparidae and Pleuroceridae	317	0	87.5	0	50	72
Sphaeriidae	76	56	87.9	12	6.2	12
Amnicolidae, Valvatidae, etc.	0.8	0	0.1	0	8.5	0
Chironomidae	0.2	182	4.2	128.6	1.8	0
Oligochaeta	0.3	173	0.9	40	1.3	8
Other insects, worms, Crustacea, etc.	1.9	0	3.9	0	7.7	0
Grand total	396.2	411	184.5	180.6	75.5	92

2. MIDDLE PEORIA LAKE, MOSSVILLE TO AL FRESCO PARK

	Channel		4-7-ft. zone		1-3-ft. zone	
	1915	1920	1915	1920	1915	1920
Viviparidae and Pleuroceridae	26.1	0	57.1	0	18.5	0
Sphaeriidae	42.7	0	54.0	1.5	66.6	6
Amnicolidae, Valvatidae, etc.	0	0	1.7	0	0.6	0
Chironomidae	1.5	5	7.1	51	3.3	42
Oligochaeta	0	19	0	1.2	0	0.4
Other insects, worms, Crustacea, etc.	3.9	0	3.8	0	7.0	0
Grand total	74.2	24	123.7	53.7	96.0	48.4

3. LOWER PEORIA LAKE, STRAW-BOARD MILL TO LIBERTY STREET

Viviparidae and Pleuroceridae	391.6	110	446.3	24	174.0	0
Sphaeriidae	3.1	2.9	28.1	0	1.2	0
Amnicolidae, Valvatidae, etc.	0	0	27.4	0	8.6	0
Chironomidae	0	85.6	0	132.4	0	24.1
Oligochaeta	0.6	6.4	0	0	0	5
Other insects, worms, Crustacea, etc.	5.0	0	5.8	0	7.4	0
Grand total	400.3	204.9	507.6	156.4	191.2	29.1

4. PEORIA NARROWS, (STRONG CURRENT)

	Channel		4-7-ft. zone	
	1915	1920	1915	1920
Viviparidae and Pleuroceridae	46.3	227.	No coll.	174
Sphaeriidae	0.5	0.5	"	6
Amnicolidae, Valvatidae, etc.	0	0	"	0
Chironomidae	0	39.6	"	108
Oligochaeta	0	0	"	0
Other insects, worms, Crustacea, etc.	2.1	14.4	"	0
Grand total	48.9	281.5	"	288.0

5. PEORIA AND PEKIN UNION RAILWAY BRIDGE

(BELOW FOOT OF LAKE, IN STRONG CURRENT)

Viviparidae and Pleuroceridae	224.6	0	60	237
Sphaeriidae	8.3	0	136.7	0
Amnicolidae, Valvatidae, etc.	0	0	0	0
Chironomidae	7.0	0	0	3.6
Oligochaeta	0	0	0	1.2
Other insects, worms, Crustacea, etc.	13.9	0	9.6	24
Grand total	253.8	0	206.3	265.8

The Illinois River, Liverpool to Havana
(Mile 199.0—207.0 below Lake Michigan)

The changes between 1915 and 1920 in the appearance and odors of the muds in the eight-mile section of the Illinois next above Havana, whose upper and lower limits are respectively about 34 and 42 miles below the foot of Peoria Lake, and 199 and 207 miles below Lake Michigan, are, if anything, more striking than those that have occurred in the five years between Chillicothe and Peoria. In this part of the river in 1915

the mud had nearly uniformly a quite wholesome earthy odor in midsummer, and except locally along shore immediately below fish markets or large drains no more bubbling was noted when the bottom was disturbed than was normal at the same time at points fifty to a hundred miles farther south. In early July and early September, 1919, and in September, 1920, the muds taken both in and outside the deeper channel at Liverpool, at Hogfat Bend, three miles above Havana, and just above Havana were distinctly foul-smelling and hundreds of large gas bubbles rose to the surface each time the sampler hit bottom. In calm hot weather in late August, 1919, spontaneous bubbling was observed at Hogfat Bend and just above Liverpool; and at Liverpool in early September, 1920 the mud samples from the channel were of the same spongy texture previously noted in the samples from Rome and Chillicothe.

Both the shrunken volumes and altered composition of the collections of small bottom-animals taken at the fourteen stations worked in this section in 1920 add their clear testimony to the advance of pollution this far southward since 1915. While the average weight of the channel haul here was over 5,000 pounds per acre in 1915, in 1920 it was less than 250 pounds—a net loss of 95.3 per cent. In the 4—7-ft. zone for the same five-year period the average haul showed a shrinkage of 95.9 per cent., or from 2,122 pounds to only 87 pounds per acre. The change in the composition of the small bottom-fauna, in turn, includes the disappearance since 1915 of five out of seven families of snails; of more than half a dozen species of bottom-dwelling larval midges; and of twelve out of thirteen or fourteen families of “other insects,” worms, small Crustacea, and other small bottom-invertebrates.

By far the greatest destruction, as measured by bulk and weight as well as in numbers, appears to have been accomplished among the snails in the five-year period, the percentage declines in average snail-poundage in the channel and in the 4—7-ft. zone since 1915 (98.7 and 98.0 per cent.) being greater than the percentage decreases in poundage of total hauls (95.3 and 95.9 per cent.), and much greater than the percentage declines in snail yields in some important sections of river between Chillicothe and Peoria. While in Peoria Lake, as already pointed out, the decrease in snails in the five-year period was largely or altogether compensated by increase in the weight of the midge larvae and sludge-worms (principally the former), it is clear that under the circumstance in this section of a decline in snails from several thousand pounds to less than a hundred pounds per acre, an increase in Chironomidae from a trace to as much as 150 pounds per acre could go but a little way toward making up the snail deficiency. The following tabulation of changes in the snail fauna is substantially the same as the one previously given for the Peoria—Chillicothe section, showing the same three species—one each of Viviparidae, Pleuroceridae, and Sphaeriidae—still surviving, and principally the same list of about seventeen species that disappeared from the section in the five-year period under discussion.

SNAIL FAUNA OF BOTTOM MUDS OF ILLINOIS RIVER, LIVERPOOL TO HAVANA, 1913—1915 TO 1920

I. *Species surviving in 1920, and their distribution.*

1. Viviparidae	1. Campeloma subsolidum	Channel and 4—7-foot zone.
2. Pleuroceridae	2. Pleurocera sp.	“ “ “
3. Sphaeriidae	3. Musculium transversum	“ “ “

II. *Species present in 1913 to 1915 but not found in 1920, and distribution in former period.*

1. Viviparidae	1. Lioplax subcarinata	Abundant in channel, common in shallower zones.
“	2. Vivipara contectoides	Common to abundant, all zones.
“	3. V. subpurpurea	Present in channel.
2. Pleuroceridae	4. Goniobasis sp.	Present, 4—7 feet, off Cook's Island.
3. Amnicolidae	5. Amnicola emarginata	Common locally, various depths.
“	6. Somatogyrus sp.	Present, 4—7 feet, below Quiver Chute.
4. Valvatidae	7. Valvata bicarinata	Present within 7-foot line.
“	8. V. tricarinata	“ “ “
5. Planorbinae	9. Planorbis trivolvis	Common within 7-foot line.
“	10. P. parvus	“ “ “
6. Physidae	11—12. Physa spp.	“ “ “
7. Sphaeriidae	13. Sphaerium stamineum	Rare; in 4—7-foot zone only.
“	14. S. striatinum	Present in two or three collections, 4—7 feet.
“	15. S. simile	Rare; in channel.
“	16. Musculium jayanum	Scattered occurrences, never common.
8. Ancyliidae	17. Ancyclus sp.	Common on shells of Unionidae in channel.

In the history of the Chironomidae of the river muds since 1915 in this district, after the disappearance of half a dozen of the old list of more sensitive species, perhaps the most important single circumstance is the appearance here in 1920 of the pollutional *Chironomus plumosus* Linn., which also invaded the Chillicothe—Peoria section for the first time in the five-year interval ending in 1920. This species was, in fact, quite common in September last year in the foul spongy mud taken at Liverpool, both in the channel and outside of it as far as the four-foot line, but was much rarer in the bottom samples at Hogfat Bend and just above Havana, its average for all the stations in the section being thus brought down to 20 per square yard.

The three other commonest species of midges represented in this section of the river in 1920 included two species of wide range or presumably tolerant habit, *Chironomus lobiferus* Say and a form near *C. decorus* Joh., and one hold-over species of more particular habit, *C. tentans* Fabr. *C. lobiferus* was recorded from Havana in 1913—1914 by Malloch, but was less common then than in 1920, when it averaged as high as 100 per square yard in channel collections. The *decorus*-like form had not been previously taken. *Chironomus tentans* F., which seems to have disappeared completely from its old range at and above Peoria since 1913—1914, as also from the lakes between Liverpool and Havana, was still holding its own in good numbers in 1920 at the lower (but not the upper) river-channel stations in the section.

MIDGE LARVAE (CHIRONOMIDAE) OF BOTTOM MUDS OF ILLINOIS RIVER, LIVERPOOL TO HAVANA, 1913—1914 TO 1920—JULY—OCTOBER

1. *Pollutional species that has come in since 1913—14.*

Chironomus plumosus L. Common at Liverpool in 1920.

2. *Tolerant or indifferent species that has come in since 1913—14.*

Chironomus sp., near *decorus* Joh., No. 1. Abundant, Liverpool to Havana, 1920.

3. *Tolerant or indifferent species found both 1913—14 and 1920.*

Chironomus lobiferus Say. Present, 1913—14. Common in channel only in 1920.

4. *Tolerant or indifferent species that have dropped out since 1913—14.*

Chironomus viridicollis v. d. W. Common, 1913—14.

C. decorus Joh. A few, 1913—14.

5. *Cleaner-water species that have dropped out since 1913—14.*

Tanypus monilis L. Common, 1913—14.

T. illinoensis Mall. Present, 1913—14.

Chironomus ferrugineovittatus Zett. Present, 1913—14.

C. modestus Say. Present, 1913—14.

Cricotopus trifasciatus Panz. Common, 1913—14.

Palpomyia longipennis Lw. Common, 1913—14.

6. *Cleaner-water species still surviving in 1920.*

Chironomus tentans F. Present in 1913—14, but less common in the river than in the connecting lakes. Commoner in the river in 1920 than in 1913—14, but apparently exterminated in the connecting lakes.

The extent of the increase in bulk and weight of Chironomidae in collections since 1915 (from a negligible quantity to 164 pounds per acre in the channel and from a similar figure to 45 pounds in the 4—7-ft. zone) is greater even than the increase shown by either the channel or all-zone figures for the Chillicothe—Peoria district. The percentage, by weight, contributed by Chironomidae to average total hauls in this district while standing practically at zero in 1915, reached 68.3 per cent. in the channel and 51.7 per cent. in the 4—7-ft. zone in 1920, these ratios comparing with 99.5 per cent. and 98.7 per cent. for snails and less than 2 per cent. for all other small bottom-animals during the period covered by the earlier valuations (table, p. 53.)

Sludge-worms, which showed a perpendicular rise from none at all in this section of river in 1915, were still far under the numbers and weight valuations recently reached in Peoria Lake, the average number per square yard at channel stations, where the largest quantities were taken, being less than 100, and the average valuation not over three pounds per acre. These figures compare with over 170 pounds per acre in the channel of upper Peoria Lake in 1920 and with over 26 pounds per acre as the all-zone average of the Illinois River and its wide waters between Chillicothe and south Peoria. The small oligochaetes taken between Liverpool and Havana in September, 1920, apparently belonged without exception to the Tubificidae, the commonest form being an undetermined species of the genus *Tubifex*.

As in the Chillicothe—Peoria reach, the miscellaneous minor groups of small bottom-animals all appeared in 1920 collections in this section in greatly reduced numbers and variety when they appeared at all. Insect families other than Chironomidae that were common in 1913—1915, but that seem to have disappeared altogether outside the 3- or 4-foot line since the latter year, include Corixidae, two species; Phryganeidae, species of *Hydropsyche* and other genera; Ephemeridae, species of *Hexagenia*, *Heptagenia*, and *Caenis*; Gomphidae, Libellulidae, and other families of Odonata; and Parnidae, as represented by adult beetles of the genus *Stenelmis*. Other small bottom-animals that have dropped out of the channel and 4—7-foot zone are the little amphipod *Hyaella knickerbockeri*, *Asellus aquaticus*, planarians of several kinds, as well as several kinds each of leeches, fresh-water sponges, and Bryozoa. The average weight-valuation of this group in 1920, 6 pounds per acre in the channel and one pound per acre in the 4—7-ft. zone, stands for comparison with 24 and 26 pounds in 1915, with the 1920 poundages largely made up of a single species of leech.

ALL SMALL BOTTOM-ANIMALS, ILLINOIS RIVER, LIVERPOOL TO
HAVANA, 1915 AND 1920

1. Average numbers per square yard

	Channel		4-7-ft. zone	
	1915	1920	1915	1920
Viviparidae and Pleuroceridae	1294	25	121	15
Sphaeriidae	0	34	3557	58
Amnicolidae, Valvatidae, etc.	2	0	0.4	0
Chironomidae	0	950	0	225
Oligochaeta	0	89	0	4
Other insects, worms, Crustacea, etc.	172	36	172	7
Grand total	1468	1134	3850	309

2. Average pounds per acre,
and per cent. decrease in five years

	Channel		4-7-ft. zone		Per cent. decrease, 1915-1920	
	1915	1920	1915	1920	Channel	4-7-ft.
Viviparidae and Pleuroceridae	5156	50	319	26	99.2	91.8
Sphaeriidae	0	17	1777	15		99.1
Amnicolidae, Val- vatidae, etc.	0.1	0	0.2	0		
Total Mollusca	5156	67	2096	41	98.7	98.0
Chironomidae	0	164	0	45		
Oligochaeta	0	3	0	0.1		
Other insects, worms, Crustacea, etc.	24	6	26	1	75.0	96.1
Grand total	5180	240	2122	87	95.3	95.9
Per cent. snails	99.5	27.9	98.7	47.1		
Per cent Chiro- nomidae	0	68.3	0	51.7		

The Illinois River from 2 miles below Havana to 1.5 miles below the Head of Grand Island

(Mile 209.0—215.0 below Lake Michigan)

Neither in July—October, 1913—1915 nor at the same season in 1920 were foul odors or abnormal bubbling noted at the muddier collecting stations in this somewhat swifter and harder-bottomed section of river than the two previously described. The conspicuous change in the physical appearance and odor of the bottom sediments that occurs in less than three miles below the wagon bridge at Havana is no doubt influenced by several factors, including as the principal ones the effect of the high Spoon River bar in favoring sedimentation in the widened river immediately north of Havana, and the lesser rate of settling and greater mobility of bottom sediments in the stretch of faster channel that begins just below it.

The improvement in the condition of the stream bottom as we proceed southward of Havana is only a little less strikingly shown in the composition of the small bottom-fauna—if we except the Mollusca—than in the physical condition of the bottom deposits. Here in 1920, for the first time below Chillicothe, we found thriving the nymphs of the common willow-fly of the middle and lower Illinois, *Hexagenia bilineata*; something like normal numbers of the common sand-caddis, *Hydropsyche* sp., as well as immature Gomphidae and other Odonata; and among non-insect bottom-animals, about the usual variety of Bryozoa, leeches, and planarians. Even on the molluscan side we did not find serious decrease in total-weight valuations over 1915, either in the channel or in the 1—3-ft. zone. But there was a decline of 95 per cent. in snail poundage compared with five years before, indicated for the 4—7-ft. zone, and the full list of snails for the section showed the disappearance since 1915 of not less than eight species, representing five families. The only species surviving were, in fact, the same three—one each of Viviparidae, Pleuroceridae, and Sphaeriidae—which have pulled through in the Chillicothe—Peoria and Liverpool—Havana sections. The disappearance of these snails from the river below Havana is not, however, to be compared in seriousness with the visitations of mortality above Havana, both for the reason that neither in the channel or the shallower zones were average snail-yields here anything like as high some years ago as above Havana, and because the remaining species have apparently quite or more than held their own in at least a part of the range since the disappearance of the more sensitive forms.

SNAIL FAUNA OF BOTTOM MUDS OF THE ILLINOIS RIVER, BELOW HAVANA,* 1913—1915 TO 1920

I. *Species surviving in 1920, and their distribution.*

1. Viviparidae	1. Campeloma subsolidum	Small numbers, both channel and shores, where there is mud.
2. Pleuroceridae	2. Pleurocera sp.	"
3. Sphaeriidae	3. Musculium transversum	"

II. *Species present in 1913—15 but not found in 1920, and distribution in former period.*

1. Viviparidae	1. Lioplax subcarinata	Scattered occurrences.
"	2. Vivipara contectoides	Common locally.
"	3. V. subpurpurea	Scattered occurrences.
2. Pleuroceridae	4. Goniobasis sp.	Rare.
3. Amnicolidae	5. Amnicola emarginata	Small numbers locally.
"	6. Amnicola sp.	Common locally in shallower zones.
4. Sphaeriidae	7. Sphaerium stamineum	Rare.
5. Ancyliidae	8. Ancyclus sp.	Not uncommon on live or dead shells.

* To 1.5 miles below head of Grand Island, 1920; to head of Grand Island, 1915.

Further evidence of a mixed status or condition of the bottom fauna in this portion of the river is furnished in the lists and figures of Chironomidae. In the first place, we note that while midge-larvae have increased greatly here since 1915, in spite of the disappearance the while of half a dozen formerly common species of clean-bottom habit, yet no distinctly pollutional species has invaded this section since 1915, and only two forms of wide range or doubtful preference (*Chironomus lobiferus* Say and a species very close to *C. decorus* Joh.) are new here since the 1913—1915 period. Further, it will be noted that more than half of the increase in weight-valuation of Chironomidae in the river below Havana in the five years preceding 1920 is not due to these two newly introduced tolerant forms, if indeed they are both so, but follows from the multiplication here recently of three of the large larvae of clean-bottom habit which were common to abundant in the *lakes above* Havana in and before 1915, but which have since been exterminated in that range, with the exception of Quiver Lake. These three species (*C. tentans* F., *C. ferrugineovittatus* Zett., and *Procladius concinnus* Coq.) occurred in good numbers in 1920 in this section of the river wherever there was mud, and the sharp reversal in their distribution, from lake and backwater above Havana to river below Havana, seems to lend some support to the supposition that their recent appearance and rapid multiplication in their new range is in some manner connected with their disappearance from the old one.

MIDGE LARVAE (CHIRONOMIDAE) OF BOTTOM MUDS OF ILLINOIS RIVER BELOW
HAVANA,* 1913—14 TO 1920—JULY—OCTOBER

1. *Tolerant species or species of doubtful preference that have come in since 1913—14.*
Chironomus lobiferus Say. Present, 1920.
C. sp. near decorus Joh., No. 2. Abundant, 1920.
2. *Cleaner-water species that have dropped out since 1913—14.*
Palpomyia longipennis Lw. Present in 1913—14.
Tanypus monilis L. Present in 1913—14.
Chironomus dux Joh. Present in 1913—14.
C. digitatus Mall. Present in 1913—14.
Cricotopus trifasciatus Panz. Present in 1913—14.
Cricotopus sp. Present in 1913—14.
3. *Cleaner-water species that have come in since 1913—14.†*
Procladius concinnus Coq. Common, 1920, shallow zones.
Chironomus ferrugineovittatus Zett. Present, 1920, 4—7-foot zone.
C. tentans F. Common, 1920, chiefly in shallow zones.
4. *Tolerant or indifferent species that has dropped out since 1913—14.*
Chironomus decorus Joh. Present, 1913—14.

* Occurrence in 1913—14 principally below Beardstown; in 1920, 2.5 miles below Havana to 1.5 miles below head of Grand Island.

† All these species were present or common both in the river and the lakes above Havana, 1913—14, but were not found in either of those ranges last year, if the occurrence of *C. ferrugineovittatus* in Quiver Lake in 1920 be excepted.

While sludge-worms showed some increase in this section since 1915, their gain was slight and of very small moment compared with the increases shown in five years either in the Peoria section or in the reach just north of Havana. All of the small oligochaetes taken, however, belonged to genera of the family Tubificidae, about half of them being species of the genus *Tubifex*.

Though, as already mentioned, a marked increase in variety as well as an actual average increase in poundage since 1915, is plainly shown by the group of "other insects, etc.", there were a good many eliminations from the lists even in this group in the five years preceding 1920. Non-insect groups or insects other than Chironomidae that were readily taken in this part of the river in 1913—1915 but that did not appear in collections in 1920, include the little crustaceans *Asellus* and *Hyalella*; two or three species of Ephemeridae; two species of Corixidae; adult bottom-beetles of the genus *Stenelmis*; several fresh-water sponges; and at least one genus and species of Bryozoa, namely, *Paludicella* sp., which was formerly common on almost all the dead shells of Unionidae.

Total average-valuations of all small bottom-animals for this section in 1920—30 pounds per acre in the channel, 89 pounds in the 4—7-foot zone, and 526 pounds in the 1—3-foot zone—exceed 1915 figures in the first and last instances; while in the 4—7-foot zone they were well under the older valuations, as shown in the table following. Both in the channel and in the 1—3-foot zone the decreases in snails were more than made up for by increases in midge larvae and "other insects" and miscellaneous species. In the 4—7-foot zone the increase in snails was greater and the increase in Chironomidae and minor insects, etc., less, either relatively or absolutely or both, than in the 1—3-foot zone. To what extent these zonal differences in distribution both of the total bottom fauna and its subdivisions may be connected with differences in wholesomeness of conditions on different sections of the river floor, or to what extent they may reflect mere casual migration of surviving species following a general mortality, our present data give us no certain basis for an opinion.

ALL SMALL BOTTOM-ANIMALS, HAVANA TO GRAND ISLAND*, 1915 AND 1920

1. Average numbers per square yard

	Channel		4-7-ft. zone		1-3-ft. zone	
	1915	1920	1915	1920	1915	1920
Viviparidae and Pleuroceridae	6	10	73	9	99	104
Sphaeriidae	6	2	84	12	89	12
Amnicolidae, Val- vatidae, etc.	0	0	4	0	2	0
Chironomidae	trace	36	2	170	6	244
Oligochaeta	0.5	2	9	33	0	24
Other insects, worms, Crustacea, etc.	3	78	20	27	12	429
Grand total	15	128	192	251	208	813

* To 1 mile below head of Grand Island in 1920; to head of Grand Island in 1915.

2. Average pounds per acre

	Channel		4-7-ft. zone		1-3-ft. zone	
	1915	1920	1915	1920	1915	1920
Viviparidae and Pleuroceridae	16	9	235	11	386	312
Sphaeriidae	3	1	42	6	44	6
Amnicolidae, Val- vatidae, etc.	0	0	0.1	0	0.1	0
Total snails	19	10	277	17	430	318
Chironomidae	trace	6	0.3	45	1	122
Oligochaeta	0.1	trace	0.3	1	0	1
Other insects, worms, Crustacea, etc.	3	14	5	26	4	85
Grand total	22	30	283	89	435	526
Per cent. snails	86.3	33.3	97.8	19.1	98.8	60.4

Three all-Bottom-land Lakes and one Sand-beach Lake between Liverpool and Havana

(Mile 199.0—207.0 below Lake Michigan)

The season's collections in Liverpool, Dogfish, and Thompson lakes in 1920 were taken in early September in almost uniformly muddy bottom between near shore and the six-foot line. All of the stations visited in these lakes at that time were in open water, though a large part of the same area in all of the lakes and most of it in some of them was well supplied with coarse vegetation between 1913 and 1915. Mud, spongy with gas, was taken at two of the stations in Liverpool Lake and there was more or less foulness of odor and abundant bubbling at all stations in all three lakes. While odors were particularly bad in the Liverpool Lake samples, they were not nearly so bad either in Thompson or Dogfish. In the last-named lake there was a light covering of lighter colored silt over older gassy black mud, the topmost layer having its origin less than six months before in the dredging operations for an agricultural drainage district immediately north.

In Quiver Lake the samples from muddy bottom in open water (mostly in the old vegetation zone, as in the other three lakes) all had bad odor and gave off abundant bubbles. Samples from the mud and mud and shell bottom in the deeper "channel" through this lake, and from the mud and sand near the east beach were decidedly less gassy and more wholesome in odor.

While not less than six families of snails, represented by about a dozen species, were common or abundant in 1913—1915 in each of these four lakes, no snails at all were taken in Liverpool or Dogfish lakes in September, 1920, and in Thompson Lake only a small number of a single species. In Quiver Lake, as in Dogfish and Liverpool lakes, no snails at all were found in the shallower, more stagnant open portion less than six feet in depth; but in the "channel" fed by Quiver Creek, and toward shore on the east side, good numbers of *Pleurocera*, and small numbers of *Musculium transversum* and *Vivipara subpurpurea* were taken.

The table following shows the detailed changes in the composition of the snail fauna in Thompson Lake only. It represents very well, also, with only slight alterations, the changes that have taken place in Dogfish and Liverpool lakes, and in the muddy portion of Quiver, the principal requirement being to transfer the little surviving sphaeriid at the head of the table to the list of species underneath that have dropped out since 1913-1915.

SNAIL FAUNA OF BOTTOM MUDS OF THOMPSON LAKE, 1913—1915 TO 1920

I. *Species surviving in 1920.*

1. Sphaeriidae	Musculium transversum	Present, 1920, in very small numbers in Thompson Lake only out of four lakes examined. Was common to abundant in all lakes of this district, 1913—15.
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II. *Species that have dropped out since 1913—15, and distribution in that period.*

1. Viviparidae	1. Campeloma subsolidum	Common, all zones.
"	2. Lioplax subcarinata	Common, deeper water.
"	3. Vivipara contectoides	Abundant locally; present nearly everywhere.
"	4. V. subpurpurea	Infrequent.
2. Amnicolidae	5. Amnicola emarginata	Common locally.
"	6. Somatogyrus sp.	Infrequent.
3. Valvatidae	7. Valvata bicarinata	Common to abundant.
"	8. V. tricarinata	" " "
4. Planorbinae	9. Planorbis trivolvis	Common, shallower zones.
5. Physidae	10. Physa sp.	" " "
6. Sphaeriidae	11. Musculium jayanum	Scattered occurrences.
"	12. Pisidium sp.	Abundant locally.

The drop in average weight-valuation of the snail fauna in these four lakes, except in the less injured portions of Quiver Lake mentioned, amounts to little short of total disappearance—namely, from 122—363 pounds per acre to nothing at all in Liverpool, Dogfish, and the muddier, more stagnant portion of Quiver; and from 409 pounds to 4 pounds per acre in Thompson.

The decrease in snail poundage since 1915 in Thompson Lake, where it is in the least ratio, was 99.1 per cent., which is greater even than the percentage decline in the river channel between Liverpool and Havana. In the Quiver Lake channel the drop in valuation figures since 1915 is only about 70 per cent., leaving an average of 248 pounds per acre in the limited range in September, 1920. Shoreward on the muddy side of Quiver Lake an average valuation of 109 pounds per acre in 1920 stands without a separate 1914 or 1915 figure for comparison.

SNAIL FAUNA OF BOTTOM MUDS, FOUR LAKES NORTH OF HAVANA, 1914—1915 TO 1920
 AVERAGE NUMBER PER SQUARE YARD
 I. Mud Bottom, 2 to 6 Feet

	1914—1915					1920		
	Viviparidae and Pleuroceridae	Sphaeriidae	Valvatidae, Amnicolidae, etc.	Total snails	Viviparidae and Pleuroceridae	Sphaeriidae	Valvatidae, Amnicolidae, etc.	Total snails
Liverpool Lake*	23	17	10	50	0	0	0	0
Thompson Lake*	113	153	98	364	0	8	0	8
Dogfish Lake†	68	138	164	370	0	0	0	0
Quiver Lake†	85	50	74	209	0	0	0	0

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II. Sandy or Sand and Mud Bottom

	Viviparidae and Pleuroceridae	Sphaeriidae	Valvatidae, Amnicolidae, etc.	Total snails	Viviparidae and Pleuroceridae	Sphaeriidae	Valvatidae, Amnicolidae, etc.	Total snails
Quiver Lake "channel"	160	0	0	160	169	0	0	169
Quiver Lake, sandy shore, east side	common	0	0	common	91	3	0	94

* Figures in 1914—15 columns are for year 1915.

† Figures in 1914—15 columns are for year 1914.

SNAIL FAUNA OF BOTTOM MUDS, FOUR LAKES NORTH OF HAVANA, 1914—1915 TO 1920

AVERAGE VALUATIONS, POUNDS PER ACRE

I. Mud Bottom, 2 to 6 Feet

	1914—1915				1920		
	Viviparidae and Pleuroceridae	Sphaeriidae	Valvatidae, Amnicolidae, etc.	Total snails	Viviparidae and Pleuroceridae	Sphaeriidae	Valvatidae, Amnicolidae, etc.
Liverpool Lake*	117	4	1	122	0	0	0
Thompson Lake*	438	16	5	459	0	4	4
Dogfish Lake†	336	10	9	355	0	0	0
Quiver Lake†	329	17	17	363	0	0	0

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II. Sandy or Sand and Mud Bottom

Quiver Lake "channel"	800	0	0	800	248	0	248
Quiver Lake, sandy shore, east side	common	0	0	common	109	2	111

* Figures in 1914—1915 columns are for year 1915.

† Figures in 1914—1915 columns are for year 1914.

In Thompson, Dogfish, and Liverpool lakes in September, 1920, not only was it true that not a single definitely recognized clean-water chironomid of the previous period (1913—1915) was found surviving in the larval or pupal stage in the muds, but, as well, the lists both of new entrants and survivals, of whatever habit of preference, showed up very meagerly both in variety and abundance as compared with the lists and figures for the Peoria Lake district and the river just above Havana. Both in Thompson and Liverpool lakes, however, there did appear last year small numbers of one new form of possibly tolerant habit, this opinion being based only on its taxonomic nearness to *Chironomus decorus* Joh. In neither of these two lakes nor in Dogfish Lake was there any evidence of the recent intrusion of species of distinctly pollutional habit, while in the muddier portions of Quiver Lake two of the older clean-water Chironomidae (*C. ferrugineovittatus* Zett., and *Palpomyia longipennis* Lw.) that were formerly present in all the lakes of this group were the principal components of the 1920 chironomid population in September.

The changes in total chironomid poundages since 1914—1915 in all of these four lakes except Quiver, quite contrary to those in the Illinois River opposite, are in the direction of decrease rather than increase, the average yields in 1920 (9 pounds per acre in Dogfish, 4 pounds in Thompson, 2 pounds in Liverpool) being in no case over 50 per cent. of the 1914—1915 yields, and at the lowest only 5 per cent.; while they are only 5 to 7 per cent. of the 1920 yields of Chironomidae from the river muds between Liverpool and Havana. The discrepancies between lake and river figures for immature midges in this portion of the river system, contrasting with essentially similar changes both in river and lake in the snail group, may be concerned with the fact of the greater ease of spread of the eggs and larvae of the midges down stream with the advance of pollution than *by wing* across the timbered ridges that separate the river from the lakes. At any rate, two of the principal pollutional or tolerant species contributing to last year's large river poundages of Chironomidae just above Havana (*C. plumosus* Linn., and *C. decorus* Joh.) did not up to that time appear to have been successful in making the trip.

MIDGE LARVAE (CHIRONOMIDAE) OF BOTTOM MUDS OF
LIVERPOOL, DOGFISH, QUIVER, AND THOMPSON LAKES, 1913—1914
TO 1920—JULY—OCTOBER

1. *Tolerant species or species of doubtful preference that have come in since 1913—14.*

Chironomus sp. near *decorus* Joh., No. 2. Common, 1920, Thompson Lake only.

C. sp. near *decorus* Joh., No. 1. Common, 1920, Liverpool Lake only.

2. *Formerly common cleaner-water species still surviving in 1920.*

Chironomus ferrugineovittatus Zett. Present, 1920, Quiver Lake only.

Palpomyia longipennis Lw. Present, 1920, Quiver Lake only.

3. *Cleaner-water species that have dropped out since 1913—1914.*

Tanypus monilis L. Common, all lakes, 1913—1914.

Procladius concinnus Coq. Common, all lakes, 1913—1914.

P. sp. near *concinnus* Coq. Common, most lakes, 1913—1914.

Chironomus tentans F. Abundant, all lakes, 1913—1914.

C. modestus Say. Common, all lakes, 1913—1914.

4. *Tolerant species that have dropped out since 1913—1914.*

Chironomus lobiferus Say. Present, 1913—1914, Thompson Lake only.

C. decorus Joh. Present, 1913—1914; lake not stated.

MIDGE LARVAE (CHIRONOMIDAE) OF BOTTOM MUDS,
LAKES NORTH OF HAVANA, 1914—15 AND 1920—JULY—OCTOBER
I. Mud bottom, 2 to 6 feet

	Number per square yard		Pounds per acre	
	1914—1915	1920	1914—1915	1920
Liverpool Lake*	38	14	26	2
Thompson Lake*	12	24	8	4
Dogfish Lake†	60	24	30	9
Quiver Lake†	33	54	6	12
Ill. River, Liverpool to Havana, 1915, for comparison	Channel, 0 4—7 ft., 0	950 225	0 0	164 45

II. Sandy or sand and mud bottom

Quiver "channel" *	0	0	0	0
Quiver Lake, sandy shore east side	Not separately counted	6	Not separately valued	1

* Figures in 1914—15 columns are for year 1915.

† Figures in 1914—15 columns are for year 1914

The increase in sludge-worms in Liverpool, Dogfish, and Thompson lakes since 1915, though comparing with decreases in midge larvae, as already mentioned, was greater even than the increase in these worms in the Illinois River channel opposite, apparently proving that this group has been able to accompany the pollution inward from the river, even if the midges have not. The sludge-worms in the first-named lake amounted in figures per square yard to 389 in September, 1920, as compared with none at all in the collections of July—October, 1915; and in pounds per acre to 14 in 1920 as against none in the former period. In Quiver Lake in 1920, both in the muddy portion and in the sandier areas, while the increase in small oligochaetes since 1915 is evident enough, it is very much less than in the other three lakes. The small oligochaetes taken in Liverpool, Dogfish, and Thompson in 1920 were nearly all Tubificidae and a great majority of them belonged to the genus *Tubifex*. In the Quiver Lake samples, on the other hand, small non-tubificid *Oligochaeta* were visibly more common than Tubificidae.

SLUDGE-WORMS, (PRINCIPALLY TUBIFICIDAE),
LAKES NORTH OF HAVANA, 1914—15 AND 1920

I. Mud bottom, 2 to 6 feet

	Number per square yard		Pounds per acre	
	1914—1915	1920	1914—1915	1920
Liverpool Lake*	0	389	0	14
Thompson Lake*	0	128	0	4
Dogfish Lake†	0	128	0	4
Quiver Lake†	12	48	0.4	2
Ill. River, Liverpool to Havana, 1915, for comparison	Channel, 0	89	0	3
	4—7 ft., 0	4	0	0.1

II. Sandy or sand and mud bottom

Quiver Lake "channel" *	0	0	0	0
Quiver Lake, sandy shore east side	Not separately counted	30	Not separately valued	1

* Figures in 1914—1915 columns are for year 1915.

† Figures in 1914—1915 columns are for year 1914.

Not only in Thompson, Dogfish, and Liverpool lakes in 1920, but in Quiver Lake also in its muddy part, we found nothing at all surviving out of a list of some ten or twelve families of minor insects and miscellaneous small bottom-animals other than the groups already passed in review that were common in all of these lakes in 1914—1915. Though this item of loss in the lakes near Havana has been greater since 1915 than in the river just above Havana, the decrease in poundage therein in comparison to totals of all small bottom-animals has not been very large, the figures that follow showing that at the best the total weight of "other insects, etc.," in the bottom muds of these lakes in 1914—1915, did not run to twenty pounds per acre. In the Quiver Lake "channel" and in the sand and mud toward the beach side our collections showed leeches, Bryozoa, larvae of caddis-flies, and nymphs of Odonata in good variety and number, the "channel" average in 1920 (32 pounds per acre) being larger than in 1915.

"OTHER INSECTS," WORMS, CRUSTACEA, ETC., OF THE BOTTOM MUDS.

LAKES NORTH OF HAVANA, 1914—15 AND 1920

I. Mud bottom, 2 to 6 feet

	Number per square yard		Pounds per acre	
	1914—1915	1920	1914—1915	1920
Liverpool Lake*	16	0	3	0
Thompson Lake*	32	0	5	0
Dogfish Lake†	22	0	13	0
Quiver Lake†	83	0	19	0

II. Sandy or sand and mud bottom

Quiver Lake "channel" *	26	36	3	32
Quiver Lake, sandy shore, east side	Not separately counted	15	Not separately valued	8

* Figures in 1914—1915 columns are for year 1915.

† Figures in 1914—1915 columns are for year 1914.

The decrease in average valuation of all small bottom-animals in the four lakes since 1915, with the sandy portions of Quiver Lake omitted, has been in ratios quite similar to those of average decline in the period in

the river opposite, viz., 89.2 to 97.4 per cent. Such a decrease, on a base of only 150 to 400 pounds per acre as of 1915, evidently leaves a much smaller residue in the lakes than remains in the river of the enormously greater poundages that were there in and before 1915. Average total-poundages in these four lakes, with the exceptions mentioned, in fact amounted to only 12 to 16 pounds per acre in 1920 as compared with 40 pounds and 87 pounds in the channel and 4—7-foot zone of the river opposite, and with 5,180 pounds and 2,122 pounds in the corresponding river zones in the former period. Compared with this enormous falling off in yields in the three all-bottom-land lakes and the stagnant portion of Quiver, the decrease in poundage of all bottom-animals in the mud-sand-and-shell bottom of the Quiver Lake channel amounted to only 65 per cent. since 1915, leaving an average of 280 pounds per acre in September, 1920. As in the river just above Havana, the great part of the decline in lake yields of all bottom-animals since 1914—1915 has resulted from the destruction of the snails, the percentage of total-weight valuations contributed by the small Mollusca dropping during the five or six-year period from 97.2 to 33.3 per cent. in Thompson Lake, and in the other three lakes, excepting the sandy portions, from 81—93 per cent. to none at all.

ALL SMALL BOTTOM-ANIMALS, LAKES NORTH OF HAVANA,
1914—15 AND 1920

1. Average total valuation, pounds per acre, and percentage by
weight of average total hauls contributed by snails

I. Mud bottom, 2 to 6 feet

	Pounds per acre		Per cent. decrease, 1914—15 to 1920	Per cent. snails, by weight	
	1914—15	1920		1914—15	1920
Liverpool L.*	149	16	89.2	81.8	0
Thompson L.*	472	12	97.4	97.2	33.3
Dogfish L.†	397	14	96.7	89.4	0
Quiver L.†	388	14	96.3	93.6	0

(Continued on next page)

II. Sandy or sand and mud bottom

Quiver Lake "channel" *	803	280	65.1	99.6	88.5
Quiver Lake, sandy shore, east side	Not separately valued	121			

* Figures in 1914—1915 columns are for year 1915.

† Figures in 1914—1915 columns are for year 1914.

2. Composition, by weight, of the grand totals,
all mud bottoms, 2 to 6 feet, pounds per acre

	Liverpool Lake		Thompson Lake		Dogfish Lake		Quiver Lake	
	1915	1920	1915	1920	1914	1920	1914	1920
Viviparidae and Pleuro- ceridae	117.0	0	437.9	0	336.0	0	329.7	0
Sphaeriidae	3.7	0	15.6	4.0	10.1	0	16.7	0
Amnicolidae, Valvatidae, etc.	0.5	0	5.3	0	9.0	0	16.7	0
Chironomidae	25.6	2.2	8.3	3.6	29.6	8.6	5.5	12.3
Oligochaeta	0	13.6	0	4.5	0	4.4	0.4	1.6
Other insects, worms, Crustacea, etc.	2.6	0	5.0	0	12.8	0	19.3	0
Grand total	149.4	15.8	472.1	12.1	397.5	13.0	388.3	13.9

While at the lower gages of the drier months of 1913 and 1914 not less than 40 per cent. of the area of Thompson Lake, probably fully 30 per cent. of Liverpool, and more than 50 per cent. of Dogfish and Quiver lakes, was well filled with mixed aquatic vegetation, in 1919 and 1920 at substantially the same gages and temperatures, it is certain that for any of these lakes 2 per cent. would have been an extravagant figure to set

as an estimate of the ratio of weeded to total area. In July or August, 1920, two per cent. would have meant about 100 acres of vegetation in Thompson at the height of the growth period, while as a matter of fact a careful examination of the lower two-thirds of this lake, which was weedier than the upper third five to seven years ago, disclosed less than two acres that could be called even partially weedy. Over a total of some thousands of acres in these four lakes since 1913—1915, the plants have disappeared as completely as dry stubble before a fire, and our observations in Peoria Lake and reports from fishermen and other river men concerning lakes that we have not entered since 1915 indicate that the destruction has been little if any less complete everywhere in the backwaters between Chillicothe and Havana.

In the scattered remnant-bunches of *Potamogeton pectinatus* still growing in Thompson Lake on the small sandy area of bottom at Warner's Cut in September, 1920, it was impossible to collect by the quantitative method used in 1914 and 1915. It is, however, clear that the former enormous weed-animal yields—over 2000 pounds per acre for 40 to 50 per cent. of the total lake and pond acreage in this district six or seven years ago—have vanished with the water plants, and that any figures that could have been obtained last year by any method would stand as wholly negligible in comparison with the old averages. Unless, in fact, we assume, as is probably the case, that in the spring and earlier summer months there is at least a somewhat greater variety and abundance both of bottom and shore animals than was shown by the examinations made in September, 1920, it is hard to understand how the surviving food and game fishes that find their principal food in the small invertebrate fauna can continue to subsist without evident general emaciation. Both the fact that they were not yet generally emaciated in the summer of 1920, and the very low indicated residues of bottom and shore animals after six or seven months feeding at the same time may, from another view-point, be taken as evidence that the food supplies are in recent seasons being *fed down* to an unusually low point before autumn; or, in other words, that the heavy declines in midsummer valuation-figures of *all* small bottom-animals since 1915 may not be quite so altogether an effect of the advance of sewage pollution as are the indicated changes in the *composition* of the fauna.

Stewart Lake, an all-Bottom-land Lake of the Shallower Type, twenty Miles south of Havana

(Mile 224.0—226.0 below Lake Michigan)

The first impression one receives upon going into Stewart Lake and handling samples of its muds, after a week of work in the barren expanses of gas-filled lake and river floor twenty miles north, is one of large and distinct improvement in the odors and physical appearance of

the muds, and in the comparative amount and variety of the old mixed aquatic vegetation still surviving. Though the evidence furnished by the state of the bottom fauna itself in this lake in 1920 was also in some directions indicative of a much more nearly normal condition than in the lakes north of Havana at the same time, the disappearance from Stewart Lake since 1915 of a large part of its old bottom fauna tells as surely of an advance of pollution thus far southward at some time or other since 1915. The evidence of extinction of almost the whole snail fauna, along with the fairly wholesome condition of the bottom muds in 1920, is, I think, probably to be taken as proof that the destruction of the snails took place a considerable time back, and that a wave of pollution such as accomplished it has not carried so far south in all recent flood seasons. The effect of the high Spoon River bar and the large natural impounding area just north of Havana in favoring sedimentation are probably more important than the eighteen or twenty miles of additional distance in protecting Stewart Lake from the regular invasions of putrescible settling suspended matter that have apparently been affecting Liverpool, Thompson, and other lakes in the Liverpool—Havana district every spring in recent years.

A snail list for Stewart Lake, 1915 to 1920, is not essentially different from one for Thompson Lake, showing the same single species (the little sphaeriid *Musculium transversum*) surviving in small numbers; and a list of around thirteen species, representing seven families, that have dropped out since 1915. While Stewart Lake was not even several years ago a heavy bottom-fauna producer, either on the snail side or otherwise, as compared with the lakes north of Havana, showing only 66 pounds per acre of snails and 74 pounds of all small bottom-animals in 1915, the 1920 figures of only 2 pounds per acre of snails (one species) and 28 pounds of all other bottom-animals look small enough even in comparison with the older figures to show that something has happened.

In the group of "other insects, etc.," Stewart Lake last year made fully as bad a showing as in small Mollusca, neither Bryozoa, leeches, small bottom-Amphipoda or Isopoda, Corixidae, Trichoptera, or Ephemeridae—all of which were found commonly in small numbers at collecting stations in this lake six or seven years ago—appearing in 1920 in any bottom collection.

Perhaps the best biological indication of a wholesomer condition of the mud in this lake than in those farther north, next after the more thriving condition of the vegetation, is the survival here in good numbers of a few of the more sensitive species of Chironomidae which have been completely exterminated in the lakes north of Havana except Quiver, and the failure of the sludge-worms to show as marked increase as in the lakes farther north. The total number of small oligochaete worms increased in Stewart Lake between 1915 and 1920 only from three to twelve per square yard—a negligible increase as compared with, for ex-

ample, 0 to 389 per square yard in Liverpool Lake and 0 to 128 per square yard in Thompson Lake in the same period.

While two of the formerly common clean-water midges, *Chironomus ferrugineovittatus* Zett. and *Procladius concinnus* Coq. were still common in the lake in 1920 and, along with a new entrant, also at least not of pollutional habit, made up the bulk of the large increase in Chironomidae in collections in this lake since 1915, the full list of species for 1920 is much smaller than formerly, and calls attention to several species, some of which are partial to cleaner bottom, that have dropped out since the earlier period.

Though separate collections of the small weed-animals were not taken in 1913—1915 in Stewart Lake, as in Thompson Lake and others just north of Havana, it is well enough known to us from general observations that there was a rich fauna of that kind here in those years. Since much the richest portion of the old weed-fauna areas in the Illinois valley lakes was found in the Potamogeton or Ceratophyllum associations, and the poorest in the Nymphaea and Nelumbo beds, and as Stewart Lake lost a very much larger proportionate amount of its Potamogeton and Ceratophyllum than of its lilies in the five years preceding 1920, it is plain that the loss in the small weed-fauna of the lake has been very large in the period, though smaller than in the lakes twenty miles north.

A table recapitulating all our 1920 distributional data on the larval midges from the river and lakes between Chillicothe and Browning follows the short lists of species from Stewart Lake next presented, and with them concludes the present section.

MIDGE LARVAE (CHIRONOMIDAE) OF BOTTOM MUDS,
STEWART LAKE, 1913—1914 TO 1920

1. *Cleaner-water species or other species present in 1913—1915 that have dropped out since then.*

Palpomyia species, 9 mm.
Tanypus monilis L.
Procladius culiciformis Lw.
Tanypus dyari Coq.
Chironomus lobiferus Say.

2. *Cleaner-water species new to the lake since 1913.*

Palpomyia longipennis Lw. Common, 1920.

3. *Cleaner-water species common both 1913—1914 and 1920.*

Procladius concinnus Coq.
Chironomus ferrugineovittatus Zett.

MIDGE LARVAE (CHIRONOMIDAE) OF BOTTOM MUDS OF ILLINOIS RIVER AND CONNECTING WATERS,
CHILLICOTHE TO GRAND ISLAND, JULY—SEPTEMBER, 1920. NUMBERS PER SQUARE YARD: RECAPITULATION

	More pollutional species										Less pollutional or tolerant species		More sensitive species					Total, including species of uncertain status, not in preceding columns
	<i>Chironomus decorus</i> Joh.	<i>Tanyptus dyari</i> Coq.	<i>Chironomus plumosus</i> Linn.	<i>Chironomus plumosus</i> Linn., var.	<i>Chironomus crassicaudatus</i> Mall.	<i>Chironomus maturus</i> Joh.	<i>Chironomus frequens</i> Joh.	<i>Chironomus lobiferus</i> Say	<i>Chironomus sp. near decorus</i> Joh., No. 1	<i>Chironomus sp. near decorus</i> Joh., No. 2	<i>Chironomus tentans</i> F.	<i>Chironomus ferrugineovittatus</i> Zett.	<i>Palpomyia longipennis</i> Lw.	<i>Procladius concinnus</i> Coq.				
Illinois River and Peoria Lake, Chillicothe to Havana:	1. Chillicothe to Spring Bay (upper lake)	channel	800	16												1,216		
		4—7-ft. zone	220	192	130											554		
	2. Mossville to Al Fresco Park (middle lake)	channel		12												36		
		4—7-ft. zone		3	60											201		
		1—3-ft. zone				84										84		
	3. Workhouse to Liberty Street (lower lake)	channel			139	37	+	+	+							244		
		4—7-ft. zone			248	60	+	+	+							332		
		1—3-ft. zone			37											198		
	4. Liverpool to Havana	channel			20				100	600		65				950		
		4—7-ft. zone			20					174		10				225		
All-bottom-land lakes above Havana, depths 2—6 feet: Liverpool Lake									10						15			
Dogfish Lake															24			
Thompson Lake										16					24			
Illinois River, 2 mi. below Havana to 1.5 mi. below head of Grand Island	channel								1		1				36			
	4—7-ft. zone									95	13	37			170			
	1—3-ft. zone									120	8			96	244			
Sand beach lake above Havana: Quiver Lake, depths 2—6 feet															54			
Shallow, all-bottom-land lake 19 miles below Havana: Stewart Lake, depths 2—5 feet															74			

* Plus sign means common, on basis of adults and pupal exuviae.

ALL SMALL BOTTOM-ANIMALS, STEWART LAKE, 1915 AND 1920

MUD BOTTOM, 2 TO 5 FEET

	Number per square yard		Pounds per acre	
	1915	1920	1915	1920
Viviparidae and Pleuroceridae	21	0	41	0
Sphaeriidae	32	4	13	2
Amnicolidae, Valvatidae, etc.	37	0	12	0
Total snails.....		66	2
Chironomidae	8	74	2	28
Oligochaeta	3	12	0.1	0.4
Other insects, worms, Crustacea, etc.	43	0	6	0
Grand total.....		74	30
Percentage of snails		89.1	6.5

Estimated Reduction of Midsummer Surplus Stocks in the Combined Acreage between Chillicothe and Lagrange Dam (103 Miles) since 1914—1915

While the necessarily restricted range of our bottom-and weed-fauna survey of 1920, compared with that of July—October, 1914 and 1915, leaves more gaps to be supplied by estimate in any general comparison than is perhaps best, it has seemed worth while, as a conclusion to the present paper, to make some computations of the approximate total loss since 1914—1915 in surplus bottom- and weed-fauna stocks as of the midsummer period for the entire acreage of river and lakes in the formerly enormously rich middle Illinois Valley district between the head of Peoria Lake and the Lagrange dam. These calculations have involved a partial reapportionment, by estimate largely, both of acreages and of acre-yields, as of 1908—1915, as published in a preceding paper,* these

* The Small Bottom and Shore Fauna of the Illinois River and its Connecting Lakes, Chillicothe to Grafton: its Valuation; its Sources of Food Supply; and its Relation to the Fishery. By R. E. Richardson. Bul. Ill. Nat. Hist. Surv., Vol. 13, Art. XV. 1921.

being here estimated as actual, outside of levees, and not as in the virgin valley—for the purpose of comparison with the 1920 data rather than with the fish-yield figures of 1908; and involving as well, the application in some cases of both river and lake acre-yield-figures for limited areas studied in 1920 to much larger acreages not collected in that year. For these reasons, only general results are given here, and tabulation is avoided as giving too much of an air of certainty to figures that are at the best only approximations.

In the 60.5 miles between Chillicothe and Havana in July—October, 1914—15 it appears, then, that there were surplus stocks of both bottom and weed animals, after deduction of shell weight, amounting to around 27,500,000 pounds in a combined open river and lake acreage, including Peoria Lake of about 29,000 acres at an approximate gage of ten feet, Peoria, or eight feet, Havana. Of this total I have estimated that about 2,700,000 pounds were in the bottom muds of the river and the wide waters of Peoria Lake between Chillicothe and the dam at Copperas Creek; about 3,800,000 pounds in the river muds between Copperas Creek dam and Havana; and about 3,000,000 pounds on the lake and other backwater floors between Copperas Creek and Havana. Considerably more than half of the total, that is, over 18,000,000 pounds (65 per cent.) of it, seems to have been made up of the small weed-living species, of which Peoria Lake apparently furnished more than 4,000,000 pounds a few years ago, and the rich lakes between Copperas Creek dam and Havana, around 14,000,000 pounds.

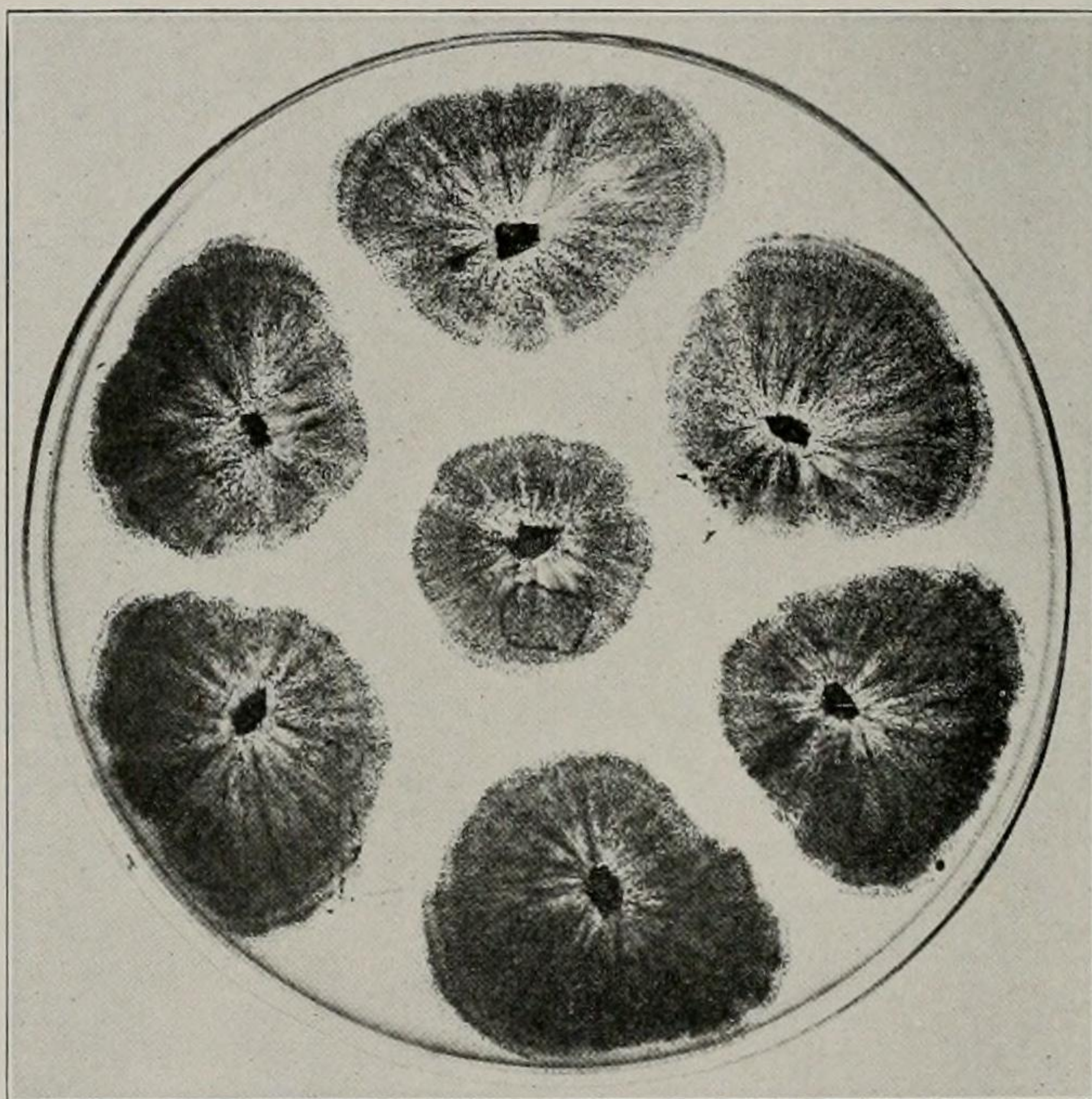
Applying to these same acreages such average weights per acre as are suggested by the findings of August—September, 1920, we note first an estimated reduction since 1915 in the bottom fauna of Peoria Lake and adjacent river between Chillicothe and Copperas Creek that amounts roughly to 50 per cent., and that affects about 10,000 acres at the lower gages of the ten years preceding 1920. Next are calculated reductions of 92 to 93 per cent. in the bottom fauna of some 1,400 acres of river and some 17,000 acres of lakes between Copperas Creek dam and Havana; and, last, reductions to practical nullity in the case of the acre-yield figures of small weed-animals both of the weedy acreage of Peoria Lake, estimated at 2,000 acres in 1910—1914, and of the one-time approximate 10,000 acres of shallow weed-area in the lakes between Copperas Creek dam and Havana. The total loss in poundage of surplus stocks between Chillicothe and Havana in five years appears indeed to have surpassed 25,500,000 pounds, or to have amounted on the average for both river and lakes, including both bottom and weed populations, to over 93 per cent. The extent of the loss is better appreciated when it is known that it is usual to figure that the weight of fish living on animal food can be increased about one pound for each five pounds of such food eaten. From this view-point the loss in potential fish-yield apparently stands at something like 5,000,000 pounds yearly for the section, if also it be true, as is

generally assumed, that stocks of the kind in question in the run of years at least reproduce themselves in weight once annually.

Below Havana we lack data for carrying out computations in the detail or with anywhere near the exactness attempted for the 60-mile section to the north, particularly in the case of the bottom and weed fauna of the lakes, having collected in only one of these in 1920. We note, first, of the 4,500 odd acres of river between Havana and the dam at Lagrange, an apparent slight gain over 1915 in the bottom yields, which is, however, probably no greater than the normal error to be expected with the apparatus and methods used. Offsetting this gain further, to the point in fact of rendering it negligible, are suggested losses of enormous size since 1914—1915 both in the bottom and weed fauna of the lakes and other backwaters in the 42.5 miles, which, combined, seem to have amounted to fully half the total stocks in the entire river and lake acreage open a little more than five years ago, or to more than twenty times the total bottom-fauna stocks of the section. This result, or a loss in the lake weed- and bottom-fauna of around 9,000,000 pounds, is simply arrived at if we estimate the loss in both the bottom- and weed-fauna stocks since 1915 at only 50 per cent. If we base conclusions for the entire acreage between Havana and the dam, on the recorded kind and extent of change in Stewart Lake since 1915 we must estimate the combined loss in both bottom and weed animals as even greater than 50 per cent., since it appears that on the weed-fauna side both the acreage and its average yield have probably been reduced that much. And as most of the lake acreage between Havana and the dam at Lagrange has since 1915 been north rather than south of the lower end of Stewart Lake, and therefore probably equally with it exposed to invasion by foul water and sediments, the estimate of a nine-million-pound loss in this district since 1915 may be allowed to stand as a minimum probable figure.

Combining a minimum loss in the first 42.5 miles south of Havana of 9,000,000 pounds with one of 25,500,000 pounds between Chillicothe and that point, we have, then, it seems, to reckon on not less than 34,500,000 pounds total reduction in the midsummer stocks of small bottom- and weed-animals in five years in about 103 miles; or, putting it another way, on about 7,000,000 pounds potential fish-yield missing from any new calculations we wish to make about the more recent value of a 103-mile section of the Illinois River fishery that was, only a few years ago, among the richest of its kind in the fresh-water stream systems of the world, being then uninjured, so far as could be seen, by the increasing pollution from the population and industries to the north that has recently so nearly overwhelmed it. It will be noted that 7,000,000 pounds is little less than a third of the largest total fish-catch ever taken from the entire Illinois River (catch of 1908), more than half of estimated total yields in 1912 and 1913, and not improbably more than the total yield for the whole year 1920.





Original isolations of the foot-rot *Helminthosporium* made
in May, 1919, from bits of tissue from wheat
grown in Madison county, Illinois.

STATE OF ILLINOIS
DEPARTMENT OF REGISTRATION AND EDUCATION
DIVISION OF THE
NATURAL HISTORY SURVEY
STEPHEN A. FORBES, Chief

Vol. XIV.

BULLETIN

Article X.

On the Numbers and Local Distribution
of Illinois Land Birds of the Open
Country in Winter, Spring,
and Fall

BY
STEPHEN A. FORBES
and
ALFRED O. GROSS



PRINTED BY AUTHORITY OF THE STATE OF ILLINOIS

URBANA, ILLINOIS

October, 1923

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DEPARTMENT OF REGISTRATION AND EDUCATION

DIVISION OF THE

NATURAL HISTORY SURVEY

STEPHEN A. FORBES. Chief

Vol. XIV.

BULLETIN

Article IV.

Changes in the Bottom and Shore Fauna of
the Middle IUinois River and its Con-
necting Lakes since 1913 — 1915 as a
Result of the Increase, South-
ward, of Sewage Pollution

BY

ROBERT E. RICHARDSON

PRINTED BY AUTHORITY OF THE STATE OF ILLINOIS

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Article IV. — Changes in the Bottom and Shore Fauna of the Middle Illinois River and its Connecting Lakes since 1913 — 1915 as a Result of the Increase, Southward, of Sewage Pollution. By Robert E. Richardson.

The following short account of the principal changes that have occurred both in the composition and abundance of the small bottom-invertebrate fauna of the Illinois River system between Chillicothe and Brownsville since 1913 — 1915 — these points being respectively 146.5 and 229.5 miles below the mouth of the Chicago River — is based on hauls made in July, August, and September, 1920, with the Petersen quantitative bottom-sampler at seventy-one stations in the river and Peoria Lake between Chillicothe and the head of Grand Island, and at twenty-five stations in five of the more important bottom-land lakes in the neighborhood of

Havana. While the composition of the small bottom-fauna was apparently normal as far north as Chillicothe in 1915,* the 1920 data herein presented disclose conspicuous changes since that time both throughout the northernmost and southernmost portions of the section of river system studied, these including sweeping reductions in numbers and poimdage of the still surviving groups of small bottom-animals, total obliteration of numerous families and species, and, in the range covered above Havana, the intrusion in large numbers of new pollutional or tolerant forms. If, as is approximately correct, we assume that Chillicothe marked about the upper limit of wholesome conditions in the bottom muds in 1915, then the added river mileage that is shown to have been more or less seriously damaged since that time figures out at not less than eighty, and represents an average southward encroachment of pollution amounting to fully sixteen miles per year for each year of the five.

Valuations of the small bottom-animals have been made in the same manner as for the 1915 material reported upon in the paper just cited. Valuable assistance in working up the Chironomidae of the collections of this year, as well as in the elucidation of older data for comparison, has been given by Dr. C. P. Alexander and Mr. J. R. Malloch.

* The Small Bottom and Shore Fauna of the Middle and Lower Illinois River and its Connecting Lakes. Chillicothe to Grafton : its valuation ; its Sources of Food Supply ; and its Relation to the Fishery. By R. E. Richardson. Bull. Nat. Hist. Survey, Vol. 13, Art. XVI. 1921.

Synoptic List of Dredging Stations, Illinois River and
Connecting Lakes, July — September, 1920

1. Illinois River and Peoria Lake, Chillicothe to Wesley

Mile 146.5 — Mile 167.8 below Lake Michigan

Channel

4—7 feet.

1—3 feet.

Total

2. Illinois River, Liverpool to 1.5 Miles below Head of Grand Island

Mile 199.0 — Mile 215 below Lake Michigan

[Begin Page: Page 35]

3. Illinois Valley Lakes, Liverpool to 3.5 Miles above Beowning

Mile 199.0 — Mile 226 below Lake Michigan

All mud bottom,

Depths, 2—6 ft.

5

a

3

4*

15

Lakes north of Havana,

Mile 199.0—207.0

Liverpool Lake

Dogfish Lake

Thompson Lake

Quiver Lake

Lakes south of Havana,

Mile 224.0—226.0

Stewart Lake

* In Quiver Lake five additional collections were made in the deep channel cut by the wash from Quil'er Creek and in the sandy-muddy zone near the east beach.

The Illinois River and Peoria Lake, Chillicothe to Wesley

(Mile 146.5—167.8 below Lake Michigan)

At all of the thirty-five lake and river stations between Chillicothe and Wesley where bottom dredgings were made in 1920, there was evidence in some form or other of deteriorating change since 1915. The various tests and observations made both in 1920 and five to seven years earlier had regard chiefly to the physical condition, appearance, and odors of the muds ; the composition and abundance of the small bottom- and shore-fauna ; and the kinds, amount, and distribution of the coarse aquatic vegetation. While sharply drawn comparisons are not easy in the first group of items, bubbling and more or less foul odors having been noted at some stations between Peoria and Chillicothe in 1915, in the second item-ization we have to do with the disappearance since that year of whole families and numerous genera and species of small bottom-animals, as well as with the entrance in their place, in several instances, of new pollutional forms ; and in the last, with the practically complete disappearance of a rich aquatic vegetation which formerly covered several square miles of shallow-lake territory at low water, along with the similarly complete extinguishment of a previously very rich shore- and weed-fauna.

The muds, taken at the eight stations in the "upper lake," between Chillicothe and Spring Bay, were all strong in odor, and bubbling was abundant, when the mud was stirred, in all depth-zones. Both in the channel at Rome and Spring Bay and in the open lake opposite Rome a peculiarly spongy and foul-smelling mud was lifted by the dredge. These samples showed a texture not unlike freshly risen bread, and gave out a distinct blubbery sound on being pressed with the hand as they lay

in the tray. Some improvement in odor and less bubbling was noted in samples taken well toward the east edge of the upper lake.

In the middle lake, opposite Mossville, the mud from the channel was spongy with gas, and in the channel of this lake as far south as Al Fresco Park, a mile and a half above Peoria Narrows, odors were foul and strong. Considerably less bubbling and milder odors were noted at the shallower-water stations in this section of Peoria Lake.

In the lower lake, opposite and below the principal sewers of the business and residence districts of the city of Peoria, all dredgings were made in the center or to the eastward of the steamboat channel and were for the most part out of the way of the worst of the local pollution. At our stations in the lake, neither in the main channel nor in the shallower water eastward were odors so bad as at upper-lake stations, although bubbling was abundant in whatever depth the dredge was let down. At all stations, both in this and in the upper and middle lake, it was noted that all dead shells of snails were badly blackened or otherwise discolored.

The principal changes in the bottom fauna in this 18-mile section since 1915 may be summarized under three heads: (1) disappearance of most species and genera and of several families of small Mollusca, along with important average decrease in numbers of the more tolerant forms

still surviving; (2) enormous increase in larval midges (Chironomidae), with invasion of several more or less distinctly pollutional species, and similar or even greater increase in sludge-worms (Tubificidae) ; and (3) disappearance throughout Peoria Lake, except immediately along shore or in the short, half-mile, stretch of swifter water in Peoria Narrows, of all "other insects"* (Ephemerae, Odonata, Phryganeidae, Corixidae, etc.), as well as of planarians and leeches, Amphipoda, Isopoda, sponges, and Bryozoa.

Although in 1913 — 1915 at least fifteen or sixteen species of snails, representing no less than eight families, were readily taken in the lake and river channel between Chillicothe and Peoria, but four species, representing three families, were found in the same range in July and August, 1930. The three principal surviving kinds (*Campclunia subsolidum*, *Pleurocera* species, and *Musculium transversum* } were those found by us farthest north — and hence most tolerant of foul water and bottom — in the upper Illinois in 1913, the first-named species occurring as far north that year as Starved Rock, and the last as far north as Marseilles. Two of the formerly abundant species of Viviparidae (*Vivipara contortoides* and *Liopora subcarinata*), two species of Valvata, two *Amnicolas*, three or four species of Physidae and Planorbinae, a species of *Ancylus*, and at least three species of Sphaeriidae seem to have disappeared altogether from the muds between 1915 and 1920.

* Understood in text and tables following to mean other insects than Chironomidae.

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38

Even the surviving snails showed in 1930 great reduction in average numbers and weight since 1915 in nearly all portions of the area studied. The extent to which they had shrunken in the different depth-zones of the upper, middle, and lower lake is shown in the comparative valuation tables appended, and it will be sufficient here to note that whereas in 1915 the weight of the combined Gastropoda and Sphaeriidae in Peoria Lake collections made up from over 85 to over 99 per cent, of the total edible matter in the average haul, the snails in 1920, except in the short swift stretch through Peoria Narrows and in a few collections in the channel of the lower lake, weighed on the average less or only a little more than did the sludge-worms or midge larvae, and made up, in fact, only from 2 to 15 per cent, of the average catch under the new dispensation.

The Viviparidae and Pleuroceridae in 1920 were found only in the channel and 4— 7-foot zone of the lower lake, opposite Peoria, and in the 1 — 3-foot zone, on the east side in the Rome — Mos§ville section. The single surviving species of Sphaeriidae (*Muscuvunn fransvcrsiiin*) showed a visibly wider distribution than the large Gastropoda, and it was some-

what of a surprise to us to take the largest hauls of this stoutly tolerant little shell among the sludge-worms and larval midges of the filthy channel-bottom between Chillicothe and the foot of the upper lake.

Snail Fauna of Bottom Muds, Chillicothe to Foot of Peoria Lake,

1915 AND 1920

1. Average number per square yard, main groups

Sphaeriidae

Upper lake 152 112

Middle lake I 91

Lower lake 5 6

204

116

97

24

3

12

277

30

24

12

Amnicolidae,

Valvatidae,

etc

Upper lake

Lower lake

Middle lake

3

12

70

32

12

40

[Begin Page: Page 39]

39

2. Average tweight, main groups, pounds per acre,
shells deducted

Sphaeriidae

Upper lake

Middle lake

Lower lake

76

43

3

56

3

54

28

12

1

6

66

1

3. Average weight of total snails
and per cent, decrease, 1915 to 1920

Lower lake

Channel

4— 7 ft.

1—3 ft.

394

501

184

113

24

71.3

95.2

100.0

12

6

- Increase.

[Begin Page: Page 40]

40

Percentage, by weight, of average total hauls
contributed by snails

The changes in composition and abundance of the chironomid population of the bottom muds in this section of the river since 1915 are perhaps even more interesting and significant than those of the small Mollusca, including, as they do, the appearance of several new and more or less pollutional species, the disappearance of a number of formerly common or abundant cleaner-water forms, and an almost sixty-fold multiplication in weight of the average chironomid contribution to hauls since 1915.

Unusually tolerant or pollutional species that have come into Peoria

Lake since 1915 seem to be several in number, and include *Chironomus plumosus* Linn., *C. matirris* Joh., *C. frequens* Joh., and a variety of the first-named species. *Chironomus plumosus* L. has before been recorded by writers in Europe as a species common in foul muds. It was taken by us in 1920 in large numbers all the way from Chillicothe to the foot of Peoria Lake, both in the channel and in the shallower zones, and also occurred in moderate numbers in the gassy river-muds eight miles above Havana. It was not found by Malloch in 1912 or 1913 collections from either above or below Peoria, but appears to have been present in the badly fouled bed of the Des Plaines River at Lockport in the autumn of 1911, as indicated by a provisional determination by Mr. Chas. A. Hart, *Chironomus matirris* Joh. and *C. frequens* Joh. are here listed as species capable of maintaining themselves in polluted muds because of their occurrence in 1920 in abundance in the Illinois River opposite Peoria, and because of the absence of definite records of them from clean muds elsewhere — either in the Illinois River or other waters.

Three more or less tolerant or pollutional species, *Tanytus d\ari* Coq., *Chironomus decornis* Joh., and *C. erassicaudatus* Mall., may be listed as hold-overs from 1913 — 1915, when, as in 1920, they were common in collections from some stations opposite or above Peoria. We note that *C. decornis* was the commonest species of this family found by Weston and Turner in the contaminated bottom of the Coweeseet River in 1916, just below the drains of the city of Brockton, Mass. *Tanytus dyari* Coq. was found by Malloch some years ago to frequent a badly polluted local

ditch in Illinois., and was taken by us in 1912 in the worst fouled portions of the Illinois River between Morris and Marseilles, though not northward of those places. None of these three species was found by us either in 1920 or in 1913 south of Peoria ; and the last one named, nowhere at all except at Peoria.

The list of larval midge-species that have dropped out of this section of the Illinois River since 1915 includes at least four, of which but one, *Climacomyia tentans* F.. is known definitely to do badly in the presence of pollution and to have been common in this section during or before 1915. This species was common to abundant in 1913 — 1915 both in the river and in the lakes all the way from Peoria Lake to Havana, but has now apparently disappeared altogether from the lakes and from the greater portion of its old river-range. Species of apparently rather indifferent habit as indicated by their distribution in this section and above and below six or seven years ago, but that failed to appear in Peoria Lake collections in 1920, are two in number — *C. lobifrons* Sav and *C. ziridicollis* V. d. W.

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The vast increase in numbers and weight of midge larvae in the muds of Peoria Lake between 1915 and 1920, the comparison being of July — September collections for both periods, goes far in some portions of the range toward making up the losses in the small Mollusca. While the average number of young midges taken to the square yard between Chillicothe and the foot of the lake was less than 10 in the summer of 1915, in 1920 it had risen for the whole lake to 318 ; while in the channel and 4 — 7-ft. zone of the upper lake, between Chillicothe and Spring Bay, numbers per yard were 1216 and 55-1. Again, while in 1915 the greatest weight per acre figured for Chironomidae in a subdivision of Peoria Lake (the 4-7-ft. zone of the middle lake) was only 7 pounds, and the average for all zones and all subdivisions in 1915 was only 1.4 pounds, in 1920 the average weight had risen in the channel and 4 — 7-ft. zones of the upper lake to 182 and 128 pounds respectively, and for all subdivisions and all /-ones to 83.3 pounds, or 59.5 times the average valuation figure of 1915. When we compare the weight of the Chironomidae with the weight of the average total haul we find that the largest catches in Peoria Lake in

1915 ran less than 6 per cent. Chironomidae, most of the collections, in fact, running less than 3 per cent. In 1920, on the other hand, we find the Chironomidae making up from 21 to 42 per cent, of the average total weight of collections in the channel between Chillicothe and Peoria, and from 70 to 96 per cent, in the 1 — 3-ft. and 4 — 7-ft. zones.

Midge Larvae (Chironomidae) of Bottom Muus,

Chillicothe to Foot of Peoria Lake, 1915 and 1920

1. Number and weight per unit of bottom area

Average

pounds

per acre

Upper lake

Middle lake

Lower lake

I

0.2 182 4.2 128

1.5 sq? 51

86 I 132

Average weight per acre, all channel collections, 1920, 89.2 lbs.

" all 4— 7-ft.-zone collections, 1920, 101.0 lbs.

" all 1— ^-ft.-zone collections, 1920, 27.6 lbs.

Average weight per acre, all collections, all zones, 1920, 83.3 lbs.

Average weight per acre, all collections, all zones, 1915, 1.4 lbs.

[Begin Page: Page 44]

li Percentage, by weiyhl. of average total lutids
contributed by Chironomidae

Much as have the sludge-worms, the larvae of the midges have increased in the past five years in Peoria Lake from an average of half a pound per acre and a maximum of one pound — representing at the most less than 2 per cent, of the average total haul — to as much as 173 pounds]er acre and 42 per cent, of the average haul in the river channel between Chillicothe and Spring Bay, and to a general average of 26.3 pounds per acre for all subdivisions and all zones collected from in the three lakes. The largest numbers reached — in the channel of the upper lake — amount-

ed to 49(j0 per square yard, 4800 of these belonging apparently to a single species of Tubifex, and 160 to a species of an undetermined genus of Tubificidae. Both in the channel and in the shallower zones, sludge-worms became less abundant southward of the upper lake, though it is noted that in the channel of the lower lake the average number per square yard in 1920 (183) was more than sixteen times the average figure for the upper lake channel (11) in 1915 (table).

Sludge -WORMS (principally Tubificidae),

Chillicothe to Foot of Pickering Lake. 1915 a.M) 1920

1. Number and weight per unit of bottom area

Average weight per acre, all channel collections, 1920, 44.5 lbs.

" all 4— 7-ft.-zone collections, 1920, 14.0 lbs.

all 1 — 3-ft.-zone collections, 1920, 4.7 lbs.

all collections, 1920, all zones, 26.3 lbs.

1915, " " 0.5 lbs.

[Begin Page: Page 45]

45

3. Percentages, by weight, of average total hauls contributed by sludge-worms

Out of a miscellaneous list of insects representing five or six families other than Chironomidae that were present or common in the bottom muds between Chillicothe and the foot of Peoria Lake in 1915, we found none at all surviving in the summer of 1930 at the thirty-one stations dredged in the sluggish waters of either the channel or shore zones of Peoria Lake proper or in the river at Chillicothe. At these same stations we failed also to find any isopods. the little amphipod *Hyaella*, any leeches or planarians, or any sponges or bryozoans. In the relatively much swifter water that continues for about a half mile through Peoria Narrows, however, and in the rapid portion of the river just below the lower outlet of the lake, large Viviparidae and Pleuroceridae were present in larger numbers than in the upper, middle, or lower lake, a bryozoan, *Fredricella* sp., was thriving on the shells of living snails, and the formerly common sand-case-building caddis larva (*Hydropsyche* sp.) was still present in considerable numbers. As the average valuation figures of this group of the bottom invertebrates ran only two to eight pounds per acre in Peoria Lake in 1915, it will be recognized that the decline is a small one compared with the losses since 1915 in Mollusca, and that it has been much more than made up in bulk and weight by the recent increases in the sludge-worms and the larvae of the midges.

Other Insects,* Worms, Crustacea, etc. of Bottom Muds.

Chillicothe to Foot of Peoria Lake. 1915 and 1920

number and weight per unit of bottom area

Average

pounds

per acre

Upper lake

Middle lake

Lower lake

4

4

6

• See foot-note p. 7.

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The sum of the various changes that have taken place in the small bottom-fauna of Peoria Lake since 1915, as shown in the summary tables next following, have not apparently affected average total valuation figures in pounds per acre since 1915 nearly as much as they have changed the composition of the fauna. In the upper lake, in fact, it appears that the 1920 figuresj for all zones — in consequence principally of the enormous increase of midge larvae and sludge-worms since 1915 — indicate total stocks slightly heavier than five years before. In the middle and lower lakes, however, average figures for all zones seem to have been cut at least in two when not divided by three, and an estimate of an aver-

age reduction of around 50 per cent, in all zones of all three lakes combined would apparently be a fair approximation of the total change.

It is, we believe, the losses in the shore and weed fauna, rather than those in the bottom animals, that have bulked greatest in Peoria Lake in the past few years. The loss in this element of the small invertebrate fauna of the lake has without question been almost a total one since 1915. The luxuriant growths of coarse aquatic plants (Potamogeton, Ceratophyllum, Scirpus, Vallisneria, etc.) that covered several square miles of Peoria Lake at midsummer and autumn levels between 1910 and 1914, and their rich fauna of small invertebrates along with them have disappeared now altogether in the upper and middle lake except for an occasional scraggly clump at the very edge. In the lower lake, a thin patch of Potamogeton and Ceratophyllum, covering less than two acres, was still growing in the small springy slough on the east side, opposite the foot of Liberty St., in August, 1920— the sole more than negligible remnant of the several hundred acres of vegetation in this part of Peoria Lake at low water five to ten years ago.

All Small Bottom-Animals, Chillicothe to Wesley, 1915 and 1920

average valuations, pounds per acre: summary

1. Upper Peoria Lake, Chillicothe to Spring Bay

Grand total

396.2

411

184.5

180.6 75.5

92

[Begin Page: Page 47]

A 7

2. Middle Peoria Lake, Mossviixe to Al Fresco Park

3. Lower Peoria Lake, Straw-hoard Mill to Liberty Street

Grand total

400.3

204.9 507.6

156.4 1 191.2

29.1

[Begin Page: Page 48]

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4. Peoria Nabrows, (Strong Current)

5. Peobia and Pekin Union Railway Bridge

(below foot of lake, in strong current)

The Illinois River, Liverpool to Havana

(Mile 199.0—207.0 below Lake Michigan)

The changes between 1915 and 1920 in the appearance and odors of the muds in the eight-mile section of the Illinois next above Havana, whose upper and lower limits are respectively about 34 and 42 miles below the foot of Peoria Lake, and 199 and 207 miles below Lake Michigan, are, if anything, more striking than those that have occurred in the five years between Chillicothe and Peoria. In this part of the river in 1915

[Begin Page: Page 49]

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the mud had nearly uniformly a quite wholesome earthy odor in midsummer, and except locally along shore immediately below fish markets or large drains no more bubbling was noted when the bottom was disturbed than was normal at the same time at points fifty to a hundred miles farther south. In early July and early September, 1919, and in Septem-

ber, 1920, the muds taken both in and outside the deeper channel at Liverpool, at Hogfat Bend, three miles above Havana, and just above Havana were distinctly foul-smelling and hundreds of large gas bubbles rose to the surface each time the sampler hit bottom. In calm hot weather in late August, 1919, spontaneous bubbling was observed at Hogfat Bend and just above Liverpool ; and at Liverpool in early September, 1920 the mud samples from the channel were of the same spongy texture previously noted in the samples from Rome and Chillicothe.

Both the shrunken volumes and altered composition of the collections of small bottom-animals taken at the fourteen stations worked in this section in 1920 add their clear testimony to the advance of pollution this far southward since 1915. While the average weight of the channel haul here was over 5,000 pounds per acre in 1915, in 1920 it was less than 250 pounds—a net loss of 95.3 per cent. In the 4 — 7-11. zone for the same five-year period the average haul showed a shrinkage of 95.9 per cent., or from 2,122 pounds to only 87 pounds per acre. The change in the composition of the small bottom-fauna, in turn, includes the disappearance since 1915 of five out of seven families of snails; of more than half a dozen species of bottom-dwelling larval midges ; and of twelve out of thirteen or fourteen families of "other insects," worms, small Crustacea, and other small bottom-invertebrates.

By far the greatest destruction, as measured by bulk and weight as well as in numbers, appears to have been accomplished among the snails in the five-year period, the percentage declines in average snail-poundage in the channel and in the 4 — 7-ft. zone since 1915 (98.7 and 98.0 per cent.) being greater than the percentage decreases in poimdage of total hauls (95.3 and 95.9 per cent.), and much greater than the per-

centage declines in snail yields in some important sections of river between Chillicothe and Peoria. While in Peoria Lake, as already pointed out. the decrease in snails in the five-year period was largely or altogether compensated by increase in the weight of the midge larvae and sludge-worms (principally the former), it is clear that under the circumstance in this section of a decline in snails from several thousand pounds to less than a hundred pounds per acre, an increase in Chironomidae from a trace to as much as 150 pounds per acre could go but a little way toward making up the snail deficiency. The following tabulation of changes in the snail fauna is substantially the same as the one previously given for the Peoria — Chillicothe section, showing the same three species — one each of Viviparidae, Pleuroceridae, and Sphaeriidae — still surviving, and principally the same list of about seventeen species that disappeared from the section in the five-year period under discussion.

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In the history of the Chironomidae of the river muds since 1915 in this district, after the disappearance of half a dozen of the old list of more sensitive species, perhaps the most important single circumstance is the appearance here in 1920 of the pollutional *Chironomus plumosus* Linn., which also invaded the Chillicothe — Peoria section for the first time in the five-year interval ending in 1920. This species was, in fact, quite common in September last year in the foul spongy mud taken at Liverpool, both in the channel and outside of it as far as the four-foot line, but was much rarer in the bottom samples at Hogfat Bend and just above Havana, its average for all the stations in the section being thus brought down to 20 per square yard.

The three other commonest species of midges represented in this section of the river in 1930 included two species of wide range or presumably tolerant habit, *Chironomus lobiferus* Say and a form near *C. decorus* Job., and one hold-over species of more particular habit, *C. tentans* Fabr. *C. lobiferus* was recorded from Havana in 1913 — 1914 by Malloch, but was less common then than in 1920, when it averaged as high as 100 per square yard in channel collections. The *decorus*-Wkt form had not been previously taken. *Chironomus tentans* F., which seems to have disappeared completely from its old range at and above Peoria since 1913 — 1914, as also from the lakes between Liverpool and Havana, was still holding its own in good numbers in 1920 at the lower (but not the upper) river-channel stations in the section.

Midge larvae (*Chironomidae*) of Bottom Muds of Illinois Rivee, Liverpool to Havana, 1913—1914 to 1920— July — October

1. Pollutional species that has come in since HUS — I./.

Chironomus plumosus L. Common at Liverpool in 1920.

2. Tolerant or indifferent species that has come in since 1913 — IJ/.

Chironomus sp., near *decorus* Job., No. 1. Abundant, Liverpool to Havana, 1920.

3. Tolerant or indifferent species found both 1913 — H and 1920.

Chironomus lobiferus Say. Present, 1913 — 14. Common in channel only in 1920.

.}. Tolerant or indifferent species that have dropped out since 1913 — H.

Chironomus viridicollis v. d. W. Common, 1913 — 14.

C. decorus Joh. A few, 1913—14.

5. Cleaner-water species that have dropped out since 1913 — U.

Tanytus monilis L. Common, 1913 — 14.

T. illinoensis Mall. Present, 1913 — 14.

Chironomus ferrugineovittatus Zett. Present, 1913 — 14.

C. modestus Say. Present, 1913 — 14.

Cricotopus trifasciatus Panz. Common, 1913 — 14.

Palpomyia longipennis Lw. Common, 1913 — 14.

Vi. Cleaner-water species still surviving in 1920.

Chironomus tentans P. Present in 1913 — 14, but less common in the river than in the connecting lakes. Commoner in the river in 1920 than in 1913 — 14, but apparently exterminated in the connecting lakes.

I

The extent of the increase in bulk and weight of Chironomidae in collections since 1915 (from a negligible quantity to 164 pounds per acre in the channel and from a similar figure to 45 pounds in the 4 — 7-ft. zone) is greater even than the increase shown by either the channel or all-zone figures for the Chillicothe — Peoria district. The percentage, by weight, contributed by Chironomidae to average total hauls in this district while standing practically at zero in 1915, reached 68.3 per cent, in the channel and 51.7 per cent, in the 4 — 7-ft. zone in 1920, these ratios comparing with 99.5 per cent, and 98.7 per cent, for snails and less than 2 per cent, for all other small bottom-animals during the period covered by the earlier valuations (table, p. 53.)

Sludge-worms, which showed a perpendicular rise from none at all in this section of river in 1915, were still far under the numbers and weight valuations recently reached in Peoria Lake, the average number per square yard at channel stations, where the largest quantities were taken, being less than 100, and the average valuation not over three pounds per acre. These figures compare with over 170 pounds per acre in the channel of upper Peoria Lake in 1920 and with over 26 pounds per acre as the all-zone average of the Illinois River and its wide waters between Chillicothe and south Peoria. The small oligochaetes taken between Liverpool and Havana in September, 1920, apparently belonged without exception to the Tubificidae, the commonest form being an undetermined species of the genus *Tubifex*.

As in the Chillicothe — Peoria reach, the miscellaneous minor groups

of small bottom-animals all appeared in 1920 collections in this section in greatly reduced numbers and variety when they appeared at all. Insect families other than Chironomidae that were common in 1913 — 1915, but that seem to have disappeared altogether outside the 3- or 4- foot line since the latter year, include Corixidae, two species ; Phryganeidae, species " of Hydropsyche and other genera; Ephemeridae, species of Hexagenia. Heptagenia, and Caenis ; Gomphidae, Libellulidae, and other families of Odonata; and Parnidae, as represented by adult beetles of the genus Stenelmis. Other small bottom-animals that have dropped out of the channel and 4 — 7-foot zone are the little amphipod Hyaloclla knickerbockeri. Asellus aquaticus, planarians of several kinds, as well as several kinds each of leeches, fresh-water sponges, and Bryozoa. The average weight-valuation of this group in 1920, 6 pounds per acre in the channel and one pound per acre in the 4 — 7-ft. zone, stands for comparison with 24 and 26 pounds in 1915; with the 1920 poundages largely made up of a single species of leech.

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Au, SMAii Bottom-Animals, Illinois River, Livebpooi. to

Havana, 1915 and 1920

1. Average numbers per square yard

3. Average pounds per acre,

and per cent, decrease in five years

[Begin Page: Page 54]

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The Illinois River from 2 miles below Havana to 1.5 miles below the Head of Grand Island

(Mile 209.0—215.0 below Lake Michigan)

Neither in July — October, 1913 — 1915 nor at the same season in 1920 were foul odors or abnormal bubbling noted at the muddier collecting stations in this somewhat swifter and harder-bottomed section of river than the two previously described. The conspicuous change in the physical appearance and odor of the bottom sediments that occurs in less than three miles below the wagon bridge at Havana is no doubt influenced by several factors, including as the principal ones the effect of the high Spoon River bar in favoring sedimentation in the widened river immediately north of Havana, and the lesser rate of settling and greater mobility of bottom sediments in the stretch of faster channel that begins just below it.

The improvement in the condition of the stream bottom as we proceed southward of Havana is only a little less strikingly shown in the composition of the small bottom-fauna — if we except the Mollusca — than in the physical condition of the bottom deposits. Here in 1920, for the first time below Chillicothe, we found thriving the nymphs of the common

willow-fly of the middle and lower Illinois, *Hcxagenia bilineata*; something like normal numbers of the common sand-caddis, *Hydropsyche* sp., as well as immature Gomphidae and other Odonata ; and among non-insect bottom-animals, about the usual variety of Bryozoa, leeches, and planarians. Even on the molluscan side we did not find serious decrease in total-weight valuations over 1915, either in the channel or in the 1 — 3-ft. zone. But there was a decline of 95 per cent, in snail poundage compared with five years before, indicated for the 4 — 7-ft. zone, and the full list of snails for the section showed the disappearance since 1915 of not less than eight species, representing five families. The only species surviving were, in fact, the same three — one each of Viviparidae, Pleuroceridae, and Sphaeriidae — which have pulled through in the Chillicothe — Peoria and Liverpool — Havana sections. The disappearance of these snails from the river below Havana is not, however, to be compared in seriousness with the visitations of mortality above Havana, both for the reason that neither in the channel or the shallower zones were average snail-yields here anything like as high some years ago as above Havana, and because the remaining species have apparently quite or more than held their own in at least a part of the range since the disappearance of the more sensitive forms.

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Further evidence of a mixed status or condition of the bottom fauna in this portion of the river is furnished in the lists and figures of Chironomidae. In the first place, we note that while midge-larvae have increased greatly here since 1915, in spite of the disappearance the while of half a dozen formerly common species of clean-bottom habit, yet no distinctly pollutational species has invaded this section since 1915, and only

two forms of wide range or doubtful preference (*Chironomus lobiferus* Say and a species very close to *C. decorvus* Joh.) are new here since the 1913 — 1915 period. Further, it will be noted that more than half of the increase in weight-valuation of Chironomidae in the river below Havana in the five years preceding 1920 is not due to these two newly introduced tolerant forms, if indeed they are both so, but follows from the multiplication here recently of three of the large larvae of clean-bottom habit which were common to abundant in the lakes above Havana in and before 1915, but which have since been exterminated in that range, with the exception of Quiver Lake. These three species (*C. tentans* ¥., *C. ferriigneovittatus* Zett., and *Procladius concinnus* Coq.) occurred in good numbers in 1920 in this section of the river wherever there was mud, and the sharp reversal in their distribution, from lake and backwater above Havana to river below Havana, seems to lend some support to the supposition that their recent appearance and rapid multiplication in their new range is in some manner connected with their disappearance from the old one.

Midge Larvae (Chironomidae) of Bottom Muds of Illinois River below Havana,* 1913—14 to 1920— July— October

1. Tolerant species or species of doubtful preference that have come in since 1913—14

Chironomus lobiferus Say. Present, 1920.

C. sp. near decorvus Joh., No. 2. Abundant, 1920.

8. Cleaner-water species that have dropped out since 1913 — H.

Palpomyia longipeunis Lw, Present in 1913 — 14.

Tanytus monilis L. Present in 1913 — 14.

Chironomus dux Joh. Present in 1913 — 14.

C. digitatus Mall. Present in 1913—14.

Cricotopus trifasciatus Panz. Present in 1913 — 14.

Cricotopus sp. Present in 1913 — 14.

5. Cleaner-water species that have come in since 1913 — 14.f

Procladius concolor Coq. Common, 1920. shallow zones.

Chironomus ferrugineovittatus Zett. Present, 1920, 4 — 7-foot zone.

C. tentans P. Common, 1920, chiefly in shallow zones.

i. Tolerant or indifferent species that has dropped out since 1913 — 14.

Chironomus decorus Joh. Present, 1913 — 14.

• Occurrence In 1913 — 11 principally below Beardstown; in 1920. 2.5 miles below Havana to 1.5 miles below head of Grand Island. '

t All these species were present or common both in the river and the lakes above Havana, 1913 — 14, but were not found In either of those ranges last year, if the occurrence of *C. ferrugineovittatus* in Quiver Lake in 1920 be excepted.

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While sludge-worms showed some increase in this section since 1915, their gain was slight and of very small moment compared with the increases shown in five years either in the Peoria section or in the reach just north of Havana. All of the small oligochaetes taken, however, belonged to genera of the family Tubificidae, about half of them being species of the genus *Tubifex*.

Though, as already mentioned, a marked increase in variety as well as an actual average increase in poundage since 1915, is plainly shown by the group of "other insects, etc.", there were a good many eliminations from the lists even in this group in the five years preceding 1930. Non-insect groups or insects other than Chironomidae that were readily taken in this part of the river in 1913 — 1915 but that did not appear in collections in 1920, include the little crustaceans *Asellus* and *Hyalella*; two or three species of Ephemeridae; two species of Corixidae; adult bottom-beetles of the genus *Stenelmis* ; several fresh-water sponges ; and at least one genus and species of Bryozoa, namely, *Paludicella* sp., which was formerly common on almost all the dead shells of Unionidae.

Total average-valuations of all small bottom-animals for this section in 1920 — 30 pounds per acre in the channel, 89 pounds in the 4 — 7-foot zone, and 526 pounds in the 1 — 3-foot zone — exceed 1915 figures in the first and last instances ; while in the 4 — 7-foot zone they were well

under the older valuations, as shown in the table following. Both in the channel and in the 1 — 3-foot zone the decreases in snails were more than made up for by increases in midge larvae and "other insects" and miscellaneous species. In the 4 — 7-foot zone the increase in snails was greater and the increase in Chironomidae and minor insects, etc., less, either relatively or absolutely or both, -than in the 1 — 3-foot zone. To what extent these zonal differences in distribution both of the total bottom fauna and its subdivisions may be connected with differences in wholesomeness of conditions on different sections of the river floor, or to what extent they may reflect mere casual migration of surviving species following a general mortality, our present data give us no certain basis for an opinion.

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All small Bottom-Animals, Havana to Grand Island*, 1915 and 1920

1. Average numbers per square yard

• To 1 mile below head of Grand Island in 1920; to head of Grand Island in 1915.

2. Average pounds per acre

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Three all-Bottom-land Lakes and one Sand-beach Lake between
Liverpool and Havana

(Mile 199.0—207.0 below Lake Michigan)

The season's collections in Liverpool, Dogfish, and Thompson lakes in 1920 were taken in early September in almost uniformly muddy bottom between near shore and the six-foot line. All of the stations visited in these lakes at that time were in open water, though a large part of the same area in all of the lakes and most of it in some of them was well supplied with coarse vegetation between 1913 and 1915. Mud, spongy with gas, was taken at two of the stations in Liverpool Lake and there was more or less foulness of odor and abundant bubbling at all stations in all three lakes. While odors were particularly bad in the Liverpool Lake samples, they were not nearly so bad either in Thompson or Dogfish. In the last-named lake there was a light covering of lighter colored silt over older gassy black mud, the topmost layer having its origin less than six months before in the dredging operations for an agricultural drainage district immediately north.

In Quiver Lake the samples from muddy bottom in open water (mostly in the old vegetation zone, as in the other three lakes) all had bad odor and gave off abundant bubbles. Samples from the mud and mud and shell bottom in the deeper "channel" through this lake, and from the mud and sand near the east beach were decidedly less gassy and more wholesome in odor.

While not less than six families of snails, represented by about a dozen species, were common or abundant in 1913 — 1915 in each of these

four lakes, no snails at all were taken in Liverpool or Dogfish lakes in September, 1920, and in Thompson Lake only a small number of a single species. In Quiver Lake, as in Dogfish and Liverpool lakes, no snails at all were found in the shallower, more stagnant open portion less than six feet in depth ; but in the "channel" fed by Quiver Creek, and toward shore on the east side, good numbers of *Pleurocera*, and small numbers of *Mtisculium transversum* and *Vivipara subpurpurea* were taken.

The table following shows the detailed changes in the composition of the snail fauna in Thompson Lake only. It represents very well, also, with only slight alterations, the changes that have taken place in Dogfish and Liverpool lakes, and in the muddy portion of Quiver, the principal requirement being to transfer the little surviving sphaeriid at the head of the table to the list of species underneath that have dropped out since 1913-1915.

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The drop in average weight-valuation of the snail fauna in these four lakes, except in the less injured portions of Quiver Lake mentioned, amounts to little short of total disappearance — namely, from 122 — 363

pounds per acre to nothing at all in Liverpool, Dogfish, and the muddier, more stagnant portion of Quiver; and from 409 pounds to 4 pounds per acre in Thompson.

The decrease in snail poundage since 1915 in Thompson Lake, where it is in the least ratio, was 99.1 per cent., which is greater even than the percentage decline in the river channel between Liverpool and Havana. In the Quiver Lake channel the drop in valuation figures since 1915 is only about 70 per cent., leaving an average of 248 pounds per acre in the limited range in September, 1920. Shoreward on the muddy side of Quiver Lake an average valuation of 109 pounds per acre in 1930 stands without a separate 1914 or 1915 figure for comparison.

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In Thompson, Dogfish, and Liverpool lakes in September, 19'20, not only was it true that not a single definitely recognized clean-water chironomid of the previous period (1913 — 1915) was found surviving in the larval or pupal stage in the muds, but, as well, the lists both of new entrants and survivals, of whatever habit of preference, showed up very meagerly both in variety and abundance as compared with the lists and figures for the Peoria Lake district and the river just above Havana.

Both in Thompson and Liverpool lakes, however, there did appear last year small numbers of one new form of possibly tolerant habit, this opinion being based only on its taxonomic nearness to *Chironomus dcorus* Job. In neither of these two lakes nor in Dogfish Lake was there any evidence of the recent intrusion of species of distinctly pollutational habit, while in the muddier portions of Quiver Lake two of the older clean-water Chironomidae (*C. ferrngineovittatits* Zett., and *Palpomyia longipennis* Lw.) that were formerly present in all the lakes of this group were the principal components of the 1920 chironomid population in September.

The changes in total chironomid poundages since 1914 — 1915 in all of these four lakes except Quiver, quite contrary to those in the Illinois River opposite, are in the direction of decrease rather than increase, the average yields in 1920 (9 pounds per acre in Dogfish, 4 pounds in Thompson, 2 pounds in Liverpool) being in no case over 50 per cent, of the

1914 — 1915 yields, and at the lowest only 5 per cent. ; while they are only 5 to 7 per cent, of the 1920 yields of Chironomidae from the river muds between Liverpool and Havana. The discrepancies between lake and river figures for immature midges in this portion of the river system, contrasting with essentially similar changes both in river and lake in the snail group, may be concerned with the fact of the greater ease of spread of the eggs and larvae of the midges down stream with the advance of pollution than by wing across the timbered ridges that separate the river from the lakes. At any rate, two of the principal pollutional or tolerant species contributing to last year's large river poundages of Chironomidae just above Havana (*C. plumosns* Linn., and *C. decorus* Job.) did not up to that time appear to have been successful in making the trip.

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MIDGK Larvae (Chikonomiuae) of Bottom Mrn.s of

LrvBRPOoL, Dogfish, Qutvf.r, and Thompson Lakes, 1913 — 1914

TO 1920 — July — October

1. Tolerant species or species of doubtful preference that have come in since-

1913— IJ,.

Chironomus sp. near *decorus* Joh., No. 2. Common, 1920, Thompson Lake

only.

C. sp. near decorus Joh., No. 1. Common, 1920, Liverpool Lake only.

2. Formerly common cleaner-water species still surviving in 1920.

Chironomus ferrugineovittatus Zett. Present, 1920, Quiver Lake only.

Palpomyia longipennis Lw. Present, 1920, Quiver Lake only.

3. Cleaner-water species that have dropped out since 1913 — 1914.

Tanypus monilis L. Common, all lakes, 1913 — 1914.

Procladius concinnus Coq. Common, all lakes, 1913 — 1914.

P. sp. near concinnus Coq. Common, most lakes, 1913 — 1914.

Chironomus tentans F. Abundant, all lakes, 1913 — 1914.

C. modestus Say. Common, all lakes, 1913 — 1914.

1/. Tolerant species that have dropped out since 1913 — 1914.

Chironomus lobiferus Say. Present, 1913 — 1914, Thompson Lake only.

C. decorus Joh. Present, 1913 — 1914; lake not stated.

Mn)GE Larvae (Chironomidae) of Bottom Muds,

Lakes north of Havana, 1914 — 15 and 1920 — July — October

I. Mud bottom, 2 to 6 feet

Number per square yard

1914—1915

1920

Pounds per acre

1914—1915

II. Sandy or sand and mud bottom

1920

Quiver "channel" *

Quiver Lake, sandy shore

east side

Not separately counted

Not

separately

valued

• Figures in 1914 — 15 columns are for year 1915.

t Figures in 1914 — 15 columns are for year 1914

The increase in sludge-worms in Liverpool, Dogfish, and Thorhpson lakes since 1915, though comparing with decreases in midge larvae, as already mentioned, was greater even than the increase in these worms in the Illinois River channel opposite, apparently proving that this group has been able to accompany the pollution inward from the river, even if the midges have not. The sludge-worms in the first-named lake amounted in figures per square yard to 389 in September, 1930, as compared with none at all in the collections of July — October, 1915 ; and in pounds per acre to 14 in 1920 as against none in the former period. In Quiver Lake in 1920, both in the muddy portion and in the sandier areas, while the increase in small oligochaetes since 1915 is evident enough, it is very much less than in the other three lakes. The small oligochaetes taken in Liverpool, Dogfish, and Thompson in 1920 were nearly all Tubificidae and a great majority of them belonged to the genus Tubifex. In the Quiver Lake samples, on the other hand, small non-tubificid Oligochaeta were visibly more common than Tubificidae.

Sludge-worms, (principally Tubificidae),

Lakes north of Havana, 1914 — 15 and 1920

I. Mud bottom, 2 to 6 feet

• Figures in 1914 — 1915 columns are for year 1915.

t Figures in 1914 — 1915 columns are for year 1914.

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Not only in Thompson, Dogfish, and Liverpool lakes in 1930, but in Quiver Lake also in its muddy part, we found nothing at all surviving out of a list of some ten or twelve families of minor insects and miscellaneous small bottom-animals other than the groups already passed in review that were common in all of these lakes in 1914 — 1915. Though this item of loss in the lakes near Havana has been greater since 1915 than in the river just above Havana, the decrease in poundage therein in comparison to totals of all small bottom-animals has not been very large, the figures that follow showing that at the best the total weight of "other insects, etc.," in the bottom muds of these lakes in 1914 — 1915, did not run to twenty pounds per acre. In the Quiver Lake "channel" and in the sand and mud toward the beach side our collections showed leeches, Bryozoa, larvae of caddis-flies, and nymphs of Odonata in good variety and number, the "channel" average in 1920 (32 pounds per acre) being larger than in 1915.

"Other Insects," Worms, Crustacea, ktc. of the Bottom Muds.

xiakes north op havana, 1914 — 15 and 1920

I. Mud bottom, 2 to 6 feet

* Figures in 1914 — 1915 columns are for year 1915.

t Figures in 1914 — 1915 columns are for year 1914.

The decrease in average valuation of all small bottom-animals in the four lakes since 1915, with the sandy portions of Quiver Lake omitted, has been in ratios quite similar to those of average decline in the period in

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the river opposite, viz., 89.2 to 97.4 per cent. Such a decrease, on a base of only 150 to 400 pounds per acre as of 1915, evidently leaves a much smaller residue in the lakes than remains in the river of the enormously greater poundages that were there in and before 1915. Average total-poundages in these four lakes, with the exceptions mentioned, in fact amounted to only 12 to 16 pounds per acre in 1920 as compared with 40 pounds and 87 pounds in the channel and 4 — 7-foot zone of the river opposite, and with 5,180 pounds and 2,122 pounds in the corresponding river zones in the former period. Compared with this enormous falling off in yields in the three all-bottom-land lakes and the stagnant portion of Quiver, the decrease in poundage of all bottom-animals in the mud-sand-and-shell bottom of the Quiver Lake channel amounted to only 65 per cent, since 1915, leaving an average of 280 pounds per acre in September, 1920. As in the river just above Havana, the great part of the decline in lake yields of all bottom-animals since 1914 — 1915 has resulted from the destruction of the snails, the percentage of total-weight valuations

contributed by the small Mollusca dropping during the five or six-year period from 97.2 to 33.3 per cent, in Thompson Lake, and in the other three lakes, excepting the sandy portions, from 81 — 93 per cent, to none at all.

All Smaix Bottom-Aximaus, Lu\kes sobth or Havax.x.

1914—15 AXD 1920

J. Average total valuation, pounds per acre, and percentage by iceight of average total hauls contributed by snails

I. Mud bottom. 2 to 6 feet

(Continued on next page)

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II. Sandy or sand and mud bottom

Quiver Lake

"channel" *

Quiver Lake,

sandy shore,

east side

803

Not

separately

valued

280

121

65.1

99.6

8S.5

* Figures in 1914 — 1915 columns are for year 1915.

t Figures in 1914 — 1915 columns are for year 1914.

2. Composition, by weight, of the grand totals,

all mud bottoms, 2 to 6 feet, pounds per acre

While at the lower gages of the drier months of 1913 and 1914 not

less than 40 per cent, of the area[^]of Thompson Lake, probably fully 30

per cent, of Liverpool[^] and more than .00 per cent, of Dogfish and Quiver

lakes, was well filled with mixed aquatic vegetation, in 1919 and 1920 at

substantially the same gages and temperatures, it is certain that for any

of these lakes 2 per cent, would have been an extravagant figure to set

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as an estimate of the ratio of weeded to total area. In July or August, 1920, two per cent, would have meant about 100 acres of vegetation in Thompson at the height of the growth period, while as a matter of fact a careful examination of the lower two-thirds of this lake, which was weedier than the upper third five to seven years ago, disclosed less than two acres that could be called even partially weedy. Over a total of some thousands of acres in these four lakes since 1913 — 1915, the plants have disappeared as completely as dry stubble before a fire, and our observations in Peoria Lake and reports from fishermen and other river men concerning lakes that we have not entered since 1915 indicate that the destruction has been little if any less complete everywhere in the back-waters between Chillicothe and Havana.

In the scattered remnant-bunches of *Potamogeton pectinatus* still growing in Thompson Lake on the small sandy area of bottom at Warner's Cut in September, 1930, it was impossible to collect by the quantitative method used in 1914 and 1915. It is, however, clear that the former enormous weed-animal yields — over 2000 pounds per acre for 40 to 50 per cent, of the total lake and pond acreage in this district six or seven years ago — have vanished with the water plants, and that any figures that could have been obtained last year by any method would stand as wholly negligible in comparison with the old averages. Unless,

in fact, we assume, as is probably the case, that in the spring and earlier summer months there is at least a somewhat greater variety and abundance both of bottom and shore animals than was shown by the examinations made in September, 1920, it is hard to understand how the surviving food and game fishes that find their principal food in the small invertebrate fauna can continue to subsist without evident general emaciation. Both the fact that they were not yet generally emaciated in the summer of 1920, and the very low indicated residues of bottom and shore animals after six or seven months feeding at the same time may, from another view-point, be taken as evidence that the food supplies are in recent seasons being fed down to an unusually low point before autumn ; or, in other words, that the heavy declines in midsummer valuation-figures of all small bottom-animals since 1915 may not be quite so altogether an effect of the advance of sewage pollution as are the indicated changes in the composition of the fauna.

Stewart Lake, an all-Bottom-land Lake of the Shallower Type,
twenty Miles south of Havana

(Mile 224.0—226.0 below Lake Michigan)

The first impression one receives upon going into Stewart Lake and handling samples of its muds, after a week of work in the barren expanses of gas-filled lake and river floor twenty miles north, is one of large and distinct improvement in the odors and physical appearance of

[Begin Page: Page 71]

the muds, and in the comparative amount and variety of the old mixed aquatic vegetation still surviving. Though the evidence furnished by the state of the bottom fauna itself in this lake in 1920 was also in some directions indicative of a much more nearly normal condition than in the lakes north of Havana at the same time, the disappearance from Stewart Lake since 1915 of a large part of its old bottom fauna tells as surely of an advance of pollution thus far southward at some time or other since 1915. The evidence of extinction of almost the whole snail fauna, along with the fairly wholesome condition of the bottom muds in 1920, is, I think, probably to be taken as proof that the destruction of the snails took place a considerable time back, and that a wave of pollution such as accomplished it has not carried so far south in all recent flood seasons. The effect of the high Spoon River bar and the large natural impounding area just north of Havana in favoring sedimentation are probably more important than the eighteen or twenty miles of additional distance in protecting Stewart Lake from the regular invasions of putrescible settling suspended matter that have apparently been affecting Liverpool, Thompson, and other lakes in the Liverpool — Havana district every spring in recent years.

A snail list for Stewart Lake, 1915 to 1920, is not essentially different from one for Thompson Lake, showing the same single species (the little sphaeriid *Mnscjidium transversum*) surviving in small numbers; and a list of around thirteen species, representing seven families, that have dropped out since 1915. While Stewart Lake was not even several years ago a heavy bottom-fauna producer, either on the snail side or otherwise,

as compared with the lakes north of Havana, showing only 66 pounds per acre of snails and 74 pounds of all small bottom-animals in 1915, the 1920 figures of only 2 pounds per acre of snails (one species) and 28 pounds of all other bottom-animals look small enough even in comparison with the older figures to show that something has happened.

In the group of "other insects, etc.," Stewart Lake last year made fully as bad a showing as in small MoUusca, neither Bryozoa, leeches, small bottom-Amphipoda or Isopoda, Corixidae, Trichoptera, or Ephemeridae — all of which were found commonly in small numbers at collecting stations in this lake six or seven years ago — appearing in 1920 in any bottom collection.

Perhaps the best biological indication of a wholesomer condition of the mud in this lake than in those farther north, next after the more thriving condition of the vegetation, is the survival here in good numbers of a few of the more sensitive species of Chironomidae which have been completely exterminated in the lakes north of Havana except Quiver, and the failure of the sludge-worms to show as marked increase as in the lakes farther north. The total number of small oligochaete worms increased in Stev/art Lake between 1915 and 1920 only from three to twelve per square yard — a negligible increase as compared with, for ex-

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ample, to 389 per square yard in Liverpool Lake and to 128 per

square yard in Thompson Lake in the same period.

While two of the formerly common clean-water midges, *Chironomus ferriigneovittatis* Zett. and *Procladius concinnus* Coq. were still common in the lake in 1920 and, along with a new entrant, also at least not of pollutional habit, made up the bulk of the large increase in Chironomidae in collections in this lake since 1915, the full list of species for 1920 is much smaller than formerly, and calls attention to several species, some of which are partial to cleaner bottom, that have dropped out since the earlier period.

Though separate collections of the small weed-animals were not taken in 1913 — 1915 in Stewart Lake, as in Thompson Lake and others just north of Havana, it is well enough known to us from general observations that there was a rich fauna of that kind here in those years. Since much the richest portion of the old weed-fauna areas in the Illinois valley lakes was found in the *Potamogeton* or *Ceratophyllum* associations, and the poorest in the *Nymphaea* and *Nelumbo* beds, and as Stewart Lake lost a very much larger proportionate amount of its *Potamogeton* and *Ceratophyllum* than of its lilies in the five years preceding 1920, it is plain that the loss in the small weed-fauna of the lake has been very large in the period, though smaller than in the lakes twenty miles north.

A table recapitulating all our 1920 distributional data on the larval midges from the river and lakes between Chillicothe and Browning follows the short lists of species from Stewart Lake next presented, and with them concludes the present section.

Midge larvae (Chironomidae) of Bottom Muds,
Stewart Lake, 1913—1914 to 1920

1. Cleaner-water species or other species present in 1913 — 1915 that have
dropped out since then.

Palpomyia species, 9 mm.

Tanytus monilis L.

Procladius culiciformis Lw.

Tanytus dyari Coq.

Chironomus lobiferus Say.

2. Cleaner-water species new to the lake since 1913.

Palpomyia longipennis Lw. Common, 1920.

3. Cleaner-water species common both 1913 — 1915 and 1920.

Procladius concinnus Coq.

Chironomus ferrugineovittatus Zett.

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All smalt, Bottom-Animals, Stewart Lake, 1915 and 1920

mud bottom, 2 to 5 feet

Percentage of snails

89.1

Estimated Reduction of Midsummer Surplus Stocks in the Combined Acreage between Chillicothe and Lagrange Dam (103 Miles) since 1914¹⁹¹⁵

While the necessarily restricted range of our bottom-and weed-fauna survey of 1920, compared with that of July — October, 1914 and 1915, leaves more gaps to be supplied by estimate in any general comparison than is perhaps best, it has seemed worth while, as a conclusion to the present paper, to make some computations of the approximate total loss since 1914 — 1915 in surplus bottom- and weed-fauna stocks- as of the midsummer period for the entire acreage of river and lakes in the formerly enormously rich middle Illinois Valley district between the head of Peoria Lake and the Lagrange dam. These calculations have involved a partial reapportionment, by estimate largely, both of acreages and of acre-yields, as of 1908 — 1915. as published in a preceding paper,* these

The Small Bottom and Shore Fauna of the Illinois River and its Connecting Lakes, Chillicothe to Grafton: Its Valuation; Its Sources of Food Supply; and its-Relation to the Fishery. By R. K. Richardson. *J. Ill. Nat. Hist. Surv.*, Vol. 13, Art. XV. 1921.

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being here estimated as actual, outside of levees, and not as in the virgin valley — for the purpose of comparison with the 1920 data rather than with the fish-yield figures of 1908 ; and involving as well, the application in some cases of both river and lake acre-yield-figures for limited areas studied in 1920 to much larger acreages not collected in that year. For these reasons, only general results are given here, and tabulation is avoided as giving too much of an air of certainty to figures that are at the best only approximations.

In the 60.5 miles between Chillicothe and Havana in July — October, 1914 — -15 it appears, then, that there were surplus stocks of both bottom and weed animals, after deduction of shell weight, amounting to around 27,500,000 pounds in a combined open river and lake acreage, including Peoria Lake of about 29,000 acres at an approximate gage of ten feet, Peoria, or eight feet, Havana. Of this total I have estimated that about 2,700,000 pounds were in the bottom muds of the river and the wide waters of Peoria Lake between Chillicothe and the dam at Copperas Creek ; about 3,800,000 pounds in the river muds between Copperas Creek dam and Havana; and about 3,000,000 pounds on the lake and other backwater floors between Copperas Creek and Havana. Considerably more than half of the total, that is, over 18,000,000 pounds (65 per cent.) of it, seems to have been made up of the small weed-living species, of which Peoria Lake apparently furnished more than 4,000,000 pounds a few years ago, and the rich lakes between Copperas Creek dam and Havana, around 14,000,000 pounds.

Applying to these same acreages such average weights per acre as are suggested by the findings of August — September, 1920, we note first an estimated reduction since 1915 in the bottom fauna of Peoria Lake

and adjacent river between Chillicothe and Copperas Creek that amounts roughly to 50 per cent., and that affects about 10,000 acres at the lower gages of the ten years preceding 1920. Next are calculated reductions of 92 to 93 per cent, in the bottom fauna of some 1,400 acres of river and some 17,000 acres of lakes between Copperas Creek dam and Havana; and, last, reductions to practical nullity in the case of the acre-yield figures of small weed-animals both of the weedy acreage of Peoria Lake, estimated at 2,000 acres in 1910 — 1914, and of the one-time approximate 10,000 acres of shallow weed-area in the lakes between Copperas Creek dam and Havana. The total loss in poundage of surplus stocks between Chillicothe and Havana in five years appears indeed to have surpassed 25,500,000 pounds, or to have amounted on the average for both river and lakes, including both bottom and weed populations, to over 93 per cent. The extent of the loss is better appreciated when it is known that it is usual to figure that the weight of fish living on animal food can be increased about one pound for each five pounds of such food eaten. From this view-point the loss in potential fish-yield apparently stands at something like 5,000,000 pounds yearly for the section, if also it be true, as is

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generally assumed, that stocks of the kind in question in the run of years at least reproduce themselves in weight once annually.

Below Havana we lack data for carrying out computations in the detail or with anywhere near the exactness attempted for the 60-mile

section to the north, particularly in the case of the bottom and weed fauna of the lakes, having collected in only one of these in 1920. We note, first, of the 4,500 odd acres of river between Havana and the dam at Lagrange, an apparent slight gain over 1915 in the bottom yields, which is, however, probably no greater than the normal error to be expected with the apparatus and methods used. Offsetting this gain further, to the point in fact of rendering it negligible, are suggested losses of enormous size since 1914 — 1915 both in the bottom and weed fauna of the lakes and other backwaters in the 42.5 miles, which, combined, seem to have amounted to fully half the total stocks in the entire river and lake acreage open a little more than five years ago, or to more than twenty times the total bottom-fauna stocks of the section. This result, or a loss in the lake weed- and bottom-fauna of around 9,000,000 pounds, is simply arrived at if we estimate the loss in both the bottom- and weed-fauna stocks since 1915 at only 50 per cent. If we base conclusions for the entire acreage between Havana and the dam, on the recorded kind and extent of change in Stewart Lake since 1915 we must estimate the combined loss in both bottom and weed animals as even greater than 50 per cent., since it appears that on the weed-fauna side both the acreage and its average yield have probably been reduced that much. And as most of the lake acreage between Havana and the dam at Lagrange has since 1915 been north rather than south of the lower end of Stewart Lake, and therefore probably equally with it exposed to invasion by foul water and sediments, the estimate of a nine-million-pound loss in this district since 1915 may be allowed to stand as a minimally probable figure.

Combining a minimum loss in the first 42.5 miles south of Havana of

9,000,000 pounds with one of 25,500,000 pounds between Chillicothe and that point, we have, then, it seems, to reckon on not less than 34,500,000 pounds total reduction in the midsummer stocks of small bottom- and weed-animals in five years in about 103 miles ; or, putting it another way, on about 7,000,000 pounds potential fish-yield missing from any new calculations we wish to make about the more recent value of a 103-mile section of the Illinois River fishery that was, only a few years ago, among the richest of its kind in the fresh-water stream systems of the world, being then uninjured, so far as could be seen, by the increasing pollution from the population and industries to the north that has recently so nearly overwhelmed it. It will be noted that 7,000,000 pounds is little less than a third of the largest total fish-catch ever taken from the entire Illinois River (catch of 1908), more than half of estimated total yields in 1912 and 1913, and not improbably more than the total yield for the whole year 1920.

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Original isolations of the foot-rot Helminthosporium made

in May, 1919, from bits of tissue from wheat

grown in Madison county, Illinois.

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STATE OF ILLINOIS

DEPARTMENT OF REGISTRATION AND EDUCATION

DIVISION OF THE

NATURAL HISTORY SURVEY

STEPHEN A. FORBES. Chief

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BULLETIN

Article X.

On the Numbers and Local Distribution

of Illinois Land Birds of the Open

Country in Winter, Spring,

and Fall

BY

STEPHEN A. FORBES

and

ALFRED O. GROSS

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