The Fauna of an Artificial Pond

by

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Introduction

The purpose of this study has been to make a general survey of the life of an artificially constructed pond:--

(1) To determine the forms of life living there as well as the conditions under which they are living; (2) to note the seasonal changes that take place over a period of one year; (3) to make comparisons with studies made on typical ponds.

I wish to acknowledge my gratitude to Dr. H. H. Lane for his advice and instruction concerning this work. To Miss Vera G. Smith for the suggestion of the problem and her kind interest and encouragement. Also to Dr. H. B. Hungerford for many helpful suggestions and his aid in faunal determinations. I am greatly indebted to Dr. E. A. Berge, C. D. Marsh, R. W. Sharpe for determinations of Cladocera, Ostracoda, Copepoda. I also wish to express my thanks to Dr. A. A. Schaeffer, Prof. W. Horr and R. Beamer for determinations of Protozoans flora and Odonata and for many other kindnesses which aided in making this paper possible.
Allee (1911) of the University of Chicago made a study of the seasonal variations in animal habitats in ponds. These ponds are in the oldest part of the slough system at the south end of Lake Michigan. He defined seasonal succession as the gradual replacing of one complex of animal life by another. These complexes may be designated in terms of species that are dominant at any given time. Dominance comprises two factors (1) pure numerical dominance and (2) distribution in pond. But since many forms never rise to a dominant position, seasonal succession requires a study of the seasonal development of each member of the complex. Allee's work included a quantitative as well as a qualitative study of the fauna present.

As a result of his investigation, Allee concluded that the phenomena of seasonal succession holds, both in regard to succession of species and to the number of individuals in a species. Also that forms tend to distribute themselves over the whole pond, but are much more restricted during the breeding season. He summarized the external factors that influence seasonal succession as: temperature, amount of water, chemical composition, amount and character of food and the physical conditions of the habitat. He also states that, in seasonal succession, the dynamic effect of the animals themselves upon their
own habitat is not nearly so marked as in ecological succession; yet this dynamic effect can be demonstrated to be present so that the phenomena of seasonal succession may be regarded as the cyclic or slightly spiral process by means of which ecological succession is carried on.

Muttkowski (1918) worked out the macroscopic fauna of Lake Mendota in Wisconsin. He made a qualitative and a quantitative survey of macrofauna, its distribution and food relations, with special reference to insects as fish food. As to distribution, Muttkowski states that altho the lake taken as a unit is a place of relatively slight and slow changes, yet it contains within itself a series of well defined habitats, each with its own controlling factors and its own biota. Type of vegetation, kind of bottom, current, enemies food supply, are all factors which influence the choice of a habitat. It is on the basis of physiological, physical and biotic aspects that it is possible to divide the lake into various habitats as: littoral or phytal region; the aphytal region; and pelagic region. The littoral area in Lake Mendota extends to a depth of 7 meters. He further divides the littoral area into the enlittoral area and the sublittoral. The enlittoral area being the area of photosynthesis, hence the region of plant growth. Below this lies an area characterized by the absence of spermatophytes, a place where minimal amount of photosynthesis may take place
and this is the sublittoral. He also divides the enlittoral area into shore line, breaker line and plant zone. The aphytal region indicates the area below sight meters and means plantless. The pelagic region pertains to the open water and the distinctive abode of the plankton.

His comparison of the bulk percentage and the food relations of the various groups shows two important results (1) The scavengers are the dominant forms of the lake (2) Trichoptera are dominant in the littoral area hence in region of plant food. In relation of the insects to fish food, Muttkowski states that the different groups do not form the same percentage of fish food that they form of the lake complex. Certain faunal types are comparatively rare in fish diet as the Leptocella uwarowii, perhaps because of its repellent secretions or perhaps the rigidity of cases. Corixae and Gyrini are not uncommon in fish stomachs. He concludes that, as a whole, the place of insects in the fish diet is a variable one, depending upon the habitat and species of the fish.

Muttkowski also made a comparison with other hydrobiota and other lakes. He states that adjustment to aquatic life has developed to its highest point in lake life and rapids where molar agents have forced a complete separation from aerial respiration. In comparison he concludes that the associations of lakes, rapids, and spring outlets are distinctly related as to general makeup.
They form the water breathing communities. In contrast to them he placed the communities of streams, creeks, ponds, swamps and shallows as typified by air-breathing animals. Muttkowski gives as the characteristics of ponds: stagnancy, shallowness, tendency toward swamping, minimal circulation, isolated patches of warmer and cooler-water.

Scott (1910) studied the fauna of a typical solution pond which is located one half mile Northeast of the campus of Indiana University. He determined the fauna present, analyzed the physical factors and environment, and determined the processes at work.

The conditions of this study were then compared with those of lakes and rivers and a correlation made with cave plankton. According to Scott the physical factors that condition the existence of these organisms are: level, light, temperature and food relations. He showed that there are extreme levels in this pond. It varies from zero to 46 inches above the lowest point. This irregularity, more than any other factor, prevents the fauna of this pond and all small ponds from becoming even relatively static. He also concludes that variation in the level may result in the elimination of a species or in its abnormal development. Scott indicates that seasonal development is due to changes in temperature. Temperature above 4°C does not affect
the forms which are found in the pond throughout the year as beetles, Corethra larvae, amphibia larva, but below the temperature of 4°C their activity is decreased until 2°C they are quite passive and a temperature lower than 2°C may prove fatal especially to Corethra larvae. Also the formation of ice on the surface does not cause a quiescent stage in Amphibian larvae but a temperature of 2°C does reduce their activity.

The light in this pond is reduced considerably by the growth of Typha. Scott made comparative observations on another pond similar in area and depth but without Typha growing in it. He found Cladocera, Copepoda and Chlorophyceae much more in evidence in it during September than in the pond with Typha growth. From this observation Scott concludes that it is very probable that the reduction of light due to Typha growth has resulted in fewer species and individuals developing in the pond.

As to food relations Scott showed that there is a correlation between the animals and their habitat and also between each other. The animals present in his pond are herbiverous, carniverous, and some omniverous. He concludes that altho there is a possibility that aquatic animals derive some food from the water by direct absorption of nutrient solutions, nevertheless, the higher animals in his pond, for the most part, utilize solid food. He based his statements of observations of feeding and on examination of the alimentary tract.
In his comparison of this pond and a lake, he states that the fundamental differences are, dimension, depth, effect of level (as the lowering of the lake level one-half meter would not affect its fauna to any marked degree).

There is not the variation of temperature in ponds that is found in lakes. Ponds lack variety of associations. Conditions are relatively static in lakes while in ponds there is greater change from year to year. Altho a single pond contains relatively few species, all the ponds in an area of several square miles show a greater variety. Scott states that this variety has an important bearing upon the relation of pond plankton to that of caves. From his observations he shows that the cave plankton is a composite of such organisms of the contributing ponds as are able to withstand cave conditions. The greater the number of contributing ponds, the richer will be the fauna at the outlet of the cave stream.
Object of Study

Location

The body of water under consideration in this study is located in the north-east part of the city of Lawrence, Kansas. Its exact location may be seen by reference to the map of the city, Plate I. This pool is 805 feet south of the Kansas River. The land lying adjacent to the pool is very level and affords very little, if any, drainage into the pool.

Form and Size

This pond, which is in the form of a large, circular, brick walled cistern, has a circumference of 192 feet, or 58.52 meters, a depth of 18 1/4 feet. The wall is 18 inches thick. The top of the wall is from one to two inches above the level of the surrounding ground.

The water in this pit has an average depth of 7 3/4 feet or 2.36 meters. The water level of the pool was 1.65 feet above that of the Kaw River on February 12, 1926. This was shown by survey made at the point (X) in plate I. Survey of the level of the water at the east side of the bridge, (Y) plate I, which is just above the dam, showed the river level to be 13.33 feet above that of the pool. Records were kept of the height of the river and a gauge was set to measure any change in the depth of the water in the pool. The level of the water in the pool remained
quite constant and was affected only by the precipitation and evaporation; 3 inches was the greatest change in level.

History

This pond is owned by the Citizens' Light, Heat, and Power Company of the city of Lawrence. According to their records, it was built just prior to 1882 (This being the nearest correct data I could find). It was used as a holder for a steel tank which contained artificial gas. There are at present iron uprights on the sides of the pit, which were used as runways for the rollers on the steel tank. During the time that this pit was in use, water was kept in it at a level of two feet from the top. In 1884 the steel tank was removed and the pit was remodeled. It was then refilled with water and the steel tank replaced and was in use until October 15, 1905,—that being the date on which natural gas was first used in Lawrence. However, the steel tank was not removed from the pit until August 1917. From that date until the spring of 1925, the pit was unused except as a dumping ground. In the spring of 1925 the Zoology Department of the University of Kansas leased this pit for the purpose of Scientific study. The general form of the pond may be best understood by reference to Plate II, which shows actual photographs of the pool.
The bottom of the structure is of brick the same as the walls. As it was used for dumping purposes by the Gas Company for several years, there is a large amount of debris, such as bricks, boxes, bottles, pieces of iron, wire, and numerous other articles found on the bottom. The debris was so great that it was very difficult to use any sort of apparatus to discover the nature of forms living on the bottom. Due to the fact that there is practically no drainage into the pool from the adjacent land, and the height of the brick walls above the level of the land, there is a very small amount of sediment or mud on the bottom of the pool. The small amount present is more of the nature of decayed vegetation.
Methods

The Zoology Department had a six foot wire fence placed around the top of the pool. A large pontoon raft was made and placed on the water at the south side of the pool. This raft was fastened securely to the wall and descent was made to this by means of a ladder. A small raft, composed of a simple board platform and four barrels, furnished a means of moving about over the water.

For collecting insects, insect larvae, amphibia and larvae, ordinary insect and dip nets, with an opening 12 inches in diameter, made of scrim, were used. A tow net was used at times, but only for qualitative work. For quantitative work of the smaller forms, as the Ectomerostraca, an apparatus was made which consisted of a quart jar placed on a small platform and fastened to an upright measuring stick. The lid of the jar was fastened to a strip which was hinged to the upright in such a way that the lid fit securely on the jar. A spring extended from this strip to the platform. This spring served to keep the jar closed. A wire was also fastened to the lid strip and served as a means of opening the jar, Plate III. This jar could be lowered to any depth desired, the jar could be opened and let fill, and by releasing the wire the spring would close the jar. Great care was used in making the lid fit securely so that water could not seep in as the jar
was lowered. A wide mouthed 50 c. c. bottle was placed upright in the jar. The contents of this bottle were then brought to the laboratory. This water was filtered until approximately 5 c. c. remained. To this a few drops of 95% alcohol was added to kill the organisms. The counting was all done with the microscope using a simply made counting slide. This slide was made in laboratory by glueing small strips of wood along the edges of a glass slide making sure that the trough thus made was water tight. The water was transferred to this slide by a c. c. pipette and the forms counted until the entire unfiltered portion was counted. This gave the approximate number of forms present in the 50 c. c. bottle of water. Counts were made from 6 1/2 feet below surface and from the surface. Water was also taken from four feet below the surface but the results were not of enough importance to continue that depth. Other forms were estimated as to the numbers observed per entire pond at each time of study.

The apparatus shown in Plate IV was used in securing samples of water for making tests for the amount of dissolved oxygen present. This apparatus was made from plans suggested by G. C. Whipple '14 "Microscopy of Drinking Water". The Winkler Method of determining the amount of dissolved oxygen was used--Berge and Juday--Wisconsin Geological and Natural History Survey--No. XXII.
A Colorimetric method was used in making pH tests. The set used was checked against the LaMott Standard set.

Observations were made approximately once a week, except during the months of July and August when trips were made on an average of every three days because of the rapid changes taking place during those months. During December and January observations were only made at irregular intervals because of cold weather and the frozen condition of the water.

The time of study was not confined to anyone time of day. During the summer months most of the work was done during the morning hours, as the heat was too intense in the afternoon. The largest share of the fall and winter observations were made in the afternoons.

As a matter of convenience the study was divided into collections of different types: Collection A--Surface work not exceeding one foot below surface; Collection B--Air net work; Collection C--Dip net, along walls etc; Collection D--Tow net work; Collection E--represented collections made with the jar with the spring lid.

Material from these collections was studied and classified. Specimens of the forms were preserved in 70% alcohol to have classification verified by expert authority.

Plate V shows the type of apparatus that was used
to study the bottom. Lead weights were fastened to this apparatus, to keep it on the bottom, and then it was dragged by means of a rope. In making quantitative counts of the bottom fauna, the size of the opening of the apparatus and the distance dragged were used to estimate the numbers per cubic foot.

The temperature of both the air and water was taken at each period of study. A centigrade thermometer graded to tenths was used. The complete daily temperatures for the year were also obtained from the weather bureau.

The study of this pond extended from March 1925 to March 1926.
Floral List

Blue green algae
   Rivularea
Bacillariaceae
   Diatoms
Chlorophyceae
   Desmidiaceae
      Cosmarium Locare
      Cosmarium Wolleanum
Zygnemaceae
   Zygnema
   Sphaergyra
Volvocaceae
   Volvox
Coelastraceae
   Scenedesmus
Hydrodictyaceae
   Hydrodictyon
   Conferva vulgaris
Faunal List

Protozoa

I. Rhizopoda

Amoeba radiosa
Trichamoeba fluida

II. Mastigophora

1. Flagellata

Anesonema grande (Steen)
Denobryon sertularia
Euglena ehrenbergi
Phacus longicauda
Chilomonas oblonga
Trachelomonas hispida
Gymnodinium umberrimum
Polytoma uvella
Heteronema acus

III. Ciliata-Infusoria

1. Holotricha

Frontonia acuminatum
Coleps bertus
Cinetochilum margareticium

2. Heterotricha

Halteria grandinella
Spérostomum ambiguum
3. Hypotricha
   Oxytrichia peelionela
   Aspidisca lyncaster

4. Peritricha
   Vorticella campanulata
   Charchesium polynenum

Trochelininthes

I. Rotifera

   Anuerea

   Diglена.

   Rotifer

   Paradoxa

Annelida

I. Oligochaeta

II. Hirudinen

Mollusca

Phya forsheyi Lea
Arthropoda

I. Crustacea

1. Cladocera
   Daphnia pulex
   Chyadorus sphaericus

2. Copepoda
   Cyclops leuckarti, Claus
   Cyclops albidus, Jur.
   Diaptomus, (siciloides, Lilli?)

3. Ostracoda

II. Insecta

1. Ephemeroidea May Flies

2. Odonata
   (a) Zygoptera Ariga (Damsel Flies)
   (b) Anisoptera (Dragon ""
      Libellula lectuosa--Burmeister
      Pachydiplax longipennis--"
      Pantana hymenaea--Say
      Parthemis domitia--Drury
      Variety Tenera--Say

3. Hemiptera
   (a) Corixidae--"Water Boatman"
      Arcto-corixa alternala--Say
   (b) Notonectidae--"Back Swimmer"
      Notonecta undulate--Say
      Buenoa Margitacea
      Buenoa scimitra
   (c) Nepidae
      Ranatra fusca
(d) Belostomatidae
   Belostoma flumineum—Say

(e) Velüdae
   Microvelia

(f) Mesovelüdae
   Mesovelia besiguata

(g) Gerridae
   Gerris marginatus—Say
   Gerris remigis—Say

4. Diptera
   (a) Chironomidae

5. Coleoptera
   (a) Haliplidae
      Peltodyes

   (b) Dytiscidae
      Laccophilus fasciatus
      Cybiaster funbriolatus

   (c) Gyrinidae

   (d) Hydroplulidae
      Tropisternus
      Hydroplulus

III. Arochnida
   1. Acarida—water mites

Graniata

I. (Batrachia)
   1. Urocdela
      Ambystoma tigrinum

   2. Anura
      Acris gryllus—Leconte
2. Anura (cont)

Rana pipiens

Rana castosbiana
Seasonal Changes

Trochelminthes

Rotifera

Five rotifers were found in this pond two others were noted but were not identified as they was so rare and so hard to preserve for identification. In March and April Anciarea was the main form found. Many of these bore eggs. Diglena, Rotifer and Paradoxa were found in October. The highest point in their cycle appeared in July, when it was estimated that there were 150 per 50 c. c. of water. They remained quite uniform until the middle of August, when there was a decrease to 10 per 50 c. c. of water in September. Then in October there was a slight rise in numbers to 21 per 50 c. c., but the November and December data showed a drop to seven and eight per 50 c. c. of water.

Samples of water were taken from the first surface foot and also from six feet below the surface, but when the data were averaged and compared there was only, 9 more rotifers in 50 c. c. of the six foot water than in 50 c. c. of surface water.

In January ice was broken and water from just beneath the ice was brought to the laboratory and eight rotifere were found in the 50 c. c. In February they were present in approximately the same numbers as in January.
Annelida

Only two classes out of this group were represented in this pond, *Oligochaeta* and *Hirudinea*. A few *Oligochaeta* were observed in October in Algae taken from the walls. Two were found in mud secured from the bottom in March 1926. They were so few in numbers and were not observed until so late in the study that no seasonal study or quantitative study was made of them. The leeches were only observed a very few times and then only two or three were seen at one time. No special study was made of them.

Mollusca

Gastropoda—Snails

Physa forskyi Lea is the only representative of the Mollusca present in this pond. The snails confine themselves to the walls at the water's edge and to the boards and twigs floating in the water. They were found there when the study was commenced on March 1st 1925. The eggs were first seen on the 7th of March and were present in large quantities during the months of March, April, and May. A few eggs were found at times in the algae during the entire summer but in smaller numbers than earlier. The young snails hatched from the spring egg,
supply were first observed on March 27th.

During the months from March to July, Physa was in evidence in large numbers upon the walls along the water's edge. They would be found sometimes an inch or two above the water, but not above the line reached by the water as the wind lapped it against the wall. Every little twig and board floating in the water was covered with snails. There was a steady increase in their numbers during June, due to their rapid proliferation. But during July as the temperature rose, the snails began to disappear from the water's edge and from the boards until by the latter part of the month approximately only one half as many were visible. The walls and boards were devoid of snails during August. During this time the Physa were only found in the algae on the walls, three to four feet below the surface, where the heat and light were less intense and the moisture abundant. The first week of September the temperature of the water lowered from 26°C to 18°C and October 8, the snails were again residents of the boards in great numbers as may be seen by Plate VII. But they did not rise to as high a peak as in June and were not present for as long a time. As the temperature continued to lower during October Physa again began to disappear, seeking shelter for the winter in the algae or mud of the bottom. They were found in the algae of the wall at a depth of five feet during the winter and
were usually quite inactive.

Hungerford (1919, Biology and Ecology of Aquatic Hemiptera) notes the fact that the snails are used as food by members of both the Belostom atidae and Gerridae families. This, no doubt, as one of the factors which lowered the number of snails during July. It will be noted by Plate XVI that both the Gerridae and Belostom atidae reached their highest numbers in June and July. However, the heat seems to be the main reason for seeking shelter in the algae in July. The fact that Physa had probably been preyed upon, coupled with the low rate of reproduction at this time of year in comparison with the high rate in May and June, are factors which cause the second peak in the Physa cycle to be lower than the first one.
Arthropoda

I. Crustacea

Entomostraca

1. Cladocera
   Daphnia pulex
   Chydorius sphaericus

2. Copepoda

3. Ostracoda
Cladocera

**Daphnia pulex**

**Chydorus sphaericus**

Both of these species were found in great abundance in March. The collections for March and April showed both of these mature with eggs in the brood case, which is inclosed by the shell on the back of the female. During the month of May there was a rapid decrease in the number of the water fleas until by the 25th of the month, the Daphnia had disappeared entirely and only two Chydorus were found. No water fleas were found during June, July or August although the same apparatus was used as for the rotifers and the other Entomostraca. But on July 29th algae were taken from the wall, three feet below the surface. This material was found to be densely populated with Daphnia. These were mainly females bearing egg cases ready to be deposited for the winter. After that, no more Daphnia were found until in February, when they were again present in the Algae in great numbers. Also two were noted in 50 c. c. of water taken from six feet below the surface.

Specimens of Chydorus were observed throughout almost the entire year. But only two were found during the month of May. In July and August Chydorus was taken in tow-net collections, approximately ten per 50 cubic feet of water.
During September and October no representatives of Chy-
dorus appeared, then in November, December, January and
February they were again observed in great abundance in
the Algae from the walls. Those collected in February
had very small eggs within the brood cases as was true
also of Daphnia.

Copepoda

The Copepoda that were observed in March were mature
forms, at least 60% of them being females with egg sacs.

Their numbers remained fairly constant until the
first part of May. Then there seemed to be a sudden
decrease, however, those observed were still females with
eggs. During the last week of May and the first week of
June there was a rapid increase due to developing of the
nauplius into young cyclops. Estimates for June and
July showed approximately an increase from 25 to 110 per
50 c. c. of water. The decrease in May was probably due
to the increase of other animal life in the pond which
used the Copepoda for food. The Copepoda had not yet
reached the stage where their reproduction out-ran the
demand for them as food. As soon as the young began to
develop, their reproduction more than balanced the demand.
Then in August there was another drop in numbers to 30
per 50 c. c. of water. This could only be accounted for
on the hypothesis that the greatest period in development
was over, but the food demand was still on the increase.
This depression lasted until the first part of October when there was another rise in numbers to 50 per 50 c. c. of water. These data also show that at least one fourth of the 50 were nonplius and young Cyclops. The first part of November found the Copepoda again decreasing and by the last of the month they numbered 3 per 50 c. c. of water and December only 2 per 50 c. c. was the estimate. During January no representatives were observed except in the Algae. But in February there were seven in 50 c. c. of water taken from six feet below the surface. From this it is clear that the Copepoda had three periods of maximum numbers March, July and October, with the highest peak of the annual cycle in July. The Copepoda were present during the entire year in the Algae of the walls.

Birge, (97 Wisconsin Academy of Science Volume 11), states that the limnetic Crustacea on Lake Mendota show a rhythm in their annual cycle. He found three maxima and minima of unequal value.
Winter Minimum

December to April, then increase to

Spring Maximum

May, followed by a great decline to

Early summer depression

June or early July

Mid summer Maximum

July

Late summer Minimum

August

Autumn Maximum

September and October, declining to winter minimum through November and December.

As will be noted these Copepoda follow the same type of a rhythm in their annual cycle.

Ostracoda

A species (undetermined) of Ostracoda was secured, though it was not so abundant as the other Entomoestraca present. In March only three were found in 50 c. c. of water. This number remained fairly constant until in June they increased to 10 per 50 c. c. of water. These data held true for the months following until September, when the number fell to two per 50 c. c. of water. None were found in the open water after November 1st. However, they were found in great quantities in the Algae from the walls during the months from November 1925 to March 1st 1926.
In making a quantitative study of the Entomostraca of this pond, samples were taken from the first foot of surface water and also from six feet below the surface. In making a comparison of the results from both depths, it was found that the numbers averaged approximately the same for both. No difference was found as to the distribution of the young and mature (females with eggs) as to the depth. It was observed however, that as a general rule the Entomostraca were found in greater numbers on the south half of the pond, as that half is shaded by the brick wall.

The Entomostraca as a whole serve as a very good food supply for many organisms in the pond. This may be clearly seen by reference to Plate XXX.
Arthropoda

II. Insecta

1. Eplumerida
2. Odonata

(a) Zygoptera--(Damsel Flies)
   Argia

(b) Anisoptera--(Dragon Flies)
   Libellula lectuosa--Burmeister
   Pachydipley Gongipennis
   Pantala hymenaea--Say
   Parithemis domitia--Drury
   Variety Tenera--(Say)
1. **Ephemeraida**

   The naiads of this form were first found in April and were present in collections made from the algae of the walls all during the year. In February two were found in Algae taken from below the ice. No adults were ever noted about the pond.

2. **Odonata**

   (a) **Zygoptera**—(damsel flies)

   The naiads of this damsel fly appeared at the surface about March 7th 1925. They were found on the underside of boards and logs floating in the water. The largest number found at any one time in March was eight, but during the months of May and June, as the temperature rose, there was an increase in the number of the naiads present at the surface. Counts were made from several different boards and logs, the same area being used. In five counts an average of two per square inch were found. One out of every ten was a young naiad. The naiads were quite uniform in their distribution upon the logs, boards, and objects in the water. The adults began to emerge about the middle of April. Adults and the empty cases were found on the walls of the pool from that time until the latter part of August. The greatest number of adults found at any one time was sixteen in the month of July. However, many more damsel flies emerged than were observed.
as could be determined from the number of empty cases left about the pool. Seventy five cases were counted on the wall, one foot above the water, of one half of the pool at one time. The damsel flies emerge during any time of the day and it was difficult to secure any exact data.

During the months of July and August the only naiads found were in the algae on the walls, three to four feet below the surface. The temperature at that place perhaps was nearer the optimum for the damsel flies. In September the naiads again appeared at the surface upon the logs and boards. Their numbers at this time exceeded those of June. The same distribution was noted and the same unit of naiads to the square inch. Seventy five percent of the naiads at this time were very young ones, most likely the young hatched from eggs deposited by adults which emerged during the summer.

As the temperature lowered in October, the naiads disappeared from the surface again to seek shelter in the algae on the wall, where they were found during the winter months from November 1925 to March 1926.

(b) Anisoptera

The naiads of dragon flies were found in the algae on the walls March 1st 1925. From March to May an average of six to eight naiads were found at each time of study.
These naiads were secured only by use of the dip net, as they remained in the algae. The adults began to emerge the second week of June and then the empty skins were found in profusion on rafts and walls. During the month of June the largest number of adults observed at one time was three. This number gradually increased during July until sixteen was maximum numbered per observation for the month. The maximum number for August was fourteen in the first week of the month. There was a gradual decrease in numbers from that time till the middle of the month when they ceased to emerge.

However, one to three naiads were found in the algae at each observation from August till November. In August two or three very young naiads were found. During December, January and February the naiads were not secured with the algae because the naiads of the Libellulidae, which were the most numerously represented in the pond, are bottom sprawlers. Search was made for dragonfly eggs but they were not secured. The dragon flies emerged in the early morning hours. Observations were made at 5:30 and 6:00 A. M. during July and August, and at that time many were observed to be emerging. A few trips were made later in the day, some at 10:00 A. M. and during the afternoon hours, but none were observed to emerge at those times.
Arthropoda

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II. Insecta

3. Hemiptera

(a) Corixidae

Arctocorixa alternata—Say

(b) Notonectidae

Notonecta undulata—Say
Buenoa margitacea
Buenoa scinitra

(c) Nepidae

Ranatra fusca

(d) Belostomatidae

Belostoma flumineum—Say

(e) Veliiidae

Microvelia

(f) Mesoveliidae

Mesovelia designata

(g) Gerridae

Gerris marginatus—Say
Gerris remipis—Say
(a) Corixidae

Arctocorixa alternata, Say was the only representative of this family found. It was only found two to three feet below the surface along the walls and sometimes in algae on the walls, and were only secured by means of the dip-net drawn along the wall. Because of that fact the only estimate made as to the numbers of this form was from collections with the dip net. A twelve inch net was used and lowered three to four feet below the surface close to the wall, then drawn along wall to surface. Their greatest numbers were found in June when an average of twelve to three square feet was estimated. During the months of January and February they were found in the algae of the walls, four to five feet below the surface of the water. They were quite active when brought to the surface from under the ice.

(b) Notonectidae

Notonecta undulata was the only back-swimmer observed from March until June 1st, when Buenoa appeared. These two genera mostly as instars gradually increased until September from their first appearance in June. Then from their first appearance in June. Then from the latter part of September to October 15th, there was a very great increase in numbers as may be seen by reference to Plate X. This increase was attributed to the fact that the "back-swimmers" were migrating to this body of water for winter quarters.
Estimates were made of the number present. Three to five counts were made at a time and an average taken from these counts. These estimates showed an increase in numbers over the entire pond from twenty in June to 300 in September. This number held till the middle of November when the number again receded to 150 per entire pond. Then as the temperature lowered they decreased to 105 in December, due to the increased death rate of the remaining instars. This number remained constant up to the time of the freezing over of the water late in December.

The Notonectidae were not uniformly distributed over the pond. They confined themselves mainly to the south eighth of the pool, perhaps because that part receives less light than the north part, the high wall shading the south eighth from the sunlight.

Collections taken during the months of March to June 1925 showed Notonecta undulata to be the more prevalent of the species of this family. But study for the months following June to December, showed a larger number of the Buenoa. Thus a typical collection, that of November 1925 shows the following counts:

- Notonecta undulata: 10 a-3rd instar nymph
- Buenoa marginata: 13 specimens

2 11
Then in contrast note a collection of May 1925 which showed

\[ \begin{array}{ccc}
\text{Notonecta undulata} & 18 \\
\text{Buenoa} & 2 \\
\end{array} \]

During the months of January and February 1926, the Notonectidae were found in the algae three to five feet below the surface. In February, at two different times, they were seen swimming about in sunny places under the ice.

A few eggs of the Notonectidae were found on a small branch of an elm tree floating in the water.

(o) Nepidae

This form was not observed until in June. Even then not more than three were found at any one time during the month. There was a gradual increase in numbers until they reached their highest point in August. This increase seemed to be due mainly to the development of numerous instars, as during the latter part of July and the first of August many juvenile stages were observed. The Ronatra were usually found along the walls or clinging to the sides of boards in the water so that the air tube pierced the surface film. They seemed to react quite suddenly to the lowering temperature, of October, as their
numbers dropped from twelve in September to only two in October. None were found after the first week of November. They evidently hibernate in the mud and trash of the bottom and in the algae of the walls.

On the 4th of February 1926, ice was broken and algae were secured from the walls, four to five feet below the surface. In these algae two Ronatra were found, and one crawling along the wall not more than six inches under the ice.

(d) *Belostomatidae*

*Belaustoma flumineum*—Say was the only species of this family found. It was possible to follow most of the steps in the life history of this species. The adults with eggs and specimens of the first, second and fifth instars were collected. The first specimen of this family was observed on April 25th. Not more than one was observed at any one period of study for that month. There was a gradual increase during May and June until they reached their maximum in July. Fifteen was the greatest number observed at any one time during the month. This increase was due to the presence of many instars in different stages of development. The egg laden males were found from the middle of April to the last of August. September was the last month in which any Belostomatidae were found. Eight were found the first part of the month, but during the last week only one could be found. The cause of this early disappearance was thought to be due to
the drop in the temperature of the water during the month causing the Belostomatidae to seek shelter in the mud at the bottom of the pool.

(e) *Veliidae*

A very few specimens of this family were observed twice during the month of June and only ten to twelve on those occasions.

(f) *Mesoveliidae*

Specimens of this family were present during the month of July, but were only found during two weeks time. If present before or after that time they were so few in number that they were not observed. They were found on the top side of logs and boards floating in the water. They were present in large numbers during their short stay and when disturbed would run out on the water in every direction.

(g) *Gerridae*

*Gerris marginatus*—Say and *Gerris remigis*—Say were the two species of this family found. These forms were not constant inhabitants of the pond. In March the greatest number seen were five *remigis*. In April both species were present. Some periods of study did not show either of the two species. Then at other times they would both be present. During the months of May and June their numbers were the greatest, when fifty five were
estimated at one time in June. At least one half of that number were Marginatus. Ten to twelve young remiges were noted also. During July the number decreased until in the latter part of July and August, only a few were seen occasionally. One was seen during the entire month of November and none after that time.

The disappearance of the Gerridae was thought to be due to the migration of Gerris marginatus which is usually winged. Then too the Gerridae form a readily available supply of food for the frogs. See Plate XIII.
Arthropoda

II. Insecta

4. Diptera

Chironomidae
Chironomidae

The first representatives of this form were noted on March 27, 1925. The pupae were in great abundance at that time, six to eight to a cubic foot of water, it was estimated. The empty pupal cases were floating about on the water, and adults which had just emerged were on the surface; a few were flying overhead. The pupae were quite uniformly distributed over the pond. Eggs also were found in great abundance at this time. The eggs were found on boards and twigs in the water. These eggs are very small and are placed in rows in a gelatinous mass. Many of them were found on the water. The pupae were found during April but after that, none were observed except that in July two were found in algae taken from the walls. The adults were present in great numbers until in June. The highest point was reached in May when counts made from air net sweeps with a 12 inch net and swept approximately three feet through the air showed an average of 25 to the stroke. In September, on one trip, six to eight were seen hovering over the pond and new eggs were found at the same time.

Larvae appeared in May and continued throughout the year. In August and September the blood worm cases were found by the hundreds all over the boards and logs in the water and edge of the barrels of the rafts. Both blood-worms and Corethra larvae were present. In December to February the blood worms were abundant in every bit of
algae on the walls. They were also found under the loose bark of a limb of an elm which was submerged in the water.
Arthropoda

II. Insecta

5. Coleoptera
   (a) Haliplidae
   (b) Dytiscidae
      Laccopelus fasciatus
      Cybiaster fumbriolatus
   (c) Gyrinidae
   (d) Hydrophilidae
      Tropisternus
      Hydrophilus

III. Archuida

1. Acarida (water mites)
(a) **Haliplidae**

The Haliplid, *Pelt odyes*, was only seen twice. In June one specimen was found and then in July a small branch of a tree, which had blown into the pond and was partly submerged, was found to be covered with these tiny beetles. Forth were counted on one twig 2 feet by 1/2 inch. At the next period, of study, two days later, not a specimen could be found. Just why they did not appear any more is a question which was not answered. Their main supply of food, the filamentous algae, is plentiful in this pond, so it must be from some other cause than food supply.

(b) **Dytiscidae**

During the first part of March, the Dytiscidae began coming out of hibernation in the algae of the walls and in the mud and trash of the bottom. There were only a very few at that time, but there was a gradual increase until July and August when they reached their highest peak. They remained fairly constant then until the latter part of October when they began going into hibernation. After the first of December, no Dytiscidae were found except as algae were gathered from the wall. During January and February, algae were gathered from the walls and a number of *Laccophilus fasciatus* were found; they were usually quite active.

*Laccoplulus fasciatus* was the common species present; only three specimens of *Cybiaster fumbriolatus* were
observed during the year.

The Dytiscidae were usually found in a strip of water extending about three feet out from the wall of the pool. They were more uniformly distributed over the pond than any other form present.

The eggs of the Dytiscidae were not found. No stage in their life history was observed except the adult.

Scott (1910 Fauna of a Solution Pond) states that the Dytiscidae are much stronger swimmers and more voracious feeders than the Hydrophilidae, which facts may account for their more successful occupancy of the pond.

(c) Gyrinidae

The members of this family appeared on the surface of the pond as early as March 1st 1925. But they were not numerous at any time during the month, ten being the largest number observed. There was a gradual increase in their numbers April to August, due to their coming out of hibernation and the Metamorphoses of pupae into adults. A small part of the increase may have been due to migration of the beetles. They reached their highest numbers in the first part of August. This number remained fairly constant even in October, but as the temperature lowered in October, they disappeared quite suddenly seeking their winter home in the algae or mud and debris of the bottom.

The eggs of the Gyrinidae were found for the first time in May 1925. They were on the boards in the water
in great abundance. The eggs were present from May until the latter part of August. Larvae were found in the Algae on the walls from the middle of June until the latter part of September. No pupal cases were ever found. Larvae were brought to the laboratory and two of them made their pupal cases out of dirt and duckweed, which had been placed on a piece of board in the aquarium. The cases were attached to leaves of a twig which was placed on the edge of the Aquarium in such a way that the leaves just touched the water. Due to an accident the pupal cases were injured and all subsequent efforts to secure pupal cases failed.

The Gyrinidae were usually found in one or two groups on the surface of the pool. It was very seldom that one would see any of the beetles isolated from the group. Plate XV shows their seasonal change.

(d) Hydrophilidae

Representatives of two genera of this family were found, Tropisternus and Hydrophilus. The first Hydrophilus was found in April. Very few specimens of genus were found. Not more than one at anyone time of study and that only occasionally.

Tropisternus was not observed until in July. They were found in the crevices of boards floating in the water. They remained quite constant in their numbers until in September, but with the drop in temperature of the water
in October, they disappeared from the surface, going into winter quarters in the rubbish and mud of the bottom. Egg-cases of the Hydrophilidae were found during July and August. Fifteen were counted on one day observations. The cases were placed on the underside of boards in the water. No larvae of this family were found.

III. Arachnida

1. Acarida (watermites)

The first representative of this group was found in April. This form was never very abundant. Ten was the greatest number found at any time during the study. In July a few of their eggs were found in the Algae. These were brought to the laboratory and hatched so as to be certain that they were the eggs of the watermite.
Cra.niata

I. Batrachia

1. Urodela

   Ambystoma tigrinum

2. Anura

   Acris gryllus Leconte
   Rana pipiens
   Rana catesbiana
1. Urodela

Ambystoma tigrinum

This is the only species of this order that was found. Only the Axoloth larva has been observed in this pond. In April 1925 approximately 50 were taken and no adults were found. Eggs were present on March 27, 1925 and until April 16th. The eggs were attached to tree branches floating in the water and strings which were fastened to corks floating in the water. On March 10th 1926, eggs were dredged from the bottom, but no eggs or salamanders were seen at the surface. On April 16th 1925, many larvae 15-20 m. m. in length were living in the algae of the wall. Then on April 25th, 60 small larvae were seen swimming about in the water. By May 23rd they were approximately 2-2 1/2 inches long and were very active. The greatest number of the large axolotl observed at any one time was twelve. They are very uniformly distributed over the pond. The best time to observe them, especially during the warmer months, is early in the morning from 6:30 to 8:00 o'clock; at those hours the Ambystoma come to the surface and feed on bread and pieces of apples thrown into the water. The stomachs of a number of the older axolotls were opened and were found to contain snails, Entomostraca and larvae—mainly Chironomidae larvae. The young larvae were found to be herbivorous.
Both male and female specimens were taken just before breeding time and dissected. The body cavity of the females were found to be full of eggs. This proved that these axolotl were sexually mature.

Parker and Haswell (Text Book of Zoology, Volume II) remark;--"A very interesting case of paedogony is furnished by the axolotl (Ambystoma tigrinum). This animal frequently undergoes no metamorphosis but breeds in the gilled or larval state. But under certain circumstances the gills are lost and a terrestrial salamandrine form is assumed". Shuel (1920 Principles of Animal Biology) states that in Mexican lakes paedogony is the usual occurrence but in Kansas and Nebraska it is rarely observed.

2. Anura

The first frogs observed in this pond were two Rana piliens on April 16, 1925. The eggs were found on the same day; one mass, which was approximately 6 x 4 inches, was attached to a tree limb which was floating in the water. No tadpoles were found at any time, but in June four young Rana piliens were seen. Acris Cryclus made its first appearance the first part of July. The bull-frogs, two in number, were first seen during this month also. The Rana calesbiana spent their time near the stationary raft on the south side and were usually almost entirely immersed in the water. The presence of these bull frogs and their voracious habits perhaps
accounts for the fact that neither of the other two species reaches a very high point in their annual cycle. These two reached their maximum number of 15 in July. This number remained quite constant through July, August, and September. Of this number six were the *Acris gryelus* while the remainder were *Rana pipiens*. As soon as the temperature began to lower in October, the frogs began to disappear. They sought winter quarters in the debris of the bottom. Two was the largest number found in October and only one *Rana pipiens* was seen in November and that in the first week. The frogs fed on Diptera and insects which happened near the water. The Gerridae and Veliidae furnished food for the *Anura* also. As has already been mentioned the bullfrogs feed on the smaller members of its family, the *Rana pipiens*, as well as the usual food of the frog. They no doubt prey upon the salamanders also, especially the young ones.
Relation of the Fauna to Temperature

The seasonal development of the different forms as indicated in Plate VI is probably due directly or indirectly to changes in temperature. The temperature of the water in this pool as varied from 28°C to 1°C at the surface. The highest point was reached during the month of July. This point was attained by a gradual rise in temperature during the month of June. The highest mean temperature of the air for the year was in July also. See Plate XXIX. When Plates XVII-XXIX are compared with VI, representing the number of forms present each month, it will be noted that the highest peak in the development of forms was during the month of July. The number of forms increased due to the developmental stages in their life histories. The temperature was favorable to these developing stages. For as soon as the temperature fell from 20.28°C in the middle of September to 11°C in October and the temperature of the water from 26°C to 13°C, there was a corresponding decrease in the number of forms present from 24 to 18. The lowering of the temperature caused some of the forms to go into hibernation thus lessening their number.

From October to January, there was a gradual drop in the minimum point. The number of forms at the surface showed a gradual decrease as the temperature lowered. While many of them sought the bottom as a winters home; for
others the algae on the walls served as a good place for hibernation. The dragon-fly and damsel-fly naiads were the first forms to disappear.

Temperature also affects the rate of metabolism. In cold blooded forms, low temperatures tend to decrease metabolism and in these same forms increased temperature increases metabolism and accelerates development (Hungerford 1925). The temperature not only affects the number of forms present at different months of the year, but it certainly affects the quantity of the different forms present each month. Plate XVI shows the nine main forms present in the pond and the highest number of each form present in each month. It will be noted that the maximum number of two forms was in June four in July, and two in August. Making June, July, and August the months of maximum number of individuals in the different forms present. The Notonectidae are an exception to this, but again the temperature is the cause, as this form seeks this pond for winter quarters and thus raises the maximum in October. Plate XXIX which shows the mean annual temperature, also shows these same three months as having the highest average temperature, with July predominating just a little. The number of each species began to decrease as soon as the temperature began to lower, due to the fact that the cold checked development and caused the animals to seek shelter for hibernation.
The pond did not become frozen until the latter part of December, when the temperature fell to 18 below zero centigrade and it remained quite cold for several weeks. On January 5, 1926 the ice was four inches thick. Water taken from just below the ice contained only Protozoa and Rotifers. On February 4, the ice was still approximately 1 1/2 inches thick on the south side of the pool. The south side does not receive as much sunlight as the north side due to the high wall. The ice on the north side was only 1/2 inch thick. Notonecta undulata was noticed swimming about under the ice. The ice was broken at the north side and algae were secured from the wall, four to five feet below the surface. These algae contained adult forms of Dytiscidae, Gyrinidae, Ronatra, Corixidae, Notonecta undulata larvae, Cyclops with large egg sacs, Daplinia with very small eggs in the egg cases, Chydorus, Oostadods, Rotifers and even a couple of May-fly naiads were found. The Notonecta undulata were the most active of any found. The algae serve them as a good shelter. Ice remained on the pond until February 10th and none formed on the pond after that.

There was very little difference between the temperatures of the surface and the bottom. The bottom was, on an average, 1.16 C lower than the surface water. The bottom temperatures were taken by lowering the glass jar, used in quantitative work, to the bottom,
the jar was filled with water and kept at the bottom until the water in jar was the same temperature as the surrounding water, it was then quickly drawn to the surface and the thermometer placed in the jar. The difference in the temperatures of the surface and bottom remained approximately the same, summer and winter.
Relation of the Fauna to Oxygen Content

Tests were made for the amount of dissolved Oxygen present in the pond per liter of water. These tests were made during each season of the year. The times chosen were during the seasons when the greatest change was taking place. The oxygen content was found to be the highest during the months of January and February 1926, when the test showed 6.44 c. c. of oxygen per liter of water. The lowest amount of dissolved oxygen found was during the month of July when it was found to be 1.34 c. c. per liter of water. Then in October the content increased to 4.48 c. c. per liter.

There is a great correlation to be found between the amount of oxygen present and the animal life. It may be noted by Plate VI that the greatest number of forms present was during the month of July. This same month shows the lowest point in the Oxygen content of the water. July also shows the highest peak in temperature. During the months of June and July there were rapid changes taking place in the life of the pool. Animal life was on the increase due to the reproductive period and metamorphosis; great activity was evident.

The rate of metabolism was higher than at any other time during the year. All of these processes increase the animals need for Oxygen and hence larger quantities are used. In October the temperature had begun to
lower, thus lessening the activity of the animal life. Numbers of forms as well as numbers of individuals decreased, due to the fact that many were going into hibernation. The period in the life cycle of the animals was a slow changing one now. Less amount of oxygen was required by the life present and hence a smaller amount was used. Thus, the supply was increased as the pond did not freeze over until quite late in the season. In the months following, up to February, the temperature continued to lower, and the water became frozen; the rate of metabolism was low, due to the extreme inactivity of the forms hibernating in the algae on the walls and in the mud on the bottom. A very small amount of oxygen was required, and since the algae continued the process of photosynthesis, even under the ice, the oxygen content was greater than the demand. Then the colder the water becomes the greater the amount of dissolved oxygen present, as heat tends to drive off oxygen. Decomposition of organic matter, which is a factor in the removal of oxygen from the water is much less at this season than during the summer months, which would also tend to increase the supply of oxygen.

The quiescent state of the larger forms in the pond is due to low temperature rather than to the amount of oxygen present. The low oxygen content of July is a result of an increase in the processes of metabolism,
and these result in metamorphosis, which gains no stimulus from the low oxygen content of the water.

The dissolved Oxygen was found to be quite uniform in its distribution in this pond.
Relation of the Fauna to Light and Level

This pond is very well lighted. There is no growth of plants like Typha to reduce the light. The high walls above the water reduce the light around the edges somewhat; this protection was taken advantage of by most of the forms present, as has already been noted.

The level of the water remained so nearly constant in this pool that it could not effect the organisms unfavorably. The average level was 7 3/4 feet and the minimum was 7 1/2 feet during the month of August. The maximum level was reached in February when the level rose 1 1/4 inches following a foot of snow on February 18th but the level again gradually lowered to 7 3/4 feet. The change in level was attributed to precipitation and evaporation. Readings of the height of the river on different days were compared with the level of the water in the pool, but the results did not show any correlation between the two. The data showed that the river had lowered 6 inches from February 12 to March 4th and the level of the water in the tank had risen 1 1/4 inches during the same period.

Tests for pH showed that the water is alkaline. The readings ranged from 7.1 in July to 8.2 in February. No correlations were determined between the pH and the animal life present.
Relation of the Fauna to Vertical Distribution

In the diagram Plate XXXI I have tried to show the vertical distribution of the animals present in this pool of water.

The Gyrinidae and Gerridae are confined to the surface. The Gyrinidae when frightened may dive under water a little way but under ordinary circumstances they are on the surface of the water. The Gerridae are inhabitants of the surface only. There are some of the forms that are not confined to the surface but are usually found on the under side of boards and logs floating in the water. These are Belostomatidae, Ranatra, Tropisternus of the Hydrophilidae. Physa and the damsel fly naiads were found in this section too, but they were also inhabitants of the algae on the walls. The frogs may be considered in this study as surface forms since they occupied the top side of boards or the first six inches of water, where they were often found along the walls, submerged all but the eyes and nostrils.

The inhabitants of the walls were Physa, Odonata naiads, Blood worms, larvae of the Gyrinidae and Corixidae; occasionally the various instars of the Notonectidae and Belostomatidae were found in the algae also. Then there was a group of forms which occupied the water from the surface to bottom; those were: Rotifers, Entomostraca, Water-mites, Protozoans,
Salamanders and Hydrophilus.

The Notonectidae and Dytiscidae were, as a general rule found in approximately the first three feet of water, altho it is likely that they occupy the entire intervening space between surface and bottom.

The bottom is inhabited by Oligochaeta worms, Blood worms Protozoans.

This pool is not deep enough to show any appreciable vertical distribution of the Entomostraca.
Food Relations

In the diagram in Plate XXX I have tried to express the most important food relations between the organisms in this pond. The main food sources in the pond are: carbon dioxide in solution in the water (derived from the air), foreign organisms accidently falling into the pond, plant life, the dead organic matter in the pond and the animal life present. The smaller aquatic animals are predatory or scavengers. "The small floating or swimming plants and animals are the basis of the food supply of larger animals" (Sheeford '13). The bacteria present in the decaying matter of the pond are used as food by the flagellates and ciliates. The ciliates also used the flagellates for food. The Protozoa also obtain food from the algae, as do also the bacteria. In turn the Protozoa are used for food by the Entomostraca which also eat diatoms and algae. The Rotifers, Corixidae and Physa use the Protozoa as well as algae for food; the Corixidae use Oligochaete worms also. The Entomostraca form a basis of life for many of the other forms as; Microvelia, Young Renatra, Notonectidae, adults and nymphs, Mesovelia, Gyrinidae. The Corixidae furnish some food for Notonectidae and serve as a host for the water mites. Physa is used for food by the Gerridae and Belostomatidae.
Gyrinidae feed upon Notonectidae, especially the nympha stages, and upon insects which accidently fall into the water. The larvae feed upon body fluids of blood worms and upon Entomostraca. Ranatra has been noted as being a prey to Notonecta undiclata and to Laccopilus fasciatus of the Dytiscidae family. Ranatra is predacious and lives on nympha instars of different forms. It has been observed to attack Odonata naiads. The young of Ranatra live on small Crestaceans and midge larvae.

Gerres is predacious upon insects such as the midges. They attack the Notonectidae nymphs and prey upon any insect that may accidently fall into the water. "The chironomidae midge larvae are among the greatest producers of animal food. They are preyed upon extensively by all aquatic carnivores", (Hungerford 1919). Approximately eighty per cent of the animal forms present are animal feeders. Of the remaining twenty per cent, at least two forms are both plant and animal feeders, the snails and the Corixidae. The remainder are mostly plant feeders.

Thus a correlation between the abundance of forms and the food supply may be very clearly seen. As has already been noted, the Entomostraca were quite abundant during most of the year.
During some seasons they were confined more to the algae on the walls and fewer numbers were found in the open water. But their abundance furnished plenty of the main food supply of many of the other forms. There has been no dearth of algae and diatoms for the Entomotracæ to live upon hence they continue to exist and reproduce. The abundance of Entomotracæ also insures, other things being equal, a large number of many other forms as the Notonectidae, Ranatra, Gyrinidae.

The abundance of algae, diatoms and Protozoa also furnishes plenty of food for the Physa, corixidae and the midge larvae. The snails, as one may note by Plate VII, were only in the open pool on boards at two periods of the year. The rest of the time they were found in the algae of the walls. The corixidae were usually obtained by collecting algae from the walls. The midge larvae were found in their greatest abundance in the algae also.

The great abundance of these larvae also provide food for a large number of Odonata naidæs, Hydrophilidae Belastomatidae, Gyrinidae. While the adults of the Chironomidae were abundant, but as their main food supply (adult Chironomidae) migrated and the Physa left the boards for the algae beneath the H O, they disappeared also. The other forms present have plenty of their type of food, hence there is an equilibrium established in this pond.
Comparisons

As a general rule, ponds have gentle sloping banks, with a certain amount of vegetation growing near the water's edge. This pond is peculiar in the fact that it has a very high perpendicular bank, devoid of vegetation except algae. This brick wall, which is 18 inches thick and extends approximately 2 inches above the level of the ground, prevents the washing of very much sediment into the pool, also the growth of water plants, as Typha, near the water's edge. These facts make it very clear that we cannot have what is known as the terrigenous margin association. The forms in this association are usually the springtails, shore bugs saldidae, tiger beetles and ground beetles.

Grass grows within eighteen inches of the edge of the wall. A few locusts have been occasionally observed in this grass and were found on the surface of the water where they accidentally fell.

The type of bank will also prevent this pond from following the ecological succession of a young pond to forest or prairie conditions. "The first formation to take possession of a pond when it is first separated from a lake, is the bare bottom formation; chara soon makes its appearance in the deeper parts and we have the beginning of the chara association. The chara
so acts upon the bottom by covering it with humus and vegetation that it renders the continued existence of the bare bottom formation impossible. At the same time it prepares a way for the vegetation which reaches to and above the surface. This in turn fills the pond still further and the strictly marsh vegetation takes possession". (Shelford '13 Animal Communities in Temperate America). Following the marsh stage the dry pond is reached and prairie or forest conditions rapidly follow.

Altho this pond has no inlet and receives fresh water only from the rain and snow, the water does not become stagnant, which according to Muttkowski is a characteristic of ponds (Muttkowski 1918, Fauna of Lake Mendota). This is due no doubt to the fact that there is a great deal of coal tar in the bottom of the pool. This tar rises to the top of the water, at times forming a thin film of oil over the surface of the water, as bubbles of Co come to the surface, droplets of the oil will accompany it. This oil was much more prevalent during the season of high temperature. During the months of July and August, the water was often time completely covered with oil. Then as the temperature lowered, the oil disappeared and in the months of cold temperature following October, no oil was noticed. The presence of this oil did not seem to have any appreciable effect upon the animals, living in the pool. Mosquitoes were
not noted on the pond at all in the spring of 1925. Neither the larvae nor the pupae were seen except at one time in a tub of water which stood on one of the rafts. But no stage of the life history was ever observed in the pond. The absence of this form was attributed to the presence of the oil as the mosquito must have a water free from any surface film.

The change in level which is prevalent in many shallow ponds due to drying and the intensive growth of summer plants are factors which are not found in this pond. Due mainly to the artificial conditions.

The period at which the pond freezes over is later than that of ponds in this vicinity. This is again due to the high wall which protects the surface.

Although this pond which we are considering is of artificial origin and lacks many of the characteristics of an ordinary pond, yet a study of the fauna found shows that the forms characteristic of pond life are present in this artificial pond, except as has already been mentioned, the shore fore forms.

Needham and Lloyd ("16 Life of Inland Waters") divide the Pond insects into four categories according to the more habitual positions while taking air:

(1) Those that run or jump upon the surface, as the water-striders and their allies.

(2) Those that lie prone upon the surface as the whirl-i-gig beetles.
(3) Those that hang as if suspended at the surface with only that part of the body that has to do with intake of the air breaking through the surface film, as beetles and bugs.

(4) Those that rest down below, equipped with long respiratory tube for reaching up to the surface for air as Ranatra.

Hungerford (1919, Biology and Ecology of Aquatic and Semi-aquatic Hemiptera) enumerates the family of water bugs as:

(1) Those limited in large measure to moist shores adjacent to the water as Saldidae.

(2) Those living upon rafts of algae or other floating vegetation as Microvelia and Mesovelia.

(3) Those which row over open water as Gerridae.

(4) Those leading a sub-aquatic life as Ranatra, Belastomatidae, Notonectidae, and Corixidae.

The factors of level, temperature, light and food relations all agree with those of typical pond conditions and meet the needs of the organisms present in this artificially constructed pond.
Conclusions

(1) Although the pond studied is artificial and lacks many of the characteristics of an ordinary pond as: stagnancy of the water, changes in level of the water, low sloping bank, vegetation, yet the fauna characteristic of ponds is present.

(2) Seasonal changes take place in this artificial pond as in any other.

(3) The external factors influencing seasonal succession are: temperature, amount of water, amount and character of food, and physical conditions of the habitat, all meet the needs of the organisms present in the pond.

(4) The temperature is the factor which affects the activity of the animals and not the Oxygen content of the water.

(5) Ecological succession of a young pond to forest or prairie conditions can not take place in this artificial pond.

(6) The Axolotl, Ambystoma tigrinum, becomes sexually mature and reproduces in this pond, which is not an unusual circumstance.

(7) One year of observation is not sufficient to make a complete study of the seasonal changes within a pond.
### Bibliography

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Year(s)</th>
<th>Title</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allee, W. C.</td>
<td>'11</td>
<td>Seasonal Successions in Old Forest Ponds.</td>
<td>Trans. of the Ill. Academy of Science Vol. IV.</td>
</tr>
<tr>
<td>Birge, E. A.</td>
<td>'94-'95</td>
<td>Plankton Studies on Lake Mendota</td>
<td>Trans. of the Wisconsin Academy of Science Vol. X. and Vol. XI.</td>
</tr>
<tr>
<td>Birge, E. A.</td>
<td>'96-'97</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Survey Bulletin #XXII.</td>
</tr>
<tr>
<td>Clark, W. M.</td>
<td>'22</td>
<td>The Determination of Hydrogen Ions.</td>
<td>Baltimore—Williams &amp; Wilkins</td>
</tr>
<tr>
<td>Cowles, R. P.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Schwitacla, A. M.</td>
<td>'23</td>
<td>The Hydorgen-Ion Concentration of a Creek, its waterfalls, swamps and ponds.</td>
<td>Ecology Vol. IV, No. 4.</td>
</tr>
</tbody>
</table>
Comstock, J. H. '23

Introduction to Entomology
Comstock Publishing Company
Ithaca, N. Y.

Dodds, G. S.

Ecological Studies of Aquatic Insects as to size of respiratory Organs in relation to environmental conditions.
Ecology Vol. V. No. 3

Hisaw, Fred L. '24

Adaptation of Caddis fly Larvae to swift streams.
Ecology Vol. VI. No. 2.

Dodds, G. S.

Effects of Oxygen and Carbon Dioxide on the Development of the White Fish.
Ecology Vol. VI. No. 2.

Hisaw, Fred L. '25

'24

Effects of Oxygen and Carbon Dioxide on the Development of the Toad.
Bufo Americanus.
Ecology Vol. V. No. 3.

Hall, Ada R. '25

Hudson, C. T. '86

Gosse, P. H.

The Rotifera or Wheel Animal Cules
<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hungerford, H. B.</td>
<td>'19</td>
<td>Biology and Ecology of Aquatic and Semi-Aquatic Hemiptera.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Kansas University Science Bulletin Vol. XI.</td>
</tr>
<tr>
<td>Kofoid, C. A.</td>
<td></td>
<td>Methods and Apparatus in use in Plankton Investigations at Biological Station of University of Illinois.</td>
</tr>
<tr>
<td>Kennedy, C. H.</td>
<td>'17</td>
<td>Dragonflies of Kansas.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bulletin of the University of Kansas. Vol. XVIII.</td>
</tr>
<tr>
<td>Klugh, A. Brooker</td>
<td>'24</td>
<td>Factors Controlling the Biota of Tide Pools.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ecology Vol. V. No. 2.</td>
</tr>
<tr>
<td>Needham, J. G.</td>
<td>'16</td>
<td>Life of Inland Waters.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Comstock Publishing Company Ithaca, N. Y.</td>
</tr>
<tr>
<td>Lloyd, J. F.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reed, Fuilford</td>
<td></td>
<td>Correlation between Hydrogen-Ion concentration and Biota of Granite and Limestone pools.</td>
</tr>
<tr>
<td>Klugh, A. Brooker</td>
<td>'24</td>
<td>Ecology Vol. V. No. 3.</td>
</tr>
<tr>
<td>Scott, Will</td>
<td>'10</td>
<td>The Fauna of a Solution Pond</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Indiana Academy of Science.</td>
</tr>
<tr>
<td>Author</td>
<td>Year</td>
<td>Title</td>
</tr>
<tr>
<td>-------------------------</td>
<td>------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>Shelford, V. E.</td>
<td>'18</td>
<td>Physiological Problems in the Life Histories of Animals.</td>
</tr>
<tr>
<td>Loomis, Helen A.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ward</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Whipple</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
John Wiley and Sons, New York

Weese, A. O.  '24 Animal Ecology of an Illinois Elm-Maple Forest
Transactions of Illinois Academy of Science.
Plate III

Explanation of Plate

Apparatus used for quantitative work

A - - - - - - - - 10 foot measuring pole
B - - - - - - - - Platform
C - - - - - - - - Ringe
D - - - - - - - - Break
E - - - - - - - - Quart glass jar
F - - - - - - - - Spring
G - - - - - - - - Copper Band
H - - - - - - - - Wire

This apparatus could be lowered to any depth desired. The jar was opened by pulling on H. When H was released F would close the jar.
Plate IV

**Explanation of Plate**

This apparatus was used for securing water for making Oxygen tests.

A A' A" - - - - - - - - - - - - Glass tubes
B - - - - - - - - - - - - Rubber stoppers
C - - - - - - - - - - - - 250 c. c. sample bottle
C' - - - - - - - - - - - - Liter bottle
D - - - - - - - - - - - - Ring and clamp
E - - - - - - - - - - - - Wooden shoulder
F F' - - - - - - - - - - - - Rubber tubing
G - - - - - - - - - - - - Punch cock

Water passed in at A through C into C' by way of A', F and A". As water entered C' it forced air out through F'.F' extended above the water and also served as a means of knowing when C' was full. To fill C' C was filled four times, thus leaving a sample in C with only dissolved Oxygen. G was then closed and the sample brought to the surface.
Plate V

Explanation of Plate

Apparatus used for making survey of the bottom.

A, B, C, D - - - - - - - - -Iron rings for attaching rope
E - - - - - - - - -Groove for attachment of sack
F - - - - - - - - -Front end of apparatus
G - - - - - - - - -Back " " "

This apparatus was made of galvanized iron. A rope was fastened to A, B, C, D, and was used to drag the apparatus. A stout sack was secured on to an iron ring and fastened into a groove at E. Both ends F and G were open so that the water could pass directly through the enclosed sack.
Apparatus

Plate V

Scale 1" = 4"

Diagram of a geometric figure with labeled points A, B, C, D, E, and F. The figure includes lines connecting these points, with dashed lines indicating additional relationships between points. The scale is indicated as 1" = 4".
Number of forms present each month

Curves:
A. Larval forms included
B. Larval stages omitted

Scale 20° = 1 month
Dragon Flies

Scale 20 = 1 month

March 1925 April May June July August September October November December January 1926 February
Plate XI

[Graph showing the distribution of Ranatra over the months from March 1925 to February 1926. The peak is in July, and the lowest points are in December and January.]
Belastomatidae

Plot IX
Plate XIII

Gerridae

Number of Gerridae per month:

March 1925 - February 1926

Scale: 20 = 1 month
Dytiscidae
Gyrinidae

Plate XV

March 1925
April
May
June
July
August
September
October
November
December
January
February

Scale 200 = 1 month
Plate XVI.
Curves
a. Notonectidae
b. Snails-Physa
c. Gerridae
d. Gyrinidae
e. Dytiscidae
f. Damsel Flies
g. Belostomatidae
h. Dragon Flies
i. Ronatra
Maximum, Mean, and Minimum
Temperatures of Air for Month of March 1925

Plate XVII
Maximum, Mean, and Minimum
Temperatures of Air for Month of April 1925

Plate XVIII
Maximum, Mean, and Minimum
Temperatures of Air for month of June 1825
Maximum, Mean, and Minimum Temperatures of Air for Month of July 1925
Maximum, Mean, and Minimum
Temperatures of Air for Month of August
1925
Maximum, Mean, and Minimum Temperatures of Air for Month of October 1925

Plate XXIV
Maximum, Mean, and Minimum Temperatures of Air for Month of November 1925

Plate XXV
Maximum, Mean and Minimum
Temperatures of Air for Month of December
1925

Plate XXVI
Plate XXVII

Maximum, Mean, and Minimum
Temperatures of Air for month of January 1926
Maximum, Mean, and Minimum Temperatures of Air for Month of February 1926
Temperature Curves

Black: Air
Red: Water

Scale 20° = 1 month

March April May June July August September October November December January February
Plate XXX

Explanation of Plate

The squares represent the main plants and animals present in the pond. The arrows point from the organism eaten to those doing the eating.
Plate XXXI

Vertical Distribution of Animals
in large open cistern.

Diameter 61'

Scale 2" = 6 2/3'