SOME ECOLOGICAL OBSERVATIONS ON
EXPERIMENTAL FARM PONDS

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This is to certify that the

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SOME ECOLOGICAL OBSERVATIONS ON EXPERIMENTAL FARM PONDS

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INTRODUCTION

History

The farm pond has increased in popularity during the last decade and with this has come much information about its productive capacity (Swingle, 1942; Patriarche and Ball 1949). In the past, the use of these ponds for commercial production has been small, particularly in the northern states. Esthetic values, sport fishing, stock watering, fire protection, irrigation along with water conservation have been, perhaps, the prime motivation in their construction (Addy, et al 1942; Moss, 1942; Swingle, 1942; Clark, 1943).

In Europe and many southern states the use of ponds for food fish and bait production has proved successful but this use has lagged in the northern states, possibly because of the abundance of public lakes. Application of information relative to production obtained in warmer climates must be cautiously tested before use in northern regions although yield in pounds of fish has been somewhat established in terms of acreage and fertility (Swingle and Smith, 1940; Patriarche and Ball, 1949), the descriptive biology of a pond is far from complete and warrants additional study. Production varies with the geographical location, size, natural and artificial fertility and the individual variability of a pond (Ball 1949).

Purpose of the study

A study of general pond biology is needed as are special investigations, in an effort to establish a more complete understanding of the factors influencing the production of either bait minnows or game fish.

It was decided that the author was not in possession of sufficient general ecological information to design a sampling experiment amenable to simple statistical procedure. Because of the lack of general descriptive ecology, it was decided to use the observational method to gain some appreciation of this material in order that subsequent studies might be designed on a quantitative experimental basis.

The complete evaluation of the bottom fauna production using the Ekman dredge samples was not undertaken, rather observations were made to open the problems and questions arising from the use of such a device and to furnish general information about the animal forms.

Some of the problems considered in this study were the description of general animal ecology in the ponds; the effects of fertilization on the growth of plants and animals; the general chemistry; the daily temperature ranges; the capturing of minnows with glass traps and the holding of minnows. Observations were recorded of the nesting and spawning habits of the endemic minnow.

Bottom sampling methods and chemical analyses used in biological surveys were followed to a large degree as described by Davis (1938). Also many valuable ideas were obtained from his instructions concerning observations that should be recorded.

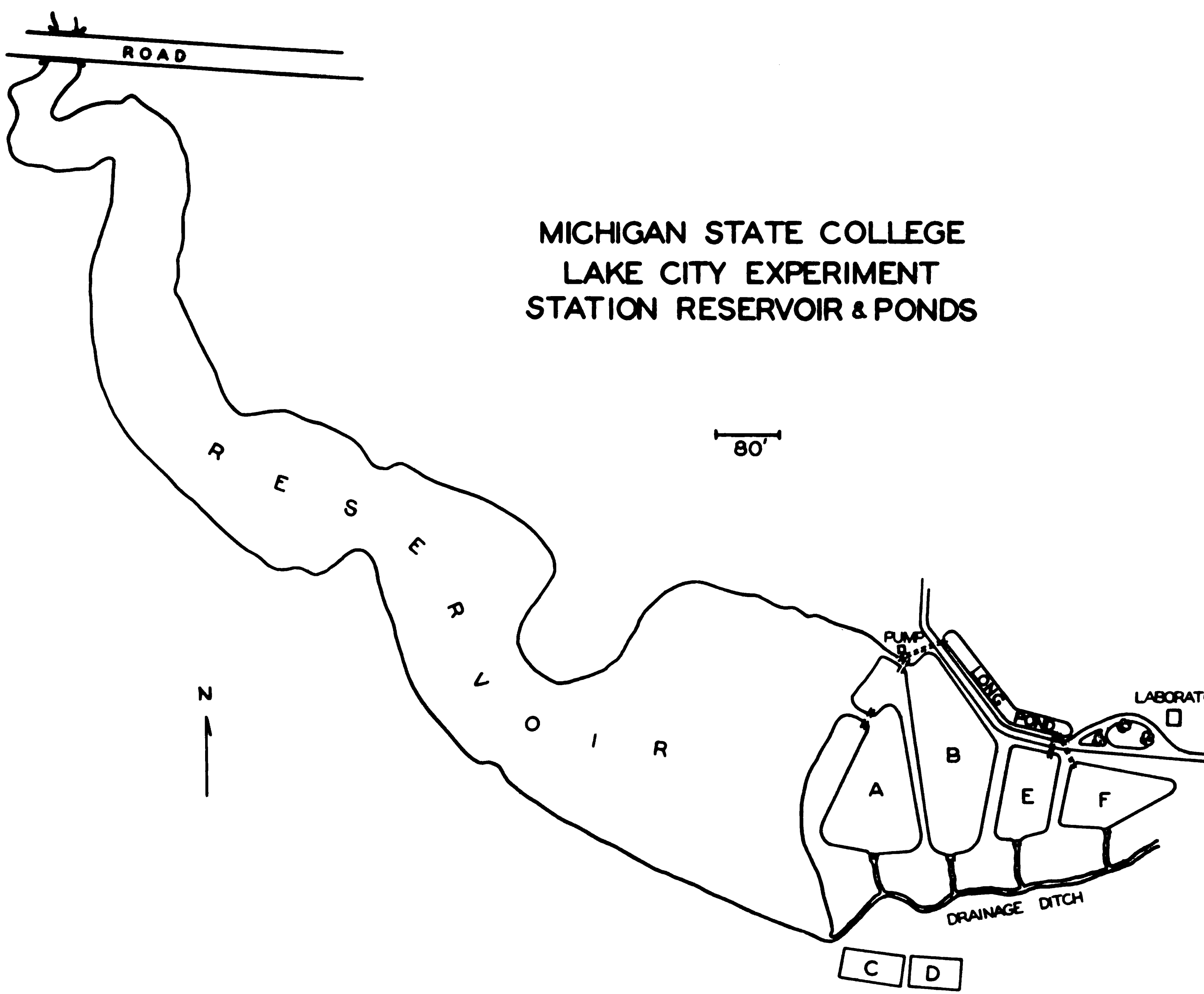
Description of ponds

The farm ponds on the Michigan State College Experiment Station, Lake City, Missaukee County were completed in June, 1945. There are six ponds, four of which are supplied with water from a reservoir adjacent to the ponds (A, B, E and F) and two of which depend on run off and ground water (C and D). The six ponds have a combined area of about one and one-half acres and the reservoir area is six and one half acres. Ponds A and B each have surface areas of almost one-half acre (Pond B is slightly larger than pond A). Ponds E and F are each less than one-quarter acre and nearly alike in size. The smaller ponds C and D each have nearly the same surface area of about 1500 square feet. The reservoir was formed by damming Mosquito Creek near its source on the Experiment Station. The four larger ponds are so constructed that they may be individually and completely drained and filled (Tack and Morofsky, 1946).

Two of the ponds (E and F) are supplied from the reservoir by means of a long ditch, two feet deep and twelve feet wide. The construction of the ponds involved the removal of muck and peat from the underlying sandy soil and bringing in of fill to form the dykes. In the years prior to this study there has been a deposition of a thick silt layer on the pond bottom varying in depth from one foot to a few inches. The only exposed sand now remaining is the slopes of the dykes and an occasional mound on the uneven pond bottoms. The bottoms of ponds A, B and F were partially graded with gravel in 1949.

Ponds B, D, E and F have been subjected to the addition of prepared fertilizers since their construction and ponds A and C have been used as controls. Ponds A, B, E and F have been drained and refilled in the early Spring and late Fall of past years and in addition there has been a gradual change of water, a result of leakage at the ontlet controls and from some natural ground water movement. Ponds C and D have a clay bottom but D has an accumulation of silt over the clay while C has an exposed clay bottom.

Figure 1. Map of ponds and reservoir on the Michigan State College Experiment Station, Lake City, Missaukee County, Michigan.


MICHIGAN STATE COLLEGE
LAKE CITY EXPERIMENT
STATION RESERVOIR & PONDS
ROAD
RESERVOIR
80'
N
PUMP
LONG POND
LABORATORY
A
B
C
D
E
F
DRAINAGE DITCH

CHEMICAL ANALYSES

General chemistry

The pond water was analyzed for the presence of oxygen, carbon dioxide and phenolphthalein and methyl orange alkalinity. Tests made from June to September were not designed to show the hourly or daily variation that may occur, but rather the general pattern that would develop during the fourth year of these ponds existence.

The water samples were usually taken at the surface, but during the periods of minnow distress they were obtained from a depth of two feet.

The samples were all collected from the ponds within a thirty minute interval, but the time of the day was not considered. However, a series of tests was made at four hour intervals to determine if the time of the day should be an important consideration when comparing weekly results.

Critical oxygen periods

Samples of pond water were tested on July 12, 13 and 14 at about four hour intervals prior to and following the application of fertilizer to the ponds. It was decided that this time of the year was a critical period of dissolved oxygen and with the fertilization of the ponds the oxygen demand might be increased. Actually the most critical period of oxygen demand occurred later in August for ponds B and E. During the July 12-14 tests pond D exhibited a low oxygen content prior to fertilization and dropped from a low of 4.7 p.p.m. at 4:00 A.M. to 3.0 p.p.m. at 4:00 A.M. the day after fertilizer had been added to the pond.

The oxygen content in the other ponds, A, B, E and F exhibited the same tendency but did not reach a critical point in terms of suffocation of the fish. They did have a low oxygen content at the 4:00 A.M. period after fertilization, and tests at 9:00 A.M. on the same day measured a low in pond F, 6.3 p.p.m. It was interesting to note that at those times the unfertilized reservoir followed the same pattern which might suggest that its changes in oxygen content were a result of a high nutrient content. However, the oxygen content in the reservoir for the summer was unstable and fluctuating, and did not vary according to the pattern exhibited by the ponds.

The low oxygen content recorded during the critical periods of oxygen demand in August suggests that there may not be an immediate change in oxygen content or demand following fertilization but that a lag occurs. This could be explained in the phytoplankton pulse resulting from fertilization.

Oxygen content values determined on August 2 were lower for pond E than the previous results for July 26. This drop from the earlier reading of 8:00 p.p.m. to 6.0 p.p.m. was the first indication of the sudden drop that was about to occur in the next three days. This pond had an unusual appearance with a milky scum formed on the surface. The 6.0 p.p.m. reading for oxygen was taken two feet below the surface. On August 5 when the other ponds were fertilized the oxygen content at two feet below the surface dropped to 3.8 p.p.m. and at the surface the results were 5.0 p.p.m. The milky to light green scum of decaying algae was found to be composed almost exclusively of _Anabaena planctonica_. Small fish were hanging motionless at the surface of the water or gasping. Fresh water was admitted to the pond and fertilization was delayed until August 8. Secchi disk reading at this time was one foot six inches.

On August 6 at 8:00 A.M. the oxygen content had risen to 6.8 p.p.m. and gasping of minnows had ceased. There was no recurrence of low oxygen content or minnow suffocation after this period in pond E.

The building up of the algal population in pond B to a point where decay reduced the oxygen content did not occur until August 16 when analysis showed a content of 6.6 p.p.m. of dissolved oxygen, a drop from an earlier reading of 8.8 p.p.m. of dissolved oxygen. On this date the increase in oxygen demand was apparent in the difference between the dissolved oxygen content at the inlet of 9.3 p.p.m. as compared to the reading at the outlet of 6.6 p.p.m. During the month of August the oxygen content in pond B ranged from 6.1 p.p.m. to 8.8 p.p.m. at the outlet. On September 6, tests for dissolved oxygen near the pond surface indicated that inlet waters had a content of 4.2 p.p.m. and outlet waters contained 3.7 p.p.m. of oxygen. On September 7, the 'sour' conditions formerly described for pond E were present and fresh water was admitted. The minnows had been observed lying motionless near the surface prior to the admission of fresh water and many small 1-2 inch bluegills or pumpkinseeds appeared at the inlet and outlet. Fish suffocation did not occur again in pond B.

Low oxygen content was found in ponds C and D prior to the low readings recorded for pond B, September 6. These two small ponds were not stocked with fish although occasional minnows and sticklebacks were present.

The insect life present was observed and the oxygen content may have influenced the kind and numbers of those animals present.

On August 23 the lowest values for dissolved oxygen were recorded for ponds C, D and E, when 2.9 p.p.m., 2.8 p.p.m. and 2.9 p.p.m., respectively, were found. These figures were questioned as to their validity because at the time heavy winds whipped the surface of the ponds daily. However, there were conditions present that may have caused this general lowering of oxygen content. The volume of water in all the ponds and reservoir was reduced, various algal blooms were present in the different ponds, these in advance states of maturity or decay and minnows in the larger ponds were collecting about the inlets but without showing other signs of suffocation. The rooted vegetation in the reservoir was very abundant and there was also a heavy growth of filamentous algae on the bottom in the end near the dam. There apparently was a heavy oxygen demand at this time of the year and critical conditions developed rapidly.

The dissolved oxygen values obtained by testing the surface water were considered generally satisfactory for the maintainance of plant and animal life. The tests were considered of special value during the critical periods of algal decay in August.

The results of tests made at four hour intervals indicated that the time of day is an important factor in comparing weekly results.

There was a shift in the values obtained for dissolved oxygen content between the outlet and inlet of the two larger ponds (A and B). The flow of fresh water into the ponds from the reservoir to replace seepage loss was very slow, but could explain those oxygen value differences. The fluctuation of oxygen demand between the two stations may depend on the quantity of algae present, light duration and intensity, temperature, decay, or wind direction and velocity.

The variation in dissolved oxygen values obtained for fertilized ponds of equal volume could have been a result of conditions not discovered in this study. A detailed study of the plankton forms and the quantities of them present might explain such a difference in oxygen demand. A refinement of the sampling technique might also explain those variations.

TABLE I

CHEMICAL ANALYSIS OF POND WATER BEFORE FERTILIZATION

Date	Pond	O_2[3] p.p.m.	CO_2[4] p.p.m.	Phth[5] p.p.m.	MO[6]	Time
July 12	AI[1]	11.13	0	18	69	8:00 PM
	AO[2]	10.08	0	15	--	
	BI	8.50	0	10	72	
	BO	11.02	0	16	73	
	C	8.61	trace	0	17	
	D	8.82	trace	0	10	
	E	9.97	0	14	73	
	F	7.35	0	14	71	
	Res[7]	10.60	0	9	74	

1 Pond inlet
2 Pond outlet
3 Oxygen
4 Carbon dioxide
5 Phenolphthalein
6 Methyl orange or total alkalinity
7 Reservoir

TABLE II

CHEMICAL ANALYSIS OF POND WATER BEFORE FERTILIZATION

Date 1949	Pond	O_2 p.p.m.	CO_2 p.p.m.	Phth p.p.m.	MO	Time
July 12	AI	9.24	0	14	70	12:00 Mid-night
	AO	9.03	0	17	69	
	BI	11.44	0	15	70	
	BO	10.08	0	19	73	
	C	7.14	trace	0	20	
	D	7.98	trace	0	13	
	E	10.08	0	9	66	
	F	10.71	0	17	61	
	Res	9.34	0	8	73	

TABLE III

CHEMICAL ANALYSIS OF POND WATER BEFORE FERTILIZATION

Date 1949	Pond	O_2 p.p.m.	CO_2 p.p.m.	Phth p.p.m.	MO	Time
July 13	AI	8.08	0	16	70	4:00 AM
	AO	8.4	0	17	70	
	BI	9.76	0	20	75	
	BO	8.08	0	19	71	
	C	4.83	trace	0	19	
	D	4.72	trace	0	12	
	E	8.40	0	8.0	65	
	F	11.13	0	15	70	
	Res	7.98	0	3	72	

TABLE IV

CHEMICAL ANALYSIS OF POND WATER AFTER FERTILIZATION

Date 1949	Pond	O_2 p.p.m.	CO_2 p.p.m.	Phth p.p.m.	MO	Time
July 13	AI	11.86	0	16	66	3:00 PM
	AO	8.71	0	11	56	
	BI	9.87	0	13	70	
	BO	9.45	0	13	81	
	C	6.72	trace	0	20	
	D	6.82	trace	0	9	
	E	7.03	0	7	62	
	F	7.66	0	13	69	
	Res	9.55	0	9	74	

TABLE V

CHEMICAL ANALYSIS OF POND WATER AFTER FERTILIZATION

Date 1949	Pond	O_2 p.p.m.	CO_2 p.p.m.	Phth p.p.m.	MO	Time
July 13	AI	8.18	0	16	68	8:00 PM
	AO	8.28	0	16	67	
	BI	7.54	0	12	73	
	BO	7.17	0	12	79	
	C	6.53	trace	0	11	
	D	6.53	trace	0	10	
	E	6.99	0	8	68	
	F	7.08	0	13	68	
	Res	8.92	0	8	73	

TABLE VI

CHEMICAL ANALYSIS OF POND WATER AFTER FERTILIZATION

Date 1949	Pond	O_2 p.p.m.	CO_2 p.p.m.	Phth p.p.m.	MO	Time
July 14	AI	7.54	0	13	63	4:00 AM
	AO	7.63	0	11	67	
	BI	9.93	0	12	70	
	BO	8.00	0	13	70	
	C	5.06	trace	0	17	
	D	3.03	trace	0	13	
	E	7.91	0	3	65	
	F	7.36	0	8	76	
	Res	6.44	trace	0	75	

TABLE VII

CHEMICAL ANALYSIS OF POND WATER AFTER FERTILIZATION

Date 1949	Pond	O_2 p.p.m.	CO_2 p.p.m.	Phth p.p.m.	MO	Time
July 14	AI	6.99	0	13	68	9:00 AM
	AO	7.54	0	14	67	
	BI	8.8	0	11	67	
	BO	8.64	0	11	68	
	C	5.88	trace	0	18	
	D	2.94	trace	0	11	
	E	6.53	0	1.0	64	
	F	6.34	0	10	65	
	Res	6.25	0	1.0	77	

TABLE VIII

CHEMICAL ANALYSIS OF POND WATER

Date 1949	Pond	O_2 p.p.m.	CO_2 p.p.m.	Phth p.p.m.	MO	Time
June 28	AI			.7	72	
	AO			1.1	71	
	BI			.7	73	
	BO			.7	71	
	C			0	23	
	D			.2	19	
	E			.4	63	
	F			.7	72	
	Res			.3	76	

TABLE IX

CHEMICAL ANALYSIS OF POND WATER

Date 1949	Pond	O_2 p.p.m.	CO_2 p.p.m.	Phth p.p.m.	MO	Time
July 4	AI	11.13	0	16	68	4:00 PM
	AO	8.92	0	14	71	
	BI	10.6	0	17	73	
	BO	8.92	0	9	70	
	C	7.98	trace	0	21	
	D	6.19	trace	0	13	
	E	8.19	0	12	66	
	F	8.19	0	16	71	
	Res	9.87	0	10	73	

TABLE X

CHEMICAL ANALYSIS OF POND WATER

Date 1949	Pond	O_2 p.p.m.	CO_2 p.p.m.	Phth p.p.m.	MO	Time
July 26	AI	6.99	0	1.0	66	
	AO	7.08	0	1.1	71	
	BI	7.17	0	1.5	68	
	BO	8.09	0	1.5	69	
	C	5.52	2.6	0	17	
	D	8.28	1.8	0	10	
	E	8.00	0	1.4	67	
	F	6.99	0	.4	69	
	Res	3.77	3.9	0	78	

TABLE XI

CHEMICAL ANALYSIS OF POND E WATER
DURING A CRITICAL PERIOD

Date 1949	Pond	O_2 p.p.m.	CO_2 p.p.m.	Phth p.p.m.	MO	Time
Aug. 2	EO[1]	6.07	0	.7	72	8:00 AM
Aug. 5	EO[2]	5.06	0	.4	75	
	EO 2ft.	3.86	0	.7	71	
Aug. 6	EO	6.25				

1 Taken at 2 feet 3 inches below surface
2 Surface test

TABLE XII

CHEMICAL ANALYSIS OF POND WATER

Date 1949	Pond	O_2 p.p.m.	CO_2 p.p.m.	Phth p.p.m.	MO	Time
Aug. 10	BO	6.8	0	3.4	75	
	BI	5.8	0	2.0	65	
	Res	3.3	2.2	0	91	
Aug. 16	AI	6.9	0	.8	84	
	AO	5.2	0	3.2	80	
	BI	9.3	0	2.3	78	
	BO	6.6	0	3.0	80	
	C	3.6	0	.1	16	
	D	6.4	12.5	0	10	
	E	9.7	0	2.1	80	
	F	5.1	0	.4	85	
	Res	6.4	0	1.0	97	

TABLE XIII

CHEMICAL ANALYSIS OF POND WATER

Date 1949	Pond	O_2 p.p.m.	CO_2 p.p.m.	Phth p.p.m.	MO	Time
Aug. 23	AI	5.6	0	2.0	71	
	AO	4.0	0	1.9	73	
	BI	6.0	0	2.2	81	
	BO	6.1	0	2.1	79	
	C	2.9	2.0	0	20	
	D	2.8	3.7	0	13	
	E	2.9	0	.3	81	
	F	5.6	0	.3	89	
	Res	6.1	0	.5	94	

TABLE XIV

CHEMICAL ANALYSIS OF POND WATER

Date 1949	Pond	O_2 p.p.m.	CO_2 p.p.m.	Phth p.p.m.	MO	Time
Aug. 30	AI	8.3	0	1.4	74	
	AO	7.2	0	1.4	76	
	BI	7.9	0	2.4	81	
	BO	7.8	0	2.1	79	
	C	4.6	trace	0	21	
	D	1.2	.65	0	10	
	E	9.6	0	1.7	80	
	F	6.4	0	.6	80	
	Res	1.0	0	.5	93	

TABLE XV

CHEMICAL ANALYSIS OF POND WATER

Date 1949	Pond	O_2 p.p.m.	CO_2 p.p.m.	Phth p.p.m.	MO	Time
Sept. 6	AI	3.0	0	1.5	73	
	AO	7.1	0	1.7	71	
	BI	4.2	0	1.0	77	
	BO	3.7	0	1.2	76	
	C	6.2	0	0.2	15	
	D	6.0	0	0.1	9	
	E	5.7	0	0.8	79	
	F	8.1	0	1.2	82	
	Res	7.9	0	1.3	95	
Sept. 7	BI	3.7				
	BO	3.8				

CLASSIFICATION OF HYDROSOLS

Veatch (1940) states that the subaqueous horizon of the soil profile can be classified only with the rather general terms 'organic' and 'inorganic' and that hydrosols can not be properly classified on the basis of our present knowledge.

Roelofs (1944) used a classification of lake bottom types in his Michigan studies which does away with such general terms as 'mud', 'ooze', etc. He defines pulpy peat as "very finely divided plant remains; parts of plants not distinguishable; varies in color from green to brown; varies greatly in consistency--often being semi-fluid." He describes muck as "black, finely divided organic matter, completely decomposed. This bottom type is found in flooded areas or at the mouths of streams; it does not form under anaerobic conditions." The hydrosols in the experiment station ponds according to his classification are then largely in these two groups along with diminishing amount, in order, of pulpy peat detritus, fibrous peat, sand, gravel and clay. The gravel was a recent introduction to the ponds and clay was hauled in to seal the dykes and cover the bottoms of ponds C and D at the time of construction. Fibrous and pulpy peat occur in the reservoir but are not found in the ponds, having been removed at the time of their construction. The ooze on the pond bottoms might be classified according to Veatch (1933) as of "the fine, slimy fluid peat."

BOTTOM SAMPLES

Methodology

The collections of bottom fauna were made with the six by six inch Ekman dredge from various areas of the ponds according to depth and to a degree of bottom type. The bulk of the samples were taken from an intermediate zone between the bottom ooze and the sandy banks of the ponds. This intermediate zone of sand and ooze was located at a depth of about three feet and was reached by wading in hip boots and lowering the dredge at arm's length. This located the dredge at the bottom of the slope of the pond dykes. In shallow ponds C and D, wading about the pond was possible and sampling was scattered in various depths and bottom types. Because of the habitat variation a special series of samples was taken to test the uniformity of results between and within these environmental areas.

The dredge contents were washed on a 30-mesh sieve, the finer contents were removed and the residue placed in the quart jars. This material was then sorted in white porcelain pans and the fauna removed to the four dram vials filled with preservative. The animals were counted and their volume measured by water displacement using a burette accurate to .1 ml. and with spaces between the gradations wide enough for estimating to the nearest .05 ml. The volume measurements and the number counts were made to compare production of the animals from one pond with that of another. The volumetric measuring was possible with those samples in which sufficient numbers of the individuals were obtained. In many cases, however, a reading was not possible because of volumes too small to measure by this method. Specific variability particularly in the Tendipedidae produced misleading results unless volume or weight was taken into account along with numbers. Identification was carried only to family as the difficulty of separating the Tendipedidae alone was prohibitive in such a broad study. Guyer (1952), identified 21 species of the tribe Tendipedini from a total of 40 species of midges found in the ponds.

The frequency of sampling was irregular, from once to four times a month, because of the time required to sort the samples, to make observations and to perform other operations. A decision as to the time to allow between samples could not be made on the basis of hatches or persistence of instars because it is known that these vary for different species, although it is not known how long they persist in any one state.

Several factors upon which the frequency of sampling might be based, but which are still undetermined, are ovoposition, habitat variation, number of species, periods of emergence and the length of time required to complete an instar.

Bottom sample apparatus

The apparatus used was a six by six inch Ekman dredge, a 30-mesh sorting sieve, numbered quart jars to hold the samples, 4-dram vials to hold the fauna and a white porcelain sorting pan. The animals were preserved with preservative composed of 1:4:5 formalin, alcohol and water.

Bottom organisms

Dredge samples were made in depths ranging from two inches to four feet in various habitats. Samples from the same depths within a pond were very similar in kind and number of animal species but there was enough variation to indicate a need for further study of their distribution. The samples from various depths indicated the need for correlation of species with particular habitat. The families found in the very shallow waters were sometimes more numerous than those found in the deep waters which often contained more individuals. In other ponds or at other times a reverse situation was found. Also some of the results did not exhibit any apparent affect of depth on the number of animals. This suggests that there are many factors influencing the distribution of these animals.

Tendipedidae was the predominant family of insects present and was found in all habitats at one time or another. There was a size variation that paralleled the depth change, larger animals generally being found in the deeper water. Since there was not an identification to species of the Tendipedids, the relationship of species to depth or habitat was not determined. The problem of the location of the animals from the time the eggs were laid until pupation was not investigated.

The selection of the environment may be made by the adult as indicated by the more numerous individuals found in the fertilized pond D as compared to the otherwise similar but unfertilized pond C. Perhaps there was a mortality factor related to the food availability. If the adult did select the fertilized pond the question arises as to what this selection was based on; perhaps it was coloration or odour.

<u>Chaoborus punctipennis</u> was identified in 1948 by Bray (1949) as being present in ponds C and D. This animal was found to be present in moderate quantity in the Ekman dredge samples taken during the present study but no netting was done to make an accurate count of their presence. It was

noted in this study that they varied in size within the same sample. Hesse, et al, (1937) states that many species of animals exhibit a form different in ponds than in lakes. Their description of Corethra plumicornis (Chaoborus sp.) indicates that the pond form is plumper, larger and of a dull coloration whereas the lake form is smaller and more transparent. They state that the tracheal bladders are plumper and that they have a larger fan.

Bray (1949) lists many forms not taken with the bottom sampler including one species of the Libellulidae and many Coleoptera. This was true of the present study and brings up a problem as to the effect of the loss from the ponds of these free swimming forms at the times of the spring and fall draining. A great loss of insect forms was noted during draining times but this varied depending upon what species appeared to be most abundant. During some drainings, quantities of Odonata were lost or destroyed; at other times Hemiptera such as the water boatman or backswimmer were the predominant species observed being lost. On one occasion Ranatra sp. was present at the outlet in huge quantities (1951). Bray suggests that the reduction of some of the Odonata such as Gomphus sp. which prey on the Tendipedids, may permit an increase in the population preyed upon in another season.

The Gomphidae were found to be very numerous in both the ponds and the reservoir during 1949 with other Odonata appearing in the samples and in the observations. Great quantities of Gomphus passed into the adult stage during the middle of May. Bray (1949) observed that the Gomphidae population in 1948 was about half as numerous as the Libellulidae population. In this study that proportion appeared to be reversed and in pond D in the shallow waters of one to six inches many Libellulidae were present, while in the deeper water of two feet, more Gomphidae appeared. The two-foot depth was sampled by sweeping with a hand net.

It was observed that along the shallow banks of all the ponds quantities of immature and mature Hemiptera, mostly water boatmen, were present but that in the preparation and the lowering of the dredge they became so disturbed that few were taken in the sampler.

Sample uniformity

A series of samples was taken from each pond on the same day and from different depths for the purpose of testing the variation of the fauna present (Tables XXIII-XXVIII). This practice of taking a series of samples from different depths was continued from April through August. The number taken at any one time depended on the time available for sorting. The depths tested ranged from two inches to four feet.

Some of the uniformity tests indicated that samples taken from the same depth would yield similar results for some species but not for others. It is thought that there were not enough samples taken from any particular depth on the same day to permit a valid conclusion to be drawn. There was enough fluctuation in results to indicate that more samples should be taken.

The variability of adjacent successive dredgings indicates the need for a carefully planned design for sampling a pond bottom.

The number of Tendipedids taken from the ponds throughout the summer (Figures 2, 3, 4), might be used as an indicator to show the productivity of fertilized ponds compared to that of the unfertilized ponds. The results of dredging from the deeper waters did indicate that the variation, with some exceptions, between samples from this depth was not as great as it was with the change of depth or of habitat and did not preclude their use in measuring the trend in numbers for the season. The variation of numbers and species with the change of depth indicates a need for other studies of specific variability as related to depth.

The types of environmental diversity were in general associated with the depth but their description was not fully explored. After discovering that the number and volume of species varied with the habitat an attempt was made to confine the weekly dredgings to a constant depth assuming that the bottom type also remained uniform.

This study raised questions additional to those answered by the present surveying techniques. Some of the problems suggested by the study are: (1) the need for a measure of the extent of availability of a standing crop of insects and plankton to the fish; (2) a need for a complete analysis of the food chain in terms of nutrient conversion; (3) a study of plant types and quantities developed in the ponds from added fertilization; (4) a method for measuring the quantity of usable plankton necessary for maximum or minimum growth of herbivores and carnivores; (5) a determination of the rates of turnover of primary producers (plankton); (6) a need for more detailed life history studies of the insects.

The genus Chironomus is often one of the more prevelant bottom organisms found in ponds (Needham and Lloyd, 1937; Patriarche and Ball, 1949) and is known to pass through several stages in its development. Investigators have described the occurance of an increase in numbers at various times of the year, Ball (1949). Ball has also observed that these insects occur in varying amounts depending on the pond location, the depth, and the application of fertilizers. This phenomenon also occurred in the ponds at Lake City.

It would be desirable to have a more complete description of the environment to explain the rate of growth, the selection of water by the adults, the mortality rate or the survival and the length of hatching periods. When a study of this type has been completed the availability of the organisms for fish food under different conditions and periods of the year might be predicted or determined for any one pond.

Figure 2. The number of Tendipedidae per one quarter sq. ft. collected in dredge samples from ponds A and B.

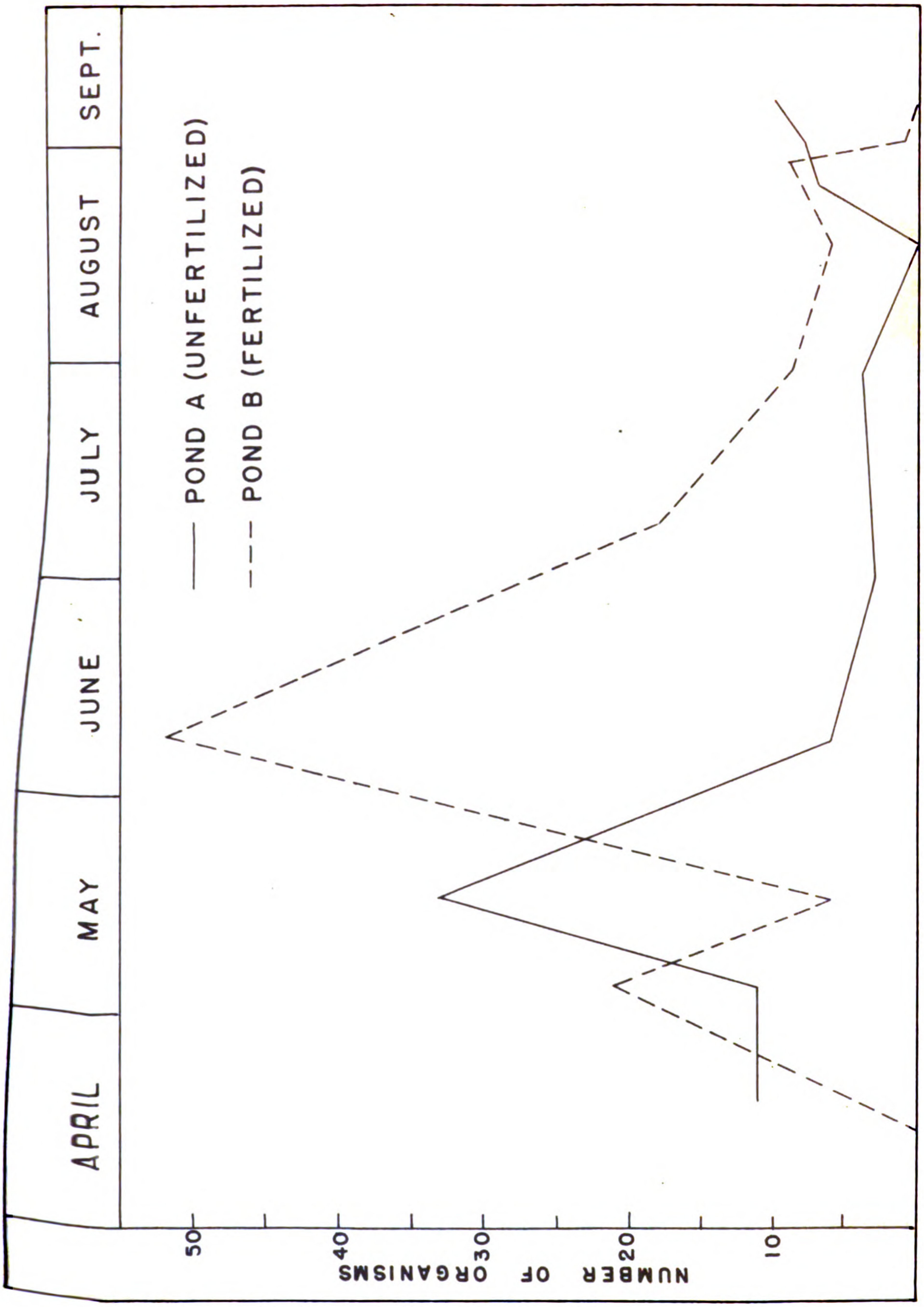

APRIL
MAY
JUNE
JULY
AUGUST
SEPT.
POND A (UNFERTILIZED)
POND B (FERTILIZED)
NUMBER OF ORGANISMS
10
20
30
40
50

Figure 3. The number of Tendipedidae per one quarter square foot collected in dredge samples from ponds C and D.

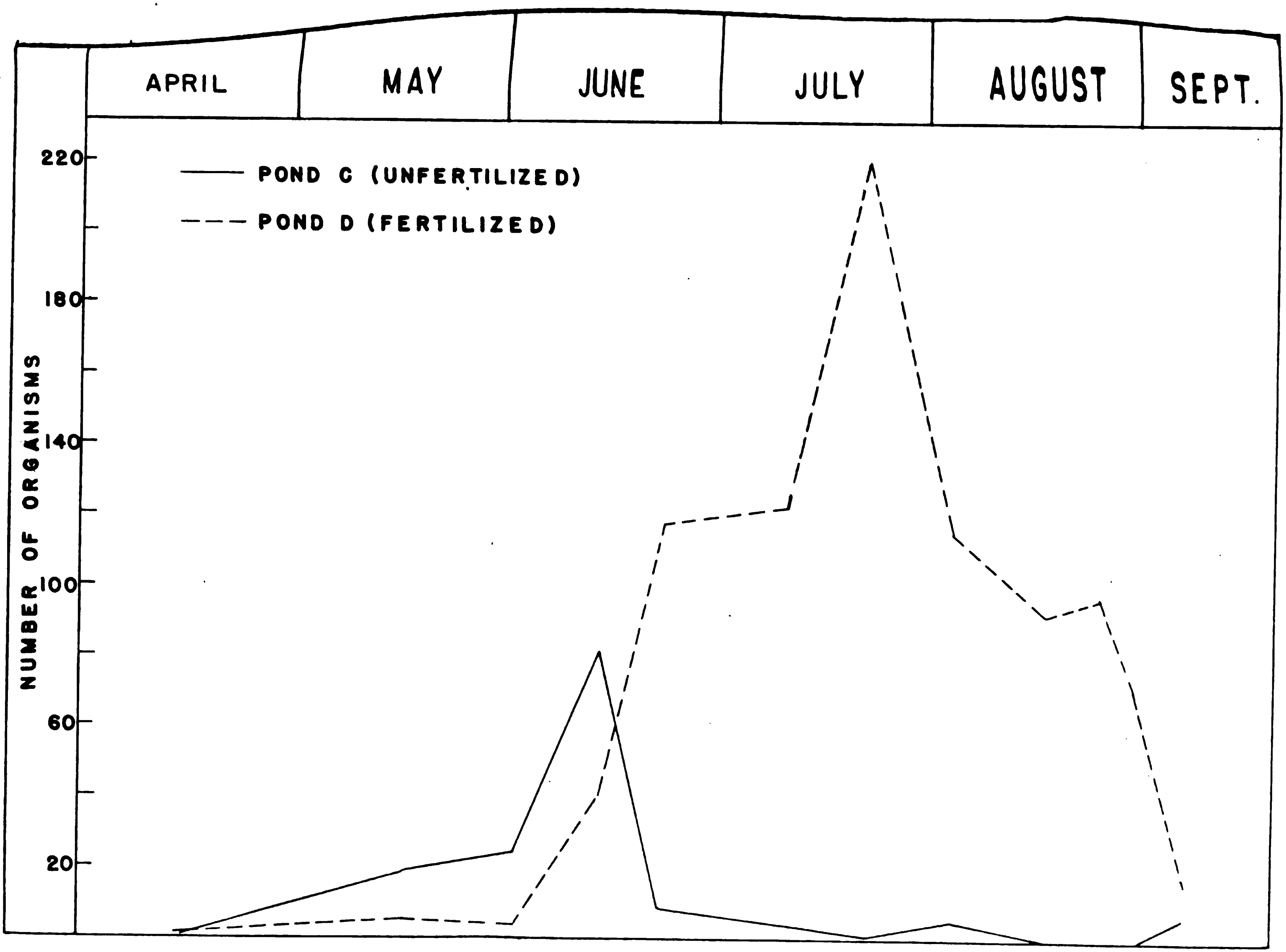

APRIL
MAY
JUNE
JULY
AUGUST
SEPT.
220
180
140
100
60
20
NUMBER OF ORGANISMS
POND C (UNFERTILIZED)
POND D (FERTILIZED)

Figure 4. The number of Tendipedidae per one quarter square foot collected in dredge samples from ponds E and F.

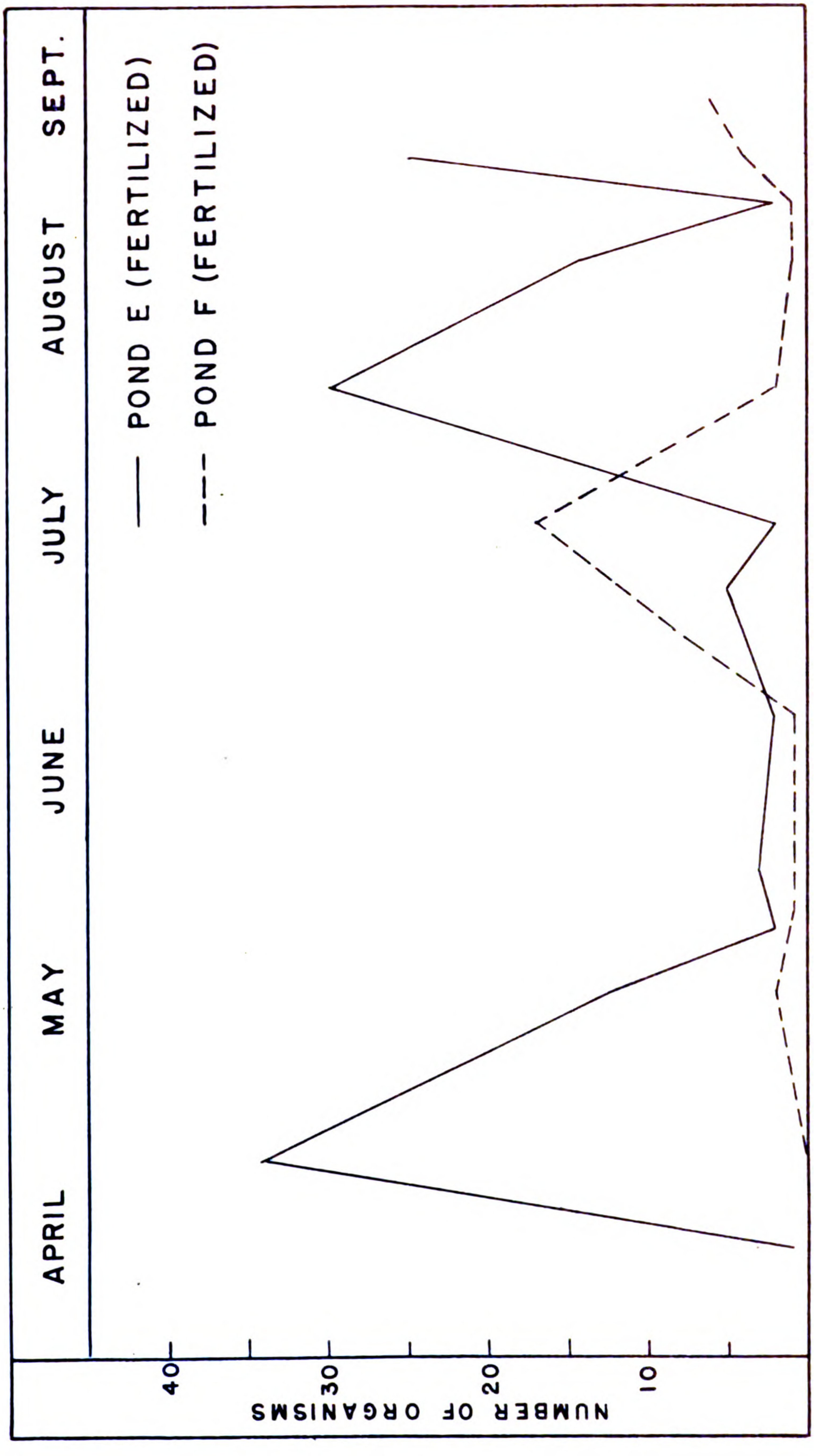

APRIL
MAY
JUNE
JULY
AUGUST
SEPT.
POND E (FERTILIZED)
POND F (FERTILIZED)
40
30
20
10
NUMBER OF ORGANISMS

TABLE XVI

A TABULATION OF THE DREDGE-SAMPLE DATA OF THE TENDIPEDIDAE IN THE SAMPLES

Date		Ponds					
		A Number of Organisms	B Number of Organisms	C Number of Organisms	D Number of Organisms	E Number of Organisms	F Number of Organisms
April	14				1	1	
	18	11					
	25					34	
May	4	11	21				
	16	33	6	19	5	12	2
	24					2	
	26						1
June	1					3	
	2			24	4		
	8	6	52				
	14			82	40		
	21					2	1
	23			9	118		
	30	3					7
July	7					5	
	8		18				
	11				123		
	12			4			
	15					2	17
	22			2	220		
	29	4	9				
Aug.	2					30	2
	4			6	116		
	17	0	6		93		
	18					19	1
	25	7			97		
	26					2	1
	28		9				
	31				70		
Sept.	1	8	1			25	4
	7	10	0	7	19		
	8						6

TABLE XVII

BOTTOM ORGANISMS TAKEN WITH AN EKMAN DREDGE FROM UNFERTILIZED POND A DURING 1949

TABLE XVII

BOTTOM ORGANISMS TAKEN WITH AN EKMAN DREDGE FROM UNFERTILIZED POND A DURING 1949

Organism		April 18	May 4	May 16	June 8	June 30	July 29	Aug 17	Aug 25	Sept 1	Sept 7
Tendipedidae....	No.[1]	11	11	33	6	3	4	-	7	8	10
	Vol.[2]	-	-	.2	-	-	-	-	-	-	-
Ephemeridae.....	No.	11	-	1	3	2	2	-	2	6	12
	Vol.	-	-	-	-	-	-	-	-	-	-
Corixidae.......	No.	-	-	-	1	1	-	-	-	-	-
	Vol.	-	-	-	-	-	-	-	-	-	-
Dytiscidae......	No.	-	-	-	1	-	1	-	-	-	-
	Vol.	-	-	-	-	-	-	-	-	-	-
Aeschnidae......	No.	-	-	-	-	-	8	48	9	21	1
	Vol.	-	-	-	-	-	-	.3	-	.3	-
Hydrachnidae....	No.	-	-	-	3	-	-	1	1	-	-
	Vol.	-	-	-	-	-	-	-	-	-	-
Gammaridae......	No.	2	-	-	6	-	16	2	10	7	15
	Vol.	-	-	-	-	-	-	-	-	-	-
Tubificidae.....	No.	-	8	-	20	2	-	-	-	-	-
	Vol.	-	-	-	-	-	-	-	-	-	-
Hirudinidae.....	No.	-	-	-	-	-					
	Vol.	-	-	-	-	-					

1 Number of organisms
2 Volume of organisms where measurable

TABLE XVIII

TABLE XVIII

BOTTOM ORGANISMS TAKEN WITH AN EKMAN DREDGE FROM FERTILIZED POND B DURING 1949

Organism		April 14	May 4	May 16	June 8	July 8	July 29	Aug 17	Aug 28	Sept 1	Sept 7
Tendipedidae....	No.	-	21	6	52	18	9	6	9	1	-
	Vol.	-	-.1	-	-.1	-.1	-.1	-	-	-	-
Ephemeridae.....	No.	-	-	-	5	-				1	
	Vol.	-	-	-	-	-				1	
Ceratopogoniae..	No.				10	7	1	1			11
	Vol.				-	-	-	-			-
Corixidae.......	No.					2					
	Vol.					-					
Trichoptera.....	No.			2			3	1			
	Vol.			.1			-	-			
Dytiscidae......	No.				1						
	Vol.				-						
Aeschnidae......	No.	4					1				
	Vol.	.2					-				
Libellulidae....	No.	1									
	Vol.	.1									
Coenagrionidae..	No.	1									
	Vol.	1									
Tubificidae.....	No.		34	4		33	56	43		42	
	Vol.		-.1	-		-.1	-.1	-		-	
Patamobiidae....	No.				1						
	Vol.				.1						
Gammaridae......	No.						1		1		
	Vol.						-		-		
Hirudinidae.....	No.								2		
	Vol.								1		

TABLE XIX

BOTTOM ORGANISMS TAKEN WITH AN EKMAN DREDGE FROM UNFERTILIZED POND C DURING 1949

Organism		April 14	May 16	June 2	June 14	June 23	July 12	July 22	Aug 4	Aug 17	Aug 25	Aug 31	Sept 7
Tendipedidae...	No.	-	19	24	82	9	4	2	6	-	-	-	7
	Vol.	-	-	.2	-.1	-	-	-.2	.1	-	-	-	-
Ceratopogoniae.	No.	3	5	-	1	-	-	-	1	-	1	-	6
	Vol.	-	-	-	-	-	-	-	-	-	-	-	-
Culicidae......	No.	-	-	-	1	-	2	1	3	7	6	-	1
	Vol.	-	-	-	-	-	-	-	-	-	-	-	-
Tabanidae......	No.	1	-	-	-	-	-	-	-	-	-	-	-
	Vol.	-	-	-	-	-	-	-	-	-	-	-	-
Ephemeridae....	No.	1	-	.15	-	1	-	-	-	-	-	-	-
	Vol.	-	1	-	-	2	-	-	-	-	-	-	-
Gammaridae.....	No.	-	-	-	-	-	-	-	-	-	-	-	1
	Vol.	-	-	-	-	-	-	-	-	-	-	-	-
Corixidae......	No.	-	-	-	-	-	-	-	1	-	-	-	-
	Vol.	-	-	-	-	-	-	-	-	-	-	-	-
Dytiscidae.....	No.	-	-	-	-	-	1	-	-	-	-	-	-
	Vol.	-	-	-	-	-	.1	-	-	-	-	-	-
Aeschnidae.....	No.	-	-	-	-	-	1	-	-	-	-	-	-
	Vol.	-	-	-	-	-	.3	-	-	-	-	-	-
Hydrachnidae...	No.	-	-	-	-	1	-	-	-	-	-	-	-
	Vol.	-	-	-	-	-	-	-	-	-	-	-	-
Tubificidae....	No.	10	16	1	11	-	31	12	-	11	31	-	33
	Vol.	-	-	-	.1	-	.15	-.1	-	-	.1	-	-.1
Potamobiidae...	No.	-	-	-	-	-	-	-	-	-	-	-	1
	Vol.	-	-	-	-	-	-	-	-	-	-	-	5.0

TABLE XX

BOTTOM ORGANISMS TAKEN WITH AN EKMAN DREDGE FROM FERTILIZED POND D DURING 1949

Organism		April 14	May 16	June 2	June 14	June 23	July 11	July 22	Aug 4	Aug 17	Aug 25	Aug 31	Sept 7
Tendipedidae...	No.	1	5	4	40	118	123	220	116	93	97	70	19
	Vol.	-	-	-	-	-	1.2	4.9	2.4	1.8	3.2	1.0	.45
Ceratopogoniae.	No.	-	-	4	6	-	-	-	-	-	-	-	3
	Vol.	-	-	-	-	-	-	-	-	-	-	-	-
Tabanidae......	No.	-	-	1	-	-	-	-	-	-	-	-	-
	Vol.	-	-	-	-	-	-	-	-	-	-	-	-
Corethra.......	No.	-	-	-	-	-	6	-	-	-	2	-	10
	Vol.	-	-	-	-	-	-	-	-	-	-	-	-
Ephemeridae....	No.	1	-	-	-	1	-	-	-	-	-	-	-
	Vol.	-	-	-	-	-	-	-	-	-	-	-	-
Corixidae......	No.	-	-	-	-	-	-	-	-	-	-	-	1
	Vol.	-	-	-	-	-	-	-	-	-	-	-	-
Dytiscidae.....	No.	-	-	-	-	-	-	-	-	-	-	-	-
	Vol.	-	-	-	-	-	-	-	-	-	-	-	-
Haliplidae.....	No.	-	1	-	-	-	-	-	-	-	-	-	2
(larvae)	Vol.	-	-	-	-	-	-	-	-	-	-	-	-
Aeschnidae.....	No.	-	-	3	-	-	-	-	-	-	-	-	-
	Vol.	-	-	.4	-	-	-	-	-	-	-	-	-
Odonata........	No.	-	-	1	-	-	-	-	-	-	-	1	-
	Vol.	-	-	.25	-	-	-	-	-	-	-	-	-

Contimued next page

TABLE XX - Concluded

Organism		April 14	May 16	June 2	June 14	June 23	July 11	July 22	Aug 4	Aug 17	Aug 25	Aug 31	Sept 7
Dytiscidae.....	No.	-	-	-	-	-	-	-	-	-	-	-	-
(larvae)	Vol.	-	-	-	-	-	-	-	-	-	-	-	-
Trichoptera....	No.	-	-	-	1	-	-	-	-	1	-	-	-
(case)	Vol.	-	-	-	-	-	-	-	-	-	-	-	-
Hydrachnidae...	No.	1	-	5	-	-	-	-	-	-	-	-	3
	Vol.	-	-	-	-	-	-	-	-	-	-	-	-
Gammaridae.....	No.	-	-	-	-	-	-	-	-	-	-	-	-
	Vol.	-	-	-	-	-	-	-	-	-	-	-	-
Hirudinidae....	No.	-	-	-	-	-	-	-	-	1	-	-	-
	Vol.	-	-	-	-	-	-	-	-	-	-	-	-
Sphaeriidae....	No.	-	-	-	-	-	-	-	-	-	-	-	-
(2 sp.)	Vol.	-	-	-	-	-	-	-	-	-	-	-	-
Nematode......	No.	-	-	1	-	-	-	-	-	-	-	-	-
	Vol.	-	-	-	-	-	-	-	-	-	-	-	-

TABLE XXI

BOTTOM ORGANISMS TAKEN WITH AN EKMAN DREDGE FROM FERTILIZED POND E DURING 1949

Organism		April 14	April 25	May 16	May 24	June 1	June 21	July 7	July 15	Aug 2	Aug 18	Aug 26	Sept 1
Tendipedidae...	No.	1	34	12	2	3	2	5	2	30	19	2	25
	Vol.	-	-	-	-	-	-	-	-	-	-	-	-
Ceratopogoniae.	No.	-	-	2	1	41	18	12	1	1	3	-	14
	Vol.	-	-	-	-	-	-	-	-	-	-	-	-
Culicidae......	No.	-	-	-	-	-	-	-	-	-	-	1	-
	Vol.	-	-	-	-	-	-	-	-	-	-	-	-
Tabanidae......	No.	-	-	-	-	-	-	-	-	-	-	-	1
	Vol.	-	-	-	-	-	-	-	-	-	-	-	.1
Ephemeridae....	No.	29	63	8	-	78	24	1	-	-	-	-	2
	Vol.	-	-	-	-	.1	-.1	-	-	-	-	-	-
Trichoptera....	No.	-	1	-	-	-	2	2	2	14	1	-	-
	Vol.	-	-	-	-	-	-	-	-	-	-	-	-
Odonata........	No.	1	-	2	-	-	1	-	-	-	-	-	-
	Vol.	-	-	.15	-	-	-	-	-	-	-	-	-
Aeschnidae.....	No.	-	-	-	-	1	-	2	-	-	2	3	-
	Vol.	-	-	-	-	-	-	.5	-	-	-	.1	-
Dytiscidae.....	No.	-	-	-	-	-	-	-	1	-	-	-	-
	Vol.	-	-	-	-	-	-	-	-	-	-	-	-
Haliplidae.....	No.	-	-	-	-	-	-	-	-	1	-	-	-
	Vol.	-	-	-	-	-	-	-	-	-	-	-	-

Continued next page

TABLE XXI - Concluded

Organism		April 14	April 25	May 16	May 24	June 1	June 21	July 7	July 15	Aug 2	Aug 18	Aug 26	Sept 1
Corixidae.......	No.	-	-	-	-	-	2	-	-	-	-	-	-
	Vol.	-	-	-	-	-	-	-	-	-	-	-	-
Gammaridae......	No.	-	2	-	-	1	1	-	-	-	-	-	-
	Vol.	-	-	-	-	-	-	-	-	-	-	-	-
Hydrachnidae....	No.	1	-	-	10	1	-	-	-	-	-	-	-
	Vol.	-	-	-	-	-	-	-	-	-	-	-	-
Tubificidae.....	No.	-	2	2	-	-	11	1	1	4	5	-	1
	Vol.	-	-	-	-	-	1	-	-	-	-	-	-
Hirudinidae.....	No.	-	-	-	-	-	3	-	1	-	-	-	-
	Vol.	-	-	-	-	-	-	-	-	-	-	-	-

TABLE XXII

BOTTOM ORGANISMS TAKEN WITH AN EKMAN DREDGE FROM FERTILIZED POND F DURING 1949

Organism		April 18	April 25	May 16	May 26	June 21	June 30	July 15	Aug 2	Aug 18	Aug 26	Sept 1	Sept 8
Tendipedidae...	No.	-	-	2	1	1	7	17	2	1	1	4	6
	Vol.	-	-	-	-	-	-	-	-	-	-	-	-
Ceratopogoniae.	No.	-	-	-	1	-	2	3	5	-	-	-	-
	Vol.	-	-	-	-	-	-	-	-	-	-	-	-
Tabanidae......	No.	1	1	-	-	-	-	-	-	-	-	-	-
	Vol.	.1	-	-	-	-	-	-	-	-	-	-	-
Ephemeridae....	No.	1	2	3	4	2	7	1	-	1	2	-	9
	Vol.	-	-	-	-	-	-	-	-	-	-	-	-
Trichoptera....	No.	1	-	-	1	-	-	-	-	-	-	-	-
	Vol.	-	-	-	-	-	-	-	-	-	-	-	-
Odonata........	No.	-	1	2	-	-	-	-	-	-	1	-	5
	Vol.	-	.25	-	-	-	-	-	-	-	-	-	-
Aeschnidae.....	No.	2	-	-	-	2	-	1	6	-	4	-	3
	Vol.	.1	-	-	-	.2	-	.15	-	-	-	-	-
Dytiscidae.....	No.	-	-	-	-	4	-	-	-	-	-	-	-
(larvae)	Vol.	-	-	-	-	-	-	-	-	-	-	-	-
Hydrophilidae..	No.	-	-	-	-	-	1	-	-	-	-	-	-
(larvae)	Vol.	-	-	-	-	-	-	-	-	-	-	-	-
Haliplidae.....	No.	-	-	-	-	-	1	-	-	-	-	-	3 (adult)
(larvae)	Vol.	-	-	-	-	-	-	-	-	-	-	-	-
Corixidae......	No.	-	-	-	1	1	-	-	-	1	-	-	5
	Vol.	-	-	-	-	-	-	-	-	-	-	-	-

Continued next page

TABLE XXII - Concluded

Organism	April 18	April 25	May 16	May 26	June 21	June 30	July 15	Aug 2	Aug 18	Aug 26	Sept 1	Sept 8

TABLE XXII - Concluded

Organism		April 18	April 25	May 16	May 26	June 21	June 30	July 15	Aug 2	Aug 18	Aug 26	Sept 1	Sept 8
Gammaridae.....	No.	-	-	-	-	-	-	-	-	-	-	-	-
	Vol.	-	-	-	-	-	-	-	-	-	-	-	-
Hydrachnidae...	No.	-	-	-	-	-	1	1	-	-	10	-	2
	Vol.	-	-	-	-	-	-	-	-	-	-	-	-
Tubificidae....	No.	2	-	-	-	-	-	1	-	-	-	-	-
	Vol.	-	-	-	-	-	-	-	-	-	-	-	-
Hirudinidae....	No.	-	1	-	1	1	-	-	-	-	-	4	-
	Vol.	-	.1	-	.3	.3	-	-	-	-	-	1.5	-
Sphaeriidae....	No.	6	22	4	35	59	1	-	3	-	-	-	-
(2 sp.)	Vol.	-	.1	-	.1	-	-	-	-	-	-	-	-
Physidae.......	No.	-	-	5	-	9	8	-	-	-	-	-	-
	Vol.	-	-	-	-	-	-	-	-	-	-	-	-

TABLE XXIII

BOTTOM ORGANISMS TAKEN WITH AN EKMAN DREDGE AT
DIFFERENT DEPTHS FROM POND A

Organism	Date -- June 8, 1949					
	Depth					
	2"		18"		48"	
	No.	Vol.	No.	Vol.	No.	Vol.
Tendipedidae.........	18	.1	6	-	3	-
Ephemeridae..........	-	-	3	-	-	-
Corixidae............	-	-	1	-	-	-
Dytiscidae........... (larvae)	-	-	1	-	-	-
Gammaridae...........	4	-	6	-	-	-
Tubificidae..........	2	-	20	-		
Hirudinidae..........	-	-	-	-	1	1.3
Hydrachnidae.........	1	-	3	-		

TABLE XXIV

BOTTOM ORGANISMS TAKEN WITH AN EKMAN DREDGE AT DIFFERENT DEPTHS FROM POND B

Organism	Date -- June 8, 1949									
	Depth									
	4"		6"		24"		36"		48"	
	No.	Vol.	No.	Vol.	No.	Vol.	No.	Vol.	No.	Vol.
Tendipedidae........	4	-	7	-	52	-	18	-	23	-
Ceratopogoniae......	1	-	2	-	10	-	7	-	13	-
Ephemeridae.........	-	-	-	-	5	-	-	-	1	-
Trichoptera.........	1	-	-	-	1	-	-	-	-	-
Corixidae...........	1	-	-	-	-	-	2	-	1	-
Dytiscidae..........	-	-	-	-	1	-	-	-	-	-
Tubificidae.........	3	-	-	-	-	-	33	-	2	-
Potamobiidae........	-	-	1	.1	-	-	-	-	-	-

TABLE XXV

BOTTOM ORGANISMS TAKEN WITH AN EKMAN DREDGE AT DIFFERENT DEPTHS FROM POND C

Organism	Date -- June 14, 1949			
	Depth			
	6"		18"	
	No.	Vol.	No.	Vol.
Tendipedidae........	82	-.1	7	.2
Ceratopogoniae......	1	-	-	-
Culicidae...........	-	-	1	-
Tubificidae.........	10	-	11	-

Organism	Date -- July 12, 1949					
	Depth					
	6"		24"		24"	
	No.	Vol.	No.	Vol.	No.	Vol.
Tendipedidae........	3	-	4	-	1	-
Ceratopogoniae......	3	-	-	-	-	-
Culicidae...........	-	-	2	-	6	-
Tabanidae...........	5	.2	-	-	-	-
Ephemeridae.........	2	-	-	-	-	-
Coleoptera..........	-	-	1	.1	-	-
Aeschnidae..........	-	-	1	.3	-	-
Hydrachnidae........	4	-	-	-	1	-
Tubificidae.........	-	-	31	.15	-	-

Organism	Date -- July 22, 1949			
	Depth			
	24"		24"	
	No.	Vol.	No.	Vol.
Tendipedidae........	2	-	2	.15
Culicidae...........	3	-	1	-
Tubificidae.........	-	-	12	-

TABLE XXVI

BOTTOM ORGANISMS TAKEN WITH AN EKMAN DREDGE AT DIFFERENT DEPTHS FROM POND D

Organism	Date June 23, 1949					
	Depth					
	18"				24"	
	No.	Vol.			No.	Vol.
Tendipedidae........	118	-.1			74	-.1
Ephemeridae.........	1	-			-	-
Coleoptera..........	-	-			1	-
Trichoptera.........	-	-			2	- (1 stick, 1 sand case)
Tubificidae.........	1	-			-	-
Hirudinidae.........	-	-			1	-
	Date July 11, 1949					
	Depth					
	12"		30"		30"	
	No.	Vol.	No.	Vol.	No.	Vol.
Tendipedidae........	55	.2	100	1.7	123	1.2
Culicidae...........	-	-	-	-	6	-
Odonata.............	-	-	1	.6	-	-
Coleoptera..........	1	-	-	-	-	-
Trichoptera.........	1	-	-	-	-	-
Hydrachnidae........	7	-	-	-	-	-
	Date Aug. 4, 1949					
	Depth					
	24"				24"	
	No.	Vol.			No.	Vol.
Tendipedidae........	116	2.4			46	.15
Odonata (im.).......	-	-			1	-
Corixidae (im.).....	-	-			-	-

Continued next page

TABLE XXVI - Continued

Organism	Date Aug. 25, 1949					
	Depth					
	3"		36"		36"	
	No.	Vol.	No.	Vol.	No.	Vol.
Tendipedidae........	-	-	97	3.2	90	1.7
Ceratopogoniae......	3	-	-	-	3	-
Culicidae...........	-	-	2	-	-	-
Ephemeridae.........	2	-	-	-	-	-
Trichoptera.........	2	-	(2 egg masses)		-	-
Corixidae...........	1	-	-	-	-	-
Haliplidae..........	1	-	-	-	-	-
Odonata.............	4	-	-	-	-	-
Tubificidae.........	6	-	-	-	-	-
	Date April 14, 1949					
	Depth					
	-				-	
	No.	Vol.			No.	Vol.
Tendipedidae........	1	-			-	-
Ephemeridae.........	1	-			-	-
Dytiscidae..........	-	-			1	- (adult)
Trichoptera.........	-	-			1	- (flat stone case)
Hydrachnidae........	2	-			-	-
	Date June 2, 1949					
	Depth					
	12"		18"		24"	
	No.	Vol.	No.	Vol.	No.	Vol.
Tendipedidae........	94	-.1	4	-	55	.7
Ceratopogoniae......	4	-	4	-	-	-
Tabanidae...........	-	-	1	-	-	-
Trichoptera.........	-	-	2	-	-	-

Continued next page

TABLE XXVI - Concluded

Organism	Date June 2, 1949 - Continued: Depth 12" No.	12" Vol.	18" No.	18" Vol.	24" No.	24" Vol.
Odonata.............	-	-	1	.25	-	-
Aeschnidae..........	-	-	3	.4	-	-
Corixidae (im.).....	1	-	-	-	-	-
Hydrachnidae........	1	-	5	-	-	-
Tubificidae.........	1	-	-	-	1	-
Nematode............	-	-	1	-	-	-
Sphaeriidae.........	1	-	-	-	-	-
	Date June 14, 1949: Depth 2" No.	2" Vol.			8" No.	8" Vol.
Tendipedidae.........	19	.35			40	-.1
Ceratopogoniae.......	1	-			6	-
Trichoptera..........	-	-			1	- (round, sand case)

TABLE XXVII

BOTTOM ORGANISMS TAKEN WITH AN EKMAN DREDGE AT DIFFERENT DEPTHS FROM POND E

Organism	Date -- April 14, 1949			
	Depth			
	-		-	
	No.	Vol.	No.	Vol.
Tendipedidae.........	1	-	-	-
Ephemeridae..........	29	-	6	-
Odonata..............	1	-	1	-
Aeschnidae...........	-	-	2	.5
Hydrachnidae.........	1	-	-	-
Tubificidae..........	-	-	1	-
	Date -- April 25, 1949			
	Depth			
	-		-	
	No.	Vol.	No.	Vol.
Tendipedidae.........	34	-	14	-
Ephemeridae..........	63	-	63	-
Trichoptera..........	1	-	-	-
Gammaridae...........	2	-	-	-
Tubificidae..........	2	-	-	-
	Date -- June 1, 1949			
	Depth			
	6"		36"	
	No.	Vol.	No.	Vol.
Tendipedidae.........	1	-	3	-
Ceratopogoniae.......	-	-	41	-
Ephemeridae..........	26	-	78	.10
Hydrachnidae.........	-	-	1	-

Continued next page

TABLE XXVII - Concluded

Organism	Date -- June 1, 1949 - Continued			
	Depth			
	6"		36"	
	No.	Vol.	No.	Vol.
Gammaridae...........	-	-	1	-
Trichoptera..........	1	-	-	-
Aeschnidae...........	-	-	1	-

Organism	Date -- July 7, 1949			
	Depth			
	4"		36"	
	No.	Vol.	No.	Vol.
Tendipedidae.........	3	-	5	-
Ceratopogoniae.......	2	-	12	-
Ephemeridae..........	1	-	1	-
Aeschnidae...........	1	-	2	.5
Trichoptera..........	-	-	2	- (sand stone case)
Tubificidae..........	-	-	1	-
Hirudinidae..........	-	-	1	- (capsule)

Organism	Date July 15, 1949							
	Depth							
	12"		36"		48"		48"	
	No.	Vol.	No.	Vol.	No.	Vol.	No.	Vol.
Tendipedidae.........	20	-	2	-	32	-	40	.10
Ceratopogoniae.......	2	-	1	-	-	-	1	-
Culicidae............	-	-	-	-	2	-	1	-
Ephemeridae..........	1	-	-	-	-	-	-	-
Aeschnidae...........	-	-	-	-	1	.5	-	-
Trichoptera..........	-	-	2	-	-	-	-	- (rd. stone case)
Hydrophilidae....... (Berosus)	-	-	1	-	-	-	-	-
Tubificidae..........	9	-	1	-	1	-	2	-
Hirudinidae..........	-	-	1	-	-	-	-	-

TABLE XXVIII

BOTTOM ORGANISMS TAKEN WITH AN EKMAN DREDGE AT DIFFERENT DEPTHS FROM POND F

Organism	Date -- April 25, 1949 (Same depth for all)					
	-		-		-	
	No.	Vol.	No.	Vol.	No.	Vol.
Tendipedidae........	1	-	-	-	-	-
Tabanidae...........	-	-	1	-	-	-
Ephemeridae.........	1	-	2	-	-	-
Aeschnidae..........	-	-	-	.25	2	.3
Hydrachnidae........	-	-	-	-	1	-
Hirudinidae.........	-	-	1	.1	5	1.7
Sphaeriidae.........	2	-	22	.1	1	-
Physidae............	-	-	-	-	2	-
	Date -- May 26, 1949 Depth					
	12"		36"		3"	
	No.	Vol.	No.	Vol.	No.	Vol.
Tendipedidae........	-	-	1	-	7	-
Ceratopogoniae......	-	-	1	-	13	-
Ephemeridae.........	4	-	4	-	6	-
Corixidae...........	1	-	1	-	-	-
Trichoptera.........	-	-	1	-	(sand	case)
Hirudinidae.........	-	-	1	.3	-	-
Sphaeriidae.........	49	.1	35	-	4	-
Physidae............	-	-	-	-	2	-
Unidentified........ (larvae)	1	-	-	-	-	-

Continued next page

TABLE XXVIII - Concluded

Organism	Date -- June 30, 1949			
	Depth			
	-		-	
	No.	Vol.	No.	Vol.
Tendipedidae.........	1	-	7	-
Ceratopogon..........	1	-	2	-
Ephemeridae..........	1	-	7	-
Gomphus..............	1	-	-	-
Corixa...............	1	-	-	-
Hydrophilidae........	-	-	1	-
Haliplidae...........	-	-	1	-
Hydrachnid...........	-	-	1	-
Sphaeriidae..........	-	-	1	-
Physa................	3	-	8	-
Planoribis...........	-	-	1	-
	Date -- July 15, 1949			
	Depth			
	12"		48"	
	No.	Vol.	No.	Vol.
Tendipedidae.........	2	-	17	-
Ceratopogoniae.......	2	-	3	-
Aeschnidae...........	4	-	1	.15
Ephemeridae..........	13	-	1	-
Trichoptera..........	1	-	-	-
Hydrachnidae.........	-	-	1	-
Tubificidae..........	-	-	1	-

MINNOW REPRODUCTION

Nesting habits

The ice which covered the ponds disappeared April 7 and observations on the mating habits of Pimephales promelas promelas, the fathead minnow, began on April 13. These fish appeared to be in breeding condition throughout the month but active nest building was not observed until after the ponds were drained and refilled on April 28. Pond E was stocked with golden shiners for breeding and during the process of filling the pond fathead minnows entered through the inlet. Fathead nesting was observed for the first time in this pond on May 14. Female fatheads removed from the reservoir contained well-developed eggs and these, with large males in the breeding condition, were placed in the long inlet pond.

Pond F was drained May 5 and while the inlet pond was empty 60 old shingles were placed horizontally from one to two feet below the normal water surface with the thick ends protruding five to six inches from the bank. On May 13 two of these shingles were being used by the male fatheads for nesting purposes. On May 16 many of the shingles were in use and on May 18 numerous nests in the reservoir were observed under logs and stones. The nests in the reservoir were from one to two feet below the water surface. Nests were later observed at a depth of four feet in pond F, but this was unusual.

The nest rock in pond E was temporarily removed on May 27 and an estimate of 600 eggs was made after counting an area containing 100 eggs. Some of the eggs present were in the eyed stage and several embryos were observed moving about within the eggs. Four days later the rock was permanently removed and fry were observed escaping from the eggs. There were many clear eggs with no evidence of the eyed stage in them and an attempt to mature these eggs in another pond was unsuccessful. The first fry were observed in pond A on May 31.

The selection of nesting sites by the fathead minnow is extremely variable. They were observed using many kinds of objects both in the ponds where sites were limited and in the reservoir where there were many devices. In pond E after a nest rock was removed the male fish selected a floating stake at the shoreline. When this was removed with eggs attached he used the stem of an emergent plant. In pond F a fathead male utilized an almost vertical root protruding from the pond bottom. The eggs were well exposed in both the latter cases and it was possible to observe the male fish constantly rubbing them with his anterior dorsal body region.

In the reservoir rocks along the dyke were employed to a large degree for nesting purposes; sticks along the bottom were commonly used and later in the summer when the floating pond weeds, <u>Potamogeton</u> <u>natans</u>, were abundant the under side of the leaves was a favorite site. These nests were easily spotted as the surface leaves were used and the ripples in the water made as the fish bumped the egg masses could be readily seen. No nests were observed more than two to three feet below the surface of the reservoir and most of them occurred at a depth of about one foot.

Mating procedure

Upon selection of a nesting site the male fathead minnow spent several days preparing the area for the breeding procedure. Ripe females entered the nest area during this time but the male rejected their advances and also the approach of other fish. When he had established his position of dominance in the area about the nest, he cleaned all fine particles, particularly organic matter, from the under side of the rock or stick. He then accepted the entry of one or sometimes two females.

Fatheads were placed in aquaria filled with pond water and large stones for spawning locations. There were three females and one male in aquarium number two. Another aquarium was stocked with too many males or with too many females for good results. The attempts of the males to dominate the nesting site prevented them from completing the breeding act. Breeding commenced in aquarium number two one day after the introduction of the fish. At the end of the second day the nest contained eggs on the under side of the rock. The size of the egg area was about one inch in diameter. This egg mass disappeared after three days.

A third aquarium was set up with fatheads in the breeding condition on May 20. The results from the aquaria were poor in terms of egg production but observations on the mating procedure were possible.

After entering the nest a female laid parallel to the male and gentle vibrating of both fish commenced. A short time later the male began a violent vibration of the body and crowded the female toward the roof of the nest. He terminated the breeding with a very rapid vibration which forced the female against the roof of the nest. The eggs were extruded at that time and the male was observed picking up the eggs and placing them in position with his mouth. There appeared to be a constant 'mouthing' of the eggs immediately after breeding and following their deposition on the under side of the nest rock.

Figure 5. Daily temperature of the surface water of the Lake City Experiment Station ponds and the occurance of eggs and fry of *Pimephales promelas promelas*.

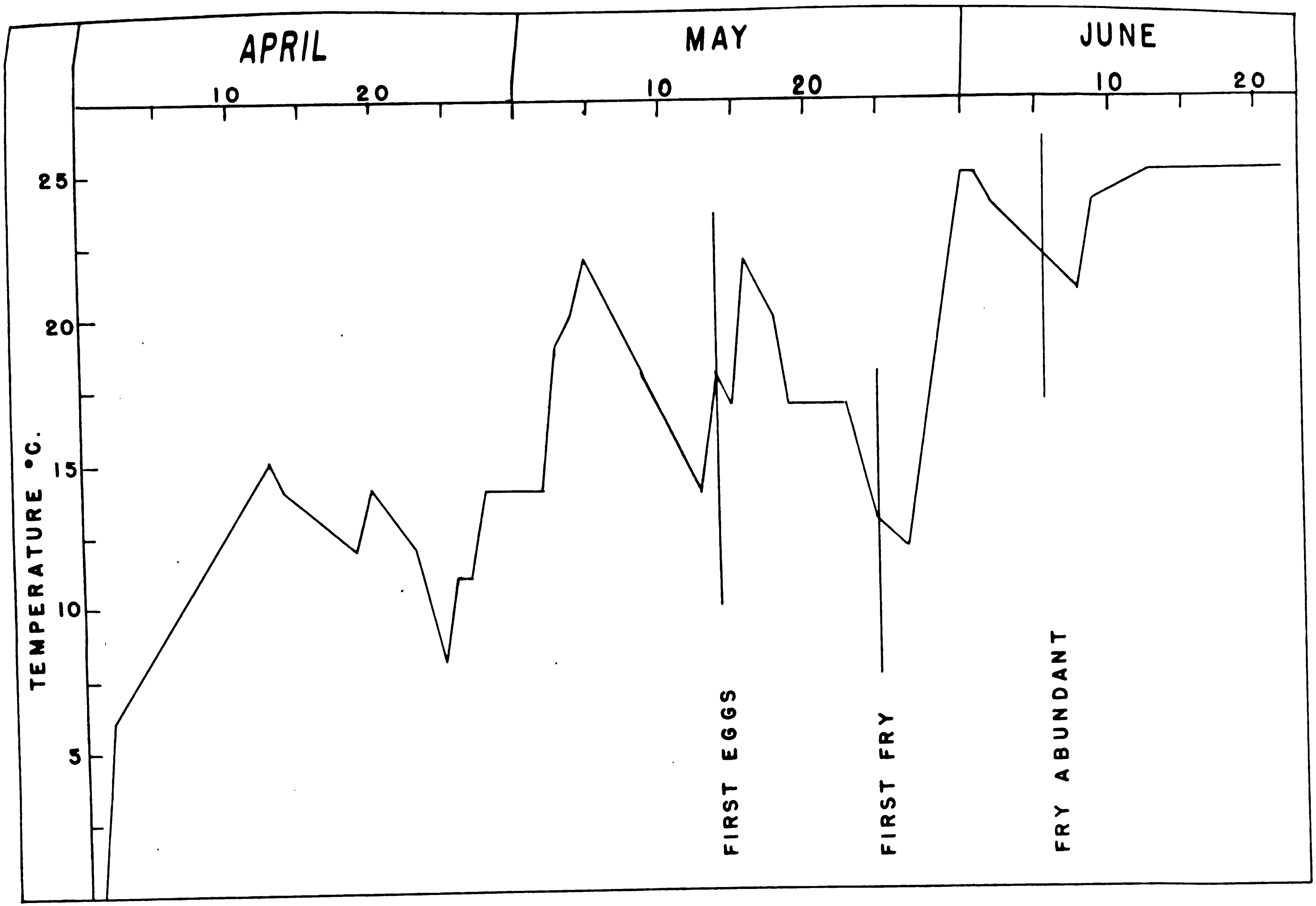

APRIL
MAY
JUNE
10
20
10
20
10
20
25
20
15
10
5
TEMPERATURE °C.
FIRST EGGS
FIRST FRY
FRY ABUNDANT

TABLE XXIX

TEMPERATURE AND BREEDING OCCURRENCE OF THE FATHEAD MINNOW

Date 1949		Air Degrees Centigrade AM	PM	Water Degrees Centigrade AM	PM
April	1	1	6		
"	2	0	8		6
"	13		12		15
"	14		13		14
"	18	2		5	
"	19	1	13	5	8-12
"	20		15		10-14
"	21		21		11-14
"	23	10		12	
"	25	10	8	8	8
"	26	11	13	9	11
"	27		13		11
"	28		15		14
May	2		17		14
"	3	19	27	13	19
"	4		26		20
"	5		27		22
"	9		18		18
"	13		22		14
* "	14		20		18
"	15	10	17	11	17
"	16		24		22
"	18		24		20
"	19		10		17
"	20		15		17
"	23		17		17
"	24	8	9	14	15
"	25		6		13
** "	27		14		12
"	31		25		25
June	1		27		24
"	2		27		24
"	6		21		22
"	8		18		21
"	9		22		24
"	13		25		25

* First eggs observed.
** First fry observed.

Trapping

The use of glass traps for harvesting the minnow crop in farm ponds was tested to determine possible production with such devices and to observe fish behavior in respect to successful glass trapping. The traps were not set in the experimental ponds as these ponds were used to measure total fish production for a season and it was not desirable to harvest any fish from them until they were drained in the fall. The reservoir, which was not artificially fertilized and which might represent the commonly used type of farm pond in central Michigan, was selected for this experiment.

This particular type of farm pond is one formed in an old creek bed by damming the stream and with the minimum removal of debris, trees and brush. The muck or pulpy to fibrous peat, did not permit wading and all trapping was necessarily done from a rowboat. The stumps, logs and branches remaining in the pond would ordinarily prohibit seining but for trapping methods these objects afforded excellent trap sites.

This reservoir was never drained and the fish present represented all age groups as well as a variety of develop species. The use of traps in controlled ponds for the capture of different species and age classes is not covered in this report.

The number of traps practicable in the collection of minnows from farm ponds may vary with the size of the ponds and the number of fish desired at any one time. It was found that the production indicated by any one trap varied with the location of the 'set', the time open before emptying, the weather conditions and the season. The time required to set and empty the traps was also found to be a factor limiting the number of traps that could be employed feasibly. This time element became more apparent when the six traps used in the early observations were increased to twenty four. Four hours in the morning and four in the afternoon were required to properly set and empty the traps and transport fish to their new location.

The traps averaged about 200 minnows during the optimum conditions and with careful settings. Twenty four traps set and emptied twice a day for one week yielded over 20,000 redbelly dace and fathead minnows. Attempts to increase this yield would have necessitated a reorganization of the holding methods and it was thought that this was possible. Occasional trapping from the banks permitted a fast disposition of the catch with corresponding ease and speed of resetting the traps.

On clear bright days with little wind and rapidly rising temperatures the minnow activity increased to a point which filled traps with as many as 500 minnows in less than 30 minutes. In several instances, traps placed on stump roots where minnow activity was great took over 300 fish in less than 15 minutes. At such times the mean yield of all the traps was not as high per trap.

The successful location of good trapping sites was best determined by first making a thorough survey of the area each day and observing where the minnows were most active. Objects in the pond about which minnows gathered or around which they had to swim in their endless school movements were likely places for traps. The tendency of the fish to follow the contour of the bottom irregularities was a means of deciding where a trap would be productive. Where the banks projected into the pond to form an obstacle to fish movement, an increase in the concentration of the minnows was noted with a corresponding increase in the number of fish captured. Traps located without regard to the observance of areas of minnow activity might be successful over a certain time period, notably at night, but the major portion of minnows captured were from areas of great activity.

Although minnow activity was observed in depths ranging from a few inches to three feet, trapping results were best at a depth of six inches to one foot. Traps set at two or more feet decreased in catches until at a depth of four feet no fish were obtained in two traps set for over a week.

In addition to depth, the position of the trap in relation to the object on or by which it was set appeared to effect the number of fish attracted into it. On submerged logs the traps worked best if the long axis of the trap was placed parallel to the long axis of the log. On stump roots the position of the trap in relation to the roots did not seem important, rather it was the minnow activity about that area which affected the catch the most. The traps which were located on the roots of stumps and on the logs were found to be more productive than those on the matted weeds. Those placed on the weeds often sank into this layer and became ineffective.

The use of bait in the traps was attempted during the early trials by placing rye bread flavored with anise oil in the trap. This was discontinued when it was observed that it had no apparent influence on the numbers caught or speed with which the fish entered the traps. The use of bait had been recommended by the manufacturer of the traps. The bullheads in the pond apparently were attracted to the bait and also were found in the traps when dead fish were left in them. Redbelly dace kept in an aquarium for some time would not respond well to the feeding of bread crumbs but fathead minnows would take the bread readily.

The use of decoys in the form of previously captured minnows seemed to entice fish into the traps, but this was true only when the site selection was good. Traps placed in areas of great minnow activity did not need bait or decoys and as soon as one minnow or more wandered into the trap the others readily followed. This peculiar response of minnows entering the traps in large numbers as soon as a few were observed trapped was not explained. The minnows first trapped became excited and their white or sometimes red abdomens could be seen flashing from some distance.

ANIMAL FOODS AND ACTIVITIES

Duck foods

The reservoir contained many plants listed by Pirnie (1935) and Fassett (1940) as duck foods. Some occurred in great quantities and others in scattered communities. In addition to plant food, the weed beds contained huge quantities of invertebrate animals available to the ducks, especially small crustaceans such as Gammarus, odonata of several genera and also molluscs such as Physa. Pirnie (1935) lists these as duck foods. Along the banks of the ponds were many species of emergent plants bearing seeds or nutlets used by waterfowl. Many of these forms grew from tubers which have been listed as duck foods.

The following compilation of plants made in 1949 lists the more abundant families that occurred in the reservoir or along its banks with some of the common genera present and their use as described by Fassett (1940):

Algae

Chara: wildfowl, harbors many small animals.

Spirogyra: wildfowl, deer.

Alismaceae (Water Plantain Family): wildfowl eat tubers and nutlets.

Sagittaria latifolia: tubers are eaten by wildfowl, muskrats; the plant attracts song birds.

Cyperaceae (Sedges): one of the most important families for wildfowl.

Polygonaceae (Buckwheat Family)

Polygonum sp. (Smartweed): only the nutlets are eaten by ducks.

Lemnaceae (Duckweed Family): these plants are considered an important duck food and harbor small aquatic animals.

Najadaceae (Pondweed Family): one of the most important families for wildfowl.

Najas flexilis: stems, foliage and seeds are eaten by wildfowl especially mallards.

Potamogeton: all species are eaten and all the parts used wildfowl; considered a staple for ducks.

P. natans: the rootstocks and nutlets are held on the plant until late in the season, duck food.

Nymphaeaceae (Water Lily Family)

Nuphar: wildfowl eat seeds.

Sparganiaceae (Bur Reed Family)

Sparganium sp: wildfowl and muskrat; attracts marsh birds.

Typhaceae (Cattail Family)

Typha sp: muskrat; attracts marsh and song birds.

The reservoir attracted large flocks of wildfowl during the spring and fall migration and during the year it served as a feeding ground for small groups of five or more ducks. Pirnie (1935) states that often the shallow head-waters of streams with an abundance of snails and water insects attract more ducks than areas further down stream.

No nesting was observed but several pairs of ducks appeared to reside continuously throughout the summer.

During the flights in the fall and spring, blue geese and canada geese appeared in the wheat fields adjacent to the ponds. The blue geese stayed for a week or more working over ponds C and D particularly. Pond D at that time had a large crop of duckweed, many Odonata in the shallower water and great quantities of Tendipedidae in the deeper water of two feet.

Other aquatic and shore birds which were numerous throughout the summer were redwings, American bitterns, great blue herons, least bitterns, greater yellow legs, sand pipers and killdeers.

Otter activity

The presence of otter about the experiment station ponds during 1947 was reported to the author by the station personnel. The animals were discovered frequenting the pond area during 1948 and at that time it was thought that their depredations of the bluegills in the ponds was responsible for the decrease in number of fish during the winter. Efforts to discourage them failed and their presence was observed in the spring of 1949.

One speciman was observed April 2, 1949 actively breaking the newly formed ice in the breather holes of the reservoir surface. This animal was disturbed on the bank of the reservoir and observed swimming under the ice toward deeper water. At about a distance of 100 yards the otter's head appeared through a breather hole. These holes, mostly frozen shut, were well distributed over the surface of the ponds and reservoir.

The wind was blowing from the otter toward the observer and the animal tried to manuever into a more favorable location in the pond. He moved in an arc about the observer located on the high reservoir bank and forced the ice from breather holes spaced three to ten feet. He finally moved about 25 yards closer and for the first time raised his body half way from the water. He did this by resting his fore legs on the ice and then executed a curious dipping motion similar to that observed among the seals.

The otter spent from 30 to 40 minutes trying to either smell or see the observer and failed in the former method but apparently met with success in seeing at about 50 to 75 yards. Later in the summer otter were observed swimming and playing about and responded to movement of human beings at greater distances.

At the time this animal was observed, snow was still present on the north exposure of the reservoir bank. Here the animal had deposited his scats in rather definite areas and had used the locations many times. Collections of the scats were made and brief observations showed the presence of fish scales and bones among the more numerous crayfish remains. Occasional parts of the larger diving beetles were also observed in the matrix of the scats. One freshly killed redbelly dace was found by a hole in the ice. Later examinations of scats through the summer revealed that the animal also ate bullheads.

In the vicinity of the scat areas tracks in the remaining snow were measured. One measurement of the tracks was possible with reasonable certainty of an average bound or leap. Toe to toe measurement of this bound was 20 inches. One foot measured 3 inches across and 4 inches long and the other measured 1 3/4 inches across and 2 inches long.

One of the most frequented scat depositing areas was an old platform formerly built for irrigation equipment. At this station over 30 deposits were made. A collection of these and other scats was made throughout the year, dated and sent to the laboratory for later analysis. Although the otter was seldom seen, nighly deposits were made about the ponds and reservoir. The animals appeared to have a daytime retreat further down stream, possibly in the old beaver dam and would make nightly visits to the ponds. The number of tracks indicated the presence of four animals. No reliable estimate of their range was possible.

Insect activity

An insect collection was made of the adult aquatic forms and other incidental arthropods. It was felt that a year-to-year collection of these animals would be a valuable addition to the laboratory for future reference, particularly in a qualitative study. Such a collection might also be useful for determining alterations or additions of the pond habitats.

The ponds at the time of this study appeared to produce few caddis fly larvae. This is apparent from the results of the Ekman dredge samples and from general observations. Large numbers of caddis fly adults appeared about the flood light on the laboratory at night. It was not determined where the larval form of these insects occurred.

It was thought that the addition of the gravel to the pond bottoms would increase the number of these insects found in the bottom samples. If it is determined that the caddis flies found in the pond area prosper on submerged twigs, the addition of brush shelters might increase the number of larvae that will survive in the ponds. It seems quite possible that any number of factors might affect the survial or occurrance of the caddis fly in the ponds. Here again appears the need for more intensive life history studies.

The Trichoptera adults which settled on the side of the laboratory at night often carried egg masses on the tip of the abdomen. These masses adhered to the wall and in time dried and became quite hard. The eggs were collected both from the building and from the insects. Several of the agglomerations were put in water and immediate swelling was observed. The clusters of eggs were then visible and both color and arrangement of the eggs in the mass appeared as distinguishing characteristics. Various shades of light brown and light green were observed. The eggs were dark but the matrix of gelatinous material was hyaline. The egg cluster of one species consistently had the form of a biconcave disk. The eggs in this mass were always light green and had a spiral arrangement. Egg arrangement in the other masses appeared to be irregular. No count was made of the eggs in a cluster. Some of the caddis eggs were placed in water on July 19 and left in a warm sunny window of the laboratory. These were successfully hatched on August 10. These insects were identified as belonging to the family Limnophilidae. The construction of a cylindrical case began immediately and was composed of algae. The use of algae for the case is not conclusive as the container offered no selection of case building materials. On August 2 bottom dredgings revealed the presence of newly hatched caddis larvae in pond E. The cases of these insects were cylindrical and composed of fine sand particles.

Large loops of eggs of Phryganea were found hatching in the reservoir on August 22. Attempts to culture the naiads in jars were unsuccessful. The loops measured over two inches in diameter. A few of these large adult caddice were taken for the collection but they did not appear to be abundant under the flood light at any time.

The emergence of aquatic insects often occurred at night when the adults gathered under the flood light attached to the wall of the laboratory. Their nightly appearance increased from a few in early April to a wealth of species and numbers during July and August. The light trap was not used during 1949 as in the previous year but a fluctuation in the number of adult insects was apparent. From August 1 to 10 observations under the flood light showed that there was a notable absence of adult insects at night. Some evenings during this period were almost completely devoid of insect activity about the light. Then on August 10 a large emergence of delicate green midges appeared. The adult Trichoptera also began to appear again in large numbers. Insects appeared to be abundant during the remainder of August and early September but did not equal the earlier observed quantities.

An abundant midge emergence was observed May 4. Dragon-flies began emerging May 6 and damsel-flies appeared May 9. Phantom crane flies, Bittacomorpha clavipes, were observed along the drainage ditches of the ponds on May 9. The first large emergence of dragon-flies occurred on May 14. On May 23 the very small two-winged may-fly, probably Caenis, appeared in large numbers. By May 31 the Odonata had become very numerous both in species and numbers.

On June 1 the egg cases of water-scavenger beetles, the Hydrophilidae, were discovered attached to dead sedge leaves floating along the shore of the ponds. Several of these egg cases were put in aquaria and the young were observed emerging on June 9. The attempts of culture of these larvae was not successful.

Several of the insects were observed preying on fish during the summer. On several occasions dragon-fly larvae were found in shallow water holding live minnows. The Anisoptera when collected and held alive with other insects and small fish were quite voracious, often capturing another animal immediately. Three giant water bugs, Lethocerus americanus, were held in an aquaria containing live fathead minnows. The insects attacked the minnows and at different times were successful in capturing and killing three-inch fish. One of these large hemiptera pierced the minnow on the dorsal surface near the head and apparently lost the terminal segment of his beak. The fish was quickly paralyzed and died in a few minutes.

SUMMARY

1. The pond water of six ponds and a reservoir was analyzed for the presence of oxygen, carbon dioxide and alkalinity in terms of phenolphthalein and methyl orange. A generally satisfactory level of these chemicals was maintained for the existence of fish and plant life.

2. The results of chemical analyses of the fertilized ponds did not explain the difference in abundance of algae exhibited between ponds E and F.

3. Critical oxygen content in the pond water for the maintenance of fish life was observed during the hot summer months during the night but fish distress from lack of oxygen occurred only once in ponds B and E.

4. The application of fertilizer in the control pond D favorably increased the growth of aquatic larvae and algae as compared with unfertilized control pond C.

5. The hydrosols were classified in order of diminishing amounts as pulpy peat, detritus, fibrous peat, sand, gravel and clay.

6. Bottom sampling methods were found to be inadequate where full time was not devoted to them and it was discovered that a carefully planned design of sampling with statistical tests should replace the procedures followed in this study. The samples were felt to be adequate in determining general trends of numbers of the more abundant animals, Tendipedidae.

7. The variation between ponds in the abundance of the Tendipedidae presented the need for continued life history studies and a more detailed chemical and physical analysis in order to explain this phenomenon.

8. The fathead minnow and the northern redbelly dace may be successfully grown in Missaukee County farm ponds for bait purposes when two to three inch minnows are desired.

9. Glass traps can be made to yield from 200 to 500 minnows in 30 minutes when properly set during the summer months.

10. The otter when present about farm ponds may limit the species of fish that may be successfully grown to the smaller fish.

11. A six-acre farm pond can be an important source of wildfowl food especially during the migration flights.

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