ANIMAL COMMUNITIES IN THE ENVIRONS OF THE ISLAND OF MONTREAL

SOME OBSERVATIONS ON CERTAIN ANIMAL COMMUNITIES IN THE ENVIRONS OF THE ISLAND OF MONTREAL.

<u>THE ECOLOGY OF TWO FRESHWATER PONDS.</u>

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LIST OF CONTENTS

INTRODUCTION

This paper is a consideration of the animal communities found in two fresh-water ponds. It is an attempt to classify the members of the associations and to determine their relations to their environment and to one another. A comparison of the two ponds will also be made.

GENERAL

It was pointed out recently by Welch (1935) that the limnological knowledge of ponds is "very fragmentary". Lakes, rivers, and streams have been the subject of most of the fresh-water research in the past, partly because of their economic importance to the fishing industry, and partly because they present a greater diversity of problems. Much of the existing literature on ponds deals with fish ponds and reservoirs, which represent to some extent artificial conditions. A great deal of the data concerning these bodies of water, and also that concerning certain regions in a lake, is applicable to natural ponds. A pond, however, presents some problems not met with in lakes and rivers, such as partial or complete drying up in summer, or complete freezing in winter, with the consequent modifications in the life cycles of the inhabitants.

Ponds are of many kinds and origins. Their nature is determined by their temperature range, latitude and altitude;

their substratum, rock, sand or clay; degree and kind of vegetation; and chemical factors such as acidity, salt concentration, and oxygen supply. They present a wide variety of conditions and habitats, many of which are peculiar to themselves. Furthermore, the ultimate fate of all lakes is that they dwindle to ponds, due to their filling up by sedimentation and the invasion of plant life from the shores. Thus it is seen that a study of ponds is desirable, both from the point of view of understanding the particular conditions which they impose on the inhabitants and the ways in which these inhabitants are adapted to the conditions, and also to complete the picture of the animal succession in the slow change from lake to dry land.

HISTORY OF THE SUBJECT

An investigation of this nature belongs to the science of Limnology, the study of fresh waters. Limnology was founded by Forel between 1892 and 1904 (See Chapman, "Ecology" ch. XII). In America, Birge and Juday first pointed out the dynamic relations of the fauna to the environment. Quantitative methods of study such as used by Birge and Juday (1922) and Adamstone (1924) distinguished ecological work from natural history. These workers dealt chiefly with limnological conditions in lakes. Investigations confined solely to ponds are recorded as early as 1908 when Walker published a paper on the microfauna of an Oregon pond. Scott (1910) described the fauna of a solution pond in Indiana.

In 1911, Murray dealt with the annual history of a periodic pond near Glasgow, Scotland. V.E. Shelford, a general ecologist of note, has devoted considerable study to pond conditions and successions. In 1912 he published a paper on ecological succession in ponds, and a chapter of his famous work "The Animal Communities of Temperate North America" is devoted to the subject. His investigations covered a series of some 95 ponds which have been cut off from Lake Michigan as it has shrunk northwards. These ponds showed successive faunal age as they occur farther from the present shore of the lake. By careful comparison Shelford was able to work out the animal succession from youth to old age in this type of pond. Peterson (1926) did excellent work correlating physical factors with animal populations in a Chara-cattail pond.

Recent years have brought considerable literature on ponds, but much of it is of a purely chemical or physical nature, or deals with some single species of inhabitant and the effects of all the environmental factors on it. There is, however, a great need for investigation of animal communities as complete units. While the ecology of an individual species is of great importance we can gain a complete picture of the formation under consideration only by studying the association of that formation as a whole. I have found very few references in the literature to Canadian investigators. Mozley (1932) worked on a temporary pond in Manitoba. In this paper he gives the succession of animals noted in a temporary pond from its formation in early spring to its end by drying in the summer. He found the pond, in spite of the extreme cold in winter and dessication in summer, to be very heavily populated during the period of its short life. In 1936, he published a statistical analysis of pond molluscs in 315 ponds in Western Canada. Using a mathematical method he investigated the tendency for any two species to associate. Reed and Klugh (1924) published a comparison of the faunas of an acid and a basic pond situated near Kingston, Ontario. Klugh (1927) in a consideration of the ecology and food relations of the entomostraca lists the protozoa, protophyta and the entomostraca found in a large number of ponds in Ontario and New Brunswick. However, in this work he was not so much concerned with the ecology of the whole association as with that of a single group.

This lack of Canadian literature indicates that information on ponds in Canada would be a distinct contribution to limnological knowledge.

PHYSIOGRAPHICAL FEATURES OF THE PONDS

LOCATION

The ponds under consideration are located on the edge of some woods to the north of the municipalities of Montreal West and Cote St. Luc. Their positions are shown marked on the map, fig. 5, which is an enlarged copy of a section of the Lachine Sheet issued by the Canadian Topographical Survey. The ponds are situated in sight of the railway line to the west, and were located on the map by pacing off the distance from the switch crossing in the S.W. corner.

DESCRIPTION OF THE SURROUNDINGS

The woods in which the ponds occur are rather thin. The chief tree is the maple, but there are also a few elms and scattered birches. There is no growth of small bushes forming the underbrush which is so common in many woods. In the more open spaces the ground is covered with grass. In the shadier parts it is either bare or partly overgrown with moss. There is an abundance of dead leaves covering the ground, especially in the fall. The surface of the ground, though at a practically uniform level, is very irregular. Everywhere there are small depressions filled with debris of dead leaves and branches and these become temporary ponds and pools in spring and autumn. The two main ponds occur in two larger depressions where the trees have been cleared. Pond I. is just on the western edge of the woods and extends partly into a fenced field used for grazing. Its margins are grass covered and slope very gently to the water level. Pond II. is farther to the north in the centre of the woods. Trees grow close to its edge on all but the east side, where the ground is grass covered and very similar to that surrounding Pond I.

The uniform level of the ground causes a great difference in the size of the ponds during the spring and fall flood seasons. In flood times the lack of any steep enclosing banks permits the ponds to flow out over the surrounding grasslands and to coalesce with the many small temporary pools already mentioned. Thus in the spring and autumn the whole district is a patchwork of land and water.

Summer finds the ponds limited to relatively small permanent basins, which, though not of any great depth, are capable of holding some water throughout the year.

DESCRIPTION OF THE PONDS

The ponds may be classified as small, shallow, ecologically youthful, permanent ponds. They are, however, permanent only in the sense that there is water in their basins throughout the year. Considered from a biological point of view, they must be classified as non-permanent, since (as a rule) they freeze to the bottom in winter and therefore cease to provide a year round habitat for aquatic creatures. Chapman (1931) has proposed the name of "aestival ponds" for ponds such as these which freeze to the bottom in winter. The term tends to imply a rather more restricted period of availability as a habitat than is the actual case. The ponds under consideration normally provide an aquatic habitat from the middle of March to the middle of December, subject to variations either way in accordance with the severity of the winter.

The winter of 1936-1937, during which part of this study was made, was an abnormally mild one for this region and complete freezing of both ponds did not take place. Water was available under the ice in Pond I throughout the entire winter. Pond II, being the shallower, froze completely. This will be discussed more fully in the sections on physical conditions and adaptations to environment.

Pond I is the larger of the two and is roughly circular in shape. It has a maximum depth of about 30 ins. in the spring. The bottom is composed of from 6 to 12 ins. of soft ooze. During the spring and fall floods it overflows on all but the north side and covers much of the surrounding grassland. The pond is exposed to the wind on the west side. There is little aquatic vegetation. The higher plants are completely absent and the existing flora consists principally of Chara. There are a few species of filamentous Algae and a little Sphaghnum. In spite of the absence of the higher plants there is no lack of organic matter in the pond. This is supplied chiefly by the dead leaves of the surrounding trees, which fall into the water and decompose. Another factor contributing organic material to the pond is the dead grass of the pasture land which is flooded by the ponds. A large proportion of the bottom ooze is composed of this decaying organic material.

Pond II is less exposed. It is more regular in outline than Pond I. The maximum depth is about 20 ins., with 6 to 8 ins. of ooze at the bottom. On the east side there is a rubbish heap of scrap metal and tin cans which extends down into the water. As in Pond I the west end is the deeper. At the east end the slope is very gentle and the bottom grades slowly into grass covered pasture. Fig. 8 is a diagram of a cross section of the ponds taken from east to west. There is no Chara present in this pond. Some filamentous algae occur in the centre, some Sphagnum and water grasses at the east end. The water has a dark brown colour in the fall, due, probably, to the large amount of decaying leaves from the large trees surrounding it.

The ponds are separated by a ridge of material which is considerably coarser than that which immediately surrounds them. There is neither inlet nor outlet to either of the ponds. Hence they receive water only when there is sufficient precipitation to cause a run off of surface water from the surrounding woods and fields. Water is lost only through evaporation and seepage.

Figs. 6 and 7 show the details of the two ponds and their environs. Summer and winter sizes are shown. Vegetation is also marked. Figs. 1 and 3, and 2 and 4 are photographs showing winter and spring conditions in ponds I and II respectively. At both times the ponds were at flood size.

AGE AND FORMATION

The soil in this district is composed of glacial drift overlying the Trenton Limestone. In a description of local geology, Stansfield (1912) says; "The boulder clay covers nearly all the surface of the island. --- The upper surface of the boulder clay is very uneven. --- Details of this drainage system (the surface drainage of the island) were several small freshwater lakes, which have been drained --- almost within human memory."

This description of the recent drainage system of the island suggests that the ponds under consideration probably occupy depressions in the surface of the boulder clay. Such being the case the ponds would of necessity be old. However, a study of the flora and fauna tends to show that the ponds are relatively new. Shelford (1912), discussing ecological succession in ponds, states the principle; "-- the quantity of living material in the form of plankton, invertebrates, and vegetation increases as a pond grows ecologically older. -- The number of large invertebrates appears to be generally closely related to the amount of gross vegetation." Thus the presence of the larger water plants may be taken as a guide to the age of the ponds.

In the two ponds there is an almost complete absence of the higher plants. Shelford, in his studies of succession in ponds, showed that the first plant to establish itself in a newly formed pond is Chara. The Chara formation gives place to Myriophyllum, Potamogeton, and water lilies. Vegetation is completely lacking in the permanent basin of Pond II, while in Pond I the only plant found is Chara. This absence of the higher plants is indicative of the relatively recent formation of the ponds. Complications arise when one considers the age in relation to the fauna. Amphibia, leeches, and planorbid snails, which are all common in Pond I, were characteristic of old ponds studied by Shelford in the Forest Region. He points out, however, that prairie ponds are of a different nature in this respect. "The differences to be noted are that the snail Planorbis trivolvis, which usually occurs in old pond only, is found in the earliest pond of the prairie pond series." The evidence, to my mind tends to favour the recent formation of the ponds. The presence of a large quantity of decaying leaves in the ponds may permit them to support an ecologically more advanced fauna than they could if they had to rely on their own aquatic vegetation alone for food materials.

The action of solution has probably played an important part in the making of the ponds. The boulder clay contains a large percentage of limestone which is highly susceptible to the solvent action of CO_2 in water. The wells of the farms in this district contain very hard water which tends to show that dissolved CO_2 is an important factor in the erosion of the soil. A temporary pond could quite possibly enlarge its basin by the action of solution on the limestone content of the soil and in time become capable of holding water all year. I present this hypothesis as the most likely explanation of the formation of the ponds. The cutting down of the large trees in the immediate vicinity of the ponds has probably favoured this action.

METHODS

The early part of the study of these ponds was entirely taken up with identifying and becoming familiar with the forms found in them. No attempt was made at first to get quantitative results. Investigations were begun at the beginning of October 1936 and collections were made at intervals until the end of April 1937.

COLLECTIONS

Samples were taken at the surface both near the shore and in the centre of the ponds. In other collections the bottom was dragged with a dredge net which brought in samples of the submerged vegetation and the bottom ooze. The under sides of floating branches and sticks are often covered with attached forms, and these were carefully examined. The dead leaves covering the bottom near the shore were disturbed to drive out any animals that might be hiding under them and to make it possible to catch these in the net. These methods make it possible to obtain samples from every ~~possible~~ habitat from the free clear water at the surface to the soft mud at the bottom and thus obtain a complete picture of all the varying habitats in the ponds.

TEMPERATURE

Temperature was recorded with a mercury thermometer calibrated in 1° intervals from -10° to 100° C. This was considered sufficiently accurate as minor changes such as diurnal variations were neither noted nor considered. The temperature of the surface waters can be taken directly, but in obtaining the readings for the bottom or any intermediate depth precautions must be taken to prevent any change in the reading due to contact with the upper layers of water and the air as the thermometer is raised. The following method was found to be both simple and effective. A bottle is first lowered to the desired level and allowed to fill with water. The thermometer is then lowered into the bottle and after allowing a few minutes for the temperature to become steady, the whole apparatus is raised and the thermometer read without removing it from the bottle.

OXYGEN

O_2 determinations were made by the Winkler method. The samples for the determinations were collected in 250 c.c. bottles fitted with ground glass stoppers. At first the samples were taken by simply immersing the bottles in the water at the desired depth. However, it was found that a considerable error occurred due to bubbling at the mouth of the bottle. Pipetting the sample out was also found unsatisfactory. The method finally adopted is one described by Noland (1925). It consists of two tubes, an intake tube and an aspirating tube, which can be fitted to the sample bottle with a rubber stopper. One end of the intake tube is of glass and reaches to the bottom of the bottle. The other free end is a rubber tube of small diameter but of sufficient length to reach to the bottom of the ponds if desired. The aspirating tube reaches just inside the stopper. The whole system resembles a wash bottle with long rubber tubes. The intake tube is lowered to the required level and the bottle filled gently and without bubbling by suction on the other tube. This method was also used to obtain samples for pH determinations.

The reactions and titrations had to be done in the University laboratory. This necessitated bringing the samples a distance of some eight miles, most of which had to be walked. Altogether, about two hours usually elapsed between the collecting and analysis. The bottles were wrapped in towels to prevent as much as possible any great variation in temperature in the two hour interval. This, however, was found to be practically impossible in the winter months. On one trip the temperature was quite low; the samples froze (solid) and burst the bottles.

ACIDITY

pH determinations were made on the spot by the colorimetric method, using Brom-thymol blue and Phenol red as indicators. Where these two ranges overlap they were used as checks on each other.

EXAMINATION

All samples were examined while fresh for Protozoa. In each case fifteen to twenty slides of the sample were made. Some contained the bottom ooze, which was pipetted out of the jar. Large samples of the clear water were centrifuged to concentrate the animals and only the deposit examined. Dead leaves and plants were agitated to dislodge any attached forms. The surface scum was also investigated. All forms were examined alive., Methyl green and Neutral Red were used to bring out details of the internal structure.

Entomostraca were killed in 5% formalin and concentrated by straining the sample through a cloth of fine mesh.

Microdissections were made under a binocular microscope for the purpose of identification. The dissections were carried out in 50% glycerine.

The larger forms, including arthropods, snails and leeches were killed and preserved in 10% formalin and examined with a hand lens or binocular.

Microscopic examinations were made with a Spencer microscope and the drawings of the smaller forms with a Zeiss camera lucida attachment. A micrometer eyepiece, calibrated against a Zeiss standard millimeter slide, was used to measure the small forms.

Some species were kept alive in a small aquarium at the laboratory to observe their actions and habits.

PHYSICAL CONDITIONS

DEPTH AND VOLUME

Depth is one of the greatest variables in the pond environment and with it varies the volume of water available as a habitat. As has been mentioned already, both ponds lack steep banks and a slight increase in the volume of water present causes a large increase in the surface area. The lack of steep banks also precludes any great variation in depth. The net result of flooding in spring and autumn is that the surface/volume ratio becomes very high. Such a state is advantageous in providing a large area for gaseous exchange for a relatively small volume of water and thus the ponds are well aerated. However, it also permits a greater fluctuation in temperature because of the larger surface for the radiation and absorption of heat.

The following tables show the variations in the depths of the ponds in fall, winter and spring when definite measurements were made.

	Depth of	Nov.	Dec.	Jan.	Mar.	Apr.9	Apr.24
POND I.	Ice.	4″	18″	20″	24″	22″	0″
	Water	22″	8″	6″	4″	8″	25″
	Total	26″	26″	26″	28″	30″	25″
POND II.	Ice	4″	14″	20″	20″	14″	0″
	Water	11″	2″traces		0″	4″	14″
	Total	15″	16′	20″	20″	18″	14″

From the table on Pond II. it can be seen that the depth increased through the fall and early winter and reached a maximum at the end of January. In the first instance this was due to the rainfall and in the second to the alternate periods of snowfall and melting which occurred during this mild winter. In Pond I. the increased volume of water in the pond resulted chiefly in an increase in area, and it was not until the ice began to melt in the spring that the maximum depth of 30 inches was recorded. The decrease in depth of both ponds in the spring is due partly to the melting of the ice which occupies a greater volume than water and to the loss through seepage as the frozen ground melted. During the winter the greater part of the depth was due to the ice present.

The depth of free water in the ponds was quite a different matter and from the standpoint of the fauna the all important one. As the ice increased, the depth of the free water under it decreased, and in Pond II. was eliminated at the end of January. Thus in the middle of March, when the total depth was nearly at a maximum, the available water was at its lowest point. The free water increased at a bound with the thaw which in 1937 occurred during the third week in April in these ponds.

Little can be said about the conditions in summer, except from observations of previous years. The water level gradually decreases during the hot months and by August there is only about 15 inches of water in Pond I. and 6 to 8 inches in Pond II.

WATER MOVEMENTS.

Water movements are the circulatory system of ponds for it is through their agency that a thorough mixing of the surface and bottom waters occurs with the result that oxygen is carried down from the surface and the decomposition products are brought up from the bottom. A thorough mixing of the water tends to keep the acidity, salt content, oxygen and CO_2 practically uniform through the whole environment. Water movements are of two types - spring and fall turn over, due to temperature changes and daily movements due to wind action. Like lakes, all ponds are subject to the former factor while only those ponds which are sufficiently exposed are influenced by the wind.

The spring and fall turn overs are the result of a reversal in the thermal stratification of the water. In the fall, as the nights become sufficiently cold, the surface water is chilled to a temperature of $4^{o}C$. The density of water is greatest at this temperature and the surface water sinks, forcing the lower layers which are warmer and lighter to the surface. Thus the clear well oxygenated water is carried down to the bottom before the pond is sealed with ice. During the winter the temperature gradient is the reverse of that found in the other seasons. The coldest water occurs just under the ice and the warmest at the bottom. The spring turn over is due to the thawing of the ice and the warming of the surface water to $4^{o}C$, at which point it sinks through the lower layers which are colder and lighter. The spring turn over renews the oxygen supply of the bottom layers after it has been exhausted by decomposition and respiration. It also carries to the surface and releases there the products of decay.

During the open season wind action plays a more or less important part in mixing the water. The wind piles up the water to one side of the pond where its weight causes it to sink. In an exposed pond wind action finally develops a circulation of the water in a vertical plane. Pond I., which is well exposed on the west and south west, benefits in this way by the action of the wind. However, Pond II. is shut off on all sides by trees and the effect of the wind is relatively unimportant.

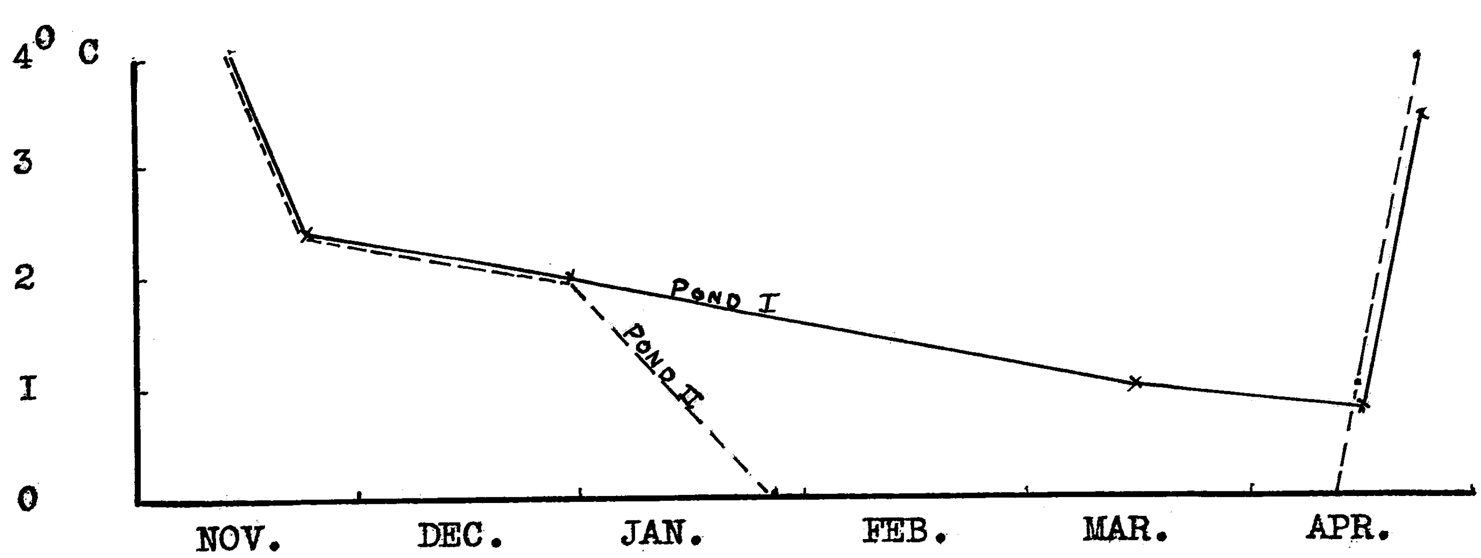
The difference in the exposure to wind action should be kept in mind in considering the differences in the acidity and oxygen content in the two ponds.

TEMPERATURE.

Due to the relatively small volume of water present and the large ratio of surface to volume the temperature of ponds tends to follow very closely that of the air. Murray (1911), working near Glasgow, Scotland, made a comparative study of the air and water temperatures of a pond for a period of one year. The two curves obtained were almost identical except that the curve for water temperature was smoother and lagged a few hours behind that for air temperature. In deep ponds there is of course a decrease in temperature with depth but this is relatively unimportant in the shallow ponds under consideration.

In the two ponds studied in this paper there is not sufficient depth to permit a thermal stratification of any importance. The water is well mixed and the temperature is practically the same at the bottom as at the surface.

In our latitudes the temperature of the water varies greatly from the temperature of the air during the winter. In mid-winter the temperature of the water under the ice is above the freezing point while the air temperature is usually well below 0°C. The following graph was drawn from a monthly record of the temperatures at the bottoms of the ponds.



BOTTOM TEMPERATURE NOV. TO APR.

With the approach of winter there is a rapid decline in the temperature of the water to the point when the formation of ice is possible. The temperature gradient is then reversed with the lowest temperature at the surface and the highest at the bottom. On Oct. 31 a thin layer of ice had formed around the edges of the ponds but this was not permanent. By Nov. 23 the permanent ice had formed on both ponds to a depth of 4 inches and it is at this point that the graph begins. The curve obtained for Pond II. represents most nearly the typical conditions for aestival ponds in this latitude, while that for Pond I. is modified by the fact that the pond was larger and in the abnormal winter of 1936-37 did not freeze completely.

At the time of the formation of the permanent ice there was a rapid fall in the temperature of the bottom layers of water to 2.5° C. In Pond II. the temperature continued to decrease until, by Jan. 30, the whole pond was frozen. The temperature of Pond I. fell gradually to 1°C at which point it remained constant from about the end of January until the end of March. Peterson (1926) found a similar effect in a pond in Illinois and Scott (1911) the same for a pond in Indiana. In both cases the bottom temperature fell to 1°C and remained there for the duration of the winter.

In April, with the advent of the thaw, there was a slight drop in the temperature of Pond I. to 0.8°C followed by an abrupt rise as the ice disappeared. The temperature of the water then approached that of the air.

The differences in behavior of the two ponds in regard to temperature is due to the difference in their depths and to the mild character of the winter which prevented the formation of ice to a depth greater than two feet.

ACIDITY.

One of the most striking differences between the physical environments of the two ponds is that in acidity. In spite of the fact that there were fluctuations in the pH, Pond I. remained at all times more alkaline than Pond II. The difference amounted only to about pH .5 to pH .8. For instance, in October, Pond I. was on the alkaline side of neutrality with a pH of 7.5 while PondII. was acid, pH 6.7. This small difference of pH .8 means that Pond II. was 8 times as acid as Pond I. since the pH figures are indices of the hydrogen ion concentration. On April 9th, after the water had been sealed in all winter by the ice, the bottom layers of both ponds were quite acid, Pond I. pH 6.6 and Pond II. pH 6.0. The figures represent the greatest fluctuations noted in the acidity of the ponds.

The pH of ponds in general shows great variation both annually and daily, and the variation in this particular case cannot be said to be very great. As has been mentioned before, the ponds are situated in a limestone region and consequently contain high percentages of carbonates in solution. According to Shelford (1925) "Carbonates give the water its buffer value --- a water with much buffer will neutralize the CO_2 from the decomposition of many organizms, and still remain alkaline, while a water with little buffer will become acid under the influence of a smaller content of living or dead organisms and decaying material from the land."

Assuming that the two ponds contain the same percentage of buffer substances in solution, the difference in pH can be explained by the fact that Pond II. contains more organic material in the form of dead leaves. The decomposition of this larger amount of organic debris exhausts the buffer salts to a greater extent, and therefore the water is more acid. Wind action may also be an important factor in keeping Pond I. alkaline by circulating the water and bringing the decomposition products to the surface.

Relatively small fluctuation in acidity in the ponds can be explained by the presence of a large quantity of the buffering carbonates.

In mid winter when the water is sealed in by a thick layer of ice, there can be no escape of CO_2 at the surface and the buffering salts become exceeded by the accumulating organic acids, so that when spring arrives the waters are definitely acid. During the spring the acidity of the waters gradually decreases.

OXYGEN.

In general the oxygen content of the ponds was high. In all comparisons made, Pond I. showed a higher O_2 content than did Pond II. The inability of getting samples to the laboratory in mid-winter makes it impossible to state the exact conditions in the ponds during that season. However, the samples taken in the late fall and early spring give indications of the probable state of oxygenation during the winter months.

On Nov. 23rd. when the ponds were covered by 4 inches of ice, the highest degree of oxygenation was noted. Pond I. had 33.4cc. of O_2 per litre at the bottom, and Pond II. 12.6cc. per litre. The saturation volume at the temperature of the water (2.5°C) is about 13.6cc. per litre. Therefore, in Pond I. the water contained two and a half times the saturation volume at that temperature. This can only be explained by the fact that the sample was taken in the Chara zone and that the photosynthesis of that plant gave out large amounts of oxygen which was prevented from escaping by the covering of ice.

That conditions of excess oxygen are by no means rare in lakes is attested to by the reports of various authors summarized by Welch (1935). Saturations as great as 364.5% have been reported from lakes. He refers to the work of Matheson and Hinman (1931) who found that in ponds containing Chara fragilis certain mosquito larvae are excluded because of the presence of O_2 bubbles in excessive amounts. Peterson (1926) reports that in the pond he studied, the highest percentage of O_2 found was just after the freeze over. His investigations showed a steady decrease in O_2 during the winter to 2cc. per litre in March. Then, with the coming of the spring thaw, he noted a sudden increase in oxygen.

On April 2, when the ponds were still frozen, the oxygen content was high, 12.68 and 4.78 cc. per litre in Ponds I. and II. respectively. Since Pond II. had been frozen completely this oxygen content must represent that which was dissolved in the water as the ice melted. In Pond I., however, where the water was present during the entire winter, this may represent the last stage in a slow decrease under the ice cover, or possibly an increase from a lower figure due to oxygenation of the melting ice.

On April 16th the margins of the ponds were free of ice but the centres were still frozen. A great decrease in the oxygen content of both ponds was noted. The readings were 2.24 and 2.15 cc. per litre for Ponds I. and II. respectively. This sudden fall is in contrast to the sharp rise found by other workers. It is probably due to the fact that the debris at the edges of the pond when thawed out and warmed began to decompose. This action rapidly exhausts the oxygen supply of the limited volume of water present. When all the ice had vanished from the ponds, the oxygen content once again rose to nearly saturation.

<u>For Attention of Examiner:</u>

The examiner is respectfully advised that owing to misinterpretation of instructions the typist of this thesis has unfortunately used a capital letter at the beginning of specific names in the lower case throughout the "Annotated List of Species " (pp. 28-68). The generic names should be allowed to stand, the first letter of the specific names should be placed in the lower case. The necessity for this correction is realised, but changes in the body of the thesis could not be made owing to the late date at which this error was found.

The examiner is humbly requested to accept the present note in lieu of actual correction.

James R Adams
May 8, 1937

ANNOTATED LIST OF SPECIES

This list contains all the species found in both the ponds during the survey. The classification down as far as orders is that given by Borradaile etc. in "The Invertebrata". Further subdivisions are those used by various authors in keys to the particular groups. The various sources of this information are given in the bibliography at the end of the paper. Notes on the groups in general and for each particular species include information as to habitat, abundance, distribution in time and observations as to habits, etc.

PHYLUM PROTOZOA

The protozoa are one of the most important groups in the pond associations. They form a large proportion of the plankton and the benthic fauna. Together with the Algae they are the chief basic food in the ponds. In this relationship they replace the diatoms which are the basic food in lakes. Protozoa occur at the surface, at the bottom and through the intermediate depths. Some are sessile and attached chiefly to plants; others are highly motile and feed on the smaller forms and bacteria. A third group, chiefly flagellates containing chlorophyll show passive vertical migrations which are correlated with photosynthesis. The chief groups found in this investigation were the Phytomastigina and the Ciliata. Protozoa in general tended to disappear from the ponds by January, when the ice covering had been present for a long time and the temperature was low. The volume of water was greatly diminished and the acidity was high. Some species were eliminated earlier and a few flourished through the whole winter.

CLASS SARCODINA

This class was represented chiefly by the testate amoebae which were found in abundance at or near the bottom. The following species were definitely identified.

Order AMOEBINA

Family Amoebidae

AMOEBA PROTEUS Pallas, Plate I, figure 1:

A. Proteus was represented in both ponds by a few individuals of small size. It favours the bottom near the shore where it creeps over the dead leaves. Individuals were found in both ponds till the end of October. None were noted after that time. Size 154 μ

AMOEBA RADIOSA Ehrenberg: Only a single specimen of this species was noted. It was collected with the debris of leaves near the shore of Pond I. on April 16th. On this date the pond was still frozen except for a narrow zone along the edge.

A. Radiosa has a spherical central portion with more or less fixed, radiating arms. It was quite small, measuring about 100 μ.

Sub Order TESTACEA

Family Arcellidae

ARCELLA VULGARIS Ehrenberg, Plate I, figures 3 and 7: This was a common species in both ponds up until the end of October. In general the shell is semi-transparent and rather thick, the thickness being equal to about half the diameter. Individuals varied in size, colour and shell pattern. Two distinct races are shown in figures 3 and 7 on Plate I. The smaller type was brown in colour and distinctly pitted. The height of the shell was about three fourths the diameter. The larger race (figure 3) varied in colour from light brown to grey. The grey individuals showed faint, somewhat hexagonal markings on the test. Sizes 76 to 114 μ.

ARCELLA DISCOIDES Ehrenberg: This species has a depth of about one quarter the diameter. It was rare, only a few individuals being found in both ponds. It is similar in habits and time range to A. Vulgaris.

Family Difflugiidae

CENTROPYXIS ACULEATA Stein, Plate I, figure 9: A few individuals were collected from the bottom of both ponds. They were commoner in Pond I than in Pond II. The species is characterized by an eccentric aperture and spines at the opposite end. There was considerable variation in size and in the number of spines on the shell. Size 100 to 180 µ. None were found after October 31st.

DIFFLUGIA OBLONGA Ehrenberg, Plate I, figures 6 and 12: This was the commonest of the Testacea in Pond I. Although it disappeared from this pond by November, I secured a specimen from Pond II. in January. This was the only record of the species for that pond. The test is pyriform with a terminal aperture. Length 80 to 160 µ. It is composed of sand grains. Plate I, figure 6 shows a single individual which was tentatively referred to this species. The test was composed entirely of small spherical green algae. It was shown recently by MacKinley (1936) that a closely related form, Nebela Collaris Leidy, will build its test of algae, fungus, or other plant remains in the absence of shell plates in its food. Since this specimen was taken in clear water away from the bottom it is quite possible that in the absence of sand grains the test was built of small algae.

DIFFLUGIA ACUMINATA Ehrenberg, Plate I, figure 2: D. Acuminata has the posterior end tapered to a blunt point. It was the commonest of the Testacea in Pond II but was rare in Pond I. Specimens were found till the end of January in the bottom mud. Length 160 µ.

DIFFLUGIA URCEOLATA Carter: This species has a large globular test with a broad lip, and a distinct spire. A few individuals were found in the autumn in both ponds. Length about 200 μ.

DIFFLUGIA CORONA Wallich: D. Corona occurred in only one collection from Pond II. in October. It has a circle of teeth at the aperature and spines on the fundus.

Order HELIOZOA

Sub Order Aphrothoraca

ACTINOPHRYS SOL Ehrenberg, Plate I, figure 4: This was the only heliozoan found and it was extremely rare. A single specimen occurred in the open water of Pond II. in November. It measured 41 μ across the body. There was a large central nucleus and the cytoplasm was highly vacuolated. The axopodia (apparently) radiate from the surface.

CLASS MASTIGOPHORA

A large proportion of the plankton of both ponds consists of various species of Euglena and Phacus. These inhabit the open water and are found chiefly at the surface. Here they are well exposed to the sun's rays and photosynthesis can be carried on. The colourless zoomastigina were found more generally distributed throughout the ponds. They occurred in greater numbers at the bottom than at the surface. Owing to their small size and transparency, identification of the zoomastigina is difficult. Very few were identified specifically. They were amongst the few forms which were capable of remaining active in the depth of the winter.

Mastigophora in general are considered as forming an important basic food for the larger ciliates, rotifers, entomostraca and insect larvae.

SUB CLASS PHYTOMASTIGINA

Order EUGLENOIDINA

Family Euglenidae

EUGLENA VIRIDIS Ehrenberg. Plate I, figure II:
This species is spindle shaped with a rounded anterior end and a pointed posterior end. It measured about 65 μ. It was the most common species of phyto flagellate found, and occurred in both ponds. It disappeared from Pond II by November but I obtained specimens from under the ice in Pond I till the end of January.

EUGLENA OXYURIS Schmarda: The largest of the flagellates found was E Oxyuris. It measured up to 200 μ. It is spirally twisted. On each side of the nucleus is a conspicuous oval body. The posterior end is sharply pointed. It was taken during the fall from Pond I. I found it most often near the surface but some specimens were also found amongst the Chara. By March 11th it had reappeared in this pond where the holes had been cut in the ice and open water was available.

EUGLENA DESES Ehrenberg: This species was small and elongated and rather blunt at both ends. Length 120 μ. Only a few individuals were found in a single collection from Pond I. at the end of October.

EUGLENA SPIROGYRA Ehrenberg: E. Spirogyra is intermediate in size between E. Viridis and E. Oxyuris. It is marked with beaded spirals. It was rare and found only in Pond I. None were taken after October 13th.

LEPOCINCLIS OVUM Ehrenberg: Common amongst the Euglena and Phacus in the surface waters was an oval form of small size. There was a stigma present at the base of the flagellum. It averaged about 35 μ. long. It was recorded only in the early fall in Pond I. Several individuals of L. Ovum and of Phacus Pleuronectes were seen to be defaecated by a Naid worm. While they showed no activity, the passage through the gut of the worm had not altered the shape nor affected the green coloration. It is possible that the cuticle of these forms is resistant to the digestive action in the worm's gut.

PHACUS PLEURONECTES Ehrenberg: After Euglena Viridis this species was the most common in the ponds. It is similar in shape and size to P. Triqueter Pl. I. fig. 10, but lacks the oblique striation. It was taken at the surface of both ponds until the end of November. Its occurrence in the faeces of a worm has been mentioned in the preceding note.

PHACUS TRIQUETER Ehrenberg, Plate I, figure 10: Oval, with a curved spike at the posterior end. It is marked by somewhat oblique striations. Size 40 μ. This species was noted in only one collection from Pond I. in October. However, it was very common at that time..

PHACUS LONGICAUDUS Dujardin: This was the largest species of Phacus. It is rather flat and the posterior end is drawn out into a long twisted spine. Length about 100 μ. Although this species was found in both ponds over a considerable period of time it did not occur in any great abundance. None were found after the end of October.

PHACUS PYURM Ehrenberg, Plate I, figure 5: This species is rather elongated and possesses a straight caudal spine. The surface is marked with oblique striations. A collection from Pond II. at the end of November contained the only specimens of this species which were found.

Order VOLVOCINA

VOLVOX SP.: In the spring of 1936 the shallow water near the margins of Pond I. abounded with Volvox. However, no specific identification was made at that time and in the spring of 1937 none of this species had made an appearance by April 24th. On April 9th, 1936 Volvox was by far the most abundant of the smaller forms in the shallow water. Although it was not present in sufficient numbers to cause a "bloom" on the pond, a jar of water containing them had a definite green tinge. Besides being so common in the large pond, every little pool left by melting snow was teeming with them.

SUB CLASS ZOOMASTIGINA

OIKOMONAS TERMO (Ehrenberg): This was the only species of this group which was definitely identified. They are all very small and colourless and extremely difficult to key down. O. Termo occurred throughout the whole period of investigation in samples taken from the bottom. In the middle of winter, when little else was to be found, O. Termo was present in abundance.

CLASS CILIOPHORA

Sub Class CILIATA

The Ciliata provide the greatest array of species of any single group in the ponds. They are characteristic of the bottom and Chara zones in Pond I but some species occur at the surface and in the intermediate zones also. Most species are holozoic feeders, some saprozoic and a few contain symbiatic green algae. Both free swimming and attached forms were found. The sessile forms occur chiefly in the Chara zone and in the shallows near the shore, where there is an abundance of twigs and leaves for attachment. The free swimming forms are more universal in habitat. Pond I. showed a greater variety of species than Pond II. Some species were found in both ponds but others appeared in only one or the other. In general the Ciliata tended to disappear shortly after the formation of the ice cover.

The Ciliata are important in the food cycles of the ponds. They are eaten by ratifers, insect nymphs and small crustacea.

Order HOLOTRICHA

Sub Order GYMNOSTOMATA

Family Holophryidae

COLEPS HIRTUS (Müller) C. Hirtus was a common species in collections from Pond I. until the end of January. It was found only once in Pond II. at the end of October. It is carnivorous and attacks Paramecium, etc. Individuals averaged 50 µ. There are twenty longitudinal rows of platelets and three posterior spines. It was found at all levels in the Ponds. Its distribution in time and space probably depends upon the availability of other species for food.

LACRYMARIA OLOR Müller: This species has a delicate contractile proboscis with a tuft of longer cilia at the end. The body is flask shaped and measured about 350 µ when extended. It was rather rare and found only during November and December in collections from the bottom of the Pond I.

DIDINIUM NASUTUM (Müller): The body is barrel shaped with a cone at the anterior end. There are only two bands of cilia. It appeared in only one collection from Pond I. on October 31st. and was rare in this collection. It feeds on other ciliates, especially Paramecium. Size 150 µ.

Family Tracheliidae

DILEPTUS ANSER Müller: D. Anser has an elongated body with a proboscis. The nucleus is moniliform. The cytostome is situated at the base of the proboscis. Like Didinium it was a rare species in the ponds. Only a few individuals were taken amongst the Chara of Pond I. at the end of October.

LIONOTUS FASCIOLA Ehrenberg: This species is somewhat similar in shape to Dileptus but possesses a stouter body. There are two spherical nuclei. It was large, measuring about 250 µ. Although found in only one collection from Pond I. in October it was numerous at that time. It occurred at the bottom in the Chara zone.

Family Chilodontidae

CHILODON CUCULLULUS Müller: C. Cucullulus was rather large, 200 µ. It is flattened at the anterior end and has a hump at the posterior end. There is a pharyngeal basket and a single oval nucleus. It was found only in Pond I. and occurred throughout the fall and winter. None were found after the end of January. It favours the Chara zone and was a rare species in all bottom collections.

NASSULA AUREA Ehrenberg: This is a large oval species with a spherical nucleus and a pharyngeal basket. It was a rare species in the ponds and was found only in October in Pond I. Size 200 µ.

Sub Order TRICHOSTOMINA

Family Urocentridae

UROCENTRUM TURBO Müller: Plate I, figure 8: This is a very rapidly moving species. It swims in a spinning fashion. It was common in the open water of Pond I. until the end of January. Length about 100 µ.

Family Ophryoglenidae

COLPIDIUM STRIATUM Stokes, Plate II, figure 2: This is a small oval species with a triangular cytostome in the anterior third of the body. Size about 50 μ It was extremely common in collections from the bottom of Pond I. till the end of January. It ingests bacteria and decomposed organic matter. Being small it forms an important food for rotifers or other larger Ciliates.,

COLPODA CUCULLUS Müller: C. Cucullus is similar in shape but stouter and larger than Colpidium. The Cytostome is nearer the middle of the body. It was rarer than Colpidium and occurred only in Pond II. in the early fall. Size 90 μ.

Family Paramecidae

PARAMECIUM (Paramoecium) BURSARIA (Ehrenberg), Plate II, figure 1: P. Bursaria is characterised by the presence of spherical green zoochlorellae in the cytoplasm. Individuals found averaged about 125 μ. in length., I found it only in Pond I. It was rather rare during the fall but by January 30th when the ice was quite thick it became the most common of the ciliates. Its ability to flourish when other species were practically eliminated is probably due to the presence of the chlorophyll-bearing symbionts. It inhabits the open water near the surface. None were found after the end of January.

PARAMECIUM CAUDATUM Ehrenberg. Plate II, figure 3: This species was one of the most abundant in both ponds in the fall. It vanished from Pond II. by the end of November but was present in Pond I. until the end of January. In one collection two races were observed, averaging 100 and 200 μ in length respectively. Conjugation was taking place between individuals of the small race but not in the larger. P. Caudatum is a very tolerant species and was noted in all the various microhabitats in the ponds. This species was especially common amongst the Chara of Pond I.

Order HETEROTRICHA

Family Plagiotomidae

BLEPHARISMA LATERITIA Ehrenberg: One of the few coloured Ciliates found in the ponds was B. Lateritia. It has a delicate rose colour said to be due to the presence of zoopurpurin. The anterior end is sickle shaped and pointed. There is a single spherical nucleus. Only one collection from Pond II. at the end of October contained this species. It was found in the trash of dead leaves at the bottom. Size 100μ.

SPIROSTOMUM AMBIGUUM Ehrenberg, Plate II, figure 7: S. Ambiguum was very common in Pond I. during the fall. All individuals were large, some well over 2 m.m. Its chief habitat was the Chara zone. I observed this species only once in Pond II.

at the end of October, although it was present in Pond I. till the end of November in large numbers.

METOPUS SIGMOIDES Claparède and Lackmann, Plate II, figure 4: This species was common in both ponds till the end of January. It is spirally twisted. The anterior end is rounded. There is a spherical macronucleus at the centre and a contractile vacuale at the posterior end. It is figured in the contracted state in which it was most often found. The expanded form was found only in Pond II. It is an active swimmer and was taken at both the surface and the bottom.

Family Stentoridae

CLIMACOSTOMUM VIRENS Ehrenberg, Plate II, figure 5: C. Virens is a large ciliate with a pale blue-green colour. The posterior end is rounded and the anterior end oblique. The macronucleus is band shaped. It was found only in Pond II during the month of October and favours the lower layers of the water. It was a rare species. Size 250 μ.

STENTOR POLYMORPHUS Müller: Although capable of swimming the Stentors are usually found attached. S. Polymorphus is trumpet shaped. There is a moniliform macronucleus. When extended it measures up to 1.25 m.m. This species was found in both ponds. It was the commonest Stentor in the fall but as winter progressed it gave way to S. Coeruleus in Pond I. None were found after the end of January.

STENTOR COERULEUS Ehrenberg, Plate II, figures 8 and 9: This species is similar in shape to S. Polymorphus but is larger and of a blue colour. Individuals measuring 2 m.m. were found. I observed it in material from Pond I. only. It was the most common Stentor in the collection of January 30th after which it disappeared..

STENTOR PYRIFORMIS Johnson: This species was rare. It is smaller and stouter than S. Polymorphus None were observed after the end of January. Spherical globules of brown and green were common in this species. Length about 500 μ. when extended.

Order HYPOTRICHA

Family Oxytrichidae

STYLONYCHIA MYTILUS (Müller): While capable of swimming this species was most often observed walking by means of its ventril cirri on debris from the bottom. It was present in both ponds, in Pond I. till the end of January, in Pond II. till the end of October. Size about 200 μ. This species is wider at the anterior end. There are 8 frontal, 5 ventral and 5 anal cirri.

Order PERITRICHA

Family Vorticellidae

VORTICELLA CAMPANULA Ehrenberg, Plate II, figure 6: This species is large and distinctly bell-shaped. The nucleus is a twisted band. It was very common attached to the dead leaves and plant growths. It occurred in Pond II. till the end of October and in Pond I. till the end of January. Length up to 150 μ.

VORTICELLA ALBA Fromental: V. Alba is small, about 50 μ long, and more delicate than V. Campanula. It was found only in Pond I. It was rare in all collections and disappeared by the end of November. However, it reappeared on April 16th on debris taken near the shore.

ZOOTHAMNIUM ARBUSCULA Ehrenberg: This species is a colonial form similar to V. Campanula. The contractile fibre is continuous through the whole stalk so that all individuals of the colony contract together. It was found only in Pond I. in November. The colony was about 6 m.m. tall.

CLASS SUCTORIA

In an old stagnant infusion which contained only material from Pond I. there appeared large numbers of an unidentified species of the Class Suctoria. It is oval in outline with tentacles radiating from both ends (Plate I, figure 13). The body is surrounded by an irregular structureless pellicle. There was no stalk or any other form of attachment visible in any of the specimens. The nucleus is bar shaped and there appear to be four contractile vacuoles. It shows similarities to the genus Sphaerophrya in some characters and to Tricho-phrya in others.

PHYLUM ROTIFERA

Not many species of rotifers were present. They live chiefly amongst the dead leaves and debris on the bottom but some are found in the open water. Their food consists of diatoms, desmids and protozoa, and they are preyed on by aquatic insect larvae.

CLASS MONOGONONTA

Order NOTOMMATIDA

Family Synchaetidae

SYNCHAETA STYLATA Wierzejski: S. Stylata was one of the first forms found in the spring. It is a good swimmer and favours the open water. The corona is the broadest part of the body and bears four long spines. The foot is present but much reduced. It was found in Pond I. on March 11th. It was rare.

Family Coluridae

METOPIDIA EHRENBERGII Perty. This species possesses a flattened lorica which is drawn out into a pair of lateral and posterior spines. The front end is conical. It was recorded in only one collection from Pond I. at the end of October.

Family Brachionidae

NOTEUS QUADRICORNIS Ehrenberg, Plate IV, figure 6.
The lorica of this species is very characteristic. It is flat and elongated anteriorly and posteriorly. The foot is unringed. This species was very common in Pond I. throughout the fall. It is a good swimmer and lives both at the bottom and in the open water.

CLASS DIGONONTA

Order BDELLOIDA

Family Philodinidae

PHILODINA ROSEOLA Ehrenberg, Plate IV, figure7:
This species was the commonest rotifer in both ponds. It was most often observed in collections of leaves and debris from the bottom where it creeps in a leech-like fashion. It is also able to swim , using the corona which consists of two disks raised on stalks. The eyes are situated in the neck above the jaws. None were observed after the end of December.

GASTROTRICHA Although this group is relatively small and unimportant it was well represented in the ponds. These small creatures were very common in the bottom ooze and Chara zones They resemble the ciliate protozoa very closely in their habits. They showed extreme hardiness and were one of the few groups present throughout the winter.

<u>CHAETONOTUS ACANTHOMORPHUS</u> Stokes.

This is a small species measuring about 100 μ. The head and neck are covered with short spines and the abdomen bears four transverse rows of five larger spines. It was common in the bottom ooze and the Chara. It remained active through the whole winter in Pond I. and was present in Pond II. as long as any free water remained.

<u>LEPIDODERMA RHOMBOIDES</u> Stokes.

Only one specimen of this species was found. It occurred during October in Pond I. It is larger than <u>C. Acanthomorphus</u> measuring about 300 μ. The body is covered by rhombic, pointed scales.

PHYLUM PLATYHELMINTHES

This group is represented in the ponds chiefly by the free living Turbellaria. Several small forms were noted during the autumn in collections from the bottoms of the ponds. No specific identifications were made. They disappeared early and none were present during the winter months.

The parasitic flatworms were represented by a single Echinostome Cercaria (Plate III, figure 3) found swimming in the open water of Pond I. on October 13th. Death occurred before an exact identification was made. However, sufficient detail was observed to verify that it belongs to the Echinata group of Sewell. It measured 628 u long by 187 μ wide. The body was full of cystogenous cells which obscured much of the detail. The acetabulum occupied the third quarter of the body and was 75 μ in diameter. The tail was about equal in length to the body and unbranched. The gut was small and had two caeca branching around the acetabulum. Salivary glands were composed of two parts indistinct in life, the inner was between the oesophagus and the main excretory tubule, the outer between the main excretary tubule and the anterior collecting tubule. There was a long anterior collecting tubule and a very short posterior collecting tubule. The bladder was partly divided into two parts by a transverse partition. Rudiments of the genital system could be seen under the acetabulum. Twelve spines were counted on the oral sucker. Angle spines were present and four were counted.

PHYLUM NEMATODA

The mud from the bottoms of both ponds contained Nematode worms. They were present in the fall and reappeared in the spring. They were relatively rare and none were identified.

PHYLUM ANNELIDA

The Annelida found in the ponds were chiefly leeches but several species of oligochaetes also occur. The oligochaetes are mostly microscopic species living at the bottom or in open water. The larger oligochaetes were found only in the bottom mud. They feed on Algae and small fragments of organic material. Very little oxygen is required by these bottom dwellers. They have the same value as their relatives the earth worms in cleaning up the bottom of the pond and turning over the upper layer of ooze.

The leeches are also more or less bottom dwellers but they prefer regions where there are hiding places, such as under leaves, sticks or stones. Some species are able to swim about in the open water by an undulating motion of the body. They were most often observed in this state in the spring of 1936. Others are capable only of creeping about on the dead leaves, stones, mud or plants. Their chief food in this locality is probably the snails and insect larvae which abound. The blood sucking forms may get an occasional meal from the drinking cows or the Amphibia.

CLASS CHAETOPODA

Order OLIGOCHAETA

Family Naididae

STYLARIA FOSSULARIS Leidy. These are microscopic worms with a characteristic elongated proboscis. The absence of "shoulders" flanking this structure serves to identify S. Fossularis. This species was found in the open water of both ponds until the end of October.

Family Aeolosomatidae

AEOLOSOMA TENEBRARUM Vejdovsky. A. Tenebrarum is also a microscopic worm with well developed setae. It is characterized by the presence of green and yellow bodies throughout. In the faeces of this worm there were found several individuals of Lepocinclis ovum and Phacus pleuronectes which have already been mentioned in the notes on these species. Several individuals were found in the collection from Pond I. on October 31st. but not in any other.

Family Naididae

DERO LIMOSA Leidy. Plate III, figure 1. As depicted in the figure, D. Limosa has several finger like processes at the posterior end. Individuals measured about 3.5 m m. Only a few were found in Pond I, in January. Specimens noted were from the bottom ooze.

Family Tubificidae

LIMNODRILUS sp. Specific identification of these larger worms is extremely difficult so that very little can be said as to the exact form present. The average length of worms found was about 4 cm. On March 12 very large numbers of these worms were present in the mud at the bottom of Pond I. It was the dominant species at this time. A pint jar one quarter full of mud contained 14 individuals. The setae are all alike and have two forks at the end.

CLASS HIRUDINEA

Order RHYNCHOBDELLAE

Family Glossiphonidae

GLOSSIPHONIA COMPLANATA (Linnaeus), Plate III, figure 6: This species measured about 1 cm. in length. It is easily recognized by the pair of lines on the dorsal and ventral surfaces. One specimen was dredged up from the mud at the bottom of Pond I. on March 12. It was hibernating at that time. On April 24th the species was again quite active and several were found.

GLOSSIPHONIA STAGNALIS (Linnaeus):

Several individuals of this species were caught on April 24th 1937. They measured about half an inch long. They were dead white in colour with a small brown spot, the nuchal plate, near the anterior end. The specimens were dislodged from a clump of submerged grass in Pond I.

Order GNATHOBDELLAE

Family Hirudinidae

MACROBDELLA DECORA (Say) Plate III figure 2: M. Decora the American medicinal leech is characteristically coloured and marked. It was found only in Pond I. In the spring of 1936 the pond was crowded with this species. They were very active, swimming about in the open water near the shore and foraging amongst the leaves on the bottom. On October 31, 1936 a single specimen was taken in a dredge sample of the bottom mud, where it had burrowed for the winter. This leech is by far the most common one in the Pond. Its regular food is the snails and insect larvae which are very common. However, it may also obtain an occasional meal of blood from the cows which drink there. The species renewed its activity by April 24, 1937. The specimens caught on this date showed swollen genital apertures indicating that breeding was in progress.

HAEMOPIS MARMORATUS (Say) A large dark gray leech which was very common in Pond I. in the spring of 1936 proved on dissection to be H. Marmoratus. The chief distinguishing character is the vesicula seminalis which is reflexed, the shorter arm being the length of the larger. Like Macrobdella this leech is a good swimmer and was similar in its activities at the time observed.

Family Erpobdellidae

ERPOBDELLA (Herpobdella) PUNCTATA, (Leidy) Moore:

E. Punctata is easily recognized by its general body shape, colour, etc. Specimens found measured from 2 to 3 inches in length. At the end of October a single specimen was dredged up out of the mud in Pond I. It was a dark brown in colour.

Specimens were caught in both ponds on April 24th. They were quite active and like the individuals of M. Decora were in the breeding condition.

PHYLUM MOLLUSCA

CLASS GASTEROPODA

The snails form the dominant group in the ponds in respect to numbers. In the fall, after the period of stagnation, the surface of the water and the edges of the pond are thick with empty shells of dead snails. The actual number of species present was small but the number of individuals was large. In spring they are very active and I observed them creeping about on the dead leaves at the bottom, clinging to any plant growths or floating twigs and branches or hanging suspended from the surface film. Snails feed on the diatoms, desmids and algae of the ponds. In spite of their size and shell they are eaten by many creatures, especially leeches to insect larvae

Order PULMONATA

Family Lymnaeidae

LYMNAEA PALUSTRIS (Müller), Plate III, figure 8: In L. Palustris the opening is shorter than the length of the spire, the columella somewhat twisted and the shell shows spirally impressed lines. In the spring of 1936 it was common in Pond I. creeping about on the dead leaves and Chara, and on floating branches. None were obtained from Pond II.

Family Planorbidae

Sub Family Planorbinae

PLANORBIS (PIEROSOMA) TRIVOLVIS Say, Plate III, figures 4 and 5: This species was the dominant form of both ponds. Very large numbers of individuals occurred during the entire open season, and in the winter hibernating individuals were obtained in every mud sample. They varied in size from ½ to 1 inch in diameter. P. Trivolvis is probably the chief food of predacious insect larvae, leeches and wading birds. The large number of empty shells at the end of the summer points to a high "death rate" for this species. However, it is still able to maintain its numerical dominance among the larger animals.

PLANORBIS PARVUS Say, Plate III, figures 9 and 10: P. Parvus has a small delicate shell about an eighth of an inch in diameter. The shell is marked with fine striae. The aperture is oval and broader than high. None of these animals were found alive but the bottom mud in the Chara zone of Pond I. abounded with their shells in the winter.

Family Physidae

PHYSA HETEROSTRAPHA Say. Plate III, figure 7. The shell in the genus Physa is sinistral, the spire short but pointed. In the species P. Heterostrapha the aperture is about ¾ the length of the shell and nearly oval in shape. The shell is pale yellow with black markings. Only a few of these snails occur in Pond I. They are similar in habits to Planorbis.

CLASS LAMELLIBRANCHIATA In the ooze at the bottom of Pond I. there are many empty shells of small lamellibranchs. None of these were identified specifically. They appear, however, to belong to the genus Sphaerium, Scopoli. On January 30 samples from Pond II. showed two very young forms about 2 mm in length. They were quite active and moved about feeding in company with some Ostracods. No identification was possible on these immature forms. The group is relatively unimportant in the two ponds studied.

PHYLUM ARTHROPODA

Representatives from the three chief groups of Arthropods were found in the Ponds.

SUB PHYLUM CRUSTACEA

The smaller forms of the Crustacea were found in great abundance in both ponds. They make up a large proportion of the plankton and serve as food for the larger animals. Every region in the ponds forms a habitat for some species. Certain species are confined to open water, some to the bottom, while others show no preference as to habitat. They were the first group to make an appearance in any great numbers in the spring and they continued through the summer and fall. Some were able to survive the rigorous conditions under the ice in the middle of winter. They illustrate very well the phenomenon of succession. This point will be dealt with in a later section.

Some species require little oxygen and survive under stagnation conditions. They feed on small algae and organic debris. It is said that certain species are able to utilize salts in solution.

CLASS BRANCHIOPODA

Order CLADOCERA

Cladocera are extremely numerous in the spring and persist through the summer and fall in decreasing numbers. None were found during the winter. Of the several forms present in the spring of 1936 only one was identified specifically.

Sub Order CALYPTOMERA

Family Daphnidae

DAPHNIA PULEX (de Geer), Plate IV, figure 2:
This is a large form, specimens of which measured about 2.57 mm. The antennules are greatly reduced. There are 12 - 17 anal spines and the claws are pectinate. Specimens taken on April 6th 1936 showed a green colour through the body wall, probably due to the food. D. Pulex was, with Volvox, the most abundant of the small forms present that year. In the spring of 1937 none of the Cladocera had appeared by April 24th.

Order ANOSTRACA

Family Chirocephalidae

EUBRANCHIPUS sp. Early in the spring of 1936 there were large numbers of fairy shrimps in the temporary pools and around the shores of the larger ponds. In 1937 Eubranchipus did not appear till May 1st. On this date it was especially common in Pond II. but large numbers also occurred in Pond I.

CLASS OSTRACODA

Tribe Podocopa

Ostracods were found throughout the different levels of the ponds during the whole year. Like the Cladocera they begin to multiply very early in the spring and are present in large numbers. Certain species of bottom forms were found in the severest winter conditions.

Family Cyprididae

Sub Family Cypridopsinae

CYPRIDOPSIS VIDUA O.F. Müller, Plate V, figures 5 and 6: This species is plump and marked by 3 dorsal and lateral dark bands. The furca also is diagnostic. Specimens measured .54 mm. on the average. C. Vidua was present in both ponds under the thick ice till the end of December. It was very active and seemed unaffected by the low temperature (2°C) of the water on that date. None were taken later. It is said to be the most common ostracod of North America.

Sub Family Cyclocypridinae

CYPRIA EXSCULPTA Fischer, Plate V, figures 1 and 3: C. Exsculpta is easily recognized by its brown colour and the network of parallel anastimosing lines on the valves. The average size was .66 mm. It was found only in Pond II. Before the total freezing of this pond I obtained numerous specimens of this species in the bottom layers of water. It had reappeared by April 16th after water had been available for about three weeks. By April 24th it was very common and second only to Candona rectieauda in numbers.

Sub Family Candoninae

CANDONA RECTICAUDA Sharpe, Plate V, figures 2 and 4: This was the largest ostracod in the two ponds. The average length was 1.19 mm. The furca of this species has a sinus near the base. The spines of the furca are gently curved. The second leg is six segmented. A large number of individuals of this species occurred in Pond II. on Dec. 29 when there was only a little water under the ice. Both sexes were present in the proportion of 13 females to 3 males. C. Recticauda reappeared in April as soon as there was enough water present to live in. Large numbers were again caught. In these two collections it was the most numerous of the bottom dwellers. It declined in numbers in Pond II. during the following two weeks of April. In Pond I. I first noted specimens in the collection of April 16. Very few were present in this pond.

C. Recticauda is strictly a bottom form and in the laboratory aquarium was always seen to be walking about on the mud and dead leaves or climbing a short distance up the stem of a Chara plant.

CLASS COPEPODA

Several species of Copepods were found in abundance in the ponds. They are chiefly plankton but since the ponds are shallow they also occurred at the bottom. They feed chiefly on unicellulor plants and animals and constitute a large proportion of the food for higher forms. Some were found in the middle of winter in very severe conditions.

Order EUCOPEPODA

Sub Order GNATHOSTOMATA

Family Cyclopidae

CYCLOPS BICUSPIDATUS Claus, Plate IV, figures 3 and 4:
The figures illustrate the diagnostic features for this species. The fifth foot (fig. 4) bears a single spine on the basal segment and two spines on the second segment. The furca has a spine at about the mid-point (fig. 3) and a small depression armed with minute spines near the base. The antenna has seventeen segments. It is interesting to note that the variety occurring in these ponds is that which is described for lakes. The furca is much larger than that of the variety described as typical of ponds. C. Bicuspidatus first appeared in early spring, April 9th. A large number were present in Pond II. but only a few in Pond I. For two weeks it remained the dominant copepod in Pond II. but gave place to C. Serrulatus on April 24th. It was rare in Pond I. on all occasions.

CYCLOPS SERRULATUS Fischer, Plate IV, figure 1:

The antenna of this species is composed of twelve segments. The outer edges of the furca bear combs of small spines. At the end of December when there was very little water present this species was found in great abundance in Pond II. It was the only copepod found on this date. In the spring it was present in both ponds. In Pond I. it was the dominant copepod from April 9th to the end of the study. In Pond II. it was rare at first but by April 24th it became the most numerous species.

CYCLOPS VIRIDIS Jurine.

This species resembles C. Bicuspidatus very closely except that the second segment of the fifth leg bears one very large spine and one very short one. The furca lacks the small pit seen in the other species. C. Viridis was found only in Pond I. during the spring. At no time was it numerous. About one individual in every twenty capepods examined at this time was C.Viridis. Like C. Bicuspidatus the variety present is that described as limnetic.

CYCLOPS FIMBRIATUS Fischer:

This is the only Cyclops known which has the antenna composed of eight segments so that recognition is easy. Several individuals of this species were taken from both ponds during fall.

Family Harpacticidae

CANTHOCAMPTUS STAPHYLINOIDES Pearse, Plate IV, figure 5: The anal plate of this species bears small stout spines less than five in number. It was found during the spring in Pond II. It was a rare species.

NAUPLIUS LARVAE

In the spring large numbers of Nauplius larvae occurred in both ponds. These represent the young stages of Entomostraca of all types.

CLASS MALACOSTRACA

Sub Class PERACARDIA

Order AMPHIPODA

GAMMARUS LIMNAEUS Smith, Plate IV, figure 7: This species was the only representative of the higher crustacea found in the study. The flagellum or the first antenna had three segments. It was found only in Pond I and made its appearance on April 16th. It is a rare species in these ponds.

SUB PHYLUM INSECTA

CLASS PTERYGOTA

Order ODONATA

The dragon and damsel flies were well represented in both ponds. The nymphs were found in the fall and again in the spring.

They pass the cold season by burrowing in the mud. The nymphs of both the damsel flies and dragon flies were very plentiful in the submerged clumps of grass, dead leaves and Chara. They are predaceous and feed on the immature forms of other insects and on small crustacea. Identification was possible only as far as the genus.

Sub Order ANISOPTERA

Family Aeschininae

ANAX sp.

This species has a rather long body, about an inch long. There are lateral spines on the 7th to 9th abdominal segments. The labium is small and flat. This species was found only in Pond II. and was rare there. It was dislodged from a submerged clump of grass near the shore. It first appeared on April 27th.

Family Libellulidae

LIBELLULA sp. Plate VI, figure 3: This species is shorter and stouter than the foregoing. The labium is spoon shaped and covers the face up to the eyes. The setae on the lateral lobe of the labium numbered 10. Libellula nymphs were abundant on the bottoms of both ponds. They were common during the fall and early winter under the ice but disappeared in mid-winter. In the spring they returned in very large numbers.

Sub Order ZYGOPTERA

ISCHNURA sp. This was the only species of damsel fly nymph present in the ponds. There were four mental setae and six lateral setae on the labium. The gills were tapered to a blunt point. The greatest length was 13 mm. This form was the commonest of the Odonata nymphs in the spring. Large numbers occurred especially around the shores of both ponds where they crawl around on the submerged grasses and dead leaves. It is the dominant insect in both ponds.

ORDER EPHEMEROPTERA

A few specimens of this order were taken from the mud of Pond I. during the fall, but were not identified. None were found in the spring, although collections were made till the 24th of April. The May Flies in this pond were mud burrowers and occurred chiefly in the Chara zone.

Plate VI, figure 5.

SUB CLASS ENDOPTERYGOTA

Order TRICHOPTERA

Owing to the late date at which the material was taken and the difficulty in identification none of the caddis worms were identified specifically. There were three distinct types of cases found in the various spring collections. All were composed of organic material. The largest of the species had a case measuring three inches long. It was composed of successive circlets of short pieces of grass stems so that the general effect was that of segmentation. The veins of the grass leaves run parallel to the length of the case. Both ends of the case were open, the anterior end being larger than the posterior. This type was found only in Pond I. on April 24th and was rare.

The second and commonest type was a very furry tube from a half to one inch in length. It was composed of very small grass fragments laid perpendicular to the axis of the tube in a log cabin fashion. It was by far the commonest of the three types and occurred in both ponds, at the surface and on the bottom near the shore.

The third species, Plate VI, figure 6, was quite small, never exceeding half an inch in length. The case was formed of a variety of materials, including chiefly grass and leaf fragments, but no sand. In spite of the irregularity of the materials used and the lack of a definite orientation to the axis, the case was quite smooth. This species occurred in both ponds. It is present only on the bottom among the dead leaves.

No larvae of the Caddis flies were found in the fall or winter, nor did they appear till late in the spring, April 24th. After that date they were very common.

Order COLEOPTERA

Both adults and immature stages of this order were found in the ponds. The larvae are very difficult to identify and most keys only go as far as the family. Pond I. supported a larger fauna of water beetles than Pond II. Most species are predaceous. Adults were identified by key and checked with specimens in the Lyman Entomological collection.

Family Dytiscidae

DYTISCUS FASCIVENTRIS Say

This is a large species, slightly over an inch in length. None were taken alive. The only specimens were found frozen in the ice during the latter part of the winter. It would appear that a period of warm weather brought them out of hibernation and that they became frozen by an abrupt return of cold conditions. Specimens were found only in Pond I.

DYTISCUS HYBRIDUS Aube, is very similar to the preceding species but was distinguished on the basis of its ventral markings. Like D. Fasciventris this species was found dead in the ice of Pond I.

COLYMBETES SULPTILUS Harrison, Plate VI, figure 2:

C. Sulptilus is about three quarters of an inch long. There are yellow markings extending part way down the outer edges of the elytra. This species was numerous in the fall in Pond I. and some few were found frozen in the ice with Dytiscus. None appeared in the spring.

ACILIUS FRATERNUS Harrison:

This beetle is about half an inch long. The sulci on the elytra extend only about half the length. The back is golden brown anteriorly and black posteriorly. There is a lighter transverse bar near the posterior end. The species first appeared on April 24th in Pond I. It was quite numerous, swimming about on the surface and diving to the bottom. All the members of this family are predaceous and live on May Fly nymphs, etc.

Family Gyrinidae

GYRINUS sp. A large number of small black beetles of an unknown species appeared in both ponds on April 16th. They were found chiefly near the edges of the ponds. They swim very quickly and with many changes in direction.

In addition to these adults, dead larvae belonging to this family were found in the ice in the winter. Plate VI, figure 4, shows one which was found in both ponds. It was about two inches long. Each leg had two claws and there were also two pairs of claws at the end of the abdomen. Each abdominal segment was produced into a long thread-like process or gill on each side. A smaller larvae having similar general characteristics, but with a shorter and stouter body, was taken from Pond II. in the spring. Identification is difficult beyond the family.

Order DIPTERA

Sub Order Orthorrapha

Family Tipulidae

HOLORUSIA sp.: In the spring, Pond II contained a large number of worm-like larvae about three quarters to one inch long. The spiracular plate was surrounded by six lobes bearing long hairs. This characteristic serves to identify the form as belonging to the genus Holorusia. These larvae were found chiefly in submerged clumps of grass near the shore. They were very numerous from April 16 on. None occurred in Pond I.

Family Culicidae

CULEX sp. Plate VI, figure 7: The mosquitos were represented in both ponds only by Culex larvae. A few were found in the autumn and these probably winter as larvae. A larger number appeared in the spring. This is due to the hatching of the eggs which were laid in the fall and which remained dormant through the winter.

Family Chironomidae

CHIRONOMUS sp. Plate VI, figure 1: Chironomus larvae were plentiful on the bottom mud of both ponds. They were present during the fall and early winter and were one of the first forms to make an appearance in the spring.

PHYLUM VERTEBRATA

CLASS AMPHIBIA

The vertebrate fauna of the ponds consists of frogs and salamanders. They are present only in the spring when the water is used for a spawning ground and a home for the young.

Order URODELA

Family Pleurodelidae

TRITURUS VIRIDESCENS Rafinesque: One of the outstanding characters of the ponds in spring is the presence of the spotted salamander T. Viridescens. This species spends most of its adult life on land under logs, stumps and leaves but must breed in the water and lay its eggs there. On May 1 these little creatures were very numerous, creeping about on the bottom. Clusters of eggs were found attached to branches and twigs in the water. Some of the adults were reddish and some olive green, but both showed the characteristic red spots ringed with black.

Order ANURA

In the spring the east end of Pond II. is the breeding place of frogs. They were just beginning to appear on May 1st. 1937 but none were caught. The species, therefore, is unknown. Clusters of eggs were found in the shallow water among clumps of grass. The adults do not live in the ponds. Only in breeding season do they visit them and lay their eggs there.

CLASS AVES

There are occasional bird visitors to the ponds. These can be seen wading in the shallow water and picking up food from the bottom. Sand pipers are the chief visitors.

ECOLOGY OF THE PONDS

Within the confines of a pond there live a large number of animals of taxonomically diverse types, which because of the similarity of habitat may be considered as a single faunal group. Ecologists have given this group the name of Formation. Within the Pond Formation, however, we may distinguish several different animal communities, chiefly on the basis of their distribution and food relations. Therefore, a short discussion of these factors will be used to introduce the subject of Associations.

SPATIAL DISTRIBUTION

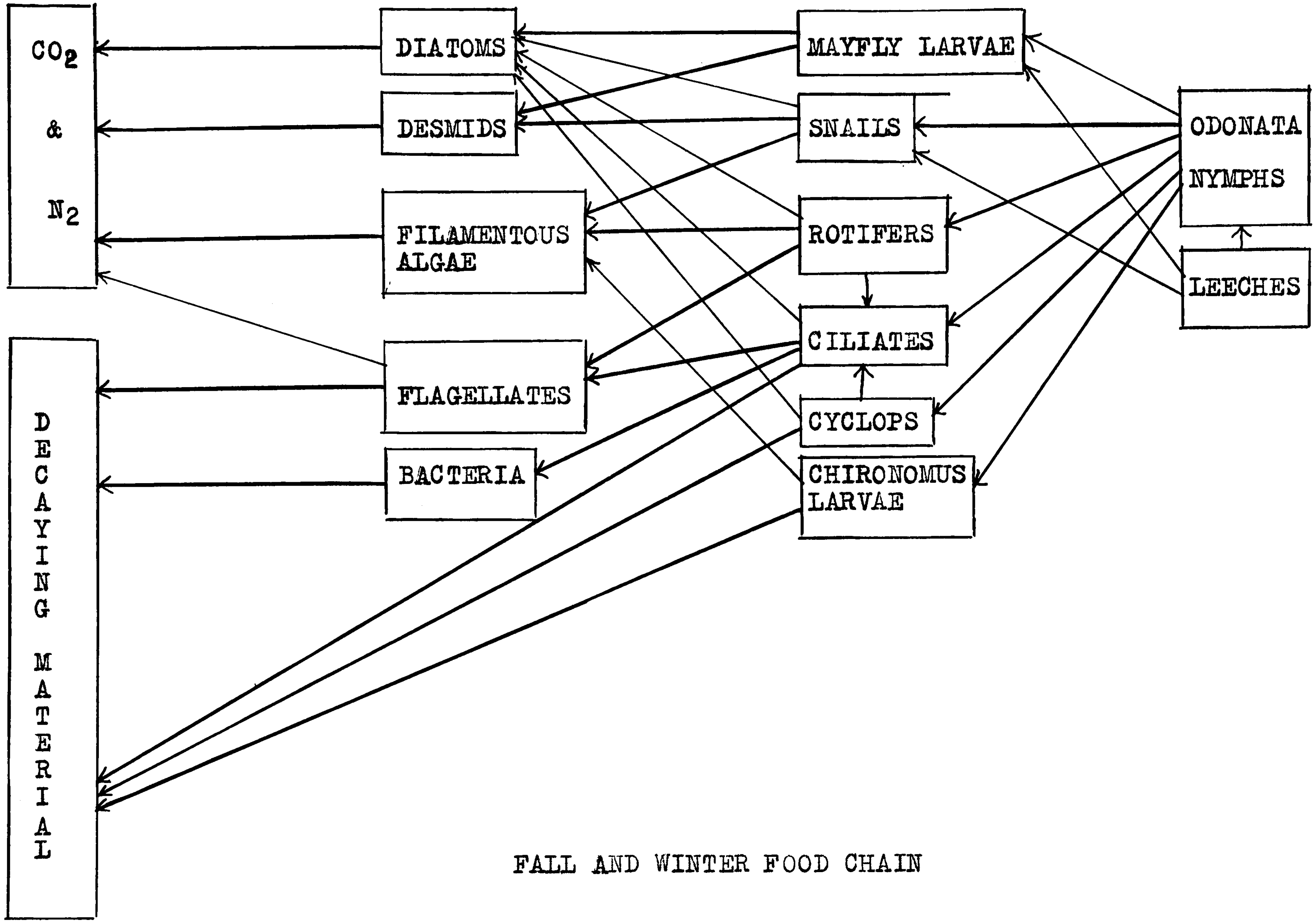
The particular habitat which an organism occupies is decided largely by the adaptations of that organism to physical factors, and by its food and enemies. In the ponds under consideration I have distinguished the following habitats: surface and open water, mud bottom, Chara zone and shoreline. To the animals in each of these habitats the name "Association" will be given. There is some difficulty in making a sharp distinction in habitat for some species which occur, for instance, both at the bottom and the surface, or at the middle and the shore. Furthermore, the close interrelation of all the animals in the ponds in their food cycles indicates that the whole fauna might well be treated as a single association.

FOOD RELATIONS

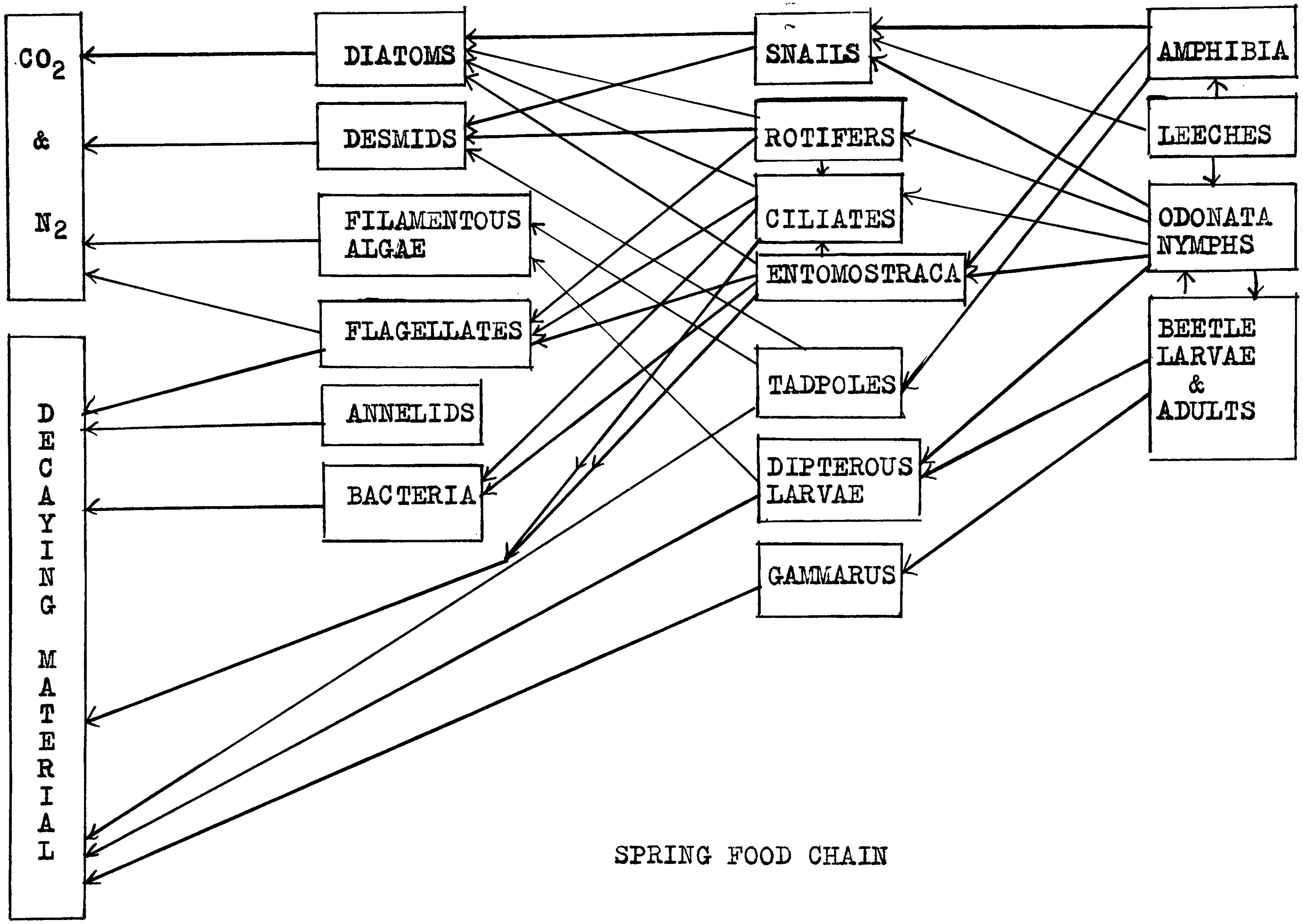
The complicated relations of the various species in their feeding habits is best shown by diagrams such as follow on the next two pages. The first of these represents the food cycle existing in the two ponds in the fall and early winter, the second shows the relation during the spring. The arrows in all cases point to the form eaten.

The first column contains the inorganic and dead organic foods which are the basis of the whole chain. This food is supplied to a large extent by the dead leaves of the surrounding trees. Decomposition of these leaves supplies simple organic products and various salts which are dissolved in the water with the gases.

The second column contains the holophytic feeders which live on the gases and salts dissolved in the water, and the saprozoic feeders which live on decaying organic material. The fate of nearly all the other animals in the ponds rests on the productivity of this group, In it are included the plants and chlorophyll bearing animals which feed by photosynthesis, and the bacteria and some Protozoa which feed on simple organic compounds. The important forms in these ponds are the bacteria, ciliates and flagellates. The diatoms, desmids and filamentous algae play a minor role. The Chara is siliceous and cannot be eaten.



FALL AND WINTER FOOD CHAIN



SPRING FOOD CHAIN

It is interesting to note that this important group is greatly reduced in winter by the impossibility of carrying on photosynthesis under the ice. In the spring the return of these species to their former numbers once more permits the support of a large fauna of higher forms.

The animals of the third group are chiefly holozoic in their feeding habits and their food is largely plant or plant-like forms. Some species are also able to utilize decomposed organic material e.g. Ciliates, Cyclops and Chironomus larvae.

The fourth column contains the predators. These animals attack live prey, chiefly the animals of the third group. They will also attack smaller species of carnivores Nearly all of them are large in size. Among the invertebrates this group contains the Odonata nymphs, beetle larvae and adults, and the leeches. All the vertebrates of the ponds belong in this class.

It will be noted that there is an increase in the size of the animals as one progresses from left to right on the table. There is also a corresponding decrease in the number of individuals correlated with increase in size. It is only logical that there are more plant feeders than predators and more plants and basic animal foods than the forms that feed on them.

ASSOCIATIONS

The Surface and Open Water Association is the largest association in the ponds. This community occupies by far the greatest proportion of the pond formation. Animals of this association invade the Bottom, Chara and Shore Associations and there is an interplay in the food relations of the various groups. Many of the larger animals of this community are very active and forage in the other regions as well as their own.

Characteristic of this formation are the plankton organisms. The diatoms, desmids, phytoflagellates and filamentous algae are found chiefly in this habitat. Feeding on them are the macroplankton organisms including the various copepods, cladocerans and ostracods in addition to rotifers and some ciliates which are intermediate in size and activity. The adult beetles are also members of this association although they obtain a large part of their food in the Chara, bottom and shore communities. The fairy shrimps and mosquito larvae are important in this group in the spring.

It is noteworthy that the major part of the basic food organisms occur in this association. They are more or less passive. Activity increases with size and type of nutrition. A great deal of the productivity of the ponds rests on the success or failure of these forms and they in turn are influenced by the volume of water and by gases and salts in solution.

The Bottom Association is next in importance in regard to productivity of basic food. In this community the saprozoic forms are dominant among the lower animals. Decaying organic material at the bottom provides food for bacteria, ciliates, Zoomastigina, Sarcodina, rotifers and some worms. A number of dipterous larvae, especially Chironomus, derive their chief sustenance from this source. Another source of food in this association is the "rain" of Algae and flagellates which descends from the overlying waters.

The bottom association contains a high percentage of the larger pond animals. Foraging among the dead leaves are the leeches, snails, salamanders and large predacious beetle larvae. Some of these, such as the snails, must go to the surface to breathe.

The bare mud bottom is the home of most of the aquatic oligochaetes which perform a useful service in cleaning up the end products of decay and turning over the mud in much the same fashion as do their terrestrial relatives. The "blood worm", Chironomus, which is a dipteran larva also favours this zone. In Pond II. the ostracod, Candona recticauda, was present in sufficient numbers to make it important in this association. Ciliate protozoa make up a large part of the population of smaller forms.

The part of the bottom covered with dead leaves has a slightly different fauna from the bare bottom. The leaves provide a lurking or hiding place for the larger forms. Here I found the snails, leeches, salamanders, caddis worms, beetle and Odonata larvae. This group of animals invades the shoreline association, which makes it difficult to state their exact habitat.

Perhaps the Chara Association should not be considered as distinct, but rather as a modified bottom habitat. The difference is that the Chara supplies support for climbing forms and a solid substratum for attached forms. The sessile protozoa, e.g. Vorticella and Stentor, were found chiefly in this Association. This is also the chief home of the Amphipod Gammarus limnaeus. Various insect nymphs and adults climb about on and beneath the Chara. The plants come close to the surface and make an excellent foraging ground for the aquatic beetles of the surface association. The smaller snails find it an ideal habitat. In general the Chara association resembles the bottom association.

The Shoreline Association is the meeting place of the bottom and surface association and there is a mixing of the two faunas. The margins of the ponds are carpeted with dead leaves and clumps of grass and later in the year are dry land. Many of the Entomostraca were found chiefly in the small, shallow baylets around the margins of the ponds. The Whirligig Beetle, Gyrinus, skims about on the surface near the shore. These are representatives of the Surface Association. At the bottom, in the dead leaves, the leeches and snails hold sway. The most numerous group in this association is the larvae of the Odonata. The nymphs of the Dragonflies and Damselflies were most abundant in the shallows where they lurk among the dead leaves and grass clumps. In Pond II. the Tipulid larvae are important members of this community. The shallow east end of Pond II. is the home of the frogs. Caddis worms are very prominent members of the shore community.

It should be borne in mind that the shoreline in spring is a much larger habitat than during the summer, and that it is the first place to be rendered untenable by ice formation in the winter. Thus it partakes of the nature of a temporary habitat. During the summer the spots which maintained such a large fauna in spring became grass carpeted pasture. The fauna recedes into the centre of the pond as it shrinks.

DOMINANCE

Planorbis trivolvis is the predominant species in both ponds. It stands out as the most numerous, constant, and conspicuous species in the whole fauna. It enters into all the various associations of the ponds but occurs in the greatest numbers in the bottom and shoreline communities.

Dominance in the various associations may vary with the time of year. Thus in the late spring Eubranchipus, the fairy shrimp, was the dominant species in the open water of both ponds. However, its life is short and it disappears entirely during the rest of the year. Similarly the nymphs of the Dragonflies and Damselflies are dominant in the shore association in the early part of the year but are greatly reduced in numbers later by metamorphasis and the emigration of the adults from the ponds. In early April the ostracod Candona recticauda dominated Pond II. but, as the ice vanished and larger forms which had been hibernating appeared, it was forced into a very minor position.

Euglena viridis is dominant among the smaller organisms living in the open water. The dytiscid beetles are dominant among the larger forms in this association.

The ability of a species to attain dominance depends to a large extent upon the availability of food. Thus in early spring the organisms existing on dead organic matter and those manufacturing their food by photosynthesis are the dominant forms. As they increase in numbers they provide a basis for the increase of the larger forms which feed on them. These in turn take over the dominant position. It may be taken from them by some predacious enemy or they may have sufficient numbers and high enough reproductive capacity to enable them to maintain their position. This is, I believe, the case of the snail Planorbis trivolvis in the ponds.

In the winter there is a great reduction in the numbers of individuals and species. The first to retire are those at the end of the food chain. This once more permits the saprozoic and holophytic feeders to regain dominance, in a greatly reduced population.

EFFECTS OF PHYSICAL FACTORS

Numerous workers have made studies of ponds to determine the effects of physical factors on the distribution and succession of the various species. After a thorough study of the variation in the fauna and in the pH, oxygen supply, temperature and water level, Peterson (1926) reached the conclusion that "It is highly improbable that any one factor causes all the observed changes, yet it seems that the succession of animals followed the temperature and depth of water conditions more closely than other factors, and that pH and oxygen frequently accompanied rather than caused the changes." Moon (1936) working at Lake Windermere, England, says that light, temperature and O_2 were in no way correlated with distribution of the fauna and that the dominating physical factor is the substratum. Shelford (1911 and 1913) stresses the nature of the substratum as the important factor in ecological succession with age. In discussing the physical factors influencing the distribution of ciliates Noland (1925) believes that the nature and amount of available food has more to do with distribution in that group than any other single factor. Reed and Klugh (1927) found a difference in the faunas of an acid and an alkaline pond situated close together. This difference in the animals present they put down to the difference in acidity.

From this it is seen that there is little agreement as to the physical factor which exerts the greatest influence on the fauna. In general pH and O_2 supply seem to be unimportant within a reasonable range of variation. Any marked divergence from the average will of course cause a change in the fauna. The factors left, therefore are temperature, water level, food and substratum.

In the ponds I have studied the substrata are so nearly the same that this factor can be eliminated. There are slight differences in pH and O_2 and in the circulation of the water. Temperature is practically the same in both ponds. I can only say that it must be the algebraic sum of all the minor physical differences which accounts for the differences in the two faunas.

As to seasonal succession in the ponds, temperature and water level show the greatest variations, and, therefore, probably are the chief factors in this phenomenon. There can be no doubt that the great difference in summer and winter temperature has an effect on the numbers and kinds of animals present. Very few animals were found under the ice in Pond I. in mid winter, although at that time the pH and O_2 were not greatly changed from the fall conditions. The larger animals were completely lacking in spite of the fact that a considerable population of the basic food organisms was present. This leaves the factors of temperature and water volume to account for the change.

Scott (1910) found that temperatures above 4° C did not affect the fauna markedly, but that further reduction caused a decrease in activity and, by 2°C, all forms became quite passive. This was not the case in my own study for many of the smaller forms were quite active at a temperature of 2°C although the larger forms had hibernated. Scott reached the conclusion that the factor which influenced the organisms of that pond most vitally was change in water level.

From my own observations I believe that all the physical factors are so intimately bound up with the activity of the fauna that it is impossible to choose any single factor as the most important. Since pond organisms have a wide tolerance to physical conditions it seems that while these factors remain reasonably normal they are all equally important, and that it is their algebraic sum which produces any effects on the fauna. However, at different times or places a single factor may depart widely from the norm. As this factor passes out of the range of tolerance of the majority of the animals it produces a marked change. This factor, then, can be singled out as the cause of the variation. The same factor is not the important one in all ponds or at all times. Rather there is a succession in the variation of physical factors which is mirrored by the succession of animals.

Thus I find that during the winter the great reduction in the amount of heat is the chief causal factor in the changes in fauna. During the rest of the year when the temperature is within the range of tolerance of the majority of animals it ceases to be the deciding influence and water level becomes the critical factor. If the oxygen supply should become exhausted while other conditions remain the same it will be the deciding factor. Availability of food varies greatly and at times probably influences the composition of the fauna to a large extent.

There can be no doubt that the nature of the substratum is the deciding factor in determining the general character of the fauna of a pond. The character of the substratum, including texture, composition, and presence of plant growths determines the nature of the whole environment. This point has some bearing on the ponds in question.

In the section on Age and Formation it was noted that, judged by the flora, the ponds are ecologically young, yet many of the animals present are those characteristic of older ponds. Shelford (1913) states, "Animal succession in ponds results from an unused increment of excretory and decomposition products." He points out that the general succession is from sandy bottom to a bottom composed of humus contributed by the successive growths of aquatic plants. This indicates that the ability of a pond to support an ecologically advanced fauna depends upon the quantity of organic matter at the bottom. Although aquatic plants are lacking, the ponds I have studied fulfil the requirements for the support of an older fauna. This is due entirely to the organic matter entering the ponds from the land. Mozley (1934) states that the ability of a temporary pond in the prairie region to support a large population during the spring is due to the presence of dead terrestrial plants on the bottom. These plants grow every summer when the pond is dry land. Thus there is "an unused increment of excretory and decomposition products."

SEASONAL SUCCESSION

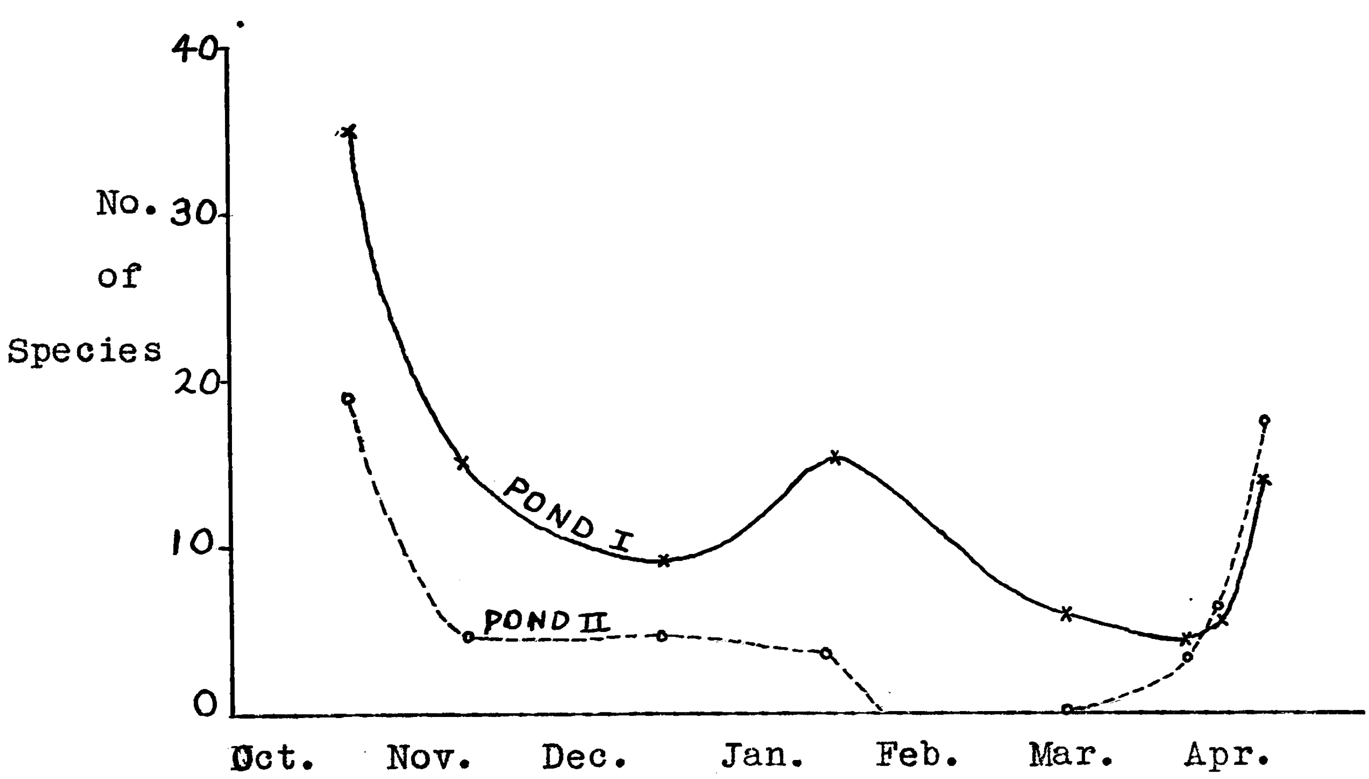
The remarks in the foregoing section make it clear that the variation in physical factors must find an expression in the quantity and quality of the organisms present. It has been shown by other workers that there are two periods of maximum numbers of pond animals during the year. These occur in the spring and fall and are associated with the productivity of the basic food organisms. The mid-winter minimum is caused by low temperature while the summer minimum is due to a decrease in water volume and in basic food.

In addition to this larger fluctuation in the number of species and individuals there are minor successions of forms over short periods. For instance, during the fall the copepod present in Pond II. was *Cyclops fimbriatus*. In mid-winter *C. serrulatus* was the only one found. In early spring *C. bicuspidatus* dominated but as the season progressed it was again displaced by *C. serrulatus.* The fairy shrimps and Amphibia are examples of animals found only in spring. The sequence of *Stentor coeruleus* following *S. polymorphus* during the winter in Pond I. has already been mentioned. Among the larger leeches

Erpobdella and Macrobdella were the first to appear in spring and were followed at a later date by Haemopis.

The general succession in the ponds is the early appearance of holophytic and saprozoic forms in spring followed by an increase in the holozoic forms feeding on them. Peterson (1926) found that the first animals to appear in spring were the last to disappear in the fall.

The following graph shows the number of species noted in the different collections.



It will be noted that there was an abrupt decrease in the number of species during November. This follows the fall in temperature and the formation of ice. The rise in the number of species found in Pond I. in January is probably due to the fact that the middle of that month was very mild with considerable rainfall and thawing. The decline, however, continued till the beginning of April. Pond II. had frozen completely by February. With the melting of the ice and the increase in temperature during April the number of species quickly increased.

BIOTIC POTENTIAL OF THE FAUNA.

Two terms have recently come into prominence in Ecology, namely biotic potential and environmental resistance. (See Chapman 1931). Biotic potential is defined as the inherent property of an organism to reproduce and survive in its environment i.e. to increase in numbers. Environmental resistance on the other hand is the sum total of all the physical and biological factors of the environment which tend to eliminate the species. It is the dynamic equilibrium between these two factors which results in a more or less constant population. Fluctuations are usually due to some change in the resistance of the environment. The terms are convenient in expressing an assortment of varying factors. Thus the biatic potential of a species includes its reproductive powers, its favourable adaptations to physical conditions and its ability to obtain food. The environmental resistance to the species consists of its enemies, any lack of food, and the whole list of varying physical factors.

The environmental resistance of the ponds studied was very high. In the winter the low temperature or total freezing eliminates many forms. In summer the great decrease in the volume of water is an adverse factor. Changes in oxygen supply and pH take their toll of many forms. Each species has some enemy which is part of the environmental resistance.

To offset this high mortality rate, we find that the biotic potential of pond organisms is very high. This is shown chiefly by the amazing reproductive powers of many of the species. It is said that a single female Daphnia pulex is capable of producing 13,000,000,000 descendents in sixty days (Morgan 1930). Various other devices by which the animals are able to survive during a period of adverse conditions are encystment, hibernation and dormancy, or the production of resting eggs or cysts. Hibernation was found among the molluscs, leeches, insect larvae and adults, and the Amphibia. Encystment is the method used by the Protozoa. Other forms, chiefly the Entomostraca, survive the winter in specially protected winter eggs.

When the environment becomes favourable in the spring hibernating forms become active and emerge from the bottom mud in which they burrowed in the fall. The eggs, cysts and resting stages hatch out and in a short time the usual fauna is restored.

Many of the winter stages can stand very low temperature. This is proved by the fact that although Pond I froze completely and the ground under it was solid to a depth of about a foot all the forms returned in large numbers in the spring. The eggs and cysts must have been frozen for a considerable period yet they were unharmed.

COMPARISON OF THE FAUNAS OF THE TWO PONDS

In the list of species on the following page the presence of an organism in Pond I. is marked with an x in the first column, and in Pond II by an x in the second.

The total number of forms found in the two ponds was 95. Of this number 86 were found in Pond I. and 48 in Pond II. The number of species found only in Pond I. was 47. The major portion of this number are Protozoa, annelids and rotifers. 10 species were found only in Pond II.

There was also a difference in the relative abundance in the ponds of some of the species which occur in both. For example, two Ostracods Candona and Cypridopsis were common in Pond II but rare in Pond I. Some of the testate amoebae were more common in Pond I than in Pond II. The chlorophyll bearing flagellates were better represented in Pond I. than in Pond II. The leeches, caddis worms and adult beetles were more common in Pond I. than in Pond II.

The major part of the difference in fauna can, I think, be put down to the difference in the exposure of the two ponds to sun and wind. Pond II. is rather closely surrounded by trees. The lower degree of illumination probably has a direct effect upon the production of the phytoflagellates and an indirect effect on the forms feeding on them. The lack of wind action in Pond II. affects other physical factors such as O_2 and pH. There is also a higher content of organic material

	Animal	Pond I	Pond II
PROTOZOA			
	Amoeba proteus	x	x
	" radiosa	x	
	Arcella vulgaris	x	x
	" discoides	x	
	Centropyxis aculeata	x	x
	Difflugia oblonga	x	x
	" acuminata	x	x
	" urceolata	x	x
	" corona		x
	Actinophrys sol		x
	Euglena viridis	x	x
	" oxyuris	x	
	" deses	x	
	" spirogyra	x	
	Lepocinclis ovum	x	
	Phacus pleuronectes	x	x
	" longicaudis	x	x
	" pyrum	x	
	" triqueter	x	
	Volvox sp.	x	
	Oikomonas termo	x	x
	Coleps hirtus	x	x
	Lacrymaria olor	x	
	Didinium nasutum	x	
	Dileptus anser	x	
	Lionotus fasciola	x	
	Chilodon cucullulus	x	
	Urocentrum turbo	x	
	Colpidium striatum	x	
	Colpoda cucullus	x	
	Nassula aurea	x	
	Paramecium bursaria	x	
	" caudatum	x	x
	Blepharisma lateritia		x
	Spirostomum ambiguum	x	x
	Metopus sigmoides	x	x
	Climacostomum virens		x
	Stentor polymorphus	x	x
	" coeruleus	x	
	" pyriformis	x	
	Stylonychia mytilus	x	x
	Vorticella campanula	x	x
	" alba	x	
	Zoothamnium arbuscula	x	
	Suctorian	x	
ROTIFERA			
	Metopidia ehrenbergii	x	
	Noteus quadricornis	x	

	Animal	Pond I	Pond II
	Philodina roseola	x	x
	Synchaeta stylata	x	
	Chaetonotus acanthomorphus	x	x
	Lepidoderma rhomboides	x	
ANNELIDA	Dero limosa	x	
	Aeolosoma tenebrarum	x	
	Stylaria fossularis	x	
	Limnodrilus sp.	x	
	Glossiphonia complanata	x	
	" stagnalis	x	
	Haemopis marmoratus	x	
	Erpobdella punctata	x	x
	Macrobdella decora	x	
PLATYHELMINTHES			
	Echinostome cercaria	x	
	Turbellaria	x	x
	Nematodes	x	x
CRUSTACEA	Daphnia pulex	x	
	Eubranchipus sp.	x	xx
	Cypridopsis vidua	x	x
	Cypria exsculpta		x
	Candona recticauda	x	x
	Canthocamptus staphylinoides		x
	Cyclops bicuspidatus	x	x
	" viridis	x	x
	" serrulatus	x	x
	" fimbriatus		x
	Gammarus limnaeus	x	
INSECTA	Anax sp.		x
	Libellula so.	x	x
	Ischnura sp.	x	x
	Dytiscus fasciventris	x	
	" hybridus	x	
	Colymbetes sulptilus	x	
	Acilius fraternus	x	
	Gyrinus sp.	x	x
	Gyrinid larva	x	x
	Caddis worms	x	x
	Mayfly nymphs	x	
	Culex sp.	x	x
	Chironomus sp.	x	x
	Holorusia sp.		x
MOLLUSCA	Lymnaea palustris	x	
	Physa heterostrapha	x	
	Planorbis trivolvis	x	x
	" parvus	x	
	Sphaerium sp.	x	x
AMPHIBIA	Rana sp.		x
	Triturus viridescens	x	x

in Pond II. and the bare mud bottom is eliminated. Some of the differences noted in the spring are probably due to the fact that Pond II was completely frozen during the winter while Pond I. was not.

The absence of frogs from Pond I. is probably due to the absence of the thick clumps of grass which exist at the shallow end of Pond II. where the frogs live. Pond I. is not as well shaded as Pond II.

ECONOMIC IMPORTANCE OF PONDS

The study of natural ponds besides furnishing information of purely acedemic interest has several indirect bearings on the relations of man to the lower animals.

It is just such ponds as the ones studied which are the breeding places for the mosquitos that are such a plague during the summer time in Montreal West and Notre Dame de Grace. The whole region north of these districts is field or woods and contains many small ponds and pools in the spring and summer. In these ponds and pools the mosquitos breed in amazing numbers. Thus these districts lying close to the city are the reservoir for the hosts of mosquitos which occur in the city during the warm months. The mosquito problem might be controlled by drainage or surface oiling.

Pond organisms often become serious nuisances in city reservoirs and pipe lines. Some give the water an unpleasant odour and taste. Others can block the pipes and cut down the pressure by their growth. Thus information as to the organisms themselves, their conditions of growth and methods of control are of value to hydraulic engineers.

The large populations of Entomostraca in ponds has interested various workers as possible sources of food for fish raising. Klugh (1927) undertook to study a large number of Canadian ponds with this end in view. The United States Bureau of Fisheries and some of the State Departments have issued bulletins to encourage the development of pond fish culture as a source of food in districts lacking large lakes or rivers. Many of these ponds are of necessity artificial and a knowledge of pond ecology is necessary to be able to duplicate natural conditions in them.

Ponds are often the feeding grounds for birds. Sandpipers are frequent visitors in the ponds I studied. Thus the preservation of natural ponds is of interest to the bird lover.

ACKNOWLEDGEMENTS:

I wish to extend my thanks to McGill University for laboratory and library facilities during the period of study and to Prof. H.B. Fantham for his supervision of this work. I also wish to acknowledge the aid and advice of Dr. Annie Porter and Dr. L. R. Richardson, who showed such an interest in the progress of the study.

S U M M A R Y

Two freshwater ponds in the vicinity of Montreal West were investigated from October 1936 to May 1937.

The literature of pond ecology was reviewed.

Various physical factors, e.g. O_2, pH and temperature were recorded.

An annotated list of the animals present has been compiled.

A comparison of the faunas of the two ponds was made and reasons were suggested for the differences.

The various associations in the ponds were discussed.

Charts showing the food relations in fall and spring were prepared.

The argument was advanced that a pond receiving a large amount of vegetable matter from terrestrial sources is able to support an ecologically older fauna than is warrented by its age alone. Evidence supporting this point was advanced.

Temperature was found to be the chief factor influencing the fauna in the winter months.

The chief factors influencing distribution were found to be the substratum and food requirements.

The phenomenon of succession was discussed.

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Opposite p. 92

Figure 1

Photograph of Pond I. in winter.

Figure 2

Pond II in winter. The ice is obscured by
a layer of snow.

1

2

Opposite p. 93

Figure 3

Pond I. in spring.

Figure 4

Pond II. in spring.

Both ponds are at maximum size and depth.

3

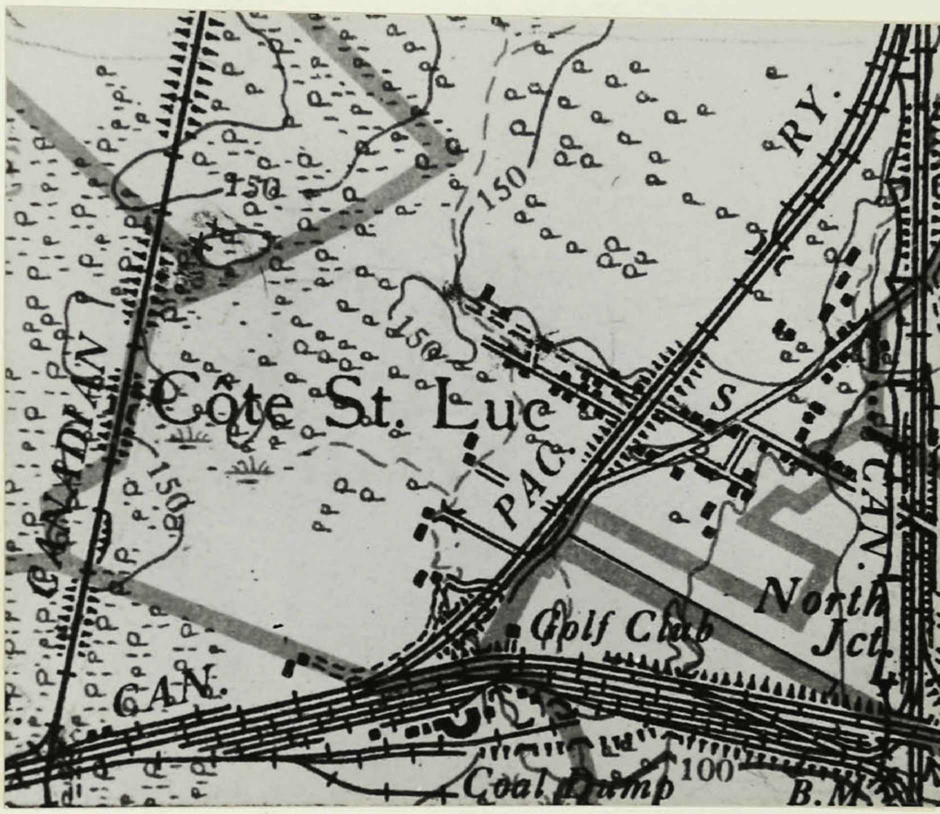
4

Opposite p. 94

Figure 5

Map of Cote St. Luc district.

The ponds are in the upper left hand corner to the east of the railway line. They are marked with an x.


CANADIAN
Côte St. Luc
150
PAC.
RY.
S
CAN.
North
Jct.
Golf Club
CAN.
Coal Dump
100
B.M.

5

Opposite p 95

Figure 6

Detailed map of Pond I.

Scale: approximately 15 feet to the inch.

Legend:

⊗ Tree or stump

Grass

Submerged grass

Boundary of the pond in summer

Chara zone

Region of dead leaves

S Collecting station.


S
S
S

Opposite p. 96.

Figure 7

Detailed Map of Pond II

Scale: approximately 15 feet to the inch.

Legend

⊗ Tree or stump

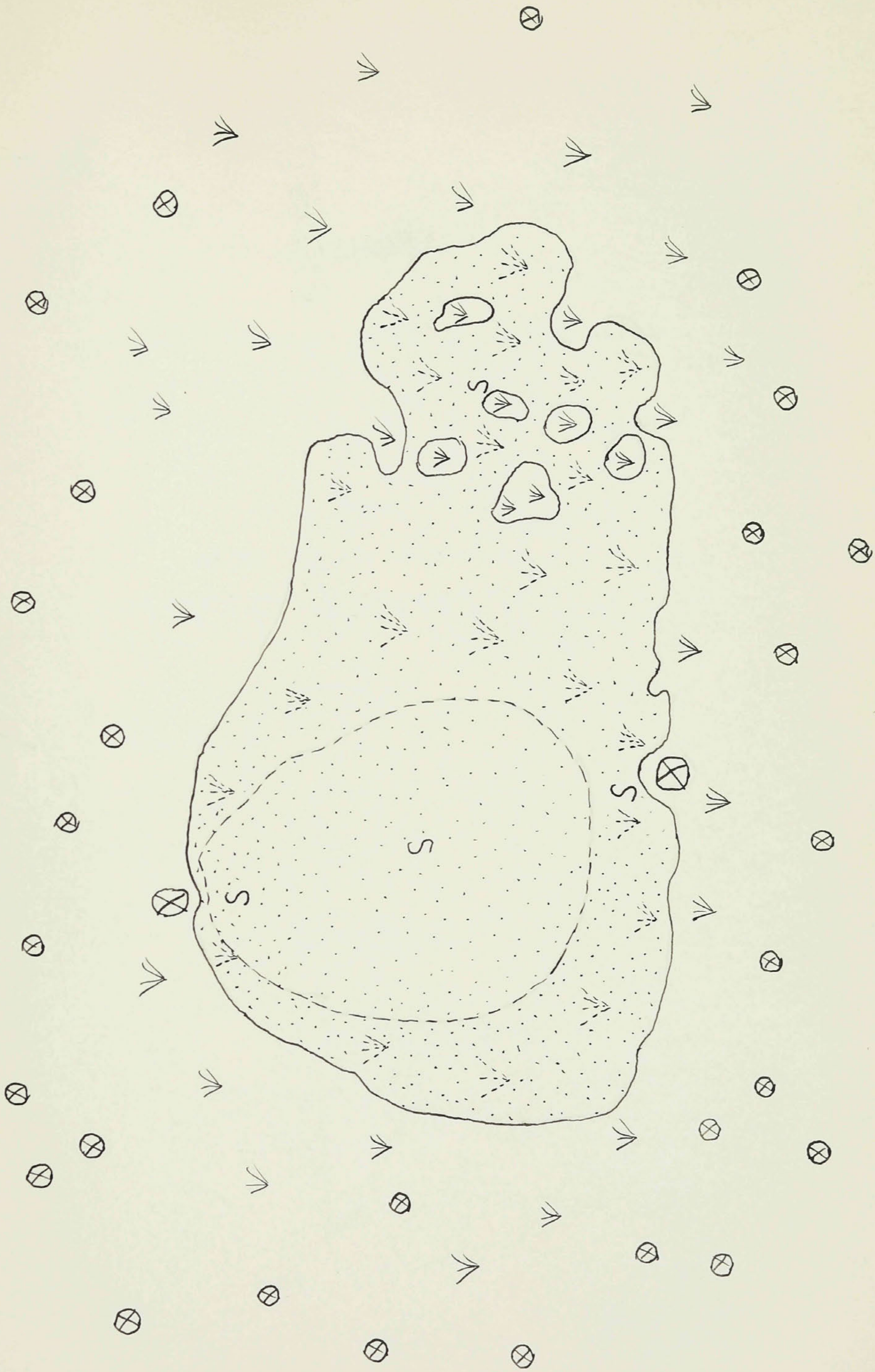
Grass

Submerged grass

Boundary of the pond in summer

Region of dead leaves

S Collecting station.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Opposite p.97

Figure 8

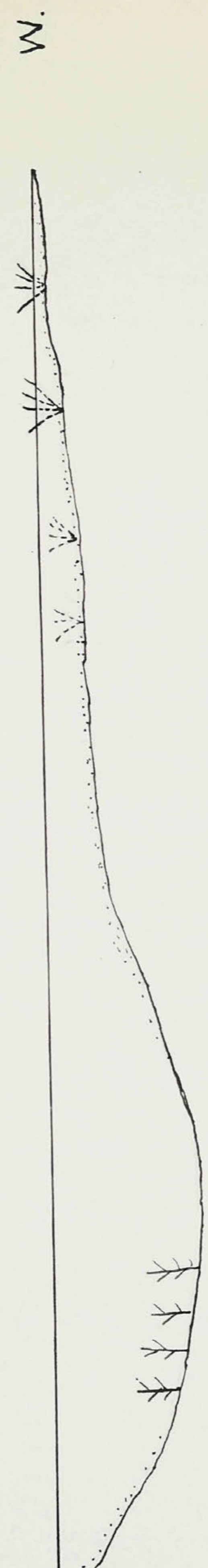
Cross section of Ponds from east to west.

Legend

Chara

Submerged grass

Leaves.


W.
E.

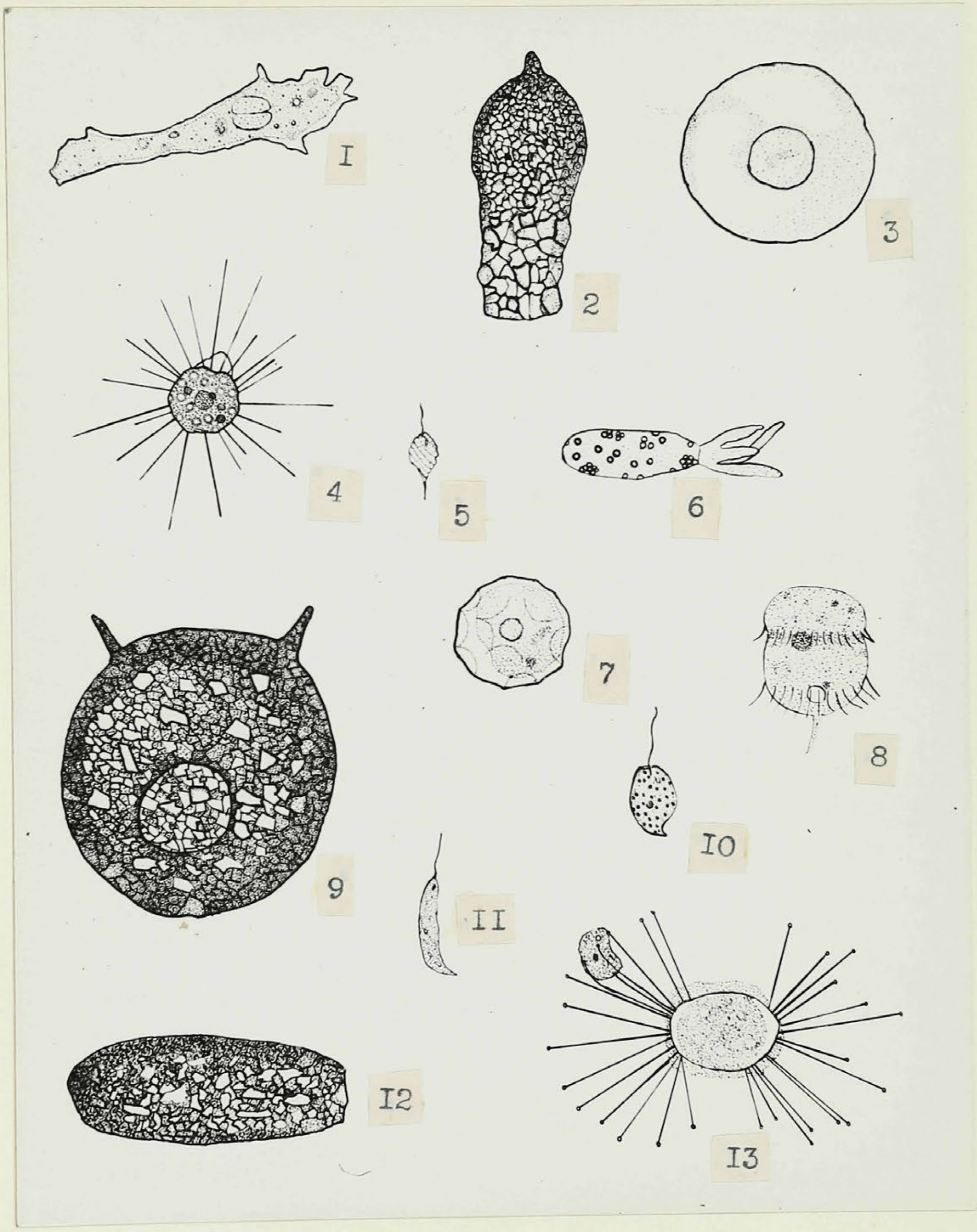
Opposite p. 98.

PLATE I.

1. Amoeba proteus
2. Difflugia acuminata
3. Arcella vulgaris
4. Actinophrys sol
5. Phacus pyrum
6. Difflugia oblonga
7. Arcella vulgaris
8. Urocentrum turbo
9. Centropyxis aculeata
10. Phacus triqueter
11. Euglena viridis
12. Difflugia oblonga
13. Suctorian

All figures X 225

Plate I.



Opposite p. 99

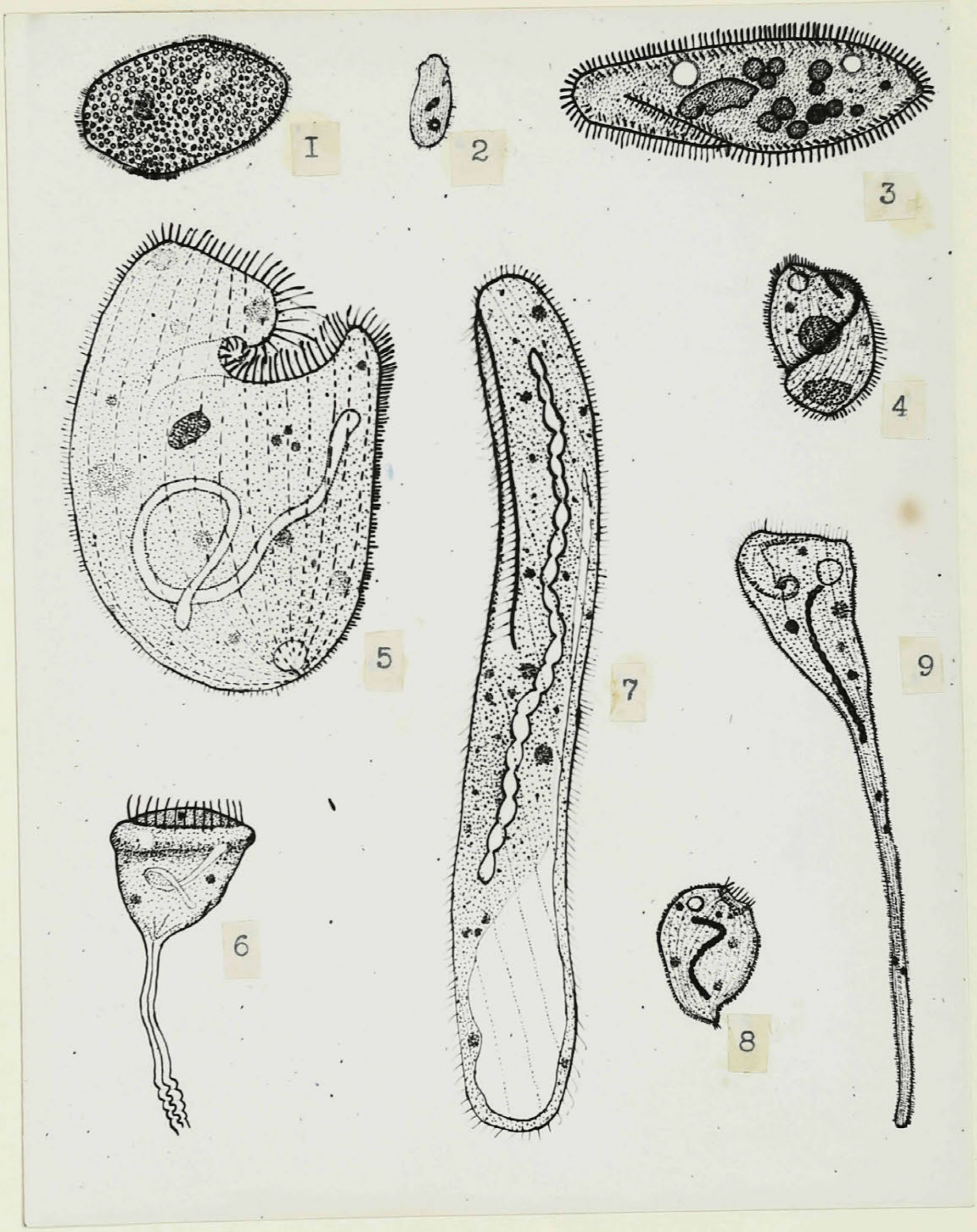
Plate II.

1. Paramecium bursaria
2. Colpidium striatum
3. Paramecium caudatum
4. Metopus sigmoides
5. Climacostomum virens
6. Vorticella campanula
7. Spirostomum ambiguum
8. Stentor coeruleus - contracted
9. Stentor coeruleus - expanded

Figures 1 to 6 x 225

Figures 7 " 9 x 50

Plate II

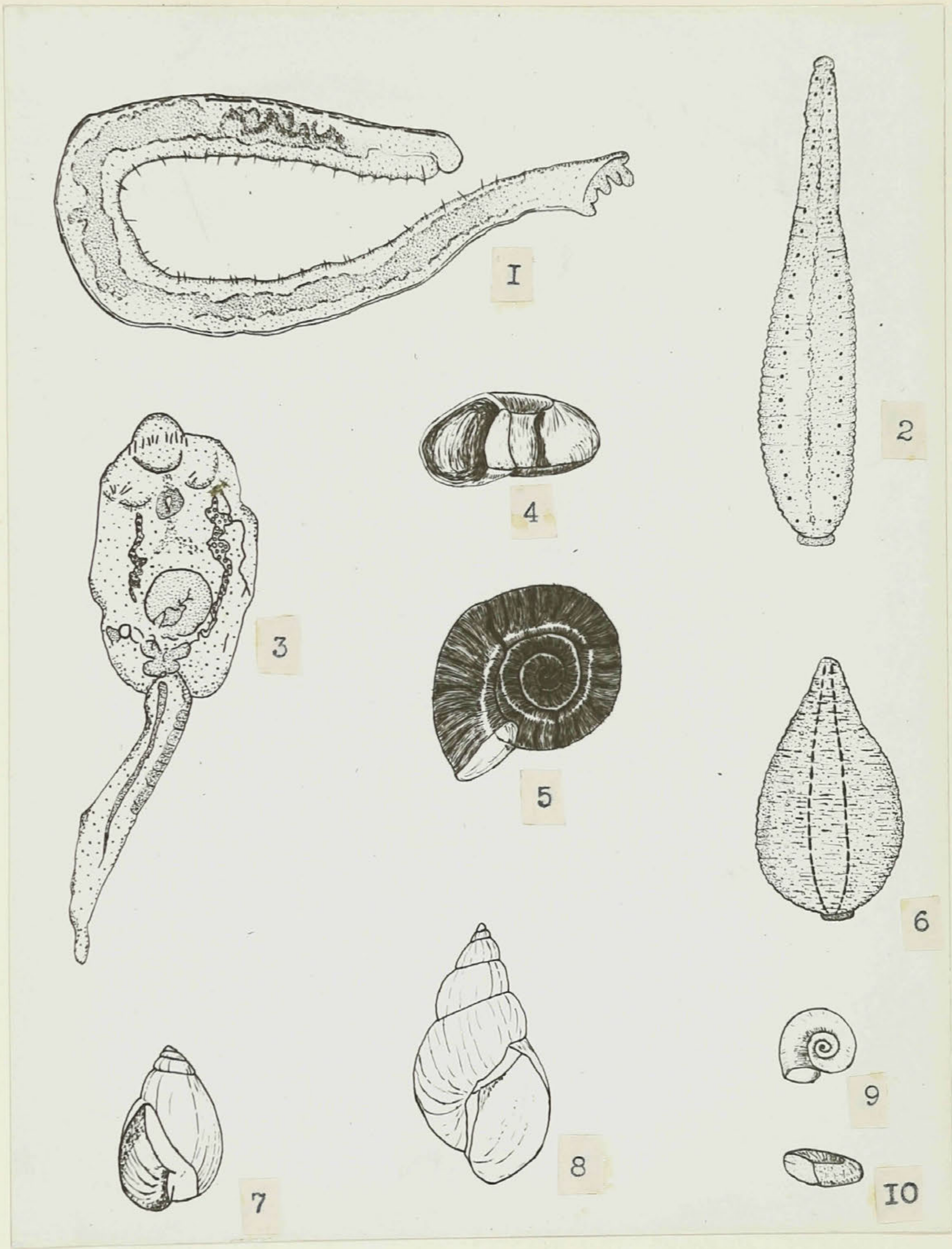


Opposite p. 100

Plate III.

1. Dero limosa x 36
2. Macrobdella decora, natural size
3. Echinostome cercaria x 120
4. Planorbis trivolvis the side
5. P. trivolvis from above, natural size
6. Glossiphonia complanata x 3
7. Physa heterostrapha x 2
8. Lymnaea palustris x 2
9. Planorbis parvus from above
10. P. Parvus from the side x 4

Plate III

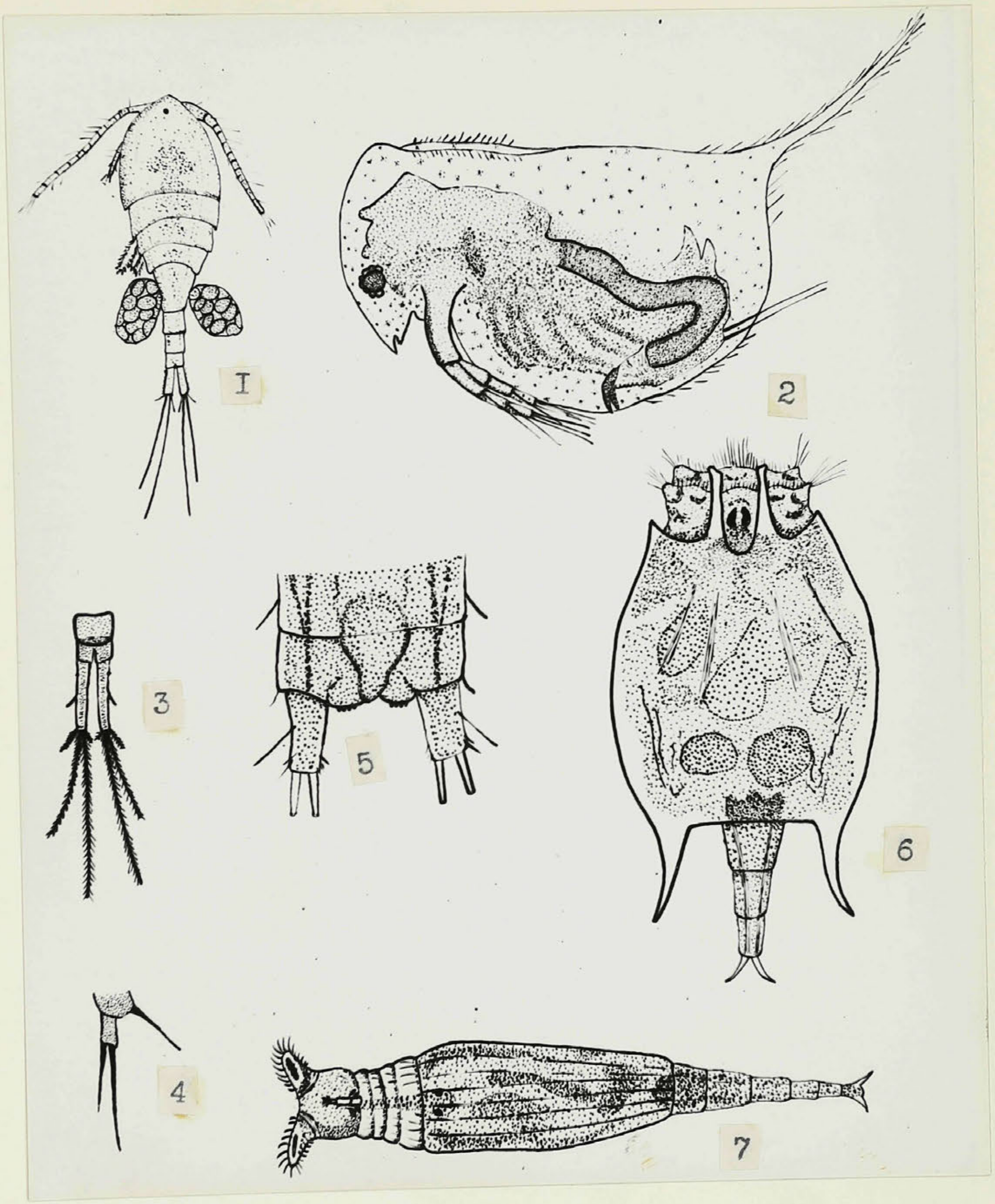


Opposite p. 101

Plate IV.

1. *Cyclops serrulatus* x 20
2. *Daphnia pulex* x 30
3. Furca of *Cyclops bicuspidatus* x 30
4. 5th foot of *C. bicuspidatus* x 135
5. Furca of *Canthocamptus staphylinoides* x 135
6. *Noteus quadricornis* x 200
7. *Philodina roseola* x 250

Plate IV.

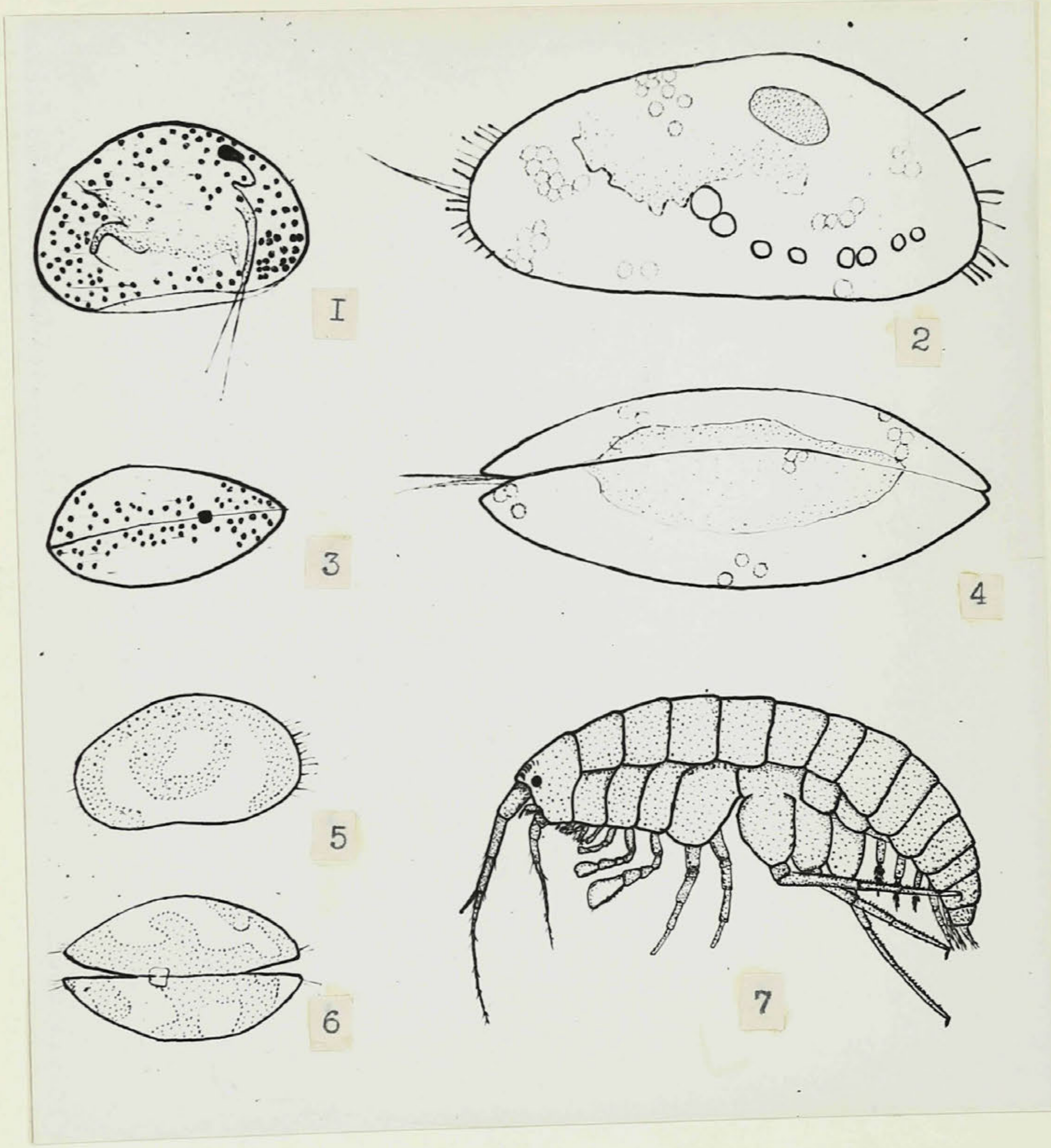


Opposite p. 102

Plate V

1 and 3.	*Cypria exsculpta*	x	50
2 and 4.	*Candona recticauda*	x	50
5 and 6.	*Cypridopsis vidua*	x	50
7.	*Gammarus limnaeus*	x	6

Plate V.



Opposite p.103

Plate VI

1. *Chironomus sp.* larva x 4
2. *Colymbetes sulptilus* x $1\frac{1}{2}$
3. *Libellula sp* nymph x 2
4. Larvae of a gyrinid beetle x $2\frac{1}{2}$
5. Mayfly nymph x 2
6. Caddis worm case x 5
7. *Culex sp*, larva x $3\frac{1}{2}$

Plate VI.