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ARTICLE VI.—A LIST OF THE PROTOZOA AND ROTIFERA FOUND IN THE ILLINOIS RIVER AND ADJACENT LAKES AT HAVANA, ILL.

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ERRATA.

Page 136, line 2, and page 182, line 17 from bottom, for '*95a* read '*95*.

Page 226, line 2, page 263, line 17 from bottom, and page 267, lines 2 and 15, for '*98*, read '*96*.

Page 233, line 15 from bottom, for '*82* read '*82a*.

Page 355, line 2 from bottom, for C. *F.* Hudson read C. *T.* Hudson.

Page 389, foot-note, for Vol. *V.* read Vol. *IV.*

Page 457, line 5, for *Genera* read *Genus*.

ARTICLE VI.—*A List of the Protozoa and Rotifera found in the Illinois River and Adjacent Lakes at Havana, Ill.** BY ADOLPH HEMPEL.

INTRODUCTORY.

The material studied in the preparation of this paper was collected at the Biological Experiment Station established on the Illinois River, at Havana, April 1, 1894, by the University of Illinois and the Illinois State Laboratory of Natural History. The work of collecting the material began April 7, 1894, and was carried on almost entirely at nine substations, designated as A, B, C, D, E, F, G, K, and L. The first three are in Quiver Lake, which is an arm of the river on its east side, about two miles above Havana. A is at the head of the lake; B, at a wet, springy place on the eastern shore, about half a mile from the head; and C, about a mile and a half from the head, including both the east and west shores at this point as well as the middle of the lake, where the towing-net was hauled, the depth here at low water being about four feet. D is about half a mile above Havana, on the east bank of the river, and E about two and a half miles north of the town, in the main river, opposite C, collections being taken especially from the west shore and the middle of the river, where the depth at low water was about nine feet. About

*Before Mr. Hempel had completed that part of his manuscript relating to the *Protozoa*, he left to accept a position in the *Museu Paulista*, in São Paulo, Brazil, and the entire manuscript was placed in my hands by Dr. Forbes to be prepared for publication. At first I was reluctant to undertake the work, but realizing the value of the paper as planned by Mr. Hempel to students and teachers of Illinois natural history, I have spared no effort to put it in the most useful form for this class of workers.

On account of the limited time and area represented in this list, it can only be regarded as a preliminary one, not sufficient for permanent generalizations on seasonal or local distribution, but rather as a history of these groups at the Station during the two years covered by Mr. Hempel's work. It seemed undesirable, for the same reason, to attempt to give keys to the species listed. I have, however, for the *Protozoa*, carefully compiled from Bütschli a synopsis of the distinctive characters of the larger subdivisions represented in the list, and have drawn up from Bütschli, Leidy, and Kent condensed generic descriptions, following, as did Mr. Hempel, the order given by Bütschli. The chlorophyll-bearing forms, such as *Volvox* and *Euglena*, are retained among the *Protozoa* since they are included by Bütschli, but it is proper to state that they are now regarded as plants by a large number of authors. For the *Rotifera*, I have compiled a synopsis of the families from Hudson and Gosse, and Mr. Hempel's generic diagnoses are mostly from the same source.

Under each species in the list is a brief account of the important points in its history for the two years. These accounts were drawn up from Mr. Hempel's records, and may prove of especial value to students at the Station. Aside from these summaries and the additions previously mentioned, the manuscript remains substantially as Mr. Hempel left it, and will be found to contain much interesting and useful information for the student of microscopic life. CHAS. A. HART.

half a mile below Havana, west of the river, is situated Phelps Lake, which is merely a shallow depression something over half a mile long and less than a quarter of a mile wide, surrounded by woodland, and usually filled with water to a depth of one or two feet; near its upper end F is located. G is in the southern part of Thompson's Lake, a large permanent body of water, about five miles long and over half a mile wide, with a depth at low water of about four feet, lying to the west of the river above Havana. K is located near the middle of Flag Lake, which is a large but very shallow body of water, about three miles long and half a mile wide, lying between Thompson's Lake and the Illinois River, and full of coarse "flags"—*Scirpus*, *Sagittaria*, etc.,—*Nymphæa*, *Nelumbo*, and *Ceratophyllum*. L is situated in Dogfish Lake, which opens into the west side of Quiver Lake, and is about a mile long and a quarter of a mile wide, and somewhat shallower than Quiver Lake at C. Collections were also made in the "Pumpkin Patch," a small marshy bay communicating with Quiver Lake at its head, and in Matanzas Lake, just east of the river, about three and a half miles south of Havana.

Studies of the *Protozoa* and *Rotifera* at the Biological Station were begun respectively in the latter part of April and of May, 1894. This work was carried on at the Station throughout the season until September 10, and all subsequent catches from that date to April 1, 1896, were examined and a record was kept of the *Protozoa* and *Rotifera* found in them. The period of time thus covered was about two years, the interval between the collections varying from a week to two months. The results of this work form the basis of the present article. Several species which were first noticed later than April, 1896, are incorporated in their proper place. The list is intended primarily as a record of the *Protozoa* and *Rotifera* found in the general collections made at the various substations, and in but few instances were data obtained from other sources. Doubtless the number of species recorded would be considerably greater if the time had been spent in endeavoring to list as many forms as could be found, regardless of substations. As it was, there were two difficulties

which materially interfered with the making of full and satisfactory substation lists. The first obstacle was the imperfect preservation of many forms in the material put up for examination, the identification of this material being thus largely restricted to those forms which possessed structures sufficiently hard to preserve without distortion. The second was due to changes in the list of substations under examination: A and B had to be abandoned, because of extreme low water, in August, 1894; Phelps Lake, in which was substation F, became entirely dry by the 18th of that month, and work there was suspended until January, 1895, when a rise in the river refilled the lake bed; and in the spring of 1895 D was abandoned and two new substations, K and L, situated in Flag and Dogfish Lakes respectively, were added to the list.

My thanks are due to my instructor, Dr. S. A. Forbes, for his interest in my work and for counsel and guidance while the work was in course of preparation; to Prof. Frank Smith and to Dr. C. A. Kofoid for suggestions and help in technique and research; to Mr. C. A. Hart, who has kindly undertaken to revise the manuscript and prepare it for the printer; and to Miss Lydia M. Hart, who has contributed the figures.

METHODS OF COLLECTION AND PRESERVATION.

During the first season, in making collections in the river and in other places comparatively free from vegetation, a tow-net of No. 12 silk was used, both surface and oblique hauls being taken at intervals of from seven to ten days. The collections along shore and among plants were secured by means of a Birge net, or cone-dredge, at different intervals varying from fourteen to twenty-five days. Many kinds were obtained by squeezing out the water from vegetation; while large forms, such as *Megalotrocha* and *Conochilus*, were picked out with forceps and pipette. In 1896 Dr. C. A. Kofoid, Superintendent of the Station, introduced the use of a pump in making collections. This method has many advantages over the earlier ones, as by means of it collections can easily be made from any desired depth, or from among weeds where a tow-net could not be hauled.

Several methods were followed in the preservation of the tows. Some of the material was killed in 50% alcohol and then transferred to 70% alcohol; another part was killed in 95% alcohol; and picro-nitric acid, followed by 70% alcohol, was extensively used. Flemming's fluid as employed by Rousselet ('93), and a solution of potassium permanganate recommended by Zacharias ('94, p. 88) were also used. A second paper by Rousselet ('95), in which he describes the method of killing with $\frac{1}{4}$% osmic acid and then preserving in a 2.5% solution of formalin, was received in time to be used in connection with the work in 1895. In 1896 nearly all the qualitative catches were killed and preserved in 2% formalin. Good results were obtained in almost all cases. If one is limited in time and can have but one killing agent, formalin comes nearest being the ideal all-around killing fluid. By far the best results, however, are obtained with osmic acid, according to the process worked out by Rousselet; but the use of this agent requires much time and patience.

PROTOZOA.

The *Protozoa* present a very attractive field for study, including a large number and great variety of species. We find here a more marked difference in structure and form than among the *Rotifera;* yet all the *Protozoa* are either simple one-celled animals or colonies of single-celled individuals.

They exhibit a great variety of structural detail, and range in length from 6 mm. to .005 mm. Many of the forms are marine, but a great number occur in fresh or stagnant water. Notwithstanding their diversity of structure, the *Protozoa* have, as a rule, the protoplasm or body substance differentiated into an inner part, called the endoplasm, and an outer envelope, called the ectoplasm. This differentiation may be temporary, as in the *Rhizopoda*, or permanent, as in the *Flagellata* and *Infusoria*. A single nucleus is usually present, though some species have more than one. The *Infusoria* are characterized by the presence of a paranucleus, or micronucleus, in addition to the larger nucleus, or mega-

nucleus. One or more contractile vacuoles are usually present except in the *Sporozoa* and *Cystoflagellata*, in which none have as yet been discovered.

As a pool dries up, the *Protozoa* it contains assume a spherical shape and secrete about themselves a chitinous shell, when they are said to be encysted, the spheres being called cysts. In this condition they can readily withstand drought, and when rain comes and fills up the pool they revive, break through the chitinous envelope, and assume their former shape. Encystment may also take place just before spore formation.

Protozoa occur abundantly in every pond or wayside pool as well as in the larger bodies of water, and one might naturally think that they would be favorites with the zoölogists and be thoroughly well studied; but in the United States there are only a few persons who have given much attention to them. Among these may be mentioned Prof. Joseph Leidy, Prof. D. S. Kellicott, and Dr. A. C. Stokes, each of whom has done much to awaken interest in these small forms and to bring them into notice.

In order to get a good idea of the structure of the *Protozoa* we may now consider some typical forms of the various groups.

The lowest of the *Protozoa*, belonging to the class *Sarcodina*, are the subclass *Rhizopoda*, or root-footed animals, so called because they send out a number of root-like processes of protoplasm, known as pseudopodia, by means of which they move from place to place. Among the forms included under this head are *Amœba*, *Difflugia*, *Arcella*, and *Euglypha*. *Amœba* consists of a small portion of protoplasm differentiated into a granular endoplasm and a clear transparent contractile ectoplasm, and having a nucleus and contractile vacuole. As already indicated, the animal moves along by thrusting out processes of protoplasm in the direction of locomotion. As these pseudopodia are thrust out at one part of the body they are drawn in at another part. Because of this peculiar movement the *Amœba* has no constant form, its shape changing continually. Aside from locomotion the

pseudopodia also serve in obtaining food, for when they come in contact with a diatom, for example, they flow around it and entirely enclose it. Then the soft parts are digested, and as the *Amœba* moves along the undigested hard parts are extruded. The structure of *Difflugia* is essentially the same as that of *Amœba*, with the exception that the *Difflugia* builds for itself a small shell or lorica, using sand, diatoms, and particles of other foreign matter. *Arcella* secretes a homogeneous chitinous shell, which is usually free from all foreign substance. *Euglypha* secretes chitinous plates and then unites them to form its shell.

The subclass *Heliozoa* includes a number of the *Sarcodina* characterized by having numerous thread-like pseudopodia. These are not continuously thrust out and retracted, but have a permanent form. The *Radiolaria* constitute another subclass of the *Sarcodina*, but as it includes only marine forms it is unnecessary to consider it here. The prevailing mode of reproduction among the *Sarcodina* is division, although budding and spore formation also occur.

The class *Sporozoa* is composed of a number of *Protozoa* which reproduce by means of spore formation. The occurrence of fission or budding among any members of the group has not as yet been demonstrated. All of them are parasitic, living in the intestines or in other organs or tissues of higher animals, and therefore show a marked degeneration of structure. *Gregarina* may be taken as a type. It is more or less oval in outline, with the protoplasm differentiated into a well-marked endoplasm and ectoplasm. The body is constricted at about one third of its length from the anterior end. A nucleus is present, but pseudopodia and the contractile vacuole are wanting.

In the class *Mastigophora* the members of the order *Flagellata* are characterized by the possession of one or more flagella which serve as organs of locomotion, and also aid the animal in securing food, since by means of them a constant current of water is directed towards the mouth. The well-known *Euglena* may be considered as a type. The body is elongate and more or less cylindrical, and is highly flexible and very

variable in shape. The endoplasm and ectoplasm are well differentiated. From the anterior end of the body projects a long slender flagellum, just below which is the mouth opening. Near the base of the flagellum is the red stigma, sometimes called the eye-spot. A little behind this pigment spot is the contractile vacuole. This empties into a sort of vestibule. The posterior extremity of the body is, in some species, prolonged into a short spine-like process. A large nucleus is present. The endoplasm usually contains a number of starch bodies.

The order *Dinoflagellata* includes *Peridinium* and *Ceratium*, which have a hard covering or shell of modified cellulose. Contractile vacuole and nucleus are present. There are two flagella; one extending out in front of the animal, while the other encircles the body and lies in an equatorial groove.

The members of the class *Infusoria* have more or less of the surface of the body covered with fine cilia. These are permanently present in the subclass *Ciliata*, but in the subclass *Suctoria* are found only in the young. In the holotrichous *Ciliata* they are comparatively uniform, and usually invest the entire body surface. By some authors these forms are all grouped under the name *Holotricha*. A large part of them, however, constitute a group sufficiently distinct from all other *Ciliata* to be ranked as a separate order, the *Gymnostomata*. The mouth is naked, and closed except when in use, the food being swallowed. In the remaining *Ciliata*, constituting the order *Trichostomata*, the mouth usually remains open, and the food is swept into it by the action of cilia or undulating membrane.

The holotrichous *Trichostomata* form the suborder *Aspirotricha*, which is well represented by *Paramecium aurelia*, the slipper animalcule. Its body is elongate, pointed posteriorly, and rounded and slightly narrower anteriorly. The entire surface is covered with fine cilia. On the ventral surface is an anterior oblique groove, at the posterior end of which the oral opening is situated. The nucleus is large. Two contractile vacuoles are present, which usually assume a stellate appearance upon contracting The ectoplasm or cuticula is

provided with a number of rods called trichocysts. These are used for defense, and are comparable with the nematocysts in *Hydra.*

The suborder *Spirotricha,* which includes the remaining ciliates, is characterized by the presence of a spiral or nearly circular wreath of cilia—the adoral wreath—leading to the mouth opening, and partly or entirely enclosing a usually well-marked area known as the peristome-field. This suborder comprises four quite well-marked divisions, *Heterotricha, Oligotricha, Hypotricha,* and *Peritricha,* distinguished largely by the ciliary structure and distribution.

The *Heterotricha* have the body clothed with short, fine cilia and an adoral circle or spiral of longer cirrose cilia at the anterior end, around the peristome-field. *Stentor polymorphus* may be taken as typical of this group. The body is variable in form, but may be described as trumpet shaped, expanded anteriorly and attenuated posteriorly. It is sometimes found in large attached colonies, and at other times is free-swimming. The body is covered with longitudinal rows of very fine cilia, while those around the peristome are modified into strong flattened structures. The left margin of the peristome is involuted, forming a little pocket, at the bottom of which is the oral opening. The endoplasm usually contains a number of granules. The ectoplasm is supplied with a layer of fine longitudinal contractile fibrils, called the myophan. The contractile vacuole is large and the nucleus large and moniliform.

The *Oligotricha* are a rather small group of short, rounded to obconic forms, with the peristome-field occupying the the anterior end, as in *Stentor,* and surrounded by a nearly or quite completely circular adoral wreath. The ciliation of the body varies in amount. A lorica is sometimes present.

The *Hypotricha* differ from the other groups in that they are usually flattened and have the locomotor cilia upon the ventral surface. These cilia are frequently modified into strong styles or uncini. The dorsal surface is smooth or furnished with a few rows of stiff cilia. The oral and anal openings are distinct. Usually the peristome-field is on the

anterior part of the ventral surface, triangular, and partly surrounded by the adoral wreath. *Stylonichia* may be regarded as typical of this group. Its body is elongate, rounded at the ends, and persistent in shape. The cilia form a continuous border around the ventral margin. The peristome-field is placed anteriorly on the left side of the ventral surface. It is well supplied with cilia and with a band-like undulating membrane. A number of the frontal cilia are modified into styles. There are several claw-like caudal setæ, and some anal spines. The contractile vacuole is single; the nuclei two in number, usually oval.

In the *Peritricha* the cilia are usually limited to an adoral wreath at the expanded end. Sometimes a circlet is present at the opposite end. The well-known *Vorticella*, or bell animalcule, is a good example of this group. The body is spheroidal or more or less bell-shaped, and the ectoplasm is prolonged posteriorly into a stalk, by means of which the animal is attached. The myophan fibrils of the body unite and form a large contractile muscular fiber extending throughout the length of the stalk. The cuticular surface is sometimes transversely striated and otherwise ornamented. The right limb of the adoral ciliary wreath descends into the pocket or vestibulum, at the bottom of which the oral opening is situated. Contractile vacuoles one or several; nucleus band-like, large.

The subclass *Suctoria* is the most highly differentiated of the *Infusoria*. This is especially seen in the matter of reproduction, for many of them reproduce by internal budding. *Tokophrya* may be considered as a type of this group. The body is usually persistent in shape, more or less oval, and fastened by the attenuate posterior end to a rigid stalk. Instead of cilia, the adult forms have a number of fine hair-like tentacles, either scattered irregularly over the anterior surface or arranged in several fascicles. These tentacles are slightly movable and may be extended or retracted, serving to capture prey and to convey food substance into the body; for, notwithstanding their slender form, particles of food from the mass being fed upon may be seen passing within these

tentacles to the body of the *Tokophrya*. The nucleus is large and usually oval in shape; the contractile vacuoles are one to several in number. All the members of this genus reproduce by internal budding. The young *Tokophrya* is provided with an equatorial circle of cilia, by means of which it swims rapidly through the water, later fastening itself to some object, when the cilia disappear and the form of the adult begins to be assumed.

METHODS OF CAPTURE AND STUDY.

All of the methods of capture suggested on a later page for the *Rotifera* will answer equally well for the *Protozoa*. Of course, infusions of hay or grass will furnish certain kinds. The method of keeping water from ponds and ditches in watch-glasses as described for the *Rotifera*, if duly attended to, will not fail to give satisfactory results. Considerable attention should be given to the examination of small *Crustacea*, aquatic insect larvæ, pond snails, small turtles, and crayfishes, as many *Protozoa* are likely to be found upon them. *Vorticella* may be found on the roots of *Lemna*, or on fixed aquatic plants.

Whenever possible, *Protozoa* should be studied alive. Good results were obtained in the preservation of *Tokophrya quadripartita* by the following process. A small colony was transferred to a drop of water upon a slide and a cover-glass placed over it, the cover-glass being raised by little supports of wax so that it did not touch the zoöids. A drop of an aqueous solution of corrosive sublimate was then added and allowed to remain about half a minute, when it was washed out and 30% alcohol substituted, this being gradually changed to 70%. Next, the zoöids were stained for about twenty minutes in Kleinenberg's hæmatoxylin and then decolorized with acidulated alcohol, consisting of .5% hydrochloric acid in 70% alcohol, which in turn was well washed out with pure 70% alcohol. Then the alcohol was gradually changed to 95%, after which clove oil was substituted and allowed to remain until the zoöids were clear. Finally they were mounted in balsam. All the changes from water to

balsam were made on the slide by the irrigation process, that is, by placing a drop of the liquid on the slide at the edge of the cover-glass, and then drawing it under the cover-glass by means of blotting-paper. The *Tokophrya* was attached to *Opercularia*, and many of the latter genus were killed well expanded, thus suggesting the idea that this method could probably be used with good results for other *Vorticellidæ*.

GEOGRAPHICAL DISTRIBUTION.

There is probably no place on earth, unless it be a sandy desert or a subterranean stream, where *Protozoa* may not be found. No stream is too clear or pond too muddy for them to thrive in. They are found in the warm waters of the tropics and in the icy waters of the northern countries. The United States stands next to Europe in the number of recorded species. A considerable number are also found in Australia. There are many cosmopolitan species, which is not so remarkable when we consider that the light cysts may very readily be carried long distances by air currents.

FOOD RELATIONS.

But little attention has been paid to the food of the *Protozoa*, and it is very desirable that students should make and record careful observations along this line.

In general it is known that *Amœba*, *Arcella*, *Difflugia*, *Vorticella*, *Opercularia*, and the like, feed largely on diatoms and desmids, diatoms especially seeming to be a favorite food of such forms as *Vorticella* and *Opercularia*. *Euglena* has been found within the body of *Opercularia*, and *Tokophyra* and *Acineta* are predaceous, living upon other *Protozoa*.

Individuals of the latter genus have been seen to kill and devour *Vorticella*. Schewiakoff ('93) says that rotifers, daphnids, and *Chætonotus* also serve as food for *Protozoa*. No doubt many of the species that possess chlorophyll derive some nourishment from gases, as plants do; while other forms absorb organic matter in solution in the water. It is probably true that plants constitute à larger proportion of their food than animals, but the data on this point are so meager that no general statement can be made.

On the other hand, the *Protozoa* play an important part in the food of other organisms. Many rotifers feed freely upon them, and even young fishes have been found with *Difflugia* in their stomachs. *Euglena*, *Volvox*, *Pandorina*, *Difflugia*, and *Codonella* are among the forms observed in the stomachs of rotifers; but so few observations on this subject have been recorded, that very little information can be gathered at present.

LOCAL DISTRIBUTION.

In the waters from which our Station collections were made the *Protozoa* were not so abundant nor so widely distributed as the rotifers. In all, ninety-three species are recorded, one of which (*Difflugia fragosa*) is here described for the first time. Species which could not be identified with certainty are not included in the list.

The most widely distributed form was *Difflugia globulosa*, which appeared at every substation and was present in nearly every month of the year. Other species of *Difflugia* and species of *Arcella* were found during a considerable part of the year, including the summer months. *Dinobryon sertularia* was very abundant, occurring from December to June; *Euglena viridis* was observed throughout the summer months; *Volvox globator* was found in every month except February; *Coleps hirtus* was present from May to October; and *Codonella cratera* was frequently seen from April to September. All through the summer months many species of *Vorticella*, *Epistylis*, and *Opercularia* were taken in the towings or upon the backs of turtles and the larger *Crustacea*, but few of them could be definitely determined.

A number of the species here recorded were found in aquaria started with dried mud from the bed of Phelps Lake.

I have found it very difficult to make a sharp distinction between the littoral or shore forms, and the so-called pelagic or limnetic forms found in the open waters. These waters were so shallow—the average depth at the various substations ranging from two to twelve feet—and so full of vegetation, that the only species that seemed entitled to be considered as

pelagic were those that evidently preferred clear open water, free from vegetation.

Thirty-five of the species here treated were found in open water, either in surface, bottom, or oblique towings. They are as follows:

Arcella vulgaris Ehrbg.
Arcella vulgaris discoides Leidy.
Arcella vulgaris angulosa Leidy.
Arcella dentata Ehrbg.
Difflugia globulosa Duj.
Difflugia pyriformis Perty.
Difflugia acuminata Ehrbg.
Difflugia lobostoma Leidy.
Difflugia corona Wallich.
Difflugia aculeata Ehrbg.
Difflugia tuberculosa Hempel.
Difflugia fragosa n. sp.
Actinophrys sol Ehrbg.
Actinosphærium eichhornii Ehrbg.
Raphidiophrys pallida Schulze.
Dinobryon sertularia Ehrbg.
Euglena viridis Ehrbg.
Euglena spirogyra Ehrbg.
Euglena acus Ehrbg.
Euglena oxyuris Schmarda.
Euglena torta Stokes.
Trachelomonas acuminata Schmarda.
Phacus longicauda Ehrbg.
Phacus pyrum Ehrbg.
Volvox globator Ehrbg.
Pleodorina californica Shaw.
Cryptomonas ovata Ehrbg.
Peridinium tabulatum Ehrbg.
Ceratium brevicorne Hempel.
Paramecium aurelia O. F. Mull.
Stentor polymorphus O. F. Müll.
Stentor cœruleus Ehrbg.
Stentor barretti Barrett.
Halteria grandinella O. F. Müll.
Codonella cratera Leidy.
Tintinnopsis illinoisensis Hempel.

To these might be added *Didinium nasutum* O. F. Müll., mentioned by Zacharias ('94a), and *Trachelomonas caudata* Ehrbg, both of which were found in aquaria started with mud from the bottom of Phelps Lake.

One peculiar fact noted was the occurrence of a number of *Rhizopoda* in the surface towings. Prof. Frank Smith ('94) lists three species as occurring in surface collections in Lake St. Clair; Dr. C. A. Kofoid lists eight species from the waters

of Lake Michigan; while at Havana nine forms were found. These are as follows:

Arcella vulgaris Ehrbg.
Arcella vulgaris discoides Leidy.
Arcella vulgaris angulosa Leidy.
Arcella dentata Ehrbg.
Difflugia globulosa Duj.
Difflugia pyriformis Perty.
Difflugia lobostoma Leidy.
Difflugia corona Wallich.
Difflugia aculeata Ehrbg.

These forms appeared in the surface collections frequently, being at times quite a constant factor in the catches.

CLASSIFICATION.

Many different classifications of the *Protozoa* have been proposed, but the arrangement given by Bütschli ('80–'89) has been followed throughout in the construction of this list. Kent's "Manual of the Infusoria" ('80–'82) was mainly used in the determination of the species of that class. For the species described since the publication of Kent's Manual and Leidy's Rhizopods ('79) citations are given, by date, to the works containing the original descriptions, and these titles may be found in the list of literature appended to this paper.

SYNOPSIS OF THE HIGHER GROUPS OF PROTOZOA.*

I. Class *Sarcodina*. Forms that move about by a simple protoplasmic movement, by a flowing motion, or by the formation of protoplasmic processes (pseudopodia).
  1. Subclass *Rhizopoda*. Form usually protean; pseudopodia lobose or slender, more or less temporary structures without axial support, often restricted by a shell to a part of the body surface.
  Order *Rhizopoda*. (Includes all the recent forms of this subclass.)
    1. Suborder *Amœbæa*. Naked; pseudopodia lobose or filiform. Two families; one mostly marine.
    Amœbidæ. Pseudopodia usually lobose, never forming a network.

*Compiled from Bütschli ('80–'89).

2. Suborder *Testacea*. Shelled forms; pseudopodia lobose or filiform. Four fresh-water families.
   Arcellidæ. Shell homogeneous or incrusted with sand grains or other foreign material; pseudopodia lobose.
   Euglyphidæ. Shell built of round or hexagonal plates; pseudopodia filiform at tip.

2. Subclass *Heliozoa*. Body usually globose; pseudopodia thread-like, constant, radiating in all directions.
   1. Order *Aphrothoraca*. Naked, or with gelatinous envelope.
   2. Order *Chalarathoraca*. Coated with silicious bodies of a definite form, spicular, discoid, etc.
   3. Order *Desmothoraca*. Skeleton shell nearly or quite spherical, latticed, with numerous openings.

3. Subclass *Radiolaria*. Body globose, with a silicious shell; pseudopodia filiform, radiating in all directions. Marine.

II. Class *Sporozoa*. Parasitic forms, multiplying exclusively by spore formation.

III. Class *Mastigophora*. Provided with one or more vibratile anterior or lateral flagella; body not ciliated.
   1. Order *Flagellata*. One or more anterior, rarely lateral, flagella, not encircled by a membranous collar; body naked or loricated.
   2. Order *Choanoflagellata*. One anterior flagellum, encircledby one or two thin membranous raised collars.
   3. Order *Dinoflagellata*. Two flagella, anterior or lateral (if we consider the advancing pole in locomotion as the anterior end), one directed longitudinally, the other transversely, and usually encircling the body more or less; body with a shell or armor; no definite mouth.
   4. Order *Cystoflagellata*. Large, phosphorescent marine forms.

IV. Class *Infusoria*. Clothed with cilia, entirely or in part; cilia variously differentiated and modified.

1. Subclass *Ciliata*. Cilia persistent through life; food taken through a mouth, except in some parasitic forms.
   1. Order *Gymnostomata*. Mouth usually closed when not in use, without undulating membrane or well-developed ciliary structures; food taken by swallowing; throat, if present, without ciliary structures, usually surrounded by a wall of more or less indurated parallel longitudinal rods. Three families.
   2. Order *Trichostomata*. Mouth or throat rarely closed, provided with well-developed undulating membrane or ciliary structures, food usually drawn in or engulfed.
      1. Suborder *Aspirotricha*. Body invested with fine and comparatively uniform cilia, no anterior spiral adoral wreath.
      2. Suborder *Spirotricha*. A spiral to nearly circular adoral ciliary fringe bordering a differentiated peristome-field and ending at the mouth; cilia of fringe often broad or lamellate.
         1. Section *Heterotricha*. Entire surface usually rather uniformly ciliated, the adoral series larger than the rest, and more or less spirally arranged. Four families.
         2. Section *Oligotricha*. Body more or less globular or obconic; peristome-field wholly on the anterior end, adoral wreath nearly or entirely a closed circle; ciliation well developed to wanting; in some instances loricated. Four families.
         3. Section *Hypotricha*. Body usually flattened; ventral cilia modified into setæ or styles, back usually with rows of stiff bristles; peristome-field about in the plane of the ventral surface, adoral wreath bordering its left and anterior sides, and sometimes a part of its right side. Four families.
         4. Section *Peritricha*. Solitary or united in social colonies; cilia confined to the adoral wreath encircling the expanded terminal peristome-field; a

second circlet of cilia sometimes present at the opposite end of the body. Three families.

2. Subclass *Suctoria*. Cilia present only in the free-swimming young; food absorbed by tubular tentacles; reproduction by budding, rarely by division. Eight families.

Class *SARCODINA*.

Subclass RHIZOPODA.

Order RHIZOPODA.

Family **AMOEBIDÆ**.

Amoeba Bory.

Body naked, with pseudopodia; contractile vacuole and nucleus present; reproduction by bipartition in the active condition.

1. **A. proteus** Rösel.

This species appeared only in towings from the river channel at E in September.

2. **A. radiosum** Ehrbg.

A few examples of this interesting form were taken in the tow-net in Phelps Lake in July.

Pelomyxa Greeff.

Amœba-like, naked, usually quite large (up to 2 mm. in diameter), moving by means of short, broad pseudopodia, and commonly more or less slug-like when in motion. Nuclei very numerous.

3. **P. villosa** Leidy.

This was found sparingly in June, July, and August: in July with the preceding species in towings from Phelps Lake; and on the other occasions at C in bottom towings and in collections from the vegetation along the east shore.

Family **ARCELLIDÆ.**

ARCELLA EHRBG.

Shell chitinous, usually round, convex above, concave beneath with a large round opening at middle; color yellow or brown, its surface smooth or thickly pitted; usually several nuclei and contractile vacuoles.

4. **A. vulgaris** EHRBG.

This species occurred in small numbers in the towings throughout the year, except during the winter months, and in summer was occasionally found in collections from the vegetation along shore. It seems remarkable that none were found in towings from Thompson's Lake except a few which appeared in March, 1895.

5. **A. vulgaris discoides** LEIDY.

This variety was usually found in company with the typical form, in about the same numbers and similarly distributed. A single finding in midwinter at C is recorded, also its occurrence in Matanzas Lake.

6. **A. vulgaris angulosa** LEIDY.

Not so common as the preceding forms, but similarly distributed.

7. **A. dentata** EHRBG.

This form was very rare, and was seen but twice; once during August, and again in September, in towings from substation C.

DIFFLUGIA LECLERC.

Shell variously shaped, sometimes chitinous, but usually composed principally of small grains of sand and other foreign substances. Pseudopodia narrow, long, sometimes branching, rounded at the ends. Nucleus usually single.

8. **D. globulosa** DUJ.

This was widely distributed, occurring at all the substations, usually in the towings, and much less frequently in the Birge-net collections. It was never very common, but con-

tinued to appear throughout the year, becoming very scarce during cold weather.

9. **D. pyriformis** Perty.

Although this was even less common than the preceding species, its occurrences were quite uniformly distributed through the entire year, and it was recorded from all the principal substations. It was also found in Matanzas Lake. It appeared usually in the towings, rarely in shore collections. In February a few were taken in a towing at C, underneath a foot of ice.

10. **D. pyriformis vas** Leidy.

Not common; taken only in July and August in towings from substations K and L (Flag and Dogfish lakes).

11. **D. pyriformis compressa** Carter.

In July and August a few appeared in towings from Thompson's and Dogfish lakes.

12. **D. urceolata** Carter.

No individuals of this species were found in any of the collections, but in November a quantity of dried mud was collected from the bed of Phelps Lake, which was entirely dry at this time, and several small aquaria were started by placing some of this mud in jars of filtered water. Several examples of *D. urceolata* appeared in these aquaria, as well as other forms which will be mentioned in their proper place.

13. **D. acuminata** Ehrbg.

Like *D. pyriformis*, this was scarce, but generally distributed through the year and at the various substations. It also occurred under the ice at C in February, and in Matanzas Lake. With one exception it was found only in the towings.

14. **D. lobostomata** Leidy.

This species was very generally distributed. It was found almost entirely in the towings, associated with *D. globulosa*. In the fall it became common and even abundant, but was noticeably sparser in winter. This species was among those collected from under the ice at C in February. It is also recorded from Matanzas Lake.

D. lobostomata may be easily mistaken at first for *D. globulosa*. It is smaller than *globulosa*, however, and long in proportion to its width. I have found both species in the stomachs of rotifers.

15. **D. corona** Wallich.

This beautiful and attractive species was moderately common throughout the year, less common in winter, appearing in collections from nearly all of the substations, usually in towings, but often also in shore collections.

Schewiakoff ('93) identifies this species with *D. lobostoma*, but in my judgment the two species are distinct. *D. corona* is larger and more spherical than *lobostoma*, and the fundus always bears one or more spines. In *corona*, the border of the mouth has quite a number of lobes or crenulations, while in *lobostoma* there are usually but three or four lobes present. Among all the specimens of *D. lobostoma* that I have examined there was but one which had more than three lobes; and, on the other hand, I have never seen a *corona* with so small a number of lobes.

16. **D. aculeata** Ehrbg.

Centropyxis aculeata Ehrbg.

The record of this species shows it to be much scarcer than the two preceding, although occurring pretty uniformly through the year. It was found both in towings and shore collections, and seems to prefer weedy waters.

17. **D. tuberculosa** Hempel ('96).

Found in three out of six towings taken on one occasion in Matanzas Lake in August. But few individuals were found. In the following season a few examples were taken in the river channel at E in September and October. It is easily recognized and remembered by its irregular outline and by the presence of tubercles.

18. **D. fragosa,** n. sp. (Fig. 1, 2.)

This form was found several times, and seems to be new.

Shell composed of fine sand grains, irregular in form, about one and a half times as long as wide, widest at fundus, thence tapering to the mouth where it is slightly constricted; mouth irregular, slightly notched. The peculiarity of this species is the presence upon the fundus of from one to eight ascending processes or spines, rounded at tip. These originate at about the middle of the shell, giving an irregular outline to the shell when seen from above. Pseudopodia simple, fine, and few in number.

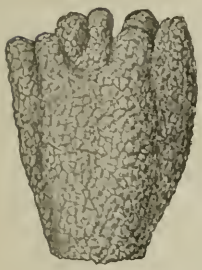

Fig. 1, Difflugia fragosa, n. sp. Lateral view.

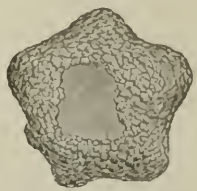

Fig. 2, Difflugia fragosa n. sp. View showing mouth opening.

Length .23 mm., width .15 mm.

It appeared occasionally from August to November of the second year in towings, mostly from the river at E, with a few from lake substations (G and C).

Family **EUGLYPHIDÆ.**

Euglypha Duj.

Shell uniaxial, formed of round or hexagonal silicious plates in overlapping rows; mouth opening usually toothed. Pseudopodia not anastomosing.

19. **E. alveolata** Duj.

Rare, occurring only in a towing from C in May.

Subclass HELIOZOA.

(Sun Animalcules).

Order APHROTHORACA.

Actinophrys Ehrbg.

Body soft, spherical, with numerous radiating fine filamentous pseudopodia; endosarc finely granular; ectosarc vacuolated; division between the two not well marked. Nucleus single, central; usually a large contractile vacuole in the periphery.

20. **A. sol** Ehrbg.

This occurred only during the warmer half of the year, from June to October, largely in collections from among vegetation, where it was on one occasion quite common. A few were found in lake towings.

Actinosphærium Stein.

Body spherical, with numerous long tapering radiating pseudopodia; protoplasm vacuolated, vacuoles of the ectosarc larger than those of the endosarc, the division between endosarc and ectosarc distinctly marked. Nuclei numerous; contractile vacuoles located at the periphery.

21. **A. eichhornii** Ehrbg.

This interesting and fine species was seen only a few times, appearing in towings from the river and Dogfish Lake from July to September.

Order CHALARATHORACA.

Raphidiophrys Archer.

Isolated, or united into colonies. Body spherical, with numerous fine, long, straight, radiating pseudopodia; division between endosarc and ectosarc not distinct. One or more nuclei. Surface layer densely filled with fine, straight or curved spicules, tangentially arranged.

22. **R. pallida** Ehrbg.

Found in small numbers in towings from substation C, in Quiver Lake, during July and August.

23. **R. elegans** Hertw. Less.

Rare, occurring only in September, in towings from C.

Class *MASTIGOPHORA.*

Order FLAGELLATA.

Suborder MONADINA.

Family **HETEROMONADIDÆ.**

Subfamily **Dendromonadinæ.**

Anthophysa Bory.

Zoöids minute, obliquely pyriform, united into round clusters of fifty to sixty, which are borne upon the extremities

of a dichotomously branching pedicel; anterior extremity prolonged into a spine-shaped process on one side. Flagella two, one much shorter than the other. Nucleus and contractile vacuole usually conspicuous.

24. **A. vegetans** O. F. Müller.

A number of colonies were found in an aquarium started with mud from the dry bed of Phelps Lake.

Subfamily **Dinobryoninæ.**

Dinobryon Ehrbg.

Animals in transparent loricæ, which are united into branching colonies. Free-swimming; zoöids with a long and a short flagellum, an anterior pigment spot, and two lateral chromatophores.

25. **D. sertularia** Ehrbg.

Very common and often extremely abundant in the towings, especially from waters containing vegetation, during the period from December to June.

26. **D. sertularia divergens** Imhof.

Observed in May, in towings from substation C.

27. **D. sertularia angulatum** Seligo.

Abundant in the towings from Dogfish Lake in April.

28. **D. sertularia undulatum** Seligo.

Common in the river towings from E during April.

Suborder EUGLENOIDINA.

Family **EUGLENIDÆ.**

Euglena Ehrbg.

Animals free-swimming, generally oval to elongate, usually obtuse anteriorly, and more or less prolonged and attenuate posteriorly. A well-developed mouth and flagellum at the anterior end, and near this end a red pigment spot. Color usually green.

In the latter part of summer *Euglena* is universally abundant, even in the smallest pools and ditches. At certain

times of day, except in case of a storm, these and related species appear in vast numbers at the surface of the water, forming the "water-bloom." In the vicinity of the Station, this frequently formed green, brown, or red patches along the shores, or drifted down the main channels in long streaks or broad areas, not dense enough to be evident when close at hand but very noticeable if viewed obliquely from a short distance. On small pools the water-bloom often becomes a dense green, paint-like, scum. It frequently consists in great part of some single species. *Euglena* is readily eaten by rotifers and by some *Protozoa*. The rotifer *Eosphora aurita* was found in the water-bloom.

29. **E. viridis** Ehrbg.

During the warmer season, from May to September, this was frequent to abundant in the towings from most of the substations, and very abundant in the water-bloom that was examined. This species is highly changeable in shape.

30. **E. spirogyra** Ehrbg.

A few were found in a towing from Phelps Lake in July. This pretty species preserves its form better than the preceding, is slightly thicker in proportion to its length, and its surface is marked with oblique rows of small bead-like elevations.

31. **E. acus** Ehrbg.

Occurred from July to September, in small numbers, in towings from the river and several lakes. It is very slender, ending posteriorly in a sharp point, and is persistent in shape.

32. **E. oxyuris** Schmarda.

Frequent and often common during about the same period as that recorded for *viridis*; occurring from June to October. It is elongate, obliquely striate, often spirally contorted. A fine species, persistent in shape, and easily recognized.

33. **E. torta** Stokes ('85).

This small species was observed but once, namely, in a towing taken from Phelps Lake in July. It agreed in all particulars with Dr. Stokes's description, and the species appears

to be well defined and valid. It is elongate, with three longitudinal spiral furrows or elevations.

Amblyophis Ehrbg.

Very similar to *Euglena* in structure and colors, but with the posterior end rounded, not at all acuminate.

34. **A. viridis** Ehrbg.

Found infrequently in the river channel at E in August and September.

Trachelomonas Ehrbg.

Differs but little from *Euglena*, except that it is enclosed in a lorica or shell, varying in shape from elongate-oval to spherical, and with a minute anterior opening, through which the flagellum issues.

35. **T. caudata** Ehrbg.

This appeared in large numbers in aquaria started with dried mud from the empty bed of Phelps Lake. Within two days after starting the aquaria the *Trachelomonas* began to develop. At first they had no loricæ, and were scarcely distinguishable from *Euglena viridis*. After a short time the lorica began to appear, first around the central and anterior parts of the body. At this stage, before the posterior part of the lorica had become fully formed and hardened, the animals while swimming about would occasionally contract the body, drawing the posterior part into the lorica.

In the second year's work a few were found in August and September in towings from the river at E.

36. **T. acuminata** Schmarda.

Phelps Lake, with its shallow water and lack of vegetation, seemed to be well fitted for the development of the *Euglenidæ* during the first season of our work, since more species were found here than at any other of the substations. *T. acuminata* was scarce, appearing in the lake in July and August. It is also recorded from Matanzas Lake.

37. **T. armata** Ehrbg.

A single occurrence is recorded, namely, at C in July.

38. **T. urceolata** Stokes.

Rare; found during September in towings from the river at E.

39. **T. torta** Stokes ('88).

Observed only in September, in towings from the river and Dogfish Lake. Not common.

40. **T. hispida** Stein.

Found in towings from Dogfish Lake in September.

Family **CHLOROPELTIDIDÆ.**

Phacus Nitzsch.

Persistent in shape, ellipsoidal to pyriform, mostly compressed and leaf-like, with a posterior, pointed, tail-like prolongation; cuticle indurated, longitudinally or spirally striated; mouth and throat asymmetric, opening dorsally; body green, with anterior pigment spot.

41. **P. triqueter** Ehrbg.

Scarce; found in September in towings from the river channel.

42. **P. pyrum** Ehrbg.

Found but once, namely, in a towing from the river channel in October.

43. **P. longicauda** Ehrbg.

This fine and attractive species was present in small numbers from June to September, and was generally distributed. A single occurrence in October is also on record.

Suborder ISOMASTIGODA.

Family **CHRYSOMONADIDÆ.**

Synura Ehrbg.

Individuals oval to elongate, each contained in a membranous lorica, commonly united into free-swimming subglobose colonies; flagella two, subequal; one or more colored eyespots.

44. **S. uvella** Ehrbg.

This species was seen only occasionally at first, a few being observed in April and a single one in July. In October and November it became common in the river towings, and from December to March was more or less abundant at all the substations under examination, reaching its maximum in January.

Family **VOLVOCIDÆ.**

Pandorina Bory.

Colonies free-swimming, spherical to oval, consisting usually of 16, rarely 32, individuals closely joined at a common center.

45. **P. morum** Bory.

Observed only during the second year's work, from April to September, and again from January to March. It was quite common, but was not found in Phelps Lake. This species forms an important element in the food of large rotifers.

Volvox Linn.

Colonies spherical, large, consisting of many thousand similar zooids forming an enclosing wall about a large central gelatinous mass.

46. **V. globator** Linn.

Abundant and well distributed in the field studied, except in Phelps Lake, where it was only seen once. In midwinter it became rare. It was abundant near the field laboratory in Quiver Lake during July, and though many were taken here in the bottom towings, none appeared in the surface towings made during the day.

Pleodorina Shaw.

Colonies more or less oval, consisting of about 128 individuals of two kinds, the large ones about one pole and the small ones about the other, enclosing a central gelatinous mass.

47. **P. californica** Shaw ('94).

Occurred from July to October in both years, often in great abundance, in towings and among vegetation in the river and deeper lakes.

Family **CRYPTOMONADIDÆ.**

Cryptomonas Ehrbg.

Free-swimming, ovate or elongate, anterior end oblique, with a peristome-like excavation, in which is the oral opening, leading to a distinct pharynx; two flagella issuing from beneath a lip-like anterior marginal prolongation; two lateral brown to green chromatophores.

48. **C. ovata** Ehrbg.

This was found in both years, but only in September and October. Except a record from substation L it was taken only in the river at E, where it was found excessively abundant in both months.

Order CHOANOFLAGELLATA. (Collared Monads.)

Family **CRASPEDOMONADIDÆ.**

Subfamily **Codonosiginæ.**

Diplosiga Frenzel.

Individuals attached singly, without pedicel; two concentric anterior membranous collars, the inner one small.

49. **D. frequentissima** Zach. ('94).

Taken abundantly in April, 1896, and in smaller numbers during the following month in towings from the river channel at E. These minute individuals were attached to the rays of *Asterionella*, a colonial diatom.

Astrosiga Kent.

Individuals united into stellate colonies by the attachment of their pedicels at a common center.

50. A. radiata Zach. ('94).

One example observed by Dr. Kofoid in plankton from the river at E, in May.

Subfamily **Salpingœcinæ.**

Salpingœca James-Clark.

Loricated, solitary, attached directly or by pedicel.

51. S. minuta Kent.

This extremely small form was found attached to the loricæ of *Dinobryon sertularia* from the river, in May.

Order DINOFLAGELLATA.

Suborder DINIFERA.

Family **PERIDINIDÆ.**

Peridinium Ehrbg.

Free-swimming, covered with an ornamented shell encircled by an equatorial groove, dividing the shell into two similar halves, the anterior formed of thirteen or fourteen plates, the posterior of seven, two of which, nearest the posterior extremity, are each often drawn out distally into a horn-like prolongation. A moderately wide longitudinal groove extends back from the equatorial groove at the middle of the ventral surface. Two flagella, one of which lies in the equatorial groove.

52. P. tabulatum Ehrbg.

Found in July and August, but only in Thompson's and Matanzas lakes, abundantly in the former situation though not in any of the intervening waters.

Ceratium Schrank.

Differing from *Peridinium* especially in the form and structure of the shell. This is somewhat flattened dorsoventrally, with a broad uncovered area on the ventral surface;

the two ends and two lateral plates just back of the equatorial groove drawn out into horn-like processes, often much longer than the width of the shell, usually the left process not developed, so that there are but three in all; the two halves similar in size and texture, the anterior with six plates, the posterior with four.

53. **C. hirundinella** O. F. Müll.

A few individuals were noted in towings from the river and Thompson's Lake in August and September of the second year only.

54. **C. brevicorne** Hempel ('96).

A few were taken in the river channel at E in August and September, also in each of six successive towings in Matanzas Lake in August.

Class *INFUSORIA.*

Subclass CILIATA.

Order GYMNOSTOMATA.

Family **ENCHELIDÆ.**

Subfamily **Holophryinæ.**

Lacrymaria Ehrbg.

A distinct circle of large cilia around the mouth; body narrowed anteriorly and more or less bottle-shaped, moderately elastic.

55. **L. truncata** Stokes ('85a).

Taken only once, in a Birge-net collection amongst vegetation at the mouth of Dogfish Lake, in August.

Subfamily **Colepinæ.**

Coleps Nitzsch.

More or less barrel-shaped, axis slightly curved; persistent in shape; covered with quadrangular plates in checker-board arrangement, with intervening spaces in which arise rows of

long cilia. A circle of cilia surrounds the large terminal mouth opening.

56. **C. hirtus** Ehrbg.

This lively and interesting little species was taken mostly from June to September in both years, with scattering occurrences in May, October, and December. It was not very common, although widely distributed.

Subfamily **Cyclodininæ.**

Didinium Stein.

Obovate or obconic, anterior end feebly convex to distinctly concave, the mouth borne on a prominent conical elevation; ciliation reduced to an anterior and a median circle, the latter sometimes wanting.

57. **D. nasutum** O. F. Müll.

One or two examples of this very peculiar protozoan were found in the aquaria started with dried mud from Phelps Lake. It is a fine species of striking form and very quick movements.

Family **TRACHELIIDÆ.**

Subfamily **Amphileptinæ.**

Amphileptus Ehrbg. (Swan Animalcules.)

Elastic, ovate, anterior part more or less flattened and produced like an elephant's trunk, along the lower edge of which (oblique in side view) extends the slit-shaped mouth; surface entirely and finely ciliate; contractile vacuoles single or multiple.

58. **A. anser** Ehrbg.

Found in August in a Birge-net collection from among plants at the mouth of Dogfish Lake.

Dileptus Duj.

Elongate, with a very long, slender flexible snout, along the ventral edge of which is a band of trichocysts, ending at the

round mouth-opening at the base of the snout. A row of cilia extends along each side of the band of trichocysts and around the mouth; ciliation of body fine and uniform.

59. **D. anser** O. F. Müll.

Taken once, in August, with the Birge net, in vegetation on the west side of the river at E.

Family **CHLAMYDODONTIDÆ.**

Subfamily **Nassulinæ.**

Nassula Ehrbg.

Oval or somewhat elongate, ends equally rounded; mouth circular, situated on the ventral surface back of the anterior extremity, left side more or less constricted beside the mouth; a row of stronger cilia extending from the mouth along the constriction; body finely and evenly ciliated, usually highly colored, with a pigment spot at the constriction.

60. **N. ornata** Ehrbg.

Found once, in an aquarium started with dried mud from Phelps Lake.

Order TRICHOSTOMATA.

Suborder ASPIROTRICHA.

Family **PARAMÆCIIDÆ.**

Paramæcium O. F. Müll. (Slipper Animalcule.)

Ovate to elongate, flexible; densely, finely, and evenly ciliated; peristomal groove feebly or moderately excavated, narrowing posteriorly, and ending in the oval mouth, which is in the middle part of the ventral surface; one or two stellate contractile vacuoles.

61. **P. aurelia** O. F. Müll.

Very few individuals of this common species were found, possibly because of the lack of stagnant water at any of the substations. A few were taken among vegetation and in towings in August, and examples appeared in towings in October and January, all in the main river.

Suborder SPIROTRICHA.

Section HETEROTRICHA.

Family **PLAGIOTOMIDÆ.**

CONCHOPHTHIRIUS STEIN.

Colorless, not elastic, strongly compressed, in lateral view oval; mouth usually near the middle of the ventral edge, which is here sinuated because of the more or less excavated trough-like peristome-field; ciliation uniform, cilia rather long, usually a few larger ones along the anterior edge of the peristome-field and at the posterior extremity.

62. **C. anodontæ** EHRBG.

Among the gills of *Unio anodontoides* from the river in July. Found also in other Unionidæ.

SPIROSTOMUM EHRBG.

Colorless or green, elongate, often very much so, very elastic and flexible, rarely compressed; peristome-field narrow and long, extending from near the anterior end nearly straight to the mouth, with a zone of adoral cilia upon its left margin, turning obliquely into the mouth; ciliary striation very distinct, and slightly oblique; dorsally a long, canal-like extension from the large contractile vacuole at the posterior end.

63. **S. teres** C. & L.

Found only once, in August, in a towing from Quiver Lake.

Family **STENTORIDÆ.**

STENTOR OKEN.

Fixed or free-swimming at will; trumpet-shaped when expanded, tapering to the attached posterior end, the anterior end broad and flattened, occupied entirely by the peristome-field, which is encircled by the adoral zone of cilia; this takes a slightly spiral course on the ventral edge of the peristome-field, descending into the pharynx; ciliation of body very

fine, in longitudinal rows, often with intervening bristles; body more or less contracted when free-swimming; when attached, often protected by a tubular gelatinous sheath.

64. **S. polymorphus** O. F. Müll.

Not very common at any time, occurring now and then from April to July in towing and vegetation collections taken in lakes. In an aquarium in the zoölogical laboratory of the University this species was very abundant, large colonies more than half an inch in diameter being formed, consisting of a gelatinous substance in which the animals were fixed.

65. **S. roeselii** Ehrbg.

Not common; found in towings and among vegetation in the river and in Quiver Lake.

66. **S. barretti** Barrett.

A few examples seen in March from the river at E. This is closely allied to *S. roeselii*, but to me the two appear distinct.

67. **S. cœruleus** Ehrbg.

Found in some catches from along the shores of Quiver Lake in May, in one of which it was common. This form also occurred in aquaria at the University laboratory. Small glass jars were filled with water containing some of them, and after these had stood for several weeks the inner surface of the jars was fairly lined with the *Stentor*. They reproduce very rapidly, and with a little care a constant supply for laboratory use can be kept on hand.

68. **S. igneus** ? Ehrbg.

A *Stentor* was found several times in the towings, which I have doubtfully referred to this species. It was found once in Dogfish Lake in August, and afterwards in towings from the river at E from November to January, being abundant in December.

69. **Stentor** sp.

A small green species was found in a weedy bay—the "Pumpkin Patch"—at the head of Quiver Lake; but was not definitely determined.

Section Oligotricha.

Family **HALTERIIDÆ.**

Strombidium C. & L.

Free-swimming, colorless, yellowish, or green, usually persistent in shape, globose, pyriform, or urceolate, usually narrowed or pointed behind; anterior end convex, encircled by the adoral zone, the oral end of which follows a ventral excavation back to the mouth-opening towards the middle of the body; without cilia except a few on the ventral surface, either irregularly scattered or in a short oblique row.

70. **S. claparedi** Kent.

Rare; taken in September and December in the river and Thompson's Lake.

Halteria Duj.

Free-swimming, colorless, persistent in shape, more or less globose, anterior end feebly convex, adoral zone about as in *Strombidium*, to which the genus is closely allied. Surface with a number of long stiff bristles or springing hairs, irregularly scattered or gathered into an equatorial zone. By means of these bristles the animal progresses with a succession of quick springing or leaping movements, as indicated by the name of the genus.

71. **H. grandinella** O. F. Müll.

This peculiar species was of frequent occurrence from June to September, and a few were seen in January and February. It was very generally distributed.

Family **TINTINNIDÆ.**

Tintinnopsis Stein.

Lorica chitinous, usually campanulate, structureless; numerous foreign particles imbedded in its outer surface, mostly grains of sand.

72. **T. illinoisensis** Hempel ('96).*

Found in April and May, in company with *Codonella cratera*, in towings from the Illinois River, Thompson's Lake,

*Subsequent studies by Dr. Kofoid indicate that this form is not specifically distinct from *Tintinnidium fluviatile* Stein.

and Quiver Lake. In the following year it was again noted in small numbers, during August and September, in towings from the river at E.

Codonella Haeckel.

Lorica indurated, short-urceolate in form, composed of hexagonal or circular areolets, each with a darker central dot; structure usually more or less obscured by a covering of foreign particles, a slight constriction at the base of the neck of the lorica; peristomal cilia often altered into leaf-like lamellæ.

73. **C. cratera** Leidy.

Difflugia cratera Leidy.

Few species among the *Infusoria* attract so much attention as this. It was frequent to abundant in towings from the deeper and more permanent bodies of water under examination, continuing apparently throughout the year. At Thompson's Lake it was abundant in December, and again in February was found in a towing from under eighteen inches of ice. On one occasion in the latter part of August six towings were taken in different parts of Matanzas Lake and examples of *C. cratera* were found in all but one of these towings. This lake is fed almost entirely by springs, and consequently the water is in places comparatively cool during the summer, thus affording a congenial habitat for species that thrive best in cold waters. One towing was taken near the point where the water from a large spring enters the lake, and contained an abundance of this form. The species serves as food for such rotifers as *Asplanchna* and *Asplanchnopus*.

Section Hypotricha.

Family **OXYTRICHIDÆ.**

Subfamily **Pleurotrichinæ.**

Stylonychia Ehrbg.

Free-swimming, persistent, obovate or elliptic, peristome not greatly narrowed; anterior styles usually eight, occupy-

ing a more or less circular area; five claw-like ventral styles and five straight anal styles; three long caudal setæ at the posterior extremity.

74. **S. mytilus** Ehrbg.

This species seems to avoid the open water, as it did not occur in the towings, although it was not uncommon in occasional shore collections among vegetation in June and again in December.

Section Peritricha.

Family **VORTICELLIDÆ.**

Subfamily **Urceolarinæ.**

Trichodina Ehrbg.

Free-swimming, more or less short-cylindrical, elastic and flexible, especially the peristome end, which bears a well-developed adoral zone; posterior end forming an adhesive disc, bearing a complicated attachment-ring of radiating structure which is encircled by a posterior ciliary wreath, used in creeping and swimming, margin of disc forming a thin transparent edge. Parasitic on the surface of *Hydra* and other invertebrates.

75. **T. pediculis** Ehrbg.

Frequent on *Hydra viridis*, in towings from Dogfish Lake (substation L) in April.

Subfamily **Vorticellinæ.**

Scyphidia Duj.

Not forming colonies; individuals elongate-cylindrical, attached by a posterior disc which does not bear a ring of cilia; peristome moderately well developed. Parasitic upon mollusks.

76. **Scyphidia** sp.

A species of this genus was observed on the siphonal papillæ of *Unio parvus*, but was not determined.

Vorticella Linn. (Bell Animalcule.)

Inverted bell-shape, attached singly by a slender pedicel containing a highly contractile central thread; peristome end usually very wide; nucleus usually band-like. Many species of this genus were found, but few of them could be determined with any certainty.

77. **V. campanula** Ehrbg.

Found in July among *Lemnaceæ* and other vegetation in Quiver Lake and the river, and once again in December in a river towing.

78. **V. microstoma** Ehrbg.

A few were noted in July, taken from among *Lemnaceæ* upon the river at E.

79. **V. similis** Stokes ('87).

Common in July on roots of *Lemnaceæ* in the very weedy bay of Quiver Lake known as the "Pumpkin Patch."

Carchesium Ehrbg.

Animals like *Vorticella*, but forming tree-like colonies, the individuals borne upon the tips of a single branching stalk, with a contractile central thread. At the forkings of the stems the contractile thread of one branch is continuous with that of the stem below, while that of the other is not connected, thus permitting the independent extension and contraction of the separate zoöids.

80. **C. polypinum** Linn.

This was also found on the roots of *Lemnaceæ* in the "Pumpkin Patch" in July. The colonies found were rather small. It was not common.

81. **C. lachmanni** Kent.

This species was abundant about the field laboratory in Quiver Lake in May. It was first noticed in some breeding-cages used in rearing aquatic larvæ. It multiplies very rapidly in foul or stagnant water. Some were placed in glass jars in the laboratory, and in a few days the entire inner surface of the jars was coated with a dense grayish layer.

82. **C. granulatum** Kell.

Many large colonies of this species were found in May upon an Asellus taken from the west side of the river at E.

Zoothamnium Bory.

Similar to *Vorticella* and forming branching contractile colonies; but in this genus the contractile central thread is continuous throughout, dividing with each branching of the stem, whereby the act of contraction involves the entire colony.

83. **Z. arbuscula** Ehrbg.

This interesting and beautiful form was met with twice in the towings; in June from Quiver Lake, and in August from the river at E. A number were found on the latter occasion. The colonies are usually large and symmetrical, and when once seen will be remembered.

Epistylis Ehrbg.

Animals forming colonies, borne on a rigid, noncontractile tree-like pedicel; individuals bell-shaped, more or less elongate to cylindrical; adoral zone encircling a slightly raised disc within the peristome margin, its oral end descending at one side, through an excavated vestibule, to the mouth opening; anterior end not so flexible as in *Vorticella*.

Several species were found, but only two could be definitely determined.

84. **E. plicatilis** Ehrbg.

Found at various times, especially in May, at a number of different places, twice in river towings, but usually attached to various insect larvæ, and on the shells of water-snails, such as *Physa* and *Vivipara*. *Tokophrya quadripartita* was sometimes found associated with it.

85. **E. flavicans** Ehrbg.

This species was noted as abundant on plants on two occasions in summer, and was found to be quite generally distributed, though not very abundant, in towings taken in the winter time.

Rhabdostyla Kent.

Similar to *Epistylis*, but not forming colonies.

Several undetermined species of this genus were found on various *Entomostraca*, on a rotifer (*Polyarthra platyptera*), and on small aquatic worms.

Opercularia Goldf.

Forming colonies as in *Epistylis*, individuals more or less narrowed at the anterior end, peristome not laterally expanded; adoral disc very strongly elevated, while the surrounding peristomal ring is deeply excavated and the vestibule conspicuously wide and very deep; the adoral disc is therefore borne upon a column, on which it is usually obliquely placed, looking like a ciliated lid to the anterior end.

86. **O. nutans** Ehrbg.

Found in May on a *Planorbis* from Quiver Lake at C.

87. **O. rugosa** Kell. ('84).

Common among vegetation; a few found in bottom towing in Quiver Lake. Observed in May and July in the river and in Quiver and Thompson's Lakes. This is a fine species, and can be easily recognized by its thick pedicel and sessile zoöids. Schewiakoff ('93) marks the species with an interrogation point, but I see no reason for it.

88. **O. irritabilis** Hempel ('96).

This fine large species was found at a variety of places from May to July, during which time it was common and aften abundant, always occurring attached to the surface of some animal, especially young musk-turtles (*Aromochelys odoratus*). It was also found upon the backs of snapping turtles (*Chelydra serpentina*), and on two kinds of crayfishes, *Cambarus diogenes* and *C. blandingii acutus*. Its food consists partly of diatoms and *Euglena*.

The species is similar to *Opercularia articulata* Ehrbg., but differs from it in the shape of the body, the character of the peristome border and pharynx, and the elevation of the ciliary disc.

Tokophrya quadripartita was found common in company with this species, as was also a small *Opercularia*, which may prove to be only a variety of *irritabilis*. The zoöids of this small form measured .08 mm. in length and .042 mm. in width, but otherwise seem to agree with those of *irritabilis*.

Cothurnia Ehrbg.

Animal similar to *Epistylis*, but more elongate; contained in a lorica which is subcylindrical, of variously modified shapes, often expanded at middle and narrowed near the opening, attached posteriorly, either directly or by a short pedicel; sometimes closed when the animal is retracted within it. Nucleus elongate, band-like.

89. **C. curva** Stein.

Found upon *Urnatella gracilis* in July, in bottom towings from the river at E.

Vaginicola Lam.

Animal similar to that of *Cothurnia*; lorica sac-like, narrowed at the opening, attached lengthwise by the ventral surface and flattened, the opening turned upwards.

90. **V. gigantea** D'Udek.

A few individuals were found in September among vegetation in Thompson's Lake.

Subclass SUCTORIA.

Family **ACINETIDÆ.**

Tokophrya Bütschli.

Solitary, not loricated, globose to elongate, attached posteriorly by a rigid pedicel; reproducing by the formation of ciliated embryos within the body of the parent.

91. **T. cyclopum** C. & L.

In May and July a few were found on *Cyclops* in towings from Quiver Lake and the river.

92. **T. quadripartita** C. & L.

This was the commonest of the *Suctoria* in our collections.

It occurred principally in May and June, in collections from a number of substations, and was usually found associated with *Epistylis plicatilis* and *Opercularia irritabilis*, attached to small animals taken among vegetation. It is recorded from *Cambarus diogenes*, *C. blandingii acutus*, *Chelydra serpentina*, *Aromochelys odoratus*, and larvæ of *Hexagenia*.

Acineta Ehrbg.

Solitary, ovate or elongated, basally or entirely within a cup-like lorica with a rigid pedicel; reproduction as in *Tokophrya*.

93. **A. mystacina** Ehrbg.

In the aquaria started with dried mud from Phelps Lake this species was quite common. It is very voracious, living upon *Ciliata*. Several specimens were observed while thus eating, and the passage of food particles through the tentacles was easily seen.

ROTIFERA.

The researches and investigations of morphologists during recent years have led to a clearer and fuller acquaintance with the details of animal structure, thus stimulating study along related lines. The field of the systematist has thus been broadened and extended. With a thorough knowledge of the anatomy of the animal body rather than a mere acquaintance with its external appearance, he is now better able to trace the relationships of the various subdivisions of the animal kingdom, and to place each form in the group to which it properly belongs. At the same time has come the study of œcology—the relation of organisms to each other and to their environment. Nothing can be more fascinating, or of more value in solving the general problems of life than this study of interrelations and dependences; but it cannot be carried on rightly unless our knowledge of the morphology, habits, etc., of the forms under observation is as complete as science can make it. Nor should this study be confined solely to animals of large size and easy of access; it must be

extended until it includes the minutest creature; for it is through these simple, minute organisms that we may arrive at the relations which exist between the inorganic and the organic.

The *Rotifera* constitute one of these groups of minute animals. It is a somewhat small group, consisting of about six hundred known species, one hundred and seventy of which have been found in the United States. They range in length from .05 to 2.5 mm. The body is usually elongate, sac-like or more or less oval, and is commonly provided with two circles of cilia on the corona or frontal border of the head, which, as the name indicates, have the appearance of two small wheels. These cilia are used in locomotion, and also assist the animal in obtaining food, since by their rapid vibration a stream of water is directed towards the mouth or buccal orifice, carrying with it particles of food material. The word *rotifer* is, however, misleading, since in many cases the circles of cilia or ciliary discs are so modified that they have lost all resemblance to a wheel. Sometimes but a single disc is present; again, there may be merely a row of cilia around the anterior border of the animal; and in rare cases the cilia are even entirely wanting. Some of the *Rotifera* have the body covered with a very thin chitinous external cuticula, while a great many have a hard, inflexible carapace or lorica. A number of species inhabit tubes, which they either secrete or build up from surrounding debris and pellets of excreta.

Members of this group are readily recognized by the presence of the mastax, a more or less irregularly three-lobed muscular organ, containing the teeth, jaws, or trophi, as they are variously called. These are composed of chitin, are hard and durable, and are true masticatory organs. Although some of the rotifers have no cilia, all of them agree in having a mastax and trophi, and as these structures are peculiar to the *Rotifera* they afford a ready means of identification.

The mastax is usually situated in the anterior part of the body, just behind the buccal orifice or lips, and a short œsophagus connects it with a large stomach lying in the posterior dorsal part of the animal. Many rotifers have the

power of protruding the trophi through the buccal orifice, and they may often be found nibbling at algæ and other aquatic plants. Although the trophi are used by many rotifers to crush their food, there are some large forms, like *Asplanchna*, that swallow their food entire, as is shown by the uninjured rotifers, protozoans, and algæ found in their stomachs.

The chitinous jaws or trophi (Fig. 3) consist typically of two hammer-like lateral parts, the mallei, bearing one to seven comb-like apical teeth, and working upon the two halves of a divided central part, the incus. The mallei are usually separable into an apical part bearing the teeth, the uncus, and a basal part, the manubrium. The two divisions of the incus are the rami and its basal projection is the fulcrum. These inner and outer pairs vary greatly in relative development, the mallei in some groups disappearing entirely. Hudson and Gosse recognize seven types of trophi, as shown in the figure below. Dr. Hudson's summary of the distinguishing features of these types is given on the next page.

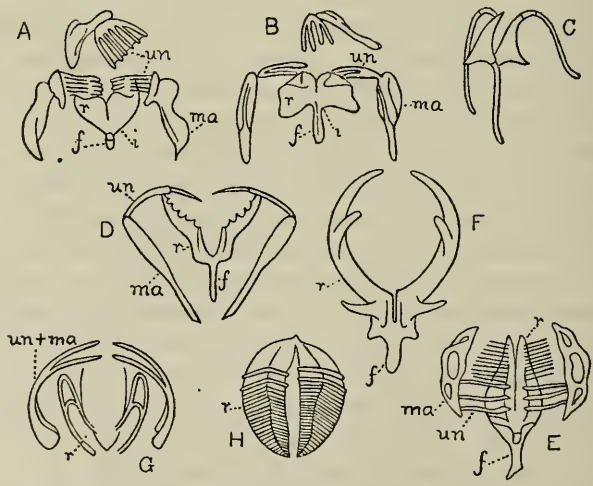

Fig. 3, Diagram of trophi: A, malleate; B, sub-malleate: C, virgate; D, forcipate; E, malleo-ramate; F, incudate; G, uncinate; H, ramate. *f*, fulcrum; *i*, incus; *ma*, manubrium; *r*, ramus; *un*, uncus. (After Hudson, from the Cambridge Natural History.)

Malleate (A). Mallei stout; manubria and unci of nearly equal length; unci 5- to 7-toothed; fulcrum short; as in *Brachionus urceolaris.*

Sub-malleate (B). Mallei slender; manubria about twice as long as the unci; unci 3- to 5-toothed; as in *Euchlanis deflexa.*

Virgate (C). Rami as well as mallei rod-like; as in *Furcularia.*

Forcipate (D). Mallei rod-like; manubria and fulcrum long; unci pointed or evanescent; rami much developed and used as a forceps; as in *Diglena forcipata.*

Malleo-ramate (E). Mallei fastened by the unci to rami; manubria 3 loops soldered to the unci; unci 3-toothed; rami large, with many striæ parallel to the teeth; fulcrum slender; as in *Melicerta ringens.*

Incudate (F). Mallei evanescent; rami highly developed into a curved forceps; fulcrum stout; as in *Asplanchna ebbesbornii.*

Uncinate (G). Unci 2-toothed; manubria evanescent; incus slender; as in *Stephanoceros eichhornii.*

Ramate (H). Rami sub-quadrantic, each crossed by two or three teeth; manubria evanescent; fulcrum rudimentary; as in *Philodina roseola.*

The œsophagus, connecting the mastax and stomach, is lined with cilia, which by their vibratory motion cause a constant stream of water to flow towards the stomach, carrying particles of food with it.

The stomach is a large sac with thin walls, and usually contains a number of oil or fat globules. This may be demonstrated by killing rotifers with osmic acid, when the oil globules will be turned black by the acid. It is astonishing to see how much may be crammed into the stomach of a rotifer. I have frequently found specimens of *Asplanchnopus* with six or seven other rotifers in its stomach, and I once found a rotifer that had just made a meal of half a dozen small crustaceans (*Chydorus*).

There are at least three sets of glands within the body of a rotifer. One pair, the supposed salivary glands, are

globular in shape and situated at the sides of the mastax. Another pair, the so-called liver or gastric glands, more or less kidney-shaped, are situated behind the mastax and on the anterior part of the stomach, and, as their name implies, are supposed to secrete a digestive fluid for the stomach. The third pair are located in the foot, and are called the foot glands. They are usually tubular, more or less elongate in form, and secrete a sticky substance by means of which the rotifer anchors itself to weeds, sticks, or other objects.

No true circulatory or respiratory organs are present, although there is an excretory system. This consists of a pair of tubes or canals, one on each side of the body, running almost its entire length, and connected posteriorly with a contractile vesicle which, in turn, opens into the cloaca. Upon each lateral canal are a number of small cup-like structures, the vibratile tags, each one probably provided with cilia or flagella by means of which the fluid of the body is caused to flow into these vibratile tags and thence into the lateral canals, thence passing to the exterior by way of the contractile vesicle and cloaca. While it is probable that all rotifers are provided with a contractile vesicle, this has not been demonstrated for every species.

All rotifers, especially the more highly organized kinds, are well provided with muscles for the extrusion and retraction of head and foot, and for the working of the skipping appendages where such exist. These muscles are transversely striated, and the striæ can be distinctly seen in such forms as *Triarthra*, *Polyarthra*, and *Pedalion*.

A nervous system and various sense organs are also present in rotifers. The sense organs consist of various styles or setæ on the head and, usually, a brush of fine setæ on each side at the lumbar region. The brain is rather large and is usually situated in front of and above the mastax. From this brain nerve fibers extend to the various sense organs. There are also from one to three so-called eyes, which are usually ruby-colored or black, and are situated either on the posterior part of the brain or on the frontal border of the head. They probably serve more for the

perception of light than for the formation of images. While the eyes are absent in the adults of some species, they may always be found in the embryonic or young forms.

Rotifers are diœcious and dimorphic; that is, the sexes are represented by separate individuals, and the males differ greatly from the females in size and organization. Descriptions of rotifers apply only to the females, as the males are but little known and may be found for only a few days once or twice a year. The male is usually inferior in size to the female, and consists of a transparent sac with a circle of cilia around the anterior border. It has no internal structures except a sperm sac and copulatory organ, eats nothing, and disappears in a few days.

Rotifers are usually oviparous, although there are forms, like *Rotifer* and *Asplanchna*, that are viviparous. There are three kinds of eggs. One of these is the ordinary egg, from which the female hatches, and which is sometimes encased in a spiny or roughened shell. Another form, from which the males are hatched, is smaller and smooth-shelled. These two are the so-called summer eggs. The third is the "lasting" or "ephippial" egg, which is larger than either of the other forms and has a hard, thick shell, well able to withstand drought and frost. The eggs are usually carried about attached to the posterior part of the lorica just above the foot.

Experiments were long ago made which show that the adult rotifer can be revived after it has been subjected to a severe drying process. Interesting results were obtained by us by starting aquaria with earth from the bottoms of dried-up ponds and lakes. Within two days after filtered water had been placed on the dried mud, full-grown specimens of *Brachionus* with eggs were found, which goes to prove that the rotifers had been dried with the mud and had revived when the water was added. Further experiments along this line might be profitably carried on to ascertain just how long rotifers can remain in this condition without having their vitality impaired, and to find out whether they will survive after being subjected to the hard frosts of a severe winter.

METHODS OF CAPTURE AND STUDY.

Rotifers should be widely studied, not only because they are interesting but because they are so easily accessible to nearly every one. Representatives of the group are found in every pool, pond, river, or other body of water. They seem to be little dependent upon the coarser aquatic vegetation, since they are equally abundant in waters with or without vegetation. No pond or mud hole is too insignificant to be populated by some of these forms. If one wishes to study them at times other than their usual season, or desires to have material for class use, all that is necessary is to collect some of the bottom of a dried-up pond and keep it until ready for the material. Then a small quantity may be put into a glass jar with some filtered water, and in twenty-four hours the forms will begin to appear. Such an aquarium may be kept up almost indefinitely by placing it in a moderately cool room in the sunlight, and renewing the water from time to time as it evaporates.

This work of starting aquaria from the bottom of dried-up bodies of water should be extensively practiced, as the observer will in this way meet many forms which he would not otherwise find; not only rotifers but numbers of *Protozoa* and microscopic plants as well.

Another method of obtaining material is to collect water from various sources and start a number of cultures by placing small quantities of the water in watch-glasses, or other small dishes, keeping a sharp lookout that the water does not dry out. If these dishes are examined from time to time they will be found to have developed certain forms of *Protozoa*, one species or another predominating in each of the dishes. After a time, if the student has been faithful, the chances are that he will be rewarded by finding in several of the dishes an almost pure culture of some particular species. This method was tried by Prof. Frank Smith in the zoölogical laboratory of the University of Illinois during the winter of 1894 with good results, pure cultures of *Distyla ohioensis*, *Hydatina senta*, *Stentor cæruleus*, *Stylonychia mytilus*, and other species being obtained.

If there are marshes, weedy lakes, or river banks in the neighborhood, many rotifers may be obtained by gathering quantities of the weeds and allowing them to remain for a day or two in a glass jar with water. An examination of the water will then usually reveal the presence of the rotifers. Sometimes it is merely necessary to gather handfuls of the weeds and press out the water, which may be immediately examined. Other forms may be found by searching carefully the roots of *Lemnaceæ*, and the fronds of *Utricularia* or *Ceratophyllum*. Many fixed forms may be obtained by carefully examining the under sides of the leaves of water lilies and pondweed (*Potamogeton*). If catches are to be made in large bodies of water free from vegetation, a tow-net made of fine bolting-cloth (No. 12) will be indispensable.

The requisites for the examination of material and the study of rotifers are a compound microscope, several large and small pipettes, watch-glasses, slides and cover-glasses, and several killing and fixing agents. Of course the best results are obtained by studying the rotifers while alive; but if for any reason this cannot be done the material may be preserved and studied later. If the living subjects under examination are too lively and energetic they may be quieted down by adding to the water, very gradually, a 2% solution of cocaine or chloral hydrate.

If material is to be preserved, good results may be obtained by killing either in 50% alcohol or picronitric acid*, either of which, after one or two hours should be replaced by 70% alcohol, and this, again, by 80% or 90%, in which the material may be indefinitely preserved. Permanent mounts may be made from material preserved in this way by gradually substituting glycerine for the alcohol, and then mounting the objects in glycerine in a cell on a slide. By far the best method of preservation thus far devised is that given by Mr. C. F. Rousselet ('95). He first narcotizes the rotifers

*The formula for picronitric acid is as follows:

Water	100 volumes
Nitric acid (25% N_2O_5)	5 "
Picric acid	as much as will dissolve in mixture.

Filter before using.

with a "cocaine-spirit mixture," made according to the following formula:

2% solution of cocaine.....30 parts.
Methylated spirit .....10 parts.
Water .....60 parts.

Just before the cilia stop vibrating the rotifers are killed with a $\frac{1}{4}\%$ solution of osmic acid, in which they are kept for about half a minute, after which they are thoroughly washed in water from a few minutes to half an hour and are then permanently preserved in a $2\frac{1}{2}\%$ solution of formalin. This is an aqueous solution of formaldehyde and as prepared for sale has a strength of 40%. The species which have gelatinous tubes are more satisfactorily preserved in a mixture of equal parts of a $\frac{1}{10}\%$ solution of corrosive sublimate and a $\frac{1}{5}\%$ solution of common salt, since formalin extends the tubes to two or three times their natural length. In place of cement cells for permanent mounting, Mr. Rousselet uses slides with concave centers and fastens the coverglass by means of Miller's caoutchouc cement.*

GEOGRAPHICAL DISTRIBUTION.

The *Rotifera* are cosmopolitan in their range, being found in all parts of the world. They inhabit mostly fresh water, but a number of species are found in the sea. Some of the species, such as *Rotifer vulgaris* and *Hydatina senta*, apparently occur in all parts of the world. There seems to be something about the organization of the rotifer that enables it to thrive under a great variety of conditions. The same forms are found in both rivers and muddy ponds in the United States, in clear streams of Europe or even in Alpine lakes, in the rivers of Egypt, and in the reservoirs of India. Climate and temperature seem to have little effect upon the distribution of rotifers.

FOOD RELATIONS.

The rotifers play an important part in the economy of nature, since they evidently take a prominent position among

*I find that Brown's transparent rubber cement answers this purpose very well.

the forms which, in the matter of food relations, bridge the gap between plants and animals. Many of the smaller forms like *Metopidia*, *Colurus*, *Monostyla*, and also *Dinocharis* and *Euchlanis* are frequently found chewing the ends of fine filamentous algæ. At one time a *Mastigocerca* was observed feeding on a piece of alga. It would puncture the outside, and appropriate the immediate contents of a cell; then it would creep along, make another puncture, and continue its meal. Diatoms also serve as food, and a *Notholca* was found that had its stomach crammed full of the rays of *Asterionella*. *Asplanchna priodonta* and also *A. brightwellii* seem to be omnivorous. I have frequently found *Pediastrum*, *Volvox*, *Codonella cratera*, *Difflugia globulosa*, *Anuræa tecta* and *A. cochlearis* in their stomachs. One *Asplanchna herrickii* was observed that had just made a meal of two *Brachionus militaris;* while an *Asplanchnopus myrmeleo* was found with its stomach gorged with *Chydorus*.

On the other hand, the larger species of *Rotifera* doubtless form a considerable portion of the food of mollusks, minnows, buffalo fish, carp, suckers, and the like. Specimens of *Anuræa cochlearis* were found in the stomach of a young "croppie" and in that of a young catfish. It is possible that the smaller *Crustacea* also live upon rotifers. This was especially indicated in Phelps Lake (substation F). There were times when the water of this lake was swarming with *Entomostraca* and the rotifers were very scarce, yet in a few weeks there would be very few *Entomostraca* and a great abundance of rotifers. Possibly the periodical disappearance of the rotifers was due to lack of food, but the disappearance of the *Crustacea* seems explainable only on the supposition that they depended on the rotifers for food. At one time a towing was taken at this substation in which there was such an abundance of *Pediastrum*—an element in the food of rotifers—that the water was colored green, and in this same towing there was an abundance of rotifers and very few *Entomostraca*.

SEASONAL DISTRIBUTION.

While our seasonal histories of the *Protozoa* show but little tendency to a concentration in any particular part of

the year, the species of *Rotifera*, on the other hand, often have a well-marked period of abundance, with scattering occurrences at other times. The season of abundance varies greatly even in species of the same genus. Some are summer and some winter species; some have shorter and some longer periods. In general the group is well represented throughout the entire year. No towing was taken by us at any time that did not contain some rotifers. In 1894 they were most abundant from June to September, while comparatively few species were listed in October. The December records show an increase in such forms as *Brachionus*, *Anuræa*, and *Notholca*. On February 23, 1895, towings were taken at substation G, under eighteen inches of ice, which were remarkable for the abundance of life they contained. Eight species of rotifers were found in this catch, three of which included individuals with eggs attached.

The forms which were common enough to show definite indications of their seasonal distribution are given in the following list, which can be greatly improved—perhaps in some cases disproved—by more extensive and systematic observations. The period of greatest abundance is given in italics.

Floscularia ornata: Sept.
Megalotrocha semibullata: July, *Aug.*
Conochilus: Jan., *Feb.–July*, Aug., Sept.
Rotifer: *July–Sept.*, Oct.–June.
Philodina: *June–Sept.*, Oct.
Asplanchnidæ: Jan., Feb., *Apr.–Sept.*, Nov., Dec.
Synchæta pectinata: *Sept.–May*, June, Aug.
S. stylata: July–Sept., *Oct.*
Polyarthra platyptera: *Dec.–Mar.*, Apr.–Nov.
Triarthra longiseta: Feb., *Apr.–Sept.*, Dec.
Plœsoma lynceus: May, June, *July–Oct.*, Nov., Dec.
Notommatidæ: June, *July–Sept.*, Oct.
Mastigocerca bicristata: May, *June–Sept.*, Oct.
Cœlopus: June–Aug.
Dinocharis pocillum: *Mar.–July*, Oct.–Jan.
Salpina eustala: June, July–Sept., Oct.
Euchlanis: Apr.–June, *July–Sept.*, Oct.–Dec.

Cathypnidæ: Mar.–May, *June–Oct.*, Nov.–Dec.
Colurus: Mar., Apr., *June–Sept.*, Oct.
Metopidia: Mar., June, *July–Sept.*, Oct., Dec.
Pterodina patina: *June–Oct.*, Nov.–May.
Brachionus pala: May–July, *Aug.–Apr.*
B. dorcas: Oct., Nov., *Dec.–Apr.*, May.
B. punctatus: *June–Sept.*
B. urceolaris: Jan., Feb., *Mar.*, Apr.
B. bakeri, angularis, and militaris: Feb.–May, *June–Sept.*, Oct., Dec.
Schizocerca: June–Sept.
Noteus quadricornis: May, June, *July–Sept.*, Oct., Nov.
Anuræa tecta and cochlearis: Jan., Feb., *Mar.–Aug.*, Sept.–Dec.
A. aculeata: *Jan.–June*, Nov., Dec.
Notholca acuminata: Oct., Nov., *Dec.–Apr.*, May.
Pedalion mirum: May, *July–Sept.*, Oct.

LOCAL DISTRIBUTION.

The Rotifera were widely distributed, being well represented at all of the substations. One hundred and eight forms were observed and identified. The five lakes under examination reflect their peculiarities in the species records. Thompson's, Quiver, and Dogfish lakes have well-defined shores, never become dry, and are more or less permanently supplied with aquatic vegetation. Their rotifer fauna was much the same. Phelps and Flag lakes, on the other hand, were very shallow, margined by mud flats which grew in size as the water dried up under the summer sun, the latter lake being substantially a reedy swamp. Species found in the other three lakes were often not present in these two, while a few forms were conspicuously more abundant in one of these than in the other three.

It is difficult to distinguish littoral and pelagic forms in this list. At most of the substations the water was comparatively shallow, its average depth where the tow-net was used ranging from about one and a half feet in Phelps Lake to nine feet in the river at E. Because of this shallowness

the forms preferring life amongst vegetation and near the shores or bottom doubtless often mingled with those inhabiting the clear open water, the same forms being usually found in both surface and bottom towings. The amount of aquatic vegetation present was an important item in the question. In Phelps and Thompson's lakes and in the river at E there was comparatively little visible plant life, while at D—in the river—and in Quiver and Dogfish lakes aquatic plants of all kinds flourished; indeed, Quiver Lake was almost entirely choked up during the first summer and autumn with *Ceratophyllum*, *Elodea*, *Spirogyra*, and the like. There was, however, a slight current in Quiver Lake, which kept a narrow channel free from weeds, so that it was possible to take towings at C during the entire season. On the whole it seems most satisfactory to consider those forms found near the shore or among vegetation as littoral, and those taken in open water free from vegetation as pelagic. Of the species studied the following twenty-four are in this sense pelagic:

Conochilus dossuarius Hudson.
C. unicornis Rousselet.
Asplanchna ebbesbornii Hudson.
A. brightwellii Gosse.
A. priodonta Gosse.
A. herrickii de Guerne.
Synchæta pectinata Ehrbg.
S. stylata Wierz.
Polyarthra platyptera Ehrbg.
Triarthra terminalis Plate.
Plœsoma lynceus Ehrbg.
Brachionus mollis Hempel.
B. pala Ehrbg.
B. dorcas Gosse.
B. dorcas spinosus Wierz.
B. punctatus Hempel.
B. variabilis Hempel.
B. angularis Gosse.
B. angularis bidens Plate.
Anuræa tecta Gosse.

A. aculeata Ehrbg.
A. cochlearis Gosse.
Notholca acuminata Ehrbg.
Pedalion mirum Hudson.

Among these pelagic forms the most abundant were *Asplanchna brightwelli*, *Synchæta pectinata*, *Polyarthra platyptera*, *Triarthra terminalis*, *Brachionus pala*, and *Anuræa cochlearis*. *Brachionus militaris* was probably the most abundant form of the littoral species.

Of all the substations under examination, C yielded the greatest number of species. There were two reasons for this. In the first place, a variety of conditions prevailed here. There was dense floating vegetation on each side of the lake, and at the same time a tolerably clear channel through the middle. Again, a greater number of collections were made here than at any other substation on account of the location of the field headquarters at this point. A and B were not satisfactory locations since they had to be abandoned early in the season. F was a constant source of surprise, and the catches made there were very interesting in regard to both numbers and variety. This was a very fruitful substation until August, when it completely dried up. D yielded nothing unusual, and the catches there were essentially the same as those among vegetation at the other substations. E was a typical river situation, and was satisfactory in every way. Next to C it yielded the largest number of species and, as might have been expected, all of the pelagic forms were found here. G was in a lake typical of the larger and more permanent lakes of the river bottoms, and contained a remarkable variety and number of organisms. Unfortunately its usefulness to us was reduced by the fact that it was difficult of access, and was consequently visited only at long intervals—usually a month, but sometimes longer.

AFFINITIES AND CLASSIFICATION.

There has been much discussion about the affinities of the *Rotifera*. Dr. C. F. Hudson ('75) thinks that such forms as *Pedalion* link them with the *Crustacea*, while, on the other

hand, forms like *Trochosphæra* seem to indicate that they are derived from the *Annelida*. The nervous and excretory systems are very similar to those of the turbellarian worms, which fact seems further to strengthen the theory that the rotifers are related to the *Vermes*. In the present state of our knowledge it seems best to class them as a separate group under the head of *Vermes*.

The entire group has been divided into four well-marked orders, mainly with reference to locomotion. These are the *Rhizota*, fixed when adult; the *Bdelloida*, "that swim with their ciliary wreath and creep like a leech;" the *Ploima*, "that swim with their ciliary wreath and (in some cases) creep with their toes;" and the *Scirtopoda*, "that swim with their ciliary wreath, and skip with arthropodous limbs."

In the preparation of the following list I have depended largely upon the superb monograph of Hudson and Gosse ('86), from which most of the descriptive matter is taken, and have in the main followed their classification, except in a few cases where it has been shown that they are in error. It seems unnecessary to give the synonymy of any forms described in the monograph, except perhaps in a few special cases regarding which there are differences of opinion; but for all forms in this list that have been described since the publication of Hudson and Gosse's Supplement ('89), a citation is given to the work containing the original description.

Other rotifers were found, as yet either unidentified or undescribed. Owing to limited time and opportunity they were not worked up, and are not included in this list.

SYNOPSIS OF THE FAMILIES OF ROTIFERA.

I. Order *Rhizota*. Fixed when adult, usually inhabiting a gelatinous tube; foot transversely wrinkled, not retractile within the body, ending in an adhesive disc or cup.

Flosculariidæ. Coronal cup usually produced into setigerous or ciliate lobes; buccal orifice central; ciliary wreath a single half circle above the buccal orifice; trophi uncinate. (Fig. 3, G.)

Melicertidæ. Corona not produced into setigerous lobes; buccal orifice lateral; ciliary wreath a marginal continuous curve, bent on itself at the dorsal surface, so as to encircle the corona twice, with the buccal orifice between its upper and lower curves, and having also a dorsal gap between its points of flexure; trophi malleo-ramate (Fig. 3, E); usually inhabiting tubes made of pellets.

II. Order *Bdelloida*. Swimming with their ciliary wreath and creeping like a leech; foot wholly retractile within the body, telescopic, ending almost invariably in three toes.

Philodinidæ. Corona a pair of circular lobes transversely placed; ciliary wreath a marginal continuous curve, bent on itself at the dorsal surface so as to encircle the corona twice, with the buccal orifice between its upper and lower curves, and having also two gaps, the one dorsal, between its points of flexure, the other ventral, in the upper curve, opposite the buccal orifice; trophi ramate. (Fig. 3, H.)

Adinetidæ. Corona a flat surface, facing ventrally; ciliary wreath the furred ventral surface of the corona; trophi ramate (Fig. 3, H); frontal column soldered to dorsal surface, and ending in two hooks.

III. Order *Ploima*. Swimming with their ciliary wreath and (in some cases) creeping with their toes.

1. Suborder *Illoricata*. Integument flexible, not stiffened to an inclosing shell, except in *Plæsoma*; foot, when present, almost invariably furcate, but not transversely wrinkled; rarely more than feebly telescopic, and partially retractile.

Microcodonidæ. Corona obliquely transverse, flat, circular; buccal orifice central; ciliary wreath a marginal continuous curve encircling the corona, and two curves of larger cilia, one on each side of the buccal orifice; trophi forcipate (Fig. 3, D); foot stylate.

Asplanchnidæ. Corona subconical, with one or two

apices; ciliary wreath single, edging the corona; intestine and cloaca absent.

Synchaetidæ. Corona a transverse spheroidal segment, sometimes much flattened, with styligerous prominences; ciliary wreath a single interrupted or continuous marginal curve, encircling the corona; mastax very large, pear-shaped; trophi forcipate (Fig. 3, D); foot minute, furcate.

Triarthridæ. Body furnished with skipping appendages; corona transverse; ciliary wreath single, marginal; foot absent.

Hydatinidæ. Corona truncate, with styligerous prominences; ciliary wreath two parallel curves, the one marginal, fringing the corona and buccal orifice; and the other lying within the first, the styligerous prominences being between the two; trophi malleate (Fig. 3, A); foot furcate.

Notommatidæ. Corona obliquely transverse; ciliary wreath of interrupted curves and clusters, usually with a marginal wreath surrounding the buccal orifice; trophi forcipate (Fig. 3, D); foot furcate.

2. Suborder *Loricata.* Integument stiffened to a wholly or partially inclosing shell; foot various. Corona and ciliary wreath various in shape, trophi of different types, but, except in the *Pterodinidæ*, these structures are never as in *Rhizota* or *Bdelloida.*

Division I. Foot jointed, stylate or furcate; not transversely wrinkled nor wholly retractile.

Rattulidæ. Body cylindric or fusiform, smooth, without plicæ or angles; contained in a lorica closed all around, but open at each end, often ridged; trophi long, asymmetric; eye single, cervical. Variously asymmetrical.

Dinocharidæ. Lorica entire, vase-shaped, or depressed; sometimes faceted, often spinous; head distinct, with a chitinous covering; foot and toes often greatly developed; trophi symmetrical.

Salpinidæ. Body more or less completely enclosed in

a firm lorica, which is open at each end, and divided down the back by a fissure whose sides are united by membrane; two furcate toes always exposed.

Euchlanidæ. Lorica of two dissimilar plates, one dorsal, one ventral, united so as to form two confluent cavities, of which the upper is much the larger; foot jointed, furcate.

Cathypnidæ. Body enclosed in a lorica which is open at each end, and consists of two plates; the dorsal more or less elevated; the ventral nearly flat, the two divided by a deep lateral longitudinal sulcus, covered with flexible membrane; toes two or one, always exposed.

Coluridæ. Body enclosed in a lorica, usually of firm consistence, variously compressed or depressed, open at both ends, closed dorsally, usually open or wanting ventrally; head surmounted by a chitinous arched plate or hood; toes two, rarely one, always exposed.

Division II. Foot transversely wrinkled, wholly retractile, furcate or ending in a ciliated cup; sometimes absent.

Pterodinidæ. Lorica entire, various; corona and ciliary wreath as in the *Philodinidæ*; trophi malleoramate (Fig. 3, E); foot jointless, toeless, ending in a ciliated cup or absent.

Brachionidæ. Lorica box-like, open at each end, generally armed with anterior and posterior spines; foot long, excessively flexible, ending in two toes.

Anuræidæ. Lorica box-like, broadly open in front, behind open only by a narrow slit; usually armed with spines or elastic setæ; foot wholly wanting.

IV. Order *Scirtopoda.* Swimming with their ciliary wreath, and skipping with arthropodous limbs; foot absent.

Pedalionidæ. Arthropodous limbs six; head truncate; corona of two concave lobes; ciliary wreath as in *Philodinidæ*; trophi malleo-ramate (Fig. 3, E).

Order I. RHIZOTA.

Family **FLOSCULARIDÆ.**

Floscularia Oken.

Frontal lobes short, expanded, or wanting; setæ very long and radiating, or short and cilia-like; foot terminated by a non-retractile peduncle, ending in an adhesive disc.

1. **F. ornata** Ehrbg.

Infrequent. Found during September on *Ceratophyllum* at substation L in Dogfish Lake.

Family **MELICERTIDÆ.**

Limnias Schrank.

Provided with a tube, which is usually dark colored, but not made of pellets. Corona distinctly two-lobed; dorsal gap wide; dorsal antenna minute.

2. **L. ceratophylli** Schrank.

This fine form was first found in an aquarium started with dried mud from the bed of Phelps Lake, and in September was discovered on *Ceratophyllum* and *Potamogeton* from Thompson's Lake. While the rotifer was expanded a constant stream of fine particles kept moving away from it, the movement being quite uniform and the direction definite, as if the stream were shot out of the nozzle of a hose.

Cephalosiphon Ehrbg.

Corona nearly circular; dorsal gap distinct; dorsal antenna obvious; ventral antennæ absent, two dorsal hooks enclosing the dorsal antenna.

3. **C. limnias** Ehrbg.

Infrequent, occurring in September on vegetation from Thompson's Lake.

Œcistes Ehrbg.

Corona a wide oval, indistinctly two-lobed; dorsal gap minute; dorsal antenna absent; ventral antennæ obvious.

4. **O. intermedius** Davis.

Infrequent, occurring during August on *Ceratophyllum* from Thompson's Lake.

5. **O. mucicola** Kell.

A few examples of this species were found in Dogfish Lake during September, 1895, on *Rivularia*.

Megalotrocha Ehrbg.

Forming spherical colonies of many individuals; corona kidney-shaped or four-sided, with a deep ventral sinus; trunk with two or four opaque warts on breast.

6. **M. alboflavicans** Ehrbg.

Colonies of this rotifer were found in Quiver Lake during June and August, 1894, the clusters being attached to *Ceratophyllum*. In September of the same year young free-swimming clusters were taken in the tow-net from the Illinois River. The young have a small corona and well-developed eyes, and might easily be mistaken for *Conochilus* were it not for the presence of the opaque warts. In November a quantity of vegetable matter was taken from the shores of Quiver Lake and put into an aquarium, and in a few days several of the colonies were found attached to the plants. During September of the following year it was found in Dogfish Lake.

7. **M. semibullata** Hudson.

This interesting form was not discovered until July of the second year, when it was occasionally found in the weedy waters of Flag Lake. It increased rapidly until the following month, when it was very abundant. The colonies seemed to hang by slender threads to stems of rushes and other aquatic plants, and when disturbed would swim through the water with a revolving motion. I was one day watching some of these colonies, when one of them, coming very near the surface of the water, was pounced upon and quickly devoured by a water beetle, *Dineutes*.

Trochosphæra Semper.

Solitary, free-swimming; body a perfect sphere; buccal orifice on the spherical surface; principal wreath dividing the

sphere into two hemispheres, and passing above the buccal orifice; dorsal gap in the wreath at the pole opposite to buccal orifice; secondary wreath a fragment on the under side of the buccal orifice; ventral antennæ extremely minute; no tube.

8. **T. solstitialis** Thorpe.

The occurrence of this rare and remarkable form in this country was reported for the first time by Dr. C. A Kofoid ('96a). It was found by him in the Illinois River and Flag Lake in June, July, and August, 1896.

Conochilus Ehrbg.

Clusters of several or many individuals, free-swimming; corona horse-shoe shaped; gap in the ciliary wreath ventral.

9. **C. dossuarius** Hudson.

This species was found in all the bodies of water under observation. It was present during the greater part of the year from January to September, reaching its maximum in March. Many clusters were taken with a tow-net in Thompson's Lake, in February, 1895, under eighteen inches of ice. These specimens appeared larger and more vigorous than those seen during the summer. It is readily recognized by the small number of individuals composing the cluster; by the presence of the two antennæ, which stand out on the arched ventral surface like tall chimneys on a building; and by the fact that eggs are almost invariably found in connection with the colonies.

10. **C. unicornis** Rousselet ('92).

C. leptopus Forbes, '93.

This rotifer was found only in May and June. During this time only a few were taken in the tow-net at C, although it was common in the river at D and E, and was taken in both surface and oblique towings at the latter substation.

Order BDELLOIDA.

Family **PHILODINIDÆ.**

Rotifer Schrank.

Eyes two, situated within the frontal column. (Trophi, Fig. 3, 4.)

11. **R. macrurus** Schrank.

In June one specimen was found in a surface towing from C, in Quiver Lake.

12. **R. vulgaris** Schrank.

A few were found during July in the surface towings from the river at E. In March it was also found in the oblique towings from the same place.

13. **R. tardus** Ehrbg.

This species was comparatively rare. In June it was found among the vegetation on the west shore of Quiver Lake at C, and in June, September, and October it occurred in the towings from the river at E.

14. **R. neptunius** Ehrbg.

Actinurus neptunius Ehrbg.

This peculiar and interesting form was found in the river at E from May to October, in Matanzas Lake in August, and in Thompson's Lake in September. Although it was not common at any time, still it was persistent during the months mentioned, and was found in both surface and oblique towings. It is rather remarkable that it was not found among the vegetation.

Philodina Ehrbg.

Eyes two, placed above the brain.

15. **P. macrostyla** Ehrbg.

Philodina tuberculata Gosse.

One specimen of this rotifer was taken in August among the vegetation on the west shore of Quiver Lake, at the mouth of Dogfish Lake.

16. **P. megalotrocha** Ehrbg.

This form was well distributed, being found in Quiver and Phelps lakes and in the river (substations C, F, D, and E). It was taken in surface and oblique towings and among vegetation. There was hardly a collection made at these substations from June to September in which it did not occur, and it was also found once in October at E.

CALLIDINA EHRBG.

Eyes wanting.

17. **C. elegans** EHRBG.

This species was found once, in September, in towings from Dogfish Lake.

Order III. PLOIMA.

Family **ASPLANCHNIDÆ.**

ASPLANCHNA GOSSE.

Body sac-like, foot wanting; corona with two apices; trophi (Fig. 3, F), two plates working together like the jaws of an insect, not inclosed within a mastax. Viviparous.

18. **A. ebbesbornii** HUDSON.

This large species was found once during June, in a surface towing from the river at E, in company with *A. priodonta*. So far as I know, it has not been previously recorded from the United States. It is a fine, attractive form, and not easily confused with other species of this genus.

19. **A. brightwellii** GOSSE.

This form was the most abundant representative of its genus in the field studied by us. It was widely distributed among the various substations, and present during nearly the entire year, reaching its maximum in July and August. It appropriates almost everything in the way of food: *Asterionella*, *Codonella cratera*, *Difflugia globulosa*, *Anuræa cochlearis* and *A. tecta* have all been found in stomachs of individuals of this species.

20. **A. priodonta** GOSSE.

This species was found from April to September in both years. In 1894 it was most abundant in May and June, and in 1895 the maximum was reached in August. It occurred mostly in towings from the Illinois River and from Thompson's Lake, but was also found in Quiver and Dogfish lakes. This form, like most of the members of this genus, is distinctively pelagic. None were found among vegetation. Like

the preceding species it is omnivorous. *Asterionella*, *Pediastrum*, *Volvox globator*, *Codonella cratera*, *Anuræa tecta*, and *A. cochlearis* were common in its food.

21. **A. herrickii** DE GUERNE.

The record of this species presents a similar history for each of the two years. It appeared in April and May, reaching its maximum in May; was not seen at all in June, and but once in July; and in August and September it occurred extensively, but was not common. Like *A. priodonta*, it was found in the river and more permanent lakes,—Quiver, Dogfish, and Thompson's,—but not in the two shallower lakes, Phelps and Flag—liable to dry up more or less in late summer.

Professor Forbes, in studying this species, found several small parasites within the body. They were apparently one-celled, very changeable in shape, and seemed to have three flagella-like pseudopodia.

Two specimens of *Brachionus militaris* were found in the stomach of one example of this *Asplanchna*, and *Anuræa cochlearis*, *Volvox globator*, and *Bosmina* also serve as food for it.

22. **A. girodi** DE GUERNE.

Taken only in towings from Flag Lake, during April, 1896.

ASPLANCHNOPUS DE GUERNE.

Like Asplanchna, but with a ventral retractile foot, ending in two toes.

23. **A. myrmeleo** EHRBG.

Notommata myrmeleo Ehrbg.

This fine large rotifer was present in small numbers from May to September. It occurred in collections from Quiver Lake, Dogfish Lake, and the Illinois River, and was found both in the open water and among vegetation. Individuals can be easily recognized in the water without a lens by their large size and sluggish movements. They are great eaters, and their stomachs are almost invariably filled with other rotifers and crustaceans, sometimes so gorged with food that

the body walls are greatly distended. *Monostyla* and *Chydorus* seem to be their favorite food.

This form has not been previously listed from the United States.

Sacculus Gosse.

Corona with one apex; trophi inclosed in a mastax, virgate, with unequal mallei; alimentary canal very large, having eight cæca; eggs attached after deposition.

24. **S. viridis** Gosse.

This species was scarce, appearing only in surface towings taken at the mouth of Quiver Lake during May, 1896.

Family **SYNCHÆTIDÆ.**

Synchæta Ehrbg.

Form usually that of a long cone whose apex is the foot; front furnished with two ciliated auricles; ciliary wreath of interrupted curves; foot small, furcate.

25. **S. pectinata** Ehrbg.

This was abundant and widely distributed, being found at all of the substations. It was not found in July, and was noticeably scarcer in June and August. At all other times of the year it was common and often abundant, especially in May and November. The records for each of the two years were substantially alike. This is a very pretty gem in the water, very quick in its movements, darting hither and thither, and consequently difficult to study, but after its characters are once made out it will long be remembered.

26. **S. stylata** Wierz. ('92).

Found only in the Illinois River and Quiver Lake, from July to October, and again in March; most abundant in October in the river.

This was also found by Jennings ('94) in Lake St. Clair.

Family **TRIARTHRIDÆ.**

Polyarthra Ehrbg.

Body small, sac-like; skipping appendages, when present, in clusters on the shoulders; eye single, occipital; mastax large and pear-shaped; trophi forcipate.

27. **P. platyptera** Ehrbg.

This is one of the four species that were present during every month of the year. It seems to thrive best in cold water, for it was most abundant during December, January, and March, and reached its minimum in June. It was found in all the bodies of water under observation. Many individuals were larger than the dimensions given by Hudson and Gosse, some of them measuring .2 mm. in length. *Rhabdostyla* was found parasitic on many that were taken in Phelps Lake.

28. **P. platyptera euryptera** Wierz. ('91).

Rare; found in September, in towings from the Illinois River.

29. **P. aptera** Hood ('93).

In November, 1894, a quantity of dried mud from the bottom of Phelps Lake was taken to the University, and, as has been previously stated, aquaria were started by putting filtered water upon this mud. This species was found at two different times in these aquaria, but was not observed at any of the substations.

Triarthra Ehrbg.

Body sac-like; spines single, two lateral, one ventral; eyes two, frontal; mastax of moderate size; trophi malleo-ramate.

30. **T. longiseta** Ehrbg.

Not especially common but generally present in both years in the river and lakes studied except Flag Lake, during the period from April to September. A very few were also seen in both years in December and February.

Plate ('85) describes a new rotifer, calling it *T. terminalis*. He says: "The attachment of the posterior spine is not ventral but terminal, just in front of the anal opening, and the spine cannot be flexed anteriorly. The spines are smooth, although I found one individual in which they bore very small spinules, as in *T. longiseta*."

Many of the individuals taken here had smooth spines, while others had them notched. The posterior spine was

inserted on the posterior part of the body. It is my belief that *terminalis* and *longiseta* are identical.

As far as known, this is the first time the species has been recorded for the United States.

PEDETES Gosse.

Body ovate, tailed; toes absent; eyes two, frontal; two leaping styles articulated to the breast.

31. **P. saltator** Gosse.

One specimen was found in an aquarium started with dried mud from the bottom of Phelps Lake. The species was probably not abundant, since several aquaria had been started before this specimen was discovered.

Family HYDATINIDÆ.

HYDATINA Ehrbg.

Not loricate; body conical, tapering towards the foot; foot short and confluent with the trunk; eye absent.

32. **H. senta** Ehrbg.

This large, fine form was rare. It was seen only in March and July, 1895, in the main river at E.

PLŒSOMA Herrick ('85).

With a lorica composed of two ovate valves united above and partially united below; foot springing from middle of ventral margin.

33. **P. lynceus** Ehrbg.

Euchlanis lynceus Ehrbg.
Plœsoma lenticulare Herrick.
Gomphogaster areolatus Vorce.
Gastropus ehrenbergii Imhof.
Gastroschiza lynceus Bergendal.
Gastroschiza foveolata Jägerskiöld.
Bipalpus lynceus Wierzejski and Zacharias.
Plœsoma lynceus Jennings ('94a.)

Not common. Found in all the more permanent waters from May to December, but most frequently from July to

October. It seems to be most at home creeping among the vegetation, such as was so abundant at substation C in Quiver Lake.

A very fine rotifer, arresting the attention by its unusual activity and attractive lorica.

Family **NOTOMMATIDÆ.**

Taphrocampa Gosse.

Body fusiform or cylindrical, annulose, furnished with two furcate toes; trophi forcipate; cilia very limited or wanting.

34. **T. annulosa** Gosse.

Infrequent, being found only at substation C in Quiver Lake, among vegetation and in open water, from July to September of the first year.

Notommata Gosse.

Body cylindrical, not annulose, furnished behind with a projecting tail; evertile and protrusile ciliated auricles on the head; brain large, usually containing opaque chalk masses; trophi virgate. Numerous species, in some of which one or more of these characters may be lacking.

35. **N. aurita** Ehrbg.

Infrequent; taken among vegetation in the Illinois River in July.

36. **N. cyrtopus** Gosse.

Infrequent, occurring during February in towings from the Illinois River.

37. **N. tripus** Ehrbg.

Occurred only during June and July, in both surface and bottom towings from Quiver Lake.

38. **N. lacinulata** Ehrbg.

This form was found once, in July, when a few were taken among the vegetation at the mouth of the "Pumpkin Patch;" a bay full of wild rice and other vegetation, communicating with the west side of Quiver Lake, near the head of the lake.

FURCULARIA Ehrbg.

Body generally larviform, cylindrical, with a tendency to enlargement in the lumbar region; front conical, broad, and deep; eye single, frontal, sometimes wanting; incus forcipate, much developed, protrusile; toes two, furcate, usually conspicuous.

39. **F. forficula** Ehrbg.

This species was scarce, being taken only in May, 1896, in surface towings at the mouth of Quiver Lake.

40. **F. longiseta** Ehrbg.

This rather peculiar form was found only in Quiver Lake. In July and August, and once in March, a few were taken. It occurred both among vegetation and in the towings.

EOSPHORA Ehrbg.

Body oblong, head dilated and furnished with protrusile auricles; foot very distinct, with telescopic joints and furcate toes; eyes three, one large, cervical, two minute, frontal.

41. **E. aurita** Ehrbg.

One morning in July, 1894, we saw a large quantity of red scum on the river. Upon examining it several specimens of this rotifer were found. In September of the same year it was again found, on the west shore of Quiver Lake, among vegetation.

DIGLENA Ehrbg.

Body subcylindric but very versatile in outline, often swelling behind and tapering to the head; eyes two, minute, situated near the edge of the front; foot furcate, trophi forcipate, generally very protrusile.

42. **D. grandis** Ehrbg.

This large form was found only in Quiver Lake in 1894, once in August, and again in October.

43. **D. catellina** Ehrbg.

This species was found in small numbers during August in the red scum at the mouth of Quiver Lake.

44. **D. biraphis** Gosse.

This species was rare, being found only in bottom towings from Quiver Lake in July.

Family **RATTULIDÆ.**

Mastigocerca Ehrbg.

Body fusiform or irregularly thick, not lunate; toe a single long style, with accessory stylets at its base; lorica often furnished with one or more thin dorsal ridges.

45. **M. carinata** Ehrbg.

This form was not very common. It was mostly found, in both years, at substation C in Quiver Lake, from June to September, the maximum being in July, when it was also seen in the river. A single occurrence in this lake in December is also noted. At one time I watched a *Mastigocerca* feeding on some *Spirogyra*. It would puncture the side of a filament with its sharp trophi and eat the green contents of the cell; then it would creep along, open another cell and appropriate its contents; and so on, until satisfied.

46. **M. elongata** Gosse.

Found but once, in a towing taken below the surface of Quiver Lake in June.

47. **M. bicornis** Ehrbg.

I found this species several times in the towings during June and July, and again in November, mostly in Quiver Lake, but in June also in oblique towings from the river at E.

48. **M. stylata** Gosse.

This form was scarce, being found only in towings from the Illinois River in August, 1895.

49. **M. bicristata** Gosse.

This species and *M. carinata* were the commonest representatives of the genus at the Station. *M. bicristata* was found but once in the river, in September, but appeared in moderate numbers in Quiver Lake from May to August, and in Thompson's Lake from August to October.

The specific characters as given by Gosse are, "Two equal subparallel carinæ, running nearly the whole length of the

dorsum." The two carinæ of the specimens taken at Havana extend a trifle more than two thirds the length of the dorsum. The carinæ are high, thick at base, and very conspicuous. The length of the specimens averages greater than that given by Mr. Gosse. I found them as long as .58 mm., including the toe, which is nearly half the entire length. The toe is slightly curved and ends in a spine, with two smaller accessory spines.

50. **M. lata** Jennings ('94).

This species was met with in June and several times during October, in surface towings, and also in towings taken below the surface, from Quiver Lake. It is easily recognized by the indentation on the right side of the body next to the foot joint, and by the flattened truncate column of the corona.

Cœlopus Gosse.

Body cylindrical, curved; foot bulbous, inclosed; toes, one broad plate with another laid upon it in a different plane.

51. **C. porcellus** Gosse.

This curious and interesting form was found in towings and among vegetation from Quiver Lake from June to August, and in surface towings from the river in June.

52. **C. tenuior** Gosse.

This form was taken in Quiver Lake in the same months as the preceding, and was generally found in company with it, although in smaller numbers.

Family **DINOCHARIDÆ.**

Dinocharis Ehrbg.

Lorica vase-shaped, faceted, with projecting plates, or armed dorsally with spines; head retractile within a chitinous cap; eye single; foot and toes very long, the former bearing spines.

53. **D. pocillum** Ehrbg.

The records of this species for both years show a seasonal distribution quite the reverse of that characterizing its relatives, which are generally commonest in the warmer months,

from June to October. This was most frequently seen, though never very numerous, from December to June, with occasional appearances in October and November and in July. Found in the towings, mostly in Quiver Lake, and not at all in Phelps, Flag, or Thompson's lakes.

Scaridium Ehrbg.

Lorica vase-shaped or pear-shaped; very thin, transparent, smooth, without spines or projecting plates; head with a chitinous cuticle, except in front; eye single; foot without spurs; toes very long.

54. **S. longicaudum** Ehrbg.

But few specimens of this rotifer were taken. It is recorded from the deeper lakes, from July to October.

Family **SALPINIDÆ.**

Salpina Ehrbg.

Lorica an oblong box, furnished with spines, but widely open at each end, split down the back; head and foot protrusile; toes furcate, long, straight; trophi submalleate; eye single, cervical.

55. **S. eustala** Gosse.

In both years this species was present from June to September, with a single occurrence in October. It was found in the Illinois River and the deeper lakes, but was not abundant.

Our specimens agree with the description given by Mr. Gosse, but average smaller, the largest individual measuring .23 mm. in length.

Family **EUCHLANIDÆ.**

Euchlanis Ehrbg.

Dorsal plate with the median portion arched; ventral plate nearly flat, usually with a flange on each side; eye single.

Members of this genus were frequently seen eating diatoms

and fine filamentous algæ. They would grasp the threads of algæ with the rami and chew them preparatory to swallowing.

56. **E. dilatata** Ehrbg.

This species was present from July to September in the river and deeper lakes, being found at the same substations as the foregoing species and reaching its greatest abundance in July. It was the only member of its genus found in Dogfish Lake, where it continued to occur until December, long after it had disappeared at the other substations. It was also found once in April in this lake.

57. **E. triquetra** Ehrbg.

Not so abundant as the preceding species; found only in the Illinois River and Quiver Lake, from June to October. This is the most conspicuous and beautiful representative of this genus. It may very readily be distinguished by the curious "three-winged" shape of the lorica.

58. **E. deflexa** Gosse.

This was found only in towings from Quiver Lake during the period from May to September.

59. **E. pyriformis** Gosse.

Of infrequent occurrence, during November, in towings from Flag Lake.

Family **CATHYPNIDÆ.**

Cathypna Gosse.

Lorica subcircular horizontally, usually much arched vertically; lateral inangulation wide and deep; toes two, furcate.

60. **C. luna** Ehrbg.

This species was present from April to December, and at all of the substations except B. Its maximum of abundance was reached in July and August. The records for the first and second year are very similar.

61. **C. leontina** Turner ('92).

Seasonal distribution about the same as that of *C. luna.* It was found in the Illinois River and deeper lakes, and was present both in towings and among vegetation. It was commonest about July.

Distyla Eckstein.

Lorica of the form of a long ellipse, open and membranous before, closed behind, depressed, higher before than behind; lateral inangulation feeble; toes two; selvage-like thickenings of the lorica around the foot.

62. **D. gissensis** Eckstein.

Found but once, in a towing from Phelps Lake in July.

63. **D. ohioensis** Herrick ('85).

Excepting a rare occurrence in April, this species was present only from July to November. It was found in Quiver and Dogfish lakes.

64. **D. stokesii** Pell ('90).

Cathypna stokesii Pell *

This little species was found four times in towings from Quiver Lake; once in July, again in September and in October, and again in March. The entire surface of the lorica is finely stippled.

65. **D. hornemanni** Ehrbg.

Occurred only in towings from Thompson's Lake, during September.

Monostyla Ehrbg.

Like *Cathypna*, but with only a single toe.

66. **M. lunaris** Ehrbg.

This form was found in January and April, but principally from June to November. It occurred upon vegetation and in towings from the Illinois River, and from all the lakes studied except Phelps Lake.

67. **M. cornuta** Ehrbg.

Taken in limited number among plants and in towings in the Illinois River and in Quiver Lake, from July to October.

Individuals have been observed nibbling and eating bits of algæ, like the species of *Euchlanis*.

68. **M. bulba** Gosse.

This species was as abundant among the vegetation as in the open water, and was found in all the bodies of water

*Jennings ('94) has pointed out that this species belongs to *Distyla* rather than to *Cathypna*.

except the two shallower lakes, Phelps and Flag. It was present from April to November, and was most common during the period from July to September.

69. **M. quadridentata** Ehrbg.

This was found at all of the substations except that in Phelps' Lake. It occurred from May to December and was uniformly present, though never very abundant, throughout the warmer months, from June to October.

70. **M. closterocerca** Schmarda.

Scattered occurrences at various times and places characterize the record of this rather rare species. A maximum in September is feebly indicated. It was found in all the deeper lakes.

71. **M. mollis** Gosse.

Rare, being taken only in towings from the Illinois River in August.

Family **COLURIDÆ.**

Colurus Ehrbg.

Body subglobose, more or less compressed; lorica composed of two lateral plates, open in front, united dorsally, gaping behind, and generally open ventrally; frontal hood in the form of a hook, not retractile; foot permanently extended; of distinct joints, terminated by two furcate toes.

72. **C. deflexus** Ehrbg.

Occurred only in oblique towings from Quiver Lake, during March.

73. **C. bicuspidatus** Ehrbg.

This species was not common at any time, and was found only in the Illinois River and deeper lakes. It was present from July to October, also once in April, frequenting both vegetation and open water.

74. **C. obtusus** Gosse.

This attractive minute species was found in Quiver Lake and once in the Illinois River. It was taken among vegetation and in towings from June to September.

METOPIDIA EHRBG.

Lorica usually depressed, entire, with an opening at each end for the protrusion of the head and foot; frontal hood in the form of a hook; foot and toes as in *Colurus*; eyes usually two.

75. **M. solidus** GOSSE.

Of rare occurrence. Found in towings from Quiver Lake in September.

76. **M. acuminata** EHRBG.

No member of this genus was common at any time. The present species was taken only in March, July, and December, in towings from the deeper lakes—Dogfish and Thompson's.

77. **M. oxysternum** GOSSE.

Rare. Found in towings from Quiver Lake and the Illinois River from September to December.

78. **M. rhomboides** GOSSE.

This species was more numerous than any other member of the genus. It was found in towings from the Illinois River and deeper lakes during August and September, and also once in December.

79. **M. triptera** EHRBG.

This species was found in Quiver Lake during July and August, and in Thompson's Lake in July.

80. **M. bractea** EHRBG.

Found sparingly among vegetation and in towings from Quiver Lake in July of both years.

81. **M. oblonga** EHRBG.

Metopidia elliptica Turner ('92).

Found sparingly among vegetation in Quiver Lake and in the river in June and July of the first year. Length of lorica .105 mm.

Family PTERODINIDÆ.

PTERODINA EHRBG.

Lorica entire, greatly depressed, of two oval, but nearly circular, plates united at their edges; foot wholly retractile,

transversely wrinkled, jointless, toeless, ending in a ciliated cup.

82. **P. patina** Ehrbg.

This species was present throughout the entire year, and was found in the river and in all the deeper lakes. As to the shallower lakes, it was rare in Flag and not found at all in Phelps. It occurred both in towings and among vegetation. Its period of abundance is evidently from June to October.

83. **P. valvata** Hudson.

Very rare, being found only once—among vegetation in Quiver Lake, in June, 1894.

Family **BRACHIONIDÆ.**

Brachionus Ehrbg.

Lorica without elevated ridges, gibbous both dorsally and ventrally; foot very flexible, uniformly wrinkled, without articulation; toes very small.

84. **B. mollis** Hempel ('96).

This active species was found, during July and August, in towings from the Illinois River, Phelps Lake, and Flag Lake, but was not common except in Phelps Lake, where it was abundant.

85. **B. pala** Ehrbg.

This species was present all the year round, and was found at nearly all of the substations. It was very abundant at times, especially in April, August, September, November, and December.

There seem to be several varieties of this species. Some individuals have no posterior spines; others have the two prominences which guard the foot developed into spines, and also have two other posterior spines. There are still others in which these posterior spines are remarkably developed, so that they are twice the length of the occipital spines.

This is undoubtedly a pelagic species, since it was found in surface and bottom towings, and but once among vegetation near the shore.

86. **B. dorcas** Gosse.

This is a winter species, as the records of both years show. It was found in towings from the Illinois River and from all the various lakes in which collections were made, from December to April, with a few scattering occurrences just before and after this period, becoming very abundant in April.

Like the preceding species, this one was found only in towings, and is recognized as a pelagic form.

87. **B. dorcas spinosus** Wierz. ('91).

But few specimens of this variety were found. It occurred in towings from the Illinois River and Quiver Lake during May, 1894, and in towings from the river and Thompson's Lake taken in January, March, and May, 1895. This indicates a seasonal history like that of the typical form.

88. **B. punctatus** Hempel ('96).

This was moderately common, and appeared from June to September. It occurred only in the open water, and was taken in most of the waters studied.

I have had the opportunity to study living examples of this rotifer since the publication of my description ('96), which was drawn up from dead specimens somewhat inflated by the preserving fluid, and is consequently not as accurate as it might be. I find that in the live specimens the dorso-ventral diameter is less than was at first supposed, the rotifer being flatter than the illustration represents it.

89. **B. urceolaris** Ehrbg.

This also seems to be a winter species, occurring from January to April. It was found only the second year, in towings from the river and from all the lakes studied except Phelps Lake, and though usually not very common, it was very abundant in Thompson's Lake in March.

90. **B. rubens** Ehrbg.

This species occurred from December to March in small numbers in towings from the river and from all the lakes but

Phelps Lake. It also appeared in the river at E in August and September, 1894, becoming very abundant in August.

This is a very difficult species to work with, since it varies greatly. Specimens were found ranging from .17 to .25 mm. in length. The pectoral edge is slightly more notched in our specimens than in the typical form.

91. **B. variabilis** Hempel ('96).

This is a very restless active species, most common from April to July, but present also in most of the other months of the year. It was found only in the open water, but at nearly all of the substations, and was very abundant in Phelps Lake at the time when the Station work first began.

92. **B. bakeri** Ehrbg.

This is preëminently a summer species, making its first appearance in our collections in May, becoming common from June to August, and disappearing again in October. It occurred in all the waters studied except Flag Lake, and was found among vegetation as well as in the open water.

This is also a variable species.

93. **B. bakeri brevispinus** Ehrbg.

Infrequent. Found in towings from the Illinois River during April, 1896.

94. **B. angularis** Gosse.

This species was common and often abundant in summer. It occurred from April to September, with occasional appearances in October, December, February, and March, its time of greatest abundance being in July and August. It was found in all of the waters of the Station except Flag Lake.

Comparatively few specimens were found that had the characteristic bluntly angled lorica. The majority of them were more or less smooth; and in many instances there were minute dots or tessellations on the surface of the lorica. In connection with this species was found the following variety with two posterior spines.

95. **B. angularis bidens** Plate ('85). (Fig. 4, 5.)
B. caudatus Barrois et Daday ('94.)

This form was present from April to September, most abundantly in July and August. It was found at the same substations as the preceding species.

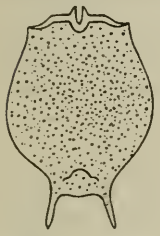

Fig. 4. Brachionus caudatus Barrois&Daday.

Dr. Plate, in describing this form, gives it specific rank. Barrois and Daday have recently described a form under the name *B. caudatus*. A careful comparison of the figures of the two forms shows that they are identical. As Plate says: "The animal is closely related to *B. angularis* Gosse, with which it corresponds in size and shape of the lorica; and differs from it alone in that the surface of the lorica is not roughened by angular ridges but is entirely smooth, or, at most, very finely punctate." The opening for the protrusion of the foot is characteristic in both forms. I found individuals grading from *angularis* to forms that had the two posterior spines even more developed than in *caudatus*. I see no reason why this form should not be recognized as a variety with the name proposed by Plate.

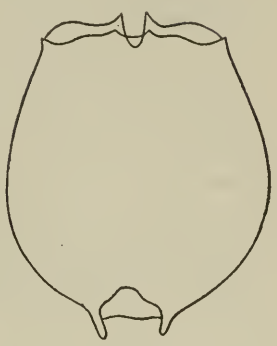

Fig. 5. Brachionus bidens Plate.

96. **B. militaris** Ehrbg.

This is also a summer species, occurring in both years from June to October, and found but once outside this period —in December. It was most abundant from July to September, and was found in all the bodies of water studied, although it was rarer in the two shallower lakes. It was equally abundant among vegetation and in open water. Notwithstanding the short period of its occurrence this was the most abundant species of the genus. Collections made among vegetation during the summer months were almost a "pure culture" of it. It became abundant very suddenly and disappeared with equal abruptness.

Schizocerca Daday.

Foot long, ending in a fork of two unequal branches, each terminated by a pair of unequal toes.

97. **S. diversicornis** Daday.

This species did not make its appearance in our collections until 1895, and then it was quite rare. It was well distributed, however, being taken in towings from the Illinois River and from the three more permanent lakes. It occurred from July to September.

98. **S. diversicornis homoceros** Wierz. ('91).

Not so abundant as the preceding, being found but twice; once in Phelps Lake in June, 1894, and again in Thompson's Lake in August, 1895; on both occasions in the towings.

Noteus Ehrbg.

Lorica faceted, and covered with raised points; gibbous dorsally, flat ventrally; foot obscurely jointed; toes moderately long; eyes wanting.

99. **N. quadricornis** Ehrbg.

This beautiful creature was found many times in the towings or among vegetation, but it was never abundant. It is evidently a summer species as it was present only from May to November. Found in the Illinois River and in the three deeper lakes.

Family **ANURÆIDÆ.**

Anuræa Gosse.

Lorica an oblong box, open widely in front, narrowly in rear; dorsal surface usually tessellated; spines present; the egg, after extrusion, carried attached to the lorica.

100. **A. hypelasma** Gosse.

This species was found only in towings from Thompson's Lake and among vegetation in Quiver Lake, in July, 1895.

101. **A. tecta** Gosse.

This species was present very uniformly throughout the year, but was not at any time common. It was found in the river and in all of the lakes except Flag Lake.

102. **A. aculeata** Ehrbg.

This is a winter species. It was present in towings from all the substations from November to June, reaching its greatest abundance in May.

103. **A. aculeata valga** Ehrbg.

Found in towings from the Illinois River and Thompson's Lake during April, 1895.

104. **A. cochlearis** Gosse.

This was the commonest representative of its genus, and was present every month in the year, most abundantly from April to September. It was found in towings from all of the substations.

105. **A. serrulata** Ehrbg.

Found once—in a towing from the Illinois River in December, 1895.

Notholca Gosse.

Lorica ovate, truncate and six-spined in front, sometimes produced behind; dorsal surface marked longitudinally with alternate ridges and furrows; extruded eggs not usually carried.

106. **N. acuminata** Ehrbg.

This is clearly a winter species, being present during both years in towings at nearly all of the substations from October to May. It reached its greatest abundance during March and April. It was found both among vegetation and in open water.

107. **N. longispina** Kell.

Found only in towings from the Illinois River in January, 1895.

Order IV. SCIRTOPODA.

Family **PEDALIONIDÆ.**

Pedalion Hudson.

Limbs arranged around the body in pairs, and parallel to its longitudinal axis; two stylate ciliated appendages on the posterior dorsal surface.

108. **P. mirum** Hudson.

This curious and interesting species was taken several times in the towings during the summer. It was first seen in the river at E in May, and was rather common there from July to October. During this period it was also taken in Phelps and Thompson's lakes.

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