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MUSEUM OF ZOOLOGY, UNIVERSITY OF MICHIGAN, NO. 71

THE ANIMAL LIFE OF TEMPORARY AND PERMANENT PONDS IN SOUTHERN MICHIGAN

BY
ROMAN KENK

ANN ARBOR
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CONTENTS

ILLUSTRATIONS

PLATES

(Plates I–III follow page 66)

FIGURES IN THE TEXT

MAP

THE ANIMAL LIFE OF TEMPORARY AND PERMANENT PONDS IN SOUTHERN MICHIGAN

INTRODUCTION

THE present paper is a report on a biological investigation of two temporary and two permanent ponds in the vicinity of Ann Arbor, Michigan. The ponds are situated in the Thumb Upland (cf. Russell and Leverett, 1915: 1), a slightly elevated district of the Lower Peninsula. The Ann Arbor region, as well as other areas of the Lower Peninsula, is rich in lakes and smaller bodies of standing water. Swamps and marshes are present in regions where drainage is poor. Water accumulates in small depressions in swampy areas, forming numerous ponds both of permanent and temporary nature. The level to which these depressions are filled with water depends mainly on the level of the ground water and is, therefore, subject to the same annual fluctuations that the ground-water table undergoes. Thus, shallow sloughs contain water only at seasons when the ground-water table is high; the deeper depressions hold the water the year round.

The origin of these small bodies of water is best understood by tracing the geologic history of the area. The surface relief of the Lower Peninsula is, in the main, the result of the action of the moving ice masses that overran the area in the glacial periods. The retreating ice sheets left behind them a layer of sedimentary material (glacial drift) the surface of which showed typical glacial features, such as moraines, plains, and basins. After the withdrawal of the ice, the basins and depressions were filled with water. In the postglacial period, the surface of the area was modified mainly by two agents: the action of the water, which by erosion and solution removed material from the higher altitudes and deposited it in part as sediments and precipitates in the lakes, and the growth of plants, which likewise built up deposits of muck and peat in shallow depressions or ponds and swamps and on the banks of larger basins or lakes. Many of the smaller depressions were filled completely and now appear as flat patches of land with a very dark, often black soil. The temporary ponds of the area represent a transient evolutionary stage which follows the permanent ponds and precedes the complete disappearance of standing surface water.

In recent years, man has speeded the disappearance of ponds and marshes by artificial draining. Even within a single generation the change has become conspicuous, as older people living in the Ann Arbor area will testify. Many of the old ponds and woods pools have disappeared.

Of the two temporary ponds chosen in the Ann Arbor area, one was situated in wooded land and the other in an open grassy region. To facilitate the comparison of the animal life of temporary pools with that of permanent stagnant-water habitats, two permanent ponds also were selected in the same general area and studied by the same methods. One of the permanent ponds was of the type that is the predecessor of temporary pools, and the other, a backwater pond, was a part of an impoundment of the Huron River.

I am indebted to many specialists who have contributed materially to this paper by kindly furnishing identifications and other data on animals submitted to them. The following have responded generously to my request, some of them at a considerable sacrifice of their time: Professor H. L. Blomquist, Duke University (algae), Mrs. Betty Robertson Clarke, University of Michigan (higher plants), Professor William A. Kepner and Dr. Wayland J. Hayes, University of Virginia (rhabdocoel and alloeocoel turbellarians), Professor J. Percy Moore, University of Pennsylvania (Hirudinea), the late Dr. Charles B. Wilson, Westfield, Massachusetts, and Dr. R. R. Langford, University of Toronto (Cladocera), Dr. Willis L. Tressler, University of Maryland (Ostracoda), Mr. Paul Illg, University of California (cyclopoid Copepoda, winter collections), Mr. Harry C. Yeatman, University of North Carolina (Harpacticoids, Cyclopoids), the late Professor S. F. Light, University of California (Diaptomid Copepoda), Mr. Clarence Shoemaker, United States National Museum (Amphipoda), Professor J. G. Mackin, East Central State College, Oklahoma (Isopoda), Mr. Karl E. Goellner, University of Michigan (Decapoda), Professor A. M. Chickering, Albion College (Araneida), Professor Ruth Marshall, Rockford College (Acarina), Professor Melvin E. Griffith, North Dakota Agricultural College (Collembola), Professor E. M. Walker, University of Toronto (Odonata), Dr. F. Earle Lyman, Tennessee Valley Authority (Ephemerida), Professor H. B. Hungerford, University of Kansas (Hemiptera), Mr. Hugh B. Leech, Dominion Entomological Laboratory, Vernon, British Columbia, and Dr. Adam Böving, U. S. Bureau of Entomology (Coleoptera), Dean Cornelius Betten, Cornell University (Trichoptera), Dr. Henry K. Townes, U. S. Bureau of Entomology (Tendipedidae and Ceratopogonidae), Dr. Thomas H. G. Aitken, Captain, Sanitary Corps (Culicidae), Dr. Maurice T. James, U. S. Bureau of Entomology (Stratiomyiidae), Mr. C. T. Greene, U. S. Bureau of Entomology (miscellaneous Diptera), Mr. Calvin Goodrich, University of Michigan (Gastropoda and Pelecypoda), Dr. Mary D. Rogick, College of New Rochelle (Bryozoa), Professor Carl L. Hubbs, then of the University of Michigan (Pisces), and Miss Grace L. Orton, University of Michigan (Amphibia).

METHODS OF INVESTIGATION

The four localities were visited at regular intervals of about two weeks throughout the period in which the temporary pools contained water. Measurements of certain physical and chemical factors were made in accordance with the *Standard Methods* compiled by the American Public Health Association (1925). For the determination of the hydrogen-ion concentration, a colorimetric device, the "Hellige Pocket Comparator," was used. The dissolved oxygen was determined by the Rideal Steward modification of the Winkler method and the alkalinity of the water by the methyl-orange method.

In analyzing the biological conditions in the ponds, the employment of strictly quantitative methods appeared to be impracticable. The small volume of the water in the pools, the dense and constantly changing vegetation, and the difficulties encountered in collecting during the winter, would have prevented the collection of accurate quantitative samples. Instead, it was preferred to estimate the approximate abundance of animals in the collections and to express it by such words as "abundant," "common," and "rare." The collecting was done, in the main, with the aid of a dipnet for animals of the open water, and by the "stove-pipe" method for bottom organisms.

Only macroscopically visible animals were studied. Therefore, a number of invertebrate groups which were well represented in the pond fauna could not be considered in this investigation (Protozoa, Rotifera, Nematoda, and Gastrotricha).

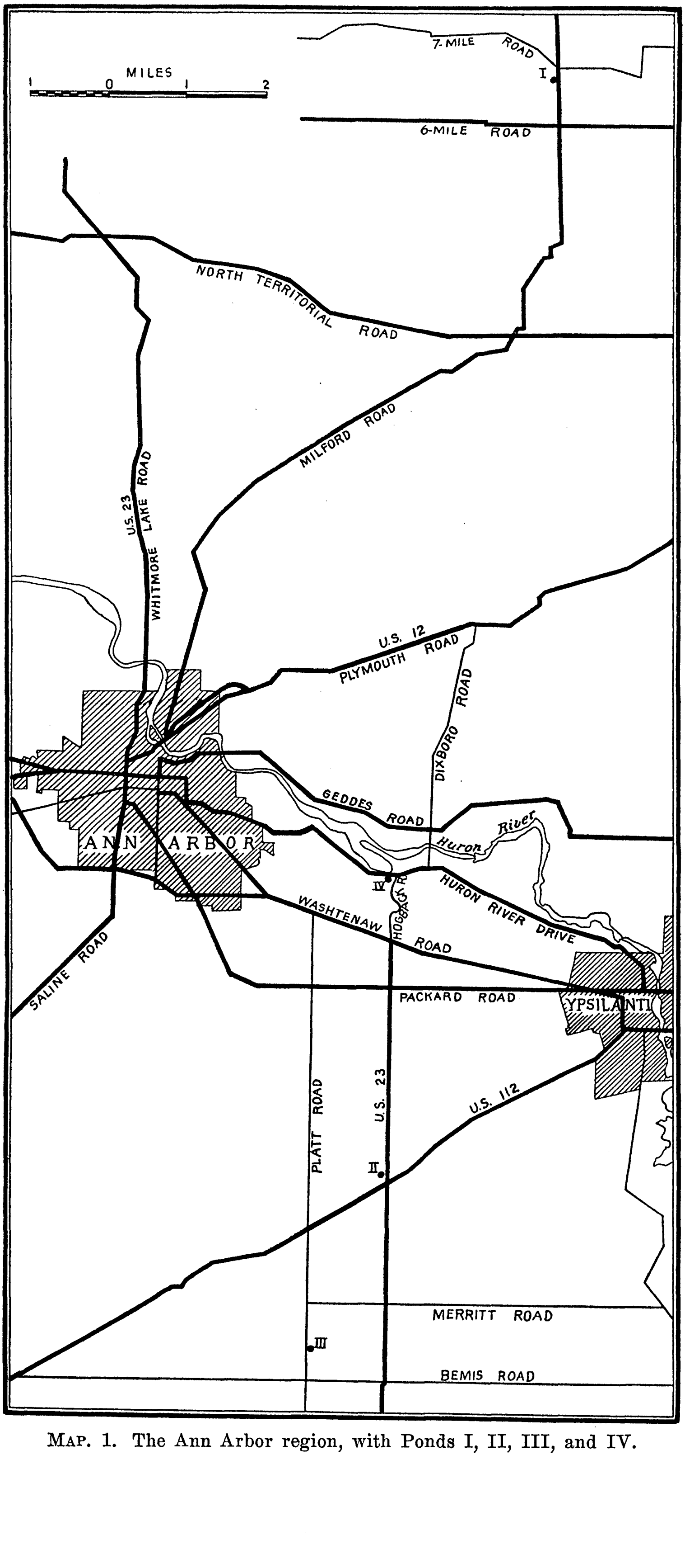
A small part of the animals collected in the season of 1940–41 was, unfortunately, lost before it could be identified (the Cladocera and Copepoda of the spring collections). To make up for this loss, new material of the missing groups was procured in the spring of 1945.

THE PONDS AND THEIR FAUNA

POND I

Pond I (Figs. 1 to 3; Pl. II, Fig. 1; and Map 1) is a temporary pond on the west side of Milford Road, between Six-Mile and Seven-Mile Roads, six-tenths of a mile north of the crossing of Six-Mile Road and nine miles northeast of Ann Arbor. It is situated at the edge of a second-growth hardwood forest. This pond probably resembles the original woodland pools of southern Michigan more closely than any one of the other three ponds investigated. The pond is exposed to the east, but is shaded from the afternoon sun by the trees of the forest which, in part, overhang its surface. Its dimensions are approximately twenty by thirty-two meters; its greatest depth, fifty centimeters.

Pond I was dry in the summer and autumn of 1940. Rains in September and October left no pools for any appreciable length of time, for the water was soon absorbed by the ground. The pond started to fill up in the early part of December, but did not reach its highest water level until the snow was melting in March and April, 1941. Throughout May and the greater



Map. 1. The Ann Arbor region, with Ponds I, II, III, and IV.

part of June, the water level was falling. The pond dried out about June 25.

The physical and chemical conditions obtaining in the pond during the period of observation are recorded in Table I. During January and part of February, the water had a very low oxygen content (1.3 to 1.7 parts per million). The high alkali reserve (up to 623 parts per million) and the relative stability of the hydrogen-ion concentration (7.0 to 7.8) were remarkable.

The pond is characterized by a dense vegetation of rooted hydrophytes.

TABLE I

POND I (TEMPORARY POND ON MILFORD ROAD)
Physical and chemical conditions, October 1940 to June 1941

Date	Water Temperature (° C.)	pH	Dissolved Oxygen (p.p.m.)	Methyl-orange Alkalinity (p.p.m.)	Thickness of Ice (Centimeters)	Remarks
Oct. 23	....	......	......	....	....	Pond dry
Dec. 17	0.8	7.5	4.8	255	1	Water in lowest areas
Jan. 2	0.3	7.2	1.7	386	0.8	
Jan. 10	0.6	7.2	1.3	457	5	6 cm. of snow above ice
Feb. 10	0.4	7.2	1.3	623	18	3 cm. of snow above ice
Feb. 24	1.0	7.0	4.3	260	16	6 cm. of snow above ice
Mar. 11	0.7	7.2	5.1	113	10	4 cm. of snow above ice
Mar. 26	1.0	7.4	6.1	46	0–10	Ice melting, only patches left
Apr. 9	2.7	7.4	4.9	306	0	
Apr. 22	7.8	7.6	4.5	299	0	
May 6	18.8	7.8	2.3	431	0	Water level falling
May 20	19.0	7.6	4.2	......	0	Water colored, level falling
June 5	19.0	7.8	9.3	410	0	Water colored, level falling
June 10	14.0	7.7	3.1	432	0	Water colored, level falling
June 29	....	......	......	....	....	Dried out recently

Toward the center of the pond, the dominant plant is ripgut (*Carex riparia* var. *lacustris* Willd.). With it are about seven stalks of cattails (*Typha latifolia* L.). Other members of the association are bulrush (*Scirpus cyperinus* [L.] Kunth), skullcap (*Scutellaria laterifolia* L.), yellow dock (*Rumex elongatus* Guss.), *Lycopus uniflorus* Michx., bittersweet (*Solanum Dulcamara* L.), royal fern (*Osmunda regalis* L.), and horsetail (*Equisetum fluviatile* L.). Dogwood (*Cornus stolonifera* Michx.), wild black currant (*Ribes americanum* Mill.), meadow sweet (*Spiraea* sp.), swamp roses (*Rosa*

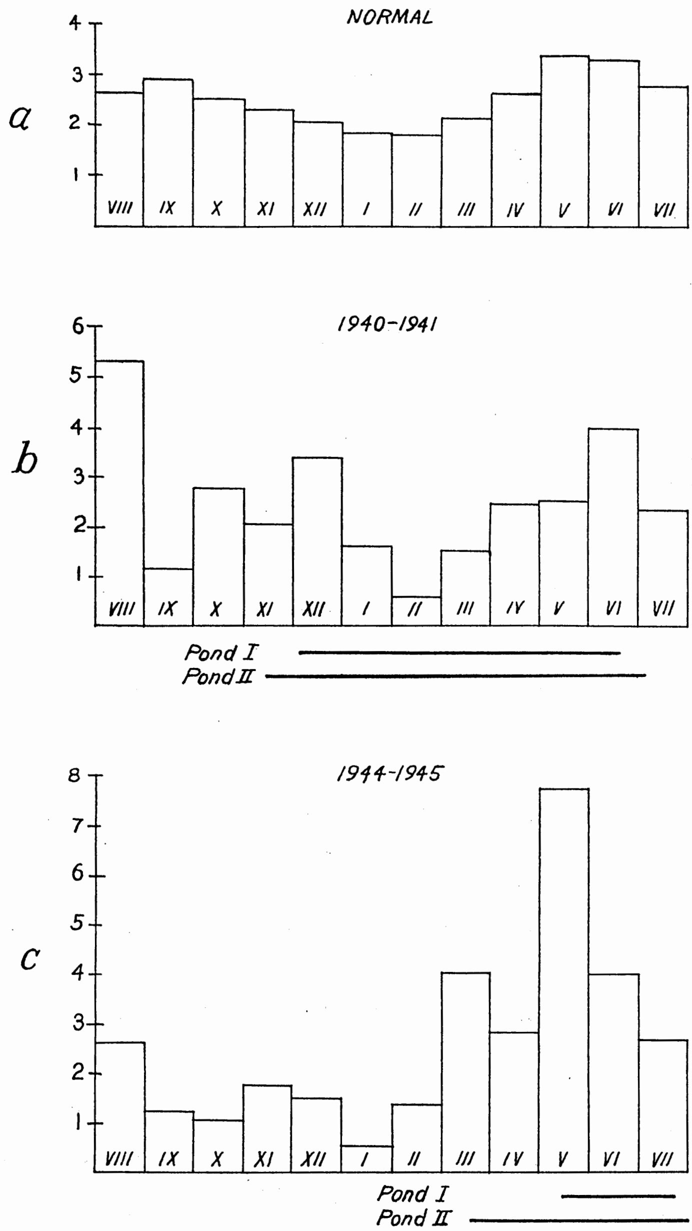


FIG. 1. Monthly precipitation in inches in Ann Arbor: (*a*) "normal" precipitation (average of recorded data), (*b*) precipitation in 1940–41, (*c*) precipitation in 1944–45. Data taken from *Climatological Data* (U. S. Weather Bureau), Vols. 27, 28, 31, and 32. The thick horizontal lines below graphs *b* and *c* indicate the periods when temporary Ponds I and II contained water.

palustris Marsh.), and willow shrubs (*Salix* sp.) are scattered over the area of the pond and its vicinity.

Algae became noticeable in April, but never reached excessive abundance. At first the algal growth was confined to dead submerged parts of rooting plants and consisted practically of a single species, *Tribonema bombycinum* (Ag.) Derbes and Sol. Later, in June, in the last stages of the pond, algae were also seen floating in the pond in a few places.

Pond I was first visited on September 25, 1940, after a moderate rainfall on the preceding day. There was no water above the ground. The pond was overgrown with dense vegetation. It had apparently been empty for several months. Two samples were taken of the bottom, each comprising an area of about four hundred square centimeters and reaching twelve centimeters deep. One of the samples was examined dry in order to determine the possible presence of estivating animals. It contained, in the main, terrestrial species such as Enchytraeidae, Lumbricidae (earthworms), a land isopod (*Porcellionides virgatus* [Budde-Lund]), terrestrial spiders (species of the genera *Pirata, Pardosa,* and *Microneta*), Collembola, beetles (Staphylinidae, *Cercyon* sp., *Hydraena pensylvanica* Kiesenwetter), aphids, *Hebrus* sp. (a hemipteran inhabiting moist ground), and land snails (*Zonitoides nitidus* [O. F. Müller]). Only a few pond animals were recovered from the sample: one dipterous larva, last instar, of the *Bezzia-Palpomyia* group (Ceratopogonidae); one snail (*Lymnaea palustris*); and several sphaeriids (*Sphaerium occidentale* and *S. truncatum*).

The other sample was placed in an aquarium and covered with water. The following animals emerged within two days: terrestrial forms, Enchytraeidae and Lumbricidae; aquatic species, numerous Protozoa, Rhabdocoela, Rotifera, Naididae (Oligochaeta), Copepoda, few Ostracoda, two ceratopogonid larvae, and many small Sphaeriidae.

Subsequent samples of the pond bottom taken October 10, 15, and 23, before the pool started to fill up, and placed in water, yielded essentially the same results as the first samples. Additional aquatic animals obtained from the samples were: rhabdocoels (*Macrostomum* sp. and *Stenostomum* sp.), small nematodes, a few Gastrotricha, Naididae (*Pristina longiseta* and *Aeolosoma hemprichi*), dipterous larvae (*Eulalia vertebrata* [?] and Orthocladiinae), and small aquatic snails (*Gyraulus parvus* and *Armiger crista*).

In the early part of December there was a period of cold weather with some snowfall, followed by several warm days. The water from the thawing snow started to fill the pond. On December 17, when the first collections were made, only the lowest parts of the pond contained water. The deepest depressions were filled with ice covered with about 12 centimeters of water. A thin ice sheet, about 1 centimeter thick, had formed on the surface during the preceding night (Fig. 3). The fauna was poorly developed. Apart from unidentified Protozoa, Rotifera, and microscopical Nematoda, the following animals were collected: six small specimens of *Phagocata vernalis,* white, obviously recently hatched from cysts; one *Simocephalus serrulatus* (Cladocera) bearing an ephippium; many harpacticoid Copepoda (*Attheyella northumbrica americana* and *Canthocamptus staphylinoides*); two ostracod larvae; one young *Asellus militaris;* one nymph

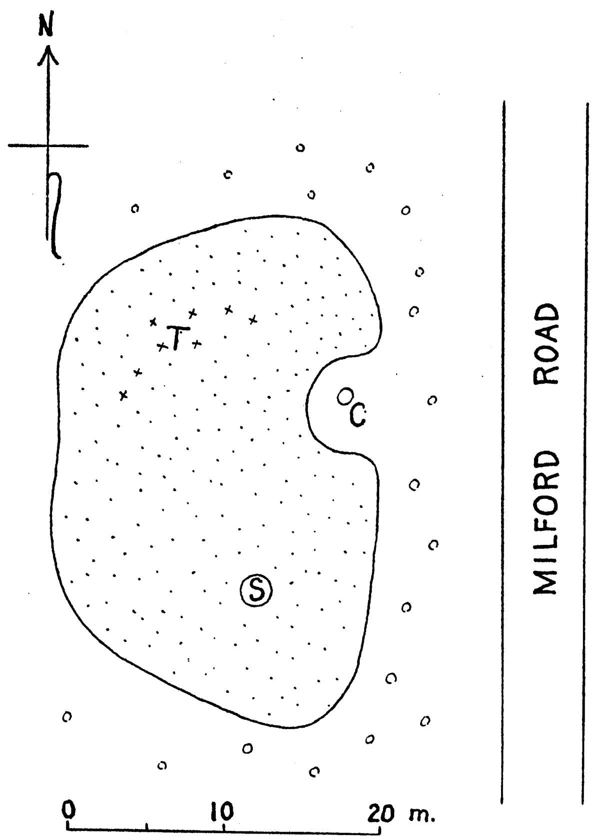


FIG. 2. Pond I, on Milford Road: *C, Cornus; S, Salix; T, Typha.*

of *Piona* sp. (Hydracarina); one ceratopogonid larva, about half-grown, of the *Bezzia-Palpomyia* group; five chironomid larvae; two specimens of *Gyraulus parvus;* and one young *Succinea* sp. (a terrestrial snail living in wet localities).

During the period when the pond contained water, collections were made at intervals of two to three weeks. An analysis of the results is given in Table V.

Throughout the winter and until the ice disappeared in the latter part of March, the animal life in the pond remained poor quantitatively and qualitatively. The fauna consisted, in the main, of flatworms, small crustaceans, dipterous larvae, and mollusks. The most characteristic animal of the winter season was the flatworm, *Phagocata vernalis*. Only one species of ostracods, *Candona decora,* was represented. Two copepods, *Cyclops bicuspidatus* and *C. vernalis* became rather numerous in February and March. *Crangonyx gracilis* and *Asellus militaris* increased in number toward the end of the winter. Water mites were in general rare. *Gyraulus parvus* and sphaeriids were the dominant mollusks. An oligochaete, *Lumbriculus variegatus,* appeared in the latter part of the winter, but never became abundant.

After the ice had melted in March, the pond began to warm up gradually. At the same time, the animal life in the pond became richer and more diversified. The period of rising temperature lasted from the beginning of April to the early part of May. A number of animal groups that had not been previously found in the pond appeared, either emerging from eggs or

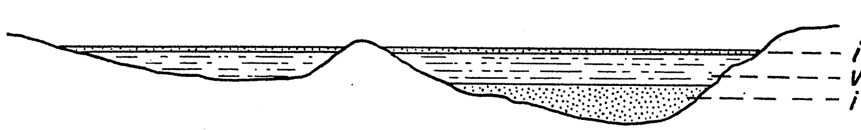


FIG. 3. The water conditions in Pond I on December 17, 1940: *i,* ice; *w,* water.

latent stages or introduced from the outside: Cladocera, Odonata, Hemiptera, Coleoptera, Trichoptera, and Amphibia. Other groups, Ostracoda and Acarina, greatly increased in the number of species as well as of individuals. The triclad turbellarians (*Phagocata vernalis*) disappeared soon after the ice had melted, and a rhabdocoel turbellarian, *Dalyellia* sp., became the dominant flatworm. The typical species of the early spring season was the fairy shrimp, *Eubranchipus* sp.

During the greater part of May and June, the water temperature was relatively high and the water level was falling. In this late spring stage, gradual changes occurred in the composition of the pond fauna. The number of predatory animals (beetle larvae, dragonfly larvae, Hemiptera, and spiders) increased considerably. Strictly vernal forms such as the fairy shrimp disappeared, though clam shrimps (*Lynceus*) were present to the middle of June.

A final collection was made July 7, after the pond had been empty for about twelve days. The ground-water level at that time was about eight centimeters below the deepest area of the former pond. Moist leaves at the edge of the woods, as well as two bottom samples, were examined. A few pond animals were recovered: one young oligochaete (*Lumbriculus*), two copepods, two ostracods (*Pionocypris obesa* and *Cypria exculpta*), dipterous larvae (a species of Sciomyzidae and *Tendipes decorus*), beetle larvae (*Enochrus* sp. and a nonaquatic form, *Cercyon* sp.), snails (*Gyraulus parvus* and numerous specimens of *Planorbula armigera*), and bivalves (*Sphaerium occidentale* and *S. truncatum*).

To recapitulate, life in Pond I exhibited during the period of observation roughly three successive stages or phases which corresponded to the presence or absence of water and to the prevailing temperature conditions:

a) The cold-water stage, from the beginning of December to the end of March. The pond was frozen over most of the time. The animal life was restricted, the most characteristic active species being a flatworm, *Phagocata vernalis.*

b) The spring stage, from the beginning of April (after the melting of the ice) to the time when the pond dried out near the end of June. The animal life reached its greatest development during the earlier half of this period (April and part of May). The typical faunal representative of this early stage was the fairy shrimp, *Eubranchipus.* In the latter part of the spring stage, a great number of predaceous forms appeared, and life was in general declining. The clam shrimp, *Lynceus,* was the characteristic animal of the late spring.

c) The dry stage, from the end of June to late autumn.

The period during which Pond I contains water depends to a large extent on meteorological factors, in particular on the amount of precipitation in the various seasons. Its filling and emptying coincide with the rising and falling of the ground-water table. This correlation was well illustrated by observations made in the season of 1944–45. The latter half of 1944 and the months of January and February of 1945 were unusually dry. The total precipitation in the Ann Arbor region during that period (11.75 inches) was far below the "normal" precipitation (19.16 inches). Consequently, the pond remained empty throughout the cold season. After the spring thaw and subsequent heavy rains in March, the ground water was still 30 centimeters below the bottom of the pond (March 22). The pond did not begin to fill until the middle of May, and dried again in the latter part of July (Fig. 1, *b* and *c*). Thus, it contained water for only ten weeks, as compared with six and one-half months in the season of 1940–41. Nevertheless, it had a rich and apparently normal fauna in the latter part of May and throughout June.

POND II

Pond II (Figs. 1, 4, 5; Pl. I, Figs. 1 and 2; and Map 1) is a temporary pond on the west side of U. S. Highway 23, about 300 meters north of the crossing of U. S. Highway 112, five and one-half miles southeast of Ann

Arbor. It is situated in open grassland, in a shallow depression bounded on the west side by a low elevation. When the pond is filled, the water covers a roughly circular area with a diameter of about 45 meters. The maximum depth of the water is approximately 60 centimeters. In 1940 the pond began to fill during the month of November. Even before that time, transitory pools of water had accumulated in the lowest area after rainfalls, but had disappeared again in subsequent dry weather. At the beginning of January, 1941, the pond was filled almost to capacity. The water level remained high until the middle of May. In the latter part of May,

TABLE II

POND II (TEMPORARY POND ON U. S. HIGHWAY 23)
Physical and chemical conditions, October 1940 to July 1941

Date	Water Temperature (° C.)	pH	Dissolved Oxygen (p.p.m.)	Methyl-orange Alkalinity (p.p.m.)	Thickness of Ice (Centimeters)	Remarks
Oct. 23	....	......	....	......	....	Pond dry
Nov. 19	....	5.8	....	......	2.5	Shallow pools in lowest area
Dec. 9	1.1	5.9	11.1	12	5	
Jan. 1	3.0	6.2	4.7	18	0.7	
Jan. 31	0.8	6.8	1.5	80	21	Foul odor
Feb. 14	1.0*	7.6*	11.3*	4*		Water above the ice
Mar. 5	0.3	6.8	8.3	22	24	Slightly foul odor
Mar. 20	0.8	6.6	6.9	30	28	3 cm. of snow above ice; foul odor
Apr. 2	2.1	6.9	6.7	20	1	New ice
Apr. 15	17.0	7.7	7.4	3	0	Water colored
Apr. 29	16.0	7.2	5.4	10	0	Water colored
May 13	11.8	7.2	3.9	10	0	Water colored
May 27	23.5	7.2	8.0	7	0	Water colored
June 10	20.0	6.8	7.2	20	0	Water colored
June 29	....	......	....	......	0	Drying out; little water
July 7	....	......	....	......	....	Dried out recently

* The data refer to the water above the ice (see Fig. 5).

and throughout June, the level was falling until all free water disappeared at the beginning of July.

Table II contains some physical and chemical data for Pond II obtained during the period of observation. Attention is called to the low oxygen content of the water on January 31, 1941 (1.5 parts per million), and to the foul odor of the water noticed on that date, indicating a disintegration of organic matter in the pond.

The vegetation of the pond has a rather regular concentric zonation. There is a central area in which rooted plants are scarce and are represented mainly by grasses and other nonaquatic forms left over from the preceding summer. In a wide marginal zone the prevailing plant is the water plantain (*Alisma Plantago-aquatica* L.), which is accompanied by arrowheads (*Sagittaria latifolia* Willd.), mosses (*Drepanocladus aduncus* var. *polycarpus* [Bland.] Warnst.), and floating liverworts (*Ricciocarpus natans* [L.] Corda). Two small clumps of spatterdock (*Nuphar avena* Ait.), with leaves standing upright, were also seen in this zone. There is a stand of cattails (*Typha latifolia* L.) in the northeastern corner of the pond.

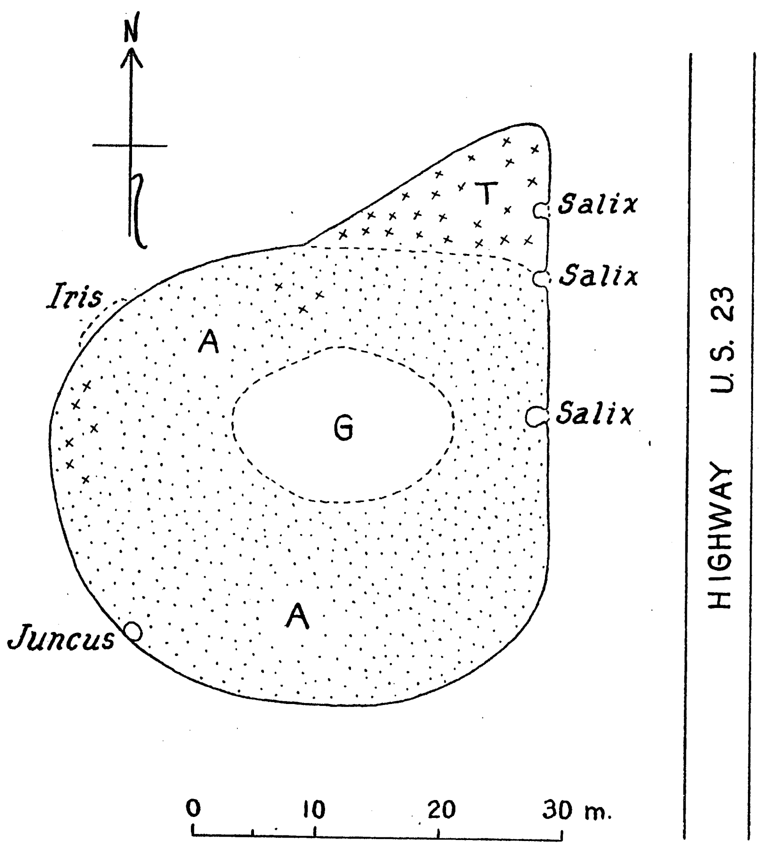


FIG. 4. Pond II, on U. S. Highway 23: *A*, *Alisma*; *G*, grasses; *T*, *Typha*.

Along the bank, the vegetation is composed of such hydrophytes as manna grass (*Glyceria septentrionalis* Hitchc.), sedges and rushes (*Carex vulpinoides* Michx., *Eleocharis Smallii* Britton, *Juncus effusus* L.), swamp milkweed (*Asclepias incarnata* L.), asters (*Aster* sp.), beggar-ticks (*Bidens* sp.), buttonbush (*Cephalanthus occidentalis* L.), blue flag (*Iris versicolor* L.), willow bushes (*Salix* sp.), and bittersweet (*Solanum Dulcamara* L.).

A profuse algal vegetation develops in spring after the water of the pond has become warm. The algae grow on submerged parts of dead higher plants and also float in dense masses in the water of the pond. By far the most plentiful species is *Tribonema bombycinum* (Ag.) Derbes and Sol., with *Cylindrocapsa geminella* Wolle and *Vaucheria sessilis* (Vauch.) DC. subordinate.

In early autumn, 1940, Pond II was dry for a considerable time. A heavy rainfall occurred in the night of October 6–7. On October 8, water was still present, forming shallow pools in the depressions of the pond bottom. Ostracods (*Cypria exculpta*) and copepods (many *Cyclops vernalis*, the majority in the copepodid stage, one *C. bicuspidatus*, and several specimens of *Canthocamptus staphylinoides*) were active in the water. Numerous Collembola (*Achorutes nivicolus* and one specimen of a shore form, *Isotomurus palustris*) were observed on the water surface. A soil sample of the bottom contained two young specimens of *Crangonyx gracilis* and many small clams, *Sphaerium truncatum.*

Additional bottom samples were taken October 15 and 23 and were placed in aquarium containers, which were filled with water. The following animals were observed in these cultures within a few days:

Turbellaria: *Stenostomum* sp., *Catenula lemnae* (became very numerous in some aquaria).

Rotifera, Gastrotricha, and Nematoda (unidentified species).

Oligochaeta: *Aeolosoma hemprichi, A. leidyi, Pristina longiseta, Dero limosa, Slavina appendiculata, Nais* sp., *Lumbriculus variegatus.*

Hirudinea: *Erpobdella punctata* (?) (one young specimen), *Dina microstoma* (two individuals).

Ostracoda: *Cypria exculpta.*

Copepoda: *Cyclops vernalis* (numerous), *C. bicuspidatus.*

Acarina: *Piona* sp., (one nymph).

Collembola: *Achorutes nivicolus.*

Odonata: *Libellula pulchella* (one nymph).

Diptera, Tendipedidae: Orthocladiinae (unidentified larvae), *Calopsectra* sp.

Diptera, Ceratopogonidae: one larva of the *Bezzia-Palpomyia* group.

Gastropoda: *Gyraulus parvus, Physa gyrina.*

Pelecypoda: *Sphaerium truncatum.*

The pond began to fill up in the latter part of November, 1940. During the cold-water stage from November to the early part of April, the fauna was, as in Pond I, very meager. The characteristic winter species was again *Phagocata vernalis,* though a few specimens of this flatworm were still present after the water had warmed up in spring. Young individuals of *Eubranchipus vernalis* appeared in November, but the species did not attain its main development until April. Several animal groups, such as Hemiptera and Odonata, were lacking in the winter fauna. Others, including Hirudinea, Acarina, and Trichoptera, were sparingly represented. A small number of Coleoptera, belonging to various species, occurred throughout the winter; they had reached the pond probably in late autumn before it had frozen over. A list of the animals collected during the winter stage is given in Table V.

The spring stage of the pond, lasting from the early part of April to the time when the water disappeared at the beginning of July, was characterized by a fauna abundant in species as well as in individuals. The winter flatworm, *Phagocata vernalis,* persisted in small numbers throughout the month of April. The fairy shrimp, *Eubranchipus,* was very numerous in April, but vanished at the end of that month. The clam shrimp, *Lynceus,* was present throughout the spring. Various species of Hirudinea, Acarina, Hemiptera, Coleoptera, and Trichoptera were represented in great numbers throughout this season.

As in Pond I the composition of the fauna changed gradually from early to late spring. The latter part of May and all of June were charac-

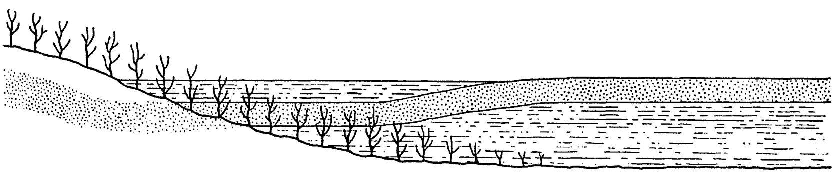


FIG. 5. The water conditions in Pond II on February 14, 1941.

terized by a high water temperature and a falling water level. At that time certain predaceous animals such as Odonata, coleopterous larvae, and Hemiptera reached the peak of development, while the numbers of other inhabitants of the pond were gradually declining (Table V).

A collection was made on July 7 when the pond had been empty for about five days. The bottom was still moist and was covered with an organic layer consisting mainly of algal masses. Bottom samples, to the depth of about twelve centimeters, contained: leeches (*Erpobdella punctata*), ostracods (numerous individuals of *Cypria exculpta,* one of *Pionocypris vidua,* and two of *P. obesa*), copepods, nonaquatic beetles (adults of *Anacaena limbata* Fabricius and *Paracymus subcupreus* [Say], and larvae of *Cyphon* sp.), dipterous larvae (Ceratopogonidae and Sciomyzidae [?], *Calopsectra* sp., and *Polypedilum* sp.), snails (*Gyraulus parvus, Physa gyrina*), and mussels (small specimens of *Sphaerium truncatum*).

With regard to seasonal phases in Pond II, the same three successive stages as in Pond I were observed:

a) The winter stage, from the latter part of November, 1940, to the early part of April, 1941. The fauna was poor in species and in individuals, the characteristic active form being the flatworm, *Phagocata vernalis.*

b) The spring stage, from early April to the beginning of July. In the early part of this stage, the fairy shrimp, *Eubranchipus vernalis,* reached its full development. In the latter part, when the water level was falling and the water had warmed up, in general life in the pond declined. The clam shrimp, *Lynceus brachyurus,* was again the characteristic form of the late spring.

c) The dry stage, from the disappearance of the water at the beginning of July to late autumn, when the pond started filling up again.

In the winter of 1944–45, which followed an unusually dry summer and autumn, Pond II remained empty. It started to retain water only after a heavy rain in the second half of March, 1945 (Fig. 1, *c*). On July 24 a considerable amount of water was still present, and the pond was covered by dense vegetation. Further observation was discontinued. It may be assumed, however, that the surface water did not disappear completely until some time in August. The "spring" fauna, from April through July, had the usual composition and abundance.

POND III

Pond III (Fig. 6; Pl. II, Fig. 2; and Map 1) is a permanent pond situated on the east side of Platt Road, between Bemis and Merritt Roads, four-tenths of a mile north of the crossing of Bemis Road, and about seven and one-half miles south-southeast of Ann Arbor. The original pond was partly filled in at the time of the construction of Platt Road. As a consequence, the west edge of the pond, which is at the same time the east shoulder of the road, is steep, and on the east side the pond shallows out gradually into marshy ground. On the north and south sides the pond continues into ditches flanking the road. The dimensions of the pond, apart from the ditches, are about sixty by seventeen meters, the longer diameter being parallel to Platt Road. The maximum depth, at high water level, is about eight-tenths meter.

Pond III was selected for study because it was expected to combine characteristics of both temporary and permanent pools. The ditches along the road, as well as the swampy ground to the east of the pond, represent temporary aquatic habitats which are inundated only when the ground-water table is high, particularly in early spring. The permanent accumulation of water in the pond itself facilitates the existence of animals that lack special adaptations to a drying-out of the habitat.

Table III shows some physical and chemical data concerning the water of the pond.

Arrowhead (*Sagittaria latifolia* Willd.) is the only rooted plant growing submerged in the water, along the east edge of the pond. Duckweed (*Lemma minor* L.) and liverwort (*Ricciocarpus natans* [L.] Corda) float on the surface of the water, but are not abundant. Cattails (*Typha latifolia* L.) grow near the east bank and in the adjoining ditches. To the east of the pond, a typical sphagnum-bog flora is developed. Manna grass (*Glyceria septentrionalis* Hitchc.) is dominant along the edge of the water. Other plants growing on the wet ground are sedges (*Eriophorum virginicum* L., *Carex vulpinoidea* Michx., and *Dulichium arundinaceum* [L.] Britton), rushes (*Juncus articulatus* L., *Eleocharis obtusa* [Willd.] Schultes, and *Scirpus cyperinus* [L.] Kunth), rice cut-grass (*Leersia oryzoides* [L.] Swartz), bur reed (*Sparganium androcladum* [Engelm.] Morong.), water plantain (*Alisma Plantago-aquatica* L.), bedstraw (*Galium* sp.),

TABLE III

POND III (PERMANENT POND ON PLATT ROAD)
Physical and chemical conditions, October 1940 to May 1941.

Date	Water Temperature (° C.)	pH	Dissolved Oxygen (p.p.m.)	Methyl-orange Alkalinity (p.p.m.)	Thickness of Ice (Centimeters)	Remarks
Oct. 17	12.3	8.0	9.5	147	0	
Oct. 25	15.4	8.2	8.9	143	0	
Nov. 6	7.2	8.1	7.5	148	0	
Nov. 19	1.2	7.2	8.9	157	Trace	
Dec. 9	0.9	6.4	4.3	101	7	
Jan. 2	1.8	6.8	17.0	45	0.7	
Feb. 4	0.9	5.8	8.5	110	19	
Feb. 14	1.0	6.8	10.2	34	12	
Mar. 5	0.8	7.0	9.1	40	18	
Mar. 20	0.9	6.8	12.2	68	17	2 cm. of snow above ice
Apr. 2	5.1	6.8	11.8	26	Trace	New ice in southern half of pond
Apr. 15	20.0	7.0	5.5	67	0	Water colored
Apr. 29	19.2	6.9	4.1	60	0	Water colored
May 13	15.7	6.9	6.6	....	0	Water colored
May 27	27.0	7.2	5.1	85	0	Water colored

bittersweet (*Solanum Dulcamara* L.), and blue flag (*Iris versicolor* L.). Included in the abundant growth of shrubs on the marshy east bank are buttonbush (*Cephalanthus occidentalis* L.), leatherleaf (*Chamaedaphne calyculata* [L.] Moench), dogwood (*Cornus stolonifera* Michx.), red maple (*Acer rubrum* L.), steeple bush (*Spiraea tomentosa* L.), and black alder (*Ilex verticillata* [L.] Gray).

Algae occur in the pond, mainly attached to submerged vegetation, more rarely in floating masses. Species of *Oedogonium, Spirogyra, Zygnema, Lyngbya,* and also *Mougeotia scalaris* Hass., *Vaucheria sessilis* (Vauch.) DC., and *V. geminata* (Vauch.) DC. are represented.

The animal life in Pond III was investigated only during the period in which the temporary ponds contained water, that is, in the winter and

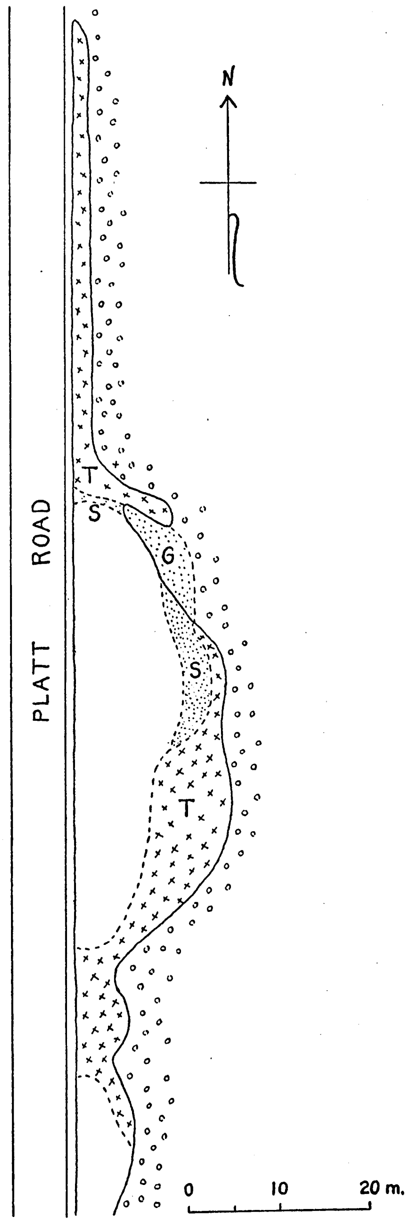


FIG. 6. Pond III, on Platt Road: *G, Glyceria; S, Sagittaria; T, Typha.*

spring. In order to facilitate a comparison of the faunas of these habitats, the collection data were grouped separately for the winter and spring seasons. The winter season was taken as the period from the first appearance of ice, in November, 1940, to the time when the ice had melted and the water had started to warm up again at the end of March, 1941. The observations during the spring season covered the months of March and April.

The fauna of Pond III was in many ways comparable to that of the temporary Ponds I and II. A number of animal species was common to both types of habitat. The essential difference between the winter faunas of the temporary ponds and of the permanent ponds was that the latter ponds contained faunal representatives, such as hydras, dragonfly and mayfly nymphs, and tadpoles, which lacked adaptations for surviving a dry period and, therefore, were absent from the temporary pools. In other respects, the faunas of the three ponds were almost identical (Table V).

After the melting of the ice, the animal life in Pond III underwent the same changes that were observed in the temporary ponds. The number of species and individuals increased, due in part to the emergence of animals from latent stages and in part to introductions from outside. Mites (Acarina), dragonfly nymphs (Odonata), water bugs (Hemiptera), and beetles (Coleoptera) that had been only meagerly represented in the winter fauna, became abundant. Fairy shrimps (*Eubranchipus vernalis* and *E. bundyi*) appeared in April to vanish again after a few weeks (Table V).

In recapitulation, the fauna of the permanent Pond III, was rather similar to that of the temporary Ponds I and II. In the winter stage it contained more elements that had been brought over from the preceding warm season. The faunal changes in the spring were analogous to those observed in temporary ponds.

POND IV

Pond IV (Fig. 7; Pl. III, Figs. 1 and 2; and Map 1) is a large permanent backwater pond of the Huron River, situated on the south side of Huron River Drive, 140 meters west of Hogback Road and about three miles east of Ann Arbor. It is connected through a narrow channel, passing below Huron River Drive, with the impoundment created by Geddes Dam. The pond is approximately 65 meters wide and 95 meters long. The maximum depth is about one meter. Table IV gives some physical and chemical data for this pond.

The pond is characterized by a very rich vegetation. In the center, coontail (*Ceratophyllum demersum* L.) is very abundant in association with pondweed (*Potamogeton natans* L. and *P. zosteriformis* Fernald), waterweed (*Anacharis canadensis* [Michx.] Planchon), bladderwort (*Utricularia vulgaris* var. *americana* Gray), water lily (*Nymphaea odorata* Ait.), and arrowhead (*Sagittaria latifolia* Willd.). Duckweed (*Lemna trisulca* L. and *L. minor* L.) and watermeal (*Wolffia columbiana* Karst.) are floating on, or near, the surface.

Along the edge, bur reed (*Sparganium eurycarpum* Engelm.) is the dominant plant, associated with cattails (*Typha latifolia* L.) and sedges (*Carex comosa* Boott., *C. substricta* Kükenth., *C. vulpinoidea* Michx., and *Eleocharis Smallii* Britton). Other typical plants growing on the wet bank of the pond are water plantain (*Alisma Plantago-aquatica* L.), swamp milkweed (*Asclepias incarnata* L.), beggar ticks (*Bidens* sp.), asters (*Aster* sp.), bedstraw (*Galium* sp.), cut-grass (*Leersia oryzoides* [L.] Swartz), horsetail (*Equisetum fluviatile* L.), and cowslip (*Caltha palustris* L.).

On the east and south banks of the pond, there is a wide zone of shrubs starting a short distance from the edge of the water. *Potentilla fructuosa* L., *Cornus stolonifera* Michx., and *Salix* sp. are the dominant species here. The west bank continues into a marsh, and the north bank is formed by the steep fill of Huron River Drive.

TABLE IV

POND IV (BACKWATER OF HURON RIVER)
Physical and chemical conditions, October, 1940, to June, 1941.

Date	Water Temperature (° C.)	pH	Dissolved Oxygen (p.p.m.)	Methyl-orange Alkalinity (p.p.m.)	Thickness of Ice (Centimeters)	Remarks
Oct. 17	13.2	8.2	10.3	221	0	
Oct. 25	16.0	8.2	9.7	216	0	
Nov. 15	0.3	8.2	9.2	241	1.5	
Dec. 9	0.8	7.9	9.5	264	11	
Jan. 3	1.8	8.1	11.9	212	0.8	
Feb. 7	0.4	7.4	7.7	330	12	
Feb. 24	0.8	6.9	4.5	379	15	2 cm. of snow above ice
Mar. 11	0.8	7.2	8.4	208	Some	6 cm. of soft ice and snow
Mar. 26	3.9	7.9	15.9	202	Trace	
Apr. 9	12.0	7.9	12.0	248	0	
Apr. 22	14.0	8.0	13.0	237	0	
May 6	20.2	7.6	5.0	....	0	
May 20	24.5	8.0	6.2	....	0	
June 5	25.0	8.0	10.3	178	0	

A comparison of the fauna of Pond IV with that of the previously discussed permanent Pond III reveals certain differences of both qualitative and quantitative nature. As Pond IV is a sidewater pool of the Huron River, elements of the river fauna have penetrated into it. Fishes may have had a profound influence on the composition of the invertebrate fauna, by eating many of the animals and even preventing the establishment of exposed species, such as, for example, phyllopods. The fish species taken occasionally with a dipnet were carp (*Cyprinus carpio* L.), western golden shiner (*Notemigonus crysoleucas auratus* [Rafinesque]), bluntnose minnow (*Hyborhynchus notatus* [Rafinesque]), pumpkinseed (*Lepomis gibbosus* [L.]), and bluegill (*Lepomis macrochirus macrochirus* Rafinesque). This is probably not a complete list of the fishes in the pond, for no detailed study of the fish population, with suitable collecting methods, was made.

Samples of the fauna taken at intervals during the cold period, from the appearance of the first ice in the middle of November, 1940, to the onset of warmer weather at the end of March, 1941, contained annelids, crustaceans, and insects (particularly dipterous larvae). The density of the animal population was, however, rather low (Table V). The faunal changes

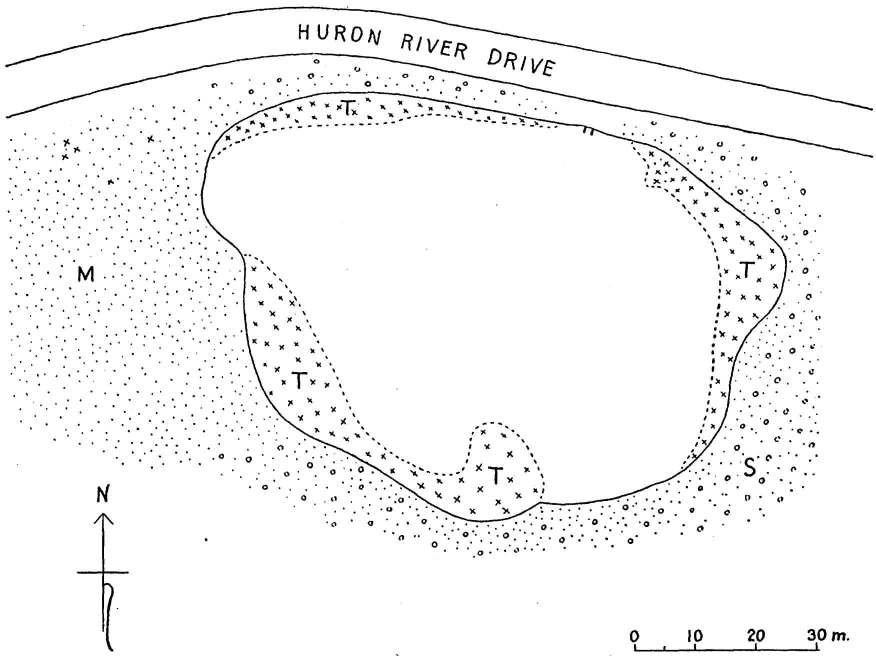


FIG. 7. Pond IV, on Huron River Drive: *M*, marsh; *S*, shrubs; *T*, *Typha*.

that occurred in the spring, after the ice had disappeared, were much less marked than they were in the other three ponds. There was no sudden increase in the number of species, and the fauna remained comparatively poor during the period studied. Such typical vernal forms as the fairy shrimp and clam shrimp were absent. The limited number of cladocerans, copepods, water mites, and beetles was remarkable.

TABLE V

Seasonal Occurrence of Animals in the Four Ponds, I to IV

The abundance is expressed by symbols: a, abundant; c, common; r, rare; or by the number of specimens taken. Months are indicated by the first two letters, except Mr—March, My—May, Je—June, and Jy—July. Other abbreviations: i, immature; la, larva; m, mature or adult; ny, nymph; pu, pupa. The collections were made in the season 1940–41, except for the spring fauna of Cladocera and Copepoda which was collected in the spring of 1945.

Animals	Pond I		Pond II		Pond III		Pond IV	
	Winter	Spring	Winter	Spring	Winter	Spring	Winter	Spring
Cnidaria								
Pelmatohydra oligactis	...	...	...	...	r,Mr	c,Ap	...	...
Chlorohydra viridissima	...	...	...	...	...	c,My	...	...
Turbellaria								
Rhabdocoela, unident.	1,Ja	r,Ap	...	2,Ap	...	1,Ap	...	1,My
Macrostomum sp.	...	...	...	...	...	...	...	1,Ap
Dalyellia sp.	...	c,Ap–Je	...	c,My	...	...	...	...
Phaenocora sp.	...	...	...	...	...	...	c,De–Fe	1,Ap
Mesostoma sp.	...	...	...	...	...	...	...	1,Ap
M. ehrenbergi	...	...	...	2,My	...	...	...	...
Bothromesostoma sp.	...	1,Ap	...	c,Ap	...	1,Ap	...	...
Prorhynchus stagnalis	...	1,Ap	...	...	...	...	...	...
Phagocata vernalis	c,De–Mr	...	c,Ja–Ap	r,Ap	...	...	...	...
Nematoda, unident. sp.	c,De–Ja	r,My	...	r,My–Je	...	c,Ap	...	...
Oligochaeta								
Naididae	...	...	a,Ja	c,My	2,De,Fe	...	...	...
Chaetogaster limnaei	...	...	...	...	...	c,Ap	...	...
C. diaphanus	...	...	...	...	...	...	...	2,My
Pristina sp.	...	...	...	...	1,Mr	...	...	...
P. leidyi	...	...	...	1,Je	...	...	...	...
P. longiseta	...	1,Ap	...	...	...	...	...	...
Dero limosa	...	c,My–Je	...	c,Je	...	r,My	...	1,Je
Slavina appendiculata	...	...	...	1,Ap	...	...	...	?1,Je
Nais sp.	...	...	...	2,Ap–My	...	c,Ap–My	...	...
N. variabilis	...	...	...	...	...	...	...	c,My–Je
Tubificidae, unident. sp.	...	1,Ap	2,Mr	...	a,Mr	a,Ap	a,No–Mr	a,Ap; c,My–Je
Tubifex multisetosus	...	...	...	...	...	...	a,No–Mr	c,Ap
Lumbriculus variegatus	r,Fe–Mr	r,Ap–My	c,Ja–Ap	c,Ap–My	3,Fe	...	...	...

TABLE V—(*Cont.*)

Animals	Pond I		Pond II		Pond III		Pond IV	
	Winter	Spring	Winter	Spring	Winter	Spring	Winter	Spring
Hirudinea								
Helobdella stagnalis	...	...	...	r,My–Je	r,Fe–Mr	1,My	1,Mr	...
H. fusca	...	...	...	1,My	...	...	2,Fe	...
Glossiphonia heteroclita	...	...	...	...	...	...	...	1,Ap
Placobdella parasitica	...	...	...	...	...	1,Ap	...	...
P. picta	...	...	...	c,Je	2,Fe–Mr	r,Ap–My	...	...
Placobdella rugosa	...	...	...	1,My	...	...	...	...
Erpobdella punctata	...	...	...	c,My–Je	c,Mr	c,Ap–My	...	...
Dina bucera	...	...	c,Ap	a,Ap–My	c,Fe–Mr	c,Ap–My	...	...
Phyllopoda								
Eubranchipus sp.	4,Ja,la 4,Mr,la	a,Ap–My	c,De,Ja r,Ap	a,Ap	...	c,Ap	...	...
Lynceus brachyurus	...	a,My–Je	...	a,Ap–Je	...	c,Ap–My	...	...
Cladocera								
Diaphanosoma brachyurum	...	...	...	...	...	r,My–Je	...	
Daphnia pulex	...	c,My,i+m a,Je,i+m	...	r,Ap,i	3,No	a,Mr–My	...	
Simocephalus vetulus	...	...	c,De–Ja,Mr	c,My–Je	...	c,Mr–Je	...	
S. serrulatus	1,De	...	...	...	...	a,My–Je	...	
Scapholeberis mucronata	...	c,Je,m+i	...	...	...	1,My,m	...	No collections
Ceriodaphnia reticulata	...	...	1,De	...	...	a,My–Je	...	
C. quadrangula	...	...	...	c,Ap,m+i c,Je,m	...	...	...	
Moina brachiata	...	...	r,Ja	...	...	...	...	
Kurzia latissima	...	...	...	r,Je,m	...	r,Je,m	...	
Alona rectangula	...	...	...	r,Ap,Je,m	...	c,My–Je,m	...	
Pleuroxus denticulatus	...	...	...	c,Ap–Je	...	...	...	
Ostracoda	2,De,la	...	...	...	...	...	...	...
Pionocypris vidua	...	...	r,No–De	c,Ap–Je	1,Mr	c,Ap–My	...	2,My
P. obesa	...	c,My–Je	...	...	1,Ja	r,Ap	...	...
Cyprois marginata	...	c,Ap–Je	...	...	...	...	...	...
Cypris subglobosa	...	c,My–Je	...	...	...	1,My	...	...
Eucypris crassa	...	2,Je	...	...	...	2,My	...	...
E. fuscata	...	a,Ap–My	...	c,Ap–My	...	c,Ap	...	...
Cypricercus tincta	...	c,My	...	c,Ap–My	...	...	...	2,My
Cypria exculpta	...	c,Ap	a,No–Ja c,Mr–Ap	a,Ap–Je	r,Ja	c,Ap–My	...	...

Animals	Pond I		Pond II		Pond III		Pond IV	
	Winter	Spring	Winter	Spring	Winter	Spring	Winter	Spring
Ostracoda (*Cont.*)								
Candona crogmaniana	....	....	....	....	a,Ja–Mr	c,Ap	....	....
C. decora	c,Ja–Mr	c,Ap–Je	....	....	....	....	....	....
C. truncata	....	1,My	....	....	a,Ja–Mr	r,Ap	....	....
Copepoda								
Calanoida	....	r,My–Je	....	c,My–Jy	....	1,Je	....	
Cyclops gigas latipes	r,Fe–Mr	c,My–Je,m r,Je,i	....	....	....	....	....	
C. vernalis	a,Fe–Mr	c,My,m	a,De c,Ja–Mr	c,Ap–Jy,m c,My,i	c,Fe	c,Ap–Je,i c,My–Jy,m	....	
C. bicuspidatus thomasi	c,Fe	a,Ap–My,m	a,No–Mr	a,Mr–Ap,m c,My,i	c,Fe	a,Mr–My,m a,My,i	....	
C. bicuspidatus navus	....	a,My–Je,m r,My,i	....	....	....	....	....	No collections
C. varicans rubellus	....	c,My–Je,m	r,De	r,My,m c,Jy,m	....	c,My–Jy,m	....	
Eucyclops speratus	....	....	....	....	1,Mr	....	r,No–Mr	
Mesocyclops leuckarti	....	....	....	r,Je,m a,Jy,m + i	....	a,Jy,m + i	....	
Macrocyclops albidus	....	....	....	....	r,Ja–Fe	....	r,No–Mr	
Platycyclops fimbriatus	....	....	....	....	....	r,Je,m	....	
Canthocamptus staphylinoides	c,De,Fe–Mr	a,Ap–My,m r,Ap,i	a,No–Fe	c,Mr–My,m r,My,i	c,Ja–Fe	c,Mr–My,m c,My,i	c,No–Mr	
Attheyella northumbrica americana	c,De,m	a,Ap–Je,m r,Ap,i	....	a,Mr–Jy,m c,My,i	....	a,My–Je,m r,My–Je,i	....	
Amphipoda								
Crangonyx gracilis	a,Fe–Mr	a,Ap–My r,Je	a,Ja–Ap	a,Ap–My r,Je	....	....	....	....
C. obliquus	....	....	....	....	a,De–Mr	a,Ap–My	....	....
C. shoemakeri	....	1,Ap	....	....	....	....	....	....
Hyalella azteca	....	....	....	....	....	....	c,No–Mr	c,Ap–Je
Isopoda								
Asellus militaris	r,De–Ja a,Fe–Mr	a,Ap–Je	c,Ja–Ap	a,Ap–My r,Je	....	....	....	....
A. communis	....	....	....	....	....	....	r,No–Mr	1,Ap

TABLE V—(*Cont.*)

Animals	Pond I		Pond II		Pond III		Pond IV	
	Winter	Spring	Winter	Spring	Winter	Spring	Winter	Spring
Decapoda								
Cambarus fodiens	…	r,My–Je	…	2,Ap,My	…	…	…	…
C. immunis	…	…	…	…	1,Ja	1,Ap c,My	…	3,My–Je
Araneida								
Microphantidae, unident. sp.	…	1,My	…	…	…	…	…	…
Dolomedes triton sexpunctatus	…	c,My–Je	…	c,Je	…	1,My	…	1,Je
Pirata sp.	…	…	…	1,My	…	…	…	…
Acarina								
Eylais sp.	…	c,Ap–Je	…	c,Ap–Je	…	3,Ap–My	…	…
Hydrachnidae, unident. sp.	…	…	2,Ja–Fe	…	…	…	…	…
Hydrachna sp.	…	r,Ap,Je	…	c,Ap–My	…	…	…	…
H. crenulata	…	…	…	1,My	…	…	…	…
H. conjecta	…	…	…	1,My	…	…	…	…
H. magniscutata	…	…	…	r,My	…	1,My,pu	…	…
H. miliaria	…	…	…	1,My,ny	…	…	…	…
H. rotunda	…	…	…	1,My	…	…	…	…
H. stipata	…	…	…	r,My–Je	…	…	…	…
Thyas sp.	r,Ja–Fe	r,Ap–Je	…	…	…	…	…	…
Hydryphantes ruber	…	…	…	c,Ap–My	…	3,My	…	…
H. ruber mozlei	…	r,Ap–My	…	…	…	…	…	…
Oxus connatus	…	…	…	1,Ap	…	…	…	…
Limnesia maculata	…	…	…	1,My	…	c,My	…	…
L. undulata	…	…	…	…	…	1,Ap	…	2,My–Je
Piona sp.	c,De–Ja,ny	c,Ap	2,Mr–Ap,ny	a,Ap c,Je	…	3,Ap,ny	…	…
P. carnea	…	…	…	…	…	c,Ap–My	…	…
P. constricta	…	…	…	a,Ap–My	…	1,My	…	…
P. pugilis	…	…	…	…	…	…	…	1,Je
Acercus torris americanus	…	r,Ap–Je	…	r,Ap–My	…	…	…	…
A. simulans	…	1,My	…	…	…	…	…	…
Arrenurus sp.	…	c,Ap–My	…	c,Ap–My	…	…	1,De	1,My
A. planus	…	1,My	…	1,Ap	…	…	…	…
A. kenki	…	…	…	r,Ap	…	…	…	…
non-Hydaracarina	c,Ja	1,My	…	…	…	…	…	…
Microtrombidium sp.	1,Mr	…	1,Ja	…	…	…	…	…

Animals	Pond I		Pond II		Pond III		Pond IV	
	Winter	Spring	Winter	Spring	Winter	Spring	Winter	Spring
Collembola	....	....	....	c,My–Je	....	....	....	....
Achorutes nivicolus (Fitch)	....	....	a,Mr	a,Ap	....	....	....	....
Neuroptera, larvae	....	....	....	....	....	3,Ap–My	....	....
Odonata, nymphs								
Lestes sp.	....	....	....	....	....	1,Ap	....	....
L. congener Hagen	....	....	....	a,Ap–My	....	c,My	....	....
L. rectangularis Say (? or *forcipatus*)	....	c,My–Je	....	a,My	....	....	....	1,My
L. dryas Kirby	....	....	....	c,My	....	c,My	....	....
Enallagma civile (Hagen) (? or *E. hageni*)	....	....	....	....	....	c,Ap	....	....
E. ebrium (Hagen) (? or *E. carunculatum*)	....	....	....	....	....	c,Ap	....	1,Ap
Ischnura verticalis (Say)	....	....	....	....	2,Ja,Mr	c,Ap	c,Fe–Mr	c,Ap–My
Gomphus villosipes Selys	....	....	....	....	....	1,Ap	....	....
Anax junius (Drury)	....	....	....	....	....	....	....	2,Je
Libellula sp.	....	1,My	....	....	....	....	....	....
L. pulchella Drury	....	....	....	....	c,De–Mr	c,Ap–My	....	....
Sympetrum obtrusum (Hagen) (? or *S. decisum* [Hagen])	....	c,My–Je	....	c,My	....	a,Ap–My	....	....
Pachydiplax longipennis (Burmeister)	....	....	....	....	....	1,Ap	....	....
Leucorrhinia intacta Hagen	....	....	....	....	r,Ja–Mr	r,Ap–My	....	....
Ephemerida, nymphs	....	....	....	c,Je	....	....	....	....
Callibaetis sp.	....	....	....	....	c,No–Fe	1,Ap	2,De	....
Caenis sp.	....	....	....	....	r,De–Mr	c,Ap–My	....	r,Ap,Je
Hemiptera								
Hydrometra martini Kirkaldy	....	....	....	....	....	1,My,m	....	....
Gerridae, unident. sp.	....	c,My–Je	....	....	....	....	....	....
Gerris marginatus Say	....	c,Ap–Je	....	r,My–Je,m	....	....	....	1,Ap,m
G. buenoi Kirkaldy	....	c,Ap–Je	....	1,Je,m	....	....	....	....
G. incurvatus Drake and Harris	....	....	....	....	....	1,Ap,m	....	....
Plea striola Fieber	....	....	....	....	....	a,Ap–My	r,Fe,m	a,Ap–Je
Notonectidae, unident. sp.	....	c,Je,ny	....	a,My–Je, ny	....	....	....	....
Notonecta undulata Say	....	....	....	c,Ap–Je,m	c,Ja	....	....	....
Belostoma sp.	....	c,Je,ny	....	a,Je,ny	....	c,My,ny	....	....
B. flumineum Say	....	....	....	2,My–Je,m	....	....	....	....
Nepa apiculata Uhler	....	....	....	....	....	....	1,No,m	....
Ranatra sp.	....	....	....	....	....	2,My	....	1,My

TABLE V—(*Cont.*)

Animals	Pond I		Pond II		Pond III		Pond IV	
	Winter	Spring	Winter	Spring	Winter	Spring	Winter	Spring
Hemiptera (*Cont.*)								
Ranatra fusca Palisot-Beauvois	....	....	....	2,My,m	....	....	....	....
Corixidae, unident. nymphs	....	c,My–Je	....	a,My–Je	....	c,My	1,Mr	1,Je
Sigara sp.	....	1,Je	....	....	....	....	....	....
S. alternata (Say)	....	....	....	....	r,Ja	2,Ap	....	....
S. hubbeli Hungerford	....	....	....	....	r,Fe	....	....	....
S. vulgaris Hungerford	....	....	....	2,My, m	....	1,Ap	....	2,Je,m
Trichocorixa sp.	....	....	....	....	r,No	....	....	1,Je
Coleoptera (adults if not otherwise specified)								
Haliplus sp.	....	1,Je,la	2,Ja,la	....	....	....	....	....
H. connexus Matheson	....	....	....	....	....	1,Ap	....	....
H. pantherinus Aubé	....	....	....	....	....	1,My	....	....
H. subguttatus Roberts	....	....	....	1,My	....	....	....	....
H. immaculicollis Harris	....	....	....	....	....	c,Ap–My	....	....
H. blanchardi Roberts	....	....	....	c,Ap–My	....	1,Ap	....	....
H. longulus LeConte	....	a,Ap–Je	....	c,Ap–Je	....	c,Ap–My	....	....
Pelodytes pedunculatus Blatchley	....	1,Ap	....	....	....	2,Ap	....	....
P. edentulus Le Conte	....	1,Ap	....	....	2,Ja	c,Ap–My	....	2,Je
Hydrocanthus iricolor Say	....	....	....	....	....	2,Ap	....	....
Laccophilus sp.	....	....	....	....	....	....	....	1,Je,la
L. maculosus (Germar)	....	....	....	....	....	1,Ap	....	....
Hydroporinae, unident. sp.	....	....	....	....	....	1,My,la	....	....
Hydrovatus pustulatus (Melsheimer)	....	....	1,Ja	1,Ap	....	c,Ap–My	....	....
Desmopachria convexa (Aubé)	....	a,My–Je	c,Ja–Fe	c,Ap–Je	....	r,Ap–My	....	....
Bidessus affinis (Say)	....	....	....	2,Je	....	....	....	....
Hygrotus sayi Balfour-Browne	....	c,My–Je	1,Ap	c,Ap–Je	....	1,Ap	4,Mr	....
H. turbidus (LeConte)	....	r,Ap–My	....	....	....	....	....	....
H. dissimilis Gemminger and Harold	....	1,My	....	....	....	....	....	....
Deronectes griseostriatus (De Geer)	....	....	....	1,My	....	....	....	....
Hydroporus sp.	....	1,Je,la	....	c,Ap–My,la	....	1,My	....	1,My,la
H. undulatus Say	....	....	1,Ja	2,My	....	r,Ap–My	....	....
H. lobatus Sharp (?)	....	....	2,Fe–Mr	c,Je	....	r,Ap	....	....
H. consimilis LeConte	....	....	1,Fe	r,Ap–My	....	r,Ap	....	....
H. signatus Mannerheim	....	1,Je	2,Ja,Mr	....	1,Mr	....	....	....

Animals	Pond I		Pond II		Pond III		Pond IV	
	Winter	Spring	Winter	Spring	Winter	Spring	Winter	Spring
Coleoptera (*Cont.*)								
Hydroporus niger Say	...	1,My	1,Fe	1,My	2,Fe	...	...	...
Agabus bifarius (Kirby)	...	1,Ap	...	...	...	...	...	...
Rantus sp.	...	c,Ap–Je,la	...	c,Ap–My,la	...	1,Ap,la c,My,la	...	...
R. tostus LeConte	...	1,Ap	...	...	...	1,Ap	...	...
Dytiscus sp.	...	c,Ap–My,la	...	2,My,la	...	...	...	...
Acilius sp.	...	r,My–Je,la	...	1,My,la	...	...	...	...
A. semisulcatus Aubé	...	1,Ap	...	...	...	...	...	...
Graphoderus sp.	...	...	...	1,Ap,la	...	a,My,la	...	...
G. liberus (Say)	...	...	...	...	1,Fe	1,Ap	...	...
G. fascicollis (Harris)	...	...	1,Mr	...	...	...	...	...
Dineutus nigrior Roberts	...	...	...	2,My	...	...	...	1,My
D. assimilis Kirby	...	...	...	...	...	1,Ap	...	...
D. horni Roberts	...	...	...	...	...	...	...	1,My
Gyrinus sp.	...	1,My,la	...	...	...	1,My,la	...	...
G. lecontei Fall	...	c,My–Je	...	1,Ap	...	1,Ap	...	...
Helophorus lineatus Say	...	r,Ap,Je	...	...	...	...	...	...
Hydrochus currani Brown	...	r,Ap,Je	...	...	...	...	...	...
H. squamifer LeConte	...	c,Je	...	...	...	...	...	...
Berosus sp.	...	3,Je,la	...	...	...	...	...	...
B. striatus (Say)	...	r,Ap,Je	...	r,Ap–Je	...	2,Ap	...	...
Hydrophilus sp.	...	...	...	1,Je,la	...	...	...	...
Hydrochara sp.	...	c,My–Je,la	...	...	...	...	...	...
Tropisternus sp.	...	...	...	c,My–Je,la	...	1,My,la	...	1,Je,la
Tropisternus mixtus (LeConte)	...	...	...	2,My–Je	...	...	...	...
Enochrus ochraceus (Melsheimer)	...	r,My–Je	...	...	...	...	...	...
Trichoptera								
Phryganeidae, unident. larvae	...	...	...	...	...	...	r,De,Fe	...
Limnephilidae, unident. larvae	...	...	1,Ja	c,Ap	c,De–Fe	...	...	...
Limnephilus indivisus Walker	...	a,Ap–Je,la c,Je,pu	...	a,Ap–My,la	...	c,Ap,la	...	...
Leptoceridae, unident. larvae	...	...	2,Ja	1,My	1,Mr	...	...	...
Triaenodes sp., larvae	...	...	...	c,My–Je	...	a,Ap–My	...	...
Lepidoptera								
Nymphulinae, unident. larva	...	...	...	...	1,Fe	...	...	...

TABLE V—(*Cont.*)

Animals	Pond I		Pond II		Pond III		Pond IV	
	Winter	Spring	Winter	Spring	Winter	Spring	Winter	Spring
Diptera, Tifulidae larvae	r,Fe–Mr	1,Ap	a,Fe–Mr	…	…	…	…	1,Ap
Limnophila sp. (?)	…	1,Ap	…	…	…	…	…	…
Tipula sp.	…	…	…	…	1,Fe	…	…	…
Diptera, Tendipedidae, larvae	c,De,Fe	My	1,De	…	…	3,My	2,Mr	2,My
Pentaneura sp.	…	3,My	…	1,Je	…	…	…	r,Ap–Je
Anatopynia (*Macropelopia*) sp.	c,Ja,Mr	1,Ap	…	…	…	…	…	…
Pelopia stellata (Coquillett)	…	…	…	…	…	…	…	2,Je
Procladius sp.	…	…	…	…	c,De–Mr	a,Ap	c,No–Mr	c,Ap–Je
P. bellus (Loew)	…	…	…	…	…	a,Ap,My	…	…
Clinotanypus caliginosus (Johann.) (?)	…	…	…	…	…	…	1,Fe	…
Orthocladiinae, unident. sp.	1,Mr	…	a,De–Ja	a,My–Je	2,Mr	…	…	…
Corynoneura sp.	…	c,My–Je	…	…	…	…	…	…
Cricotopus sp.	…	r,My–Je	1,No	…	c,Mr	1,Ap	…	c,Ap–Je
Micropsectra sp.	…	…	…	…	1,Ja	…	r,De,Mr	2,My
Calopsectra sp.	…	r,My–Je	3,No	c,My–Je	c,De–Mr	c,Ap–My	r,No–Mr	r,Ap
Lauterborniella sp.	…	…	…	2,My	…	…	…	…
Microtendipes pedellus (De Geer)	…	…	…	…	…	…	r,Fe	…
Paratendipes sp.	…	…	…	1,Je	c,De–Mr	…	…	…
Polypedilus sp.	…	…	1,Mr	…	1,Mr	c,Ap–My	2,De,Mr	3,My
Tanytarsus (*Endochironomus*) sp.	…	…	…	2,My	…	a,Ap–My	r,Fe–Mr	c,Ap–Je
Glyptotendipes sp.	…	…	…	c,Ap–My	2,Fe–Mr	…	…	…
G. paripes (Edwards)	…	…	…	…	…	1,Ap	3,Fe	…
Cryptochironomus sp.	…	…	…	…	r,Ja,Mr	…	…	1,Ap
Harnischia sp.	…	…	…	?3,Ap	…	2,Ap	…	…
Tendipes (*Limnochironomus*) sp. (?)	…	1,Je	…	2,My–Je	c,De–Mr	r,Ap	c,Fe	r,Ap–Je
T. decorus (Johannsen)	…	a,My–Je Je,pu	…	c,Je	…	…	a,De–Mr	c,Ap–Je
Diptera, Ceratopogonidae, larvae								
Forcipomyia sp.	r,Ja,Mr	…	…	…	…	…	…	…
Bezzia-Palpomyia group	c,De–Mr	c,Ap–My	c,Ja–Mr	c,Ap–Je	c,De–Mr	c,Ap–My	1,Mr	r,Ap–My
Bezzia glabra (Coquillett)	…	…	…	…	…	1,My	1,Mr	2,My
Sphaeromias sp.	c,Ja,Mr	1,Je	…	2,Ap	…	4,Ap	c,De–Mr	1,Ap
Diptera, Psychodidae, larvae								
Telmatoscopus albipunctatus (Willis.)	…	…	1,Ja	…	…	…	…	…

Animals	Pond I		Pond II		Pond III		Pond IV	
	Winter	Spring	Winter	Spring	Winter	Spring	Winter	Spring
Diptera, Culicidae, larvae								
Dixa (*Paradixa*) sp.	....	2,Je	....	....	....	....	....	....
Chaoborus sp.	....	c,Je	....	c,My–Je	....	....	....	....
C. americanus (Johannsen)	....	....	....	....	a,No c,De–Mr	c,Ap–My Ap,pu	....	....
Culex apicalis Adams	....	1,My	....	....	....	....	....	....
Aedes sp.	....	....	....	....	....	2,Ap,pu	....	....
A. excrucians (Walker)	....	c,Ap	....	....	....	....	....	....
A. fitchii (Felt and Young)	....	2,Ap	....	a,Ap–My	....	....	....	....
A. impiger (Walker)	....	?2,Ap	....	1,Ap	....	....	....	....
Diptera, Ephydridae, larvae								
Lycoria sp. (?)	c,Ja–Fe	c,Ap–My	....	....	....	....	....	....
Diptera, Stratiomyiidae, larvae								
Eulalia sp.	c,Ja	a,Ap–Je	....	c,Ap–Je	....	a,My	....	....
E. cincta (Olivier)	....	1,My	....	....	....	1,Ap	....	....
E. truquii (Bellardi) (?)	....	1,Ap	....	....	....	....	....	....
E. vertebrata (Say)	1,Ja	c,Ap–Je	2,Ja,Ap	c,Ap–Je	....	1,Ap	....	3,My–Je
Diptera, Tabanidae, larvae								
Chrysops sp.	....	....	....	....	2,Mr	....	1,Mr	r,Ap–My
Tabanus sp.	....	....	2,Ja	....	....	1,Ap	....	....
Diptera, Dolichopodidae, larvae	1,Fe	....	....	....	....	....	....	....
Diptera, Tetanoceridae, larvae	....	....	2,Mr	....	....	....	?1,Mr	?1,Ap
Sepedon sp. (?)	....	1,Ap	....	1,My	....	....	....	....
Diptera, Ephydridae, larvae	....	....	?1,Ap	....	....	....	....	1,Ap
Gastropoda								
Lymnaea humilis modicella Say	....	....	....	....	....	....	1,Mr	6,My
L. obrussa Say	....	....	....	....	....	....	....	4,Ap
L. palustris (O. F. Müller)	1,Mr	a,Ap–Je	3,Ja	a,Ap–Je	....	c,Ap–My	....	....
Armiger crista (Linnaeus)	....	r,Ap a,My–Je	....	....	....	....	....	2,My
Gyraulus parvus (Say)	c,De–Ja,Mr	a,Ap–Je	c,De–Fe,Ap	a,Ap–Je	c,Ja–Mr	c,Ap–My	2,No,Mr	c,Ap–Je
Helisoma trivolvis (Say)	....	....	....	2,My	....	2,My	....	....
Menetus exacuous (Say)	....	....	....	....	....	....	....	1,My
Planorbula armigera (Say)	....	c,My–Je	....	1,Ap	r;Ja–Mr	a,Ap–My	....	....
Physa gyrina Say	....	c,Ap–Je	....	a,Ap–Je	r,De–Mr	a,Ap–My	....	....

TABLE V—(*Cont.*)

Animals	Pond I		Pond II		Pond III		Pond IV	
	Winter	Spring	Winter	Spring	Winter	Spring	Winter	Spring
Gastropoda (*Cont.*)								
Aplexa hypnorum (Linnaeus)	...	c,My–Je	...	...	...	...	...	...
Ferrissia sp.	...	...	...	...	...	2,My	...	...
F. rivularis (Say)	...	...	...	...	...	...	...	3,My
Pelecypoda								
Sphaeridae, unident. young	a,Ja–Mr	c,Ap–Je	...	...	a,De–Mr	c,Ap r,My	...	...
Sphaerium occidentale Prime	r,Fe–Mr	c,Ap–Je	...	...	c,De–Mr	c,Ap–My	...	...
S. (*Musculium*) *truncatum* (Linsley)	r,Ja	a,Ap–Je	c,Ja–Mr	a,Ap–Je	c,De–Mr	a,Ap–My	...	...
Pisidium abditum Haldeman	...	...	...	...	...	...	1,Mr	...
P. rotandatum Prime	...	1,Je	...	...	...	...	...	...
P. walkeri Sterki	...	...	...	...	...	...	1,Mr	2,Ap–My
Bryozoa								
Plumatella casmiana Oka	...	...	...	...	...	...	...	a,My
Stolella indica Annandale (?)	...	...	...	...	...	...	...	a,My
Pectinatella magnifica Leidy	...	...	...	...	...	...	No,Ja, statobl. see text	My, statobl. see text
Pisces	...	...	...	...	...	...		
Amphibia, larvae								
Ambystoma jeffersonianum (Green)	...	1,Je	...	...	...	...	...	...
Bufo americanus Holbrook	...	...	...	1,Je	...	...	...	...
Pseudacris nigrita triseriata (Wied)	...	a,My–Je	...	a,Ap–Je	...	2,My	...	...
Hyla versicolor (LeConte)	...	...	...	2,Je	...	...	...	...
Rana sylvatica cantabrigensis Baird	...	c,My–Je	...	...	...	...	...	...
R. clamitans Latreille	...	...	...	...	c,De–Mr	...	...	...
R. pipiens Schreber	...	...	...	c,Ap–Je	...	...	...	...
Reptilia								
Chrysemys picta marginata (Agassiz)	...	...	...	...	...	1,Ap	...	...

ECOLOGY OF THE POND ANIMALS

CNIDARIA

Pelmatohydra oligactis (Pallas) was taken in permanent Pond III throughout the period of observation (winter and spring). *Chlorohydra viridissima* (Pallas) occurred in the same locality in May. No hydras were found in the two temporary ponds.

TURBELLARIA, RHABDOCOELA

The rhabdocoel turbellarians of North America are still very incompletely known. Since the identification of the members of this group requires, in most cases, a detailed study of their anatomy, it was not possible to identify the majority of the animals to the species. Rhabdocoels are frequent and regular inhabitants of both temporary and permanent bodies of water. Spandl (1925: 95–97) listed twenty-three species of rhabdocoel and alloeocoel turbellarians that had been reported from temporary pools in Central Europe, and recent authors have added more species to this list. In the Ann Arbor ponds, rhabdocoels were rarely found during the winter, but they reached their greatest development in the early spring period.

Catenula lemnae Dugès and two species of *Stenostomum* appeared in considerable numbers in infusions of earth from the dry bottom of Pond II in October, 1940.

Macrostomum sp. was taken in Pond IV, in April.

Dalyellia sp. was a common and very characteristic member of the spring fauna of both temporary Ponds I and II. Dr. Wayland J. Hayes, Jr., who studied my material of this species, informs me that it differs from the European species, *Dalyellia viridis* (Shaw), which was considered by Hofsten (1912: 620) to be a typical inhabitant of vernal pools in Switzerland. My form differs from *D. viridis* in several respects, particularly in the anatomy of the female genital organs and in the shape of the penis stylet. The species is new to America if not a new species. It may prove to be identical with the "green flatworm" ("*Vortex viridis*") reported by Shelford (1913: 185) from temporary prairie ponds in the Chicago region.

Phaenocora sp. occurred only in mud samples from the backwater Pond IV, never in great numbers.

Mesostoma ehrenbergi (Focke), probably the form *wardi* Woodworth, was taken in small numbers in Pond II at the end of April. Another species of *Mesostoma* was collected in Pond IV, likewise in April.

Bothromesostoma sp., a small brown species, appeared in April in both temporary Ponds I and II, and permanent Pond III.

This list of rhabdocoels is obviously very incomplete. The collecting methods employed were not suitable for the study of these extremely delicate animals. This interesting group, the distribution of which in the Western Hemisphere is to a great extent still unknown, would well deserve a thorough investigation.

The majority of the rhabdocoels of temporary ponds spend the dry season probably in the egg state. This is certainly true of *Dalyellia* sp., of which specimens bearing eggs were collected in late spring. *Mesostoma ehrenbergi* is likewise known to produce thick-shelled eggs ("Dauereier") that can withstand unfavorable conditions. Other forms, such as *Stenostomum* and *Catenula lemnae,* probably estivate as adults in cysts formed by a hardened slimy secretion.

TURBELLARIA, ALLOEOCOELA

Prorhynchus stagnalis M. Schulze.—A single specimen of this form was collected in Pond I in early spring. The species, which is a frequent inhabitant of ground-water wells, has also been reported from temporary pools. At the onset of the dry season, it may either encyst or retreat into the soil following the sinking ground-water table (Reisinger, 1923: 59–60).

TURBELLARIA, TRICLADIDA

Phagocata vernalis Kenk was the only triclad living in temporary Ponds I and II. The first specimens, recently hatched and still devoid of pigment, were taken soon after the ponds had started to fill up, for example, in Pond I in the middle of December. The species was common throughout the winter, but it vanished soon after the spring thaw, when the water became warmer. Sexually mature animals were extremely rare; only two were seen in Pond II in January and April, respectively, and none in Pond I. The species reacts to the warming-up of the habitat by a modified multiple fission (fragmentation), small pieces being successively detached from the posterior end until the entire animal is reduced to a number of fragments. Each fragment rounds up and secretes a layer of slime which hardens into a resistant cyst. The cysts can withstand a considerable amount of drying, though complete drying kills them. Young animals hatch from the cysts when the pond fills again during the next autumn (Kenk, 1944: 25–26).

Fragmentation and encystment are otherwise rare phenomena among fresh-water triclads. They have been observed so far in only one other species, *Phagocata velata* (Stringer). In a European triclad, *Phagocata (Fonticola) vitta* (Dugès), whole animals are reported to enclose themselves in slime capsules when subjected to unfavorable conditions. In this case there is no preceding fragmentation.

OLIGOCHAETA

Two species of *Aeolosoma, A. leidyi* Cragin and *A. hemprichi* Ehrenberg, appeared in infusions of earth samples from the bottom of Ponds I and II. The samples had been taken in the autumn when the ponds had been empty for several months.[1] Obviously, these species lead an active life in the ponds under suitable conditions. No specimens, however, were collected in the seasons when the ponds contained water. It is probable that they escaped detection on account of their small size or that the sieves used in the washing out of the bottom samples did not retain them. This, however, would not have been likely to occur had they been present in large numbers. The species of *Aeolosoma* are known to surround themselves with a slime cyst when conditions become unfavorable. In this encysted state they may persist in the dry mud during the summer and autumn periods.

Members of the family Naididae were likewise obtained from infusions of dry bottom material from the temporary ponds (*Pristina longiseta* Ehrenberg, *Dero limosa* Leidy, *Slavina appendiculata* [Udekem], and *Nais* sp.). They probably hatched from cocoons present in the soil. One should not discard the possibility that Naididae may also estivate in an encysted condition, though encystment has not so far been observed in this family. In the four ponds studied, Naididae were absent during the winter period. They appeared in spring after the water temperature had begun to rise (April, May, and June). The species observed in the temporary ponds were *Pristina leidyi* F. Smith, *P. longiseta* Ehrenberg, *Dero limosa* Leidy, *Slavina appendiculata* (Udekem), and *Nais* sp. In permanent Ponds III and IV, *Chaetogaster diaphanus* (Gruithuisen), *C. limnaei* Baer, *Dero limosa, Slavina appendiculata, Nais variabilis* Piguet, and another species of *Nais* were collected. *Chaetogaster limnaei,* an ectoparasitic form, was found on the snail, *Physa gyrina.*

Tubificidae were encountered only rarely in the temporary pools; one individual of an unidentified species in Pond I in April, and two specimens in Pond II in March. In permanent Pond III, tubificids were common in autumn and appeared again in March and April. The backwater pond of the Huron River, Pond IV, contained numerous tubificids throughout the winter and spring, among them the species *Tubifex multisetosus* (F. Smith).

A species of *Lumbriculus,* probably *L. variegatus* (O.F. Müller), was a regular inhabitant of temporary Ponds I and II. It emerged in winter (January in Pond I and February in Pond II) and remained in the ponds until the water disappeared. In permanent Pond III, a few specimens of this form were observed in February. The species was also recovered from a sample of dry bottom material taken from Pond II in autumn. *Lumbriculus variegatus* is a widely distributed oligochaete occurring in both permanent and temporary waters with muddy bottoms. Mrázek (1913),

[1] An earlier note by me (Kenk, 1941) referred to their occurrence in these habitats.

who made an extensive study of the life history of this species, and other authors found it frequently in pools that dry up periodically. Stephenson (1922: 291–93) observed it in cysts that had been collected on the banks of two Scottish lakes, each cyst containing one to sixteen fragments of the animal. It appears probable, therefore, that in temporary ponds *L. variegatus* undergoes fragmentation when the habitat begins to dry and that the fragments estivate in cysts. Sexual reproduction has been observed only rarely in this species.

HIRUDINEA

Although Pond I contained no leeches, the other temporary pond, Pond II, had a rather rich and diversified leech fauna composed of the following species: *Helobdella stagnalis* (Linnaeus), *H. fusca* (Castle), *Placobdella rugosa* (Verrill), *P. picta* (Verrill), *Erpobdella punctata* (Leidy), *Dina microstoma* Moore, and *D. bucera* Moore. *Dina bucera* was formerly designated as the "unspotted" or "plain" variety of *Erpobdella punctata.* An anatomical study of the animals revealed that they represented a new species of the genus *Dina.*[2] The two permanent ponds, Ponds III and IV, contained *Glossiphonia heteroclita* (Linnaeus) (IV), *Helobdella stagnalis* (III, IV), *H. fusca* (IV), *Placobdella parasitica* (Say) (III), *P. picta* (III, IV), *Erpobdella punctata* (III), and *Dina bucera* (III). The majority of these leeches are widely distributed species and none shows a marked preference for temporary pools.

Leeches of temporary ponds spend the dry summer and autumn periods in the ground. Some species are known to tolerate a certain amount of desiccation and may even lose a considerable amount of water from their tissues without serious detriment. They have been found occasionally,

[2] J. Percy Moore, who kindly examined my leech material, furnished the following description of the new species:

"*Dina bucera,* n. sp. Resembles *D. parva* in size and form, not exceeding 20. × 4. mm. in moderate extension and mostly smaller and mature. Cephalic sucker and mouth small. Eyes three pairs, one pair of large buccals on somite III, two pairs of small labials on sides of IV. Gonopores (on all of 47 examples) separated by two annuli, usually ♂ on XII*a2* (third annulus of somite XII), ♀ in tertiary furrow of XII*b6* (last annulus), but both may be in the following furrows (XII*a2*/*b5* and XII/XIII). Atrium globoid, not deeply incised dorsally for nerve cord, atrial cornua large and conspicuous, their length definitely exceeding diameter of atrium, simply curved and directed laterad and somewhat cephalad; no preatrial loop of sperm duct (ductus ejaculatorius) reaching to ganglion XI. Testes small and numerous, about 60 on each side in somites XVII to XXV. Color of preserved specimens somewhat dusky but no pigment or pattern except in eyes; in life probably reddish from cutaneous blood vessels. Most closely related to *Dina fervida* (Verrill) as identified by me, but the latter may be twice as long, frequently has four pairs of eyes, the atrial cornua are relatively smaller and the testes are only about half as many in one counted. A full description will be published elsewhere" (personal communication).

surrounded by a layer of secreted slime, in small cavities in the dry mud (cf. Herter, 1937: 371–72). Of the species listed above, few have been studied with regard to their ability to survive partial drying. *Helobdella fusca* was observed to occur in a temporary pond in Canada (Mozley, 1932: 244). *Dina microstoma* was reported to be very sensitive and to die in a short time if taken out of the water (Gee, 1913: 233). It must be remembered, however, that the bottom material of a "dry" pond still contains a great amount of moisture and that the animal may protect itself by rolling up and secreting a slime layer. *Helobdella stagnalis* is somewhat more resistant to drying (Gee, 1913: 233). More is known about the drought tolerance of several species of *Erpobdella* (Kulajew, 1929; Spandl, 1925: 129) and of other genera not represented in our pond fauna.

Samples of the uppermost layer of the bottom of Pond II, taken October 15 and 23, contained two specimens of *Dina microstoma* and one of *Erpobdella punctata* which emerged soon after the samples had been placed in water. Nevertheless, no leeches were taken in the temporary pond during the entire winter while the water was frozen over. They showed up soon after the ice had melted. It appears, therefore, that they remained inactive, buried in the earth, through the entire cold season. It is well known that the motility of leeches is greatly affected by temperature. At low temperatures their movements are slowed down, and the animals enter a state of torpidity when the temperatures approach the freezing point (cf. Herter, 1936: 242–47). Obviously, the leeches of the temporary pond hibernated in a lethargic state without entering the open pond. In Ponds III and IV a few leeches were collected also in winter.

PHYLLOPODA

Fairy shrimps (*Eubranchipus*) occurred in both temporary Ponds I and II, and in permanent Pond III. The species in Pond II was *E. vernalis* (Verrill); Pond III contained both *E. vernalis* and *E. bundyi* Forbes in about equal numbers. In Ponds I and II there were two hatching periods, one in December and early January, when a small number of nauplii and young specimens were taken, and another in March and April when many larvae and adults appeared. The animals that hatched in early winter evidently died, for no individuals were collected in February. The species reached their peaks of abundance in April and disappeared in the middle of May. In Pond III, *Eubranchipus* was collected only once (April 15), when both young and adults were observed.

It had long been believed that the eggs of *Eubranchipus* and related genera of Anostraca must be exposed to drought and frost before they will hatch. Under experimental conditions, however, as reported by various authors, development may also take place without the eggs being either dried or frozen. Nevertheless, both desiccation and freezing appear to stimulate the processes of development and hatching (Weaver, 1943: 501). Shelford (1913: 177–79) reported an interesting observation made in the Chicago region when early freezing weather was followed by a period of warm weather in December. *Eubranchipus* sp. hatched in early winter, but was killed when cold weather set in again. For several years afterwards, the species was very scarce in the vicinity of Chicago. Similarly, in our ponds, the first hatching occurred in early winter and the resulting brood died during January. Another, more abundant, hatching took place, however, in March and April and the animals attained maturity in due time. It cannot be ascertained, without further observations, whether this occurrence in the winter of 1940–41 was normal or exceptional. Weaver (1943: 502) stated that *E. vernalis* has two hatching seasons near Akron, Ohio, and that both broods mature and deposit eggs. Analogous observations were made by Lowndes (1933: 1094) on a related species, *Chirocephalus diaphanus* Prévost.

The fact that *Eubranchipus vernalis* was found in a permanent pond, Pond III, is not surprising, since the marshy east bank and the ditches on its north and south sides have the character of temporary habitats.

Lynceus brachyurus O. F. Müller, a clam shrimp, appeared in Ponds I, II, and III in the middle of April or in early May and reached its greatest abundance in May after *Eubranchipus* had disappeared. A few specimens were taken in June.

The Phyllopoda are counted among the most typical crustaceans of temporary waters. Permanent ponds with fluctuating water levels are likewise suitable habitats, provided they are not populated by fish. Phyllopods are, on account of their slow swimming in the open water, an easy prey to fishes and predaceous insects (water bugs, beetle larvae). The disappearance of the fairy shrimp at the time when these insects become numerous in the ponds may not be a mere coincidence.

CLADOCERA

Cladocera occurred in the temporary ponds in both the winter and spring seasons. Unfortunately, the material collected in the spring was lost before it was identified. In general, the cladoceran fauna was rather poor throughout the cold season, but increased considerably in abundance in April and May, to decline again in June. In Pond II, *Simocephalus vetulus* (O. F. Müller) was the most regular, though not abundant winter cladoceran. *Ceriodaphnia reticulata* (Jurine) was taken in December and *Moina brachiata* (Jurine) at the beginning of January. In Pond I, only one specimen of *Simocephalus serrulatus* (Koch) with an ephippium was found in the first winter collection (December 17), and no more cladocerans were seen until next April. The permanent ponds likewise contained no active species during the greater part of the winter. The young of a species of *Daphnia* appeared here first in the latter part of March (Pond IV).

To substitute for the loss of the collections made in the spring of 1941, new samples were taken in 1945 in Ponds I, II, and III. In Pond I, *Daphnia pulex* (De Geer) was the most abundant species of the late spring, and *Scapholeberis mucronata* (O. F. Müller) appeared in June in considerable numbers. In Pond II, *Simocephalus vetulus, Ceriodaphnia quadrangula* (O. F. Müller), and *Pleuroxus denticulatus* Birge were common, while *Daphnia pulex, Kurzia latissima* (Kurz), and *Alona rectangula* Sars were rather rare. In the spring fauna of Pond III, *Daphnia pulex, Simocephalus serrulatus,* and *Ceriodaphnia reticulata* (Jurine) were the dominant forms, *Simocephalus vetulus* and *Alona rectangula* were common, and *Diaphanosoma brachyurum* (Liéven), *Scapholeberis mucronata,* and *Kurzia latissima* occurred in insignificant numbers.

Among the Cladocera mentioned, only *Moina brachiata* appears to be a regular inhabitant of temporary pools (cf. Spandl, 1925: 114), though it is by no means restricted to this habitat. The remaining species are more frequently met in permanent pools and shallow ponds.

Although both young and adult Cladocera are very sensitive to drying, they appear, nevertheless, to be able to withstand drought for a short time if buried in wet mud. Only so can it be understood that a specimen of *Simocephalus serrulatus,* bearing an ephippium, was found in Pond I on December 17, when the pond had just started to fill. Scott (1910: 410) observed *Simocephalus vetulus* under similar circumstances in a pond in Indiana:

> Adults were taken two days after the rain which terminated the drouth in 1908. It was found that in cultures it takes from 10 to 12 days for adults to develop. From these facts it appears that this crustacean was able to survive the drouth as an adult. To do this, it must have worked its way down through the vegetable debris to the water level.

We must, however, consider these cases as exceptional. Cladocerans survive the dry periods normally in the egg state, especially as fertilized eggs enclosed in ephippia ("Dauereier"), which are very resistant to drought and frost and which require a certain rest period. Under favorable conditions, in early spring, cladocerans multiply rapidly, generally by parthenogenetic reproduction.

OSTRACODA

Pionocypris vidua (O. F. Müller) occurred in temporary Pond II, and in both permanent Ponds III and IV. In Pond II, a few specimens appeared in late autumn (November and December), but none was taken in the winter. The species reappeared in April and reached its peak in May. One specimen was collected with an earth sample soon after the pond had dried, and two individuals were observed in an infusion of dry bottom material taken in October. In Pond III, the species was likewise absent through the greater part of the winter (only one individual being collected in March), but was observed in autumn as well as in spring (April and May). It probably was present throughout the warmer season. In Pond IV, only two specimens were seen in May. *P. vidua* has a very wide geographic range (Europe, Asia, North and South Americas) and has been found in practically every type of fresh-water habitat suitable for the occurrence of ostracods. It has been observed in all seasons of the year, but only rarely in winter (Ferguson, 1944: 719; Scott, 1910: 410).

Pionocypris obesa (Brady and Robertson) was common in Pond I in May and June. One individual was recovered from a bottom sample taken in July, soon after the disappearance of the water. In Pond II, no specimens were observed while the pond contained water, but a few animals appeared in bottom samples taken during the dry period (July, October). In Pond III, the species was rather scarce, a few specimens being seen in January and April. *P. obesa,* recorded from Europe and North America, appears to be principally a summer ostracod (Furtos, 1933: 431; Hoff, 1942: 33).

Cyprois marginata (Straus).—This species was observed only in Pond I from April to June. Elsewhere, in Europe as well as in North America, it has also been recorded from temporary habitats (cf. Spandl, 1925: 116–17; Furtos, 1933: 438) and is, generally, a species of the spring and early summer, though it has been observed occasionally in autumn.

Cypris subglobosa Sowerby.—In Pond I, this species appeared in May and remained until early June. One young specimen was also seen in Pond III in May.

Eucypris crassa (O. F. Müller) was rather rare in the ponds studied. Two young individuals were taken in Pond I in the early part of June, and two more in Pond III in May.

Eucypris fuscata (Jurine) was collected in temporary Ponds I and II in April and May. In Pond I it was the dominant ostracod of the early spring period. A few specimens were taken also in Pond III in the latter part of April. *E. fuscata* appears to have a decided preference for temporary waters, though it is known to occur in permanent ponds as well (Wohlgemuth, 1914: 27; Furtos, 1933: 452). Wolf (1919: 94) considered it to be a cold-water species, an assumption which is not borne out by the observations of other authors nor by its occurrence in Michigan.

Cypricercus tincta Furtos was another vernal ostracod observed in

Ponds I and II, for a short period in April and May. In permanent Pond IV, only two specimens were taken (in May). Furtos (1933: 457) described this species from a temporary marsh in Ohio.

Cypria exculpta (Fischer).—This ostracod was very common in Pond II, where it occurred in winter and spring. It showed two peaks of abundance, one in December and the other in April. No specimens were taken in February and only few in March. Young individuals were seen in May. The species also emerged in cultures of bottom material taken soon after the pond had dried (July) and in autumn (October). Moreover, it was present in great numbers in shallow transient pools left on the bottom of the pond about thirty-six hours after a heavy rainfall in early October. In Pond I a small number of specimens was taken in April. In Pond III the species was likewise scarce (January, April, and May). With regard to the occurrence of *C. exculpta* in temporary waters, an experience of Creaser (1931*a*) is of great interest. This author found a concentration of individuals in the water filling the pocket of a crayfish burrow, three feet below the bottom of a dry slough, in Missouri. Burrowing crayfish occur also in our two temporary ponds. *C. exculpta* is a common species inhabiting ponds, marshes, ditches, and streams in Europe and North America. It is supposed to be an ostracod of the warmer seasons, spring, summer, and autumn (Sharpe, 1897: 418; Wohlgemuth, 1914: 34). It was common, however, in Pond II in December and January.

Candona crogmaniana Turner inhabited only permanent Pond III. It was taken in November, and again from January to April, reaching its greatest abundance in March. It disappeared soon after the spring thaw. The species is so far known only from North America, where it inhabits both permanent and temporary ponds.

Candona decora Furtos occurred in Pond I in the winter and spring periods, from January to early June. The species was never abundant, but seemed to be more numerous in winter than in spring. Furtos (1933: 478) recorded it from ponds and small lakes in Ohio.

Candona truncata Furtos was taken in permanent Pond III in early November and in winter (January to early April); subsequently it disappeared. In Pond I only one specimen of this form was collected (May). In Ohio the species is a common ostracod of temporary and permanent ponds and marshes (Furtos, 1933: 481).

The majority of the ostracods occurring in the ponds investigated are widely distributed forms, some ranging over several continents. Several species appear to have a marked preference for temporary waters (*Cyprois marginata, Eucypris fuscata, Cypricercus tincta,* and possibly *Candona truncata*), though they may occasionally be found in shallow permanent ponds and ditches.

Attention is called to the seasonal occurrence of the ostracods. Wohlgemuth (1914: 28–36) pointed out that in the European fauna only a limited number of ostracods may be found all the year round ("Dauerformen"), while others are restricted to definite seasons (seasonal forms) such as spring, summer, and autumn forms. Among the ostracods of the Michigan ponds studied, only *Cypria exculpta* may be encountered at any season (except for a short span in February). *Candona crogmaniana* and *C. truncata* appear to be species of the late autumn, winter, and early spring; *C. decora* occurs in winter and spring; *Cypris subglobosa, Cypricercus tincta, Cyprois marginata, Eucypris fuscata,* and *E. crassa* are vernal species. *Pionocypris vidua* and *P. obesa,* both forms of the warmer seasons, were observed in spring and late autumn, but seemed to be absent, or at least very rare, in the winter. They reached their maximum abundance in May. It must be remembered, however, that no collections were made in the ponds during the summer and early autumn and that no data can be given for these seasons.

The greater part of the ostracods of temporary pools estivate in the egg state. The eggs have a resistant shell consisting of two calcified layers and can withstand drying for a considerable time. This is apparently the mode of estivation generally employed by the vernal species. "A great many of the species that appear in small pools in the spring produce eggs that seem to require a certain amount of desiccation before development is possible" (Furtos, 1933: 420). It is known, however, that ostracods, both young and mature, may survive prolonged drought by burying themselves in the mud and remaining motionless until they are again exposed to water (cf. Wolf, 1919). Only in this way can the occurrence of mature ostracods in infusions of dry earth after a short time be explained. Only summer forms and those present throughout the seasons were obtained by this method (*Cypria exculpta, Pionocypris vidua, P. obesa*). The abundance of *Cypria exculpta* in Pond II after a heavy rain likewise points to the emergence of resting stages. Finally, a third method of surviving the drought was observed by Creaser (1931*a*) who noted *Cypria exculpta* in summer in crayfish burrows below the ground-water level.

COPEPODA

Copepoda were present in the four ponds throughout the period of observation in the season 1940–41. Only the copepods collected in the winter were identified, for the material taken in spring was lost. New samples were collected in Ponds I, II, and III in the spring of 1945. Since the two temporary ponds, Ponds I and II, had been dry throughout the winter of 1944–45, the supplementary samples taken in 1945 may not represent quite faithfully the normal occurrence and succession of copepods in these habitats. It is with this reservation that the following data are presented.

Calanoid copepods were absent in the winter fauna of all four ponds. They appeared in Ponds I and II in May and throughout the warmer stages of the two ponds until they dried in June and July, respectively. In Pond III, only one specimen was obtained, in June.

Cyclops gigas latipes Lowndes, a form rather rare in America, was collected only in Pond I. It occurred throughout the winter, but never in great numbers. In the spring of 1945, this species was common in May and June. It is very similar to *C. viridis* (Jurine), which has been frequently observed in temporary ponds. The American records of *C. viridis* appear to be uncertain (Yeatman, 1944: 18–21).

Cyclops vernalis Fischer occurred in both temporary Ponds I and II, and in permanent Pond III. It was the dominant winter copepod of Pond I and appeared there also in the collections of May, 1945. In Pond II a great number of individuals was obtained on October 8 in shallow pools about thirty-six hours after a heavy rain. The great majority of the animals were copepodids, the rest were adults. Copepodids and adults also emerged in infusions of bottom material taken October 15 and 23. The species was present in Pond II throughout the winter and spring, but was greatly outnumbered by *C. bicuspidatus* during the colder season. In Pond III only a moderate number of specimens of *C. vernalis* was collected in November and February, though the species became more abundant in the spring collections, particularly after the onset of warmer weather. Harry C. Yeatman informed me that the specimens collected in Pond I in March had very slender and lengthened appendages and furcal rami. Temperature experiments with this species indicate that specimens reared at low temperature tend to be larger and more elongate in appendages and furcal rami than those reared at high temperatures. The species is very common in Europe, Asia, and on both American continents.

Cyclops bicuspidatus thomasi Forbes was very common in Ponds I, II, and III. In Pond II, the first specimen was collected in a transitory rain pool in early October. More individuals, both copepodids and adults, were obtained from cultures of bottom material prepared October 15. The species was exceedingly plentiful in the pond throughout the winter. It reached its peak of abundance in the three ponds in the cooler part of the spring season (April and May) and disappeared when the water became warmer. *C. bicuspidatus* is a common copepod occurring in a great variety of stagnant-water habitats in North America, Europe, Asia, and North Africa. Birge and Juday (1908) observed that in Lake Mendota, Wisconsin, the species may spend the warmer season in a resting stage, enclosed in a slime capsule.

Cyclops bicuspidatus navus Herrick was present only in Pond I. It appeared in May, replacing *C. b. thomasi,* and became the dominant copepod in the late stages of the pond. The subspecies (or species?) *navus* has been reported from very few localities in America.

Cyclops varicans rubellus Lilljeborg appeared in May in Ponds I, II, and III and increased in numbers during June and July. A few specimens were also in Pond II in a single winter collection (December 9). *C. varicans* is a widely distributed species and has generally been observed only during the warmer seasons (cf. Spandl, 1926: 17).

Eucyclops speratus (Lilljeborg) was obtained in small numbers in permanent Pond IV from October to March. In Pond III only one specimen was collected in March. Spandl (1925: 122) reported a closely related, if not identical, species, *E. serrulatus* Fischer, also from temporary pools in Europe and stated that adult individuals may withstand partial desiccation of their habitat for a period of about forty-five days.

Mesocyclops leuckarti (Claus) was observed only during the warmer season in Ponds II and III. It became very abundant in July. The species appears to be rather rare in America.

Macrocyclops albidus (Jurine) was present during the winter in permanent Ponds III and IV, but was never plentiful. The form lives elsewhere in many types of habitats including temporary ponds (Walker, 1908: 80).

Platycyclops fimbriatus (Fischer), a typical summer copepod, was observed only in permanent Pond III, where a few specimens were taken in June.

Two species of harpacticoid copepods, *Canthocamptus staphylinoides* Pearse and *Attheyella northumbrica americana* (Herrick), were represented in the four ponds studied. Pond I contained both species in December, 1940, soon after it had begun to retain water. Throughout the winter, only *Canthocamptus* was present. In 1945 the pond had been dry all winter and a small excavation, about 40 centimeters deep, was made in March, 1945. In the water accumulating in the hole, below the bottom of the pond, both species were taken in March and April. In Pond II both harpacticoids were collected in transitory rain pools in autumn. Again, only *Canthocamptus* was represented in the winter collections, where it occurred in considerable numbers. In 1945, both harpacticoids appeared as soon as Pond II started filling in March. *Canthocamptus* disappeared in the two temporary ponds after May; *Attheyella* reached its peak of abundance in late May and in June. In permanent Pond III *Canthocamptus* was observed from January to May and *Attheyella* from May to June. *Canthocamptus* was common in the winter collections from Pond IV; no spring samples of copepods from this locality were studied. Both harpacticoid species are widely distributed in America.

The copepods of temporary pools show several adaptations which enable them to survive the dry periods (cf. Coker, 1933: 285). Some Calanoida and Harpacticoida are known to form drought-resistant eggs. The genus *Diaptomus* (Calanoida) includes several species that have been observed regularly in periodic habitats in Europe (Spandl, 1925: 120–22). It is believed that the eggs of *D. amblyodon* Marenzeller require desiccation before they will develop. No eggs with comparable resistant shells have been seen in the third group of copepods represented in our ponds, the Cyclopoida. Cyclopoids and harpacticoids can withstand a certain amount of desiccation when buried in the ground. They remain in a lethargic state (drought torpidity, "*Trockenstarre*") and become active again when placed in water. This has been observed in young as well as adult animals. Complete desiccation, however, is fatal to them. The formation of hardened slime cysts has been reported in representatives of the Cyclopoida and Harpacticoida. Thick-walled cysts were observed so far only in cold-stenothermic species during the summer season (*Cyclops bicuspidatus* in lakes of Wisconsin and Michigan, see Birge and Juday, 1908, and Moore, 1939: 574–76; and several harpacticoids). Whether or not they are formed regularly in temporary waters is still an open question. It is more probable that the animals protect themselves with a layer of slime without forming elaborate cysts, as Roy (1932: 169, 174, and 176) has demonstrated in *C. bicuspidatus* and two other cyclopoids. Coker (1933) showed that the development of a species of *Cyclops* may remain arrested in the fourth copepodid stage for a long time. He pointed out that this stage may correspond to the period of estivation in temporary pools. The appearance of *Cyclops vernalis, C. bicuspidatus,* and of harpacticoids in Pond II after rains in autumn and in soil infusions can be interpreted best as an emergence from dormant stages. Copepods also may survive the dry seasons by following the ground water, if suitable channels are present. Creaser (1931*a*) recovered a calanoid, *Osphranticum labronectum* Forbes, in a crayfish burrow which reached below the ground-water level.

AMPHIPODA

Crangonyx gracilis Smith was abundant in both Ponds I and II. The first specimens appeared in early winter, when the ponds were frozen over. Their number gradually increased and reached its peak in April. During May and June the number of mature animals decreased rapidly until, shortly before the ponds dried, only small specimens of the new brood were seen. These young animals apparently dig into the ground when the pond dries out. Two young specimens were recovered from a bottom sample of

Pond II on October 8, 1940, after the pond had been empty for a long time. Each brood of *C. gracilis* has, in the temporary ponds studied, a lifetime of about fourteen months, from March or April of one year to approximately May or June of the following spring. Only one brood is produced in the lifetime of an individual. Hubricht and Mackin (1940: 200) wrote as follows about the ecology of the species: "Though this species occurs in permanent streams elsewhere, in the vicinity of St. Louis it lives only in temporary ponds, probably because it can not compete with the cannibalistic *E. forbesi* in the permanent streams." Creaser (1931*a:* 244) found *C. gracilis* in a burrow built by a crayfish (*Cambarus diogenes*) in a dry slough in Missouri. The burrow reached down to the water level which at that time (August 27) was about three feet below the bottom of the slough. It is interesting to note that Ponds I and II likewise contain a burrowing crayfish (*Cambarus fodiens*) whose burrows may aid other animals in reaching the ground water when the ponds dry.

Crangonyx obliquus (Hubricht and Mackin) was the amphipod of permanent Pond III. It was active throughout the winter. The breeding season was in the early spring (April), and the first young of the new brood appeared in May. The species was described by Hubricht and Mackin (1940: 195) from a creek in Arkansas, but has been recently recorded by Hubricht (1943: 689) from many localities in the southern and midwestern states.

Crangonyx shoemakeri (Hubricht and Mackin).—Only one female of this species was taken in Pond I in April, 1941. The species is a typical inhabitant of temporary pools and temporary streams (Hubricht and Mackin, 1940: 198).

Hyalella azteca (Saussure) was common in Pond IV throughout the period of observation. Females with brood pouches were seen in April, young individuals in May and June. It is probable, however, that reproduction continues through the entire warm season (Jackson, 1912: 54). *H. azteca* is a widely distributed amphipod living in a great variety of habitats such as streams, ponds, and lakes.

ISOPODA

Asellus militaris Hay.—This species occurred in both Ponds I and II. It showed up soon after the ponds had begun to retain water (December, January). Among the first specimens observed were both immature and mature, though small, individuals. The animals were active throughout the winter. Toward the end of the cold season the percentage of mature animals increased gradually. Females with brood pouches were taken in May and June, and in the same months the young of a new generation appeared. The large animals decreased in number. They probably died soon after reproduction. There can be no doubt that this species of *Asellus* estivates in the ground. The animals probably follow the retreating water table when the ponds dry out. From the fact that at least part of them are in the mature stage when they emerge during the next winter, one may conclude that they had remained active and had grown and matured during the subterranean stage of their life. *A. militaris* is widely distributed in North America. It is a typical inhabitant of temporary pools and of waters with widely fluctuating surface level.

Asellus communis Say was present in small to moderate numbers in Pond IV throughout the seasons of observation. It is a widely distributed but rather rare species inhabiting permanent bodies of water, particularly streams and lakes. It probably had entered Pond IV from the Huron River.

DECAPODA

Two species of crayfish were observed in the four ponds investigated, *Cambarus fodiens* (Cottle) in the temporary ponds and *C. immunis* Hagen in the permanent ponds. *C. fodiens* shows a decided preference for temporary waters. When the water level sinks it resorts to burrows which may reach to a depth of five feet (Faxon, 1884: 116, *C. argillicola*). It probably spends the winter in its burrow and does not emerge until after the spring thaw. Only a few specimens were taken in Ponds I and II, all in the spring (April to June). *C. immunis,* a species generally occurring in stagnant waters with muddy bottoms, was seen in Pond III in January, April, and May, and in Pond IV in May and June. This is not a burrowing species when it occurs in permanent waters. However, it has been reported from temporary ponds, where it builds shallow burrows in which it spends the dry period (Creaser, 1931*b:* 265). Cummins (1921) observed that the species migrates extensively in early spring.

A possibly important role of crayfish burrows in temporary ponds, which reach to the ground-water level during the dry season, has been pointed out by Creaser (1931*a*), who observed a great concentration of small crustaceans (ostracods, copepods, and amphipods) in the water filling the pocket of the burrow. Thus, the burrows may serve as channels through which other pond animals may approach the ground water.

ARANEIDA

Several species of spiders were observed on the vegetation of the ponds; the majority, however, were terrestrial forms. Only *Dolomedes triton sexpunctatus* Hentz was more closely associated with the aquatic habitats. "Of all our species of *Dolomedes* this is perhaps the most truly aquatic" (Bishop, 1924: 54). The animals were seen in May and June, usually resting on water plants. When approached, they ran rapidly over the surface of the ponds or dived into the water and remained submerged for a long time. When the temporary ponds dried, the spiders obviously resorted to terrestrial life.

ACARINA

The study of the mites offered considerable difficulties inasmuch as, in many instances, young stages and even adult females cannot be identified to the species. Hydracarina, true water mites, were well represented in the fauna of our ponds, and a few "land mites" of the families Trombidiidae (*Microtrombidium* sp.) and Notaspidae (*Notaspis* sp.) were taken occasionally in these same habitats (Table V).

In both the temporary and permanent ponds Hydracarina were scarce in the cold season. Only species of the genera *Thyas* and *Piona,* the majority being nymphs, were present in the winter collections from Ponds I and II. With the onset of warmer weather the number of species and of individuals increased rapidly until the maximum development was reached in May. During June the mites were again declining, at least in the temporary ponds. The following species were observed in the temporary ponds in the spring period: *Eylais* sp., *Hydrachna conjecta* Koenike, *H. crenulata* Marshall, *H. magniscutata* Marshall, *H. miliaria* Berlese, *H. rotunda* Marshall, *H. stipata* Lundblad, *Hydrachna* sp., *Thyas* sp., *Hydryphantes ruber* (De Geer), *H. r. mozlei* Marshall, *Oxus connatus* Marshall, *Limnesia maculata* (O. F. Müller), *Piona constricta* (Wolcott), *Piona* sp., *Acercus torris americanus* Marshall, *A. simulans* (Marshall), *Arrenurus planus* Marshall, *A. kenki* Marshall,[3] and *Arrenurus* sp. Though this species list is rather impressive, it must be pointed out that of several of the species only a few individuals or even single specimens were taken. The two permanent ponds had a less diversified mite fauna, composed of *Eylais* sp., *Hydrachna magniscutata, Hydryphantes ruber, Limnesia maculata, L. undulata* (O. F. Müller), *Piona constricta, P. carnea* (Koch), *P. pugilis* (Wolcott), *Piona* sp., *Arrenurus marshallae* Piersig, and *Arrenurus* sp.

It is open to argument whether or not the Hydracarina should be considered typical inhabitants of temporary ponds. Spandl (1925: 125–26) expressed the opinion that mites are only accidentally introduced in temporary waters. It must be kept in mind that Spandl's definition of temporary pools includes only habitats that contain water for a period not longer than two months. It is known that some species of the genus *Thyas* occur almost exclusively in waters which dry up in summer. The genera *Thyas* and *Hydryphantes* contain forms that can tolerate drought for a considerable time and that probably estivate as adults or as nymphs in the

[3] Described from Pond II, see Marshall, 1944: 631–33.

dry mud (cf. Viets, 1923: 49; 1936: 8–9; Wesenberg-Lund, 1937: 615–16). Little is known of the drought resistance of the eggs which in many water mites are enclosed in a protective cement layer.

There can be no doubt that a great number of the Hydracarina observed in the temporary ponds were introduced in the spring, after the ice had melted, by insects such as water bugs, beetles, dragonflies, which entered the pond from other, permanent, bodies of water. Most water mites pass in their development through stages in which they live as ectoparasites on aquatic insects (cf. Soar and Williamson, 1925: 16–26). This may account, to a great extent, for their abundant appearance in the ponds at the time when their temporary hosts have flown in.

INSECTA

Insects constituted the bulk of the animal population of the temporary ponds in late spring. Table V gives a list of the species observed and indicates their occurrence in the four ponds studied and the time of their presence. Nevertheless, they must be considered only accidental inhabitants of periodic waters and cannot be treated here in detail. The majority of the insects observed do not complete their life cycles in the ponds, for only the larval stages lead an aquatic life (Odonata, Ephemerida, Diptera). Among the Hemiptera and Coleoptera, however, are truly aquatic species in which the adults as well as the larvae live in water.

In general the insect fauna of the temporary ponds resembled closely that of shallow permanent bodies of water (e.g., Pond III).

The insects enter the temporary pools usually in early spring soon after the spring thaw. They may fly in as adults (Hemiptera, Coleoptera), or may hatch from eggs laid in the ponds by the terrestrial adult stages (Odonata, Ephemerida, Diptera). Larvae become very abundant in the latter part of the spring season. As many larvae have predatory habits (Odonata and many Hemiptera and Coleoptera), they are probably to a considerable extent responsible for the general decline of the pond fauna observed during May and June. Insect larvae with a short period of development may complete their aquatic life before the ponds dry, but great numbers of them undoubtedly perish when the water disappears. Only a few dipterous larvae seem to be able to survive partial desiccation buried in the moist bottom and to continue their development when the ponds fill again.

Collembola.—*Achorutes nivicolus* (Fitch), the snow flea, appeared in great numbers on the surface of the snow covering Pond II and its banks in March, after a period of mild weather. When the ice melted in April thousands of specimens were floating on the surface of the pond. Young individuals were observed in October, when the pond was dry, accompanied by a shore springtail, *Isotomurus palustris* (O. F. Müller). Neither of the two common and widely distributed species is truly aquatic.

Odonata.—Dragonfly and damselfly nymphs occurred in the temporary ponds only in the spring season; in the permanent ponds they were present both in winter and spring. A nymph of *Libellula pulchella* Drury was in a bottom sample from Pond II in October. It may have hatched during a rainy autumn period, but certainly would have died in the subsequent dry weather.

Ephemerida.—Mayfly nymphs were observed only rarely in Pond II (June). In the permanent ponds, nymphs of *Callibaetis* sp. and *Caenis* sp. were rather common in the winter and spring collections.

Hemiptera.—No Hemiptera were present in the temporary pools in the winter. They appeared in spring soon after the ice had melted, having flown in from their winter habitats. Hungerford (1920: 23–27) gave a very interesting account of the hemipterous fauna of vernal ponds and of the ecologic relationships between the various species and other members of the aquatic association. The majority of water bugs and their nymphs have rapacious habits and feed on other insects, small crustaceans, and even snails and tadpoles. When the ponds dry, adult Hemiptera may leave the habitat in search of new quarters. Many nymphs and eggs, however, are doubtlessly destroyed.

Coleoptera.—Pond I contained no beetles throughout the winter. The first specimens, all adults, were taken in early April. Both adults and larvae reached their greatest abundance in late spring (May and June). In Pond II a few adult beetles and two larvae were taken in the winter collections. They obviously had reached the pond in late autumn before the onset of inclement weather. In spring the number of species and of individuals increased and larval forms were abundant from late April to June.

Trichoptera.—*Limnephilus indivisus* Walker was the most common caddis fly species in Ponds I and II. Larvae were taken from April to June, pupae in June. The species has a decided preference for pools which dry up in summer (Lloyd, 1915: 205). How it spends the dry period is not known. Lloyd (1921: 5) believed that there is evidence that the larvae of temporary-pond Trichoptera may burrow beneath the ground.

Diptera.—The two temporary ponds harbored a rich fauna of dipterous larvae, particularly in spring. Many Diptera can, on account of their short larval development, complete their aquatic stages and metamorphose before the ponds dry up. A few larval forms also appear to be able to withstand a certain amount of drought and to survive the dry period buried in the mud. Earth samples taken in September and October from the dry bottom of Ponds I and II contained living larvae of the families Tendipedidae, Ceratopogonidae, and Stratiomyiidae. The specimens from Pond I were larvae of an unidentified species of Orthocladiinae, one last instar of the *Bezzia-Palpomyia* group, and one larva of *Eulalia vertebrata* (Say) (?). Samples from Pond II yielded Orthocladiinae, *Calopsectra* sp., and a larva of the *Bezzia-Palpomyia* group. The survival of tendipedid and ceratopogonid larvae in the earth has been reported by previous authors (Harnisch, 1922: 89–90; Spandl, 1925: 129).

GASTROPODA

Lymnaea palustris (O. F. Müller) was the most common lymnaeid of temporary Ponds I and II, and of permanent Pond III. In the temporary ponds it appeared generally in late March or early April and remained active until the ponds began to dry. Only in Pond II were these snails taken in winter (three specimens in a dip-net sample on January 1). It is possible, however, that they were lifted by the net from the uppermost layer of mud. The animals spend the dry season as well as the greater part of the winter buried in the soil. Estivating individuals were recovered from the dry-bottom samples in autumn. Thus, in the temporary ponds the animals lead an active life only for about three months during the year, a fact that agrees with the observations of other investigators (cf. Cheatum, 1934: 349, and others). In permanent Pond III the species was absent in the winter collections. *L. palustris* is a widely distributed (circumboreal) species generally inhabiting stagnant waters, both permanent and temporary. The species is exceedingly variable, and it appears that the taxonomy of the numerous forms of the *palustris* group has not yet been worked out satisfactorily. Some of the specimens collected in Pond I had thickened apertures and resembled the shells for which Walker (1892: 33) established the subspecies *michiganensis*.

Lymnaea humilis modicella Say and *L. obrussa* Say occurred in Pond IV. Only a few individuals of each species were taken (March, April, and May).

Armiger crista (Linnaeus) was taken in Pond I from March to June. Numerous individuals appeared also in the culture of a soil sample from the bottom of the pond, prepared in October. No specimens were collected from December to February. The animals obviously estivated buried in the dry mud and, after the pond had filled, remained inactive in the soil until the latter part of the winter. In Pond IV the species was scarce, and only six individuals were collected in October and May. *A. crista* is a species common to Europe and America. Precht (1939: 132) studied the drought resistance of this species and reported that it did not survive one day after being exposed to air on filter paper. Obviously, the experimental conditions, particularly with regard to the humidity of the medium, were quite different from the conditions under which the animals survive the dry periods in nature.

Gyraulus parvus (Say) was the most abundant planorbid species of the four localities investigated. The winter collections from the temporary ponds contained only a few specimens, which may indicate that the animals were less active during the cold season than they were in spring. It is also possible that the specimens obtained in the winter with a dip net were hibernating in the upper mud layer. In April the species became numerous and then remained in the ponds until the water disappeared. Many individuals were recovered from soil samples taken in September and October from the dry bottom of Ponds I and II. In Pond III, *G. parvus* was observed throughout the winter and spring seasons, and in Pond IV it was collected in autumn and spring. The species is widely distributed in North America east of the Rocky Mountains and usually lives in stagnant waters with dense vegetation. Its occurrence in temporary ponds and its resistance to summer drought were studied by Strandine (1941).

Helisoma trivolvis (Say).—A few specimens of this form were taken in Ponds II and III, all in May.

Menetus exacuous (Say).—One individual of this common stagnant-water species was collected in Pond IV in early May.

Planorbula armigera (Say) occurred in the spring collections from Ponds I and II. In Pond I it appeared in May and became abundant in June. Numerous individuals were in a soil sample taken in July about twelve days after the pond had dried. In Pond II the species was rare, only one individual being seen in April. *P. armigera* also occurred in Pond III, where it was numerous in autumn and spring; only single specimens were taken in winter. It appears, therefore, that the snail hibernates, probably in the upper layer of the mud.

Physa gyrina (Say) was present in all four ponds studied. In the temporary ponds it emerged in April and disappeared when the habitat dried out. Several individuals were in a soil sample taken from the bottom of Pond II on July 7 about five days after the pool had dried, and one living specimen was taken in October after the pond had been empty for several months. Permanent Pond III had a rich population of *P. gyrina* in autumn and in spring, but only a few individuals were taken in winter. In Huron River Pond IV the species was rare. *P. gyrina* is generally an inhabitant of stagnant waters and also occurs occasionally in creeks with slow water current. Though it has certainly no preference for habitats that dry up intermittently, it nevertheless is a regular member of the temporary pool association (cf. Baker, 1928*a:* 454–55).

Aplexa hypnorum (Linnaeus) was taken in Pond I, where it occurred in late spring (May and June). The species has a circumboreal distribution and is considered a typical inhabitant of temporary waters (cf. Baker, 1928*a:* 474), though it is by no means confined to this type of habitat.

Ferrissia rivularis (Say) and *F. fusca* (C. B. Adams) were observed only in Pond IV, and in insignificant numbers. Both species are typically inhabitants of streams and probably have entered the pond from Huron River.

The Gastropoda constitute an important part of the vernal fauna of temporary pools. Though none of the species encountered in the Michigan localities is restricted in its distribution to periodic habitats, they all have the ability to withstand long periods of drought without detriment. Generally, the snails retreat into the soil to various depths when the ponds dry. Several species may secrete a thin membrane (epiphragm) which closes the aperture of the shell and persumably protects the animal from excessive desiccation. Most of these snails also seem to fall, at low temperatures, into a state of torpidity in which their mobility is at least greatly reduced (hibernation). Since, in the temporary ponds the period of drought is, as a rule, followed immediately by the cold season, the majority of them do not emerge from the soil until warmer spring weather sets in. Thus, their active life is reduced to a period of only a few months of the year (cf. F. Baker, 1911: 39; Mozley, 1932, 246–47; Cheatum, 1934: 388–94; and others). Less is known about the drought resistance of the eggs of snails which were also suspected of being capable of surviving the dry season (H. B. Baker, 1914: 35).

PELECYPODA

Only one family of bivalves, the fingernail shells or Sphaeriidae, was present in the four ponds investigated. Several sphaeriid species are known to occur in temporary waters, particularly in vernal pools, often in very large numbers. They retreat into the soil when their habitats dry out and they can tolerate long periods of desiccation.

Sphaerium occidentale Prime inhabited Ponds I and III. The animals of the temporary pond remained somewhat smaller than those of the permanent pond (the largest specimens measured 6.9 and 8.8 mm., respectively). Fully grown individuals were collected in Pond I in June shortly before the pond dried; the animals taken in winter and autumn were all small or half-grown (not more than 4.5 mm. long). It is obvious, therefore, that the large animals die when the pond dries and that only young specimens survive the dry season. F. C. Baker (1928*b:* 348) assumed that a few old specimens probably estivate and bear young in the following season. This assumption, however, is not borne out by the observations in Michigan.

H. B. Baker (1914: 35) reported individuals of *S. occidentale* buried in the soil in which the mother animals were dead, but the shells contained numbers of surviving embryos. In our ponds the young born in the spring bury themselves in the mud when the summer approaches. They emerge again when the pond fills in autumn and grow to their maximum size in the following spring. Toward the end of the second spring period they perish. The life span of the individual in temporary ponds is, therefore, a little more than one year. The same seems to be true, in general, for the animals living in permanent Pond III. The largest specimens taken in winter were smaller than the ones collected in spring. As no observations were made in the summer and autumn seasons, it cannot be stated when the fully grown animals die. In any case no individual appears to overwinter more than once.

Specimens of *S. occidentale* collected at various times were opened and investigated under a binocular dissecting microscope. All individuals of a certain size (above 5.4 mm.) contained brood pouches with embryos regardless of the season. Usually, there were three or four pouches of various sizes in each inner gill, the largest pouch enclosing the oldest embryos. Obviously, the embryos grow and are expelled in as many successive broods as there are brood sacs in each gill. The number of embryos in one pouch varied widely, but was usually smaller than ten (however, up to seventeen were counted in an exceptional case). The largest embryos observed in the gill pouches were 1.7 mm. long.

Young specimens of *S. occidentale* were recovered from soil samples taken from the bottom of Pond I in September and October.

Sphaerium (*Musculium*) *truncatum* (Linsley) was present in Ponds I, II, and III. This species has a life cycle similar to that of *Sphaerium occidentale.* In the temporary ponds the animals lived about one year, spending one dry period in the soil and dying toward the end of the next spring. In permanent Pond III large specimens were still taken in late autumn (November), but none was taken in winter. Here the fully grown individuals died at the onset of inclement winter weather.

Brood pouches in the gills are being formed when the animals reach a length of 3.5 to 4.5 mm. In large animals two to four pouches were in each inner gill; each pouch contained a brood of embryos of about uniform size. The largest embryos measured about 1.5 mm. in length. The total number of embryos that could be recognized under a binocular microscope was usually between seven and thirteen in one grown-up individual (maximum number, twenty).

Many young specimens of *S. truncatum* were observed in infusions of bottom material from Ponds I and II prepared in September and October.

Pisidium abditum Haldeman.—A few individuals of this species were taken in the backwater pond of Huron River (Pond IV) in winter and spring.

BRYOZOA

In Pond IV statoblasts of *Pectinatella magnifica* Leidy were taken during the winter and spring months, and numerous colonies of *Plumatella casmiana* Oka and *Stolella indica* Annandale(?)[4] covered dead submersed leaves of cattails. *P. magnifica* is known to occur in Huron River (Brown, 1933: 275).

No Bryozoa were collected in temporary Ponds I and II nor in Pond III. Though Bryozoa do not commonly occur in temporary bodies of water they were recorded by Mozley (1932: 243–44, *Fredericella sultana* Blumenbach) from two Canadian localities which are in many ways similar to our Michigan temporary ponds. It appears that the statoblasts, which can tolerate considerable desiccation and which require a rest period before germination, should be ideally suited to carry the animal over the dry summer and autumn seasons provided that the ponds remain filled in the spring for a sufficient time to allow the colonies to grow and to form statoblasts.

PISCES

Ponds I, II, and III contained no fishes, but Pond IV was populated with several species of fishes (see pp. 23–24) which had entered from Huron River.

AMPHIBIA

Amphibian larvae were observed in all four localities studied (Table V). The temporary ponds contained predominantly tadpoles of species which emerge early in spring and have short larval periods, such as the swamp tree-toad *Pseudacris nigrita triseriata* (Wied) and the wood frog, *Rana sylvatica cantabrigensis* Baird. These tadpoles completed their aquatic life and underwent metamorphosis in June, before the ponds dried out. There were, however, in the temporary ponds, also larvae of other amphibians in which metamorphosis normally takes place at a later season and which presumably had to die when the ponds became empty. Among these were tadpoles of the American toad, *Bufo americanus americanus* Holbrook, and

[4] Dr. Mary D. Rogick, who kindly examined and identified these colonies, informed me that the species she designated as "*Stolella indica* (?)" differs, to some extent, from the specimens she had collected some time ago at Westtown, Pennsylvania (cf. Rogick, 1943). The zooecia of the Michigan colonies do not taper quite as much at the proximal ends as they do in the Westtown material. The floating statoblasts of the Michigan specimens are slightly more covered by their floats. The animals agree, however, in other measurements and proportions and also in the very wrinkly appearance of the zooecial walls.

of the common tree-toad, *Hyla versicolor versicolor* (LeConte), and a larva of a salamander, *Ambystoma jeffersonianum* (Green). To what extent these species may be able to compensate for the drying of the ponds by accelerating their metamorphosis remains to be more extensively investigated. Tadpoles of the green frog, *Rana clamitans* Latreille, which overwinter before metamorphosis, were seen only in permanent Pond III, apparently leading an active life under the ice throughout the winter. Of all the species observed in the ponds, the wood frog is perhaps most closely associated with the vernal pools.

REPTILIA

The only reptile encountered in one of the ponds was a specimen of the western painted turtle, *Chrysemys picta marginata* (Agassiz), taken in Pond III in early April.

GENERAL PHYSICO-CHEMICAL AND BIOLOGICAL CONDITIONS IN THE TEMPORARY PONDS

The term temporary pond, as used in this paper and generally in the limnological literature, designates a small shallow pond that regularly contains water during one or more periods of the year and is dry at other seasons. It is advantageous to include under this term all natural bodies of stagnant water that fit the above definition. Spandl (1925: 77), however, attempted to limit the name "temporary" or "periodic" waters to pools which hold water only for a short period, not exceeding one and one-half to two months. Such a restriction does not appear to be justified. It is true, as Spandl argued, that pools of very short duration have a peculiar faunal composition and are least contaminated with elements that live generally in permanent bodies of water. Many animals which show a marked preference for habitats that dry out in the warmer season would not be able to survive in ponds that contain water for only two months. It appears, therefore, more appropriate to apply the term "temporary" to all aquatic habitats that dry up regularly and to stress the regularity of this occurrence rather than the seasonal duration of the ponds.

The two temporary ponds investigated began to fill in the latter part of the autumn of 1940 and contained water for about seven months. It is obvious that the time at which they begin to retain water is to a great extent dependent on meteorological conditions. In the winter of 1944–45 after an unusually dry summer and autumn period the two ponds were still empty when heavy snow fell in December. They started to fill only after the snow had melted and copious rain had fallen, in March and May, respectively (Fig. 1). As the ponds are ground-water ponds, their levels rise and fall with the fluctuations of the ground-water table.

The physical and chemical conditions in temporary ponds are known to be extremely variable. As may be noticed in Tables I to IV, the annual changes of the temperature in Ponds I and II corresponded approximately to those observed in permanent ponds of comparable surface and depth (Ponds III and IV). During the winter of 1940–41 the two temporary ponds never froze to the bottom, but doubtlessly they may freeze in years when the ponds are filled to a lower level. The water temperatures measured during the winter were all slightly above the freezing point, obviously on account of the fact that, in breaking an opening into the ice cover, the water was somewhat disturbed and some water from the deeper and warmer levels was brought to the surface.

The fluctuations of the hydrogen-ion concentration in the temporary ponds were approximately of the same magnitude as those of the permanent ponds during the winter and spring seasons (Pond I, 7.0 to 7.8; Pond II, 5.8 to 7.7; Pond III, 5.8 to 8.2; and Pond IV, 6.9 to 8.2). The lowest numerical values of pH were measured in February in Pond I and in the two permanent ponds. Pond II was an exception to this rule, inasmuch as it was rather acid (pH, 5.8) when it began to fill and the pH rose gradually up to the end of January; an insignificant drop occurred in March.

The amount of dissolved oxygen in the temporary ponds varied widely, from 1.3 to 9.3 parts per million in Pond I, and 1.5 to 11.1 p.p.m. in Pond II. The lowest readings were obtained in midwinter (late January and early February). In Ponds III and IV the oxygen values were never so low, the winter minima being 4.3 and 4.5 p.p.m. respectively. The low winter concentration of oxygen in Ponds I and II apparently went hand in hand with an extensive dying of pond organisms (winter kill). A distinctly foul odor was noticed in Pond II at the time of the greatest oxygen deficiency.[5]

The alkalinity of the water, as measured by titration with sulfuric acid, with methyl orange as indicator, is subject to wide seasonal variation. Pond I was characterized by an exceedingly high alkalinity which reached its maximum when the volume of liquid water was restricted by the presence of a thick ice cover (February 10; alkalinity, 623 p.p.m.) and its

[5] After the winter kill, the water discolored a greater amount of potassium permanganate than it did in the earlier part of the winter. The determination of oxygen by the Rideal Steward method calls for the addition of sulfuric acid and potassium permanganate to the water. If oxidizable substances are present, part of the permanganate is reduced and discolored. The water of Pond I on February 10 required 8 cc. of permanganate solution before the color would remain pink, although 1 cc. was sufficient at the beginning of the winter. Since the permanganate consumption may be taken, with certain reservations, as a rough measure of the content of organic matter in the water, it indicates that the amount of oxidizable organic matter increased markedly during the period of oxygen deficiency.

minimum during the spring thaw (March 26, 46 p.p.m.). Similar conditions prevailed in Pond II with the main difference that the fluctuations occurred at a much lower level of alkalinity (between 80 and 3 p.p.m.). In Ponds III and IV the variations of the alkalinity were less pronounced.

The biological conditions obtaining in periodical ponds, and their annual cyclic variation, have been so far little studied in North America. Shelford (1913, 1919) observed seasonal succession of animals in temporary ponds of the Chicago region; Jewell (1927: 294–95) reported on the aquatic biology of prairie ponds; Mozley (1932) gave an extensive account of a pond near Winnipeg, Manitoba; and Eddy (1931, 1934: 26–28) studied the plankton of periodic ponds in Illinois. Many important observations on the temporary-pond fauna were made by students of various animal groups such as copepods, crayfishes, mollusks, and others. No attempt is made to review these contributions here, as many of them have been quoted in earlier sections of this report.

With respect to the biological conditions, the two Michigan ponds compare closely with the pond studied by Mozley (1932) and with some of Shelford's (1913, 1919) localities. They show a much richer animal life than do the European habitats considered by Spandl (1925) to be typical periodic pools. As was pointed out above, Spandl's concept of temporary ponds excluded all habitats that contain water for more than two months at one time. Other European authors, however, analyzed biotops that in many ways agree with our Michigan ponds (e.g., Mrázek, 1900; Wesenberg-Lund, 1937: 799–803).

The individual members of the temporary-pond association are to various degrees characteristic of the periodic habitat. Very few of them, if any, occur exclusively in waters that dry up regularly. Even the most typical species, such as the fairy shrimp, may live also in permanent bodies of water. It is to be remembered that in permanent ponds in which the water level fluctuates markedly, the banks constitute temporary aquatic habitats. Nevertheless one may, with sufficient accuracy, classify the various members of the fauna in the following three groups: (1) species that show a marked preference for temporary ponds; (2) species which occur generally in stagnant waters, both permanent and temporary; and (3) species that are not well fitted for continued life in temporary habitats.

The inhabitants of the two temporary ponds which appear to have a distinct preference for temporary habitats are Turbellaria (*Catenula lemnae, Dalyellia* sp., *Phagocata gracilis*); Phyllopoda (*Eubranchipus vernalis, E. bundyi*); Ostracoda (*Cyprois marginata, Eucypris fuscata, Cypricercus tincta*); Amphipoda (*Crangonyx gracilis, C. shoemakeri*); Isopoda (*Asellus militaris*); Decapoda (*Cambarus fodiens*); Trichoptera (*Limnephilus indivisus*); and Gastropoda (*Aplexa hypnorum*).

The second category, animals that occur normally in both permanent and temporary habitats, comprises a great number of animal forms. Of the species of this category, the following are the most regular inhabitants of the temporary pools: Oligochaeta (*Lumbriculus variegatus*); Phyllopoda (*Lynceus brachyurus*); Cladocera (*Daphnia pulex*); Ostracoda (*Pionocypris obesa, Cypria exculpta*); Copepoda (*Cyclops vernalis, C. bicuspidatus thomasi, Canthocamptus staphylinoides, Attheyella northumbica americana*); the majority of the Acarina and Insecta observed in the pools; Gastropoda (*Lymnaea palustris, Armiger crista, Gyraulus parvus, Planorbula armigera, Physa gyrina*); and Pelecypoda (*Sphaerium occidentale, S. truncatum*).

In the third group, animals that are not well adapted for the life in temporary habitats, one may place certain insect and amphibian larvae that were observed in the ponds, but that obviously could not complete their aquatic development by the time the water disappeared (e. g., *Bufo americanus, Hyla versicolor*). Truly aquatic species may also be introduced accidentally and may retain a precarious hold in the ponds. Here one would probably have to count some of the species that were observed only in single or in very few individuals. It would be premature, however, to speculate on the history and the fate of these species without having more factual information.

The inhabitants of temporary bodies of water have developed various adaptations that enable them to survive during the dry periods. Some of the animals are not exclusively aquatic and can leave the ponds, when they dry, in search for new quarters (adults of Coleoptera and Hemiptera). Nymphs of Acarina may be transported while attached to insects. In other animals, such as the majority of insects and amphibians, only the larval stages are aquatic and metamorphosis is, as a rule, completed before the habitat dries. The most typical members of the association, however, spend the dry period either as "dormant" stages or follow the retreating ground-water table.

The dormant stages may be conveniently classified as follows (cf. Spandl, 1925: 128–30; Brehm, 1930: 194–97):

a) Dormant eggs: Turbellaria (some Rhabdocoelida), Oligochaeta (Naididae), Phyllopoda, Cladocera, Ostracoda, Copepoda (Calanoida, Harpacticoida).

b) Cysts enclosing young or adult animals or fragments of animals: Turbellaria (Catenulidae, *Prorhynchus stagnalis* [?], and *Phagocata vernalis*), Oligochaeta (*Aeolosoma,* Naididae [?], *Lumbriculus*), Copepoda (Cyclopoida, Harpacticoida).

c) Animals buried in the ground and remaining in a state of torpidity until the ponds fill again (some secrete a protective slime layer):

Hirudinea, Cladocera (possibly for short periods), Ostracoda, Cyclopoida, Acarina (?), larvae of certain Diptera, Gastropoda, and young of Pelecypoda (*Sphaerium*).

In some of the dormant stages, particularly as eggs, the animals can withstand a great degree of desiccation and remain viable over a long period of time. In others, such as many cysts and stages of drought torpor, they are sensitive to excessive drying. The bottom of temporary pools, however, rarely dries completely and then only in the uppermost layer. As a rule it retains a considerable amount of moisture, particularly if it is covered with a dense vegetation in the dry period.

Some animals regularly follow the sinking ground water. This seems to be the case in a turbellarian, *Prorhynchus stagnalis*. Crayfish burrows also are built to reach below the ground-water level. Amphipoda and Isopoda appear to remain active in the ground water throughout the period of drought, since, when they emerge in the next wet season, they have grown and matured. Ostracoda, Copepoda, and Amphipoda have been observed to live in summer in the water filling the pockets of crayfish burrows.

Little is known about the variation of the pond fauna from year to year (cf. Welch, 1935: 341). There is much evidence, however, that the faunal composition in the temporary ponds varies to a greater extent than does that of any other aquatic habitat. As the filling and drying of the ponds depend so much on meteorological factors, it is to be expected that extreme weather conditions have a profound influence on the animal life in the ponds. More field observations on this question, however, would be desirable.

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PLATE I

FIG. 1. Pond II, on U. S. Highway 23, in May, 1941.

FIG. 2. Pond II in September, 1940, in the dry season. The bottom of the pond is covered with profuse vegetation.

PLATE I

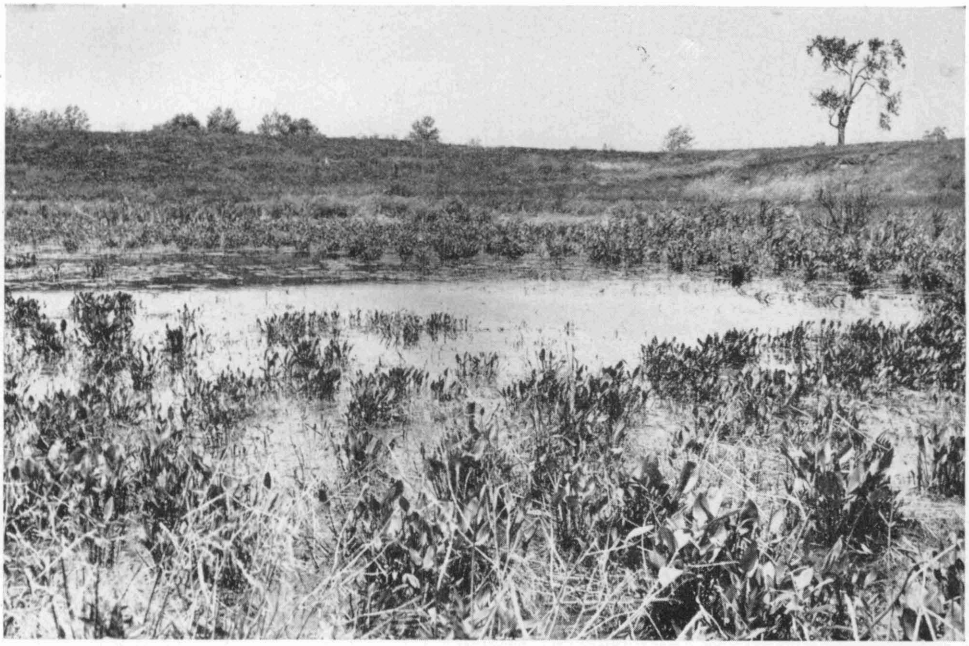

Fig. 1

Fig. 2

PLATE II

FIG. 1. Pond I, on Milford Road, in May, 1941.
FIG. 2. Pond III, view from Platt Road.

PLATE II

FIG. 1

FIG. 2

PLATE III

FIG. 1. Pond IV, on Huron River Drive. View of the east bank in May, 1941.
FIG. 2. Pond IV, western part, in May, 1941.

PLATE III

FIG. 1

FIG. 2

(Continued from inside front cover)

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