THE GEOLOGICAL AND NATURAL HISTORY SURVEY OF MINNESOTA.

THE TWELFTH ANNUAL REPORT,

FOR THE YEAR 1883.

N. H. WINCHELL, STATE GEOLOGIST.

MINNEAPOLIS:
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V.

CRUSTACEA.

C. L. Herrick.

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A FINAL REPORT

ON THE

CRUSTACEA OF MINNESOTA

INCLUDED IN THE ORDERS

CLADOCERA AND COPEPODA,

Together with a synopsis of the described species in North America, and keys to the known species of the more important genera.

By C. L. HERRICK, Assistant in Zoology.

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PREFACE

IN presenting what may be denominated a final report of the work done in this state upon the group of crustacea best represented, and, all things considered, most important, the author must admit that the term "final" refers only to his own opportunities and the limitation of time imposed by circumstances.

While a comparatively large proportion of all the species existing within our limits have been examined during the progress of these investigations, there undoubtedly remain many additional and curious forms to reward the search of the student. A great variation in the degree of completeness with which the different genera and species have been treated will be observed, due in part to the circumstances under which they were studied, and frequently to the poverty of material. The entomostracean fauna is quite different at different seasons, and a complete knowledge of even our local fauna requires a long period of observation. Even the dead of winter is a favorable time to study some groups. The late autumn is, perhaps, the most favorable opportunity; for then, in one group, the sexual activities are just at their height, and both sexes may be studied. A number of cladocera are restricted to this season. There are a number (how large it is not yet possible to tell) of species in both groups which are to be sought by night though no phosphorescent species are yet known. Our larger, and, especially, deeper lakes have a quite different fauna from the shallow pools and rivers. In general, the flowing waters are poor in entomostraca. The cladocera or shelled entomostraca, have here received a large share of attention, and more particularly the Lynceidæ, which are the most minute of arthropods. This study has been rewarded with an unexpectedly large number of forms, and a particularly large number of species identical with those of Europe and elsewhere. Prof. Birge is the only American writer who has attempted this group, and his valuable work has made us familiar with the more striking new species. A few new species are included in our list and several varieties hardly yet known in Europe. The remarkable Monospilius is among these. This animal has but a single larval eye in the middle of its forehead, and wears its old covering over the newly-formed shell till the latter is a curious patchwork mass. The attempt has been made to incorporate a brief description of all American species with those found in Minnesota, and also to frame keys for the larger genera, so that the place of a species among its congeners may, at least approximately be found. The difficulty of framing such keys is very great; for few authors have employed the same distinctions in their descriptions, and it is necessary to select points sharply distinctive and conspicuous from the often meagre remainder after striking off scattering particulars. In some cases this difficulty has been greatly enhanced by the possibility that some of the species should be considered synonyms or varietal forms. The tendency to combine questionable forms thus produced it was necessary to offset by what may seem a too great conservatism. Faulty, however, as these keys may be, it is hoped that they will serve a good purpose in the extent which they cover. While the limits of this work preclude much more than a systematic outline, opportunity is taken here and there to admit a word on the anatomy or development. Such allusions must be considered simply accidental, for a complete treatment of these subjects would require large volumes, and the material will be long in gathering. A larger proportion of the rare males of the cladocera are here referred to than in any previous work of equal extent. The genus Cyclops, one of the bugbears to fresh-water carcinologists, is perhaps somewhat summarily treated. The excuse must be the condition of the synonomy. However, most of the combinations made were the result of careful study of large series from different localities. The sketches illustrating this paper are photo-printed from the writer's own drawings, and, without the elegance of lithographs, serve the purpose of explaining points of structure which cannot be communicated verbally. I am indebted to Prof. A. S. Forbes for very timely aid in bibliography, without which the paper could not have been completed. To Dr. Lindthal, through my friend Mr. Oestlund, I am indebted for a like service. But my obligation is deepest to Prof. Rudolph Leuckart of Leipzig, who kindly afforded access to almost a complete set of works on European entomostraca. Prof. C. W. Hall has collected at much expenditure of time and labor a set of specimens from different parts of the state which he kindly placed in my hands, thus enabling me to observe the great similarity of widely-separated faunæ. Mr. Lieberg also sent specimens of Diaptomus stagnalis from saline pools in Dakota.

INTRODUCTION.

"Evading e'en the microscopic eye,
Full nature swarms with life ; one wondrous mass
Waiting the vital breath, when Parent Heaven
Shall bid the spirit blow. The hoary fen,
In putrid streams, emits the living cloud
Of pestilence. Through subterranean cells,
Where searching sunbeams scarce can find a way,
Earth animated heaves. The flowery leaf
Wants not its soft inhabitants. Secure
Within its winding citadel, the stone
Holds multitudes. * * where the pool
Stands mantled o'er with green, invisible
Amid the floating verdure, millions stray.
* * Nor is the stream
Of purest crystal, nor the lucid air,
Though one transparent vacancy it seems,
Void of their unseen people."—*Cowper*.

To the poet only, and the man of science, is it given to meet these "unseen people" on those familiar terms which warrants the use of the word intimacy; yet may not we who, like Sam Weller, find our "vision limited," because we have only eyes, avail ourselves of the kind introduction these people give us, and shake hands, as it were, though perhaps a little stiffly, with our neighbors, the unseen people.

Whether we like it or not—Cowper intimates we shall not—these people, in one way or another, touch us constantly, and like diminutive sprites are ever active in hatching mischief or doing their little favors to humanity. Happily most of these are amiable goblins, and are tireless in endeavors to secure us against our insidious enemies of their own ilk. With your permission we will draw the curtain which separates us from the naiades of our pools and streams.

The numbers of living forms to be found in any pool is a constant surprise even to the student of this subject, and the variety and unique character of the animals, particularly, cause a constant flow of wonder and admiration. Confining ourselves to the crustacean forms which are, perhaps, most typical, abundant and interesting of the smaller animals of fresh waters, it is to be remarked that they are of a practical value to an extent which can hardly be correlated with their seeming insignificance.

To understand this fact it is first necessary to recollect that water in some form is an indispensable vehicle for the nidus of disease germs as well as of all life; desiccation means death. The abundantly-watered portion of our country must become permeated with the pestilential hordes ingendered in its fens did not this army of devouring animalculæ destroy the decaying matters accumulating in the waters.

Their importance depends largely on their minute size and unparalleled numbers. The majority of non-carnivorous crustaceans are so constituted that their diet is nearly confined to such floating particles of matter as are present in the water, in a state of more or less fine comminution; for, nearly without prehensile organs, these animals, by means of a valvular or, at most, ladle-like labrum, dip from the current of water kept flowing by the constant motion of the branchial feet, such fragments as the snail and scavenger-fish have disdained. All is fish which enters the net. Think of it, poor dyspeptic, a constant supply of food of every variety and no question asked for stomach's sake! Bits of decaying algæ or the broken fragments of a disintegrated mosquito, all alike acceptable and unhesitatingly assimilated.

Nor is the sanitary aspect the only one in which the *entomostraca*, as our minute crustacea are collectively called, command attention; they are valuable also as a food supply.

Now, does some one jump at the conclusion that the water we drink is filled with aliment in such pleasant form as that represented above—that Dr. Tanner after all lived on a watery solution of entomostraca? Too fast, my friend—food for fishes, but not therefore an insignificant element in our cuisine economy; for it has recently been shown by Prof. Forbes of Illinois, that some of our best fresh-water food fishes are almost dependent on some one or more species of entomostraca. Darwin shows that cats regulate the clover crop of England via field-mice and humble-bees, but it is not half as far from our "bugs" to the price of trout and whitefish.

Still we are not prepared to be surprised at this, for have we not long understood that whales go fishing, with their whalebone nets, for little mollusks not big enough to excite the cupidity of the catorial small boy?

The fact is, that the principle laid down by the Deacon (of venerable memory) that "the weakest pint must stand the strain," maintains in nature aside from the nature of "shays." The minutest forms are in some sense the most important, for they are the links which stand nearest the rock, and if they be loosened the dependent series falls.

The animals of the above group are, it is likely, the best criteria by which to judge of the purity of natural waters if their distribution were correctly understood. The presence of some species in great numbers is sufficient evidence of organic impurity. A critical study of the contents of samples of such waters will enable us to determine their character almost as well as by analysis. The following list of the animal life visible in a quart of filthy pond-water, taken by simple dipping, will perhaps be suggestive on this point:

Daphnia pulex	6
Ceriodaphnia	1400
Simocephalus	56
Cypris	50
Cyclops	30
Sand-fleas	120
Total Crustacea	1662
Infusoria	35
Arachnida (*Hydrachna*)	1
Vermes	5
Insecta—	
Coleoptera (larvæ)	8
Diptera (larvæ)	11
Hemiptera	10
Mollusca	35
Total	1767

The above are simply the animal forms visible to the (trained) unassisted eye; the truly microscopic forms number vastly more.

But each gathering includes specimens of carnivorous entomostraca as well, and these are not less interesting and bizarre than the cladocera.

The common cyclops, busy picking the bones of a luckless polliwog (must we say purwiggy?), is not less benevolent than the animate filters mentioned above. The amount of such material that they will dispose of in a short period of time is truly astonishing. It is the province of the following chapters to describe briefly such of these animals as fall in the two groups Cladocera and Copepoda and have been noticed in America.

CHAPTER I.

THE ENEMIES OF ENTOMOSTRACA.

First among these rank the young of various fishes which prey upon, and find their entire support in, these minute animals. This subject has been fully treated by Forbes, Ryder and others.

The enemy next most dreaded by entomostraca is, perhaps, the "spectre animalcule" or the larva of the little frost-gnat, corethra. It is no unusual thing to see a corethra carefully gorging itself with a fat cyclops, suddenly seized by the protractile jaws of the dragon-fly larva, shaken for a minute and then engulfed in the tomb-like cavernous mouth below. Nor is the road to the stomach of the dragon-fly always so circuitous. Water-tigers also, with other larvæ, prey upon these unfortunates. The hydra considers them a dainty morsel, and at once paralyzes them by the touch of his nematocystiferous arms; in other words, by the poisonous barbs coiled in concealment in the cells of the tentacles.

If the animal flys from these ubiquitous enemies he almost certainly is betrayed by carnivorous plants which abound in all our waters. Forbes says: "In ten bladders of *Utricularis vulgaris*, taken at random, I found 93 animals, either entire or in recognizable fragments, and representing at least 28 species. Seventy-six of the animals found were entomostraca, and belonged to 20 species." "Just one-third of all the animals found in these bladders belonged to the single species *Acroperus leucocephalus*, Koch."

But among the ranks of enemies must be included certain parasites, both external and internal, of which a variety are known. A few of the most remarkable of these will be mentioned. I may be permitted to quote from an article in the American Naturalist, April, 1883:

"We have discussed the relation of the minute fresh-water crustacea to sanitary science in a paragraph in a recent article in the Naturalist, but it remains to touch upon another phase of the subject. It may be thought unnecessary to trouble ourselves about the pathological conditions prevailing among such lowly animals, but it can be shown that these same causes of disease may not be unimportant in connection with human diseases.

It is a fact constantly receiving new exemplification, that the parasites infesting small animals, particularly water animals, are frequently but the immature forms of parasites of animals higher in the scale. These alternating generations are exceedingly difficult to study, so that while all stages may be separately known, only a fortunate combination of circumstances or patient accumulation of facts can connect the individual factors into the complete cyclus.

Thus, for example, Prof. Leuckart has but recently worked out the full life-history of *Distomum hepaticum*, although the adult has been a stock example in helminthological study in the laboratory for years.

The importance of such parasites, even in a commercial view, needs but a reference to trichinosis to illustrate. I am not aware that endo-parasites are known in entomostraca except in the case of cyclops. Embryos of *Cucullanus elegans*, a nematoid worm, enter the body cavity of cyclops and undergo two moults and then are transferred to the intestinal canal of food fishes.[1]

A similar parasite of cyclops is *Filaria medinensis*.[2]

The cladocera are generally quite free from parasites, but I have found in several instances young nematoids in the blood sinus in front of the heart in *Daphnia schœfferi*. These worms subsist upon the nutriment in the blood which constantly bathes the animal. True cysts could not be formed in the cobweb-like tissues of the hosts. This is, so far as I can learn, the first publication of entozoa from cladocera, and the parasites are figured in Plate T, Fig. 15. The animals were from 'Schimels Teich,' Leipzig.

While collecting copepods near Tuscaloosa, Ala., I gathered a number of specimens of *Cyclops tenuicornis*, and nearly all were unusually pale and feeble. On examination they proved to be infested with a worm of the sub-order Distomeæ. This sub-order includes many distressing parasites and forms which are adapted to be widely distributed by a long period of adolescence, and the number of stages passed through before maturity is attained."

"The larvæ live frequently in mollusca, and in maturity inhabit the intestine of vertebrates.

Upon examination, the cyclops individuals collected were nearly

1Claus. Kleines Lehrbuch d. Zoologie, p. 368.
2Fedschenko. Ueber d. Bau. u. d. Entwicklung d. *Filaria medinensis*, Moscow.

all found affected, some having as many as five parasites of various sizes about the alimentary canal, in the common vascular cavity which corresponds to the entire arterial and venous system of the more highly organized Calanidæ. The Cercerian or tailed stage was not found. Were the life-history known it would probably appear that the larval stage is passed within some young mollusks, and that the adult infests some vertebrate, probably fish, and would thus be perhaps transferred either in food or drink to the human system.

It is worthy of notice that the host was soon destroyed by the parasite, the post-imago or coronatus form being absent; most of the individuals thus infested possessed abnormally persistent larval characters in antennæ, etc." (See also below on Lagenella mobilis).

The external parasites are more numerous but, in the main, less dangerous. Among these are a variety of algæ, and colonies of Vorticellæ and related animals. There is almost always a colony of Acineta near the anus of Cyclops phaleratus. Rarely Stentor is found upon the body of Cyclops.

The most remarkable ectoparasite among the protozoa is the remarkable louse-like ciliate protozoan, to be described beyond, found as a parasite of Diaptomus pallidus.

Finally, certain of the rotifera are very constant enemies of the entomostraca, one species making its diet almost exclusively of Chydorus sphæricus and stowing them away with remarkable facility with its forceps-like jaws.

A New Species of Corethra.

(Plate V. Figs. 1-4)

The Corethra plumicornis as known in the larval form is one of the most abundant of the inhabitants of our inland waters, and its form and habits are sufficiently well known. (See *Types of Animal Life* by the author for description and figures.)

A second, and presumably new, species was found in a night gathering from Lake of the Isles near Minneapolis. In motion it differed so entirely, though indescribably, that the eye recognized it at once as new. The few specimens then obtained were all that have been seen, but I will here give a brief description of the larva and pupa in hope that the imago may finally be encountered.

The form is more slender than in C. plumicornis. The tracheal vessels are of a different form and color, and the viscera have obvious differences. Most conspicuous variations, however, are seen in the shape of the head, which is slender and attenuated toward the insertion of the antennæ. The antennæ are shortish and have a spine outwardly. The cuticular appendages have an unusual form as has the labrum. The anterior part of the head is spiny. The armature of the end of the abdomen is peculiar.

The posterior rudimentary appendages are of a different form, and the claws are replaced by club-shaped bodies. A curious appendage below is indicated in the name. The pupa has an extraordinarily elongate abdomen which terminates in two paddle-like appendages loosely ciliated outwardly. This species may be called

Corethra appendiculata, sp. n.

A New Ectoparasitic Protozoan.

(Plate V. Figs. 12–13.)

The very strange monocellular animal referred to was found scurrying over the body of Diaptomus pallidus in a manner like that of a louse scrambling over a bare spot upon its host. The body is disc-shaped and about .04 mm. in diameter. The lower or ciliated side is flat and circular. The upper or aboral portion is convex with an annular depression of greater or less regularity about half way from the center to the margin. The lower side has a chitinous barred ring, corresponding to the depression above, containing about 25 radially arranged bars, each of which, apparently, forms the support for a long cilium which with the others forms a circlet extending beyond the margin. These cilia are used as feet and by them the animal is able to move in any direction, apparently with none of the uncertainty of motion usual to ciliate infusoria. The protoplasm is granular and contains one or more contractile vesicles, one of which appeared very regularly in the center of the chitinous ring before mentioned. These animals can also swim freely, but after a short excursion usually came quickly back, and after shuffling or sliding over the smooth surface of the crustacean assumed a position of repose. The generic affinites of this protozoan are uncertain (Chilodontidæ?); the specific name may, perhaps, be safely applied as follows:

pediculiaris, sp. n.

Cragin notices the occurrence in American species of Cyclops of *Lagenella mobilis*, Rehberg. This gregarine (?) was found by him at Cambridge, inhabiting in large numbers the digestive tract of species of Cyclops, and has since then been observed in Minnesota.

CHAPTER II.

ORDER CLADOCERA.

This very extensive group contains a variety of types, but there are sufficiently evident connecting links uniting the extremes of structure. The Gymnomera which, following the usual custom, we include here, stand distinct from the other groups, yet have sufficiently evident cladoceran affinities. It is very unfortunate for ætiological speculation that this the only truly marine group should stand thus isolated from its fellows. According to the notions at present prevailing, the Phyllopods stand nearest the primitive type of crustacea. There are unmistakable hints at an early origin for that group, and not less evident are certain analogies with both Cladocera and Copepoda.

There has, however, recently been made an attempt to derive the Phyllopods from an original cladoceran stem with, as we think, somewhat unsatisfactory results. Do we not the rather see in both groups two like phases which may be looked upon as incidental and comparatively trivial. The shelled and the shell-less phasis appears in both. The most closely shelled Phyllopod is unmistakably nearer Branchipus even than any of the Cladocera. It would seem that the brief and imperfect embryonic nauplius condition of the latter sufficiently indicated their later origin. Again no fanciful analogy can unite the Ostracoda with the Lynceidæ. We know of no recent discoveries casting discredit on the remark of Balfour: "the independent origin of the Ostracoda from the main crustacean stem seems probable."

Prof. Packard says:[1]

"We imagine that when a permanent body of fresh water became established, as, for example, in perhaps early Silurian times, the marine forms carried into it in the egg-condition, possibly by birds

[1] "A Monograph of the Phyllopod Crustacea," etc., *XIIth Annual Rep. U. S. Geol. and Geog. Surv. Terr.*

[sic?] or by high winds, hatched young, which under favorable conditions, changed into Sida, Moina, and Daphnia-like forms. The Cladocera are, then, probably the more generalized forms, from which the Phyllopods, at this time and probably ever since Devonian times, *par excellence* a fresh-water assemblage of forms, took their origin." Whatever affinity there may be between the shelled Phyllopods and the Cladocera, it would seem that the evidence is conclusive that the latter group is not the direct continuation of the line of development inaugurated by an ostracode ancestor. As shown beyond, the present centre of the group seems near Moina with indications of a divergence from this rather generalized type, especially of degradation and heteronomy on the side of the Lynceids.

It seems at the present time that more might be accomplished for ætiology by a careful study of such groups as the present, in which are a variety of closely allied forms than by the attempt to join widely separated groups. When we shall have siezed upon the latest eddies and mapped their direction, it may become possible to combine the indications in such a way that lines of divergence thus traced accurately through some small part of their course may be produced backward to their intersection. This then is our present duty—the accurate mapping of minute districts and the careful noting of any moving straws, competent to indicate movements in the vast complex of vitalized nature. We conceive the cladocera to have had a comparatively recent origin, and to express the culmination and retrograde development of a plan of structure first differentiated after the appearance of clear bodies of fresh water. All the species save a very few are confined to inland waters. Accepting the above mentioned theory, the Sididæ will occupy the first place as departing least from the type from which the whole group sprang, while it is connected by the genus Daphnella with the Daphnidæ. The Daphnidæ, beginning with Moina, find their ultimate development in some monstrous forms of the genus Daphnia, but pass into the Lyncodaphnidæ by way of Macrothrix. The links uniting all these minor groups are very obvious.

Our own ideas of the relationships among the Calytomerous Cladocera are expressed in the accompanying table. This table is to be considered a projection of a portion of a genealogical tree, seen from below, in which the genus Moina forms the arbitrarily chosen fixed point. The heavy dotted line is imagined as directed downward vertically. That branch rising toward the top of the page is growing obliquely upward. The Daphnidæ are represented as expanding upon the same plane as Moina, and the Lyncodaphnidæ extend diagonally downward, producing the Lynceid branch The Bosminidæ spring from the stem at a lower point. These relations are made obvious by the figure giving a view of the ideal tree as seen from the side.*

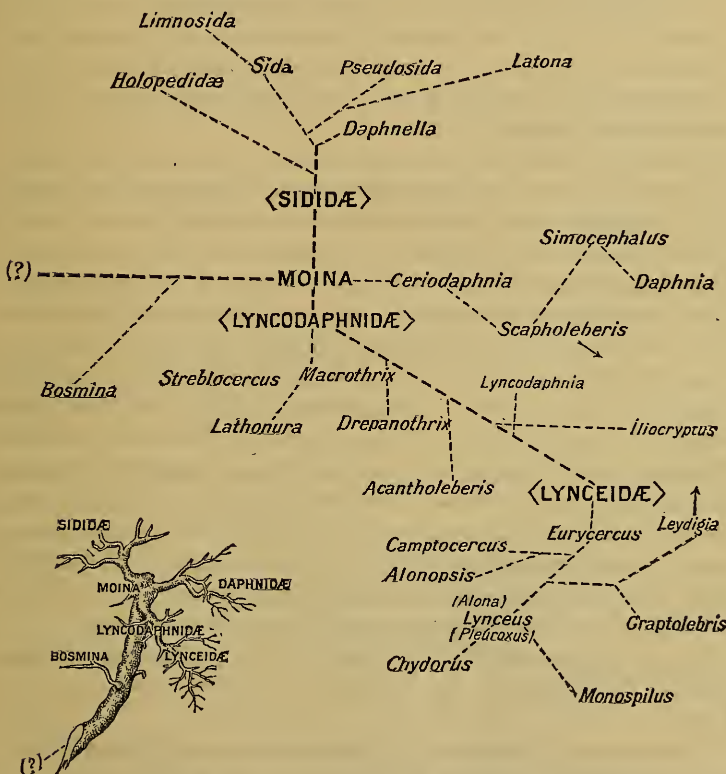

FIG. 1.—TABLE ILLUSTRATING THE RELATIONS OF THE

CLADOCERA CALYPTOMERA.

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*NOTE.—To adapt the diagram to the theory that the Lynceidæ are the progenitors of Cladocera, it is only necessary to revolve the imaginary line to the right, till it coincides with the axis of that family. The question mark may be understood to indicate that the source of the pivotal group, Moina, is uncertain. The author must confess that his inclination is toward a belief that the line culminating in the Daphnidæ diverged from a group of organisms resembling Phyllopoda, more definitely, resembling Limnetes. There is a very remarkable resemblance between the larva of Limnetes and Bosmina. The lateral spines of the former are, as will be shown true homologues of the antennules of Bosmina. The later origin of the Phyllopoda in their present form may be well admitted.

[1] Entomostraca, seu Insecta testacea, quæ in aquis Daniæ et Norwegiæ reperit descripsit, etc. *Otho Friedric Mueller*, 1785.

[2] Monoc. qui se trouvent aux Envir. de Geneve.

The Cladocera or Daphnoidea are characterized by the more or less leaf-like feet, and the lamina of thin chitine which encloses the greater part of the body, or at least forms a sac for the protection of the eggs. This so-called shell springs as a fold from the maxillary segment and is the most conspicuous and variously formed, while really least important, of the structural peculiarities.

All Cladocera begin life with a single median eye, but some lose it during later life. In one case it remains the only visual organ.

The outer covering is in most cases changed by frequent moults. The period of the moult is one of the most precarious in the life history of the animal.

Although figures and brief descriptions of animals belonging to this group are to be found in the works of Swammerdam, Leewenhoek, Trembley and other of the older authors, Mueller[1] was the first to produce a systematic work upon these in common with other minute fresh-water crustacea. He may be called the father of the study of micro-crustacea. Jurine,[2] an eminent Swiss naturalist, was the next to contribute important discoveries relating to these interesting animals, though Ramdohr had given anatomical details of several species. Gruisthuisen, a little later gives farther details of Daphnia sima (Simocephalus). The work of Milne Edwards gives a resume of what was known regarding these animals in that period. Soon afterwards the work of Baird became the beginning of a new era, and the study of the minute crustacea sprang into importance at once. The Scandinavian peninsula being the birth-place of the science, it is proper that the most exhaustive work on the group should be performed there.

The most important of the later writers are Leydig, Schoedler, Fischer, Lilljeborg, P. E. Mueller, Sars, Weismann, Claus and Kurz.

The complete bibliography of the subject up to Mueller's time is found in Baird's *British Entomostraca*; the greater part of the later bibliography is to be found in P. E. Mueller's Danmark's Cladocera. A few only of the more important works are here mentioned.

Koch, C. L., Deutchlands Crustaceen, etc.
Schoedler, J. E., Ueber Acanthocercus rigidus, etc.
Dana, J. D., Crustacea of the Wilkes' Exploring Expedition.
Lievin, Die Branchiopoden der Danziger-Gegend.
Fischer, Leb., Ueber die in der Umgegend von St. Petersburg vorkommenden Crustaceen, etc., 1851.
Lilljeborg, W., De Crustaceis ex ordinibus tribus, (or) Om de inom Skane forekommande Crustaceer af ordningarne Cladocere, Ostracoda och Copepoda.

This valua'le work is particularly good on the Cladocera, but is unfortunately without Latin descriptions; so that the Swedish text is a hindrance to its usefulness. It is chiefly of historic value now. Large 8vo; Lund, 1855.

Schoedler, J. E., Die Branchipoden der Umgegend von Berlin, 1858.
Smitt, F. A., Sur les Ephippes des Daphnes.
Lubbock, J., An account of the two methods of reproduction in Daphnia, etc.
Leydig, Fr., Naturgeschichte der Daphniden.

The most magnificent work published.

Lilljeborg, W., Leptodora hyalina, 1861.
Sars, G. O., Om Crustacea Cladocera, iagttagne i Omegnen af Christiania, 1862.

This valuable work is difficult of access, printed on thin paper and without illustrations. A second paper by the same author in 1863 is mentioned, but I have never seen it.

Schoedler, J. E., Neue Beitrage zur Naturgeschicte der Cladoceren, 1863.

One of the most important works on the Lynceidæ. The author is rather too credulous and inclined to form new species.

Klunzinger, Einiges zur Anatomie der Daphniden nebst kurzen Bemerkungen ueber die Susswasserfauna der Umgegend Cairo's.
Sars, G. O., Norges Ferskvandskrebsdyr Cladocera ctenopoda, 1865.

The best work on the Sididæ, etc.

Mueller, P. E., Danmark's Cladocera.

One of the most useful books on the subject. Especially good on Lynceidæ and Bosminidæ.

Plateau, Felix, Recherches sur les Crustaces d'eau douce, etc., 1867-69.
Mueller, P. E., Note sur les Cladoceres des Grands Lacs de la Suisse.
Weismann, A., Bau und Lebenserscheinungen Leptodora hyalina.
Sars, G. O., Om en dimorph Udvikling Samt Generationsvexel hos Leptodora, 1873.
Claus, C., Zur kennt. d Organ. u. d. feineren Baues der Daphniden.
Claus, C., Zur kennt. des Baues, etc., der Polyphemiden.
Gruber and Weismann, Ueber einige neue oder unvollkomen gekannte Daphniden.
Weismann, Thierleben im Bodensee, 1877.
Lutz, A., Untersuchungen ueber Cladoceren der umgebung von Bern.
Claus, C., Die Schalendruse der Daphniden, 1874.
Spangenberg, Fr., Ueber Bau und Entwicklung der Daphniden.
Lilljeborg, W., Crust. Suececorum Ordin. Branchiop. et Subord. Phyllop., 1877.
Pavesi, P., Nuova Serei di recherche delia fauna pelagica nei laghi Italiani, 1877-1879.
Grobben, C., Zur Entwicklungsgeschicte d. Moina rectirostris, 1789.
Weismann, Beitrage zur Naturgsch. der Daphnoiden, Leipzig, 1876-79. (Valuable on the physiology).

The American literature may be catalogued in a few lines. The first descriptions and figures with which I am familiar are those in the Rep. of the U. S. Fish Commission, 1874, where S. I. Smith notes Daphnia galeata, D. pellucida and D. pulex; also a species of Bosmina, Eurycercus lamellatus and Leptodora hyalina.

A. E. Birge was the first to systematically study Cladocera in America, and his "Notes on Cladocera" furnished a basis upon which to build. A few notes were published by the writer a little later.

A few additional notes and descriptions of new species were published in the *eleventh annual report of the Minnesota geol. and nat. hist. survey.*

Prof. Birge published other notes in the *Medical Journal and Examiner* of Chicago, which I have not seen.

Prof. Forbes of Normal, Ill., in an article in the *American Naturalist*, July, 1882, adds a number of facts and one new species.

In addition to the above, a figure of Sida was printed in one of Hayden's Survey Reports, and some account of the Cladocera of lake Michigan was given by B. W. Thomas, I believe, in one of the official reports of the Chicago Water Commission.

CLASSIFICATION OF THE CLADOCERA.

SUB-ORDER I.—CALYPTOMERA (membrane-clothed).

Body enclosed in a bivalve shell. Mandibles truncate below. Maxillæ distinct, spiny. Thoracic ganglia discrete.

TRIBE I.—CTENOPODA.

Feet six, similar, foliaceous, all distinctly branchiate.

FAM. 1.—SIDIDE.

Swimming antennæ with two unequal rami, intestine simple.

FAM. 2.—HOLOPEDIDÆ.

Swimming antennæ simple, elongate cylindrical (in the male prehensile), intestine with two lateral dilations.

TRIBE II.—ANOMOPODA.

Feet five (or six) pairs, the anterior pair more or less prehensile and destitute of branchiæ.

FAM. 1.—DAPHNIDÆ.

Rami of antennæ three and four-jointed, five pairs of feet, the last with a curved appendage guarding branchial sac; antennules of female short, one-jointed.

FAM. 2.—BOSMINIDÆ.

Six pairs of feet, antennules elongated, many-jointed.

FAM. 3.—LYNCODAPHNIDÆ.

Antennules of female elongated, but one-jointed; intestine simple or convolute.

FAM. 4.—LYNCEIDÆ.

Antennæ with both rami three-jointed, intestine convolute, with abdominal but no anterior cæca.

SUB-ORDER II.—GYMNOMERA (destitute of covering).

Body without or nearly destitute of bivalve shell; feet not branchiate, spiny. Anterior thoracic ganglia in one mass.

FAM. 1.—POLYPHEMIDÆ.

Abdomen curved, terminating in two long stylets.

FAM. 2.—LEPTODORIDÆ.

Abdomen straight, ending in short claws.

FAMILY SIDIDÆ.

Head separated from the body by a depression, without prominent fornices (or spreading shields) over the base of the antennæ. First pair of antennæ, or antennules, as we shall uniformly call them, one-jointed, usually rather small in the female, but extending into a very strong flagellum in the male. Antennæ long, biramose, with unequal branches. Mandibles truncate at the end. Maxillæ armed with large spines. The form is usually elongate, and the abdomen often extends beyond the edge of the shell behind. The male openings are usually in the end of long appendages which depend from the base of the post-abdomen. This interesting family is represented in America so far by four species, one of which constitutes a new genus. Others will undoubtedly be found upon a careful study of the fauna of the great lakes Most of the species prefer the clearer and colder water of large lakes. The processes of development, as traced by the writer, vary very little from the method exhibited by Moina. The ephippial condition, however, is not found in these animals which are less subject to destructive influences of the climate. They do, however, produce so-called winter eggs which are laid in October and are distinguished from the summer eggs, which hatch in the brood cavity, by a brown color and the presence of fatty spheres. These eggs are produced in large numbers in distinction from most other Cladocera in which the winter eggs are very few. These eggs are permitted to settle to the bottom and there develop at the proper time. Sida crystallina is often found in immense numbers in large lakes which contain abundant plant growth. The size, and especially the reproduction activity, is very dependent on the environment, and hence little success is obtained in preservation in aquaria. Some of the genera are nocturnal and should be sought at the surface on quiet evenings.

I.—GENUS SIDA. Straus.

(Plate N. Figs. 12-14.)

Body elongate, hyaline. Head small, quadrate. Fornices absent. Antennules of female small, truncate; of male, with a long flagellum. Second antennæ with the rami two and three-jointed. Male with the sexual openings just behind the last pair of feet. It is the upper or longer branch of the antennæ which in Sida is three-jointed, while the reverse is the case in the next genus. The only species, according to P. E. Mueller, is the ubiquitous S. crystallina. The S. elongata of Sars is distinguished by the smaller head and its concave lower margin and more elongate shell. The terminal joint of the longer ramus has one less seta than S. crystallina, while the post-abdomen has more numerous spines. We incline to believe it a valid variety at least. The bibliography below is extracted from a previous report:

Daphne crystallina, MUELLER.
Daphnia crystallina, LATREILLE, BOSC.
Sida crystallina, STRAUS, Mem. Mus. Hist. Nat.
Sida crystallina, M. EDWARDS, Hist. Nat. Crust.
Monoculus crystallinus, GMELIN, MANUEL. FABRICIUS.
Monoculus elongatus, DE GEER, Mem. servir. Hist. Ins.
Sida crystallina, LIEVIN, Branch. d. Danziger Geg.
BAIRD, Brit. Entom.
LILLJEBORG, De crust. ex ord. trib.
FISCHER.
SCHOEDLER, Die Branch. d. Umg. v. Berlin.
Neue. Beitr.
LEYDIG, Naturg. d. Daph.
SARS, Norges Ferskv—Krebsdyr.
Sida elongata, SARS, " " "
Sida crystallina, P. E. MUELLER, Danmark's Cladocera.
KURZ, Dodekas Neuer Cladoceren.
BIRGE, Notes on Cladocera.
HERRICK, Microsc. Entom.
LUTZ, Untersuch, u. d. Cladoceren d. Umg. v. Bern., 1878.
WEISMANN.
GROBBEN, Entwicklung. Moina.
HERRICK, Crustacea of Minnesota.

II.—GENUS PSEUDO-SIDA. Herrick. (Genus n.)

Similar to Sida. Antennules of the female, with a long flagellum, like that of the male of Sida, sensory setæ lateral. Body elongate, head short, extending into a sharp beak. The post-abdomen is armed with groups of sharp spines or bristles. Most characteristic, however, is the fact that the antennary joint, which in Sida is two-jointed, in this species is tri-articulate, and the two-jointed ramus has a great number of setæ (16-17).

Sp. 1. **Pseudo-sida bidentata,** Herrick. (Sp. n.)

(Plate K. Fig. 9.)

Post-abdomen armed with 12–14 clusters of spinules in a transverse row; the terminal claw armed with two long basal spines, and with numbers of fine teeth on the inside. The two-jointed ramus of the antennæ has six setæ on the basal, and ten or eleven on the terminal joint, while the three-jointed ramus has a short terminal joint bearing three spines. The valves are marked with sparse spines on the lower margin. In most respects this species is like Sida, which it resembles in size. In the form of the female antennæ it is like Latona which it also somewhat resembles in the number of joints of the antennæ and the numerous setæ they bear. It is certainly an interesting transition form. Found only in swamps bordering Mobile bay, Ala., but whether in brackish or fresh water my notes do not inform me. Sida crystallina lives far out in the bay, and Daphnella is found in pools along shore.

III.—Genus Limnosida. Sars.

(Plate N. Fig. 9.)

Head crested; eye in a conical prominence. Shell elongated, produced above in an acute angle. Antennules small, truncate in the female; in the male of enormous size; antennæ very long. Post-abdomen smooth; terminal claw spiny.

The one species, L. frontosa, Sars, is not yet known in America.

IV.—Genus Daphnella. Baird.

Neither beak nor fornices present. Antennules of female small, truncate; those of male long, flagellate. Antennæ with two-and three-jointed rami. Male with a hook on the first foot, and large copulatory organs attached to the base of the post-abdomen.

Sp. 1. **Daphnella brachyura,** Lievin.

Sida brachyura, Lievin, Branch. d Danziger Geg.
Daphnella wingii, Baird, Brit. Entom.
Sida brachyura, Lilljeborg, De crust. ex ord. trib.
Diaphanosoma brandtianum. Fischer. Erganzig. Berichtig.
Daphnella brandtiana, Sars, Norges Ferskv.—Krebsdyr.
Daphnella brachyura, P. E. Mueller, Danmark's Cladocera.
Daphnella brachyura, Lutz, Untersuchung u. die Cladoceren d. Umg. v. Bern.
Sida brachyura, Pavesti, Nuova serie di recerche della fauna pelagica nei laghi Italiani (L. Trasimene).
Daphnella brachyura, Herrick, Notes on Crustacea of Minnesota.
(Compare also *D. expinosa*, Birge, Notes on Cladocera p. 3.)

The species of Daphnella found about Minneapolis, occasionally abundant, seems not to differ in any important character from European types of D. brachyura, although I formerly regarded it as distinct (D. winchelli, Microscopic Entom., Addenda).

Head less than $\frac{1}{2}$ the body (about .27 mm., while the body is .6 mm. long); eye about $\frac{1}{4}$ head; antennæ when reflexed extend a little beyond $\frac{2}{3}$ the length of body. Male, .7 mm. long; antennæ reflexed, reaching base of shell; anterior antennæ extremely long; copulating organs reaching nearly to end of claws. Having carefully compared our specimens with the descriptions and figures given by Birge for his D. expinosa, the evidence seems to indicate not only that they are identical, but both are really D. brachyura. The distinctive characters of D. expinosa are a greater indentation between head and body, absence of caudal teeth, greater length of male appendages, and the opening of the vasa deferentia below the "instep" of these appendages.

The absence of teeth upon the post-abdomen is of even generic importance according to Sars, who gives it in his synopsis of genera as typical for Daphnella. In our specimens the claws are at least pectinate if not serrate, while the appendages of the male reach generally nearly to the middle of the claws. The relative length of these appendages and the antennæ of the male is variable.

Sp. 2. Daphnella brandtiana, Fischer.

Head as long as half the body, antennæ when reflexed reaching beyond the posterior margin of the valves. Length 0.8 mm. Of the validity of this species we can form no conclusion. It is usually considered a variety or phase of the above.

V.—Genus Latona, Straus.

(Plate N. Fig. 8.)

Body elongate, broad; head large and square, appendaged below with triangular laminæ; fornices present. Antennules rather large. The larger ramus of the antennæ is two-jointed and has an expanded process at the base. The lower posterior angle of the shell has a peculiar diverging set of setæ. The shell is often ornamented with numerous flecks of bright color. There is a copulatory apparatus in the male.

Latona setifera, Mueller,

Is the only species, and is not yet recognized in Minnesota, but was found by Prof. Birge in lake Michigan.

FAMILY HOLOPEDIDÆ.

Genus Holopedium, Zaddach.

(Plate N. Fig. 11.)

The peculiar animal bearing the name Holopedium gibberum has the brood cavity greatly elevated, and the whole upper part of the animal is covered by a jelly-like mass secreted as a protection or float. The antennæ are simple in the female and extend through a slit in this covering. In the male they are prehensile and have rudimentary inner rami. It would be difficult to recognize the affinity of the female with its monstrous form were it not for the male and particularly the development history. Found in this state probably only in lake Superior. Forbes mentions it from lake Michigan.

FAMILY DAPHNIDÆ.

The family Daphnidæ contains the genera Moina, Ceriodaphnia, Scapholeberis, Simocephalus and Daphnia, which include the commonest, as well as some of the largest, Cladocera. The genera may be distinguished by the following table:

I. Head rounded, not beaked; antennules long in both sexes, shell not covering the end of the abdomen.......................... *Moina.*
II. Head rounded; antennules rather short; shell enclosing whole body.. *Ceriodaphnia.*
III. Head somewhat beaked below, shell angled below or extending in long spines from the lower angle, pigment fleck roundish... *Scapholeberis.*
IV. Head beaked below; shell rounded below, with a blunt spine above; pigment fleck elongate.................................. *Simocephalus.*
V. Head beaked below; shell extending in a sharp spine at the upper posterior angle; pigment fleck small............................ *Daphnia.*

THE CIRCULATORY SYSTEM OF THE DAPHNIDÆ.

In the *Daphnidæ*, and, indeed, the Cladocera in general, we meet an instance of great development of surfaces at the expense of solidity of form and compactness of organs. The whole body is composed of an aggregate of laminæ, and the appendages all approximate more or less toward this fundamental modification. Thus, for example, the head is a leaf-like body with a laminate shield above and a pair of flat organs beneath. The abdomen terminates in a knife-like post-abdomen, while the thorax, with its narrow form, foliaceous feet and, far more, the enormous development of the outer wall to enclose, more or less fully, the entire body, is the typical illustration of this fact. Necessarily this structural modification exerts a formative influence on the internal organs which are all more or less influenced by it; and this is peculiarly the case with the more external and, in general, the paired organs. Thus the "shell glands," so called, which in Copepoda are generally coiled tubes, become here greatly flattened organs closely united with the shell. The physiological result of this modification is the sensitiveness to changes in the environment, which is universal among the *Daphnidæ.* The compact Copepoda survive the vicissitudes of confinement with comparative immuity, but the first taint in the water destroys the delicate organism of *Daphnia.* The cause for this may be found in the exposure of the most vital and delicate parts of the organism to the influences of the surrounding aqueous medium. In particular the circulatory and respiratory systems, which here are not easily to be distinguished one from the other, constitute a relatively very large area of close contact with the water. It thus happens that the central organs are influenced in a very short time by whatever deleterious substances may be disseminated in the water.

Notwithstanding this lack of centralization, the structure of these animals is of a very considerable degree of complexity and, presenting so many instructive modifications under circumstances so favorable for study, has been very thoroughly investigated. The very transparency which has made it possible to clear up many questionable points in crustaceology from the lessons learned in *Daphnia,* has rendered the investigation of certain sets of organs extremely difficult, and among these may be mentioned the circulatory system. The circulation of the nutritive fluid and the general facts connected with the heart were indeed early understood; but there remains many a detail and some important relations which are as yet either imperfectly known or entirely misunderstood. The following notes are offered as a contribution to the, as yet incomplete, knowledge of the circulatory apparatus.

The observations were confined for the most part to *Daphnia schæfferi* and *Simocephalus vetulus*, with occasional comparisons with *Eurycercus*, *Pleuroxis, Pasithea* and others. It is greatly to be desired that the study might be carried to the Sididæ, in which the larger size and superior transparency would doubtless reward the search with several, as yet doubtful details. The circulation of the nutritive fluid in the Daphnidæ, then, is somewhat complicated, but may be divided into a superficial and a deep system. It must be remarked that this distinction is arbitrary and only used for its convenience. The one extends over the entire inner surface of the carapace, while the latter is in close relation with the vegetative organs, and extends into the branchial vessels of the feet. The nutritive fluid which is normally colorless and supplied with corpuscles of organized nutriment, (it seems doubtful if they should be called blood corpuscles) is confined for the most, if not its entire, course within membranous walls of connective tissue which, however, instead of assuming a definite form as "blood vessels," for the most part conform to the contour furnished by the firmer organs.

This membrane which is frequently folded upon itself and invests the body walls and the inner organs, is in some places free, and may be seen as a pulsating, swinging film, or, more frequently, it can only be detected as a swaying line (seen in optical sections), thus giving rise to the misapprehension that one is dealing with a thread, or as moving grains, in which case the film is itself invisible but its presence is indicated by the attached grains of protoplasm. About the heart the free swaying portions of this membranous layer are so numerous as to render it almost impossible to distinguish the essential from the accidental appearances.

This membrane must serve the most various purposes; aside from the mere retention and direction of the blood currents, it is often transformed into a branchial surface. At definite points it becomes the bearer of the cells which were above mentioned as grains of protoplasm. These are most numerous in young and well-fed animals, and in particular in gravid females, while, on the contrary, mature males and females after the escape of the young, are nearly devoid of such bodies. These are most numerous in angles of the membrane, particularly about the heart, shell glands, ovaries, intestine and the branchial spaces in the feet.

These cells vary in size from that of the blood corpuscles to larger cells with nuclei of comparatively very large size. It would be too much to say that such cells are developing blood corpuscles; but that they are reservoirs of nutriment which serve to supply the increased demand upon the blood in exigencies of the existence of the animal, cannot be doubted. It is a well known fact that the number of blood corpuscles, so called, likewise varies, and apparently under the same conditions. It seems altogether probable that the two facts may be considered as supplementary, *i. e.* that the same process of depauperating of the blood, which deprives it of its corpuscles in an earlier stage, lays waste those supplies laid up in the cells referred to (whether by their actual separation as blood corpuscles or simply desolving of the contained material is of little importance). These cells also are thus paralellized with the "oil globules" of *Copepoda*. In such copepods as *Cyclops* and *Canthocamptus*, which appear to have no differentiated heart, there are always present drops of colored fluid, which are most numerous in well-fed and pregnant specimens. These drops occupy the same relative position as the blood globules of other Crustacea, *i. e.*, they lie within a very thin membrane corresponding to the vascular walls of other animals. This membrane, in general, invests the alimentary canal, as can be very readily seen in the abdomen, where it encloses a considerable space about the intestine, which is filled with fluid, investing more or less completely the muscles and other organs. As there is no rapid circulation of blood, these "oil drops" are comparatively stationary, and yet are moved slowly by the constant contraction of the walls of the alimentary canal which, in the anterior part, or stomach, are thick and glandular, while in the abdomen they seem to be more fitted for respiratory function.

The above arrangement in *Cyclops* is correlated with its compact habit and thick carapace, and forms a simple starting-point for the study of the circulatory system in arthropods. It seems that the walls of the membranous blood cavity are themselves also, in places, furnished with muscles, so that the fluid is not dependent entirely on the vermiform or the peristaltic motions of the intestine for its escape from stagnation. If this be correct, we here have an indication of the origin of the central organ of the circulatory system.

But to return to Daphnia, the heart lies in the dorsal region over the intestine upon which it may be said to ride, as it were astride, though as we shall see, it is separated from the intestine by other organs. In *Eurycercus* this is most evident, as here the heart is more obviously bifurcate.

The heart and circulation in Daphnia has been described more or less at length by many authors, in particular *Claus* (Zur Kenntniss der Daphniden und verwanter Cladoceren. Zeitsch. f. Wiss. Zool. Bd. xxvii.) and *Gruithuisen* (the work of this author I have not seen), while *Weismann* (Ueber Bau und Lebenserscheinungen von Leptodora hyalina, 1874) describes the heart of Leptodora, and *Claus* (Zur Kenntniss des Baues und der Organ. der Polyphemiden), that of the Polyphemidæ. Other authors, except *G. O. Sars*, who elucidates some points in the circulation of blood in Sida, seem to have added little or nothing to our knowledge of this interesting subject.

As already often described, the heart occupies a place in a definite space—*the pericardial chamber*—the summit of which is the dorsal shield which, we believe, should be distinguished from the remainder of the so-called cephalic shield. (It is usual to describe the shell of Daphnia as consisting of a bivalve posterior portion or *ormostegite*, and a simple anterior *cephalostegite*; but it seems much more proper to consider that portion of the shell which covers the pericardial space, and is the point of attachment of the powerful muscles of the abdomen and of the membranous walls of the pericardium, as a distinct portion of the carapace, as it often evidently appears through the presence of a distinct suture, or, in its absence, through the peculiar sculpture of the shell. In such case it might also be proper to distinguish two regions on the lateral appendages of this dorsal shield, an upper and a lower, separated by the more or less obvious line, extending from the union of the lateral lines of the dorsal and cephalic shield in nearly a straight line toward the posterior portion of the shell, and indicating the insertion of the muscles which move the feet and post-abdomen. The lateral walls of the pericardial space are the shell-walls themselves, and the floor is formed by a membrane supported on, and investing in part, the strong muscles which connect the abdomen with the upper anterior part of the dorsal plate. Thus a space is left between the pericardium and the intestine which is occupied by a special blood sinus leading toward the posterior and lower part of the abdomen. The posterior wall of the space is formed by a chitinous partition which bounds the brood space, or its homologue, and is connected by chitinous processes (stutzbalken) with the outer skeleton. The anterior, on the other hand, is only bounded by the supporting ligaments of the abdomen above described and membranous partitions. As usually described, the heart lies suspended in the cavity thus defined, by slender muscular threads, more or less like those of the heart of *Corethra* larvæ and the like; and such seems to be the case at first, but a more careful study shows that this is far from correct. On the contrary, the chief supports of the heart are membranes which, seen in cross-section with the attached grains or blood globules, assume the appearance of exceedingly slender structureless threads. The action of re-agents indicates that these supposed threads are not muscles, but composed of connective tissue; while by changing the focus the sharpness of the line is frequently not altered, but *its relative position is changed*,—a simple test which often serves to dispel an illusion of this sort. That there are some threads of the character above mentioned is not to be doubted, as in connection with the valves of the heart; but the proper support of the heart is found in the membranes which invest it in part, and are reflected upon the walls of the shell and, anteriorly, of the intestine. It is not yet possible to fully describe the insertion of these tissues, as there is so large a number, especially about the anterior opening, where they lie in all directions and at all angles, and are so transparent, that only their vertical sections appear as dark lines. Thus the same membrane appears and disappears, only to re-appear in a different position where it might be readily taken for a distinct membrane. In general, however, I hope to make no serious error in the following summary. Before going into detail, however, it will be necessary to consider the intimate structure of the heart, as well as its general shape and position.

The general shape is that of an irregular oval with the greatest convexity posterior (*Daphnia*, *etc.*), or it may be strongly bifid and thus somewhat Y-shaped *(Eurycercus*, *etc.)*. It is held in position in the pericardial cavity by the membranes above alluded to, to which it is attached at definite points, the principal of which are two slight enlargements on the lower posterior portion, which are in part opposed to each other and also to a superior posterior point of insertion. All three of these points are thus held in relation with the shell with which the attached membrane is connected on either side below and above. The membrane then extends part way along the heart wall towards the anterior and is then reflected to the shell wall. The result of this is that the pericardial space is an angular cavity opening in front. It would seem as though the membrane attaching the heart were identical with that lining the cavity itself. The heart proper is obviously composed of series of muscular elements, which are considered as simple cells by Claus, and which in young individuals show very destinct nuclei of comparatively large size. These are arranged like the meridian lines of a globe uniting above and below, thus forming the most effective apparatus possible for contracting the heart. In the smaller Daphnidæ, as stated by Claus, there seems to be but a single layer of muscular rays, but in D. schæfferi and Simocephalus I have repeatedly satisfied myself that some of the longitudinal rays sink below the others and form a series of *longitudinal muscles*, as stated by earlier writers. These are furnished with a nucleus which is frequently more or less external, appearing like a spherical appendage. In *Leptodora* Weismann has shown the heart to consist primarily of a membrane of connective tissue, upon which the muscular fibres or cells sit in somewhat the same position as in Daphnia, except that there is not the same regularity in the arrangement. There are many considerations which would lead us to expect the same structure in Daphnia, though it is not yet demonstrated; and the structure of the anterior opening seems to point in the same direction. At any rate there is a close connection between the muscular and connective parts of the heart. We have, then, in the heart of Daphnia a highly developed apparatus for closing it, but apparently none for its opening. This certainly is not accomplished by the few fibers which connect the heart with the shell, the very contractility of which is doubtful. Nay, more, these are insufficient even to hold it in its place in the cavity. Still less can we assume that the heart, from any inherent power, can open itself. This must be explained by the operation of two factors which are interdependent, *i. e.*, the elasticity of the supporting membranes and the unequal pressure of the blood in different parts of the body. 1. The membranes which support the heart are attached not at right angles, but, on the contrary, in a direction more nearly parallel to the walls of the heart, and thus whatever elasticity they possess is greatly increased; and the diminishing of the size of the heart draws these membranes out of their position at the expense of their elasticity, which tends to restore them to their original position when the pressure is removed, in the same way a drum-head returns after a blow to its normal position. This factor is, however, only operative so long as the whole system of membranes to which these belong is distended with fluid. If this blood cavity be punctured, the fluid flows out and the heart shrivels. It may continue to beat for some time, but it will be seen that the effort consists simply in a vigorous contraction which is followed by no perceptible enlargement. 2. After the systole the blood of the heart is forced toward the head, whence it is prevented from re-entering the pericardial space directly by the valves and the membrane enclosing the arterial blood. The pressure is therefore increased in all parts of the system, except the pericardial chamber where it is greatly diminished. The membranes supporting the heart are thus unusually tense, and the muscular effort having ceased, the walls of the heart are distended, and blood flows in in the direction of the least resistance through the two lateral openings or ventral valves of the heart. The contraction of the heart during the systole is not simultaneous in different parts, but begins by the contraction of the posterior part where, being nearly free, the motion is more marked. At the close of the systole the heart is irregularly contracted, the points of attachment above described being more distended than the remaining portions. The anterior of the heart is rendered very difficult to study by the fact that its opening is covered by the muscles of the mandibles and obscured by the many supporting and vibrating membranes alluded to.

It is, however, suspended by two folds of membrane which I have been inclined at times to believe blood-vessels through appearances resulting from the confused currents flowing about them. The upper margin is also attached by a pair of cords directly to the superior part of the shell. The anterior opening or arterial valve is most perplexing, and the following description which applies only to Daphnia schæfferi must be subject to some doubt. It appears however that it has been in a measure misunderstood by previous writers, and namely by Claus, who compares it with that of Leptodora, which if correctly described by Weismann, is not at all identical in form, but quite comparable with one of the sides or lips of the venous opening. It does not seem to be connected by a thread, as stated for *Leptodora*, with the aortal bulb, for in reality there is no aortal bulb; the heart simply is connected with the system of membranes which more or less inclose the system. The floor of the so-called aortal space is a membrane which separates the outflowing stream from a current which flows toward the abdomen and passes directly under the arterial opening, so that it appears as though there was a stream entering the heart from before as well as at the sides; the arterial opening being nearer the dorsal part of the heart than is naturally expected, and the slight enlargements at the attachment of the supporting membrane favoring the impression that there is here a veritable opening. The out-flowing blood stream is bounded at first by the membrane above mentioned, which is farther on reflexed onto the shell and intestine so that the streams in the head flowing just under the shell are separated from the deep dorsal stream flowing from the heart.* This main current passes to the region of the eye between the horns of the cæca of the alimentary canal, and thence beneath the stomach, and here divides, part becoming external and a deeper part passing under the intestine, thence in front of the heart, flows into the deep sinus which, as before said, passes beneath this organ. Other portions of the returning stream flow around the angle of the union of the head and body and constitute a stream just above the feet in which the current flows vigorously.

Yet other portions flow into the region of the shell-gland and are united with blood which here passes through the numerous sinuses described by Claus as surrounding this organ (Die Schalen-

*In *Pasithea rectirostris* this septum is easily seen as a swaying membrane, which near the eye is reflexed to the top of the shell.

druse der Daphnien) and thence flows into the abdomen, uniting with the other two streams. A part also of the current in the head flows into the antennæ where it follows a deep course through the basal joint in which the corpuscles may be seen to emerge to the surface from two points where are spaces between the powerful muscles, the first being near the base and the second near the extremity of this joint, and then to return and join the superficial current.

The corpuscles appear to enter the rami very rarely if at all. That part of the superficial stream which reaches the interior of the pericardial chamber passes between the muscles of antennæ and jaws and seems to find its way into the great current beneath the heart, though I have also thought to have seen it flow directly into the pericardial space as the lateral superficial streams do. That part of the superficial stream which reaches the posterior margin of the shell returns through a canal formed by the walls of the shell and the brood-space,between the"stutzbalken"of which the blood corpuscles can be seen to glide more rapidly than in the free lateral spaces.

Lastly,it only remains to follow the fortune of the strong stream flowing along the neutral surface of the abdomen. The strong current flowing beneath the heart enters a broad sinus which lies over the intestine and extends for over a third of its length, where its walls unite with the surface of the intestine above and thus open downward on either side.

The stream thus directed flows toward the openings of the base of the feet. The structure of the branchiæ has not yet been clearly described. Instead of nearly spherical or oval chambers they are really tubes which connect, on one hand with the opening above, and below with the general cavity of the limb, whence the blood returns to the abdomen. The current is very rapid through these tubes. The blood having been returned to the abdomen, courses in the well known manner through the post-abdomen and flows over the intestine, thence over the back-flowing stream to the posterior lower opening of the pericardial chamber.

The study of the actions of the heart is rendered more difficult by the fact that in order to secure the greatest possible transparency, the living animal must be covered and a little pressure applied, which is frequently attended with abnormal variations of the circulation. In particular if the usual exit of the blood be stopped by the cæca of the intestine, as is frequently the case, the operation of the heart may be reversed, when a vigorous stream may be seen to enter the arterial opening and emerge from the ventricles. This process would be impossible if the anterior valve were as described by Claus and Weismann; while being really more like the venous valves, it is easily and frequently permitted. The current of the blood in this case stagnates except near the heart.

The rapidity of the pulsations of the heart varies with age and condition of rest or motion.

In D. schæfferi this variation may range from about 150 per minute to perhaps 250, 200 being probably a fair average. In a young Simocephalus I have observed a heart beat 300 times in a minute. Again, in a specimen of D. Schæfferi at rest the heart was beating 170, but during the spasmodic motion of feet and antennæ the pulse rose to over 200.

I.—Genus Moina. Baird.

The systematic position of this genus has been the theme of some discussion. it being claimed, with good reason, that there are many resemblances to the Lyncodaphnidæ (P. E. Mueller considers it a transition to the Bosminidæ and lyncodaphnids); on the other hand, Leydig and Kurz regard it more closely allied to the Sididæ, with equally good reason. The long antennæ, long narrow antennules and many peculiarities in form, etc., suggest the macrothroid crustaceans; the extended abdomen and especially the location of the male seminal opening are like Daphnella, which Moina resembles in motion and habit very strikingly. The absence of the pigment fleck is no more a characteristic of the Sididæ than of other groups. After all has been said, the immediate affinities of the genus are acknowledged to be with the Daphnidæ.

The true place of the genus, as it appears to the writer, was hinted at by Birge (Notes on Cladocera). Moina seems to be the pivotal point of the Cladocera, at least of the families above mentioned. Without going into phylogenetic speculation, it is suggestive that this genus can and does by preference live in very impure water and may therefore have had an early origin. From Moina diverges the stem of the Daphnidæ by way of Ceriodaphnia, Simocephalus and Daphnia. These two latter genera are intimately connected by Simocephalus daphnoides, Herrick. Scapholeberis is connected with Ceriodaphnia through S. angulata, Herrick. The Sididæ seem to diverge by the way of Daphuella, through which by means of Pseudo-sida the genus Sida is reached, and finally Limnosida, Latona and Holopedium. The relationships of the curious Polyphemidæ are less evident.

The Lyncodaphnidæ make an easy transition to the Lynceids proper, while the Bosminidæ are still quite isolated, but are suggested by Macrothrix pauper. The fact that Moina stands thus related to radiating groups is simply suggestive, but it *is* suggestive of its possible antiquity and synthetic character.

The three species of this genus stand very poorly distinguished from one another and their specific validity may be doubted.

The most exhaustive study of the embryology of the Cladocera was based on Moina. (*Grobben*, *Entwick d. Moina*, *etc.*)

The genus is characterized by Weismann and Gruber[1] about as follows:

Head prone; separated by a depression from the thorax; fornices obscure; rostrum none; pigment fleck absent; antennules of the female large, moveable, furnished with a sensitive seta near the middle, flagelliform; antennules of the male very large, hooked at the end. The setæ of the antennæ are all ciliate; the tri-articulate ramus with five setæ; posterior margin of the valves thicker in the median line; caudal setæ very large, about twice in the length of the animal; anus above the claws; feet of the first pair of the male with a strong hook.

Weismann has shown that both summer and winter eggs originate from groups of four cells, one of which only is transformed into the egg, the remaining three serving simply as a supply of nourishment for the egg, which absorbs it directly. Both eggs and nutrient cells develop from the epithelium of the termination of the ovary. The summer eggs have less yolk than the winter brood, and the yolk is bluish in the summer eggs and deep red in the winter eggs of Moina rectirostris; while in M. paradoxa the summer eggs have yellow and the winter set snow-white yolk. There are never more than two winter-eggs in any of the Daphnidæ, but there are as many as twenty summer eggs in some cases in Moina. In M. rectirostris only one winter egg is produced, which is one of the best distinctions of the species, as this is, perhaps, the only case. (*Naturgeschichte der Daphnoiden*, *Weismann.*) The first generation, springing from the winter eggs (impregnated eggs), is composed solely of females which reproduce parthenogenetically; the second brood contains sexual males and females, thus completing the cyclus.

1 *Ueber einege neue oder unvolkommen gekannte Daphniden, Freiburg*, 1877.

Sp. 1. Moina rectirostris, Mueller.

(Plate A. Figs. 2, 5, 8, 10, 11.)

A. Var. vera.

Daphnia rectirostris,	O. F. MUELLER, LATREILLE, BOSC, DESMAREST, SCHRANK, LEYDIG.
Monoculus rectirostris,	GMELIN, FABRICIUS, MANUEL, JURINE.
Pasithea rectirostris,	KOCH.
Moina rectirostris.	BAIRD, WEISMANN, KURZ, BIRGE.

B. Var. brachiatus.

Monoculus brachiatus.	JURINE.
Daphnia brachiata,	DESMAREST, EDWARDS, LEYDIG.
Moina brachiata,	BAIRD, WEISMANN.

C. Both varieties.

Moina brachiata.	P. E. MUELLER. LILLJEBORG.

The only tangible difference between the two forms thus united is the fact that M. rectirostris produces but a single winter ovum and hence has a one-chambered ephippium, while M. brachiata has a two-chambered ephippium.

The [illegible] separated from the thorax by a marked depression; there is a deep depression above the eye; the margins of the shell have few bristles. The post-abdomen, which extends far beyond the edge of the valves, bears about eleven hairy spines on either side, the lower spine being two-cleft at the end; the base of the claws bears a comb of small teeth, and the posterior margins are bristled. The ephippium is oval; and the single cavity in M. rectirostris has its longer axis horizontal, while the two cavities of M. brachiata are vertical. The depression above the eye is deeper in the males, in which sex also the antennæ are longer and bent at the middle. The seminal bodies are stellate. Length 1, 2 mm. The form is subject to the greatest variation due to the varying number of summer eggs. Birge finds this species abundant. I have found both this and the following species in various parts of the Mississippi valley from Mobile to the upper river region.

Sp. 2.—Moina paradoxa, Weismann.

(Plate A. Figs. 1, 3, 6, 7, 9.)

The species differs in a few very insignificant points from the previous one. The head is short and nearly evenly convex above, with no deep depression above the eye; teeth of terminal claws reduced to bristles which are only a little longer than the series extending down the claw as in the above species; the first

[1] "Gruber and Weismann, ueber einige neue oder unvollkmmen gekannte Daphniden Freiburg, 1877

foot of the male is furnished with a long bristle; the lower shell margins are more bristly than in the previous forms; the ephippium has two cavities, while the seminal bodies are crescent-shaped.

Sp. 3.—Moina micrura, Kurz.

This form may be of specific value, but it is not sufficiently distinguished to make this certain. As described by Kurz, it seems to be smaller (1 mm.) and most to resemble M. paradoxa, which was not at that time described. The post-abdomen is short and has few (6) spines, while the terminal claws are short and smooth; the head has a sinus above the eyes; the eyes are smaller, with numerous lenses; the antennules are shorter (?) than in M. rectirostris; the mandibles are partly exposed, while the shell margin overlying is notched. Males and ephippial females were not observed. Not distinguished in America.

II.—Genus Ceriodaphnia, Dana.

The genus Ceriodaphnia is the successor to Moina, which some species greatly resemble; the post-abdomen, however, is shorter and has a habitus resembling Daphnia; the antennæ are smaller, and the shell is thick and coarsely reticulated.

Ceriodaphnia has the same general mode of life as Moina, living in muddy pools in late summer and bearing numerous broods which often greatly extend the brood cavity. The antennules are shorter but have a similar form; the male antennæ show a transition in the various species from forms adapted for prehension to such as are found in Daphnia. The brood cavity is closed by two ridges on the abdomen instead of one, as in Moina, or three, as in Daphnia.

The ephippium contains but a single ovum. In general, the form is oval or quadrate, angled but not spined posteriorly; head separated from the body by a deep depression; pigment fleck present; beak absent; antennules moveable, rather short; antennæ with the three-jointed ramus with five setæ; first foot of the male with a hook or flagellum.

The members of this genus are danger signals from a hygienic point of view, for they frequent water containing decaying matter; as many as 1,400 were counted in a single quart of such water. The genus is particularly perplexing, as the varieties named seem to be hardly entitled to specific rank and are so similar as to require great care to properly distinguish.

The following artificial key, it is believed, will assist in placing the specimens which may be obtained in America. There seems no reason to doubt that our fauna is very similar to that of north Europe. Of the twelve species here enumerated at least one-third may be synonyms and others of the remainder are with difficulty distinguished.

Artificial Key to the Genus Ceriodaphnia.

A. Shell irregularly striate.

1. *C. megops*, Sars.
2. *C. cristata*, Birge.

B. Shell with hexagonal meshes.

a. Shell with doubly contoured markings.

(aa) Head broad, short.

3. *C. pulchella*, Sars.

(bb) Head narrowed, depressed.

4. *C. rotunda*, Straus, (antennules normal.)
5. *C. alabamensis*, Herrick, (antennules elongate.)

b. Shell simply marked.

(cc) Claws with teeth.

6. *C. reticulata*, Jurine.

[7]. *C. dentata*, Birge.

(dd) Claws without teeth.

I. Antennæ very long.

8. *C. punctata*, P. E. Mueller.

II. Antennæ normal or short.

* Post-abdomen broad.

9. *C. laticaudatus*, P. E. Mueller. 1 mm. long.

[10]. *C. consors*, Birge. 0.5 mm. long.

** Post-abdomen narrow.

† Head not angled behind the eye.

11. *C. quadrangula*, Mueller.

†† Head abruptly angled behind the eye.

12. *C. scitula*, Herrick.

C. Sheil reticulate with rectangular meshes.

13. *C. nitida*, Schoedler.

[14]. *C. textilis*, Dana.

Sp. 1. Ceriodaphnia megops, Sars.

(Plate A. Figs. 16, 20.)

Ceriodaphnia megops, Sars, P. E. Mueller, Kurz. (The earlier synonymy is doubtful See note, page 26, Schoedler's Neue Beitrage zur Naturgeschichte der Cladoceren.

This species is one of the largest and most readily distinguished as well as rarest of the genus. Very characteristic is the fine anastomosing striation which breaks up into reticulation only near the shell margins. This species seems to form the transition toward Simocephalus with Scapholeberis, which, however, diverges along its own peculiar track. The length is sometimes 1 mm. The head is obscurely angulated in front of the antennules, which are large. The antennules of the male are long and have a hooked setæ at the end.

Typical C. megops has not yet been found in America, but the following form takes its place.

Sp. 2 **Ceriodaphnia cristata,** Birge.

The description given by Birge would apply in almost every particular to C. megops, though he seemed to overlook the close conformity. The size is much less (0.7 mm.), and the post-abdomen seems more abruptly truncate; moreover the number of anal spines is less. The crest upon the dorsal margin may be the effect of prominences such as are described by P. E. Mueller; at any rate, in view of the fact that but few specimens were discovered, the suggestion lies near that C. cristata is the young or, at least, a reduced form of C. megops.

Found at Southampton, Mass.

Sp 3.--**Ceriodaphnia pulchella,** Sars,

(Plate A, Figs. 14, 19,)

Ceriodaphnia pulchella, SARS, P. E. MUELLER, KURZ.

Very much like C. reticulata, but smaller. Head large, turgid, and angled in front of the antennules, forming almost a right angle; fornices moderate; antennules rather large; shell oval, reticulated with double contour lines; post-abdomen of medium size, narrowed toward the end, slightly truncate, with about nine spines; terminal claws short, smooth. The flagellum of the male antennæ is but slightly hooked, 0.5—0.6 mm. long. This species is not certainly identified from America, though a form with smooth claws and small fornices occurs with C. dentata in some places.

Sp. 4. **Ceriodaphnia rotunda,** Straus.

(Plate B. Fig. 1, Plate A. Figs. 13 and 23.)

Daphnia rotunda, STRAUS, BAIRD.
Ceriodaphnia rotunda, SCHOEDLER, SARS, P. E. MUELLER, KURZ.

As said by Kurz, this species is not easily mistaken; the small head (only paralleled by the following), the very evident reticulations and the broad abdomen give it a peculiar habitus which is unmistakable.

Head depressed, small, spiny below, not angulated; fornices prominent, thorned; body rotund, almost spined above; shell doubly reticulate; post-abdomen broad, with seven or eight anal spines; claws large, smooth. The male antennules are little larger than those of the female. I have not yet seen this species in America.

Sp. 5. Ceriodaphnia alabamensis, Herrick,

(Plate B. Fig. 2.)

(American Naturalist, May 1883. Plate v, Figs. 11, 12.)

This species was seen but once and is insufficiently known. The body is elongate, quadrate, the shell reticulated with double contour lines, the head very small and produced downward below the eye, which is very small, the antennules are longer than in any other species, obviously two-jointed, with a lateral seta; the antennæ are very long; post-abdomen long and rather narrow, with the margins nearly parallel, truncate at the end, with over nine anal spines; claws smooth, abruptly truncate. My drawing represents a daphnia-like set of processes for closing the brood cavity. Length 1 mm. (?)

Tuscaloosa, Ala.

Sp. 6 Ceriodaphnia reticulata, Jurine.

Monoculus reticulatus, JURINE.
Daphnia reticulata, BAIRD, LEYDIG.
Ceriodaphnia quadrangula, SCHOEDLER.
Ceriodaphnia reticulata, SARS, P. E. MUELLER, KURZ, HERRICK.

Head long, obscurely angled in front of the antennules; fornices very prominent; antennules small; post-abdomen of moderate size, rounded at the end, slightly tapering; about eight long anal teeth: terminal claws with a series of sharp spines at the base. The reticulations are sharp but simple. The flagellum of the male antennule is either straight or moderately curved. Kurz says that some varieties have the fornices blunt while others are sharp. I have seen only the blunt form which is then much like the next.

Sp. 7. Ceriodaphnia dentata, Birge.

This form differs from the above only in having the inside of the claws fringed with minute bristles (sometimes absent), the angle of the head being more marked and the fornices less prominent. It is difficult to say whether our Minnesota specimens most resemble this or the typical C. reticulata of Europe. They seem intermediate, some having fornices with an abrupt angle. It may be instructive to quote Kurz on the European C. reticulata—"Examples occur 0.8–0.9 mm. long, others on the contrary only 0.5–0.6 mm. long and combining with the smaller size some differential characters. In the larger variety I found the fornix obtuse, while in the smaller it extends in a sharp thorn directed upward and outward. In this small sub-species the secondary teeth of the claws of the post-abdomen seemed to be absent, though in C. reticulata 3–5 are constantly present."

Sp. 8. Ceriodaphnia punctata, P. E. Mueller.

(Plate A. Figs. 1-3.)

Head depressed, rounded at the end, not angulated, ornamented with minute spines within the hexagonal areas. Fornices slightly prominent, either smooth or spiny; antennules very long; shell rotund, reticulated; post-abdomen of medium size, width nearly uniform, truncate below at an obtuse angle; anal spines large, increasing toward the end; claws smooth. Length 0.7—0.9 mm.

Found as yet only in Scandinavia.

Sp. 9. Ceriodaphnia laticaudata, P. E. Mueller.

(Plate A. Fig. 22.)

Ceriodaphnia quadrangula, SARS, (fide MUELLER.)

Head small, depressed, rounded at the end, not angulated; fornices prominent; shell roundish, or sub-quadrangular, moderately reticulated; antennules rather large; post-abdomnen broad, narrowed from the middle to the end; the nine or ten small anal spines nearly equal; claws large and smooth. In P. E. Mueller's time males unknown. Length 1 mm. Specimens 0.6 mm. long from Minnesota agree in most respects, but the reticulation is very marked and irregular and the terminal claws are pectinate. This form constitutes a transition to the next.

A species related to C. laticaudata, but only half the size, was found in Clarke's lake, a small but very deep pool, containing a fauna like that of the great lakes. The appearance is like the small form alluded to under that species, but the claws are smooth, the head is slender and strongly angled behind the eyes, and the antennules are of rather large size. The fornices are not very prominent. The shell is large-reticulate and the abdomen is large and obliquely truncate, the anal teeth being very large and strongly curved. The only individuals seen were ephippial females measuring .55 mm. This may be.

Sp. 10. Ceriodaphnia consors, Birge.

This species differs from C. laticaudata in one or two points, being about one-half the size and having fewer caudal teeth. Birge says the abdomen is broad and obliquely truncate. The difference between being obliquely truncate and narrowed at the end in some circumstances disappears, so that really this species seems quite close to laticaudata.

Found in Madison, Wis.

Sp. 11. Ceriodaphnia quadrangula, Mueller.

(Plate A. Figs. 17–18.)

Daphnia quadrangula, O. F. MUELLER.
Daphnia reticulata, BAIRD.
Ceriodaphnia quadrangula, P. E. MUELLER.

Head depressed, rounded at the end, only slightly angled; fornices prominent, antennules large; post-abdomen narrow, of equal width for the lower half, rounded at the end, with about eight small spines; claws smooth, length about 0.6 mm. This species resembles a smooth-clawed D. reticulata.

Sp. 12. Ceriodaphnia scitula, (Sp. n.)

(Plate B. Figs. 5-7.)

One of the most abundant species of Ceriodaphnia in Minnesota is a large form much resembling C. quadrangula. The post-abdomen is exactly as in C. reticulata or C. dentata, which latter it resembles in having a sharp angulation in front of the antennules. The shell is oblong and heavily marked with minute, regular hexagonal lining; the upper angle is rather sharp. The head is closely appressed, the fornices are prominent and abruptly truncate at the tip, the eye is small, the pigment fleck also small; antennules short. The post-abdomen is of moderate size, narrowed toward the end and armed with about ten powerful curved spines; the terminal claw itself is large and curved, armed only with fine spines extending down the entire inner side. The size is 0.8—1.0 mm.; color pinkish, opaque; antennæ, especially, often bright pink. Male 0.6

mm., flagellum of the male antennæ long; sensory filaments lateral, also one anterior, lateral flagellum.

Distinguished from C. quadrangula by the prominent fornices, large anal spines, small reticulations, form of head and larger size.

A small variety resembling the above very closely is the commonest form in our larger lakes; the reticulation is commonly larger but less distinct, the head is depressed and narrowed, with a sinuous upper outline. The fornices are prominent and the form of the post-abdomen is exactly as in the last. The spines of the post-abdomen are very long and seated on small eminences. The length hardly exceeds .55 mm. The claw is densely ciliated, but not spined; these smaller forms have but few eggs (two). The young have a thorn on the angle of the fornices. Plate J. Fig. 1 represents the ephippial female of this species. There seems no reason to doubt that this is only a variety of C. scitula. The small form of C. reticulata mentioned by Kurz might be referred here, while the larger form with less prominent fornices is not so diffierent from the American C. dentata.

Sp. 13. **Ceriodaphnia nitida**, Schœdler.

Ceriodaphnia quadrangula, LEYDIG.

This species seems to be characterized by the quadrangular form of the meshes of the shell-markings and the presence of teeth upon the claws.

Sp. 14. **Ceriodaphnia textilis,** Dana.

This species is not sufficiently fully figured to allow of a suggestion as to its affinities.

Daphnia rotundata, Say, is very probably a member of this genus, though the description is hardly intelligible. "Body rounded behind; upper antennæ three-branched, a small spine above at the joints; lower five-branched; color white. Length 0.5." It is probable that we should read "upper branch of antennæ with three setæ", etc., in which case we may identify the above with Chydorus or the like.

III.—GENUS SCAPHOLEBERIS.

The genus Scapholeberis stands rather closely related to Ceriodaphnia, from which it is at once distinguished by the angled or spined lower posterior angle of the shell. The head is rather clumsy, and the continuation of the fornices runs toward the apex of the incurved beak, which commonly lies within the valves of the shell. The lower anterior angle has a prominence and there is a basin-shaped area inclosing the base of the antennæ, part of which lies on the shell and part on the head. This area is more strongly lined or reticulated than the rest of the shell. The lower margin is straight and terminates, in most forms, in a long scythe-shaped spine which is directed backward. The shell itself is usually indistinctly reticulate or unmarked, and commonly is deep colored. The post-abdomen is very like Ceriodaphnia or more as in Simocephalus; the anal spines are few and the older specimens have more than the young; the place at which additional spines are to appear is marked by prominences. The eye is of moderate size, the pigment fleck rather small and the antennules short and hidden by the beak. The antennæ are of small size and generally dark colored. The ephippium contains but one egg; the males do not have altered antennæ or feet. The sexual periods fall in early summer and in autumn, according to Weismann; the males appear but sparingly. The species S. mucronata is very abundant everywhere, while the others are less frequently seen.

Sp. 1. Scapholeberis mucronata, Mueller.

(Plate J. Fig. 5.)

Daphnia mucronata, MUELLER, LEIVIN, LILLJEBORG, FISCHER, LEYDIG, BAIRD, HERRICK.
Scapholeberis mucronata, SCHOEDLER, P. E. MUELLER, KURZ, WEISMANN, BIRGE, HERRICK.

This well-known species with rather short spines below is found abundantly everywhere. In this country at least it is characterized by a dark color. The head is large, rounded in front of the large eye, serrate below and extending posteriorly into a roundish beak, back of which are the short antennules. The fornices are very short and rounded; a line connects the fornices with the beak by a sudden deflection downward; it sets off the area which forms a part of the basin of the antennæ. A second line springing from just above the termination of the fornices passes over the eye by a broad curve. The post-abdomen is truncate and bears beside the terminal claws four or more spines which rapidly decrease in size. The claws are minutely spined; the spines on the shell are of variable length, but do not exceed one-fourth the length of the remainder of the lower margin. This species ranges over all Europe and eastern United States.

Length 0.6 mm.—0.8 mm.

Sp. 2. Scapholeberis cornuta, Schoedler.

(Plate T. Fig. 6.)

Monoculus bispinosus, DEGEER.
Daphnia mucronata, var. acute rostrata. BAIRD.
Scapholeberis mucronata, var. fronte cornuta, P. E. MUELLER.

This species differs from the above only in having a sharp curved horn on the head in front of the eye. The use of this appendage can only be conjectured; but it may be that, like the curved beak of Ripophilus, it serves to clear away rubbish in the filth in which these animals frequently live. This form, be it variety or species, is not known in America.

Sp. 3. Scapholeberis armata, (Herrick.)

(Plate B. Figs. 10-11.)

Scapholeberis mucronata. var. armata, HERRICK.

A very beautiful and unique species, which possesses the extreme development of the peculiarities of the genus. The head is shaped very much as in the previous species, the fornix is squarish, the basin for the antennæ is small. The upper lines from the fornix meet behind the eye; the form of the shell is as in the above, but the spines upon the lower margin are longer. The scythe-like spine on the lower angles of the valves is extremely long, falling little short, in extreme cases, of being as long as the entire lower margin, in others about one-half as long. There are the usual lines parallel to the lower edge of the shell. The specimens having the longest spines were found in fresh water about Mobile, Ala., but the species occurs in Minnesota and intermediate points, though sparingly.

S. aurita Fischer

Sp. 4: Scapholeberis nasuta, Birge.

Form much as in the last, head shorter, "prolonged into a rather sharp beak, at whose apex the continuations of the fornices unite. The beak does not project downward as in S. mucronata, but backward, and in its natural position lies between the valves." The usual reticulated and lined areas are present and the balance of the shell is covered with "small pointed projections." "The antennules are much larger than in S. mucronata, though they do not project beyond the rostrum." The pigment fleck is long and large; the post-abdomen is much as in the preceding species; the terminal claws have several fine teeth. The males have the opening of the vas deferens close behind the terminal claws; mucro short and blunt, length 1 mm. This species is very near the next, but differs in several particulars. It forms the transition to the next, which is the extreme of the genus in a direction converse to that pursued by the S. armata.

Sp. 5. Scapholeberis angulata, Herrick.

(Plate B. Fig. 9. Plate T. Fig. 7.)

American Naturalist, 1883.

Form as in the above, but comparatively larger; valves quadrangular, anterior margin strongly arched; head short, only slightly concave below the eyes; the beak is as in S. nasuta, but seems to be directed more nearly directly downward than in that species. The antennules are long and resemble those of Simocephalus. The pigment fleck is square and rather large; the antennæ are of the usual size. The reticulated areas are as in the other species. The post-abdomen is more as in Daphnia, not so squarely truncate and with five to seven large teeth; the first foot has one elongated jointed seta; the posterior angle of the shell has no spine, at most there is a somewhat prominent acute angle, the inner shell layer is armed at this point with some elongated teeth as in the corresponding situation in Simocephalus. On the whole, there is a similiarity to that genus in this as well as in the previous species. S. nasuta has a short spine and elongated pigment fleck; the present species has a squarish but rather large fleck and no spine; the post-abdomen has a greater number of spines than any other species. South of Tennessee river, in Alabama and Mississippi.

The species of this genus are predominatingly American, four out of the five being found in the United States; the fifth, moreover, is more often regarded a variety of one of the others; in fact, the absence of S. cornuta from America is one of the most important supports of the specific independence of the two forms. All the species delight in disporting themselves near the surface in sunny weather.

IV.—Genus Simocephalus.

Although a very well circumscribed group, this genus passes into the next rather directly by means of S. macrothroides. The connection on the other hand seems to be by the way of Scapholeberis, though there is a rather broad separation between even Scapholeberis angulata and any known Simocephalus. The enlarged spines near the angle of the shell and the form of the antennules as well as some other points, show a transition through that species toward the present genus. The general form is quadrate with the lower posterior margin sinuate; in young specimens the shell is nearly a perfect rectangle. The upper margin is produced more or less at the point of union with the free posterior margin and the shell is either arched or very abruptly angled above the prominence in old females. The head is produced into a projection at the eye while the beak proper is between the anterior margins of the valves; the pigment fleck is rather large and variously shaped. The fornices are larger than in Scapholeberis and extend to the front of the head over the eyes; the antennules have a lateral flagellum which is large and lance-shaped. The post-abdomen varies very little in shape; it is truncate and excavated below and very broad. The anal teeth are few, large, curved, pectinate; the claws are straightish and pectinate or spined; the labrum is shaped as in Daphnia; the anterior part of the stomach has the usual cæca.

The members of this genus are among the most abundant and conspicuous of the family and are more persistent during the changing seasons than any other form. S. vetulus, the commonest species, stands in the centre of the genus, while two extremes are expressed by the other members of the group.

The winter or sexually produced eggs are lodged in an ephippium or saddle-like modification of the shell, which is finely reticulate; while the shell is usually marked by fine anastamosing lines which, in some species, show clearly their derivation from a rather fine hexagonal marking.

The sexual periods, when males are produced, occur in autumn and spring. The males have few distinguishing characteristics, the form being that of the young female.

The opening of the vasa differentia is back of the anus, hence these ducts cross the course of the intestine. They have ejaculatory muscles about the lower part. The smaller species are frequently deeply colored with pink, purple and brown fatty deposits and the markings are more conspicuous than in the American Eurycercus, which is itself often brightly spotted with blue or purple. The aspect in the water is between that of Eurycercus and Daphnia.

The first mention made of any member of this genus in America is Say's description, repeated in Dekay's Crustacea of New York, of Daphnia angulata. This description which follows is quite sufficient to identify the genus, and indeed to indicate that either S. americanus or a related form is intended, but it is hardly competent to alter names the significance of which is quite clear.

"Sides striate with numerous parallel minute oblique lines; hind edge of the body with a prominent angle in the middle. Antennæ with four filaments on the upper and five or the lower branch. Color white or red. Length 0.1; stagnant water in the forests of the Southern States."

Sp. 1. Simocephalus vetulus, Mueller.

Daphnia vetula, BAIRD, HERRICK.
Daphnia sima, MUELLER, LATREILLE, BOSC, RAMDOHR, GRUITHUISEN, DESMAREST LAMARCK, M. EDWARDS, KOCH, GMELIN, MANUEL, JURINE, LILLJEBORG, LEYDIG.
Simocephalus vetulus, SCHOEDLER, P. E. MUELLER, KURZ, WEISMANN, CLAUS, LUTZ, BIRGE.

This commonest and one of the largest species is apparently distributed over the northern hemisphere and abounds in all the more shallow lakes. The head is rounded in front and is not angled between the prominence of the eye and the beak. The body is very large and not abruptly angled above, the spine of the shell being inconspicuous and high, so that the free posterior edges of the shell lack little of equalling the greatest hight of the shell. The shell is covered with minute dense striations which spring from the free edges. The pigment fleck is elongated in old specimens and the upper angle follows up beside the suture separating the antennary basin from the rest of the shell of the head. The antennules are ornamented with minute spines. At the lower angle of the shell are three curved spines which differ from the preceding filaments. The number of eggs which are produced at once is truly immense. Under favorable circumstances this species reaches a large size, falling little if any short of 3 mm. S. vetulus lives, by preference, among the leaves of aquatic vegetation. With us this species seems to live in the smaller pools as well as in lakes of some size. I am not able to see any difference in this respect between the various species.

Sp. 2. Simocephalus serrulatus, Koch.

Daphnia serrulata, KOCH, LIEVIN. FISCHER, LILLJEBORG.
Simocephalus serrulatus, LEYDIG, SCHOEDLER, P. E. MUELLER, KURZ.

Head narrow, extending anteriorly into a sharp spiny angle in front of the eye. Dorsal line of the shell abruptly angled or curved posteriorly, projecting to form a broad obtuse spine behind;

this spine is serrate with sharp teeth and lies somewhat above the middle of the hight of the animal, so that the free posterior margins of the shell fall much short of reaching the greatest hight of the shell. Post-abdomen of the usual form, with the claws armed with two series of spines or bristles, the outer being much the larger; anal teeth curved or angled, dentate; pigment fleck triangular or rhomboidal. Length 2.0 mm., 2.5 mm.

I am not sure that the three following species are more than varieties; the first in particular is very close to the European type.

Sp. 3.—Simocephalus congener, Birge.

My own observations of this form made throughout the Mississippi valley are not in complete accord with the description of Birge, but it seems improbable that there is any mistake in the identification. The very generally distributed form on which this species rests is subject to marked variations within certain limits. This species differs from S. serrulatus in the following points. The head, although prominent and spiny near the eye, is not angled between this prominence and the beak; in fact, it is either straight or simply curved. The pigment fleck is usually rhomboidal and only occasionally oval, triangular or irregular. In other respects the agreement is rather close; the terminal claws have two series of spines, one of which is larger (not, as said by Birge, equal); the outer series is not so much larger as in S. rostratus, but not nearly as inconspicuous as in S. vetulus. The terminal claws are rather evenly curved. This species is frequently colored with pink or brown markings. In old females the back is squarely angled above, forming a pocket for the eggs. The size falls short of that of the last species. I have found this species from the gulf of Mexico to Minnesota.

Sp. 4.—Simocephalus rostratus. (Sp. n.)

This form is of the size and color of S. americanus, and approaches nearest to Schodler's S. expinosus in general characters. The back is arched above but not abruptly angled; the spine is as in S. americanus but not so low. The free posterior shell margins are somewhat shorter than the greatest hight of the shell. The head is produced below the eyes in an angle like a right angle, which is not spiny. The lower margin of the head is excavated to form a right angle, and in front of the smooth antennules forms a very prominent beak, beyond which the antennules reach but a short distance. The terminal claws of the post-abdomen are straightish and are more heavily spined than in the preceding; the anal spines are doubly curved or geniculate. The pigment fleck is rhomboid or pentagonal; the antennules are smooth. The abdominal processes differ somewhat from the previous species, in which the second one is rounded above, for in this it is squarely truncate. This species was found only in shallow pools at Ocean Springs, Mississippi, and was very carefully compared with S. americanus which is also found there.

Sp. 5. **Simocephalus exspinosus,** Koch.

Head extending into an obtuse angle at the eye, pigment fleck rhomboidal. Shell without a spine; maximum hight of the shell greater than that of the free posterior margin. Caudal claws with an unequal series of spines; anal spines evenly curved. There is little to distinguish the above from this species save the geniculate anal spines and the presence of a blunt spine on the shell.

Var. congener, Schoedler,

has the lower outline of the head sinuate instead of angled.

Sp. 6. **Simocephalus daphnoides,** Herrick.

American Naturalist, 1883.

A curious transition form, found only south of the Tennessee river, was described in the American Naturalist in May, 1883, under this name. By an oversight a comparison made with S. americanus appeared as though made with S. vetulus. The general shape is oval; the greatest hight of the valves lies near the middle and not posterior to it as in all the other species. The head is short, depressed, rounded in front; the beak is wanting; the lower margin of the head is straight. The pigment fleck is small, oval or irregular; the fornices are small and short. The antennules are smooth.

The post-abdomen is narrow, shaped more as in Daphnia; the terminal claws are straightish and fringed part way with spines; the anal spines are slightly curved. The processes of the abdomen are long, as in Daphnia. The shell is covered by the characteristic striations and extends into a blunt spine. In every detail, almost, there is an approach toward the genius Daphnia, while the general result is sufficiently like Simocephalus. The lower angle of the shell is not armed with the peculiar curved spines as in all the other species. This species beçomes over 1-10 inch long. In such old individuals the spine is nearly midway of the hight.

One could wish a trifle closer link to Scapholeberis than that furnished by S. angulata; but, on the whole, the position of this genus can not well be called in question. America has four species out of the six known and but one of these certainly identical with the European, though others are probably too closely related.

NOTE.—On p. 47 read *S. Americanus*, Birge, not *S. Congener*.

V. GENUS DAPHNIA.

Long considered the type of the family, this genus is most frequently seen, or, at least, is more conspicuous than any other group. It has already been pointed out that the forms here united are the extreme development of a diverging line. Simocephalus is the link connecting it with the typical forms of the family. As might be expected, this genus presents more puzzling problems than any of the others. It contains more peculiarities of structure and diversities of habit and development than any other of the genera. Here the sexual differences are most interesting. The young are hatched with a pendant appendage attached to the upper posterior angle of the shell, which soon becomes the rigid spine characteristic of the younger stages and males of the genus. The females almost immediately after birth commence the production of eggs by an asexual process. Groups of epithelial cells containing four each are formed and one of the cells of each group develops at the expense of the others, forming the egg. Many such eggs are laid simultaneously and deposited in the cavity between the shell and the dorsal part of the animal. The eggs are prevented from escaping by means of three long processes, of which the first is much the larger and curves forward. At stated periods in spring and autumn the males appear; the females of the generation in which occur the males have a tendency to produce eggs of a different sort charged with a different mission. At the same time the upper portion of the shell (that surrounding the brood cavity) becomes finely reticulated and pigment is deposited between its layers. This ephippium, as it is called, in allusion to its saddle-like form, is the case in which the winter egg is to pass the period of cold or drought which is to follow. The method of the formation of the ephippium is obscure and, in spite of the investigations of Lubbock and Smitt, considerable remains to be learned with reference to this interesting modification of the shell. Some rather careful study has been devoted to this subject by the writer, but it was unfortunately interrupted before completion. The most promising method of persuing the investigation is that of sectioning ephippial females in various stages with the microtome. A preparation of soap was employed with partial success as a medium for embedding, and figures of some of the many sections made are drawn on plate P. Figure 10 is a vertical section through the middle of an ephippium which has been cast off. The outer and inner shell layers are distinct and one of the eggs is divided in the middle. No pigment or protecting material was deposited in this case, which is the simplest possible. Fig. 9 represents a section just back of the head; it passes diagonally, severing the heart longitudinally (h). The intestine (a), the ovaries (g), the mandible (m), the labrum (l), and certain suspensorial muscles (?) are seen *in situ*. Only a portion of the ephippium is cut and the double layers enclose a large mass of protective matter. Fig. 8 is a vertical section through the middle of the animal, and the usual form of the ephippium is seen with its large amount of protective matter obscuring all else. Fig. 7 is a longitudinal section of an ephippium similar to that seen in Fig. 10. It is hoped to present at some more appropriate time a fuller account of the formation and process of moulting this saddle.

Development of Daphnia.

Although the careful researches of Claus and Grobben have added much to our otherwise rather meager knowledge of the development of the cladocera, there still remain many interesting points, particularly with reference to the individual species, which merit careful study.

The following observations relate to the single species (D. schæfferi) which was available during a short stay in Leipzig:

The winter eggs of D. schæfferi are two in number and are lodged in the well known manner in an ephippium.

The shape of these eggs is sharply ovoid, there being no distinguishable difference between the two ends. The position in the ephippium is not, as might be expected, with the longer diameter paralled to the axis of the body, but the posterior end is slightly elevated. This is undoubtedly due to frequent elevation of the abdomen between the valves during the extrusion of the eggs.

The color is dark green and the only protection as the egg leaves the ovary is a thick, tough shell which is at first so soft as to be susceptible to pressure. It is thus reticulated, apparently through the simple pressure of the walls of the ephippium.

The length is 0.43 mm.; width .33 mm. in the average, though eggs were occasionally found of an elongated form, measuring .48, .31 mm. The contents of the egg consist of spheres of greenish plasma of various sizes and fat or oil drops. These oil globules are not very numerous as compared with those of the summer eggs, and likewise never attain the dominant size seen in the latter. The various forms assumed by the plasma balls are perplexing but frequently result from the action of external agents. The cleavage stage was not seen, and if actual segmentation takes place, it must be inconspicuous as would be expected from the large quantity of yolk present. The differentiation of the blastoderm occurs very early, perhaps in the ovary itself, and the result is a tolerably uniform layer of prismatic cells. The egg now comes to a period of repose after the blastoderm has produced a second external envelope apparently by simple secretion.

This envelope consists of a fine structureless membrane. The egg, under ordinary circumstances, remains dormant during the winter in this most favorable stage. The reason for which is evidently the fact that the differentiation has proceeded to the extent of producing the greatest number of protective layers without materially increasing the complexity, and thus the sensitiveness, of the organism. Under favorable circumstances the development proceeds farther and near one pole appears a slight indenture of the surface which grows deeper and seems to form a true invagination. This blastopore, if such it really be, remains for some time, generally till the two "scheitel" plates appear. These "scheitelplatte" are formed by a simultaneous thickening and lengthening of the cells of limited areas on opposite sides of the egg, near the opposite pole from that occupied by the blastopore. The "scheitelplatte" are situated at right angles to a plane perpendicular to the blastopore. The nuclei of the cells of the "scheitelplatte" are nearly .0208 mm. in diameter, while those of the other blastoderm cells are about half that size.

The egg remains a long time in this stage, while the following stages are passed through quite rapidly till the embryo assumes its nauplius form. The remainder of the development agrees, so far as seen, quite fully with that of the summer eggs, to which we will now return.

The summer eggs vary greatly in size and number, but are nearly as large as the winter eggs. The number is sometimes reduced to two or three or rises to as many as fifteen or even more. In color the eggs also vary from green to brown. The fresh egg consists, as the winter egg, of two sorts of yolk spheres. The plasma or formative yolk contains colored globules of rather small size, distributed throughout the whole of the mass quite uniformly. The food yolk or oil globules assort themselves in two sizes; first, a few (generally three) very large oil drops, which persist throughout the ealier stages of the embryo; second, smaller globules of apparently the same character, which are quite numerous and form a very considerable part of the contents of the egg, In an egg of about .35 mm. in diameter, the largest of the smaller size of oil drops measured .029 mm. while the larger three exceeded .060 mm. The oil drops are distinguishable by their light refractive power, pellucidity and the intense dark brown or black color assumed when treated with osmic acid. The latter reagent affects the formative yolk but slightly. It will be seen that though the summer egg is nearly as large as the "dauerei" in some cases, yet the relative amount of formative yolk is more diverse than at first appears.

The great similarity between the two sorts of eggs in Daphnia schaefferi is throughout striking as compared with Moina, the only one of the Daphnidæ the development of which is fully studied. In the summer eggs I have not been able to see the complete segmentation described for Moina. The following stages are much as described by Grobben. An invagination occurs and a median swelling appears on the ventral aspect of the egg.

Labrum and second antennæ bud out and are soon followed by the antennæ, mandibles and two pairs of maxillæ, after which the five pairs of feet soon appear. In an early stage there is present a basal palpus to the second antennæ, a fact not before observed, and this persists as the small two-bristled wart found on the basal joint of the antenna. It is a conspicuous object in the embryo and is thus a true embryonic organ.

The eyes of the embryo appear as two separate pigmented flecks which approximate and are covered with an oval refractive body, which later is penetrated by the pigment and divides to form the small lenses. Soon after this the shell grows over the eye as described for Moina.

The first indication of the shell appears as two folds of the maxillary region of the back, being thickest laterally. These grow forward and backward to form the cephalic and body shield. At a little later stage there appears a very interesting modification of the shell which stands in close relation to the growth of the brood sac. A slight protuberance appears on the margin of the shell in the median dorsal line and extends toward the abdomen. It grows much more rapidly than the other parts of the shell and, in a later stage, forms a comparatively enormous tail, which curves under the animal between the shell valves which now extend beyond the body. This "tail" extends well along the ventral margin of the shell and reminds, by its position, of the tail of a frightened dog. The true tail, or post-abdomen, is, in the meanwhile, well developed and is constantly kicking the useless protuberence of the shell upwards. As the animal leaves the egg this projection becomes straightened as in the young D. pulex, finally becoming the still considerable spine, though it is proportionately much shorter than in the embryo. The spine becomes shorter with successive moults and the mature form has only a slight rounded knob in place of a spine more than half the length of the body.

The use of the long spine in the young Daphnia is a matter of interest. Its length agrees pretty well with that of the brood cavity and it seems possible that it serves to prevent the shell from bending abruptly down when it is only partially removed during the moult and thus breaking off and so leaving a portion of the clothing of the brood-cavity therein to become a source of irritation. This is more necessary for the young since the brood cavity is narrow and the shell weak, so that while the outer shell is removed like a glove from the finger, it can not be pulled upward or downward, but directly backwards. It is well known that male Daphniæ often have the spine, while the females may have none, and here again it is possible that the narrower cavity over the abdomen requires this assistance, while this is not the case with the females.

The shell gland is early formed and the branchial lamellæ of the feet appear almost simultaneously with the feet themselves as distinct lobes. The branchial chamber is not a simple chamber, but is essentially a curved tube as can be very well seen in the last foot of the adult. This tube doubles upon itself and crosses in the manner of a loop and a constant stream flows rapidly through it.

The nervous system is, at first, paired from beginning to end and first unites anteriorly, the ocular ganglia fuse after the union of the two pigment flecks in the compound eye, then the cephalic ganglion is formed by the union of the two preœsophagal ganglia, the commissures passing about the œsophagus. I have not been able to determine if the subœsophagal ganglia become fused. From the anterior ganglia spring the nerves to the antennæ and jaws, which latter are the larger in the embryo, being exceedingly large nerves.

This key contains the majority of the genus, but falls short of completeness. The following species are uncertain. W. Schmankewitsch described as new *D. degenerata* and *D. rudis*, from salt or brackish waters. These he regards as degenerate forms produced by the inferior aeration of dense waters. The author does not appear to recognize the modern distinctions of genera so that, not having seen the work, even the generic position can not be definitely stated. His investigations seem to show that the proximity of salt waters influence the form of the body, or, perhaps, that there is a constant interchange between the sub-marine and fresh-water species. *Daphnia brevicauda*, Chambers, is an incorrectly figured and described Simocephalus.

Key to the Genus Daphnia.

Section I. Pigment fleck present.

A. Head short, equally rounded.

1. *D. psittacea*, Baird.

B. Head not regularly rounded, more or less beaked.

(a) Claws spiny.

I. Abdomen broad, series of anal spines nearly equal, neither head nor back keeled.

† A marked sinuosity in the posterior outline of post-abdomen.

2. *D. schæfferi*, Baird.
D. ovata, Sars.
D. pennata, Mueller.

†† No well marked depression.

3. *D. pulex*, Mueller.
4. *D. schœdleri*, Sars.
D. hastata, Sars.
D. obtusa, Kurz.

II. Abdomen narrow, shell keeled somewhat dorsally.

5. *D. minnehaha*, sp. n.
6. *D. carinata*, Sars.

(b) Claws nearly or quite smooth.

I. Head not crested.

7. *D. longispina*, Leydig.
8. *D. rosea*, Sars.
9. *D. similis*, Claus
D. lacustris, Sars.
D. cavifrons, Sars.
10. *D. hyalina*. Leydig.
11. *D. dubia*, Herrick.

D. pellucida, P. E. Mueller.
D. galeata, Sars.
12. (?) *D. lævis*, Birge.

Section II. Pigment fleck absent.

A. Head but slightly crested.
1. *D. longiremis*, Sars.

B. Head strongly crested.
2. *D. cristata*, Sars.
3. *D. cucullata*, Sars.
D. apicata, Kurz.
4. *D. kalbergensis*, Schoedler.
D. cederstromii, Schoedler.
D. retrocurva, Forbes.
D. vitrea, Kurz.
5. *D. magniceps*, sp. n.

SECTION I.

A. *Head short, evenly curved.*

Sp. 1. Daphnia psittacea, Baird.

Mentioned by SCHOEDLER, FRIC and KURZ.

This species is at once recognized by the head, which is very short and evenly curved, or nearly so, from the heart to the beak. The shell is high, oval, with a rather short spine. The fornices are wide and angled behind; the antennules are longer than in most species; the post-abdomen is very large, but narrows toward the end and has comparatively few anal teeth, which are of unequal size. This is one of the largest of the genus. Not yet found in America.

B. *Head more or less concave below, at least not evenly arched.*

Sp. 2. Daphnia schæfferi, Baird.

(Plate M. Figs. 1—4.)

Daphnia pennata, MUELLER.
Daphnia pulex, STRAUS, KOCH, (fide P. E. MUELLER.)
Daphnia magna, LILLJEBORG, LEYDIG, etc.
Daphnia schæfferi, SCHOEDLER, KURZ.

The largest species of the genus, is of an elongated oval and ventricose form. The spine is entirely absent in old females and of only moderate length in the young. The antennules of the male are long and have a very long flagellum. The post-abdomen is narrowed suddenly below the anus so that the spines consist of two sets; the terminal claws are spiny at the base. Although very similar to D. pulex, it may be recognized at once by the concavity of the dorsal margin of the post-abdomen. The plate will make any detailed description superfluous. A common species in Europe, but not yet found in America.

Daphnia ovata, Sars, seems probably this species, but Sars was troubled by Straus' mistaken reference.

Daphnia pennata of Sars may also be this species or, more probably, D. pulex. The Latin discription given by Sars is appended for convenience of reference.

Daphnia pennata, Sars.

"Antecedenti (D. pulex) simillima, caput autem a latere visum latius, rostro breviore, supra visum testa cetera parum angustius fere cordiforme, antice acumlnatum. Processus anteriores duo disjuncti. Margo posterior postabdominis in medio sinulo parvo et infra hunc utrinque aculeis 16-18 armatus. Color ut in antecedente. Longit. 2⅓mm."

Daphnia ovata, Sars.

"Caput a latere visum ante oculum fere angulatum, margine inferiore leviter concavo in rostrum longum apicem versus attenuatum, extremitate tenuissima exeunte, spura visum ut in D. pennata cordiforme. Testa cetera a latere visa ovata, margine superiore et inferiore in femina adulta fere æquæs arcuatis, postice in medio spinam formans brevissimam vel omnino obsoletam. Processus anteriores duo abdominis disjuncti. Margo posterior postabdominis in medio sinuatus, utrinque aculeis 20-22 armatus. Color albido—flavescens vel-virescens. Longit. circit 3 mm."

Sp. 3. Daphnia pulex, Mueller

This commonest of our Daphnids is apparently circumpolar in distribution. I have found it in Alabama near the Gulf and it also occurs near lake Superior.

Oval, either elongate or short, spine springing from the upper angle of shell or in some cases near the middle. The spine is rather long in young individuals but becomes very narrow in older ones or entirely disappears. The abdominal processes are long, not coalescent, or slightly united at the base. The head is concave below and extends into a prominent beak. This species is either very variable or several species are frequently united under the term. Two types have been recognized in America. One, abundant in spring in smaller ponds in Minnesota, is rather short, arched above, and in old females with the spine situated near the middle of the posterior margin. This form is quite typical for the species and occurs from April to mid-summer. Another variety was found in Alabama in late autumn, and similar animals in mid-winter in lake Calhoun, Minnesota. This type has a much more elongate body, the very slender but rather short spine springs from the upper margin of the shell or is quite wanting. This longer form has the beak slightly arched so as to resemble a "Roman nose." The anal spines are less numerous (10-14 while typical D. pulex has nearly 20). The young of this form, which may be called

Daphnia pulex, var. nasutus, (Var. n.)

(Plate N. Figs. 1-4.)

vary much among themselves but, in general, resemble the young of the European form.

Daphnia pulex has been mentioned by a number of authors in America, Smith, Birge, Chambers and Herrick having noted its occurrence in various parts of the United States. *D. obtusa*, Kurz, is apparently only the spineless condition of the above or a related species. *No Daphnia* is without the spine through life; such a form would constitute a new genus at once.

Sp. 4. D. schoedleri, Sars.

Seems to resemble D. pulex very closely but differs in having the lower margin of the head nearly straight, terminating in a short straight beak. The spine springs from the middle of the posterior margin. The anal spines are 14-16 in number. Length 2.33 mm.

This name is applied by Sars to Schoedler's D. longispina which is not D. longispina of Leydig.

Sars' D. hastata is so insufficiently defined that it will probably be necessary to drop it from the list.

Sp. 5. Daphnia minnehaha, (Sp. n)

(Plate K, Figs. 1, 2; Plate L, Figs. 1, 2.)

This species, which occurs in small pools in autumn (affluents of Minnehaha creek, etc.,) closely corresponds apparently to Sars' Daphnia carinata but differs in numerous points. It, in fact, is more nearly related to D. pulex than the group under which that species is placed.

The form is oval, arched above, narrowed posteriosly, terminating in a rather short spine which curves lightly upwards. In males and young females the spine springs from the upper angle, but in old females having many summer eggs the spine is nearly median. The head is depressed, strongly arched and keeled slightly above the eye, which occupies the extreme end of the forehead. The keel of the head extends into a slight angle over the heart and continues down the back. In young females and in males the slight angle is replaced by a strong knife-like projection which extends into from 1 to 4 sharp teeth, the anterior tooth being directed forward. The males, in particular, have this feature emphasized. D. longispina has a somewhat similar projection but the more nearly related forms seem not to show this peculiarity, The beak is slightly curved and the lower margin of the head is slightly sinuate. The shell has the usual square reticulations and is usually very transparent but in peaty waters becomes brownish. The size is small but variable; 1.8 mm. is a common measurement. The post-abdomen is narrow, the claws are armed with four or more teeth and a series of lateral bristles. The anal spines are eleven or more in full grown females and decrease only moderately upward. The processes of the abdomen are distinct. The males are smaller and strongly carinated above and of the same form as young females The antennules are rather long, with a short lateral and a long terminal flagellum, which latter is more than twice the length of sensory setæ which are partially lateral. The first foot has a strong claw and a long flagellum, while the second feet have a small spiny hook. There is a single abdominal process which is not hairy as in D. pulex.

Sp. 6. **Daphnia carinata,** Sars.

Very similar to the last but, according to Sars, the claw has no well marked teeth, a short flagellum on the male antenna, and the abdominal processes are united at the base (which may indeed be sometimes the case in the above.)

D. cavifrons, Sars, has a prominence on the forehead and the lower margin of the head is strongly concave, otherwise hardly destinguishable save by the absence of the keel above.

Sp. 7. **Daphnia longispina,** Mueller.

D. longispina, O. F. MUELLER. BAIRD, LEYDIG, SARS, P. E. MUELLER, KURZ, WEISMANN, etc.

Oval, elongate; head large, rounded in front, lower margin somewhat concave; rostrum long. Spine very long, springing from the middle of the posterior margin. Post-abdomen attenuated toward the end. Terminal claws smooth or simply cilate, spines few. The abdominal processes are united at the base a very little, Flagellum of the male antennule hardly longer than the sensory setæ. The young have three teeth above as in D. minnehaha. There is a great deal of diversity of opinion as to the value of this name. Not that there is any doubt of the existence of a widely distributed form which in general is that intended by Leydig and others, but the variation is so great that the possibility remains that more than one species is included under the one title.

P. E. Mueller recognizes two varieties depending chiefly upon the length of the spine.

D. lacustris, Sars, is nearly related, if not a variety of the above.

Sp. 8. **Daphnia rosea,** Sars.

(Plate K. Figs, 10-12.)

In form very like D. longispina, this species, which is the only representative of this smooth-clawed, unkeeled group yet found in America, might perhaps be appropriately re-united with that species, but, as there seems little doubt of the identification with Sars' variety, as above, I prefer to use his name.

Body oval, moderately ventricose; head of moderate size, lower margin nearly straight; eye situated in the anterior prominence. The beak is not very prominent. The upper outline of the head is slightly concave above the eye or rather less convex. The head is separated from the body by a marked depression. The spine of the shell springs from the upper angle or is quite wanting. The post-abdomen is of moderate size, somewhat narrowed toward the end. The claws are smooth, the anal spines nearly equal, straight, about 14 in number. The abdominal processes are not coalesced or but slightly so. Length 1.50 mm. to 2.0 mm. The species was collected sparingly in a large gathering of D. pulex from a small lake in early spring.

The size and conformation of the abdominal processes is very variable and the long and very slender spine is frequently absent.

Sp. 9. **Daphnia similis,** Claus.

The description of this species, which was bred in confinement from eggs brought in mud from Jerusalem, I am, unfortunately, unable to quote. Judging however, from the figures which alone I now have access to, it belongs in the group of *D. longispina*, though in many particulars it resembles D. schæfferi. The form is elongate, the spine short and springing from the upper margin. The antennule of the female is very large and flagellate, while that of the male is like that of D. schæfferi. The flagellum and hook of the first foot of male are rather small.

We now come to a group of related species which are most difficult to circumscribe on account of their extreme variability. According to the view of Lutz they would all fall into the old D. hyalina of Leydig. More probably, however, some of these forms are of nearly or quite specific value.

Sp. 10. Daphnia hyalina, Leydig?

(Plate L, Figs. 3, 5.)

Daphnia longispina, HERRICK.

I have elsewhere given a brief account of the post-embryonic development of a species which agrees best with Leydig's figures of D. hyalina.

The lower outline of the head is nearly straight, the eye being always approximated toward it. In young specimens the head is sharp in front and crested. The lower margin of the head appears very long and the beak turns backward. The spine is very long in young forms but is short in old females. The male resembles very much the young female. The post-abdomen is narrowed toward the end, the terminal claws are smooth, the anal teeth few and the abdominal processes united. Our specimens are from Paducah, Ky., south of the Ohio river.

I do not know how to distinguish *D. lævis*, Birge, from D. hyalina, save that the abdominal processes are said to be distinct. Both forms were observed in the above mentioned gathering. If, however, Birge's figures are characteristic, he had a different variety before him from ours; it seems somewhat like D. galeata.

D. pellucida, P. E. Mueller, differs from D. hyalina in the presence of a series of small teeth on the caudal claws, and a more strongly curved beak.

It is just now brought to my attention that P. E. Mueller, in a late work, identifies D. pellucida with D. hyalina, though he still holds D. galeata distinct.

Daphnia galeata, Sars.

(Plate T. Figs. 7, 8.)

According to P. E. Mueller, this species differs from D. pellucida in the absence of teeth on the caudal claw, and, in one variety, by the acuminate head, which seems the only form for which the name is distinctive. Kurz found only the var. frons rotundata. According to Forbes, both varieties, the first of which he identifies with D. pellucida, occur in lake Michigan.

S. I. Smith finds both in lake Superior, and seems to have no doubt of their distinctness. One of the forms which I have seen differs a little from either of the above, and had a different habitat. Kurz has described the male, which has a very short flagellum upon the antennule. A single source for D. galeata was found in a small pool known as Clarke's lake. This is the more remarkable, as this species, which is almost confined to larger bodies of water, is found nowhere else in the vicinage of Minneapolis, while this minute lake, though as deep, perhaps, as any of the largest in the county (say 40 feet), contains a number of forms known otherwise only in the Great Lakes. Kurz's remarks on the specimens collected by him apply equally to these. Were the claws dentate, the animal would pass as D. pellucida. The young have no horn on the head. The spine of the shell is nearly as long as the whole animal in the young. The male of our form is 1.2 mm. long, excluding the spine which measures 47 mm. The flagellum is a very little longer than the sensory setæ, and there is a very minute lateral flagellum. A peculiarity of this species is the scattered thorny armature of the spine of the shell. There is but little change in the form of head with age. The form of the last feet is peculiar. The ephippium occupies comparatively a small part of the valves and the spine becomes very short and quite smooth. The sexual period occurs in September and October.

The above statements regarding D. galeata require a modification, for in another deep lake the writer has since secured the typical crested D. galeata with even a higher crest than that figured by P. E. Mueller. The head ends in a sharp angle. The single female seen was in company with the rounded variety and numbers of D. kalbergensis, which it resembles in many respects. Our fauna therefore is quite complete in these remarkable forms.

(See Plate U. Fig. 6.)

Sp. 11. **Daphnia dubia,** Herrick.

(Plate L. Figs. 7, 8.)

American Naturalist, 1883.

The life history of this form is insufficiently known, but there seems no reason for doubting that it constitutes a new and easily recognizable species. It is nearly related to D. hyalina, but the head is strongly crested all round and the eye is withdrawn, in young as well as old specimens, toward the middle of the head. This peculiarity is shared in this degree by no other Daphnia

The form is as in D. pellucida, but the spine is more slender and directed upward. The head is shaped much as in D. vitrea in the young, but is much less prominent. The older form has a shorter and more slender spine (none were seen in the ultimate or spineless stage). The head is more evenly rounded, but still well crested. The abdomen is very slender and the anal teeth diminish rapidly in size from below upward. The claws are very short and armed down the whole length with fine bristles. The abdominal processes are well united at the base in old specimens, so that the second seems a small process of the first. The shell is very transparent and the spine is longer than in any other Daphnid. In a young specimen the spine was 1. mm., the body 0.7 mm., and the head 0.4 mm. In this specimen the spine was slightly curved, the head elongate with a slight ridge in front. Another individual had the spine 1.1 mm. long, while the remainder of the animal was 1.3 mm. This specimen also had a knife-like hyaline ridge on the crest, which was obliquely truncate in front; it also had numerous summer embryos in the brood sac. The spine was perfectly straight and but slightly inclined upward. Older individuals have a rounded crest as figured and no ridge. The spine is relatively somewhat shorter but much more slender. The characters which most clearly distinguish this species are the well crested head, which in young as well as sometimes older specimens has a median hyaline ridge, the withdrawal of the eye from the margin and the very long spine. It resembles D. galeata in earlier stages. It is very much like D. lævis or, in other words, is in the group of D. hyalina; but the study of a considerable number of specimens from different localities convinces me that it can not be united with that species in any of its varieties. This species has only been found in autumn, Sept.—Nov., lake St. Croix and Richfield in Hennepin county.

Section II.

Pigment fleck wanting. Head crested. The small, hyaline species constituting this section, elevated by Schœdler to the rank of a genus (Hyalodaphnia) and by Sars to that of a subgenus (Cephaloxus), are chiefly residents of the deeper parts of our larger lakes. These forms, from their rarity, have been little studied and it is uncertain how far the assumed specific distinctions are valid.

Two species are known in America and they are not confined to large lakes.

Sp. 1. **Daphnia longiremis**, Sars.

Hyaline, compressed, seen from the side, rounded, lower margin strongly arched; spine long, straight, oblique. Head rounded, lower margin nearly straight, ending in a beak directed downward, acute anteriorly. Eye small. Antennæ very long. Length 1 mm.

The abdomen is said to be similar to that of D. longispina. From the brief description given by Sars it would appear that this species is characterized by a rounded and uncrested or slightly crested head. Though imperfectly described, it is here mentioned to direct attention toward any such species as may be found in America.

Sp. 2. **Daphnia cristata**, Sars.

Compressed, long. Head acute in front, strongly crested, lower margin nearly straight. Dorsal line of body little curved, spine long in the young, strongly curved. Head of male smaller, flagellum of antennule twice as long as the setæ; first foot well clawed. Length of female 1.33 mm.

Sp. 3. **Daphnia cucullata**, Sars.

D. berolinensis, SCHOEDLER.

Very like the above, but the margin of head is not straight below, is, however, extremely variable and ends in a sharp angle. The eye lies nearly midway between the heart and the end of the head and near the lower margin. The two anterior processes of the abdomen are united for most of their length. The flagellum of the male antenna is about as long as the terminal setæ.

D. apicata, Kurz, seems to be a large variety lacking the sharp spine of the head. In the main it agrees quite well. Although the post-abdomen is broader than figured by Mueller, the number of teeth corresponds with Sars' description.

Sp. 4. **Daphnia kalbergensis**, Schoedler.

(Plate U. Figs. 1—3).

Form oval, spine long. Head high, compressed, enormously elongated, beak obtuse. Eye small. Abdominal processes not united. Caudal claws ornamented with small setæ. Antennæ of male with a short flagellum. Length of head nearly equal to that of body exclusive of spine.

D. vitrea of Kurz seems not improbably a varietal form of the above though the crest is lower, the size is less and the post-abdomen is more slender and has fewer teeth; the differences are, however, hardly specific.

I am not convinced that either *D. cederstromii*, Schoedler, or *D. retrocurva*, Forbes, are really distinct species, although the latter, with its more strongly crested head, is said also to have a series of teeth on the terminal claw. Perhaps it forms with D. cederstromii the fifth and extreme phase of this group.

Since writing the above account of Daphnia kalbergensis this truly monstrous species has come to light in the vicinity of Minneapolis. The opportunity is thus afforded to verify the suspicion expressed above that a number of species must be united under this name. P. E. Mueller gives the following measurements for D. kalbergensis: head 0.9—1.0mm., body 1.0—1.1mm., spine 0.7—0.75 mm. Kurz for his D. vitrea gives a length of 0.85 mm. plus 0.25 mm., the length of the spine. Judging from his figure, the head would not measure over 0.35 mm.

Forbes says of his D. retrocurva that the head is two thirds as long as the body.

Our specimens measured as follows:

No. 1. 1.6 mm, head somewhat more than half the body and almost exactly like D. vitrea in form.

No. 2. Head 0.6 mm., body 0.9 mm., spine 0.5 mm.; about 9 anal spines. Head in this case moderately curved upward.

No. 3. Head 0.95 mm., body 0.95 or less, spine 0.5 mm.; or the head as long as or, indeed, considerably longer than the body and directed upward.

The males have the crest much lower, the spine longer, and the form of antennules figured by P. E. Mueller. In the older females the beak is elevated above the antennules, as remarked by Forbes, but in smaller individuals there is very little difference between our specimens and Mueller's figures.

The claws of the post-abdomen have, besides the row of fine teeth mentioned by Mueller, a cluster of sharp teeth just at the base.

Found, together with typical D. galeata and the rounded form, in a small deep lake or expansion of a creek not far from Medicine lake, Hennepin county, Minn.

Sp. 5. **Daphnia magniceps**, (Sp. n.)

(Plate U. Fig. 15).

The peculiar form figured in the Tenth annual of this survey seems indubitably new and is distinguished by the peculiar shovel-shaped head, which is scarcely crested but is broadest beyond the middle. The spine is long, the claws smooth, the abdominal processes united and the shell transparent. The eye is near the end of the rounded head and is large; the pigment fleck was apparently absent. Found with Daphnia minnehaha in a shallow swampy pool in autumn.

Family Bosminidæ.

The sole genus of the family, Bosmina, contains over a dozen nominal species which are among the most difficult to define of any cladocerans. The number is here reduced to nine and the probable position of the rejected species is indicated. This is not done because the author presumes upon the slender material at hand to revise the genus; but simply from the fact that the descriptions of the earlier writers do not permit a proper discrimination; so that this necessity is entailed upon any one who would give a birds-eye view of the members of the genus. The B. diaphana is founded upon a different twist in the antennules and no hesitancy is felt in uniting it with Sars' B. lilljeborgii. The other species, B. brevirostris and B. nitida, are omitted simply because there seems to be no way of separating them satisfactorily from B. maritima and B. obtusirostris respectively. Three species have been found in Minnesota, but practically no attention has been given to the genus here.

Bosmina macrorhyncha found in Egypt is not here included, its description being inaccessible to me.

B. lævis, Leydig, seems simply a smooth condition of other species. Whether B. curvirostris, Leydig, is or is not valid must, so far as I am concerned, remain at present doubtful.

Genus Bosmina.

A. Shell extending into a spine behind.

(a) Antennæ curved outward.

1. *Bosmina cornuta*, Jurine.

(b) Antennæ not curved outward,

I. Shell reticulated, at least in part.

† Flagellum midway between eye and the sensory setæ of antennæ.

2. *Bosmina longirostris*, Mueller.

†† Flagellum nearer eye.

3. *Bosmina maritima*, P. E. Mueller.

4. *Bosmina longispina*, Leydig, (B. brevirostris?)

II. Shell striate.

† Antennules long.

5. *Bosmina striata*, Herrick.

†† Antennules short.

* Rostrum long.

6. *Bosmina lacustris*, Sars.

** Rostrum short.

7. *Bosmina obtusirostris*, Sars. (B. nitida, Sars?)

B. Shell not spined behind.

(a) Shell strongly arched above.

8. *Bosmina lilljeborgii*, Sars. (B. diaphana?)

(b) Shell moderately curved above.

9. *Bosmina microps*, P. E. Mueller.

Concerning the identification of Bosmina longispina, Leydig, with B. brevirostris, P. E. Mueller, it must be said that the bow is drawn at a venture, for Mueller, in his paper on the Cladocera of Swiss Lakes, in a fit of absent-mindedness refers to B. lacustris, P. E. Mueller, citing p. 149 of Danmark's Cladocera. On the page in question are descriptions of B. maritima and B. brevirostris of which the latter is probably the one meant. Sars' B. lacustris seems quite different, being strongly marked by longitudinal lines, while Leydig says of B. longispina "shell striped and small reticulate," and P. E. Mueller says in B. brevirostris the shell is "utydeligt reticuleret" i. e. indistinctly reticulate.

The three species so far identified in America are B. longirostris, of which a figure is given (plate J, fig. 2,) B. cornuta and B. striata, which may possibly be yet identified with one of the European species, though it seems improbable. I have also seen a species like Leydig's B. lævis, but considered it a smooth variety of B. longirostris.

FAMILY LYNCODAPHNIDÆ, Sars, 1861; Herrick, 1881.

This is a rather small family with seven genera of minute animals which are abundant only in summer. Many and, indeed, most of the species are among the rarer of fresh-water crustaceans of this group, and a few are among the rarities which only now and then reward the collector. This family undoubtedly is the link connecting the Daphnidæ with the Lynceidæ, relationships to which are expressed by Macrothrix, on the one hand, and Lyncodaphnia, on the other.

The rank of this group as a family must be, of course, a matter largely of opinion. Sars was the first to adopt this view, sustained by certain curious transition forms leading toward Lynceidæ. Later writers seem never to have found these genera and the group was again included with the Daphnidæ. The writer, upon the discovery of the Lyncodaphnia, was forced to regard this group as of equivalent grade with the above mentioned families and again proposed the family name Lyncodaphnidæ.[1]

The genus Ilyocryptus is a little one side the normal course of the family and seems related to the lynceid genus Leydigia.

The waters of the northern United States are very rich in members of this family.

The aberrant family Bosminidæ finds its only connection with other Cladocera through this group by means of the remarkable Macrothrix (?) pauper; and here it is only vaguely hinted at in the elongated antennules and angled lower margin of shell, as well as the presence of certain bodies near the base of the antennules. It has been affirmed that none of the Lyncodaphnidæ have an ephippium, i. e. the saddle-shaped thickening of the shell walls to include and protect the winter eggs; but I have discovered it in the case of Macrothrix tenuicornis, Kurz, and presume it may occur exceptionally in others. Kurz says that Ilyocryptus has no moult proper, but this probably refers only to the European I. sordidus. The American species differs from the generic description given by Kurz, and may be different in this respect also.

In this family the regularity in the disposition of the setæ on the antennæ is broken and the fringing of these hairs serves the purpose of specific distinction. The antennules are always long and frequently differ considerably in the sexes. The pigment fleck is always present (Kurz is in error in denying its existence in Lathonura). In many forms there is no free posterior margin of the valves, while the lower is generally thickly beset with movable spines. The Lyncodaphnidæ will be distinguished from Ceriodaphnia, which they resemble, by their motion, which is a succession of quick bounds, while the broader Ceriodaphniæ hobble along as though heavily weighted by the enormous mass of eggs with which they are generally laden. The abdomen is usually short and the anus is behind the terminal claws, but in Ilyocryptus the claws are long and spined at the base. In the American I. spinifer the anal opening is elevated to a point nearly underneath the stylets, and there is a rudimentary anal cæcum as in Lynceids.

The males have the opening of the vasa deferentia in front of the claws, which may be absent; the antennules are also modified, being longer and curved. In Lathonura the abdomen is elongated

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1 Notes on some Minnesota Cladocera. 1881.

posteriorly till it begins to suggest a transition to Polyphemus. The known genera and their distribution is as indicated below.

Half of the known species are found in America; one sixth being peculiar to it.

GENERA.	Total number of species.	European.	Also American.	Only in America	Total American.
1. Macrothrix	4	3	2	1	3
2. Lathonura	1	1	1	.. .. .	1
3. Drepanothrix	1	1	....	....	....
4. Streblocercus	1	1	......	....	....
5. Acantholeberis	1	1	....	....	....
6. Ofryoxus	1	1	1	....	1
7. Lyncodaphnia ?	1	....	....	1	1
8. Ilyocryptus	3	2	.. ..	1	1
Totals	13	10	4	3	7

I. Genus Macrothrix, Baird.

Body oval, pointed behind; head broad; antennæ of first pair long, nearly straight, beset with spines, olfactory threads terminal; swimming antennæ large and powerful, propelling the animal by bounds; three-jointed ramus with a greatly elongated seta which is thorned and jointed; labrum with the basal joint enlarged, resembling that of Lynceids; first foot with a hook in both sexes; last foot with a long process (respiratory body); abdomen short; claws short; caudal stylets often with a bush of hairs at tip. The intestine is straight and without cæca in front or behind.

The first one to observe a member of this genus, apparently, was O. F. Mueller whose Daphnia curvirostris is usually referred to Macrothrix laticornis.

The name Echinisca was proposed by Lievin, but Macrothrix was applied by Baird in 1843. Four species are known, three of which occur in America and without doubt the fourth will ultimately be found. No males of this genus were known till 1877 when the male of M. laticornis was described and figured.[1] Nearly two years later the male of M. rosea was described from Wisconsin by E. A. Birge. Descriptions of the male of Lathonura are also given in both the above mentioned sources.

Sp. 1. **Macrothrix laticornis**, Jurine.

(Plate C. Figs. 7, 8 and 9.)

Daphnia curvirostris(?), MUELLER.
Monoculus laticornis, JURINE.
Lynceus laticornis, DESMAREST.

1 Gruber und Weismann, Ueber einige neue oder unvollkommen gekannte Daphniden. Freiburg.

Macrothrix laticornis, BAIRD, Ann. Mag. Nat. Hist.
Acanthocercus curvirostris (?), SCHOEDLER, Erichs. Archiv, 1846.
Daphnia curvirostris, FISCHER.
Macrothrix laticornis, LILLJEBORG, LEYDIG, BAIRD, P, E. MUELLER, FRIC, KURZ, SARS, LUTZ, CLAUS (Die Schalendruse d. Daphnien), NORMAN and BRADY (Monogr. Brit. Entom.), GRUBER and WEISMANN, WEISMANN, (Beitrage zur Naturgeschichte d. Daph.)

This is the commonest European species and is the type of the genus, showing its rather conservative position by the broad tip of the antenna which is a feature exhibited by embryos and young of other species. The shell has a warty surface and is toothed above, while the lower margins are fringed with long unequal spines in groups of threes or fours.

The form is roundish with a blunt posterior angle, the ventral margin being regularly curved. The antennules are short and enlarged at the end. The form is an irregular pentagon; a pair of slender spines sits at the angle near the base.

The swimming antennæ with the seta on the first joint of 3-jointed ramus very long. Post-abdomen truncate at the end, short, posterior margin beset with series of bristles.

Length of male 0.5—0.6 mm., of female 0.4 mm.

This is the smallest of the genus and will undoubtedly be found in America.

Sp. 2. **Macrothrix rosea**, Jurine.

(Plate C. Figs. 5, 6, 11, and 13.)

Monoculus roseus, JURINE.
Lynceus roseus, DESMAREST.
Daphnia rosea, M. EDWARDS, JURRELL.
Echinisca rosea, LIEVIN.
Macrothrix rosea, BAIRD, LILLJEBORG, P. E. MUELLER, BIRGE.

The body is sub-oval, terminating behind in an acute angle; the lower margin is less conspicuously spined than the last or the following; the antennæ are but slightly dilated at the end and nearly straight. The longest seta of the antennæ is longer than in the last, reaching beyond the tips of the terminal setæ; abdomen more slender, sinuate in front, beset with short hairs.

Length 0.6 mm, male 0.3 mm. The male has no claws on the end of the post-abdomen, and the antennules are curved and elongated. Figures 5 and 13 are copied from Birge.

Sp. 3. Macrothrix tenuicornis, Kurz.

(Plate C. Figs. 1, 1 a, 2, 3, and 12.)

(See Notes on Cladocera of Minnesota, p. 245.)

The body is oval, produced posteriorly in a sharp point; the abdomen is strongly arched, while the upper outline of the head is a regular curve or slightly extended in front of the eye; the antennules are long, nearly straight and a very little narrowed toward the end, just in front of which is a series of short teeth; there is no lateral spine, but a strong terminal one in addition to the sensory filaments; the pigment spot is large, the eye small and the lobus opticus well separated from the ganglion; the antennæ have a very powerful basal joint; the elongated seta is very stout and densely spiny, with a tooth at its flexure; two of the terminal setæ are spiny, for the basal half; the valves are beset with very long spines in sets of three each, all having different positions; the abdomen is nearly as in M. rosea, but the posterior margin has a series of long sharp teeth; the mandibles are nearly completely exposed by the arched anterior margin of the valves.

The labrum, in this species, is an odd link between that of the Daphnidæ and Lynceidæ. The basal segment is greatly enlarged and is sub-triangular in outline, with a movable lip attached to the inner free face; the typical daphnoid structure is preserved, but the enlarged salient angle of the basal portion shows how the transition to the great triangular labrum of Alona, etc., is made. In young specimens the head is proportionately larger, the antennules are broader at the tip, and the dorsal outline is less convex; the marginal spines of the valves are also proportionally larger, as are the appendages of the first and last pairs of feet. This is one of the largest species of the genus, 0.75 mm. being the length. This is very close to M. rosea but seems distinct.

This form is quite common about Minneapolis, Minn., but is not yet noted elsewhere in America.

Sp. 4. Macrothrix pauper, Herrick.

(Plate C. Fig. 4.)

This species is described from a single specimen from L. Minnetonka, and I can add nothing to the very meager notice given then.[1]

[1] Notes on some Minnesota Cladocera. 1881. C. L. Herrick.

The body is broad and very narrow, the lower outline is angled and nearly unarmed; the pigment fleck and eye are small and approximated; antennules very long and curved backward and outward; abdomen short, ciliate below; claws short, ciliated. This female had a full complement of eggs but the antennæ resemble those of a male. This is unusually interesting and should be rediscovered and studied; for there seems to be some affinity between this species and Bosmina, and it is probable that it requires to be distinguished generically from Macrothrix.

II. Genus Lathonura, Lilljeborg.

The form is oval; the head is curved more than in Macrothrix and the shell is more obtuse behind, sinuate below where it is beset with short spines anteriorly; first antennæ long, straight; second antennæ with five setæ on each ramus; only four pairs of feet apparent; abdomen short, prolonged upward to the insertion of the caudal stylets; male similar but smaller.

Sp 1. **Lathonura rectirostris**, O. F. Mueller.

(Plate D.)

Daphnia rectirostris, O. F. MUELLER.
Pasithea rectirostris, KOCH, Deutschland's Krust., etc.
Daphnia brachyura, ZADDACH, Syn. Crust. prussicorum. LIEVIN, Die Branch. d. Danziger Gegend.
Daphnia mystacina, FISCHER, St. Petersb. Branchiop.
Lathonura rectirostris, LILLJEBORG, De Crust. ex ord. trib.
Pasithea rectrirostris, LEYDIG, Naturg. d. Daph.
Lathonura rectirostris, NORMAN and BRADY, Monogr. Brit. Ent.; P. E. MUELLER, Danmark's Cladocera.
Lathonura spinosa, SCHOEDLER, Branchiop. d. Umg. v. Berlin.
Pasithea rectirostris, GRUBER and WEISMANN, Ueber einige neue od. unvollk. gekannte Daph.
Lathonura rectirostris, BIRGE, Notes on Cladocera. HERRICK, Notes on Minnesota Cladocera.

The only species of the genus is distributed probably over the entire northern temperate zone. It has been found in America at Cambridge, Mass., and in the vicinity of Minneapolis, at both of which places it is very rare.

The form is a rather quadrangular oval, the head being strongly arched to the beak which is much farther posterior than in Macrothrix, in this respect resembling the Daphnidae; the eye occupies the center of the lower part of the head margin, and is of moderate size; the pigment fleck is near the base of the antennules and well removed from the eye; the antennæ are straight and long, with a sensory bristle near the base in front and two bristles a third from the end; the second antennæ are furnished with a powerful basal joint, while each of the main subdivisions of the rami has its bristle, which are nearly equal; two of the terminal setæ are toothed for the basal half and pectinate distally, but the others are feathered throughout; the four-jointed ramus has a spine on the second joint and a longer one at the end, and all the joints of both rami are ornamented with triple series of spines; the maxillæ are three-spined at the end and are in almost constant motion; the first pairs of feet have curious comb-like bunches on some of the setæ; the abdomen is very short and terminates in inconspicuous teeth, the posterior part of the abdomen being ornamented with teeth flattened longitudinally so as to look like spines from the side; the last foot is simple but bears a large appendage; the posterior third of the shell is fringed by extremely minute spines, but anteriorly by lanceolate stiff spines flattened longitudinally like the spines of the abdomen; the caudal setæ are seated on a high prominence of the abdomen, and are fringed along their whole length, not merely at the end. The female is 1 mm. long, the male 0.5—0.6 mm., in which sex the antennules have more numerous lateral bristles, the first foot has a claw and the back is less elevated. The semen bodies are irregularly round with small nuclei.

III. Genus Streblocercus, Sars.

In form like Macrothrix laticornis, head terminating in a long rostrum bearing the long, twisted antennules. Antennules very large, curved backward and outward. Head not separated by a destinct depression from the body, very high, slightly arched above, abrubtly curved below with spines upon the margins. The antennæ are large; four-jointed ramus much the longer, with four setæ. Labrum with a large process. Post-abdomen as in Macrothrix laticornis. Eye near the beak ; pigment fleck small, below it at the base of the antennules. Length .33 mm. S. minutus is the only species.

Our Macrothrix pauper seems a near approach to this genus; both have a strong spine or claw on the first foot which projects beyond the shell, but there are many differences. M. pauper is 1 mm. long.

IV. Genus Drepanothrix, Sars.

The head not separated from the valves by a depression; fornices moderate; rostrum rather acute, distant from the anterior edge of the valves. The form is subrotund; reticulate, with the margins of shell fringed below by long movable spines; pigment fleck present; swimming antennæ with three ciliated setæ on the 4-jointed ramus, the 3-jointed ramus with its basal joint armed with an unjointed, strong, spinous seta and four ciliated setæ on the remaining joints. The post-abdomen is broad. The male has longer antennæ and a hook on the first foot.

Sp. 1. **Drepanothrix dentata**, Euren.

(Plate C. Fig. 14.)

Acantholeberis dentata, EUREN.
Drepanothrix setigera, SARS.
Drepanothrix hamata, SARS.

This animal is only 0.5 mm. in length. The antennules are laterally curved in the middle and ornamented with notches on the margins; the pigment fleck is quadrate and rather large; the post-abdomen is truncate at the end, convex behind and ornamented with a series of small spines. Only found in Scandinavia as yet.

V. Genus Acantholeberis, Lilljeborg.

Head separated by a depression from the body, with fornices above the base of the swimming antennæ; rostrum erect, rather acute; shell oblong, truncate behind, ciliate below with long setæ; macula present; antennules rather long, movable, sensory setæ terminal, bifid at the apex.

The tri-articulate ramus has a long spiny seta on the basal joint; feet six pairs; no abdominal process; post-abdomen wide, large; intestine without cæca.

Sp. 1. **Acantholeberis curvirostris**, Mueller.

Daphnia curvirostris, O. F. MUELLER.
Acanthocercus rigidus, SCHOEDLER. LIEVIN.
Acantholeberis curvirostris, LILLJEBORG, P. E. MUELLER.

This species of a genus approximating the Lynceids has not yet been found in America but is to be expected.

The abdomen is rounded toward the end and spiny posteriorly; the terminal claws are furnished with two strong teeth at the base, followed by a series of fringing bristles. The length, according to Mueller, is 1.5 mm. This is a rare form in Europe.

VI. Genus Ofryoxus, Sars.

The single species constituting this genus seems to have been seen by no writer save Sars. At the time my previous paper on Cladocera was published, Sars' description seemed not to apply to the form called Lyncodaphnia. Since then several stages in the growth of Lyncodaphnia have been encountered, which so far agree with what is said of Ofryoxus gracilis that it is doubted if the two forms are not identical.

VII. Genus Lyncodaphnia, Herrick.

(Plate B. Figs. 12, 15; Plate B1, Figs. 1, 3.)

Body elongated, somewhat rectangular as seen from the side, greatest width and hight of shell a little posterior to the heart; head separated by a depression from the body, truncate below; antennæ and antennules much as in Macrothrix; 4-jointed ramus of antennæ with no lateral setæ; eye small, pigment fleck present; intestine twice convoluted, expanded posteriorly, with anterior but no posterior cæca, opening near the "heel" of the post-abdomen: post-abdomen large, triangular; terminal claws long, rather straight, with two accessory spines at the base.

The species upon which this genus was founded[1] occurs in August and September in the larger lakes of Minnesota.

Lyncodaphnia is, as was suggested, a curious transition form linking the Daphnidæ with the Lynceidæ.

A farther study of the genus shows that, in some respects, it is more closely allied to both groups than before suspected. The habit and appearance in the water reminds us of Simocephalus, a resemblance which an occasional spot of pink or blue color hightens. L. macrothroides not only has the disc-like last foot colored but the swimming antennæ are banded with purple as in Simocephalus rostratus, Her., and S. americanus, Birge. The intestine has anterior cæca, which is not the case in lynceids nor, indeed, in other Lyncodaphnidæ.

The four-jointed ramus of the antennæ approaches Lynceidæ in the absence of a lateral seta, but the other ramus is as in Macrothrix. The convolution of the intestine, the form of the post-abdomen and the situation of the anus, are all of a strictly lynceid

1 Notes on Minnesota Cladocera, p. 247.

type; moreover the flattened appendage of the last foot is like that of Eurycercus.

Even in the form of the shell there is a combination of characters; the anterior part of the shell has the form peculiar to Lyncodaphnidæ; but posteriorly it again expands and becomes truncate behind; the form in the adult is not unlike that of some Lynceidæ, but the young has a long spine posteriorly exactly like the spine of Daphnia. The latter fact is very instructive, for it indicates that the theory proposed (Am. Naturalist, 1882, p. 815) to explain the origin of this appendage is probably the correct one. Professor Leuckart suggested that this spine was a balancing rod intended to keep the proper equipoise over the center of gravity; but it is difficult to see why these long-bodied forms, in which the greater part of the weight lies "abaft" of the pivotal point—the base of the antennæ—should be thus provided while the shorter forms are not. We conceive that it is an apparatus for effecting the moult of the inner lining of the brood cavity of long-bodied and tender-shelled animals such as Daphnia and the present genus. The great development of the head in the crested Daphnidæ may undoubtedly be explained upon Prof. Leuckart's theory.

Sp. 1. **Lyncodaphnia macrothroides,** Herrick.

(Perhaps = Ofryoxus gracilis, Sars.)

Notes on Cladocera of Minn., p. 247.

Sub-rectangular, greatly elongated, truncate behind, with a slight spine above; head and eye small, fornix moderate, beak truncate; antennules rather long, slightly curved, tapering a little toward the end, whence spring three lanceolate spines and several sensory filaments, five stout spines behind, above the middle, and several more slender ones; swimming antennæ very long, terminal setæ smooth to the joint; labrum as in Daphnia; mandible attached behind a salient angle of the front margin of the shell; no abdominal processes; post-abdomen broad above, triangular; terminal claws pectinate, furnished with one very large toothed accessory spine and a smaller one; the first foot has a hook; the last foot consists of a large oval plate which bears posteriorly the ordinary branchial coil, here shaped like a thumb and forefinger. The young is of a different shape and bears a long spine. The male is unknown.

VIII. Genus Ilyocryptus.

Form compact, short; head short, triangular, with large fornices forming a roof over the head; the posterior margin of shell nearly as long as the inferior; lower angle a broad curve; antennules two-jointed, basal joint very short, second joint straight, rather long; setæ terminal, but one seta near the base; the four-jointed ramus of the antenna with but three (terminal) setæ; six pairs of feet, last pair rudimentary; tail large, as in Lyncodaphnia, anus elevated; intestine straight, without cæca, but an expansion near the rectum sometimes simulates one; the margin of the shell is bordered with long spines, which may be branched or simply pectinate. There is often, perhaps generally, a failure to entirely remove the moulted shell; when this occurs, the newly-formed shell from each moult remains under the older ones till the animal seems to be wearing six or more overcoats, and the spaces so formed become filled with algæ and filth till the animal is no longer able to swim. P. E. Mueller and Kurz, who seem to have seen only I. sordidus agree that Ilyocryptus can not swim, but poles along in the mud on the bottom by means of antennæ and abdomen; our I. spinifer, on the other hand, swims freely till loaded up with old clothes and filth.

This genus is also closely allied with the Lynceidæ.

Sp. 1. **Ilyocryptus sordidus**, Lievin.

(Plate C. Figs. 15, 16, 17.)

Acanthocercus sordidus, LIEVIN, LEYDIG.
Ilyocryptus sordidus, SARS, NORMANN, P. E. MUELLER, KURZ.

Body higher than long; head small, terminating anteriorly in almost a right angle; posterior part of the shell margins covered with branching, thorny spines; antennules cylindrical; antennae short: four-jointed rami with no lateral setæ; post-abdomen large, broad; terminal claws with two spines at the base; anus in the middle of the posterior margin, which is very heavily armed with spines; a hairy abdominal process is present according to Kurz.

There are no anterior cæca (my statement that P. E. Mueller described such cæca was an error; see Notes on Cladocera of Minn., p. 246).

Sp. 2. Ilyocryptus spinifer, Herrick.

(Plate C. Figs. 18—19.)

Usually longer than high; head rounded, almost exactly like I. sordidus, but the form of the post-abdomen differs a little in the higher situation of the anus and the great elongation of four or five of the lower spines of the posterior margins; the margins of the shell are beset with pectinate setæ which do not branch. The nearest approach to branching setæ yet seen are figured on plate C, fig. 18 a; this consists in the outgrowth of a spine from near the base, and such setæ are found only on part of the posterior margin.

It seems that our form is rather close to I. sordidus though clearly distinct.

This species occurs in many of our lakes, and is found most frequent in late summer.

Sp. 3. Ilyocryptus acutifrons, Sars.

This species is only mentioned in the appendix to the paper of Sars on the Cladocera from the vicinity of Christiania. The following is a condensation of the description.

Head large, acute in front. Shell truncate behind, with shorter setæ behind than below. Antennules shorter and thicker than in I. sordidus. Antennæ long and robust. Abdomen with a short, obtuse process. Post-abdomen shorter than in I. sordidus, posterior margin continuous, anus terminal; caudal claws straight, very long, with two minute basal spines. Pigment fleck almost touching the eye. Length less than in I. sordidus.

This species seems in some respects more like a true lyncodaphnid than either of the other species. It is doubtful if it belongs here.

FAMILY LYNCEIDÆ.

GENERA.	Number of known species.	European.	Also in America	In America only.	Total American.
1. Eurycercus	1	1	1	....	1
2. Acroperus	2	2	1	....	1
3. Camptocercus	6	5	1	1	2
4. Alonopsis	3	2	1	1	2
5. Leydigia	2	2	2	....	2
6. Graptoleberis	2	2	1	....	1
7. Crepidocercus	1	....	....	1	1
8. Alona	21	14	6	7	13
9. Alonella	5	5	2	....	2
10. Pleuroxus	14	8	1	6	7
11. Harporhynchus	1	1	....	....	....
2. Chydorus	8 (?)	6 (?)	3	....	3
13. Anehistropus	1	1	....	....	1 (?)
14. Monospilus	1	1	1	....	1
Totals	68	50	20	16	37

Out of the fourteen genera, two (or perhaps only one) are not yet known from America, while one is restricted to it. The American species, 45 per cent of which are new, aggregate 72 per cent of the European. 54 per cent of all the known species are American, and most of these have been found within a range of ten miles of Minneapolis. It is probable that the number of species peculiar to America is too high proportionately rather than the reverse, and the comparatively high per cent of new species is due to an actual larger fauna in the New World, while many Old World species remain to be identified. A few of the European species are very likely synonyms, permitting farther reduction.

This family, which is numerically the largest among the Cladocera, is, in the main, well limited, though there are transitions toward the Lyncodaphnidæ, which are quite direct. The genera Lyncodaphnia, Ofryoxus and Ilyocryptus lead toward the Lynceidæ unmistakably. Most of the members of this family are small, comparatively few exceeding one millimeter in length. The head is covered with an arched shield, which frequently passes with no indentation into the shell of the body. This head-covering generally extends forward and downward to form more or less of a sharp angle in front, while in several genera it is simply rounded in front. It, in either case, arches over the more fleshy lower side of the head from which hang the two short antennules and the labrum, while the strong two-branched antennæ spring from well up under its posterior expansion. The rounded sides of this shield, which protect the insertion of the antennæ, are called the fornices. Above the insertion of antennules is a dark fleck lying near or on the lower angle of the brain; this is the larval or nauplius eye, which is the first to appear in all these small crustacea. This *macula nigra* is not infrequently as large as the eye itself,* or even larger, and in one genus it is the only visual organ. The antennules are small and bear on the end several sensory filaments as well as a lateral flagellum. The antennules of the male differ very little from those of the female. The labrum is furnished with a process, which is triangular or semicircular and is usually larger than the terminal portion. The mandibles are as in Daphnidæ but usually shorter. Maxillæ are often conspicuous, but the first pair of feet serve, by a slight alteration at the base, the same purpose. There is rarely an indication of the sixth pair of feet, and the antennæ have both rami three-jointed. The terminal part of the body, or

* The name "Lynceus" is derived from that of the son of Aphareus who was famous for the sharpness of his vision.

post-abdomen, is usually enlarged, and the anal opening is near its base; the armature is usually considerable. The form of the post-abdomen is one of the best criteria for distinguishing genera and species—a process often attended with much difficully.

The shell is of various forms, frequently beautifully sculptured. The number of eggs produced at one time is limited, and the winter eggs are very often laid in the brood-cavity with no preparation of the shell previous to it, in other words, the ephippium may be absent. On the other hand, sometimes the shell is considerably modified, and generally there is a deposit of dark pigment in the upper part of the shell. The males are very rare and until recently few were known. The diligence of Kurz has added a great many, and we now have a fair idea of the sexual variations. These consist usually in a narrower body and shorter beak, in a strong hook of chitin on the first foot and certain modifications of the post-abdomen. The hook mentioned is simply an enlargement of one of the terminal bristles of the foot, and serves to fasten the animal to the shell of the female. In one American species of Pleuroxus we find an approach to this structure in the female—an interesting example of inheritance of sexual peculiarities across the sexes. The alterations in the form of the post-abdomen consist in a narrowing or excavation of that organ to permit its introduction into the brood-cavity, and in some forms (Chydorus) this change can only be understood by observing the form of the shell of the female about to produce winter eggs. In general, as in other Cladocera, males are found only at the period when the females are sexually perfect. The ordinary method of reproduction is by virgin-bearing or parthenogenesis. In some cases it would seem from Weismann's observations that the sexual method occurs only incidentally. The orifice of the male organs is between, or anterior to, the terminal claws of the post-abdomen (Eurycercus alone excepted). The males are usually but not always smaller. Plate E gives views of typical Lynceidæ Fig. 1 is particularly instructive, for in it the details which can be usually made out in the living object are represented. The following points may be especially noticed. The large size of the pigment fleck, the large antennules (A^1), the keel of the labrum (Lb.), the peculiar modification of the first pair of feet to assist the maxillæ (not shown) which are exceedingly small, the largely developed anal gland (A. g.), the form and muscular mechanism of the abdomen, which, however, is better illustrated by fig. 10 of the same plate. Fig. 1 contains an embryo seen from the side with the partially developed limb. Fig. 3 shows the appearance of a different embryo from below and in an earlier stage. Fig. 2 illustrates the relation of the brain to the eye and the very small optic ganglion. Fig. 9 of plate G gives details of the feet in another species, and the modifications seen in the male of the same species are sufficiently shown in fig. 1 of the same plate, which also well illustrates the various sculpture of the shell displayed by this group. Figures 4 and 9 of plate F show curious modifications of the post-abdomen of the male, and fig. 7 exhibits the structural peculiarity of sexually perfect females which is correlated with it or, perhaps we may say, occasions it.

SUB-FAMILY 1.—EURYCERCINÆ.

A single species constitutes the sub-family, and it will be necessary to point out only those points which are distinctive.

The Eurycercinæ differ from the true Lynceidæ and approach the Lyncodaphnidæ in having the digestive tract not coiled, with two cæca in front and the anus at the end of the post-abdomen. Many eggs are produced at once. The male opening is at the base of the abdomen, as in Sididæ. The general habitus is, however, lynceid. The males appear in autumn or when, by the gradual drying up of the water or other causes, the continued existence of the animals is threatened.

I. GENUS EURYCERCUS, Baird.

Characters of the sub-family.

Eurycercus lamellatus, O. F. Mueller.

(Plate H, Figs. 5–6.)

Lynceus lamellatus, MUELLER, EDWARDS, KOCH, ZADDACH, LIEVIN, LEYDIG, ZENKER
Eurycercus lamellatus, BAIRD, LILLJEBORG, SCHOEDLER, P. E. MUELLER, KURZ, BIRGE, HERRICK.
Eurycercus laticaudatus, FISCHER, SCHOEDLER.

A gigantic lynceid, reaching the dimension of 3 mm. The figure of the male given will sufficiently illustrate the general form. The abdomen is broad and armed behind with a dense row of saw-teeth. The eye is larger than the rather small pigment fleck, and the intestine is bent upon itself but not coiled. The last foot is found in few other Lynceidæ. Acroperus has the same, and Pleuroxus unidens also has a rudimentary sixth foot.

SUB-FAMILY II.—LYNCEINÆ.

Intestine coiled; anus near the end of the post-abdomen; opening of vas deferens nearly terminal. There are no anterior cæca but usually a single anal diverticle of the intestine. Rarely or never more than two embryos produced at once.

SERIES A.

Head or dorsal line keeled or ridged ; abdomen long ; shell marked with diagonal striæ. This section is proposed for the old genera Camptocercus, Acroperus and Alonopsis, which seem to form a natural group though passing directly into Alona.

II.—GENUS CAMPTOCERCUS (>*Camptocercus*, Baird).

This easily recognizable genus contains two groups, each with several nominal species, which are distinguished mainly by the width of the post-abdomen. In both the shell is elongated, more or less quadrangular, longitudinally striate, armed behind with one to four minute teeth. The head and back are keeled and the former strongly arched. The antennules rarely extend beyond the beak and are commonly curved laterally. The eye is proportionately small. The post-abdomen is long and furnished with a lateral row of scales. The terminal claws have a single basal spine and are serrate. There is an ephippium, and the male opening is in front of the terminal claws.

SUB-GENUS 1.—ACROPERUS, Baird.

Post-abdomen broad, margins parallel; anal teeth very minute lateral scales large and usurping their place. Antennæ with eight setæ $\left(\frac{300}{311}\right)$. Three species are described, one of which is very abundant in Minnesota.

Sp. 1. Acroperus leucocephalus, Koch.

(Plate E, Fig. 5. Plate I, Fig. 9.)

Lynceus leucocephalus, KOCH, FISCHER.
Acroperus harpæ, BAIRD.
Acroperus leucocephalus, SCHOEDLER, P. E. MUELLER, KURZ
Acroperus sp., HERRICK.
Acroperus striatus, JURINE, M. EDWARDS, LIEVIN, LILLJEBORG, LEYDIG, etc., seems to belong here, but I am able to add nothing to the elucidation of the puzzle.

Body rounded above, angled behind; head moderately arched and carinated. Lower margin of the shell pectinate, terminating in two teeth. The antennæ are long and when reflexed the setæ reach nearly to the posterior margin of the shell. The posterior angle is not always as prominent as shown in fig. 5.

Sp. 2. Acroperus angustatus, Sars.

(Plate I. Fig. 10.)

Acroperus angustatus, P. E. MUELLER, KURZ.

This species is distinguished from the former by the head, which is higher and very strongly arched. The dorsal contour is nearly straight. The antennæ are shorter. The form of the post-abdomen of the male is less different from that of the female than in the above. The length of both species is about 0.7 mm.

The American form figured in fig. 5 of plate E differs from both the above slightly. The head is carinated and incurved almost as in C. angustatus; the antennæ fall a little short of reaching the posterior margin of the too low and oblong shell; there is an obvious depression between the head and body. However, in the main there is close agreement with C. leucocephalus, to which it has been previously referred. There is always a rudiment of an additional pair of feet.

A. cavirostris, P. E. Mueller, is not known in the female sex. The male has a twisted caudal claw.

Sub-genus 2.—Camptocercus, Baird.

Although the general form is similar to the last section, the body is usually longer; the post-abdomen narrows toward the end; the anal teeth exceed the lateral row; the antennæ have usually but seven setae $\left(\frac{300}{310}\right)$.

The species enumerated are so closely related as almost to baffle definition.

Key to the Sub-genus Camptocercus (verus).

Beak pointed.
- (a) Head depressed.
  - I. Pigment fleck larger than the eye.
    - 1. *C. biserratus*, SCHOEDLER.
  - II. Pigment fleck smaller than the eye.
    - 2. *C. macrurus*, O. F. MUELLER.
- (b) Head directed forward.
  - 3. *C. rectirostris*, SCHOEDLER.

Beak truncate below.
- 4. *C. latirostris*, KURZ.

Beak cleft below or with a forward projection.

(a) Antennules shorter than the beak.

5. *C. lilljeborgii*, SCHOEDLER.

(b) Antennules longer than the beak.

6. *C. rotundus*, HERRICK.

Sp. 1. Camptocercus biserratus, Schoedler.

(Plate I. Fig. 4.)

Is very nearly related to the next, from which it is distinguished chiefly by the fact that the pigment fleck is larger than the eye. Schoedler overlooked the fact that in C. macrurus there is a lateral line of scales on the abdomen, and relied upon that character to distinguish this form. (Schoedler says that the pigment fleck in C. macrurus is smaller than the eye, P. E. Mueller says they are nearly equal, while in our specimens they are much smaller or nearly equal.) If much variability is found, Schoedler's species seems to rest on a slender basis. The basal spine of the claw, however, seems to be peculiar in sitting on a distinct prominence.

Sp. 2. Camptocercus macrurus, Mueller.

(Plate E. Fig. 10.)

Lynceus macrurus, LILLJEBORG, SCHOEDLER, P. E. MUELLER, KURZ, BIRGE, HERRICK.

This universally distributed species occurs in our larger bodies of water and is not rare, though hardly abundant.

The body is long and nearly rectangular; the head strongly arched and keeled. The keel of the head is extended down the whole dorsal line. The dorsal line is moderately curved, while the shell is but slightly excavated below. The head extends into a blunt beak looking downward; the direction of the head is somewhat variable (from vertical to an angle of about 30°). The eye is much larger than the pigment fleck; the antennules are shorter than the beak, and have one elongated terminal seta. The post-abdomen is very long and has numerous anal teeth as well as a lateral row of scales. The basal spine of the claws is large and serrate, the claw itself being nearly straight and armed with an increasing series of spines to beyond the middle. The lateral scales of the post-abdomen are inconspicuous. The shell gland is long. The antennules reach to almost the end of the beak, are curved and bear a lateral flagellum. The first foot of the female has a sort of hook (branchial sac?). The labrum is armed with teeth on the posterior face of the triangular process. The intestine is very trongly, almost twice coiled. The lower margins of the valves are feebly spined for three-fourths their length, and armed with from one to four teeth at the angle. Length 0.8 mm. to 1.0 mm.

Sp. 3. Camptocercus rectirostris, Schoedler.

(Plate I. Figs. 1—3.)

Camptocercus rectirostris, SCHOEDLER, P. E. MUELLER, KURZ.

Distinguished from the above, which it closely resembles, by the form of the head, which is less rounded and directed anteriorly. It hardly exceeds half the hight of the body. The beak is sharp. I am not sure that Weismann's figures (l. c., plate XI, figures 13 and 14) really belong to this species, for the drawing of the post-abdomen does not agree with that of P. E. Mueller fully. Outline copies of the former are given in plate I, figs. 1 and 2. The male has a hook upon the first foot. Not yet recognized in America.

Sp. 4. Camptocercus latirostris, Kurz.

(Plate I. Figs. 5—6.)

C. lilljeborgii, P. E. MUELLER (?).

Closely allied to the next, but distinguished by the position of the head, which is a little less depressed, and, especially, by the truncate beak. The dorsal margin is convex and crested; the lower outline is also convex. The claws are toothed more as in C. macrurus than the following. The basal spine springs from the claw itself and not from the post-abdomen as in the next. Length 0.9 mm. to 1.0 mm.

Sp. 5. Camptocercus lilljeborgii, Schoedler.

(Plate I. Figs. 7—8.)

Head depressed, rounded in front: beak divided at the end by the extension of the fornices. The terminal claws are pectinate for their entire length, and the basal spine is seated on the end of the post-abdomen. This species, in the main, closely resembles C. macrurus.

Sp. 6. Camptocercus rotundus, Herrick.

The second of the two species found in America is this short, strongly carinated form, which is known from a single gathering. It differs from all the above species, with which it agrees pretty well in shape, by its more compact form; high dorsal keel (which extends the entire length of the body); the long antennules, which extend far below the beak; and the somewhat pointed beak. The head is much as in the last, but it is not certain that the beak is cleft, although it has a peculiar form (not indicated in the figure) near the end. The length is 0.7 mm. The terminal setæ of the antennules are very unequal; but in most points, as in the armature of the post-abdomen, the details resemble C. macrurus.

III.—Genus Alonopsis, Sars.

This curious genus includes three species of small lynceids, which exhibit a combination of characters. The form of the beak and head is like that of Pleuroxus, which the form and sculpture of the shell otherwise resembles. The back is extended more or less in a knife-like ridge above, thus resembling Acroperus, a resemblance hightened by the excavated lower margin. The form of the post-abdomen approaches that of Acroperus, but in that genus it is of about equal width throughout and in this it rapidly narrows. The internal organs and feet are of the typical lynceid form, while the antennæ are as in Pleuroxus.

The type of the genus, A. elongata, is apparently much closer to Acroperus than the two species which have been identified in America.

Shell sub-rectangular, high, produced into a ridge above; lower margin convex anteriorly, concave behind; beak rather long; antennules slender; antennæ with eight setæ; abdomen long, narrowed toward end, incised at the extremity; claw rather large, with median spines and a basal thorn; third foot with a long bristle. Male smaller, without the carina above; orifice of sexual organs in front of the claw, which is removed from the anterior margin. The young are more elongate and (sometimes) have hexagonal reticulations instead of the usual strong diagonal striæ. Motion slow.

Sp. 1. **Alonopsis elongata**, Sars.

Lynceus macrurus, LIEVIN.
Lynceus macrurus, ZENKER, LEYDIG.
Alona elongata, SARS.
Acroperus intermedius, SCHOEDLER.
Alonopsis elongata, P. E. MUELLER.

The shell is wide, the upper margin forming an even curve, manifestly angled behind; ventral margin nearly straight, ciliated throughout, with a single tooth behind. Fornices large; head narrow, not carinate. Post-abdomen compressed, truncate at the end, armed with a series of marginal spines and of lateral scales; caudal claws large, with a single spine at the base and two median spines followed by a series of minute setæ.

This form I have never seen, and it seems somewhat doubtful that the following really belong with it.

Sp. 2. Alonopsis latissima, Kurz.

(Plate E, Fig. 8. Plate G, Figs. 1 and 9.)

Body very high, compressed, with a high dorsal keel or ridge; the upper outline strongly and evenly arched, terminating behind in no angle; lower margin almost angled at the anterior third, rounded behind, fringed with long bristles anteriorly, with short ones posteriorly. Head very narrow; beak extremely long; fornices small; antennules nearly as long as the beak, straight and narrow; pigment fleck smaller than the eye. The abdomen is long, somewhat narrowed toward the end, where it is deeply cleft; the terminal claw is furnished with a large and small basal spine, while there is an increasing series of spines extending to the middle.

The elongated spine of the third foot is pectinate and reaches nearly to the posterior margin of the shell. The shell is marked by few strong striæ which are diagonal except anteriorly where are a few parallel to the front margin. The male is small and lacks the crest on the back, while the lower margin is straight; the antennæ are longer than the beak and differ somewhat from those of the female. The first foot has a claw. The post-abdomen lacks the anal teeth. Kurz gives the size as 0.5 mm.

The American form varies between 0.45 mm. and 0.55 mm., and seems to have a higher dorsal keel and longer beak. Kurz speaks of but a single accessory spine on the terminal claws; there is, however, a second very minute spine or cluster of hairs in this as well as the following.

Found in the same gathering with the following near Minneapolis (marshy off-set from Bassett's creek near Oak Lake Addition).*

*NOTE TO ALONOPSIS LATISSIMA. (See Fig. 1, Plate G.) Since writing the above the males of our American form have been found; they are shaped as the females, with a high dorsal keel; the post-abdomen is rounded, with transverse series of small bristles; the claw has a minute median spine, and the *porus genitalis* is anterior and elevated.

Sp. 3. Alonopsis media, Birge.

(Plate E. Fig. 9.)

I give Birge's description verbatim:

"Rostrum prolonged, and shell sharp, somewhat quadrangular in shape, marked by striæ. The dorsal margin is convex, the hinder margin nearly straight. Its lower angle is rounded and without teeth. The lower margin is concave and has long plumose setæ.

The front margin is strongly convex. The post-abdomen is long and slender, resembling that of Camptocercus, and is notched at the distal extremity; it has two rows of fine teeth and some fine scales above them. The terminal claws are long, slender, with a basal spine, a spine in the middle, and are serrated. The antennules are long and slender, but do not reach to the end of the rostrum. They have each a flagellum and sense hairs. The antennæ are small and have eight $(\frac{300}{311})$ setæ and two $(\frac{100}{100})$ spines. The labrum resembles that of A. leucocephalus, but is slightly prolonged at the apex. The intestine, cæcum and color resemble those of Acroperus. There is a trace of a keel present on the back."

The specimens seen in Minnesota resemble this species very nearly, apparently, but there are some differences. The terminal claw of the post-abdomen has an increasing series of spines to the middle; there seems to be no lateral row of scales beside the anal teeth; the abdomen is rather broad at the base and narrows toward the end. The shell is not square behind. The lower margin has a few long hairs anteriorly which are followed by a series of teeth, and in the concave part a somewhat longer set to a point just before the lower curved angle.

The pigment fleck is nearly or quite as large as the eye. The antennule is shorter than the beak (which is almost as in Pleuroxus hastatus), and has a flagellum about midway; at its base it is narrowed and inserted on a prominence.

The embryo still in the brood sac had a more elongate form and hexagonal reticulations upon the shell, while the antennules were longer than the very long beak, and the pigment fleck was smaller than the eye. Length of female 0.52 mm. The color is darker, and the striæ more numerous, than in A. latissima.

Series B.

This section includes forms with (usually) no keel above, or, if keeled, the post-abdomen is not long. The majority are highly arched dorsally, and have comparatively short post-abdomen and pointed beak. The antennæ are usually feeble and the motion slow.

A. Post-abdomen nearly round in outline, armed with very long stout spines, terminal claw with one minute basal spine or none ; greatest hight of shell about equal to the posterior margin.

1. Genus *Leydigia.*

B. Greatest hight of shell moderately exceeding that of posterior margin ; post-abdomen more or less triangular, armed with bristles ; shell marked with hexagonal meshes.

(a) Head nearly horizontal, blunt ; post-abdomen prominent in the anal region.

2. Genus *Graptoleberis.*

(b) Head depressed, acute; post-abdomen excised near the anus.
3. Genus *Crepidocercus*.

C. Post-abdomen more or less quadrangular, armed with one or two rows of small teeth on either side behind; terminal claws with one or two basal spines; hight of posterior shell margin usually less than the greatest hight of shell.
4. Genus *Lynceus*.

D. Greatest hight of shell little less than that of posterior shell margin; post-abdomen terete; terminal claws very minute.
5. Genus *Phrixura*.

E. Greatest hight of shell more than double that of posterior margin.
(a) Eye and first foot normal.
6. Genus *Chydorus*.
(b) First foot with a claw which extends beyond the shell.
7. Genus *Anchistropus*.
(c) Eye absent, only pigment fleck used for vision.
8. Genus *Monospilus*.

IV.—Genus Leydigia, Kurz.

In this genus, both the known species of which are found in America, the posterior part of the shell and body is emphasized at the expense of the anterior. The curved posterior margin is equal to the greatest hight of the shell. The head and anterior part of the body are of the form characteristic of Alona; indeed, the whole body is in plan like Alona, but in the back part the organs are all enlarged. The general form of the body and abdomen recalls Ilyocryptus; the post-abdomen, in particular is very like that genus. The last two pairs of feet are much enlarged. The shell is usually irregularly marked with longitudinal striæ; the lower margin is covered with long spine-like setæ. The post-abdomen is armed with several sets of long spines and aggregations of bristles and small spines; it is almost round and enormously enlarged. The intestine is coiled and expanded at the end, but the anal cæcum is rudimentary. The antennæ are heavily spined and have eight setæ; the labrum is more or less hairy. The male has a strong hook on the first foot, and between the terminal claws of the abdomen is a peculiar intromittent organ.

Sp. 1. Leydigia quadrangularis, Leydig.

(Plate H. Fig. 4.)

Lynceus quadrangularis, LEYDIG, FRIC.
Alona leydigii, SCHOEDLER, P. E. MUELLER.
Leydigia quadrangularis, KURZ.

The shell is comparable to that of Alona quadrangularis, but higher behind; the markings are not very distinct; shell transparent. The head is very small; the eye smaller than or of about the size of the pigment fleck. The post-abdomen is very broad, the posterior margin nearly the segment of a circle, armed with numerous very long unequal spines which extend only about half the hight, being replaced by short close hairs; the anal opening is very high; the terminal claws are long, straightish, and have a small thorn near the base.

The males are smaller than the females, and the abdomen is less broad; the antennules are longer than the beak and furnished with a flagellum. The sexual period occurs in September or irregularly. This species has only been encountered once, during September, in Poplar river, Cullman county, Alabama.

Sp. 2. **Leydigia acanthocercoides**, Fischer.

Lynceus acanthocercoides. FISCHER, LEYDIG.
Eurycercus acanthocercoides, SCHOEDLER.
Alona acanthocercoides, P. E. MUELLER.
Leydigia acanthocercoides, KURZ.
Leydigia quadrangularis, HERRICK.

This species, reported in a previous paper, is, as was said, nearest like L. acanthocercoides; and I am now able to verify the very inconspicuous differences upon which the two are separated. Our specimens of the L. quadrangularis have the pigment fleck fully as large as the eye, Kurz to the contrary notwithstanding, and the claw of the post-abdomen is present, while in the present species the pigment fleck is much larger and furnished with lenses; the spine of the claw is wanting; the labrum is densely hairy; the abdomen is narrower, and the shell higher. The shell is very obviously striped in the posterior portion. The anus is higher than in the previous species. In other respects the two seem alike.

v.—Genus Graptoleberis, Sars.

A genus containing two closely allied species, having some affinities with Alonella. The shell is entirely reticulated, and there is a sort of crest along the back; while, on the other hand, the head is flattened and rounded in front. There can hardly be said to be a beak. Seen from above, the animal resembles some species of Alonella, but the head is larger proportionally and more horizontal. The lower posterior angle is spined. The antennæ have seven setæ and are very long, in this respect resembling Camptocercus. The dorsal contour is not greatly arched. The post-abdomen has short claws and anal bristles, but no teeth.

Sp. 1. Graptoleberis testudinaria, Fischer.

Lynceus testudinarius, LEYDIG, LILLJEBORG.
Lynceus reticulatus, FRIC.
Alona testudinaria, SCHOEDLER.
Graptoleberis testudinaria, KURZ.
Graptoleberis inermis, BIRGE.

Form trapezoidal; lower margin straight, armed behind with two teeth, thickly beset with long hairs in front; the dorsal margin is not greatly elevated, rounded at the posterior angle, forming a slight "hump" where it unites with the head shield. The head and shell are reticulated with hexagonal or quadrangular markings. The shell gapes below and rises to a sharp ridge above. The antennæ have long rami, the antennules being hardly longer than the fornices. The eye is large; the pigment fleck is small. The post-abdomen is narrowed toward the end, rounded in front; the terminal claws are small and have two basal teeth. The dorsal margin of the post-abdomen is covered with tufts of hairs. The winter eggs have no ephippium. Length 0.55 mm. to 0.7 mm. The male is smaller and has a lower dorsal keel; the post-abdomen is excavated behind.

The only differences between the Minnesota specimens and the typical European form seemed to be the absence of the very minute spines on the front of the terminal claws. The eye and pigment fleck are of about the proportions figured by Kurz. Birge's figure of the post-abdomen does not agree with his description fully. Our Minnesota specimens have an obvious but not high keel.

Sp. 2. Graptoleberis reticulata, Baird.

Alona reticulata, BAIRD, P. E. MUELLER.
Lynceus reticulatus, LILLJEBORG, LEYDIG.
Alona esocirostris, SCHOEDLER.
Graptoleberis reticulata, SARS, KURZ.

Shell almost rectangular, reticulate, ventral margin straight, ciliate anteriorly, with two teeth behind. Pigment fleck smaller than the eye. Post-abdomen short, narrowed towards the end, dorsally covered with clusters of spines; caudal claws with a minute tooth at the base. Length 0.4 mm. to 0.5 mm.

The pigment fleck is nearer the end of the beak than the eye, and is smaller than in the previous species, but, on the whole, there is perhaps, too great similarity.

VI.—Genus Crepidocercus, Birge.

The characters of this group place it rather near Alonella or between that and Pleuroxus. Form sub-quadrate with rounded angles; dorsal line uniformly arched, terminating in a sharp angle behind; lower margin convex, armed behind with a single spine as in Pleuroxus unidens, and along the entire length with loose setæ. Beak of moderate length, acute. Post-abdomen deeply incised in the anal region; lower posterior margin straight, rounded at the apex; ventral margin straight or concave; claws with a single basal spine and a few teeth. The post-abdomen is shoe-shaped and armed with transverse rows of setæ.

The antennæ are large, having eight setæ and the usual spines. Shell smooth or reticulate.

Sp. 1. **Crepidocercus setiger,** Birge.

(Plate F. Fig. 13.)

Length 0.4 mm. to 0.5 mm. Minnesota specimens measured 0 5 mm. This, the only species of the genus, is but rarely encountered, and is so peculiar as to be easily recognized when seen. Alona intermedia has a post-abdomen with clusters of bristles, but in Crepidocercus the post-abdomen is more as in species of Graptoleberis than any other genus. The markings upon the shell are very indistinct.

VII.—Genus Lynceus, O. F. Mueller.

The perplexing inter-relations between the three genera Alona, Alonella and Pleuroxus give rise to the utmost confusion. No two authors are agreed as to their respective limits, and the points given by Kurz, who has carefully gone over the ground, are obviously insufficient. Although there may be practical benefits to be derived from the continuance of the nomenclature in use for groups which in the general view can be distinguished, the value from a theoretical standpoint is reduced to a minimum.

The genus Camptocercus (including here Acroperus, which differs solely in the form of the abdomen, as a sub-genus) passes through Alonopsis into the group represented by Alona. Leydigia, although very near such forms as Alona quadrangulata, may be conveniently distinguished as a transition to species like Ilyocryptus.

Phrixura, Graptoleberis and Crepidocercus, each containing few species which can be readily recognized, fill a place in the system; but it is practically impossible to distinguish Alona from Pleuroxus without instituting the very indefinite genus Alonella to contain a variety of small intermediate forms. Percantha, Rhypophilus, Harporhynchus and Pleuroxus seem to be pretty generally regarded as constituting a single group which may be recognized by the long rostrum, high shell and greater development of the antenna bristles. Alona, on the other hand, with its broader fornices, shorter beak, fairly developed antennæ, and more rectangular shell, is, perhaps, the pivotal point of the group. According to this view, then, the old name *Lynceus* is revived for the aggregate; and the other names are retained, in part, as titles of largely conventional groups or sub-genera, thus:

GENUS LYNCEUS.

Sub-genus ALONA.
Section A. *Alona vera.*
Section B. *Alonella.*
Sub-genus PLEUROXUS.
Section A. *Pleuroxus verus.*
Section B. *Leptorhynchus.*[1]

Characters of Percantha and Rhypophilus are combined in the species P. procurvus, Birge, so that one must be dropped or new diagnoses formulated. I am not sure that the same species is not at first Pleuroxus verus[2] and only later assumes the form known as Rhypophilus. So with Percantha the amount of serrature of the posterior margin is in part a question of age.

SUB-GENUS ALONA.

This group contains two sections which resemble each other in form and, in general, in detail; but it is exceedingly difficult to formulate a diagnosis that shall strictly limit it. The form is generally sub-quadrangular with rounded corners; the terminal claw is armed with but a single spine at the base; the beak is rather short; and the prevailing marking consists of longitudinal lines.

Section A. *Alona* (*vera*). Baird.

This genus contains a large number of minute animals which are widely distributed.

1 Instead of Harporhynchus, a name preoccupied in zoology.

2 Embryos of P. procurvus have the part which is to be curved forward attenuated before leaving the brood-cavity, however.

The authors who have done the most to elucidate this genus are Schoedler, P. E. Mueller, and Kurz. Birge has contributed most largely, thus far, to the knowledge of American species, which are, for the most part, identical or very close to the European. No other genus is so difficult among the Lynceidæ, for the most minute differences are relied upon to distinguish species. The species of this genus are not greatly altered by the production of the winter eggs. The males are frequently but little smaller than the opposite sex, and are recognized by the altered form of the post-abdomen and the presence of a hook on the first foot. The form is more perfectly rectangular than in the next section; the shell is only exceptionally reticulated and very rarely tuberculate, occasionally smooth. The lower angle of the shell is not armed with spines, but is generally rounded. There is only one basal spine upon the claw of the post-abdomen, which usually bears a row of scales beside the anal spines. The antennæ have eight setæ. The claw of the male post-abdomen is removed from the lower angle.

About twenty species are known, all of which that seemed recognizably defined have been included in the following key, which is believed to be more nearly natural in its arrangement than that of Kurz, which would separate the European and American representatives of the A. parvula group. Many more forms remain to reward the labor of American students. Those mentioned from Minnesota could probably all be found by a few days search in one locality.

Key to Section A, Alona.

A. Shell reticulate.

(a) Reticulations horizontal.

1. *A. guttata*, Sars.

(b) Reticulations oblique.

2. *A. angulata*, Birge.

B. Shell lined, smooth or tuberculate.

(a) Over 0.5 mm. in length.

I. Shell densely striate.

3. *A. sanguinea*, P. E. Mueller.

II. Shell normally, evidently striate.

* Post-abdomen narrowed at the end.

† Armed with elongate teeth below.

4. *A. tenuicaudis*, Sars.

†† Teeth of post-abdomen nearly equal.

5. *A. lineata*. Fischer. (Shell arched.)

6. *A. modesta*, Herrick. (Shell straight above.)

** Post-abdomen not narrowed.

† Antennæ with seven setæ.

(?) 7. *A. costata*, Sars.

†† Antennæ with eight setæ.

8. *A. quadrangularis*, Mueller.

III. Shell faintly, irregularly striped; eye of same size as pigment fleck.

9. *A. oblonga*, P. E. Mueller.

IV. Shell smooth.

10. *A. affinis*, Leydig.

(b) Under 0.5 mm. in length.

I. Post-abdomen armed with a row of hairs terminating in large teeth.

11. *A. dentata*, P. E. Mueller.

II. (One or) two rows of teeth present.

* Shell densely and evenly striate.

12. *A. elegans*, Kurz.

** Shell not densely lined.

† Shell smooth or lined longitudinally.

‡ Teeth of post-abdomen unequal, the lower ones enlarged.

13. *A. porrecta*, Birge.

‡‡ Teeth nearly equal.

§ Form elongated ; abdomen with a lateral line of spiny scales.

14. *A. spinifera*, Schoedler.

§§ Form squarish ; abdomen with a lateral line of simple spines or bristles, or neither.

15. *A. parvula*, Kurz.

16. *A. glacialis*, Birge.

‡‡‡ Clusters of bristles, not spines, on the posterior edge of the post-abdomen.

17. *A. intermedia*, Sars.

†† Shell smooth or tuberculate.

18, 19. *A. tuberculata*, Kurz, Herrick.

Sp. 1. **Alona guttata,** Sars.

A small species of sub-quadrangular form. The beak is very short; the eye small, but larger than the minute pigment fleck. The shell is short, with a rounded posterior angle and marked by hexagonal or rectangular meshes running about parallel with the lower margin. The post-abdomen is of moderate size, rounded at the apex, with a series of stout teeth behind; the terminal claw has a minute basal spine. P. E. Mueller, in Danmark's Cladocera, confused this with A. intermedia, which he described under this. The post-abdomen in that species is larger, less rounded behind, and armed with clusters of spines instead of teeth. The length is about 0.3 mm. in both.

Sp. 2. Alona angulata, Birge.

Dorsal margin considerably arched, terminating in a more or less obvious angle at the hinder corner; the hinder edge is convex, as is also the front margin; the ventral margin bears plumose setæ. Beak pointed, extending nearly to level of ventral margin of the valves. Fornices broad. Shell obviously striated diagonally and less obviously marked by cross lines. Post-abdomen broad, truncate; about twelve anal teeth, with a series of scales and hairs back of them. The pigment fleck is much smaller than the eye. Male smaller; beak shorter; post-abdomen with a lateral row of hairs; anterior feet hooked; sculpture less distinct. [Birge.] Length of female 0.4 mm; male 0.35 mm.

Sp. 3. Alona sanguinea, P. E. Mueller.

(Plate I. Fig. 20.)

Body nearly rectangular; ventral margin nearly straight, with short setæ; posterior angle rounded, unarmed. Beak short; pigment fleck much larger than the eye. Post-abdomen large, the end truncate, broadened; posterior margin rounded, with a series of spines and a lateral row of scales; terminal claw with a small spine. The shell is ornamented with fine, close, longitudinal striations. Length 0.9 mm. Alona elegans is very near to this and should have followed. In August, 1878, I took an Alona marked as in A. sanguinea and agreeing with Mueller's description in all points which can be verified in the drawing. The small size of the eye is remarkable for so large an animal. I have never again seen this species; it seems to be very rare here and in Europe.

Sp. 4. Alona tenuicaudis, Sars.

(Plate I. Fig. 11.)

Alona tenuicaudis, SARS, P. E. MUELLER, KURZ.
Alona camptocercoides, SCHOEDLER.

Form nearly rectangular; ventral margin rounded, with long setæ, posterior angle rounded. Beak short, pigment fleck smaller than the eye. Post-abdomen with sides parallel, long, incised below; lower angle armed with about six strong teeth, remainder of the series small; a lateral line of scales present; claws with a strong basal spine. The shell is striate with longitudinal lines. Length 0.5 mm.

One of the most easily recognized species; not identified in America.

Sp. 5. Alona lineata, Fischer.

Lynceus lineatus, FISCHER, LEYDIG.
Alona lineata. SCHOEDLER, P. E. MUELLER, KURZ.
Alona rectangularis, SARS.

The upper margin is rounded, the lower one somewhat sinuate, with setæ of moderate length. The beak is tolerably long, reaching nearly to the level of the lower margin of the shell; the pigment fleck is less than the eye to which it is much nearer than to the end of the beak. Post-abdomen short, broad and tapering toward the end, truncate, armed with about ten large teeth; caudal claws with a small basal tooth. Shell marked with distinct lines running horizontally. The ephippial females are recognized by a deep color and the greater elevation of the back. Length 0.5 mm., 0.6 mm. The male has a weak hook on the first foot, and the post-abdomen is narrowed toward the end; the terminal claw has no spine.

The Minnesota representative of this widely distributed species differs in some respects. The lower margin is nearly straight and rather sparsely hairy; the beak is blunt, but, on account of the spreading of the extremely wide fornices, does not appear so except under pressure.

The beak reaches nearly to the lower shell margin. The antennules are narrow, one or more of the setæ being elongated. The dorsal margin is either nearly straight or strongly arched behind; in either case the greatest hight of the shell is back of the middle. The pigment fleck is large. The post-abdomen is just as in A. lineata, but the lateral row seems to be of spines rather than fringed scales. The shell is marked by rather evident or indistinct lines. The form agrees pretty well with Schoedler's figure, except that the posterior shell margin is much higher. The antennæ have eight setæ, but the last one is very weak. The terminal setæ seem sometimes to be spined, as figured by Schoedler, but in some specimens they are perfectly smooth. There is a circlet of spines on the second joint of the setose ramus. There is a hair on the inner aspect of the protuberance of the labrum. The eye is somewhat nearer the pigment fleck than is the end of the beak. If it is desirable to apply a new name to a form at least so near the European A. lineata, it may bear the name first given it in my note-book.

? Sp. 6. Alona modesta. (Sp. n.)

(Plate H, Fig. 3; and Plate Q, Fig. 4.)

The length varies between 0.41 mm. and 0.55 mm. The smaller forms have the back most rounded, while a specimen 0.55 mm. long will appear very like A. quadrangularis. Males are elongate; hook of first foot strong, accompanied by a heavy growth of small spines; terminal claw of abdomen with a minute spine.

? Sp. 7. Alona costata, Sars.

Founded practically upon the absence of the eighth seta of the antennæ. The description given by Sars will not render it recognizable so that there is no occasion to repeat it here. In all the species of this section the eighth seta is small and may be absent.

Sp. 8. Alona quadrangularis, Mueller.

(Plate E. Figs. 1—2.)

Alona sulcata, SCHOEDLER.
Alona quadrangularis, P. E. MUELLER, KURZ, HERRICK. The further synonomy of the species may well be doubtful, for there are species so closely allied as to render a strict determination difficult.
Lynceus quadrangularis, O. F. MUELLER, is the name employed, and is thought to be identical with the Alona quadrangularis of Baird.

Shell quadrangular, highest behind; lower margin straight; posterior margin curved; lower angle rounded, striped with rather evident lines which are parallel and straight. The beak is quite long; the pigment fleck is smaller than the eye. The post-abdomen is broadest near the end, where it is strongly rounded; the numerous anal spines are strong and emarginated, supported by a lateral series of scales; the terminal claw and its basal spine (in American forms) are denticulate (Kurz says smooth in European specimens). The feet are of the typical Alona form (see plate E, fig. 1). The shell gland is rather conspicuous; no true ephippium. The abdomen of the male lacks the spines, but is otherwise similar. Length 0.6 mm. to 0.7 mm. Less abundant in Minnesota than the next. Both this and the following species were recognized in 1878, but were thought to be the same species. (See *Microscopic Entomostraca*, p. 109.)

Sp. 9. Alona oblonga, P. E. Mueller.

Alona oblonga, KURZ, BIRGE.
Alona quadrangularis, LILLJEBORG.

Differs from A. quadrangularis in the following points:—the greatest hight of the shell is anterior to the middle; the lines are less evident, and all confined to the lower part of the shell, while the centre of the valves is marked with very minute striæ; the pigment fleck equals the eye; and the post-abdomen is of about the same width throughout and hardly as round below. This and the preceeding species have a well marked keel on the process of the labrum. The size is greater, this being one of the largest and most abundant, as well as one of the most striking species. It, perhaps, should rank as a well marked and permanent variety of the above. Length 0.9—1.0 mm. The abdomen of the male is narrowed at the end and lacks the teeth. Lakes about Minneapolis.

(A small form of A. quadrangularis in lake Calhoun had the eye and pigment fleck equal and the terminal claw smooth.)

Sp. 10. Alona affinis, Leydig.

(Plate F. Fig. 14.)

Lynceus affiinis, LEYDIG.
Alona affinis, SCHOEDLER.

Form sub-quadrangular; hight about once and one-half in length; the dorsal outline forming a regular and low curve from end of head to upper posterior margin; lower outline very slightly sinuate, anterior one not at all: posterior angles rounded; head nearly horizontal; eye of moderate size; pigment fleck considerably smaller; antennules rather large, with unequal sensory hairs at the end, one spine just above the end in front and a bunch of minute hairs near the base behind; antennæ comparatively large, basal joint spiny, outer ramus with three setæ, two of which have thorns at their middle, also a terminal spine; inner branch with two of the terminal setæ thorned and the upper lateral seta reduced. The post-abdomen is very broad and short, expanded below and rounded at the end; the terminal claws are straightish, denticulate, and the spine at the base is also dentate; there is a series of heavy spines on the upper margin of the post-abdomen, accompanied by a series of scales on the side. The shell is unornamented and fringed below with short bristles. Length 0.9 mm., or more. This fine species is recognized by its smooth shell, the horizontal position of the head, and the form of the post-abdomen; it belongs among the largest of the genus. Lakes near Minneapolis, not rare.

Birge quotes A. spinifera from Wisconsin. In all probability that species is the younger stage of the above.

Sp. 11. Alona dentata, P. E. Mueller.

(Plate I. Figs. 12—13.)

Form sub-rectangular, somewhat arched above, obscurely longitudinally striated; lower angle obtuse, margined below with short setæ. Post-abdomen small, slender, armed with a lateral line of scales and two strong teeth at the lower angle; claw with a minute basal spine. The form of the post-abdomen is identical with "Harporhynchus" falcatus, Sars, which this species also resembles in having the pigment fleck larger than the eye, and in general form and the character of the striation. The beak, however, is very short. In size P. E. Mueller says it is among the smallest of the genus.

Sp. 12 Alona elegans, Kurz.

(Plate I. Fig. 14.)

Form rectangular; back slightly elevated, posterior margin high, lower margin straight. Shell covered with minute striations springing from the region of the attachment of the head shield. Head rather large, pigment fleck smaller than the eye. The antennæ have eight setæ and a circlet of spines on the second joint of the inner ramus, and a single thorn on its first joint. The post-abdomen is short and broad, rounded at the end, and is armed with about ten anal teeth and a lateral row of scales. Length 0.4 mm.-0.5 mm.

Sp. 13. Alona porrecta, Birge.

Sub-rectangular ; ventral line nearly straight; valves marked by longitudinal striæ; beak short. Post-abdomen truncate, with about twelve teeth, three or four of which at the end are larger, and a row of hairs above the teeth. Male similar. Length 0.34 mm. Distinguishable from the following small species in the armature of the post-abdomen.

Sp. 14. Alona spinifera, Schoedler.

If not the young of A. affinis, this little species mimics it very closely. The head is less horizontal and more acute than in that species, otherwise almost identical excepting in size which is about one-third. The sensory setæ of the antennules are said to be nearer equal. Found by Birge in Massachusetts and Wisconsin, but not yet encountered in Minnesota.

Sp. 15. Alona parvula, Kurz.

The body is sub-quadrangular, arched above; ventral margin straight, rounded behind. Shell marked by longitudinal, feeble and irregular lines. The post-abdomen is narrower toward the end, with eight or more teeth; the row of scales is absent; at the end it is sharply truncate and incised; the claws have short basal spines. Hardly to be distinguished from the next.

(18) Alona parvula, var. tuberculata, Kurz.

Alona tuberculata, KURZ.
Alona verrucosa, LUTZ.

The species described by Kurz in 1874, and more at length by Lutz under a different name in 1878, appears to be simply a tuberculate variety of the above. Observations upon the American representatives of the two forms indicate a close relationship between them. The shell is covered with rows of tubercles (or depressions?) which vary in number greatly.

Sp. 16. Alona glacialis, Birge.

(Plate G. Figs. 2, 3 and 8.)

I do not know how to distinguish this certainly from A. parvula. It, however, seems to have the lower angle of the post-abdomen less squarely truncate and the incision less obvious. Birge says that the abdomen is rounded. I have found specimens which apparently belong here, with the post-abdomen rather sharply angled and deeply incised; there were about fourteen teeth with a row of hairs in front. The form is hardly to be distinguished from another variety which has a shorter post-abdomen, rounded below, and with only about seven or eight teeth and with a smooth shell. This form passes directly into a tuberculate variety, having the post-abdomen similar but the shell covered with numerous rows of tubercles. Sometimes a transition from a lined shell to a tuberculate shell is seen (as in plate G, fig. 14). Alona tuberculata, Kurz, is said to have a truncate and incised post-abdomen with no lateral row of hairs. Birge thinks these identical; if so, our form referred to A. glacialis is identical with A. parvula. There is also a form found with the above in which no markings are visible and the shell is considerably arched; these were, however, nearly all ephippial females or approaching that period.

(19.) Alona glacialis (?), var. tuberculata, (Var. n.)

(Plate G. Figs. 4—7 and 14),

will, then, be our tuberculated Alona with a lateral row of scales and a series of fine spines along the anus.

Alona glacialis (?), var. lævis, (var. n.)

is the smooth form with higher dorsal margin.

The antennæ of the two last have spines at the end of the rami of the antennæ, a circlet of spines on the outside of the second joint of the setose ramus, and a spine on the basal joint of the other ramus; two of the setæ at the end of the setose ramus have spines at the angles. The males found among the above small forms have the same characters as var. lævis and the abdomen is rounded at the end; the claw is situated in the middle of the lower margin, in front being the opening of the *porus genitalis* and behind a cluster of hairs; the spines are absent, but there is a lateral row of long bristles. A strong hook is found on the first foot. Length 0.3 mm

Sp. 17. Alona intermedia, Sars.

(Plate I. Fig. 15.)

Alona guttata, P. E. MUELLER.

Form sub-rectangular, rounded below; beak short; shell marked by longitudinal lines, which may be broken into indistinct rectangular meshes. Post-abdomen short and wide, rounded at the end, ornamented by clusters of minute spines behind as well as a lateral row of scales. About 0.3 mm. long.

Section B. ALONELLA, Sars.

In this group are included small species with a combination of characters, forming the link between Alona and Pleuroxus. An obvious character is the fact that the shell is usually partly marked by oblique striæ, which run in two directions: first, a set extending forward and upward from the lower posterior angle of the valves; second, a set springing from the anterior and lower angle, running across the others. At the central part where these two series intersect, they each become zigzag; the result is a series of hexagonal markings, which may extend to the middle of the lower margin.

The beak is short and the fornices broad; the shell is more or less rectangular, but somewhat elevated in the middle above.

There are usually but seven setæ on the antennæ, or the eighth is a minute hair; on the ramus having the lateral setæ one of the terminal setæ is frequently reduced. In many cases the whole shell is marked by minute striæ in addition to the proper markings, but this is also found in some species of the true Pleuroxus. Kurz gives, as a character of Alonella, the presence of but a single basal spine to the claw of the post-abdomen; but P. E. Mueller figures two spines on the claws of one of his species (A. exigua), and Schoedler figures eight setæ on the antenna of A. excisa. American specimens of A. excisa and of A. pygmæa both certainly have a very minute eighth seta. There remains, therefore, positively no point which can be relied upon to distinguish these little lynceids from Pleuroxus or Alona. Perhaps, however, these species, as a group, may be recognized by what has already been said. Three species are found in Minnesota.

A. Rostrum long, bent backwards.

1. *A. rostrata*, Koch.

B. Rostrum short.

I. Lower posterior angle toothed.

(a) Shell more or less reticulate.

* Reticulated areas minutely striate.

2. *A. pulchella*, Herrick.

3. *A. excisa*, Fischer.

** Reticulated areas smooth.

† Head depressed.

4. *A. exigua*, Lilljeborg.

†† Head horizontal.

(?) 5. *A. grisea*, Fischer.

(b) Shell marked by lines running diagonally upward and backward.

6. *A. pygmæa*, Sars.

II. Lower posterior angle smooth, shell longitudinally striate.

7. *A. striata*, Schoedler.

Sp. 1. Alonella rostrata, Koch.

Lynceus rostratus, KOCH, LILLJEBORG, SCHOEDLER.
Alonella rostrata, SARS, KURZ,
Alona rostrata, P. E. MUELLER.

Body long, rapidly narrowed behind; dorsal line strongly arched in front toward the depressed head; the lower margin straight, with 0—3 small teeth at the angle. The fornices are broad, but the beak is sharp; the pigment fleck is but little smaller than the eye, to which it is three times nearer than to the beak. The post-abdomen is long, very much as in A. excisa, but longer. Length 0.4—

0.5 mm. Schoedler says the lower margin is concave and the angle unarmed, a condition not inconsistent with specific identity, as can be seen in many other species. The shell seems to be variably marked, but most conspicuous are the diagonal, curved striæ. Schoedler compares the sculpture to P. exiguus; Kurz, however, leaves the impression that only slight reticulation is present in the female.

The male has the post-abdomen narrowed, ornamented with clusters of hairs behind, and the small claws have no basal spine, while the genital opening is in front of the claws.

Sp. 2. Alonella pulchella. (Sp. n.)

(Plate Q. Figs. 1—3.)

A minute form very recently obtained is described under the above name. Although closely allied to A. exigua, this species is more like Graptoleberis than any other member of the genus. It is the smallest of the lynceids, excepting A. pygmæa. The shell is high and rather strongly arched; the posterior margin is short and armed with four teeth below, which point in different directions as in Graptoleberis. The head is short and the antennules long. The pigment fleck is of moderate size, but smaller than the eye. The post-abdomen is short, rounded below, and armed with sharp and small anal teeth, besides which is an inconspicuous row of minute setæ. The claw is very small, and has a single very minute tooth. The shell is marked by reticulations, which below are regular hexagons but above pass into elongated meshes, and finally on the beak and head become longitudinal striations. The areas are lined as in A. excisa. Thus this species combines the form of abdomen of A. exigua with the teeth of Graptoleberis and the markings of A. excisa.

Length hardly 0.27 mm. Motion active. The specimen figured contained a single large ovum. The head may possibly have been somewhat protruded by pressure. Habitat, vicinity of Minneapolis.

Sp. 3. Alonella excisa, Fischer.

(Plate E, Fig. 6; and Plate G, Figs. 10. 11.)

Lynceus excisus, FISCHER.
Pleuroxus excisus, SCHOEDLER.
Alonella excisa, KURZ.
? *Pleuroxus insculptus*, BIRGE.

This species is closely allied to Alonella exigua; yet that species shows appreciable differences, (which can hardly be claimed, perhaps, for Pleuroxus insculptus.) The various authors who have written of this lynceid have all laid emphasis upon the sculpture of the shell, almost to the exclusion of other points in the description. Prof. Birge has found a quite different form, apparently, which has the same peculiar markings; and even the common Alona oblonga has a part of the valves covered by minute striations. Schoedler's figure of this species is unrecognizable; but, as identified by Kurz, the species seems undoubtedly the same that is common in shallow pools in Minnesota, during autumn, and probably also in Massachusetts.

The variations to which this species is subject are considera-able and may account for the marked disagreement in the accounts of our different authors. Schoedler gives his specimens a length of .20-.25 mm., while Kurz says .35 mm. Birge gives .27 for the length of Pleuroxus insculptus, and our specimens varied in the same gathering between .24 mm. and .40 mm. Schoedler figures three teeth at the lower posterior angle; Kurz says "several (4);" Birge describes one or two, and Minnesota specimens show gradual transitions from an inconspicuous angle to three or perhaps four teeth. These teeth are the extensions of some of the strong ridges or crenulations which mark the shell. P. E. Mueller's figures of the shell and abdomen of P. exigua would apply to our species perfectly, save the absence of minute striations; Kurz's statements with reference to the differences bet-tween these two forms seem to agree only in part with those of Schoedler. I must here express my suspicion that the Pleuroxus aculeatus, P. exiguus and P. excisus all belong under this species. I have seen a small form which lacked the fine striations; and there appeared to me to be, at times, a slight indication of a second series of hairs upon the post-abdomen.

The form is oblong, truncate behind, variously arched above, but usually with a rather low, evenly curved dorsal contour; the lower shell margin is either nearly straight or convex in front and con-cave along the posterior third, and is heavily beset with very long pectinate bristles. The head is moderately depressed, with a very broad, blunt and short beak (in some positions this beak seems acute, but it is an optical delusion); the fornices are very broad, covering the antennules completely; seen from above the head is broad and truncate in front; the eye is larger than the large pig-ment fleck, which is nearer it than the end of the beak. The antennæ have eight setæ, the last of which is minute; the five-spined ramus has a strong thorn on the end, and the inner terminal seta is reduced. The post-abdomen is rather broad and truncate or somewhat rounded below; its length is very variable, being short in small individuals; its form is subject to concomitant variations. The seven to eleven anal spines extend in a series of minute bristles above the anus. The lower posterior angle of the shell bears one to four teeth; the marking consists of wavy ridges and striæ, producing, by the crossing of two sets springing from the two lower angles, a reticulation covering more of less of the entire shell. The head-shield and the spaces between these markings are densely striated. Color yellowish, often opaque. Length 0.24.-0.40 mm. At times abundant. Birge alone has seen the males; his description agrees with Kurz's account of the male of A. exigua, save that the former speaks of spines, and the latter of thorns, along the post-abdomen.

Sp. 4. **Alonella exigua,** Lilljeborg.

Lynceus exiguus, LILLJEBORG, LEYDIG, FRIC.
Alonella exigua, SARS, KURZ.
Pleuroxus exiguus, SCHOEDLER, P. E. MUELLER.
? *Lynceus aculeatus*, FISCHER.

Aside from the differences in the male sex as above indicated, this form is said to have a convex lower margin, a rounded post-abdomen, and the pigment fleck nearer the end of the beak than the eye, The absence of the fine striation, finally, is the most marked characteristic. Length 0.30-0.33 mm. Not identified in America.

(?) Sp. 5. **Alonella grisea,** Fischer.

This species is included here on the authority of Kurz. The shell may or may not be toothed at the lower corner, and is partly lined and partly reticulate; but the only character which at all separates this species from the above seems to be the position and form of the head, which is said to be blunt and nearly horizontal, as in Camptocercus rectirostris. Is this a transition to Graptoleberis?

Sp. 6. **Alonella pygmæa,** Sars.

(Plate H. Fig. 7.)

Alona pygmæa, SARS.
Pleuroxus transversus, SCHOEDLER.
Alona transversa, P. E. MUELLER.
Lynceus nanus, FRIC.
Alonella pygmæa, KURZ.

The form is rotund, much like species of Chydorus in the highly arched dorsal outline; the beak is rather short and depressed; the lower outline of the valves is very convex in front, and barely sinuate behind, where it terminates in a minute spine. The shell is marked, as in no other lynceid, by lines running diagonally backward, and only on the lower part reticulated, if at all.

The post-abdomen is short, broad and rounded below; the claw has a single basal spine. Length 0.20 mm.—0.28 mm. This is the smallest member of the Cladocera. In form it so nearly resembles Chydorus that upon first sight the writer took it for a member of that genus. Our one specimen measured 0.25 mm. The shell is marked by plications rather than striæ, which arch over the back.

Sp. 7. **Alonella straiat,** Schoedler.

This species is said to resemble A. exigua in habit and sculpture of shell; the form is quadrangular and not greatly elevated in the middle; the lower margin is nearly straight and fringed with bristles; the posterior angle is rounded and unarmed. The antennules with their setæ extend beyond the beak; the pigment fleck is smaller than the eye and half way to the beak. The post-abdomen is long and narrowed toward the end; there are seven or eight anal spines, and two spines on the terminal claw. Length about 0.5 mm.

Sub-genus Pleuroxus.

Section A. *Pleuroxus* (*verus*), Baird.

This group of lynceids is most obviously defined by the long "beak", formed by the extension of the chitinous covering of the head. (There is rarely a beak in the sense of that word as applied in the case of Scapholeberis or Daphnia, but the antennules are simply attached to low prominences on the under side of a broad shield-like projection of the shell.) This beak-like projection is acute and often long and either curved backward or even bent forward. The fornices, or lateral projection of the head-shield, are narrow. The form varies much, but is almost always very strongly convex above, and the posterior margin is thus only a fraction of the whole hight of the animal. In some American species the body is very much elongate, and these also depart from the characteristic habitus of the genus in having strong longitudinal striæ instead of reticulations. The lower posterior shell angle has teeth which, in a few cases, extend across the entire posterior margin. The post-abdomen is slender, usually truncate and armed behind with a single set of sharp teeth on either side; the terminal claw has usually two spines and may be serrate.

The male has a shorter beak, the post-abdomen is more or less modified, and the first foot has a powerful hook. The winter eggs frequently have a true ephippium; and sometimes this structure is like that of Chydorus, toward which the round forms of this genus seem to lead. There are upwards of a dozen valid species, several of which are American.

Key to Section A, Pleuroxus verus.

§ Beak not curved forward.

A. Shell reticulate.

(a) Post-abdomen very narrow.

1. *P. hastatus*, Sars.
2. *P. stramineus*, Birge.

(b) Post-abdomen not very slender.

* Terminal claws with two spines.

3. *P. trigonellus*, O. F. Mueller. (?)

?. *P. ornatus*, Schœdler.

** Terminal claws with a single spine.

4. *P. acutirostris*, Birge.

B. Shell smooth, except upon the front margin.

5. *P. aduncus*, Jurine.

C. Shell striped.

(a) Shell very long and low.

* With one tooth below.

10. *P. unidens*, Birge.

** Without a tooth; female with a hook upon the first foot.

8. *P. hamatus*, Birge.

*** Without a tooth on the shell or claw on the foot.

9. *P. affinis*, Herrick.

(b) Shell high.

* Lower angle spined.

† Antennæ with eight setæ, anterior margin of valves toothed.

7. *P. denticulatus*, Birge.

†† Antennæ with seven setæ.

6. *P. bairdii*, Schoedler.

** Whole posterior margin of shell spined (Percantha.)

11. *P. truncata*, O. F. Mueller.

§§ Beak procurved (Rhypophilus.)

A. Shell reticulate.

* Faintly and regularly.

13. *P. glaber*, Schoedler.

** Strongly and irregularly.

14. *P. personatus*, Leydig.

B. Shell striped.

* Posterior margin toothed.

12. *P. procurvus*, Birge.

** Only lower angle toothed.

15. *P. uncinatus*, Baird.

Sp. 1. Pleuroxus hastatus, Sars.

(Plate I. Fig. 16.)

Pleuroxus lævis, SARS.
Pleuroxus hastatus, P. E. MUELLER.

Form somewhat oval, dorsal line strongly curved, posterior margin short, with a tooth below; head short, beak very long, straightish; shell obscurely reticulate. Post-abdomen very long, narrow, with small teeth; claw with two basal spines. Color corneous. The sculpture consists of faint reticulations. The ephippium forms a truncation of the upper part of the shell. Length 0.50—0.55 mm. The male has a shorter beak; the first foot has a weak hook, and the spermatozoa are spherical.

? Sp. 2. Pleuroxus stramineus, Birge.

This form is the American representative of the preceeding, if not identical with it. Birge mentions minute striæ in the meshes. P. stramineus is said to be lower than P. hastatus, while its beak is shorter. Undoubted specimens of P. denticulatus exhibit the same differences, an increase in the convexity of the shell accompanying an increase in the length of beak. The form of the abdomen appears nearly identical, if we compare P. E. Mueller's plate IV, fig. 18, with the outline given by Birge at plate II, fig. 11. The color in both is deep, especially during the period when the winter egg is forming. The direction of the reticulations is said to differ, but P. E. Mueller's figure does not furnish positive evidence of this. Length 0.6 mm.

Sp. 3. Pleuroxus trigonellus, O. F. Mueller.

Lynceus trigonellus, O. F. MUELLER, LIEVIN, LILLJEBORG, LEYDIG, FRIC.
Pleuroxus trigonellus, SCHOEDLER, P. E. MUELLER, KURZ.
? *Pleuroxus ornatus*, SCHOEDLER.

Dorsal line strongly arched; the beak rather long, straightish; pigment fleck smaller than the eye. Shell faintly reticulate, the markings consisting of transparent ridges. Post-abdomen widest in the middle, attenuated slightly toward the end, which is truncate; claw large, with one long and one very small basal spine. The anal margin of the post-abdomen has a series of small spines, and the lower shell-margin is hairy. The post-abdomen of the male is somewhat as in Crepidocercus, and densely hairy; the first foot has a moderate hook.

To judge from Kurz's statements, P. ornatus, Schoedler, is not specifically distinct. Not yet identified in America.

Sp. 4. **Pleuroxus acutirostris,** Birge.

This form, with Harporhynchus, imitates in some respects the Alonellæ, from which they differ in having the beak elongated and recurved. Birge's description does not state what the form of the fornices is, but he intimates that the general resemblances are with Pleuroxus. The general shape is as in P. hamatus.

"The post-abdomen is broad, compressed, truncated, with numerous fine caudal teeth. The terminal claws have only one basal spine." "The valves are reticulated as in P. [Alonella] insculptus, although not so plainly." Length 0.35 mm. Southampton, Mass.

Sp. 5. **Pleuroxus adunctus,** Jurine.

Monoculus adunctus, JURINE.
Pleuroxus adunctus, SCHOEDLER, P. E. MUELLER, KURZ.

Very like P. trigonellus, but with the back more strongly arched. The anterior part of the shell is striped. The beak is shorter than in P. trigonellus, but no other permanent differences are discoverable. The temptation to believe this a mere varietal form of P. trigonellus is great. Indeed, four species (the two here noted, P. bairdii and P. denticulatus, Birge,) are very nearly related. The ephippium, where known, is marked by minute punctation and a darker color.

Sp. 6. **Pleuroxus bairdii,** Schoedler.

Pleuroxus trigonellus, BAIRD.
Pleuroxus bairdii, KURZ.

This form, so far as can be gathered from Baird's brief description and figures, differs from the others in having the shell marked by straight parallel lines running diagonally backward and upward, and in lacking one of the terminal bristles on the 5-setose ramus of the antennæ. The first is a possible but unusual structure, while the second might result from an overlooking of the very small seta which fills this place in the other forms. Baird himself did not distinguish it from P. trigonellus.

Sp. 7. **Pleuroxus denticulatus**, Birge.

(Plate G. Figs. 12—13.)

Resembling very closely P. adunctus, which, however, has a broader post-abdomen than the ordinary P. denticulatus. The posterior angle of the shell is armed with from one to four (generally three) teeth. The beak is very long.

The character most emphasized by Birge is a series of teeth along the anterior margin of the valves. The same thing is found in P. procurvus, as I have repeatedly satisfied myself. In certain positions these teeth do not show, or the smaller teeth on the lower margin only appear. P. adunctus, as figured by Schoedler, has similar teeth on the lower margin, and very likely has them anteriorly. The edges of the valves are heavily fringed with pectinate setæ. The male has a shorter beak and the post-abdomen simply rounded without the peculiar modification seen in P. adunctus.

There seem to be two varieties in Minnesota both of which have the characteristic irregular striations of the shell, which radiate from an irregularly marked or unmarked area in the center toward the edges; both have the toothed posterior angle and the serrated posterior angle and the serrated anterior margin. But the common form is much longer, with the dorsal margin less convex and the beak shorter. The robust form has a larger pigment fleck, while the post-abdomen is shorter and more robust, resembling more nearly Schoedler's figures of the abdomen of P. adunctus. There is another variation or abnormality, in which the lower margin is quite concave. The resemblance to P. procurvus is remarkable in some phases.

I have collected this species in Blount springs, Ala., in the St. Croix river, and at various intermediate points, as well as very often in Minnesota.

Sp. 8. **Pleuroxus hamatus**, Birge.

(Plate H. Fig. 1.)

This species is smaller than those of the preceding group and forms a transition to the two next to be described in the greater elongation of the shell, which is, however, higher and more strongly arched. The head and beak are much as in P. denticulatus. The lower margin is concave posterior to the middle and slightly convex at the posterior angle, which is unarmed. The lower margin is hairy. The markings are as in P. denticulatus, but, in addition, there is a set of horizontal striæ all over the shell. The post-abdomen is widest in the middle and almost exactly as in P. denticulatus. The first foot bears a claw such as ordinarily distinguishes the males.

The only specimens which I have seen were from the Tennessee river, near Waterloo, and near Decatur, in Alabama. My notes contain no reference to the minute striations, which could perhaps be hardly seen with the instrument employed. The process of the labrum is long and rather acute, the beak moderate, and the pigment fleck very large. The markings on the anterior of the valves are irregular and are inter-connected by cross lines or anastomoses. Ova two. (The genus Anchistropus has a hook upon the first foot, but is like Chydorus.)

Sp. 9. **Pleuroxus affinis.** (Sp. n.)

(Plate H. Fig. 2.)

A small species with elongated shell and longitudinal striæ, forming a link between the preceding and the next, to which it is closely related. Shell broadest in front, upper contour nearly straight; anterior part of the lower margin evenly arched, posterior margin rather low. Head very short; beak very long, narrow and somewhat incurved; antennules and antennæ very small; eye evidently larger than the pigment fleck. The post-abdomen is as in P. denticulatus, or a little longer proportionately. The markings, so far as observed, consist of diagonal, faint, numerous and parallel lines posteriorly, and others springing from the anterior margin. There is no tooth behind; the teeth on the post-abdomen are small and not numerous. The upper margin of the shell is not sharp but rounded. Thus this pretty and unique form is clearly distinguished from all its allies although unfortunately only this very imperfect description and schematic figure can be given. Found in Weakly pond, Culbert county, near Florence, Alabama, where with an Alona, Chydorus sphæricus and Scapholeberis, it formed the cladoceran fauna of the pool.

Sp. 10. **Pleuroxus unidens,** Birge.

(Plate F. Fig. 15).

An extreme among these elongated species, the length of body falling little short of double the hight. The dorsal line is very flat and slightly but evenly arched; the lower margin is evenly convex or nearly straight, covered by long pectinate bristles. The head is short, and the beak is long and sharp; the antennules are of moderate size, with a lateral seta one-fourth from the end; pigment fleck less than the eye; antennæ rather long, with strong thorns on the terminal joints. The post-abdomen is long, as in P. hastatus, sides nearly parallel; anal teeth sharp, small and numerous; claws pectinate, with two strong basal spines. The shell is strongly striate with longitudinal striæ, which are parallel with the different margins. Birge says that there is a reticulated area. The lower angle is rounded, and anterior to it is a small tooth directed backward. This species is distributed throughout the Mississippi valley. I have notes of it from Swan lake, near Decatur, Alabama. It is often rather abundant about Minneapolis, but is thought by Birge to be absent from the eastern states. Almost all the specimens I have seen are very dark, often brown, so as to appear to the eye like dark specks as they swim about. The length varies from 0.55 mm. to 0.85 mm. About 0.60 mm. is a common size, according to my observation. Birge mentions a rudimentary sixth foot in this species. This organ is found in Eurycercus and other lynceids, according to Schoedler.

Sp. 11. **Pleuroxus truncata,** O. F. Mueller.

Lynceus truncatus, MUELLER, KOCH, ZADDACH, LIEVIN, FISCHER, LILLJEBORG, LEYDIG, FRIC.
Percantha truncata, BAIRD, SCHOEDLER, KURZ.
Pleuroxus truncatus, P. E. MUELLER.
Percantha brevirostris, SCHOEDLER.

This species is widely distributed in Europe, but is replaced in America by the following. The shell is high, the dorsal contour arched; beak rather long and straight; lower margin slightly convex, setose; posterior margin straight, armed with very strong teeth entirely across it; the anterior margin also is dentate, as in the next. The valves are covered with strong striæ, springing from the anterio-central part and radiating toward the free margins. The post-abdomen is of moderate size and in form much as in the next. The ephippium causes a considerably change in form and coloration. In the male the beak is shorter, and the abdomen has finer teeth. The first foot has an extraordinarily large hook. The length is about 0.5 mm. to 0.6 mm. Percantha brevirostris, Schoedler, differs in the length of the beak only.

Sp. 12. **Pleuroxus procurvus**, Birge.

(Plate E. Figs. 3, 4.)

In size and general appearance this most interesting species is similar to the above, and, especially, to P. denticulatus. The general form and even the details of structure agree almost to identify with the latter. The structure of the posterior margin is like Percantha, while the rostrum is bent abruptly upwards as in Rhypophilus. In small individuals the length is greater proportionally. The lower margin is slightly convex or nearly straight, and fringed by bristles which are stronlgy pectinate; the anterior and lower margins are toothed as in Percantha. The shell gland is more as in the Daphnidæ than most lynceids. The number of posterior teeth is variable. The ephippium is as in P. denticulatus. Length 0.40 mm. to 0.50 mm. Not rare, but less common than P. denticulatus. The male post-abdomen is like that of P. denticulatus; the rostrum is as in the female.

Of the species following it may suffice to say that they are corpulent, filth-loving representatives of P. trigonellus, P. adunctus and P. bairdii, respectively, which have turned up their noses at a superficial existence and buried themselves in the mire and debris at the bottom of the pools. It might be fanciful to assume that the curved snout is used for "rooting," but the fact that these "Schmutzpeterchen" lynceids would find a long straight beak in the way is suggestive.

Sp. 13. **Pleuroxus** *(Rypophilus)* **glaber,** Schoedler.

Pleuroxus personatus, P. E. MUELLER.

The shell is high and squarish, the fornices narrow, the beak slightly pro-curved, the lower margin nearly straight, with two or more teeth at the posterior angle. The antennæ have seven setæ only. The male is almost exactly as that of P. trigonellus. Length 0.55 mm. to 0.65 mm.; male 0.5 mm.

Sp. 14. **Pleuroxus** *(Rypophilus)* **personatus,** Leydig.

That this species is really distinct is by no means certain; however, it is stated that the shell is less regularly aud more markedly reticulated, and the markings lack the elevations described under P. trigonollus, which are present in the previous species. It lives in filth and covers itself with it.

Sp. 15. Pleuroxus *(Rypophilus)* uncinatus, Baird.

The shell is ridged with lines running upward and backward, as in P. bairdii; the lower angle of the shell has three teeth, and the beak is more horizontal than in the above. In size and characters this is almost identical with P. bairdii, with which it occurs in England.

This completes the list of swine-like members of the genus; these well deserve to be studied from a morphological stand-point.

Pleroxus nasutus, Gay, is a poorly described form from Chili, resembling, according to Schoedler, P. ornatus = trigonellus.

A species of Percantha (Lynceus armatus, Gay) is found in Chili.

NOTE TO PLEUROXUS.—The two species P. unideus and P. affinis are quite diverse from the type of the genus and approach in some respects to Leptorhynchus. P. affinis, particularly, has a recurved beak. I am in doubt about P. hamatus and P. acutirostris, which is said to be reticulated; but it seems likely that the species above mentioned stand in closest relation to Leptorhynchus.

Section B. *Leptorhynchus*, Herrick.[1]

The species for which Sars formed the genus Harporhynchus is of Alona-like habit, but has a beak which exceeds that of any known Pleuroxus in length, being simulated in this respect by the American P. acutirostris, which is, however, in other respects more nearly allied to Pleuroxus.

Leptorhynchus falcatus, Sars.

Harporhynchus falcatus, SARS.
Alona falcata, SARS, P. E. MUELLER.

Body oblong, arched above; ventral margin nearly straight, setose, with a spine at the posterior angle; beak strongly curved, folded laterally; pigment spot larger than the eye. The post-abdomen is wide, sides nearly parallel, armed with a few strong teeth below and a lateral line of spines; caudal claw with a single small basal spine.

VIII.—GENUS PHRIXURA, P. E. Mueller.

Oblong, wide; posterior shell-margin little less than whole hight. Post-abdomen terete, obtuse at the end, which is armed with a cluster of spines of which the terminal ones are similar to the others.

1 Harporhynchus is preoccupied in ornithology.

Sp. 1. **Phrixura rectirostris,** P. E. Mueller.

(Plate I. Fig. 18.)

Beak acute; shell striated longitudinally, slightly arched above; ventral margin rounded, with a round and unspined angle behind. Length 0.5 mm. Not yet encountered in Minnesota.

IX.—Genus Chydorus, Leach.

This genus, if it be really of generic value, contains minute rotund animals which appear in the water like animate pin-heads of small size. Their motion is a rolling, wavering hobble; and they live by preference upon vegetation, or in slime at the bottom of pools. Occasionally they may be seen in sunshiny weather, disporting themselves near the surface in immense numbers. There are two common species, and six more which are more rare or in part not valid.

The sexual period occurs at two different periods (i. e., May—June, and December), but in probability is not confined to any periods. The males, which only rarely are found even in these periods, have the abdomen narrowed or excavated to accomodate it to the peculiar alteration of the brood-cavity which takes place in the sexually mature female. The connection takes place by the insertion of the abdomen within this chamber, which is facilitated by the reduced size of the abdomen. The modification of the shell of the brood-cavity above referred to consists in the thickening of the wall posteriorly, which may or may not result in the deforming of the shell, as shown in plate F, fig. 7, taken from Kurz. This may be termed an ephippium, although it differs somewhat from the modified shell so called in Daphnia. The male element consists of nearly round nucleated cells, and the opening of the vas deferens is anterior to the terminal claws. The members of this genus are among the most minute forms of the family or the entire group. Concisely put, the characters are as follows:

Form globose, not obviously truncate behind; head terminating in a sharp, long, curved beak, which lies close upon the anterior margins ot the valves; antennæ short; eye larger than the pigment fleck; abdomen flattened, excavated in the male; intestine with nc anterior cæca, doubly convoluted, with an anal cæcum. Three species found in Minnesota.

Sp. 1. Chydorus sphæricus, Mueller.

(Plate F. Figs. 4, 7, 8 and 10.)

Lynceus sphæricus, O. F. MUELLER, M. EDWARDS, KOCH, ZADDACH. LIEVEN, FISCHER LILLJEBORG, LEYDIG, TOTH, ZENKER, FRIC.
Monoculus sphæricus, JURINE.
Chydorus muelleri, LEACH.
Chydorus sphæricus, BAIRD, SCHOEDLER, P. E. MUELLER. LUTZ, KURZ, BIRGE.

Form nearly spherical, as seen from above broadly oval; in young specimens truncate behind; antennules of moderate size, in the male very large, with curved flagellum near the middle of anterior margin; pigment fleck often nearly as large as eye; beak of moderate length, blunt in the male; first foot strongly hooked in the male; post-abdomen short, broad, rounded at the end, armed with 8—9 sharp teeth; shell reticulated with polygonal meshes. Color light, unspotted. Length 0.50 mm.

This species occurs in Spring earlier than most forms, and is ranked as the most abundant of the micro-crustacea, being found over the whole circumpolar land-area. The ephippium for the winter egg was observed by Kurz, but the period at which it is formed seems variable.

C. sphæricus of a previous report seems to have been the following species which is more common in Minnesota in the clearer lakes. A small form in our large lakes measures 0.3 mm.; it may be distinct.

Sp. 2. Chydorus globosus, Baird.

(Plate F. Figs. 1, 2, 3 and 9.)

Chydorus globosus, BAIRD, LILLJEBORG, SCHOEDLER, LEYDIG, P. E. MUELLER, FRIC, KURZ, BIRGE.

Form globose, very broad; antennules very large with a strong lateral seta on a small elevation; swimming antennæ exceedingly small; the shell gland is well developed; the pigment fleck is much smaller than the eye; beak very long and incurved; post-abdomen rather long, more slender than the last, broader near the end which is truncate, bearing about 20 spines on the margin near which is a lateral series of minute bristles; the terminal claws are straightish, spined along the basal half, and have an accessory spine; the shell is very indistinctly reticulated and spotted; color dark; length 0.7-0.8 mm.; male 0.55 mm. The males have the abdomen very narrow for the entire length.

This species is considered rare elsewhere, but is not infrequent in August near Minneapolis.

Sp. 3. Chydorus ovalis, Kurz.

(Plate F. Fig. 11.)

Form oval, nearly twice as long as high; beak long; antennules two-thirds as long as the beak, with two elongated sensory filaments above the others; pigment fleck nearly as large as the eye; antennæ small; shell margins heavily fringed anteriorly; post-abdomen of moderate size, rounded at the end, with about 8 teeth near the end; shell smooth. Length 0.4 mm.

This species is rather near C. sphæricus, differing in having the shell smooth, antennæ shorter, and beak longer. This species is not yet known in America.

Sp. 4. Chydorus cælatus, Schoedler.

(Plate F. Fig. 12.)

Chydorus adunctus, SCHOEDLER.

This small species is about 0.4 mm. long, and resembles the young of C. globosus in form, from which as well as from all known species it is distinguished by the markings of the shell, which consist of series of rounded elevations (or depressions?) arranged parallel to the lower margins of the shell and head. The description is very incomplete, and the only other author who appears to have seen the animal is Kurz, who adds that the sensory filaments of the antennæ are unequal in hight, and that the so called elevations are really depressions. A form with a few depressions about the edge and characters of this species was once seen in the vicinity of Minneapolis.

Sp. 5. Chydorus nitidus, Schoedler.

(Plate F. Figs. 5, 6.)

Shell smooth and regularly punctate; the head resembles C. sphæricus, but the pigment fleck is much smaller than the eye, to which it is much nearer than to the end of the beak; the post-abdomen is broader near the end, and bears a row of 10—12 teeth on either side.

(?) Sp. 6. Chydorus latus, Sars.

Very possibly a variety of C. globosus, from which it differs in the shorter beak and greater size. Length 0.66 mm.

Sp. 7. **Chydorus piger**, Sars.

Sub-rotund, prominent above, sinuate behind; lower and posterior margins rounded, lower margin ciliated. Head movably united to the body; beak long, separated by an indentation from the head shield. The shell is broad, as seen from above. Shell punctate anteriorly and marked below by indistinct oblique striæ. Antennules with seven setæ and two small thorns on the end of each ramus. Post-abdomen truncate; the terminal claws with a minute tooth at the base; posterior margin sinuated, rounded below and there densely armed with minute teeth. Abdominal setæ long and flexible. Pigment fleck of medium size, much nearer to the eye than to the beak. Length about 0.33 mm.

(?) **Chydorus latifrons**, Dana. (U. S. Exploring Expedition, Rep. on Crust., vol. II, p. 1274.)

Very tumid; in side view rotund, head not separate, very short-beaked; beak slender and close to the body, acute; in upper view animal very broad, truncate anteriorly, the front thereby nearly as broad as the body; behind low, triangular and obtuse. Feejee islands.

(?) **Chydorus albicans**, Gay,

from Chili, is imperfectly described; but it is interesting to note the occurrence of this genus there.

x.—Genus Anchistropus, Sars. (?)

Very similar in form to Chydorus; valves gaping below anteriorly; antennules small; process of labrum rounded. Post-abdomen attenuated toward the end, densely covered with fine teeth; terminal claws denticulate. First foot with a powerful claw, protruding beyond the shell. Eye very large. Shell indistinctly reticulate. Sars says of his Anchistropus emarginatus that on cursory inspection it would be taken for the young of Chydorus globosus. He found but few specimens, about 0.35 mm. long. The suggestion is still possible that the young males of some Chydorus are here mistaken for a new genus. The males of Chydorus globosus were not known till 1878, and their early form is still unknown. The young females have a tolerably strong claw, though it is not much curved. I have once found a peculiar lynceid measuring 0.46 mm., with unevenly but distinctly reticulate shell, slender abdomen, and a strong claw which was dentate. There were several young (more than two), and the shell in these was more regularly reticulate. All efforts to find a second specimen failed, and the one seen was somewhat mutilated; hence I am unable to determine its real position.

XI.—Genus Monospilus, Sars.

Head separated by a depression from the body; shell high, compressed, posterior margin somewhat less than the greatest hight of the shell. Post-abdomen broad, ornamented with lateral and posterior spines; claws large, with a single basal tooth. The compound eye is absent, its place being taken by the pigment fleck, which is the functional eye.[1]

Monospilus dispar, Sars.

(Plate I. Fig. 21.)

Lynceus tenuirostris, FISCHER, Abh. ueber einige neue Daph. und Lynceidæ. p. 427; tab. III, figs. 9—10 (*fide Sars*).
Monospilus dispar, SARS, Crust. Cladoc. i Omgn. af Christiania, p. 165.
Monospilus dispar, MUELLER, Danmark's Clad., p. 196.

Shell roundish; ventral margin setose; posterior angle rounded, marked above with numerous impressions. Antennules small; antennæ long, with seven setæ. Post-abdomen short and broad, bearing a series of spines along the excavated posterior margin, and ornamented on the sides with clusters of bristles. The shell in old individuals is not moulted but remains as in Ilyocryptus, covering the greater part of the new shell. The figure shows an old individual with its successive coverings still clinging to it. Like Ilyo-

1 So much interest attaches to this species that we reproduce the Latin description of Sars. "Testa in adultibus valvulis composita pluribus, altera alteri imposita, a latere visa lata, latitudine maxima in parte antica sita; margine superiore antice valde prominente, posteriore et inferiore ciliato rotundatis. Caput mobile, perparvum et valde depressum, supine impressione parva sed distincta, a testa cetera disjunctum, deorsum in rostrum rectum et breve apice obtuso exiens. Animal supra visum sat compressum, latitudine maxima capite majore ante medium sita. Pars superior testæ et capitis impressionibus numerosis rotundatis notata. Antennæ 1-mi paris minutæ structura ut in ceteris Lynceidis; 2-di paris sat longæ, ramo altero setas 4 et aculeum unum apicalem, altero setas 3 et aculeos duos, quorum alter longus articulo primo ejusdem rami adfixus est, gerunte. Postabdomen breve et latum, apicem versus truncatum; margine posteriore supra obtuse angulato, ad angulum inferiorem rotundatum seriebus duabus aculeorum inque lateribus setis vel spinulis brevibus numerosis præditum; ungues terminales ad basin aculeo longo armati. Intestinum, ut in ceteris Lynceidis, in thorace laquem fere duplicem format. Macula nigra unica minima prope basin antennarum 2-di paris; maculæ infra oculari in ceteris Lynceidis simillima, in capite conspicitur, quæ, quum oculus verus compositus in omnibus ceteris Crustaceis Cladodoceris distinctus omnino absit, organum quamquam rudimentare visus habenda est. Animal parum pellucidum, colore fulvescente. Longit. parum supra ⅓ mm."

cryptus, this animal passes its life in filth at the bottom of pools, and rarely emerges to the light of day. What little visual function there may be is vested in the larval organ.

The specimen from which the drawing was made measured 0.45 mm. The first glance at this rarest of all entomostraca affords proof of its unique character. The strongly arched shell is so compressed as to bear little resemblance to Chydorus. The dorsal line passes with little angle into the high posterior margin. There is a rounded angle below, armed with two teeth—the shortened representatives of the fringing spines of the straight lower margin. The head is depressed and very short, but the narrow beak is produced to below the margin of the valves. It is rounded so as to resemble, as seen in front, a duck's bill. The fornices are narrow and flare so that the eye is left partly exposed upon the side. The antennules are not long but slender. The labrum has a very large lamella, which is crenulate in front and acute below, the labrum proper being large. The systematic position of this genus is a matter of considerable interest, for it is the only member of the whole order in which the larval eye is the only one developed, and the first thought would be that this must be a primitive synthetic type, in other words, historically the oldest of Cladocera. Closer study does not warrant the theory. There is much to indicate that, though essentially lynceid, it stands in close connection with the higher members of the family and perhaps has more than a superficial resemblance to such degraded lyncodaphnids as Ilyocryptus. All things considered, however, our diagram stands with this genus as a degraded offshoot of the more typical stem of Lynceidæ.

SUB-ORDER II.—GYMNOMERA.

This group is easily recognized by the almost entire absence of the shell, which forms so conspicuous a part in the greater number of the Cladocera. Here it serves simply to form a pouch or brood-sac for carrying the eggs and embryos. The feet are nearly terete and prehensile, with but slight indications of branchial appendages.

FAMILY POLYPHEMIDÆ.

Feet five pairs. Antennæ with the rami three- or four-jointed.

I.—Genus Polyphemus, De Geer.

Head very large, separated by a depression from the compact body; shell covering but a part of the dorsal region. Feet all with an internal dentate, and an external lamellate appendage. Caudal seta upon a long process of the post-abdomen.

Sp. 1. Polyphemus pediculus, Linn.

(Plate B^1. Figs. 4—6.)

Monoculus pediculus, LINNÆUS, 1746. GMELIN, Linn. Syst. Nat. FABRICIUS, Ent. Syst., etc. SULZER, Insecten. MANUEL, Encyclop. Meth.
Monoculus pediculus ramosus, DE GEER, Mem. pour serv. a l'Hist. des Ins.
Polyphemus oculus, MUELLER, Zool. Dan. Prod. et Entomost. CUVIER, Tab. element LATREILLE, Hist. Nat. Crust., etc. LEACH, Edin. Encyc.
Polyphemus stagnorum, LEACH, Dict. Sc. Nat. LATREILLE, Cuv. Rig. An. DEMAREST, Cons. Gen. Crust.
Polyphemus pediculus, STRAUS, Mem. Mus. d'Hist., etc. M. EDWARDS, Hist. Nat. Crust.
Monoculus polyphemus, JURINE, Hist. Nat. Monoc.
Cephaloculus stagnorum, LAMARCK, Hist. An. Vert. BOSC, Man. d'Hist. Nat. Crust.
Monoculus oculus, GMELIN, Linn. Syst. Nat.
Scalicerus pediculus, KOCH, Deutsch. Crust.
Polyphemus pediculus, BAIRD, Brit. Entom.
Polyphemus oculus, LIEVIN, Branch. d. Danz.
Polyphemus stagnorum, FISCHER, Ueber die in d. Umg. von St. Petersburg, vorkom. Crust.
Polyphemus pediculus, LILLJEBORG, De Crust. ex ord. trib.
Polyphemus oculus, LEYDIG, Naturg. d. Daph.
Polyphemus pediculus, SCHOEDLER, Neue Beitr. zur Naturg. d. Cladoceren.
Polyphemus kochii, " " " "
Polyphemus oculus, " " " "
Polyphemus pediculus, P. E. MUELLER, Danmark's Cladocera. KURZ, Dodekas neuer Cladoceren. WEISMANN, Beitr. zur Naturg. der Daphnoiden. BIRGE, Notes on Cladocera.
Polyphemus occidentalis,[1] HERRICK.

There are two well-marked varieties of this species: one is found commonly in the clear lakes; the other, which I have only once seen, was found in a very shallow weedy marsh. The difference in size is quite remarkable. Our ordinary form measures less than 1 mm. The larger form, including the stylets, is 1.6 mm. The ordinary variety, although highly colored, is yet transparent, while the large variety is deep red and quite opaque. The relationship between the two forms is quite like that maintaining between Diaptomus stagnalis and D. sanguineus. Some slight structural differences are observable between the two varieties, as in the form of the antennules, yet quite insignificant when compared with the striking difference in size and coloration. Number two may be called

1 Polyphemus occidentalis, Dekay = Limulus.

Sp. 2. Polyphemus stagnalis. (Sp. n.)

In order to make the relation clear between these forms, I add measurements of this species, following each with the corresponding measurement of P. pediculus in parenthesis; animals of the same age, as far as possible, being chosen. Head (capsule of eye) 0.3 mm. (0.2 mm.); head and thorax 0.7 mm. (0.45 mm.); abdomen 0.7 mm. (0.56 mm.); caudal stylet 0.36 mm. (0 26 mm.); caudal filaments 0.36 mm. (0.3 mm.). Whole length of antennæ 0.54 mm. (0.42 mm.); first, second and third joints of the 3-jointed ramus 0.08, 0.06 and 0.10 mm., respectively. The formation of the resting eggs or "dauer-ei" seems to go on at the same time with the parthenogenetic reproduction.

II.—Genus Bythotrephes, Leydig.

Much like Polyphemus, but the external appendage of the feet is rudimentary, and the abdomen extends out into a most enormous spine. The single species is that described by Leydig as B. longimanus, which was found in the stomach of Coregonus wartmanni. B. cederstromii, of Schoedler and P. E. Mueller, the latter author now identifies with the above, and concludes that the supposed differences arose from "l'etat de maceration des examplaires examines." *(Les Cladoceres des Grands Lacs de la Suisse*, p. 11.) This species may be looked for in the depths of the Great Lakes. (See plate U, fig. 10.)

III.—Genus Podon.

IV.—Genus Evadne.

These are compact oval forms confined to the sea. See Claus, *Zur Kenntniss des Baues der Polyphemiden*, Vienna, 1877, for the best account of the anatomy.

FAMILY LEPTODORIDÆ.

Feet six pairs. Antennæ with both rami four-jointed. Body elongated, not curved; shell very much reduced.

Leptodora hyalina, Lilljeborg,

(Plate N. Figs. 6, 7),

the only species, is found rarely in the larger lakes of Europe and America.

See *Bau und Lebenserscheinung von Leptodora hyalina*, Weismann, 1874; also, *Om en dimorph Udvikling samt Generationsvexel hos Leptodora*, G. O. Sars, 1873; also, *Bidrag til Cladocerenes Forplantningshistorie*, P. E. Mueller.

The work of Sars is particularly valuable, showing that the young produced from the winter eggs pass through a metamorphosis not experienced by the summer or parthenogenetic brood. P. E. Mueller mentions the pathological condition induced by the plants of the Saprolegnia.

CHAPTER III.

ORDER COPEPODA.

This extensive order contains minute and predominatingly predaceous animals which constitute no inconsiderable part of the fauna of fresh and salt waters. They serve a beneficent purpose both as scavengers and as providing food-supply for the fry of fishes and other aquatic animals.

Copepods are never enclosed in a bivalved shell but ordinarily exhibit a more or less elongated cylindrical form composed of two obvious sub-divisions. There are a few species which, by the great prolongation and expansion of some of the tergites or dorsal shields, seem to simulate shelled crustacea. The anterior part of the body, or cephalothorax, is composed of ten somites which are frequently considerably united or fused. Five of these segments constitute the head and bear respectively the following appendages: first, a pair of several- to many-jointed antennæ which are never primarily sensory in function, although they usually are provided with sense hairs or other like organs; second, a pair of two-branched antennules, which sometimes become almost simple or prehensile; third, a pair of mandibles in the form of masticatory or piercing organs, these being usually provided with a palpus; fourth, a pair of maxillæ of various form and function; fifth, a pair of maxillipeds which not infrequently subdivide in later life to form what appear to be two distinct pairs.

The five thoracic segments have each a pair of swimming feet consisting typically of a two-jointed base and two like, three-jointed rami. The symmetry is frequently broken by the retardation of the development of the inner ramus, while the fifth pair of feet may become rudimentary and in various ways subserve the organs of sex. The five abdominal segments are nearly devoid of appendages and are continued posteriorly by two caudal stylets which bear strong setæ constituting, in many forms, a tail-fin or spring.

All copepods, even such as are, in later life, parasitic, begin their existence as free-swiming nauplii, such as are represented on plate S, fig. 13, and plate K, fig. 8.

Though the vast majority of genera and species are marine, it would seem that fresh-water copepods make up in the number of individuals what they lack in variety.

As we are dealing primarily with the fresh-water species, no lengthy description of the group is here necessary.

The earlier history of our knowledge of the animals of this order is given by Baird. According to this authority, the first to mention any fresh-water species of this group was *Stephan Blankaart*[1] in his *Schou-burg der Rupsen, Wormen, Ma'den, en vliegende Diekens tot Amsterdam. Leeuwenhoek* adds numerous interesting details and is accredited by Hoek with being to first to discover the relation between the remarkably diverse stages which occur in the history of the cyclops. However, it is evident that he had a very incomplete knowledge of the metamophoses.

De Geer gives rather characteristic figures of a cyclops in *Memoires pour servir a l'Histoire des Insectes*, vol. vii, 1778.

Mueller, in his great work on *Entomostraca*, adds new facts, defines species and forms the genus Cyclops.

Ramdohr in 1805 gave sundry additions to the knowledge of these animals in his *Beitraege zur Naturgeschichte einiger Deutschen Monoculus-arten.* In this work the post-embryonic history is quite fully outlined.

Jurine, in his classic work *Histoire des Monocles qui se trouvent aux Envirous de Geneve*, 1820, crystallized what previous authors as well as his own original experiments had brought to light of the anatomy and biology of these animals.

Ferussac (Memoire sur deux novelles espices d'Entomostraces) redescribes known species.

Gunner, *Stroem*, and *Viviana*, seem to have had little effect on the knowledge of the group, though they wrote prior to Jurine.

A recent author attempts to revive the names of Jurine, though hitherto it has been thought hazardous to attempt a specific identification.

The German author, *C. L. Koch*, who only incidentally studied this group, distinguished more or less perfectly, a variety of species which have been reinstated in our literature by Rehberg. Although

1 Latinized *Stephanus Blanchardus*. Hoek recognized Cyclops brevicaudatus or C. bicuspidatus as the one described, chiefly through knowledge of the present inhabitants of the locality.

this proceeding seems quite unjust to the careful authors whose descriptions are recognizable in themselves, the law of priority must probably prevail. Koch's *Deutschlands Krustaceen* appeared in 1838.

Baird's British Entomostraca, without greatly extending our knowledge of this order, put in readable form and made available to English readers what was known, and added interesting facts. He distinguished two families of Copepoda, (1.) Cyclopidæ, (2.) Diaptomidæ. The first included the genera (1.) Cyclops, (2.) Canthocamptus, (3.) Arpacticus, (4.) Alteutha; and the second the general (1.) Diaptomus, (2.) Temora, (3.) Anomlocera.

Fischer, who contributed not a little to our knowledge of the distribution of fresh-water Cladocera, was the next to describe valid species. He described the species found near Moscow and St. Petersburg, Russia.

Ouchakoff is likewise a Russian author, but his writings are quite unknown to me.

The justly famous Swedish naturalist, *W. Lilljeborg*, who has left his mark on so many branches of natural science, has not neglected the microscopic crustacea of his fatherland. *Om de inom Skaane foerekommande Crustaceer af ordningarne Cladocera, Ostracoda och Copepoda* is the somewhat formidable title of his work, published in 1855. He recognized the following genera of Copepoda: Diaptomus, Temora, Dias, Ichtyophorba, Tisbe, Tachidius, Harpacticus, Canthocamptus, and Cyclops. A species each of Diaptomus and Canthocamptus is described, and two species of Cyclops. (It would seem from authors' quotations that other species are described in an appendix, but the copy I have seen lacks this.) The author who has done most for micro-carcinology in general is *Carl Claus*, of Vienna. His principal works are:

1. "Das Genus Cyclops," etc. In *Wiegmann's Archiv fuer Naturgeschichte*. 1857.
2. "Weitere Mittheilungen ueber die einheimischen Cyclopiden." The same, 1857.
3. *Die Freilebenden Copepoden,* 1863.

The later work especially is indispensable to the student of Copepoda, though in reality it is more important in respect to marine Copepoda.

In the meantime a work appeared in Norwegian, with Latin descriptions, from the pen of *G. O. Sars*. This has been largely overlooked. It is, unfortunately, unaccompanied by plates, but the descriptions bear the stamp of the naturalist.

A little later a second brief contribution from this author was published, but I have not seen it.

Sir John Lubbock in 1863 describes species of fresh-water copepods, but the publication seems no longer necessary.

Heller, in Tyrol, *Fric*, in Bohemia, and *Uljanin*, in Asia, have studied the copepod fauna.

A Russian paper by *Poggenpol* and *Uljanin* is quoted as "A Catalogue of the Copepoda, Cladocera and Ostracoda of the vicinity of Moscow," by Rehberg, and as from the *Protokolle der kais.-naturw. anthropol. und ethnogr. Ges. in Moskau*, but by Cragin who publishes a translation apparently of the same paper, in part, as from the "Bulletin of the Friends of Natural History."

Hoek, in the *Tijdschrift der Nederlandsche Dierkundige Vereeniging* (Magazine of the Zoological Society of the Netherlands) 1875, and later in German in the *Niederlaendisches Archiv fuer Zoologie*, gave excellent figures and descriptions of some species which Claus had too hastily treated.

In 1878 *A. Gruber* gave descriptions of "Two fresh-water Calanidæ."

In the same year the first volume of *Brady's* fine "*British Copeoda*" appeared. A purely technical work and briefly written, it is yet very comprehensive and in the main reliable. This is a worthy successor of the Ray Society's earliest publication on entomostraca —Baird's great work.

In the sixth vol. of the *Abhandlungen d. naturwissenschaftlichen Vereine zu Bremen*, Herman Rehberg gives a systematic review of synonomy, and in the revision unites several species in a manner that the present writer had independently been driven to do. It is probably impossible either to substantiate or positively deny some of this writer's identifications of the species of the older authors.

This paper also contains an observation of a hermaphroditic cyclops, which it is interesting to compare with similar anomalies, described by Kurz in Cladocera.

In the vii Band of the same periodical, Rehberg adds to and modifies some of the views expressed above. In the same number is a description of a new species of Temora by *Poppe*. (The same species occurs in the semi-saline waters of the Gulf of Mexico, and had well-nigh gone into print under a new name when this was seen.)

In the above review we have noticed only the more important foreign works on the Copepoda and those including fresh-water forms. *Dana's* magnificent *Crustacea of the Wilkes' Exploring*

Expedition is not included because it is essentially restricted to the marine species, the few descriptions of fresh-water species, being quite valueless. Among important contributors to the exclusively marine Copepoda, are *Boek (Oversigt over Norges Copepoder* and *Nye Slægter og Arter af Saltvands-Copepoder)*, *Brady* and *Robertson*, *Lubbock* and *Claus*.

The history of the American literature can be quickly traced.

Say described imperfectly an American species of Cyclops in 1818. *Haldeman* describes in vol. viii, of the Proc. of Phila. Academy of Science, p. 331, Cyclops setosa (which may be C. serrulatus). *Pickering* very imperfectly described a new genus of copepods from lake Ontario in Dekay's *Zoology of New York*. This genus is, most likely, Epischura of Forbes and, in strictness, ought to rank it. In 1877 appeared "A List of Illinois Crustacea," by *Prof. Forbes*, in which two species of Copepoda were described which may rank as the first descriptions at all adequately framed of American members of the order. In the *annual report of the Minnesota state geologist* for 1878, a brief article by C. L. Herrick outlined, in the light only of the then English literature, the micro-crustacea of Minnesota. No attempt was made to treat the Copepoda, but two species of Diaptomus are indicated which will prove valid. Occasional papers in the *American Naturalist* and elsewhere follow till, in July and August of 1882, Prof. Forbes added two new genera and several species of Copepods, constituting by far the most considerable addition to the subject yet produced.

In the *report of the state geologist of Minn.* for 1881, C. L. Herrick makes a considerable addition to the knowledge of American Cyclopidæ, enumerating ten species, of which six seemed new. This writer also describes a new genus and several new species of Calanidæ, some of which unfortunately are identical with those described by Forbes and published about simultaneously.

Several articles in the *Naturalist* bring the bibliography up to May, 1883, when *F. W. Cragin* published in the *Trans. Kansas Academy of Science*, "A Contribution to the History of the Fresh-water Copepoda." In this paper ten species of Cyclops are described or mentioned. The author ignored previous American literature and thus adds somewhat to synonomy. The plates are lithographic, and are carefully, if not artistically, prepared. A valuable feature is the translation of the descriptions of Poggenpol's species from the Russian.

These papers, together with the outline presented beyond, it is hoped, will form a basis for future work.

Since writing the above, it is brought to my notice that in April, 1881, *V. T. Chambers* gave some account of a species of the Harpacticidæ referred by him to Tachidius. This species is particularly interesting on account of its novel habitat. Tachidius (?) fonticola, Cham., is found in the saline waters of Big Bone Springs, Ky., and thus is very distant from any marine congeners. It is perhaps doubtful if the generic reference can be sustained, but the species is worthy of further study. The Diaptomus described by the same author is hardly recognizable.

FAMILY CALANIDÆ.

This group is pre-eminently marine and contains diverse and graceful forms mostly with very elongated bodies and antennæ. Of the six genera here enumerated as more or less habituated to the use of fresh water, two are found as yet only in America and one is confined to Europe.

Heterocope, namely, is very near Epischura, both being restricted to fresh water. Diaptomus and Osphranticum are likewise only accidentally found in the seas, though their nearest allies are marine. The genus Limnocalanus is as yet found in America only in the Great Lakes.

In the distribution of genera we here follow Brady, whose definition of the family Calanidæ, including Calanidæ and Pontellidæ of authors, we quote: "Body elongated; composed of from ten to twelve [obvious] segments. Abdomen nearly cylindrical, much narrower than the cephalothorax and prolonged at the posterior extremity into two more or less cylindrical caudal branches [stylets]. First segment of thorax often anchylosed with the head; fourth and fifth segments also often coalescent. Head only rarely divided into two segments. Anterior antennæ very long and composed of twenty-four or twenty-five joints; that of the right side in the male often modified for grasping [geniculate]. Posterior antennæ large, composed of a basal joint, from which spring usually two branches, the primary branch consisting of two, the secondary of several joints. Mandibles strongly toothed at the apex, palp (usually) two-branched. Maxillæ strong, and provided with a many-lobed palp. Foot-jaws strongly developed: first pair very broad; the basal joints having on the inner margin wart-like processes, from which spring long ciliated bristles; the distal extremity divided into three short joints which are thickly beset with strong and long, ciliated setæ; second pair longer and more slender, basal portion forming two long oval joints; apical portion usually 4-6-jointed. First four pairs of feet 2-branched, the outer branches always three-jointed. Fifth pair either like the foregoing, or much modified, unlike on the two sides, and in the male forming clasping organs. A heart is present. Eyes either median and stalked or paired (lateral) and sessile; in the latter case being often coalescent and composed of several lenses. Sexual organs in the female symmetrical, in the male asymmetrical. Ovisac single, borne in front of [below] the abdomen.

I.—Genus Heterocope, Sars.

Cephalothorax 7-jointed; abdomen of female three-jointed; caudal stylets short, with three large setæ and other small spines. Antennæ long, slender, 25-jointed; right male antenna geniculate, the six joints preceding the nineteenth swollen slightly, the previous ones coalescent; external ramus of the antennules 7-jointed; labrum tri-lobate; feet of the four anterior pairs with the inner rami one-jointed; fifth feet of female with a single ramus, three-jointed, with a terminal spine. The right foot of the male is cheliform, four-jointed, second joint extending into a long cylindrical process, the terminal joint with two apical claws.

The writer is familiar with but three species—H. appendiculata, *Sars*, H. saliens, *Lilljeborg*, (= H. robusta, *Sars*,) and H. alpina, *Sars*. None of these have as yet been positively identified in America* and their place seems supplied by the following genus.

II.—Genus Epischura, Forbes.

(= Scopiphora, Pickering?)

Undoubtedly the most remarkable of fresh water copepods are the two American species of this genus. It is not yet certain that the second species may not be a young stage of the first but it seems quite improbable.

Related with Heterocope, Sars. The antennæ are 25-jointed, the right of the male being geniculate. The thorax is 6-jointed, the last two segments being partially coalesced. The abdomen is five-jointed in the male and four-jointed in the female, one branched, in the male modified for prehension. Abdomen of male with a

*Heterocope is said by Patten (Cragen) to be common at Watertown, Conn.

prehensile appendage on the left side, often more or less distorted. Inner rami of swimming feet one-jointed. Caudal stylets with three long setæ. The first mention of an animal of this genus seems to be Pickering's description of Scopiphora vagans from deep water in lake Ontario. It seems almost certain that the species so imperfectly described in Dekay's Crustacea of New York, is none other than a species of Epischura, but I hesitate to substitute for a name accompanied by good descriptions and figures, and one which has already been incorporated, to some extent, into our literature, one which is founded on a description so imperfect and general that one incidental character alone enables one to guess its application. The following is Pickering's description:

"Body small, eye single, near the anterior margin of the shield. Antennæ large, and as long as in the preceding genus [Cyclops], and has the same motions in the water. Abdomen terminating in two styles, each with three setæ; last or three last joints. Ovaries none; legs spiny."

What is meant by the "brush" fails to appear, unless the specimens were ornamented with some parasitic plants or animals. The three setæ of the caudal stylets and long antennæ will place this form in no American genus save Epischura. But even this statement of Pickering may be held doubtful.

Sp. 1. **Epischura lacustris,** Forbes.

(Plate Q. Fig. 15.)

"The scond segment of the abdomen of the male is twice as long as the first, and produced to the right as a large, elongate, triangular process, somewhat hooked backwards at the tip. The third segment is similarly produced, but rounded and expanded at the tip, which is roughened before and behind.

From the right side of the fourth segment arises a stout process bearing at its apex a hatchet-shaped plate with seven broad obtuse serratures on its anterior margin. This process is roughened behind, where it is opposed to the concave side of the left ramus of the furca. From the same side of the fifth segment, a short flattened plate, of a spatulate or paddle-like form, extends forward above or beyond the toothed process just mentioned.

The antennæ are 25-jointed, and reach to the second segment of the abdomen. There are especially prominent sensory hairs on the first and third joints, borne at the tips of long spines. The antennules are short, the ramus apparently but three-jointed, the short, median joints common in this appendage being only obscurely indicated. The mandible has but seven teeth, the first simple and acute, separated from the second by an interval about equal to the second and third, the second to the sixth bifid, the seventh entire and acute. The usual plumose bristle is replaced by a sharp, simple spine.

The outer ramus of the fourth pair of legs has two teeth at the outer tip of each of the two basal joints. The terminal joint of this ramus is armed as follows: a short simple spine at middle of outer margin and another at the distal outer angle; a single and long terminal seta, strongly and sharply toothed externally and plumose within, and four long plumose setæ attached to the inner margin.

The left leg of the fifth pair in the male, viewed from behind, has the basal joint very large, broader than long, with the inner inferior angle produced downwards as a long, stout, curved process or arm as long as the two remaining joints. The second joint is trapezoidal, shortest within. The third joint is about half as wide at base as the first, is straight without, with a sharp, small tooth at its distal third, and bifid at tip. On the inner margin this joint is at first dilated a little, and then deeply excavated to the narrow tip, to receive the lower end of the left leg, the lower two-thirds of this margin forming the segment of a circle.

The right leg is two-jointed, the first joint twice as broad, enlarged at the lower end, forming an auriculate expansion at its inner inferior angle. The second joint is conical in outline and about two-thirds as long as the first.

The terminal bristles of the rami are very broad and strong in the female, the outer one especially having an extraordinary size and thickness. There is also at the outer angle of each ramus a short, stout spine, that on the left ramus being inflated like the outer bristle. Length .065 in.

The legs of the fifth pair in the female are three-jointed and similar, the basal joint short and broad, the second two and one-half times as long as wide. The leg terminates by four diverging teeth, preceded by two others, one on each side.

Taken in the towing net abundantly in October, 1881, at Grand Traverse bay; also obtained rarely by Mr. B. W. Thomas, from the city water of Chicago."

Occurring in Minnesota, probably in lake Superior.

Sp. 2. Epischura fluviatilis, Herrick.

(Plate Q. Figs. 14 and 16.)

Similar to the above but smaller (.04 in.) The females are very similar, though the fifth feet are more elongate and differently spined. The abdomen is perfectly straight and the three caudal setæ are of nearly equal size. The claw is armed with eight teeth, all but the first of which are emarginate. The abdomen of the male is straight, but has a strong process on the left side which bears a movable claw laterally and a small second segment which terminates in two small spines. The fifth foot of the male is peculiar; the inner ramus (or the left foot) lamelliform, one-jointed, with two opposable claws; the right branch is simple and 3-jointed, in form like that of the female. Here we have the most marked difference between the two species. Found in Mulberry creek, Cullman county, Alabama. Although a considerable number were examined no oviferous females were found, while the males contained the spermatophores and can hardly be thought immature, and, as it is in the male that the most marked differences appear, the two species seem certainly distinct.

III.—Genus Temora, Baird.

(Plate H. Figs. 8—16.)

This genus contains several marine forms and two which are found also in streams opening into the sea. The species seem to be as follows: *T. velox*, Lilljeborg, *T. longicornis*, Mueller, (=*T. finmarchia*, Baird, =*Diaptomus longicaudatus*, Lubbock), *T. armata*, Claus, *T. inermis*, Boeck, and *T. affinis*, Poppe. T. clausii, Hoeck, is said by Poppe to be certainly identical with T. velox. Hoeck's figures are incomparably better than any of the preceding, but he seems to have been misled by errors in Lilljeborg. The species described by me before the Academy of Sciences of Minnesota (but still unpublished) as T. gracilis, from the brackish waters bordering the gulf of Mexico, agrees very closely with T. affinis, Poppe. (Abhandlungen v. naturw, Vereine z. Bremen, 1880, p. 55.) This name must therefore take precedence. This species has been found in the Rhine and rivers flowing into the gulf of Mexico, as well as in the marine or brackish waters into which these rivers flow. The occurrence of the genus in American fresh waters, justifies its mention here.

IV.—GENUS OSPHRANTICUM, Forbes.

(=Potamoichetor, Herrick.)

First reported as Potamoichetor before the Minnesota Academy of Sciences in 1879, but owing to a disastrous fire, publication was prevented. Priority probably belongs to Forbes' name, since, although first printed in the tenth annual of this survey, the edition was not distributed till after the August issue of the American Naturalist of 1882, containing the description above alluded to. Forbes says this genus has antennæ 23-jointed; all the specimens we have gathered from Minnesota to Alabama had 24-jointed antennæ. The original description of "Potamoichetor" is appended.

"Cephalothorax six-jointed, distal segments evident; abdomen, in the male, five-jointed, in the female four-jointed; antennæ twenty-four-jointed, the right geniculated as in Centropages (= Ichthyophorbia); first pair of feet with the rami both three-jointed, like the following; feet of the fifth pair, in the female, like the preceding, but with a spine of the joint preceding the terminal one enlarged and divaricated somewhat as in Centropages; in the male, the right with a two-jointed outer ramus, the terminal joint of which is spined and bears near its base a blunt expansion of its inner margin; outer ramus of left foot three-jointed, armed with unequal spines; inner branches smaller, similar, three-jointed; the terminal joint bearing curved spines; ovary and testes as in Diaptomus, with which the mouth parts agree in the main; eyes median, confluent."

Our own experience is that the single species of this genus prefers estuaries of running water. Forbes, however, has taken it from swamps and wayside pools.

Sp. 1. Osphranticum labronectum, Forbes.

(Plate Q2. Figs. 1—8 and 13—14.)

Potamoichetor fucosus, HERRICK, Cyclopidæ of Minnesota, etc., p. 224.

"Rather slender, and in size, as well as general appearance, resembling the smaller forms of Diaptomus; antennæ rather stout, reaching but little beyond the feet, appendaged as in Diaptomus, in the male strongly geniculated, but somewhat variously so; the six joints preceding the terminal four are thickened; those preceding the joint or hinge are arcuate on the distal margins; the secondary antennæ are about as in Diaptomus; mandibular palp two-branched, the outer three-jointed, the inner two-jointed; the terminal joint of the shorter branch bearing seven setæ, of the other four, the proximal joint of the former with three stout spines; the maxillæ nearly like Diaptomus; the processes have respectively the following numbers of setæ: the basal plate eight, the small processes at base of posterior branchial appendage one, the appendage itself twelve, terminal portion three groups, first containing nine, the second three, and the third four or five, the upper of the anterior processes two, and the lower three; fifth feet nearly like the others in size; the right in the male having the outer branch but two-jointed by the coalescence of the two outer to form an arcuate and deformed appendage, armed at the end with three stout equal spines; corresponding branch of left foot three-jointed; the terminal joint bearing three unequal spines, each of the preceding joints only one; inner branches similar, three-jointed; terminal joint being short and armed with three short lanceolate setæ and three longer ones, two of which are curved so as to be slightly prehensile; fifth foot of female with both rami three-jointed; inner ramus much smaller; antepenult segment of the outer ramus extending into a large lanceolate process; ova-sac long-ellipsoidal or spherical, reaching nearly to the end of the caudal setæ."

V.—Genus Diaptomus, Westwood.

The most widely distributed and well-known of fresh water Calanidæ, inhabiting in various species the smallest as well as the largest bodies of standing or sluggishly-flowing fresh water. Apparently a recently formed group whose nearest known ally is the curious Pseudo-diaptomus, found in the gulf of Mexico. The animals of this genus are apparently very susceptible to the influences of the environment, and are consequently extremely variable not only in color but in minor structural points. In America there is a curious fact, which is susceptible of different explanations, one of which was given in the American Naturalist at various times during the year past. The species or varieties fall in pairs, one of which is smaller and less highly differentiated, while the other is greatly enlarged and has the peculiarities emphasized. These sets occur in open and shallow water respectively. The large varieties are, as the rule, restricted to such shallow weedy pools as dry up during summer and freeze solid in winter. The forms intermingle slightly, but there are seasonal differences of greater or less extent.

The body is composed of an elongated thorax, with which the head is united, forming a six-jointed cephalothorax. The abdomen is five-jointed, though in the female these joints are so united as to cause the abdomen to appear three-jointed. The antennæ are twenty-five-jointed, and the right male limb is modified by a coalescing of some of the terminal joints, a thickening of others and the development of certain spines, hooks, and knife-like ridges to form a prehensile organ. The first pair of feet has two-jointed inner rami. The remainder have both rami three-jointed, save the last. This fifth foot is differently formed in the sexes, the inner branch of the fifth foot being one or two-jointed. Terminal joint of the outer ramus of this limb in the female very small or apparently absent, second joint produced to form a stout curved claw. The left foot is reduced in the male, serving, in some species, to affix the spermatophore to the body of the female, while the abdomen is held by the right foot. The last segment of the thorax has one or two sharp spines below. The spermatophore, or sperm case, is a long tube with coagulating expansive lining, which forces out its contents on exposure to the water. The colors are frequently brilliant.

Three or four species of this genus are known in Europe, the first being Diaptomus castor which seems universally distributed. It can hardly be doubted that the six forms mentioned below belong among the varieties of this species; yet these forms can be distinguished very well, and are deserving of distinct names. Two other forms are nearest D. gracilis of Sars, but sufficiently distinct. These stand related as do the pairs of the other section, and can not be readily distinguished.

The following is the most convenient arrangement of the genus I have been able to devise.

Key to the Genus Diaptomus.

I. Form robust; right antenna of the male with a hook, much swollen anterior to the geniculating joint.

A. Head not greatly dilated.

* Last segment of thorax prolonged into a sharp-spined angle or tooth.

† With but one tooth (?).

1. *D. castor*, Jurine.

†† With two teeth.

‡ Length under 3 mm.

§ Inner rami of fifth feet in the female 1-jointed.

2. *D. sanguineus*, Forbes.

4. *D. armatus*, Herrick.

§§ Inner rami 2-jointed.

3. *D. minnetonka*, Herrick.

‡‡ Length over 3 mm.

5. *D. stagnalis*, Forbes.

** Last segment of the thorax more or less united with the previous one, bearing very small spines.

6. *D. longicornis*, Herrick.

(a) Length under 2 mm.

var. leptopus, Forbes.

(b) Length over 2 mm.

var. similis, Herrick.

B. Head enlarged.

7. *D. laticeps*, Sars.

II. Form slender, elongate; head divided into two portions; antennæ long, slightly altered in the male.

A. Antenna of male with a hook.

8. *D. gracilis*, Sars.

B. Antenna of male without a hook.

9. *D. pallidus*, Herrick.

(a) Antennæ much longer than the body, inner rami of fifth pair of feet in the male 1-jointed.

var. pallidus, Herrick.

(b) Antennæ little longer than the body, inner ramus of fifth feet bi-articulate.

var. sicilis, Forbes.

Sp. 1. **Diaptomus castor,** Jurine. [Sars.]

"Corporis forma sat robusta. Cephalothorax in femina postice parum antice vero magis attenuatus, angulis laminarum segmenti ultimi obtusis. Segmentum 1-mum abdominale absque mucrone laterali. Rami caudales brevissmi segmento antecedente vix longiores setis crassis et brevibus. Antennæ 1-mi paris mediocris longitudinis reflexæ segmentum 3-tium abdominale vix superantes, animali natante leviter arcuatæ adque latera vergentes; articulus ultimus [?] antennæ dextræ maris in hamulum exiens acuminatum. Ramus antennarum 2-di paris exterior interiore parum modo longior, articulo ultimo quam antecedentibus 5 junctis breviore. Articulus ultimus pedum 5-ti paris in femina perrudimentaris tuberculum solum minimum aculeo uno parvo instructum formans; unguis intus curvatus maximus validusque; appendix interna indistincte bi-articulata longitudinem articuli 3-ti-superans; unguis terminalis pedis dextri maris longissimus leviterque arcuatus. Saccus oviferus parva et multa continet ova colore castaneo. Color animalis variat ex fulvo, cæruleo vel rubro. Longit. fem. interdum fere 3 mm. Habitat in aquis stagnantibus."

The description quoted above from Sars does not agree with Claus' or Brady's account of the same species. From what Brady says of the English Diaptomi one would conclude that the same variations occur there as here. D. westwoodii, which he unites with D. castor, is certainly as different from that species as our D. stagnalis is from D. sanguineus. An actual comparison of specimens will be necessary to clearly define the relation of the American and European species.

Sp. 2. Diaptomus sanguineus, Forbes.

(Plate Q. Fig. 12.)

A species found with us in stagnating pools in early spring, frequently following D. stagnalis and giving place to D. leptopus. It prefers pools less foul than those affected by the latter, though not rarely found with it temporarily. The species is quite variable, and the variations are in directions suggestive of other species. Measurements taken of specimens from a gathering from two pools, one being more stagnant than the other, showed the following results:—males from the less stagnant 1.7 mm.; males from the other pool 2.0 mm.; a difference of 0.3 mm. (Males of D. stagnalis from the latter gathering measured 3.4 mm., while the females of that species vary between 3.8—3.9 mm.) Females measure about 1.8 mm. on an average, of which 1.3 mm. is the length of the thorax. Such individuals have antennæ 1.7 mm. long. The greatest width is anterior to the middle, being about 0.5 mm.

This species differs from D. stagnalis of which, in most respects, is a miniature, by the long antennæ, short abdomen and peculiar armature of the fifth feet.

In the female the fifth foot is about 0.5 mm. long, and the outer ramus has two small spines on the terminal joint, while the segment before the last has a powerful toothed claw. The inner ramus is not evidently two-jointed. The first abdominal segment is spurred on either side. The last thoracic segment extends into a strong angle which bears a heavy spine terminally, and a smaller spine dorsally. On the dorsal median line is a protuberance or "hump" on this segment. In the male the outer ramus of the right foot of fifth pair is long, and terminates in a powerful curved, toothed claw. The inner ramus is small and narrowed toward the end; on the outside of the segment from which it springs is a blunt spine, which is nearly as large as the ramus itself, and has been mistaken for it. The left foot is very fleshy and its inner ramus very rudimentary. The color is brilliant red or purple but variable. Found in the southern states in autumn.

Sp. 3. Diaptomus minnetonka, (Sp. n.)

(Plate Q. Figs. 8—10.)

A small species, smaller than either D. longicornis or D. sanguineus, was gathered in a pool bordering lake Minnetonka, which contained also D. longicornis. It unites the characteristics of both species. The antennæ reach beyond the stylets, the color is dark, the margins of the last segment of the thorax is rather strongly spined, very much as in D. sanguineus. The fifth feet of the female resemble very much those of D. leptopus, but the first segment of the abdomen has a strong spine. The fifth foot of male resembles that of D. sanguineus more than that of leptopus. This species was seen but once, and no measurements can be given save that of the male which was 1.4 mm.

Sp. 4. Diaptomus armatus, Herrick,

Is founded upon an imperfectly known form in which the antennæ do not reach the end of the abdomen; the thickened part of the male antennæ short; the antenna armed as in D. sanguineus; the terminal claw of the fifth foot of the male with a tooth near the base; the claw being nearly as long as the ramus.

Sp. 5. Diaptomus stagnalis, Forbes.

(Plate Q. Figs. 11 and 13.)

D. giganteus, HERRICK.

The largest species of the genus and, not improbably, too close to D. westwoodii, Lubbock. The general characters are like those of D. sanguineus, but the form is much more robust and the antennæ only moderately exceed the thorax. The proportions may be gathered from the measurements given. In the female the length of thorax is 2.5 mm.; abdomen 1.2 mm.; antennæ 2.3 mm.; stylets 0.1 mm. The caudal stylets are as broad as long, or nearly so. The last thoracic segment extends into an irregular process 0.1 mm. long, bearing a spine dorsally. The first abdominal segment is spurred on either side. The fifth feet in the female have two-jointed inner rami. The terminal segment of the outer ramus is more than ordinarily distinct, while the claw is biserrate. The right foot of the fifth pair in the male is very long, its claw being strongly toothed. On the inside of the second joint from the base is a disc-like appendage peculiar to this species. The left foot is short. The longer ramus is three-jointed, but the terminal joint is a mere curved spine, opposing a spine from the penultimate segment, which is covered with minute spines or teeth. The basal joint of the ramus has a bristly protuberance distally. The inner ramus is marked with oblique ridges. The right antenna has a powerful hooked spine on the antepenult segment, the two segments beyond which coalesce in maturity as in the other related species. For measurements see above. Color deep opaque red or purple. Appearing in early spring as soon as the ice is melted from the pools which it inhabits. In the south it occurs in autumn. The name above given seems to have the priority, although this species was figured and described at about the same time in the annual of this survey.

Sp. 6. Diaptomus longicornis, Herrick

This name was applied somewhat loosely, the description given being incomplete, but re-examination of types shows it to belong unquestionably to the form since described as *D. leptopus*. In our state we have found another variety, in general, almost identical with the type specimens, but nearly twice as large. It is now proposed to extend the significance of this name so as to include both varieties, which will undoubtedly be found connected by intermediate forms, thus retaining the name given by Forbes for the variety to which it in particular applies.

(a) var. leptopus, Forbes.

This species is the commonest member of the genus in small lakes and clear pools. It is tolerably constant in coloration, but varies somewhat in size. The original description is insufficient to identify the species definitely, but taken in connection with the figure and the measurement, could hardly be refered to either of the other American forms. This species is characterized by the very compact thorax, the margin of the last segment of which has two very minute spines; and by the form of the fifth feet. The antennæ reach nearly to the end of the caudal setæ, while in the next they fall short of the length of the stylets. The outer spines of the swimming feet are denticulate on the outer margin and setose within. The fifth feet of the female are compact, the inner ramus is more or less obviously two-jointed; the third joint of the outer ramus is almost obsolete and has two short spines; the claw of second joint is strongly denticulate. The male fifth foot has a rather long inner ramus which is very imperfectly two-jointed; the left foot is rather long; the claw of the right foot is armed with crenulate teeth. Length 1.5—1.7 mm., without setæ. The body, which is broadest anterior to the middle, is bluish; the tips of the antennæ are deep purple. The eggs are not as numerous as in the next.

(b) **var. similis**, (Var. n.)

(Plate Q. Figs. 5—7.)

This form is twice as large as D. leptopus, but otherwise scarcely distinguishable. It occurs in autumn (and spring?) in shallow pools, which can but be frozen solid. The following differences are the only points yet noticed. Females of both of the species were placed side by side upon a slide and examined. D. leptopus measured 2.4 mm., exclusive of caudal setæ; the antennæ reached hardly to the base of the stylets; the eggs measured 0.12 mm., while those of D. longicornis measured 0.8 mm.; the egg-sac measured 0.8 mm., while that of longicornis was 0.5 mm. A few other minute differences were noticed, but the general form and color was identical. The peculiar doubling of the edge of the last segment is characteristic of these two forms; each has a small spine on either side of the abdomen. The base of the inner ramus of left foot of fifth pair of the male has a double series of spines.

Sp. 7. **Diaptomus laticeps**, Sars.

"Cephalothorax antice dilatatus, latidudine maxima in parte antica capitis sita, postice sensim attenuatus, segmento ultimo feminæ ad latera parum extante angulis lateralibus acuminatis. Segmentum 1-mum abdominale feminæ antice latum mucrone brevi laterali armatum, postice sensim attenuatum. Rami caudales sat magni segmenta antecentia 2 juncta longitudine æquantes setis brevissimis et robustis instructi. Antennæ 1-mi paris feminæ longitudinem corporis æquantes, animali natante rectæ et quam in D. gracili adhuc magis postice vergentes ; articulus antepenultimus antennæ dextræ maris hamulo armatus. Ramus exterior antennarum 2-di paris interiore multo longior articulo ultimo longitudinem articulorum anticedentium 5 æquante. Pedum 5-ti paris feminæ articulus ultimus parvus, cylindricus, non vero tam rudimentaris quam in D. castore, aculeo uno brevi apicali instructus ; appendix interna ne tertiam quidem longitudinis articuli 3-ti partem æquans et uniarticulata ; pedis dextri maris articulus 3-tius extrorsum aculeo forti armatus, ungue terminali valde flexuoso et subsigmoides ; sinister aculeis duobus rectis terminatus. Saccus oviferus sat multa continet ova. Color pleurumque læte cæruleus, interdum pallidior, albescens. Longit. feminæ circit. 1½ mm."

Sp. 8. **Diaptomus gracilis**, Sars.

"Corpus quam in D. castore gracilius, cephalothorace et antice et postice attenuato, latitudine maxima in medio sita. Anguli laminarum segmenti ultimi thoracalis feminæ in mucrones tenues et acuminatos producti, et mucrone simili sat magno segmentum 1-mum abdominale utrinque armatus est. Rami abdominales breves setis in femina valde divergentibus. Antennæ 1-mi paris feminæ perlongæ et tenues, longitudinem totius animalis longe superantes, animali natanti rectæ et aliquantum postice vergentes ; articulus antepenultimus antennæ dextræ maris hamulo longior, articulo ultimo rami dimidium longitudinem æquante. Pedum 5-ti paris feminæ articulus ultimus distinctus, quadratus aculeis duobus apicalibus quorum interior apicem fere unguis articuli penultimi attingit instructus ; appendix interna articulo 3-tio brevior ; unguis terminalis pedis dextri maris apicem versus valde curvatus. Saccus oviferus semper ova continet paucissima et magna regulariterque distributa. Animal pleurumque pellucidum colore albido, interdum vero facia transversa lata coloris fusci saturati in medio cephalothorace ornatum. Longit. feminæ parum supra 1 mm."

The two forms following are sufficiently distinct from the above and form a closer link with the marine Calanidæ. It is doubtful if any absolute line of demarkation exists between these varieties, although they are here distinguished.

Sp. 9. Diaptomus pallidus, Herrick.

(Plate Q. Fig. 17.)

Length 1.20 mm.; length of antennæ 1.35 mm. Colorless. Head separated by a suture into two parts; form very slender. Antennæ with elongated setæ, which are very plumose. The right male antenna has no hook. The inner rami of the fifth feet are one-jointed in both sexes. Left foot of the fifth pair of the male of peculiar form (see plate Q, fig. 17, for an extreme instance). Entire Mississippi valley.

var. sicilis, Forbes.

(Plate Q. Fig. 18.)

Like the above, but larger. Length 1.45 mm. Length of antennæ 1.5 mm. Inner ramus of male feet of fifth pair two-jointed, those of the female one-jointed. The form of feet varies a little from the above. This species has been but once encountered in Minnesota, the previous species occurring abundantly in our larger lakes.

D. kentuckyensis, Chambers, is referable to one of the above species, probably D. longicornis.

For a full account of synonymy see Rehberg, *Beitrag z. Kenn. d. freileb. Suesswasser Copepoden*, p. 552.

VI.—Genus Limnocalanus, Sars.

Cephalothorax 6-jointed, slender; abdomen in the female 3-jointed, in the male 5-jointed. Antennæ shorter than the body, 25-jointed. Caudal stylets long. Feet of the four anterior pairs with both rami 3-jointed; external ramus of the fifth foot in the female 3-jointed, second joint produced into a spine; inner rami 3-jointed in both sexes and like those of the previous pairs; external rami 2-jointed in the male, the right and left dissimilar.

Sp. 1. Limnocalanus macrurus, Sars.

A species similar to L. macrurus has been found in lake Michigan, and probably occurs also in this state in lake Superior. We can do no better than quote Sars' description.

"Corpus gracile et angustatum. Cephalothorax supra visus elongato ovatus, latitudine maxima in medio sita antice et postice æqualiter attenuatus. Caput annulum unicum præbens, a latere visum parte antica altiore et convexa sinu distincto a posteriore disjuncta, margine antico oblique descendente. Segmentum ultimum thoracis parvum neque ad latera extans in femina et mare simile. Abdomen sub-cylindricum thorace longius. Rami caudales valde elongati et angustati tertium longitudinis abdominis partem superantes, supra et ad latera spinulis vel pilis brevibus obsiti, intus ciliati, setis 5 majoribus uniarticulatis et ciliatis, quarum 2-da ab interiore numerata omnium longissima ceteræque extus graduatim longitundine decrescentes, exteriore ceteris minore absque apice sat remota ; seta adest præterea alia intus adfixa ut in generibus antecedentibus tenuissima et simplex. Frons a latere visa obtuse acuminata appendicibus tentaculiformibus duabus perbrevibus instructa. Antennæ 1-mi paris reflexæ segmentum penultimum abdominis minime attingentes, articulo ultimo setis 5, quarum posteriores 2 longissimæ, instructo, articulis antecedentibus 3 setæ simili postice vergente præditis ; dextra maris articulatione inter articulum 18-mum et 19-mum geniculans. Antennarum 2-di paris ramus exterior interiore et longior et latior, 7-articulatus, articulo 2-do omnium maximo, sequentibus 4 minimis junctis articulo ultimo brevioribus setisque longissimis instructis. Mandibulæ ad extremitatem inferiorem in dentes exeuntes 9, quorum exteriores 2 ceteris majores, interiores 2 tenues et setiferes sunt ; palpus longus et angustatus 3-articulatus, articulis ultimis 2 brevissimis, ramo exteriore, vel appendice branchiale, parvo. Maxillæ 1-mi paris eadem fere structura ac in Diaptomo. Maxillæ 2-di paris validissimæ 8-articulatæ, articulis ultimis 5 in ungues exeuntibus longissimos et fortissimos margiue altero sparsim pilosos, ad apicem falcatum vero nudos vel aculeis persubtile et dense obsitos ; 3-tii paris [Maxillipedes] valde elongatæ et angustatæ antice vergentes articulis 7 setis pleurumque longis præditis compositæ. Pedes omnes biramosi natatorii, ultimo pari in mare bi-articulatus in pede dextro et sinistro dissimilis, articulo ultimo in illo brevi et robusto ad apicem quasi truncato dentibusque 3 parvis et obtusis armato intus vero in aculeum magnum et validum excurrente, in hoc valde elongato extus et ad apicem aculeato intus vero nudo. Oculus unicus propius marginem inferiorem capitis situs. Animal quamquam pellucidissimus et fere omnino hyalinum, facile tamen accumulatione in thorace sat magna liquoris oleosi læte fulvo-rubide colorati se prodit. Longit. circit. 2½ mm."

FAMILY CYCLOPIDÆ.

Contains five genera, viz: *Thorellia*, *Cyclops*, *Oithona*, *Lophophorus* and *Cyclopina*; passing, by the genera *Misophria* and *Pseudo-cyclops,* into the *Calanidæ* or marine copepods. The affinities of these little known genera need further study, as they are very interesting, the question being still open in how far the cyclopoid forms are altered by adaptation to saline habitat, if such an adaptation takes place at all.

Cephalothorax ovate and usually much more robust than the abdomen; anterior antennæ seldom longer than the cephalothorax, those of the male alike on both sides and modified for the purpose of clasping; posterior antennæ unbranched (i. e. palpus wanting);

palps of mandibles and maxillæ usually well-developed; foot-jaws mostly less developed than in *Calanidæ*; first four pairs of feet as in *Calanidæ*, fifth pair rudimentary, alike in both sexes, and usually one- or two-jointed; ovisacs two.

The circulatory system of this family is partly lacunal and has been thought to be entirely so in the genus Cyclops. closer observation, however, shows that there is something like an imperfect central organ at the point occupied by the heart of higher Copepods. This was figured in my previous report, plate V, fig. 1, but no mention was made of the discovery. It has since been verified. The apparatus referred to is a modification of that described under Canthocamptus. In the second thoracic segment there is a set of swaying membranes which constitute a valvular apparatus, chiefly moved by the action of the stomach.

Genus Cyclops.

The sole representative of the genera of the Cyclopidæ here treated is the best known of the Copepoda. Every one is familiar with the "common cyclops," but few realize how many are the species included under this name. An attempt is here made to enable the student to recognize the more obvious distinctions upon which the genus is subdivided and to identify such of the species as seem valid and at the same time recognizable without recondite study of development. Without attempting a complete elucidation of the synonymy, which is practically an impossibility, a proximate classification of all the species known to me is attempted. Thirty sufficiently well marked species are enumerated, and the position of a number more is indicated.

Antennæ 18-jointed.

Sp. 1. Cyclops elongatus, Claus.

This species, cited hitherto, apparently, by but one other author than Claus, is distinguished from the C. pulchellus group by the 18-jointed antennæ, which are hardly longer than the first thoracic segment. The caudal stylets are longer than the two preceeding abdominal segments, and bear rather short setæ. C. elongatus has been found by Cragin near Cambridge. That this species, found thus far by but a single author in Europe, appears in America, may serve as a warning not to decide too hastily from its habitat that a copepod is new.

Antennæ 17-jointed.

I.—FIFTH FOOT 1-JOINTED.

Sp. 2. Cyclops ater, Herrick.

(Plate Q^2. Figs. 9—12.)

This is our most striking species and loves the clearer flowing waters. The thorax is broadly oval and, usually, of a deep color. Antennæ as long as the cephalothorax (1.2 mm.), slender, and tapering toward the end; formula[1] – ⏓ ⏑ – – ⏑ – ⏑ ⏑ ⏑ ⏑ ⏓ ⏓ ⏑ – – –; last three joints rather short, the last joint furnished with an unserrated knife-like ridge as in C. tenuicornis; maxillipedes rather large; fifth foot one-jointed, armed with three subequal spines; abdomen rather short, last segment especially short; stylets of moderate length; setæ rather short, internal seta much longer than the outer, lateral seta near the end of the stylet; eggs pale. Color deep blue or gray. Length 2.1 mm. The young can be recognized without a glass by the band of deep color which crosses the thorax in the middle.

Collected near Minneapolis, in "Mud lake" and Bassett's creek.

This species has been collected in different parts of the Mississippi valley from Alabama to Minnesota, but is nowhere very abundant, being but rather more so southwardly.

II.—FIFTH FOOT 2-JOINTED.

A.—*First joint of fifth foot very broad.*

Sp. 3. Cyclops viridis, Jurine. (Rehberg.)

(var. a.)
C. vulgaris, KOCH, FISCHER, SARS.
C. brevicornis, CLAUS, LUBBOCK, HELLER, FRIC, HOEK.
C. viridis, CRAGIN.
(var. b.)
C. gigas, CLAUS, SARS, FRIC, BRADY.
C. ingens, HERRICK.

The American form is usually somewhat different from the C. gigas, but the stage prior to maturity is like that figured by Brady. Observations made over a considerable territory and for a period of several years led me to the conclusion expressed by Rehberg (Ab-

1 The accent marks are used to signify that joints represented by them (counting from base) are either long –, short ⏑ or medium ⏓.

handl. naturwiss. Vereine zu Bremen. Bd. vii, 1. Heft, p. 62) that C. gigas is but a greatly enlarged form of C. brevicornis. See also American Naturalist, May, 1883, p. 499, where I have expressed a similar opinion regarding the American form.

A part of the original description of C. ingens is here given.

Thorax large; abdomen rather slender; stylets slender, with the lateral seta well towards the end; second and third setæ alone long, weakly pectinate; last joint but one of abdomen sometimes toothed along the distal, under margin; jaws with large teeth; antennæ very short, not reaching to the base of the first cephalothoracic segment; formula – ⏓ ⏑ – ⏓ ⏑ – ⏑ ⏑ ⏑ ⏑ ⏑ ⏑ ⏑ ⏑ ⏓ ⏓; fifth foot two-jointed, the proximal joint very broad with a strong spine; second joint cylindrical with a long seta and a very short spine near the end; operculum vulvæ somewhat heart-shaped; egg-sacs oval-elongated, reaching beyond the end of abdomen; length 4 mm., including stylets and setæ.

Sp. 4. Cyclops leuckartii, Claus.

? *C. crassus*, FISCHER.

Is said to be elongated and slender; the antennæ are nearly as long as the first three segments. The fifth foot is like the smaller forms of the above, but the second joint has only one spine. The proportions of the caudal setæ are very much as in the above.

Rehberg denies that Sars' identification of this species so briefly described by Claus is correct; his description is therefore copied. Sars refers also with a query to C. obsoletus, Koch.

"Cephalothorax ovatus antice sat attenuatus, fronte leviter truncata, segmento ultimo parvo vixque ad latera exstante. Segmentum abdominale 1-mum sub-cylindricum antice quam postice parum latius. Rami caudalis brevisculi longitudinem segmentorum antecedentium duorum non attingentes setis apicalibus sat longis, externa furcæ longitudinem æquante dimidiamque interni, intermediarum interiore altera aliquanto longiore longitudinem abdominis fere æquante ; seta marginis exterioris ab apice sat remota. Antennæ 1-mi paris 17-articulatæ, longæ et apicem versus attenuatæ, reflexæ segmentum 4-tum corporis fere attingentes ; 2-di paris quam in speciebus ceteris longiores. Maxillarum 2-di paris margo posticus subtilissime crenulatus. Pedes 5-ti paris bi-articulati, articulo ultimo bisetoso. Rami pedum natatoriorum omnes 3-articulati ; articulus rami exterioris intus setis 3, extus aculeis 2 instructus. Lamina partes basales pedum 4-ti paris conjugens utrinque in processum acuminatum exit. Rami interioris articulus ultimus insolito modo in longitudinem extensus in pedibus 4-ti paris aculeis apicalibus 2 subæqualibus armatus. Sacci oviferi rotunda to-ovati ab abdomine sat exstantes. Longit. parum supra 1 mm."

Sp. 5. Cyclops lacustris, Sars.

Cephalothorax sub-ovate, truncate in front. Abdomen nearly of equal width; caudal stylets longer than the last two segments of the abdomen terminal; setæ of moderate size, inner three times as long as outer, internal pair nearly equal. Antennæ as long as first two segments. The inner ramus of fourth foot has the exterior thorn very small. The second joint of the fifth foot is small and the external thorn very small. Length 1.5 mm.

Not seen in America.

B.—First joint of fifth foot of moderate size.

(a) Terminal segment of fifth foot with one long seta and a short thorn.

These small species pass into the above group and constitute one of the most difficult groups of the genus. The distinctions offered are very small and specific variation considerable.

Sp. 6. Cyclops strenuus, Fischer.

? *C. pictus*, KOCH.
C. brevicaudatus, CLAUS, LUBBOCK, HELLER, FRIC.
C. strenuus, SARS, BRADY.

Antennæ reaching about to the end of the third segment; caudal stylets slender, three times as long as the last segment; the outer of the caudal setæ shortest. The third seta is over once and one half the length of the stylet.

Sp. 7. Cyclops lucidulus, Koch.

C. lucidulus SARS.
C. furcifer, CLAUS.
C. vernalis, FISCHER.

This species is given on the authority of Rehberg. Claus considered C. furcifer a large variety of the above species.

The antennæ are as long as the first segment; the fifth foot is peculiar in form, with the second joint armed with a spine and a hook; length 1.3 mm.

Neither this nor the previous species is known in America.*

Sp. 8. Cyclops robustus, Sars.

Antennæ shorter than first segment, thick. Body depressed, first segment broad and rounded anteriorly, the others spreading; caudal stylets nearly parallel, long; inner median seta much the

*C. pulchellus, Brady is not C. pulchellus, Koch, and may be the above species.

longer, external setæ very short. Terminal joint of outer rami with three spines externally and four setæ internally. Length 1.3 mm. I know nothing of this species save the description of Sars, a part of which is quoted above.

Sp. 9. Cyclops parcus, Herrick.

(Plate R. Fig. 22.)

Cyclops parcus, HERRICK, Crustacea of Minnesota, p. 229; Plate VI., Figs. 12—15.

In form and general appearance greatly resembling Cyclops thomasi, which it nearly equals in size. The chief differences are found in the length of the caudal stylets and antennæ and in the form of the fifth foot. The antennæ are shorter than, or about as long as, the first thoracic segment. The formula expressing the length of the joints corresponds with that for C. thomasi. The antennules are shortish. The labrum is rather narrow, projecting below into obtuse angles, the middle of the lower face being occupied with nine rather small teeth. The terminal joint of the larger branch of the maxilliped bears four hairs. The second joint has a moderately large dactyl, the movable finger of which is small and sparsely spiny, the immovable finger is ornamented by an oblique series of blunt prominences and a small seta at its base. The first pair of feet has two terminal and two interior setæ and two external spines on the ultimate joint of the outer ramus, while the corresponding joint of the inner ramus bears one inner seta and large spine and three outer setæ. The fourth foot has, in the first case, two outer spines, a terminal spine and seta and three internal setæ, and, in the second, one external seta, two subequal terminal spines and two internal setæ. The fifth foot is two-jointed, bearing on the short basal joint a moderate seta and on the larger second joint a considerable seta and a small oval spine on its side. The caudal stylets are short and the lateral seta is near the end (about 1·5). The outer seta is but three-fourths the length of the inner. The inner of the median setæ is considerably longer than the outer. The shape of the operculum of the female is very characteristic, it being nearly oval. The last two joints of the thorax are acute. The entire length is about 1.5 mm.

Sp. 10. Cyclops brevispinosus. (Sp. n.)

(Plate S. Figs. 7—11.)

The form for which this name is proposed takes the place of the above in the larger lakes. It appears to be but a modified condition of the above species, from which it differs in its slender form and especially in the very slender caudal stylets. The outer caudal seta is reduced to a short ciliate thorn. The fourth foot is also modified by the great enlargement of the spines and the reduction of the setæ. The number of the setæ is the same, but they are differently disposed. The form of the operculum vulvæ is also slightly different.

(?) Sp. 11. Cyclops uniangulatus, Cragin.

Cyclops uniangulatus, CRAGIN. A Contribution to the History of Fresh-water Copepoda, p. 6.

Cragin was not conversant with the description of C. parcus, with which his description agrees save in one point. It differs from C. parcus in having three inner setæ on the terminal joint of the outer ramus of the first foot. It would be officious to suggest a possible oversight here, but C. parcus has only two in type specimens (though in all this group the corresponding ramus of the *second foot* has three setæ), so that at present the two must be kept distinct.

Sp. 12. Cyclops scutifer, Sars.

Not having identified this and the following species it will be best to quote the descriptions.

C. strenuo affinis. Cephalothorax sat elongatus, segmentis ultimis duobus in femina ad latere valde prominentibus inque processos exeuntibus laminares et hyalinos utrinque inter se contiguos, quare thoracis pars posterior tamquam clypeo fornicato quadrangulari obtecta esse videtur. Segmentum 1-mum abdominale ad basin valde dilatatum latitudine quam ad marginem posteriorem duplo majore. Rami caudales segmentes antecedentibus duobus junctis parum longiores, introrsum ciliati, setis apicalibus brevissimis, intermediarum interiore ceteris multo longiore. Antennæ 1-mi paris 17-articulatæ, reflexæ segmentum 2-dum corporis superantes setis plurumque longis obsitæ. Pedum structura eidem in C. strenuo similis. Articulus scilicet ultimus rami exterioris pedum natatoriorum setis 5 instructus in paribus anterioribus duobus 3, in sequentibus duobus 2 modo aculeis marginis exterioriis armatus; aculeorum apicalium rami interiores pedum 4-ti paris exterior brevis et rudimentaris. Pedum 5-ti paris articulus ultimus sat magnus articulo basali parum minor extrorsum sparsim pilosus introrsum aculeo armatus ciliato setaque longa terminali. Sacci oviferi parvi globosi abdomen magna ex parte obtegentes. Longit. circit. 1⅓ mm.

Sp. 13. Cyclops abyssorum, Sars.

C. strenuo et scutifero sat affinis. Cephalothorax ovatus antice obtuse truncatus, segmentis parum ad latera extantibus. Rami caudales longi et tenues satisque divergentes, longitudinem segmentorum antecedentium 3 superantes, setis apicalibus longioribus intermediarum interiore duplam longitudinem furcæ superante, exteriore quam illa parum breviore. Antennæ 1-mi paris 17-articulatæ longæ et fere rectæ distincte postici vergentes, reflexæ segmentum 3-tium corporis fere attingentes. Pedum natatoriorum structura fere eadem ac in speciebus antecedentibus; aculeorum apicalium rami interioris pedum 4-ti paris exterior dimidiam fere interioris attingens longitudine. Pedum 5-ti paris articulus basalis minimus ultimo multo brevior parumque latior. Sacci oviferi mediocres rotundato-ovales abdominique appressi. Longit. circit. 2 mm.

(b) Terminal segment of fifth foot with two rather long setæ.

* External and internal caudal setæ not extremely short.

Sp. 14. Cyclops oithonoides, Sars.

(Plate S. Figs. 2—6.)

? *C. hyalinus*, REHBERG.
? *C. tenuissimus*, HERRICK.

This most interesting species occurs under peculiar circumstances. It is perhaps the rarest member of the genus and seems, beyond a doubt, nocturnal in its habits. It was first found by Sars in saline water and named, on account of its slender form, from the marine Oithona. A similar species which, though about half as large, is hardly distinct, was found by Rehberg near Bremen. Rehberg mentions particularly that it was found oftener at night than during the day. In America a similar species was described from near Paducah, Ky., under the name C. tenuissimus; but the possibility of identity with the Scandinavian species seemed excluded by the habitat. A gathering taken at night from one of the lakes near Minneapolis contained a few specimens of similar characters, and there no longer seems to be a doubt of the identity or very close relation between these forms.

The antennæ are longer than described for C. tenuissimus, nearly equalling the thorax. The last joint of the antennæ is short, but the toothed character was not noted. The fifth feet are small, the spines are very long and slender. The margins of the abdominal segments are irregularly toothed. The species will be confused with no other. It is marked with blue in spots. Length 0. 5—1. mm.

Sp. 15. Cyclops simplex, Poggenpol.

Cyclops Leeuwenhoekii, HOEK (fide Rehberg).

This species is of more compact form than the last, which it resembles in the form of the caudal stylets and the fifth foot. The antennæ are nearly as long as the thorax, the last two joints being elongate and having a knife-like ridge which has at the end teeth like those figured in C. tenuissimus. Length 1.—2. mm.

** The two median setæ much longer than the external.

The species of this section are the most perplexing of the genus. The best that I can now do is to indicate the relations of the nominal species and express the conviction that most are of varietal value simply.

Sp. 16. Cyclops pulchellus, Koch.

C. bicuspidatus, CLAUS.

† Terminal joint of outer ramus of feet with two spines outwardly.

16 a. *C. thomasi*, Forbes.

16 b. *C navus*, Herrick.

†† With three spines.

16 c. *C. bisetosus*, Rehberg.

= *C. bicuspidatus*, Sars.

= (?) *C. insectus*, Forbes.

There are at least three well marked varieties in America, which may probably rank as species and have been ranked as such by Forbes. I give verbatim Forbes' description.

(16a) Cyclops thomasi, Forbes.

(Plate U. Figs. 4, 5, 7 and 8.)

"Elongate, slender, broadest in front and tapering backward, antennæ 17-jointed, reaching the middle of the third segment.

The first abdominal segment in the female is broad in front and slightly emarginate on each side before the anterior angles, and the last segment has a terminal circlet of small spines. The rami of the furca are more than half as long as the abdomen, and each bears two short rows of transverse spinules outside, one at the anterior the other at the posterior third. With the latter a spine occurs about as long as the outer terminal seta. The inner seta at the tip of the ramus is about half the length of the furca, the outer still shorter. The inner median seta is as long as the abdomen and furca, and the outer about half as long.

In the outer ramus of the first pair of legs the terminal joint has one spine and two setæ at the tip, one spine on the outer margin and two setæ within.

In the second, third and fourth pairs the last joint has one spine and one seta at tip, two spines externally and two setæ within. The inner rami of the second and third pairs terminate in one spine and one seta, that of the fourth pair in two spines, the inner of which is only half as long as the other.

The legs of the fifth pair are two-jointed, with the basal joint quadrate, broad, and bearing one long spine. The second joint is narrow and longer, parallel and truncate, with one terminal spine about equal to the preceding, and one about half that length.

From *C. bicuspidatus*, Claus, this species may be distinguished by the armature of the outer ramus of the first pair of legs, and from *C. bisetosus*, Rehberg, by the armature of the outer rami of the other legs.

It shares with *Diaptomus sicilis* the responsibility of affording to the young white-fish their earliest food."

(16 c) **Cyclops insectus,** Forbes.

(Plate U. Fig. 9.)

"Closely allied to the preceding, but more robust in all its parts, and with the second cephalothoracic segment widest. The abdominal segments are all bordered with spinules posteriorly. The two median caudal setæ are much more nearly equal than in *thomasi*, the outer and the inner are very short, but longer than in that species. The inner in our specimens is longer than the outer —the reverse being the case in *bicuspidatus* as described by Claus.

"The legs are armed nearly as in *thomasi*, but the last joint of the outer ramus of the first pair has two spines externally besides the one at the tip, and the terminal spines on the last segment of the inner ramus of the fourth pair of legs are about equal."

Both forms probably occur in Minnesota, though the second has been seen but once, and the identification lacks confirmation. The differences between the two are almost exactly those prevailing between C. bicuspidatus (= pulchellus) and C. bisetosus, Reh., if I correctly understand Sars. Claus' description does not agree with that of Sars. Further study of the European types will be necessary before a satisfactory settlement can be reached.

(16 b) **Cyclops navus,** Herrick.

Cyclops navus, HERRICK, Copepoda of Minnesota, p. 279.

This name, proposed at nearly the same time as C. thomasi, applies to a very closely related form which I can but regard as a variety of that species. It seems constant in its differential characters in given localities, but we are now familiar enough with the fact that changed conditions in the water occasion changes in forms in the copepods.

This form inhabits shallow pools. It is larger than C. thomasi, has much shorter stylets and differently proportioned antennæ, etc. Length 1.5 mm. Thorax 0.9 mm.; abdomen 0.6 mm.; stylets 0.14 mm.; last two abdominal segments 0.16 mm.; antennæ 0.7 mm.; first segment of body 0.5 mm. The basal segment of the antennæ is long and ornamented with several transverse series of spines, the last two segments are equal and longer than the preceding. The armature of the first and fourth feet is identical with C. thomasi, as is the form of the female openings and the fifth feet. The form of the first feet, caudal stylets and other details were correctly figured on plate V of the Cyclopidæ of Minnesota.

Specimens of Cyclops pulchellus (thomasi) were obtained from a cistern which is supplied solely by rain-water. The eggs must have been introduced in ice which had been placed in the cistern at least a year previously. The cistern is entirely dark, so that these animals must have been deprived of light for many generations. The general color was of course very white; the eye spots were pale, but present with some pigment and the lenses. No noticeable alteration in form had resulted.

(c) Terminal segment of fifth foot with three setæ.

Sp. 17. Cyclops tenuicornis, Claus.

(Plate R. Fig. 16.)

var. a. Knife-like ridge upon the antennæ smooth.
C. albidus, JURINE,
C. quadricornis, *var. b*, BAIRD.
C. tenuicornis, SARS, LUBBOCK, HELLER, FRIC, ULJANIN, HOEK, BRADY, HERRICK.
C. clausii, POGGENPOL.
C. annulicornis, SARS.
var. b. Knife-like ridge of antennæ toothed.
C. obesicornis, TEMPLETON.
C. signatus, KOCH, SARS, ULJANIN, BRADY.
C. coronatus, CLAUS, LUBBOCK, HELLER, FRIC, HOEK
C. signatus, *var. fasciacornis*, CRAGIN.

Cyclops tenuicornis, as thus comprehended, is widely distributed and variable. European specimens in our collection have longer stylets, but seem otherwise identical. The nearest relation is *C. ater*, which is easily distinguished by the compact oval form of the thorax and the one-jointed fifth foot. In the stage previous to maturity the "signatus" form has no teeth upon the ridge of the last segment of the antennæ; it is then similar to the C. tenuicornis.

Cephalothorax broad; abdomen rather slender; antennæ reaching about to base of thorax, attenuated at the end; terminal joint with a knife-like ridge; formula –⏑⏑–⏓⏑–⏑⏑⏑⏑⏑⏑⏑–––; fifth foot composed of a long basal joint bearing a long spine and a terminal three-spined division; caudal stylets twice as long as last abdominal segment; setæ all nearly terminal, inner one long. Length 2.5 mm.

Common in America, England, continental Europe, etc. C. clausii, Poggenpol, is known to me only from the citations of Rehberg and the translation given by Cragin, hence I can not judge authoritatively of its validity. Certain points in the translation are obviously erroneous, as where the larger branch of the fifth foot is spoken of. No distinctions sufficiently clear to enable us to separate it from C. tenuicornis can be gathered.

III.—Fifth Foot 3-jointed.

(See Cyclops modestus.)

Antennæ 16-jointed.

There are a few forms which, although they might more properly be ranked with the previous section, seem rarely or never to acquire more than sixteen joints.

Sp. 18. Cyclops languidus, Sars.

Thorax attenuated posteriorly, caudal stylets exceeding in length the two preceding segments, internal seta short, half as long as the outer, the inner of the median setæ as long as the abdomen. Both rami of the first foot and the inner of the second are two-jointed. Second joint of the fifth feet sub-linear, armed with a seta and a spine. The fact that some of the feet have two-jointed rami suggests a young stage of some other forms.

This species has not been seen in America.

Sp. 19. Cyclops modestus, Herrick.

(Plate R. Figs. 1—5.)

American Naturalist, 1883, p. 500 (May).

This small species, 1.0 mm. long, was first recognized in Cullman county, Alabama, but occurs also in our lakes. The color varies, but very characteristic is the peculiar shining or glaucous surface of the strongly arched thoracic shield and the evenly curved segments of the abdomen. The antennæ reach but little beyond the very long first segment; they are usually 16-jointed, but I have notes of a similar form in which the antennæ are 17-jointed. The feet are all 3-jointed and are peculiar in their armature. The fifth foot is obscurely 3-jointed, the second joint bearing a short spine and the terminal joint two spines of varying length. The stylets are once and a half as long as the last segment and are peculiarly excavated for more than the lower third, from the point where the lateral spine is situated. The outer terminal seta is short, the others being sub-equal and also short. The opening of the spermatheca is elongated, oval. The antenna of the male is divisible into five regions, the third being formed by the thickening and coalescing of four or more segments.

Antennæ 14-jointed.

Sp. 20. Cyclops insignis, Claus.

The two forms here belonging might be considered atavic varieties of Cyclops pulchellus. Brady's figures and description of his *C. insignis* (= C. lubbockii) agree almost exactly with what Rehberg says of Cyclops helgolandicus (Abh. v. naturw. Vereine zu Bremen, vii. 1. pp. 62—64). Rehberg regards that species as an atavic sub-species or variety of C. pulchellus. With C. insignis, Claus, the case seems to be different. The occurrence of this species is not conditioned by marine influence. I found it abundant about Leipzig, Saxony. The differences between it and the C. insignis of Brady are, as the latter says, very slight. Figs. 11—14 of plate T are drawn from Leipzig specimens, from osmic acid preparations. The first foot, outer ramus, has three external spines on the distal segment, two setæ at the end, and three within; the inner ramus has one internal seta, a spine and a seta terminally, and three external setæ on the distal segment. The outer terminal segment of the fourth foot is like the first; the inner one has only two external setæ. The external setæ of the caudal stylets exceed half the length of the stylet and are pectinate. The fifth foot has a short basal joint armed with a single seta, the second joint being slender and armed with two unequal setæ. The gathering above mentioned, taken near Leipzig, Dec., 1881, contained scarcely a female among scores of males in various stages of development. This is so contrary to what is expected that, notwithstanding the apparently good characters on which the species is founded, an uncertainly exists in the mind of the writer as to the permanent adult characters of this species.

Antennæ 12-jointed.

I.—Fifth Foot 2-jointed.

A.—*Terminal segment of fifth foot with a seta and a small spine.*

Sp. 21. Cyclops capillatus, Sars.

"Cephalothorax sub-ovate; anteriorly uniformly rounded; segments projecting somewhat laterally, the last being scarcely wider than the first abdominal segment. Abdomen attenuated posteriorly; caudal rami almost as long as the last three abdominal segments, hardly divergent, the external and internal apical setæ short and nearly equal; the interior of the median setæ as long as the abdomen; lateral seta about in the middle of the stylet. Antennæ of the first pair robust, slightly exceeding the first segment of the body when reflexed, with the twelve joints densely covered with long and divergent hairs. The last joint of the outer rami of swimming feet are elongated and armed externally with three spines, internally with four setæ; the interior apical spine of the interior rami of the fourth pair of feet longer than the exterior. Feet of the fifth pair large, with a large and thick basal segment and a small oval second joint bearing one long seta and a short spine. Ova-sacs small, narrow and divergent. Eye very small. Length nearly 2 mm."

Very close to C. viridis in many points. Found only in Scandinavia.

Sp. 22. Cyclops crassicaudis, Sars.

Cephalothorax elongate-ovate; segments produced laterally, especially the last, which extends into a somewhat procurved process. Abdomen short and thick, first segment somewhat excavated; caudal rami equalling the last two segments of the abdomen. External apical seta longer than the internal, both short; median setæ long. Antennæ of the first pair 12-jointed, scarcely longer than the first segment. Swimming feet short and thick, spines and setæ short; the interior apical spine of the last joint of the inner ramus of the fourth foot almost twice as long as the exterior spine. Terminal joint of the fifth foot small, armed with a spine and a seta; seta of the basal segment short. Ova-sacs oval, somewhat divergent. Length 0.75 mm.

Found only in Scandinavia.

II.—Fifth Foot 1-jointed.

Sp. 23. **Cyclops varicans,** Sars.

"Cephalothorax ovate, attenuated about equally in front and behind, with the last segment wider than the abdominal segments, produced laterally and bearing a long seta. Abdomen elongate; caudal rami scarcely as long as last two segments; the internal apical seta twice as long as the outer; median pair elongated, the internal one as long as the abdomen. Antennæ 12-jointed, robust, shorter than the first thoracic segment. * * Both rami of swimming feet two-jointed. * * Feet of fifth pair rudimentary, with a single linear segment bearing a long spine. Ova-sacs long, divergent. Length 1 mm."

Very possibly the young of some species not now identifiable. Only mentioned by Sars. (Compare C. diaphanus below.)

Sp. 24. **Cyclops serrulatus,** Fischer.

(Plate O. Figs. 17—19.)

? *Cyclops agilis*, KOCH (fide Rehberg).
Cyclops serrulatus, LILLJEBORG, CLAUS, SARS, LUBBOCK, HELLER, FRIC, HOEK, BRADY.
Cyclops longicornis, VERNET.
Cyclops pectinifer, CRAGIN.

Although Rehberg positively asserts that Koch's name applies to the present species, none of the numerous authors who have mentioned this most widely distributed form have employed any other than the familiar designation, and the practical advantage to be derived from its use seems to outweigh a quibble of doubtful synonymy.

Cephalothorax oval, compact; abdomen slender and short, suddenly enlarged previous to its union with the thorax; antennæ slender, reaching nearly, but not quite to the last thoracic segment; the last three joints are attenuated and furnish the most evident character of the species; formula – ⏓ ⏑ – ⏑ ⏑ ⏓ – ⏑ – – –; during life the antennæ tend to assume the form of a rude Z, the proximal four joints forming the base; antennules small, reaching about to the sixth joint of antennæ; jaws small with large teeth; the single segment of the fifth foot with three equal spines; egg-sacs oval, as long as the abdomen; eggs few, dark; caudal stylets very long and slender, spined along the outer margin; lateral setæ small and approximated to the upper one; outer terminal seta short, spine-like, in life set nearly at right angles to the others, spined or beaded on one margin and bristled on the other; the next seta is as long as the abdomen, being somewhat exceeded by the following one; inner seta as long as the outer, but feeble; upper seta nearly as long, approximated; length less than 1 mm.

A well marked variety of the above occurs in America, which might rank as a species, were it not probable that it is simply a post-imago form occurring only under favoring circumstances. This variety has no connection with Brady's var. montanus.

Cyclops serrulatus, var. elegans. (Var. n.)

Distinguished from the type by the greater size, and the elongation of antennæ and caudal stylets. We will first of all give the measurements which afford a criterion for judging of the form and proportions.

Total length 1.34 mm.; thorax 0.76 mm.; abdomen 0.40 mm.; stylets 0.18 mm.; greatest width 0.42 mm.; inner median caudal seta 0.60 mm.; outer median seta 0.36 mm.; inner seta 0.08 mm. The first segment of the thorax is long proportionally (0.40 mm.) The antennæ are very long, reaching to the base of the third segment (.68 mm.). The egg-sacs are elongate-oval, being more slender even than in typical C. serrulatus; in the animal measured they were 0.50 mm. long, by 0.19 mm. wide. The caudal stylets are slightly shorter than the last two segments of the abdomen. The antennules are very short, and each joint has its series of fine teeth. The free lower margins of the thorax are ornamented with series of prominences, while the last segment is extended into a blunt angle bearing long teeth. The last segment of the abdomen is spiny-margined and is ornamented with a double row of spines at the anus. The armature of the stylets as well as that of the feet is identical with that in typical C. serrulatus. The last two joints of the antennæ measure 0.1 mm. each, while the two previous measure unitedly 0.12 mm. The color is not opaque as in the smaller form usually. Brady's var. montanus has shorter stylets than the type, but seems nearest the small dark form found in peaty waters in America. Cyclops pectinifer, Cragin, has no distinctive points, it being typical C. serrulatus.

Sp. 25. Cyclops macrurus, Sars.

Cyclops macrurus, BRADY.

Closely allied with C. serrulatus. Cephalothorax ovate, rounded anteriorly; last segment fringed at the angles with numerous fine hairs. Antennæ much shorter than in C. serrulatus, about as long as the first thoracic segment, otherwise similar. Abdomen attenuated, penultimate segment margined posteriorly with spine-like setæ, the other segments pectinated. Caudal stylets very long and slender, about equal in length to the three segments preceding, bearing a group of four to five spines on the outside near the end, otherwise unarmed. Length 1.3 mm.

Here is the natural place for C. spinulosus, of Claus, but there is strong reason to suspect the validity of the species so very imperfectly characterized.

Sp. 26. **Cyclops fluviatilis**, Herrick.

(Plate Q[5]. Figs. 1—9.)

Cyclops magnoctavus, CRAGIN.

This small species with twelve-jointed antennæ and conspicuous coloration is widely distributed through the Mississippi valley. The original description is appended.

"Body elongated; thorax very long; abdomen slender; stylets about as long or longer than last abdominal segment; setæ all very short, not [always] pectinate; lateral and dorsal setæ very small; outer one spine-like, short and stout; two median setæ short; inner one very small and inconspicuous; antennæ reaching nearly to the base of abdomen [or beyond]; formula –⏓⏑–⏓–––––––; the three joints following the six basal are much elongated, while the terminal ones are but moderately so, a character which is peculiar to this species; terminal segment slightly but evidently hinged and, together with pair preceding, somewhat curved; feet with the terminal spines strongly toothed; fifth foot very small, one-jointed, bearing three small setæ; operculum vulvæ heart-shaped; egg-sacs sub-quadrangular; eggs large; abdomen in the young much elongated. Color deep indigo. Length 0.7 mm."

The first foot has upon the last joint of outer ramus three external spines, two apical setæ and three internal setæ; the outer branch of fourth foot has three external spines, apically a spine and seta and internally four setæ.

Males of this species are slender, measuring about 0.75 mm.; the abdomen being 0.28 mm., stylets 0.6 mm., first thoracic segment 0.28 mm., and the longest caudal seta 0.24 mm. The antennæ are long and much modified so as to resemble superficially the antennæ of Diaptomus.

Antennæ 11-jointed.

Sp. 27. Cyclops diaphanus, Fischer.

(Plate R. Fig. 12.)

? *Cyclops bicolor*, SARS.
? *Cyclops minutus*, CLAUS, HELLER.

If not the young of other species, this is a widely distributed form, being known from Russia, Norway, continental Europe, Madeira, and America. The synonyms above given are upon the authority of Rehberg.

The following description applies to our American form found always in connection with C. thomasi, C. parcus, or C. navus.

Very small, measuring 0.81 mm., setæ not included. The thorax is 0.5 mm., the abdomen .31 mm., the stylets .06 mm., the longest caudal seta 0.4 mm., outer median seta .36 mm., the first thoracic segment 0.3 mm., and the egg-sacs sometimes 0.4 mm. The thorax is oval, the first segment being quite large, as in larval cyclops. The antennæ rarely reach the end of the first segment and are either 11-jointed or obscurely 12-jointed; their formula is —⏑—⏒⏑⏒———⏑⏒⏒. The first joint is very large.

The second antennæ are of rather small size; the maxillipeds are armed as in C. navus. The feet have usually but 2-jointed rami, but in large individuals some of the rami are obscurely 3-jointed. The first foot has the terminal joint of the outer ramus armed with three exterior spines, two terminal setæ and three interior setæ; the inner branch has one internal spine, a terminal spine and seta and three external setæ. The fourth foot has the terminal joint of the outer ramus with two external spines, a terminal spine and seta and four internal setæ; the inner ramus has one internal spine, two unequal spines and three internal setæ. There is also a series of teeth at the place where the middle joint should appear. The fifth foot consists of a broad, basal segment nearly fused with the abdomen and bearing laterally a long spine; the terminal segment is terete and small, having a single terminal spine. The caudal stylets are but little longer than the last abdominal segment, which bears teeth below; the sides are parallel, and the lateral seta is $\frac{2}{3}$ from base. The median setæ are long and toward the end show false jointing. The inner seta is longer than the outer which is, however, heavier. Eggs eight to twenty, in narrow elongate sacs. Not uncommon, everywhere.

Sp. 28. Cyclops phaleratus, Koch.

(Plate R. Figs. 6—10.)

(var. a.)
C. canthocarpoides, FISCHER, CLAUS, LUBBOCK, FRIC.
C. phaleratus, KOCH, SARS, ULJANIN, BRADY, REHBERG.
(var. b.)
C. affinis, SARS.
C. pygmæus, REHBERG.
C. adolescens, HERRICK.(=*C. perarmatus*, CRAGIN.)
?*C. lascivus*, POGGENPOL.

That the two varieties here united are very closely allied must be admitted; that they are merely age forms is possible. Claus in figure 2 of his plate II (Freilebenden Copepoden) figures some other species than the one described as C. canthocarpoides, as can be gathered from the elongated stylets and the eight-jointed antennæ. Our Minnesota specimens combine the eleven-jointed antennæ of C. affinis with the short stylets and peculiar form of the fifth feet of the first mentioned. Rarely one is found with ten-jointed antennæ and at the same time sexually mature. The characteristic oblique lines of spines at the base of the stylets may be absent. Rehberg's figures of C. pygmæus agree very well with our species, but he has decided that it is not specifically distinct from C. affinis.

It appears to me undesirable to institute a new species for the American form, neither is it possible to sufficiently identify it with any of the above.

I here append a brief description of *Cyclops adolescens*, Herrick (=C. perarmatus, Cragin,) for comparison with the description of C. affinis as transcribed below. Thorax oval, broad, acute anteriorly; last segment large and separated by a constriction from the anterior ones. The head is beaked below; first throacic segment large and long (.36 mm.): last thoracic segment wide, united closely with the first abdominal segment, armed with series of teeth. Abdomen short, especially the last segment, which is toothed behind; stylets very short. The antennæ are much shorter than the first segment, eleven-jointed. The maxillipeds are very small. All the feet are armed with a row of very large teeth or lanceolate spines down one side; fifth foot one-jointed, with three spines, the outer being smooth, the others spiny; egg-sacs variable, narrow, appressed; eggs large, color usually dark. The animal moves like Canthocamptus, and is able to progress out of water better than other species. The following measurements will give an idea of the proportions: Length 1.26 mm.; thorax, 0.76

mm.; abdomen, 0.44 mm.; stylets, .06 mm.; longest seta, 0.34 mm.; antennæ, 0.28 mm.; width of thorax, 0.44 mm.

Cyclops affinis, Sars.

"Antecedenti [C. phalerato] simillimus. Corpus autem minus robustum colore cœruleo vel potius glauco sat saturato insigne. Segmentum ultimum thoracicum ad marginem posteriorem extrosum pilis vel spinulis subtilissimis pectenatim exornatum. Rami caudales quam in C. phalerato aliquanto longiores, setarum apicalium interna quam externa multo breviore, intermediarum interiore altera fere triplo longiore longitudinemque abdominis superante, in medio aculeata dein vero subtile ciliata. Antennæ 1-mi paris segmento 1-mo corporis multo breviores, tenues, articulis 11 compositæ. Pedes 5-ti paris distincti, uniarticulati, setis 3, quarum interior ceteris multo major et ciliata, instructi. Sacci oviferi parvi abdomini appressi. Longit. circit. ¾ mm."

Cyclops ornatus, Poggenpol (=*C. clausii*, Heller, fide Rehberg,) is almost certainly, in our judgment, a young or atavic condition.

C. helleri, Brady, though not identical, is no more worthy a specific name. If every form with eleven-jointed antennæ and egg-sacs be worthy a distinct name, it will be possible to duplicate all the seventeen-jointed forms. Fortunately, however, many species agree together in this condition, so that the number of spurious species derived from this source is rather small; among these is to be reckoned *C. nanus*, Sars, which is obviously very near the pulchellus group.

Antennæ 10-jointed.

No valid species have permanently 10-jointed antennæ. C. phaleratus is frequently found with 10-jointed antennæ. C. kaufmanni is without much doubt an immature form.

Antennæ 8-jointed.

Sp. 29. Cyclops fimbriatus, Fischer (fide Rehberg.)

(Plate R. Fig. 11.)

C. crassicornis, SARS, BRADY, HERRICK.
C. gredleri, HELLER.
C. pauper, FRIC.
C. poppei, REHBERG.
(? *C. magniceps*, LILLJEBORG.)

Our American species corresponds to that described by Rehberg as a new species. The differences mentioned in the previous report (see Cyclopidæ of Minnesota, p. 233) are just those which have led Rehberg to establish the C. poppei, which, by the way, was found with the type. I see no reason, especially in view of the latter fact, to regard it as even a well marked variety.

C. crassicornis is widely distributed in America as well as Europe, but is never very common. The color is always reddish.

Antennæ 6-jointed.

Sp 30. Cyclops æquoreus, Fischer.

A brackish-water species, .85 mm. long, which in a number of characters departs from the type of the genus. Those who have the opportunity to search the brackish pools along our coast would do science a service by looking for this interesting species.

NOTE.—Cyclops navicularis, *Say*, is perhaps C. viridis of this report. C. setosus, *Haldeman*, (Phila. Acad. Sci., Vol. VIII, p. 331) is referred in my notes to C. serrulatus, I do not now know with how much reason.

The reader is referred also to *Cyclops latissimus*, Poggenpol, as quoted by Cragin-which, although belonging to the section having seventeen-jointed antennæ, and having feet like C. tenuicornis, is said to have a disc-like body, long-jointed antennules with no armature, and the basal joint of the abdomen very long.

Cyclops ornatus is quoted by Cragin, but we are left in doubt as to the number of segments in the antennæ, a point quite essential to the definition of species.

(See under C. phaleratus.)

Cyclops longicaudatus and *C. igneus* are thought to be simply prematurely gravid young of known species.

(See Cragin, l. c., (pp. 12—13.)

Cyclops fischeri of the same author agrees with C. æquoreus in having six-jointed an, tennæ, but in nothing else apparently. It is, if correctly described, a very remarkable form, with no setæ on the antennæ.

FAMILY HARPACTICIDÆ.

Numerically the largest of the families of the Copepoda, this group contains predominatingly marine and mostly minute animals, frequently of strange and grotesque form. A few of the marine forms, inhabiting the gulf of Mexico, are figured in the report of the Minnesota Academy of Sciences for 1881. Of the over thirty genera of the family less than a half dozen are not exclusively marine, and of these most are brackish-water residents. The genus Bradya contains blind copepods living in slime.

The name was proposed by Dana, but was dropped in the final report. Again revived by Claus, it is now in use by the best authors. The general form and structure closely resembles that of the Cyclopidæ. The following characters are the more important ones in distinguishing the family from the other families of the order:

Body flattened or sub-cylindrical. Abdomen usually not much smaller than the thorax, from which it is not separated by a sudden constriction; antennæ rather short, 4- to 10-jointed; mandibles strongly toothed, palpate; maxillæ well developed, palpate; first pair of maxillipedes with strong teeth at the end, second pair usually forming a claw. The first pair of feet are often turned forward or prehensile; fifth pair one- or two-jointed, serving as egg supports in the female.

Most species live among sub-aquatic vegetation.

The Sub-Family Canthocamptinæ,

to which our sole genus belongs, is further distinguished from the other sub-families of Harpacticidæ by the fact that the seconp maxilliped has a prehensile hook. The feet of first pair are not clawed, but have the inner branch elongated, and the palp of the mandible is one-branched.

Genus Canthocamptus, Westwood.

These little animals may be secured in considerable numbers by gathering a supply of water from among weeds in shallow ponds, and permitting the debris to settle in a spot where light only touches the jar from one side, when the Canthocampti congregate on the exposed side.

Canthocamptus is an elongated animal, with the body divided rather obscurely into two portions, of which the first, or anterior portion, is largest. This part of the body has five segments, each of which has at least one pair of appendages. The first, consisting of the head proper with one of the somites of the body or thorax, as is discovered by observing that a pair of legs is attached to it, is the largest segment of the body.

As seen from above, it is triangular and extends in front into a short, stout beak or snout, like the rostrum of a cray-fish. Above the beak, in the center of the forehead, is the eye, consisting of pigment and two lenses, showing that we really have to do with two eyes confluent on the median line. This is the simplest form of a compound eye. The same method of compounding the eyes is exhibited in a more complicated manner by *Daphnia* and other Cladocera. On either side of the beak springs an antenna with six to nine joints of unequal size. The first three joints are profusely covered with hairs. The fourth joint is more slender than the preceding, and terminates in a process below, which bears besides a long hair a peculiar blunt bristle, that serves some unknown purpose—probably being sensory in function like the similar hairs on the antennæ of some Cladoceræ. The next joint is shorter than the rest, while the remaining three are spined at definite points. The antennæ of the male are curiously altered, or *geniculate*, on both sides, as in Cyclops. The three basal joints are shortened, while more or fewer of the following ones are coalescent, followed by a hinge joint and two elongated segments.

The second antennæ or antennules are two-jointed, and the basal joint has a two-jointed branch or palp; the terminal joint is covered with spines; at the end are longer and curved spines, jointed in the middle.

The mandible is a flattened plate with digitate teeth at the end, on one side of which springs a two-jointed palp, and from the other a blunt process. The maxilla is somewhat like it, but has rudiments of other elements.

The first pair of feet have two three-jointed rami. The outer ramus is shorter and with the longer branch is directed forward. The fourth foot has the inner branch two-jointed. The inner branch of the third foot of the male is peculiarly modified to form a prehensile organ, as it is this foot which fastens the spermatophore to the female. The fifth feet are composed of two flat plates.

The second division of the body, the abdomen, consists of five segments, of which, however, the first two are united in the female. The last segment of the abdomen bears two stylets, which are sometimes considered as together constituting an additional segment. Each of these stylets has, with several small spines, two elongated caudal setæ, one of which is usually as long or longer than the entire abdomen. The stylets are usually considerably longer than wide, but the proportions vary somewhat in different species.

Viscera. The body cavity is traversed by the alimentary canal, which is a straight tube with no lateral cæca or blind sacs, as in some other Copepoda. The canal is divided into four more or less distinct portions; the first section is a slender, muscular tube, extending from the mandibles nearly through the first segment, opening into the stomach proper, which is a muscular and glandular sac or tube, filling the greater part of the thorax ; at the beginning of the abdomen, the sac is constricted and becomes the intestine proper ; near the extremity again there is another change and the intestine loses its glandular character, and, by a peculiar adaptation becomes a sort of force-pump, which, during life, is constantly pumping water in and out, serving as a means of respiration. This anal respiration is quite common among aquatic animals in this as well as other orders. This latter section of the canal is the rectum, and opens beneath a toothed anal plate, above and between the stylets. No special divarications or cæca are appended to the digestive tract, and the only other organ which is at all considered to belong to the alimentary system, is what is known as the "shell-gland," present in most crustacea, but till recently thought to be absent in Canthocamptus. It is a coiled tube found in the lower part of the first segment of the thorax. It is impossible to find this organ in Canthocamptus, in every case, it being very obscure; and its office is uncertain, though it is supposed, perhaps with little reason, to be hepatic in function.

There is no functional heart in this animal, but its place is taken by a peculiar apparatus, hitherto undescribed ; this consists of a tube, surrounding the posterior portion of the alimentary canal. This sac around a sac is open in front, and serves by a double mechanism the office of a pulsating heart, though in a very imperfect manner.

There are no true hæmatic or lymph corpuscles in this animal ; so far, at least, none have been discovered. The place of these blood corpuscles is taken by globules of yellowish or red color of the most diverse size. These nutritive globules, or fat globules, as they have been called, are undoubtedly reservoirs of nutriment in a shape convenient for the animal's use, and equally certainly are derived from the contents of the intestine. In those Copepoda which have a functional heart, it is open anteriorly into a general body-cavity in the same way as in this animal. That a portion of the vascular system should surround the alimentary canal, is no unexampled thing, for in *Daphnia* a large sinus embraces a portion of the canal. The same provision as this described in Canthocamptus occurs in the Cyclopidæ. The nutritive globules are often very large, and are frequently extremely abundant, especially in females soon to become gravid. Three-hundredths mm. is not a large measurement for the diameter of such drops.

The nervous system is very hard to trace, consisting of a large pear-shaped ganglion just below the eye, from which extend commissures around the œsophagus, connecting them with the ventral ganglia lying between the bases of the feet. The senses are not apparently well developed, for, excepting the eyes, we cannot locate with certainty the organs of any sense. There are, however, two spots which are evidently devoted to special sense: first, the processes on the fourth joint of the antennæ, which may be simply the seats of tactile sense, or may have nerves suitable for perceiving chemical stimuli; second, the area on the forehead bordered by a raised line and covered with little pits, each with a small bristle. The character of this organ can be but conjectured; it may be homologized with the frontal nervous organs of the Cladocera.

The sexual organs are quite extensively developed, and periodically obscure the remaining viscera. In the male the simple testis is situated in the second segment, and the single vas deferens after numerous windings through nearly the entire length of the body, opens at the base of the first abdominal segment under a spined plate. A part of the vas deferens is of a glandular character and secretes an elongate tube, the *spermatophore*, which serves to contain the spermatozoids, and is fastened by the male at the opening of the median pore of the female; on contact with the water this tube, which is at first soft, contracts and presses the contents into the opening of the female organs. So long is the vas deferens that as many as three spermatophores are sometimes seen in the body at once. The spermatozoids are very small. The geniculated male antennæ are used in grasping the setæ on the tail of the female, and the curiously modified inner branch of the third foot of the male may assist in fastening the spermatophore upon her body. The ovary occupies the same position as the testes, and the two ducts are coiled in the body from end to end, opening in the median pore behind the fifth pair of feet. When the eggs are ready to be laid, they are forced out, carrying with them a film of the secretion of the lower, glandular portion of the ducts, which is of a collodion-like consistency, and which forms the enclosing sac. The young become fully developed sexually before they assume their final form, and it is not unusual to find ova-bearing females which are not only much smaller than the parent, but with considerable differences in the various organs.

This sort of heterogenesis is not uncommon among lower crustacea, for the young may differ much from the mother till after they have themselves produced young.

Four species have been recognized in America, of which one is certainly identical with a widely distributed European form, and a second is probably identical with an English species. C. palustris, Brady, seems to depart considerably from the norm of the genus and may prove a type of a marine genus. No true Canthocamptus is more than accidentally marine.

The ten species below enumerated are all that have fallen under the author's notice, though others may have been mentioned.

KEY TO THE GENUS CANTHOCAMPTUS,

- Inner ramus of 4th foot
  - 2-jointed. In. ram. of 1st foot
    - 2-jointed.
      - 1 mm. long; basal joint of 5th foot small.....*C. gracilis*, Sars.
      - 0.5 mm. long; basal joint of 5th foot long. *C. brevipes*, Sars (?).
    - 3-jointed.
      - Inner ramus of 2d foot 2-jointed.
        - Antennæ thick ....*C crassus*, Sars.
        - Antennæ slender.
          - *C. trispinosus*, [1] Brady.
          - *C. northumbricus*, Brady.
      - Inner ramus of 2d foot 3-jointed.
        - Stylets rather long. *C minutus*, Mueller.
        - Styl. short, oval, *C. illinoisensis*, Forbes
  - 3-jointed.
    - Male antenna normal ....*C. hibernicus*. Brady.
    - Male antenna reduced, hooked at the end ....*C.? palustris*, Brady.

Canthocamptus elegantulus, C. mareoticus and C. horridus are uncertain, probably referred to the wrong genus. C. stromii, Baird (= Dactylopus stromii,) C. rostratus, Claus (= Stenhelia ima.) C. virescens, C. linearis, and C. roseus of Dana, are marine Harpacticidæ of uncertain affinities. C. minutus of Claus is not sufficiently described, but appears to be the earlier condition of C. minutus, Mueller (C. staphynalis, Jurine).

Sp. 1. Canthocamptus gracilis, Sars,

Is elongated linear, with the abdominal segments smooth. Caudal stylets long and slender; external caudal seta about one-fourth the inner. All the feet with two-jointed inner rami; outer branch of fourth foot longer than the others, inflexed; basal process of fifth foot slightly expanded. Length 1 mm.

At Decatur, Alabama, was found a species of Canthocamptus which is different from any American species, and seems in many points nearest the above but, unfortunately, only a hasty sketch could be made at the time, and the notes are insufficient to define it. The form is not remarkably slender; the first and second abdominal segments are very large. The caudal stylets are slender and elongated, the inner seta being very long and curved, while the outer is quite short. The anal plate is covered with hairs only. The antennæ are normal, of moderate length, and the fifth foot has but a narrow process at the base.

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1 Distinguished from the following by the presence of only three spines on the process of the basal joint of the fifth foot.

If this form be worthy a distinctive name, it may be called

Sp. 2. Canthocamptus tenuicaudis. (Sp. n.)

(Plate O. Figs. 15 and 16.)

? Sp. 3. Canthocamptus brevipes, Sars.

This small form is almost certainly the young stage of some other species; yet I transcribe the description.

"Corporis forma et magnitudine C. pygmæo non dissimilis. Segmenta abdominalia vero postice magis attenuata seriebusque aculeorum destituta. Rami caudales elongati duplo longiores quam latiores, setis apicalibus brevisculis parumque divergentibus, exteriore dimidiam longitudinem interioris non attingente. Operculum anale absque dentibus. Antennæ 1-mi paris breves, articulis ultimis duobus in unum confluentibus articulum. Pedes natatorii brevissimi, ramo exteriore intus setis destituto, interiore biarticulato in pedibus 1-mi paris longitudinem exterioris æquante, in sequentibus multo breviore. Pedum 5-ti paris articulus basalis intus in processum folliformem, sat magnum et angustatum, articulum ultimum elongato-ovatum aliquanto superautem, exit. Color albidus. Longit. parum supra ½ mm."

Sp. 4. Canthocamptus crassus, Sars.

Robust; segments margined with pectinate bristles. Caudal stylets oval, contorted, constricted at the base. Antennæ thick, densely covered with long setæ. Fifth feet with long setæ; basal process rather small. All the feet excepting the first, with bi-articulate inner rami. Length 0.75 mm.

Sp. 5. Canthocamptus trispinosus, Brady.

(Plate O. Figs. 6—14.)

This species with the last and next has all the feet save the first with bi-articulate inner rami. Very near the next, from which it differs in the form of the fifth foot of the female, which has the basal process smaller, bearing only three spines, while the next has six, the second joint being longer and narrow. The male is unknown. Not yet identified in America.

Sp. 6. Canthocamptus northumbricus, Brady.

Body robust; antennæ long as first segment, nine-jointed; mandibular palp minute. In the male the inner branch of the third foot is three-jointed and dactylate, as in C. minutus.

Canthocamptus northumbricus, var. americanus. (Var. n.)

(Plate O. Figs. 6—14, 20—22.)

One of our most common species is very near the English form, so near, in fact, that I dislike to remove it from it. A few points of divergence, however, may be mentioned.

The form and proportions are much like those of C. minutus. The head is large and ends in a prominent bent beak. The antennæ are rather long and slender and have a well marked flagellum. (Brady figures no flagellum). The palp of the antennule is as in C. minutus. The mandibular palp is small. The first pair of feet normal, rather small; all the other swimming feet with two-jointed inner rami, save in the case of the male third foot. The fifth feet are exactly as figured by Brady, save that there is a prominence or tooth of the basal segment near the point of attachment of the terminal joint which is quite long. The sensory area of the head is oval and pointed. The male antenna has a long flagellum, not, as figured by Brady, a very short one. The egg-sac is very large, oblong. The animal seems to fall short of the size of the English species, though measuring upwards of 0.65 mm. Our form is very well distinguished from any other species. It is found in lake Minnetonka, lake Calhoun, and elsewhere.

Sp. 7. Canthocamptus minutus, Mueller.

Monoculus staphylinus, JURINE.
Canthocamptus minutus, LILLJEBORG, BAIRD, SARS, ULJANIN, BRADY, HERRICK.
Canthocamptus staphylinus, CLAUS, FRIC.
Canthocamptus minutus, var. occidentalis, HERRICK.

A well known species which has been frequently described and seems quite circumpolar in its distribution.

First mentioned from America in a paper by the writer in 1878. A pretty full description will also be found in the author's *Types of Animal Life*. A very abundant species, frequent in muddy pools, but somewhat variable in abundance. It may frequently be found in great numbers in winter.

Sp. 8. Canthocamptus illinoisensis, Forbes.

(Plate O. Figs. 1—5.)

This robust and pretty species was first taken near Minneapolis, by Mr. A. W. Jones, a student of the University, who found it in a peaty ditch. Forbes' description is appended.

"Length 1 mm. Head and first segment united; five abdominal segments in male, four in female. The suture between the first and second segments is not wholly obliterated above in the female.

Last abdominal segment is deeply and acutely emarginate. Branches of *furca* as wide as long, inner bristle plumose, a little longer than abdomen; outer plumose only on outer side, about half the length of the inner. The second to fifth *abdominal segments* have each a row of spinules along ventral portion of posterior,

Male with *anterior antennæ* composed of seven joints, the fourth joint very short. The front outer angle of the third is produced, the blunt process bearing three long bristles surrounding a slender olfactory club which is as long as the three following joints. The penultimate joint bears a strong spine or slender appressed process at the middle of its posterior margin. The five outer joints constitute the grasping organ. The *posterior antennæ* bear five long bristles at tip, three of which are made prehensile by the occurrence of from eight to twelve short articulations in the middle of the hair, allowing it to be bent forward. At the base of these articulations on the outer bristle, are two short spinules. Two nearly longitudinal rows of five or six strong, short spines each appear on the under surface of the outer joint of the antennule. The secondary flagellum, borne as usual on the middle of the basal joint, is not articulated, and bears four long bristles, two terminal and two on distal half of inner side. The outline of the *mandible* is exactly like that figured by Claus, but it bears about ten teeth, the upper thick and blunt, the inner sharp, slender and longer. Several are notched at tip. The lower angle bears a long simple bristle. *Mandibular palpus* two-jointed, second joint with three long terminal hairs and a shorter spine attached at basal third of anterior margin, jointed at base and directed towards tip, like a dactyl. The *maxilla* and *maxillary palpus* are scarcely to be distinguished from those of *C. staphylinus*.

The first maxillipeds are three-lobed, the outer lobe constituting a long, strong claw. The second and third are about one-third as long as the first, and bear each one strong simple spine and one weak branched hair. The inner lobe is widest, about two-thirds as wide as long. The dactyl of the *posterior maxilliped* is spinous on its inner edge, and the same edge of the hand is ciliate and bears a short, stout, sparingly plumose bristle at its base, just beyond the tip of the closed dactyl. The width of this joint (the second) is nearly half its length.

Basal joint of inner ramus of *first pair of legs* nearly or quite as long as outer ramus, the second wider but only half as long as the third, and obliquely truncate. Inner ramus of *third pair of legs* in male is three-jointed, [the outer two-jointed,]* chelate. The finger is ovate, truncate, terminating in two long plumose hairs. The dactyl is linear, curved at base, and twice as long as finger. The inner ramus of the *fourth pair of legs* is about half as long as outer, two-jointed, basal joint short, terminal joint about as long as middle joint of outer ramus. The *fifth pair of legs* is best developed in the female. In the male the length is not over one-third the width. The basal portion bears three plumose hairs on its very broadly rounded anterior margin, of which the innermost is longest. The outer plate is nearly orbicular and bears five spines on its terminal margin, of which the second from the internal angle is the longest. *Genital plates*, found in male at posterior border of first abdominal segment, beneath, are short, slightly expanded internally, with internal angles rounded, and externally bear three sub-equal bristles, jointed at base, the inner largest and strongest and semi-plumose. The *antennæ* of the female are eight-jointed, extending backward to the first free segment. The basal joint of the *fifth pair of legs* is sub-elliptical in outline, with the basal half produced externally into a broad, triangular process which bears the second joint on its posterior margin. The free end of the basal joint bears six large plumose bristles of which the inner is longest. The greatest width of the joint is nearly equal to its greatest length. The second or outer joint is ovate, sub-truncate, spined on each margin, and bears four plumose bristles at tip and one at the middle of its outer margin. Its length is about twice its breadth."

Sp. 9. **Canthocamptus hibernicus**, Brady.

A small species differing from all others save the next in having a three-jointed inner ramus of the fourth foot.

"Anterior antennæ of the female slender, 8-jointed, about as long as the first body segment, and much like that of C. minutus. Inner branch of the second antenna very small, 1-jointed. Posterior foot-jaw having a broad hand armed with a long apical claw. Inner branch of the first pair of feet scarcely twice as long as the outer; first joint longer than the entire outer branch, and nearly twice as long as the united second and third joints, both of which are extremely small. Inner branches of the second, third and fourth pairs shorter than the outer, and 3-jointed, the first joint

* Evidently a misprint, for it is the inner ramus which is chelate.

being very small. Inner segment of the basal joint of the fifth pair of feet in the *female* elongated, fringed, bearing two long and three short apical setæ; second or outer joint sub-ovate, finely fringed internally; externally bearing six long marginal setæ. In the *male* the limb is smaller, the basal joint short, broad and having six short setæ of equal length; second joint nearly like that of the female. Caudal segments somewhat longer than broad; inner seta about twice as long as the outer; anal operculum denticulate. Length .65 mm." Not found in America.

Sp. 10. Canthocamptus palustris, Brady.

(Plate K. Fig. 5.)

A brackish-water species about .9 mm. long, found in a number of places in the British Isles. The species presents several anomalies.

The antennæ of the female are 8-jointed; those of the male robust, the last joint forming a hook. The first four pairs of feet have both branches 3-jointed; the fifth pair in the *female* are 2-jointed, with a short and broad basal joint, the second joint being sub-ovate, bearing five long apical setæ; in the male the fifth pair is obsolete, being reduced to a minute setiferous lobe. Caudal segments short, bearing two principal setæ, the outer half as long as the inner.

Sp. 11. Canthocamptus minnesotensis. (Sp. n.)

(Plate T. Figs. 1—6.)

Since the manuscript of this genus was finished, a small species has been found which seems undoubtedly distinct from any of the above. A single pair were taken in a gathering from Bassett's creek containing C. minutus in abundunce. Unfortunately the characters of the swimming feet are not certainly known, but they were apparently all three jointed save the last. The antennæ are very short and thick, 8-jointed, with a long flagellum; the antennules are of the usual form, and the mouth parts rather large. The first pair of feet have the two rami of nearly equal length. The form is moderately elongate. The caudal stylets are very short, quadrate in outline and well armed with spines. The fifth foot of the female has four long and two short spines on the inner lamina, and the terminal joint has five unequal spines. In the male the fifth foot has two spines on the lamina and six on the second joint, one being a small bristle. The male antenna is of peculiar form. The teeth of the anal plate are large and emarginate (see fig. 4.)

The swimming feet are all armed with very strong spines, aside from the usual quota of spines at the end of each joint. Length .65 mm.

NOTE.—*C. frontinalis*, Rehberg. This author seems to have parted with his usual acumen in the remarks upon this species. After describing a Canthocamptus with the inner ramus of the first foot "reichlich doppelt so lang wie die beiden Grundglieder des Aussennasts," he draws a moral on the mutability of genera from the fact that Brady founded the genus Attheyella "auf grund der Eingliede des innenastes am fierten Fusspaare und einer derartigen Bildung des ersten Fusses, wie er bie C. frontinalis beschreiben ist." Brady says (Brit. Copepoda, p. 58): "inner branch of first pair of feet scarcely at all elongated, and either 2- or 3-jointed," etc. The distinctive characters being the 1- or 2-jointed 2d and 3d feet and the 1-jointed inner ramus of the fourth foot, it is doubtful if C. frontinalis is really new.

II. GENUS ATTHEYELLA, Brady.

This genus, the diagnostic characters of which have been above indicated, contains three nominal species. It is quite difficult to say what differences exist between Sars' "*Canthocamptus*" *pygmæus* and *Attheyella spinosa.* Brady did not seem to recognize the fact that his diagnosis included that species. The third species is the blind *A. cyrptorum*, of Brady, which it is interesting to compare with the blind Bradya limicola of the coast of the gulf of Mexico.

PŒCILOSTOMATA.

This group, consisting of animals more or less like Cyclops in appearance, but, during part of their existence, semi-parasitic, has been very little studied in America. Most of the fresh-water species inhabit the gill-cavities of fishes. The gills of fishes should always be examined (if practicable, microscopically) for these interesting animals.

The mouth parts are greatly reduced and their homologies uncertain.

GENUS ERGASILUS, Nordmann.

Body shaped much as in Cyclops; anterior antennæ short; antennules in the female large, four-jointed, terminating in a strong claw. Mouth opening in the center of the very large head, which is not beaked in front. The mouth parts are inconspicuous, but the maxilliped is a stout organ terminating in a long claw. The three anterior pairs of feet are bi-ramose, and each ramus is three-jointed; the outer ramus of the fourth foot is two-jointed; the fifth pair is absent or rudimentary. The abdomen is four or five-jointed, and the stylets are rather short. Ova-sacs two, large.

Ergasilus depressus, Sars.

(See Forhandlinger i Videnskabs-Selskabet, 1862.)

The form figured in plate S., fig. 1, is known from a gathering taken under the same circumstances as Sars' specimens, and consisted only of males. The animal is very transparent with deep blue markings below, especially between the bases of the feet. Sars thinks the males are always free, while the females early retire to the gill-cavities of fishes. This species may be distinct from the Norwegian form, but there is no reason for declaring that it is so.

E. depressus is probably the young of the widely distributed E. sieboldii.

NOTE.—As the systematic part of this work draws to a close, a note is received from Prof. Birge, who was so kind as to glance through advance sheets of the portion upon Cladocera. Prof. Birge informs me that his *Scapholeberis nasuta* is the same as S. (Daphnia) aurita, Fischer, as published in 1849 in the *Bull. Naturforsch. Gesellsch. in Moscau,* Bd. 22. This paper I have not seen. At Prof. Birge's suggestion, then, read on page 43.

Sp. 4. **Scapholeberis aurita,** Fischer.

Daphnia aurita, FISCHER.
Scapholeberis nasuta, BIRGE.

CHAPTER IV.

COLLECTING, PRESERVATION AND MISCELLANEOUS NOTES.

The appliances employed in the capture and study of Entomostraca are, in the main, those employed by the student of aquatic vegetation. The first in order of importance is the hand-net and its accompaniment, long rubber boots, such as cover the entire leg being preferable. Thus equipped, the student can collect by far the greater number of fresh-water crustacea. The net is best made by obtaining an ordinary gaff or dipping net of extra strength but small size. If jointed, the ferrule must be unusually strong, not, indeed, because of the weight or activity of the prizes, but because it is often necessary to lift a net full of water, which is a greater strain than the strongest fish would produce in a net with open meshes. The ring of such a net is furnished with a medium-sized bag of some porous but still rather close fabric. The writer usually uses for this purpose the thinner variety of flour sacking. This material fulls a little when wet, and permits the water to pass rather too slowly, but this is a good fault. The net is used in shallow water and among weeds. After the net has been repeatedly filled and permitted to drain nearly empty, the bottom of the net is seized and the small remaining amount of water is thrown by a dexterous movement of the hand into a large-mouthed jar, several of which are needed. By this method the animals can be secured in any desired degree of concentration, so to speak, provided care is taken to avoid fouling the net with fine mud or debris. A single jar should usually contain only a gathering from a single locality. In case the collection is not to be examined at once, the gathering, which must now be quite free from admixture of mud and filth, is concentrated as much as possible, and then poured into a thin filter-paper or a thin muslin bag. When nearly dry, the funnel is held over a small bottle, an opening is made in the apex of the filter, and the contents washed through with slightly dilute glycerine. Soon after pure glycerine is added so as to bring up the whole to the required degre of concentration. A sufficiency must be used to well cover up the whole. In case of haste the end of the filter containing the gathering may be torn off and placed at once in a bottle of glycerine or alcohol.

For the collection of Cypridæ it is recommended to use a very thin fine net, and gather as much as possible of the finely comminuted debris which settles in weedy pools. Spread this material in shallow pans and in an hour or so skim the surface with a small spoon-like hand-net, and transfer with the addition of clear water to shallow porcelain plates. Such gatherings may contain Ilyocryptus, Monospilus, the hook-nosed Pleuroxids (=Percantha) and, perhaps, also species of Canthocamptus.

The entomostraca of the larger lakes must be sought by a different method. A net of larger size, and composed of very thin material is drawn after a boat which is kept moving in different parts of the lake. Such a net should be so weighted as to receive water from the surface as well as from several inches below it. The net is emptied occasionally with plenty of water into large bottles, which may preferably be placed in the dark if to be unexamined for some time. Water kept in the dark will preserve its animal life for a much longer time than if exposed to the sunlight.

A similar net may be placed in a rapid stream in such a way that it remains partly full, but does not overflow. The accumulations of a day may be thus gathered into little space. The faucets of the city water will frequently afford a good supply of animal life, and unfortunately in Minneapolis a rather large number of forms are worms of a suspicious and unpleasant appearance. It must be observed that for this purpose the faucet must be well open so that a good current is secured, otherwise most of the impurities will be dropped on the way. A friend mentioned that very little life was found in the city water after long and careful experiment, during which, however, a very small stream was allowed to trickle through the complicated set of graduated screens. But the writer at the same time secured a rather large supply both of entomostraca and vegetable forms by simply permitting the water from the hydrant faucet to flow with full head through a muslin net.

But our methods are not yet exhausted. The dipping bottle frequently brings up animals quite different from those collected by the towing net at the surface. This consists of a large bottle weighted by a suitable bit of lead or iron and fitted with a tight-fitting cork or wooden stopple. The stopple is attached to the line fastened at the neck of the bottle in such a way that a sudden twitch of the cord opens the bottle when it has sunk to the required depth. Another method, when one does not object to mingling forms from all depths, is to lower a net weighted with a heavy ring to the bottom, there agitating it slightly and drawing it vertically upward. This serves in a poor way in the place of a dredge and will secure a larger gathering than the dipping bottle, and is quite as easily rigged. The collections secured in either of the above ways are placed in large shallow porcelain plates and, the microscope being ready, the study may begin. With a rather large hand-magnifier, with which, however, the student will soon be able to dispense entirely, the various forms seen swimming or creeping or springing about are scanned, chiefly for the purpose of noting their motions. The little black, brown or yellow imps springing on the surface are rapidly skimmed off as hindrances, and (if the student is interested in the Poduræ) consigned to a bottle of spirits. Next a great Belostoma, Corixa, Water-skater, Ranatra, or Dysticus requires the same treatment. Perhaps a half dozen "whirligig-beetle" require more time to dispose of, and then a careful removal of the dragon-fly larvæ and "water-tigers" leaves the coast comparatively clear save for sand-fleas and dipterous larvæ which must be endured as necessary evils.

With a narrow slip of paper folded trough-wise the desired animal is captured by a quick movement and the water permitted to drain off, when the specimen is placed on the object-carrier, and a square cover glass, one corner of which has been armed with a bit of wax, is placed over the animal and then adjusted so as to give the requisite amount of pressure to quiet its restless motions. The slip of paper is, in every way, more convenient than a dipping tube and avoids flooding the object-carrier. With a half-inch objective and suitable eye-piece the whole animal is drawn in as natural a position as possible, either with the aid of a camera or free hand, by the assistance of careful measurements and a given scale. A one-fifth inch objective is now substituted and all possible details added. If any dissections are necessary, the cover glass may be removed, the slide placed upon a slip of black paper and the parts separated as far as possible by the aid of a watchmaker's glass or dissecting microscope.

Up to the present time almost the only reagent which could be employed for the instantaneous killing of Entomostraca with the body in its natural position and the preservation of the same was osmic acid, which partly on account of its expense, perhaps, seems rarely to find its way into our laboratories. And even this is but partially successful or causes such a dark color as to obscure what one most desires to see. The desideratum seems to have been supplied by the discovery of Prof. Hermann Fol that ferric perchloride produces not only an instantaneous death but a fixation of all the parts with very little coloration or shrinkage. The alcoholic solution is diluted to about 2 per cent. and applied to a small quantity of water in which the animal is swimming, or a more concentrate solution is added at once to the water of a vessel containing numerous Entomostraca. The water is poured off and the animals washed with alcohol of 70 per cent., to which a few drops of nitric acid may be added to remove the ferric salts. According to Fol, in transparent animals the appearance is very little changed by this process. Specimens thus prepared may be preserved in alcohol and afford preparations for making thin sections. They do not take color well, but may be stained with gallic acid without difficulty.

As a preservative, glycerine does admirably for Copepoda, but no known fluid works satisfactorily for the Cladocera unless after such treatment as above indicated. Sections may be made by imbedding in soap, but the tissues of the Cladocera are so delicate that the writer never succeeded in making permanent preparations of such sections. Either the alcohol or the balsam as it flows in almost inevitably disturbs the natural position. 50 grammes of soap are dissolved in 200 cu. cent. heated alcohol of 96 per cent. The soap should be shaved very thin. A shallow paper trough is prepared and filled with the still warm mixture, and the animal, which lies in concentrated alcohol, is transferred into the solution and agitated till its tissues are permeated with the soap. When cold, the bit of soap is cut into the required form and is ready to be placed in the microtome.

As a preservative medium for Copepoda, Carpenters' gelatine answers well. It consists of clarified gelatine, one ounce to six fluid dramchs of pure glycerine. The preparations mounted in this require no cement, as the gelatine is quite firm when cold.

APPENDIX.

The previous pages refer to the fresh-water crustacea simply and will give a tolerable idea of the variety exhibited in the fauna of the lakes and rivers of America. The majority of Copepoda are marine and the coasts of the United States will afford the student of marine entomostraca a rich harvest of curious forms. These animals are now being investigated, it is understood, by competent naturalists. In the meanwhile any notes may be of a temporary interest. The following jottings, which are the result of a few days stay on Mississippi sound, will give an idea of the fauna of the gulf of Mexico. They are extracted from a paper offered the Minnesota Academy of Natural Sciences.

FAMILY CALANIDÆ.

Genus Pseudo-diaptomus. (Gen. n.)

Resembling Metrida and Diaptomus; compactly framed; cephalothorax 6-jointed, last two segments coalescent above; head rounded in front, beaked; eye small; antennæ appearing 22-jointed in both sexes, longer than the thorax; the right male antennæ geniculate as in Diaptomus; antennules bi-ramose, both rami rather short, inner one seeming but two- or three-jointed; mandible ten-toothed; maxillipedes well developed; feet all bi-ramose save the last, both rami 3-jointed; first feet smaller; fifth feet with inner ramus obsolescent, in the male nearly as in Diaptomus, in the female rather slender, simple, three-jointed; abdomen in the female 3-jointed, in the male 5-jointed; stylets in the female longer; ova-sac single; spermatophore pear-shaped.

This genus is of unusual interest on account of its close approach to the fresh-water section of the family.

The spermatophore in this genus is large and swollen and, as seen through the body of the male, is liable to be mistaken for eggs.

Pseudo-diaptomus pelagicus. (Sp. n.)

Rather compact; thorax alike in the sexes, antennæ short, seeming 22-jointed; first foot small, both rami 3-jointed; fifth feet in the male with but small rudiments of the inner rami, basal portion heavily armed with short teeth, otherwise almost as in *Diaptomus*; fifth feet of female slender, alike; abdomen in male very slender, with short stylets armed with five terminal setæ and a series of bristles on the inner margins, distal margin of segments of abdomen toothed; a series of spines also ornaments the middle of the first segment below; abdomen of female short and very spiny, first joint thick, second slender, oblong, third joint short; length of abdomen supplemented by that of the elongated stylets, which are spinulous on their edges; ova-sac ovoid, eggs numerous; opening of operculum vulvæ with lateral projecting lips.

This species is ornamented with irregular markings of brownish color which give it a strange appearance not observed in any other copepod. The size is like *Temora velox,* which the female resembles a little, a resemblance enhanced by the elongated stylets. By some changes in the definitions of *Metrida* and *Pleuromma* these three genera could be united, but there would then be no valid excuse for not admitting *Diaptomus*, so that, on the whole, it may be well to let matters stand until we reach some better understanding of the natural generic affinities of these animals.

Habitat, Mississippi sound, gulf of Mexico.

Genus Dias, Lilljeborg.

Slender; cephalothorax very long, narrow in front; abdomen with five segments in the male, in the female with three; antennæ 20-jointed, nodose; secondary branch of antennules one-jointed, small; labrum large; posterior maxillipeds short; swimming feet with 2- and 3-jointed rami; fifth feet with a single ramus.

Dias longiremis, Lilljeborg ?

Unfortunately the gathering was insufficient to determine with certainty the identity of our species with the above, but the female agrees quite well; and those points in the young males seen which could be compared with the descriptions of *D. longiremis* were sufficiently concordant. This species ranges, in the eastern hemisphere, from the North sea to the Mediterranean, and could be expected here. It is a very active animal and represents a well differentiated type.

Genus Temora, Baird.

Elongate; thorax five-jointed, fourth and fifth segments closely combined; abdomen with four segments in the male, three in female; antennæ 24- or 25-jointed; right antenna of the male geniculate; mouth parts as in *Calanus;* inner branches of second, third and fourth pairs of feet two-jointed, of first one- or two-jointed; fifth feet with but one branch, prehensile in the male.

Temora affinis, Poppe.

= *T. gracilis*, HERRICK, MS.

The shallow bays and estuaries along the Gulf of Mexico swarm with a species of Temora but little unlike *T. velox*.

The body is much less compact, it being rather slender in both sexes; in like manner the caudal stylets are very much elongate, being nearly as long as in *T. longicornis* of Mueller, from which it is clearly distinguished by many obvious characters, and which seems to show an approach to *Metrida*.

The antennæ in male and female are just as in *T. velox*, and the fifth feet are little, if at all, dissimilar; the spine on the second joint in the female is not serrated, however, and the basal joint of the abdomen in this sex has three teeth on either side. The caudal stylets are about six times as long as broad in the female and densely spined, as is the last abdominal segment. The stylets are more slender in the male and have few spines, but the last abdominal segment has three larger spines on either side. Inner ramus of the first foot one-jointed. The animal is generally colorless, in autumn at least, but may be variously ornamented with prismatic colors, the most constant of which markings are a band about the stylets and across the thorax and between the bases of the feet. The ova are very numerous and carried as in *Diaptomus*. This species is littoral in habitat and ranges from salt-water bays to the fresh waters of rivers, along with several varieties of *Cyclops*, *Sida*, etc.

FAMILY HARPACTICIDÆ.

GENUS AMYONE, Claus.

Body much compressed; dorsal margin strongly curved; head very large, produced and angled below; antennæ 6- to 8-jointed; antennules palpate, 3-jointed; second maxillipeds long, chelate at the end; last thoracic and anterior abdominal segments enlarged; fifth feet leaf-like, large.

A very small crustacean, little over $\frac{1}{2}$ mm. long, occurs in the gulf of Mexico in shallow water among vegetation. Insufficient material prevented its complete study, but it is nearly allied to *A. sphærica*, Claus, from which it differs in several particulars.

I can do no better than quote the remarks of Claus, the original discoverer of this peculiar genus.

"The body of this highly remarkable form, represents, in its general form, an intermediate stage between the nauplius (cyclops larvæ) and the mature copepods. The oval, almost spherical form, the slight development of the abdomen and the enlargement of the anterior thoracic segment recall the structure of the larva, while the almost complete segmentation of the body, the jointing of the antennæ and the swimming feet, as well as development of the reproductive organs, make the maturity of the creature certain." (Beitr. zur Kenntniss der Entomostraken.)

GENUS LAOPHONTE, Philippi.

Rather slender; antennæ 4-, 8-jointed; palp of antennules 1-jointed; mandibular palp 1- or -2-jointed; maxillæ palpate; first pair of feet slender, outer branch short, 3-jointed, inner branch elongated, 2-jointed; three following pairs with one ramus 3-, the other 2-jointed.

Laophonte similis, Claus?

The small crustacean which is referred to the above species occurs sparingly in the brackish waters of Mobile bay, and with *Temora* seems to be the only entomostracean not also found in the fresh waters adjacent.

From the few specimens found it could not be certainly determined that our species is identical with the European. The differences are, however, such as might be expected in immature specimens. Brady figures a similar reduction in the number of joints of the antennæ as that seen in our specimens. The fifth foot too, is less well armed with spines, but otherwise the agreement is tolerably close.

Genus Harpacticus, Milne-Edwards.

Elongate or expanded laterally; head united with the first thoracic segment; first and second abdominal segments coalescent; antennæ 8-, 9-jointed; mandibular-palp 2-branched, large; second pair of maxillipeds strongly developed; outer ramus of the first pair of feet 2- or 3-jointed, inner ramus 2-jointed; first and second joints of outer ramus elongated, second joint of inner ramus short; both rami of following pairs of feet 3-jointed; ova-sac single.

Harpacticus chelifer, Mueller. (var. n. ?)

The species inhabiting the gulf of Mexico resembles *H. gracilis*, Claus, in the length of the setæ and some other peculiarities; but the antennary palp is more like *H. chelifer*, with which it closely agrees in most respects. Remembering that the entomostraca have their highest development in temperate and arctic regions, the small size and greater proportional length of setæ and stylets may be explained. *H. gracilis* from the Mediterranean takes the place of the true *H. chelifer* of the North sea, and is regarded by Brady as the same species. Our form would, in this case, stand more nearly related to the typical form. Both branches of the first feet are two-jointed and the antennary palp has three spines on its distal segment.

Genus Bradya, Boeck. (1872.)

Antennæ very short, 6-, 7-jointed; antennules of moderate size longer than antennæ, with a 2- or 3-jointed palp; mandibular palp large; maxillipeds rather large, outer branch (first foot-jaw of Brady?) much as in *Calanidæ*; first four pairs of feet nearly alike; fifth pair small, not lamellate.

This peculiar genus is not yet well circumscribed and defined, and it is much to be regretted that lack of time prevented from ascertaining how far the western species agrees with the generic characters of the European form and thus determining the validity of the assumed generic criteria. That our species is a member of the genus can not be doubted, but the hurried examination which could be devoted to it failed to cover the entire structure.

Bradya limicola. (Sp. n.)

Body flattened; free margins of the segments of the dorsal carapace rather long; little separation between abdomen and thorax; abdomen cylindrical, rather long; stylets short; distal margin of the segments spined; antennæ very short, 6- or 7-jointed, hardly longer than the movable beak; second antennæ much longer, 3-jointed; palp long, two-jointed; mandibles palpate, teeth fine, much as in Calanidæ; palp bi-ramose, second ramus very small; maxillæ of moderate size; maxillipeds large, outer one as in Calanidæ; first four pairs of feet bi-ramose, each ramus 3-jointed; fifth foot small, with two terminal digitate processes and a seta on either side. The male is at least a third smaller and has longer caudal stylets; the antennæ are modified, but very short. *The eyes are wanting in both sexes.* This very interesting species was collected in the brackish water of a ditch shaded by high sedges so that the sun could hardly penetrate. I did not find any representative of the genus in the open waters neighboring, but it is hardly to be doubted that such exist. This species is quite distinct from *Bradya typica* of north Europe.

The only other blind copepod with which I am familiar is *Attheyella*, which is circumstanced somewhat as the above.

The European *B. typica* is pelagic; ours dwells in darkened ditches and seems to furnish another illustration of the effects of seclusion upon the visual organs. Brady seems to have transposed the maxillipeds; these are really but branches of the same organ, as shown by the development, and the outer ramus is, probably, what Brady usually calls second foot-jaw but here first foot-jaw. In the characters of the mouth parts and fifth feet our species seems to show an affinity with the elongated higher copepoda.

Ocean Springs, Mississippi.

Caligus americanus, Dana and Pickering ?

A species of Caligus was collected at dusk far out in Mississippi sound in considerable numbers. The animals were floating in a bank of vegetation and swam freely. They seem not to differ greatly from the species described by Dana and Pickering in 1838 from the cod near New York. The fish lice are remarkable for their flattened bodies and the paired sucking organs on the head.

A species of Corycæus allied to *C. varius* of Dana was also collected.

NOTE.—Prof. Forbes, to whom advance sheets of the portion on Copepoda were sent, writes me that he somewhat questions the identity of the Minnesota species of Diaptomus referred to *D. leptopus* with the species for which that name was proposed. I do not know of any facts casting doubt upon the reference, but wish to call the reader's attention to the suggestion of Prof. Forbes.

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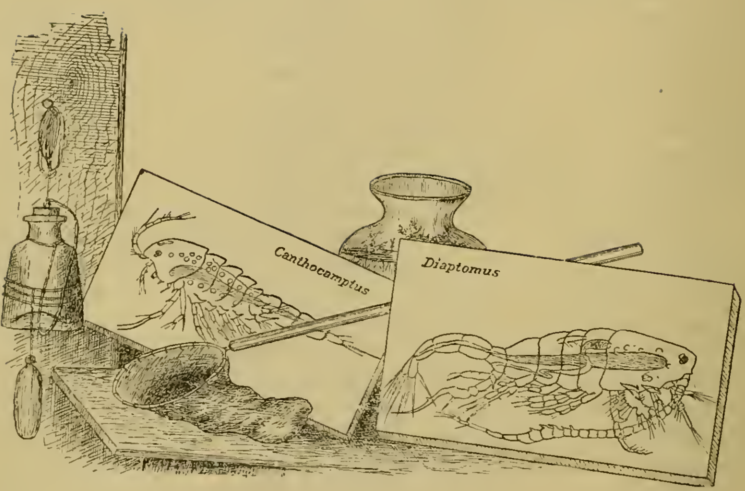
Canthocamptus
Diaptomus

PLATES OF PART V.

PLATE A.

Fig. 1. abdomen of *Moina paradoxa*, female, from Minnesota.
Fig. 1a. spine from post-abdomen.
Fig. 2. post-abdomen of *Moina rectirostris*.
Fig. 3. head of *M. paradoxa*, female, showing (a) eye with pigment and lenses, (b) supra-œsophagal ganglion, antennule with (c) its muscle, (d) its nerve, and (e) its terminal sensory filaments, (f) the cæcum of stomach, (g) optic ganglion, (h) stomach, (i) œsophagus, (j) the muscles which move the eye, also part of the labrum.
Fig. 4. antennæ of same.
Fig. 5. ephippium of *M. rectirostris*.
Fig. 6. " of *M. paradoxa*.
Fig. 7. seminal cell of *M. paradoxa* ; 7a, a group less magnified.
Fig. 8. seminal cells of *M. rectirostris*.
Fig. 9. first foot of male of *M. paradoxa*.
Fig. 10. " " " " " *M. rectirostris* (from Weismann).
Fig. 11. male *M. rectirostris* (from Weismann).
Fig. 12. head of *Ceriodaphnia rotunda*. (This and the following numbers after P. E. Mueller.)
Fig. 13. head of *C. punctata*.
Fig. 14. " *C. pulchella*.
Fig. 15. " *C. reticulata*.
Fig. 16. " *C. quadrangula*.
Fig. 17. " *C. quadrangula*.
Fig. 18. post-abdomen of *C. quadrangula*.
Fig. 19. " *C. pulchella*.
Fig. 20. " *C. megops*.
Fig. 21. " *C. reticulata*.
Fig. 22. " *C. laticaudata*.
Fig. 23. " *C. rotunda*.

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C.L.Herrick.

PLATE B.

Fig. 1. *Ceriodaphnia rotunda,* male (after Kurz).
Fig. 2. *C. alabamensis.* female.
Fig. 3. *C. reticulata,* post-abdomen of male with opening of vas deferens (after Weismann).
Fig. 4. *C. consors* ? ?
Fig. 5. *C. scitula*, head of female.
Fig. 6. do., post-abdomen.
Fig. 7. do., antennule of male.
Fig. 8. do., semen cell of male.
Fig. 9. *Scapholeberis angulata*, adult female; 9a. first foot.
Fig. 10. *Schapholeberis armata*, "
Fig. 11. do., view from below.
Fig. 12. *Lyncodaphnia macrothroides*, young.
Fig. 13. do., labrum.
Fig. 14. do., antennule.
Fig. 15. do., last foot, purple pigment in lower part.

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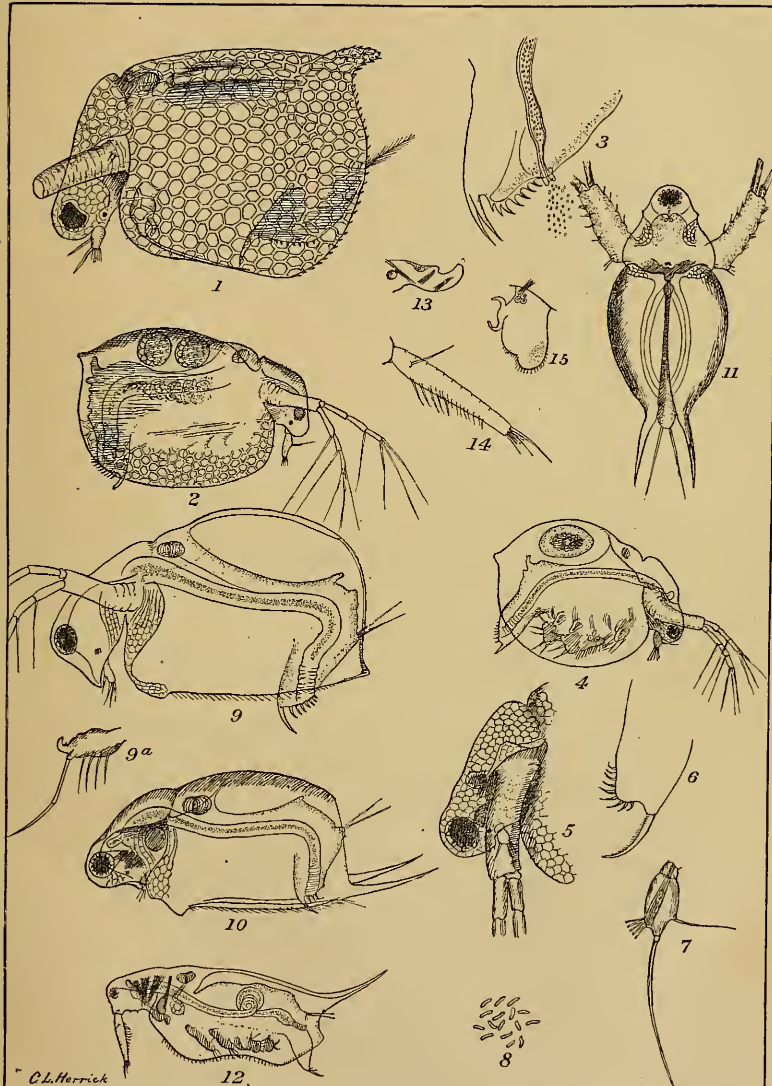

PLATE B[1].

Fig. 1. *Lyncodaphnia macrothroides* (= *Ofryoxus?*), adult female, showing coiled intestine, elevated anus, long antennules, elongated seta of second antennæ, anterior cæca, etc.

Fig. 2. post-abdomen of the same.

Fig. 3. antennule.

Figs. 4--6. *Polyphemus pediculus*, young and adult females.

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PLATE C.

Fig. 1. *Macrothrix tenuicornis*, 1a. labrum.
Fig. 2. do., first foot.
Fig. 3. do., antennæ of young.
Fig. 4. *Macrothrix pauper.*
Fig. 5. *Macrothrix rosea*, antenna of male.
Fig. 6. do., spines of shell-margins.
Fig. 7. do., post-abdomen.
Fig. 8. *Macrothrix laticornis*, male.
Fig. 9. do., semen cells.
Fig. 10. *Pasithea rectirostris,* male antenna.
Fig. 11. *Macrothrix rosea*, post-abdomen.
Fig. 12. *Macrothrix tenuicornis*, "
Fig. 13. *Macrothrix rosea*, post-abdomen of male.
Fig. 14. *Drepanothrix dentata,* antenna.
Fig. 15. *Ilyocryptus sordidus*, marginal spines.
Fig. 16. do., antenna.
Fig. 17. do., post-abdomen.
Fig. 18. *Ilyocryptus spinifer*, 18a. marginal spines.
Fig. 19. do., antenna.
Fig. 20. *Macrothrix tenuicornis*, heart and accompanying vessels.
Fig. 21. *Ilyocryptus spinifer,* post-abdomen.

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PLATE C.

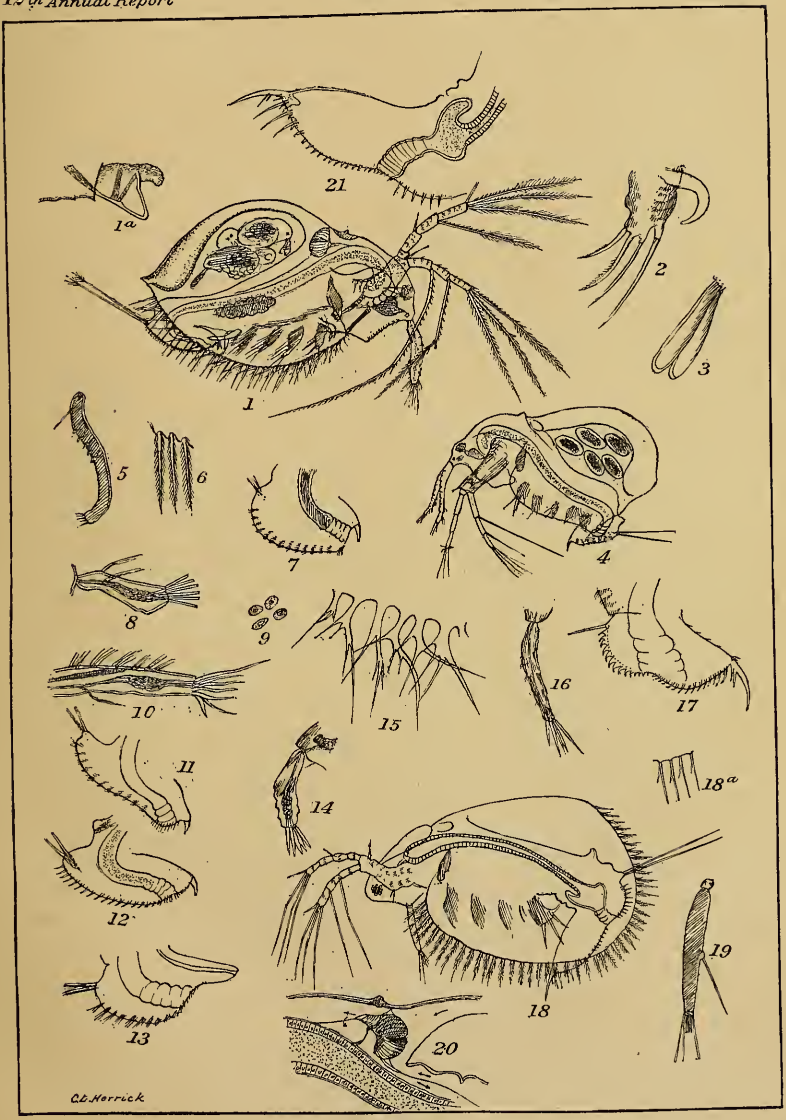

PLATE D.

Fig. 1. *Lathonura rectirostris.*
female, from above. a. eye. b. optic ganglion. c. muscles of eye. d. muscles of antenna. e. dorsal sucking disc. f. stomach. g. young in brood cavity.

Fig. 2. female, from side.

Fig. 3. head seen from below.

Fig. 4. maxillæ.

Fig. 5. first foot.

Fig. 6. ovary.

Fig. 7. antennule.

Fig. 8. last foot.

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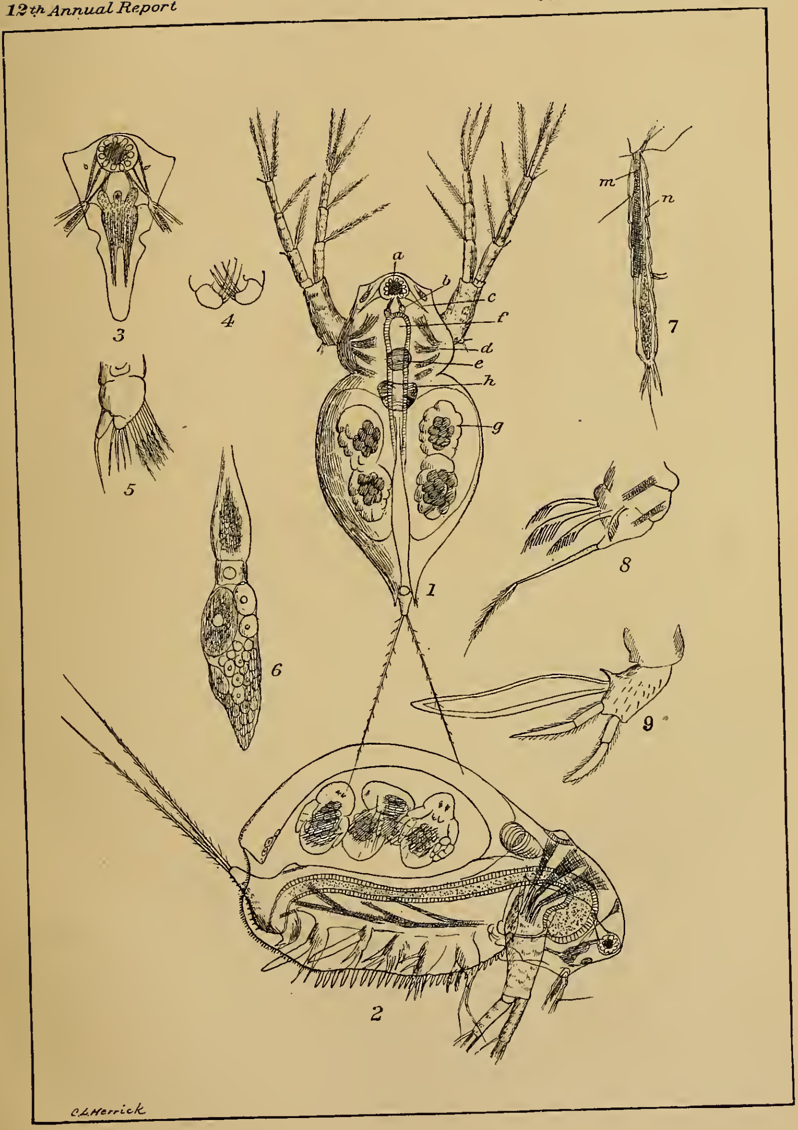

PLATE E.

Fig. 1. *Alona quadrangularis*, female.
A. antennule. Lb. labrum. Md. mandible. P-a. post-abdomen. An. anus. F. c. musculus flexor caudalis. E. c. musculus extensor caudalis. A. g. anal gland. n. g. nutritive globule in embryo. t. tail of embryo. I, II, III, IV, V. five pairs of feet of embryo. mx. maxilla of embryo. at^2. antennæ of embryo. at^1. antennules of embryo. H. heart. Sh. g. shell gland. Ov. ovary. Md. m. muscle of mandible. $At.^2$ m. muscle of antennæ. E. eye. s. œ. g. supra-œsophagal ganglion. P. F. pigment fleck.

Fig. 2. brain, eye and pigment fleck of same.

Fig. 3. *Pleuroxus procurvus*, female.

Fig. 4. foot of same.

Fig. 5. *Acroperus leucocephalus*.

Fig. 6. *Alonella excisa*, female; 6a. shell of same.

Fig. 7. antennæ of same.

Fig. 8. *Alonopsis latissima*, female.

Fig. 9. *Alonopsis media*, female.

Fig. 10. *Camptocercus macrurus*, post-abdomen.

Fig. 10a. lower angle of shell of same.

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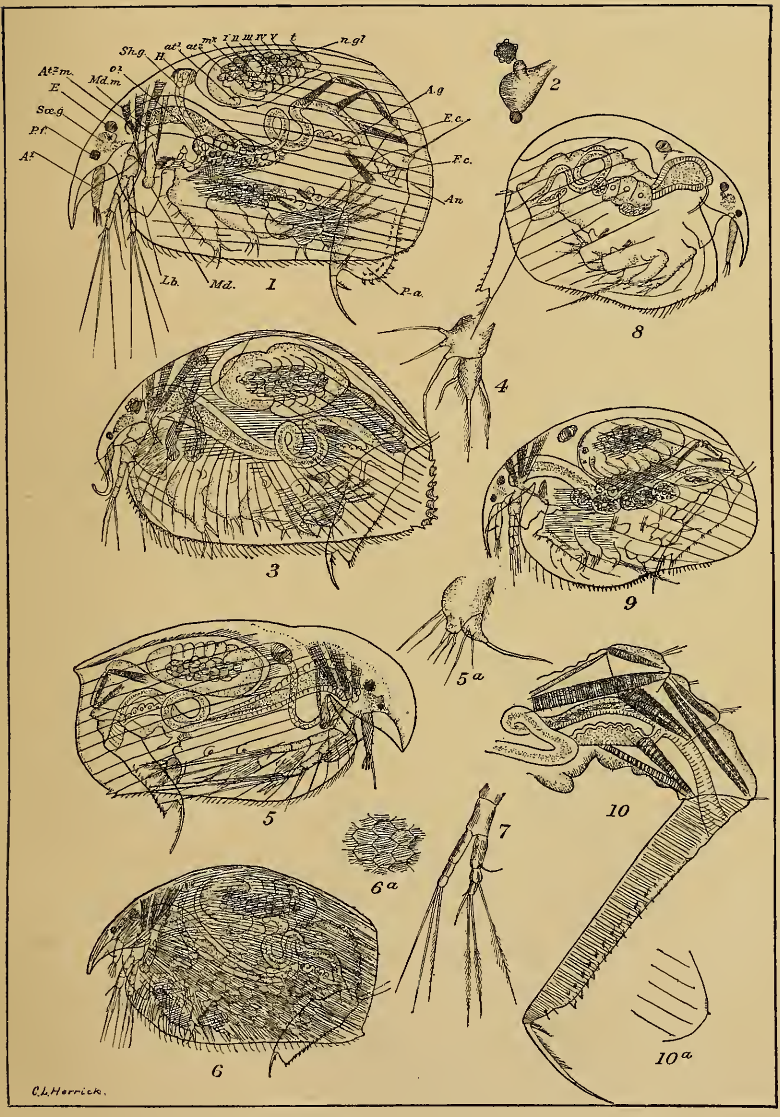

PLATE F.

Fig. 1. *Chydorus globosus.*
Fig. 2. do., first foot.
Fig. 3. do., end of post-abdomen.
Fig. 4. *Chydorus sphæricus*, male.
Fig. 5. *Chydorus nitidus*, post-abdomen of female.
Fig. 6. *Chydorus nitidus*, head.
Fig. 7. *Chydorus sphæricus*, ephippial female.
Fig. 8. do., female.
Fig. 9. *Chydorus globosus*, post-abdomen of male.
Fig. 10. *Chydorus sphæricus*, from above.
Fig. 11. *Chydorus ovalis.*
Fig. 12. *Chydorus cælatus.*
Fig. 13. *Crepidocercus setiger.*
Fig. 14. *Alona affinis.*
Fig. 15. *Pleuroxus unidens*; 15a. antenna.

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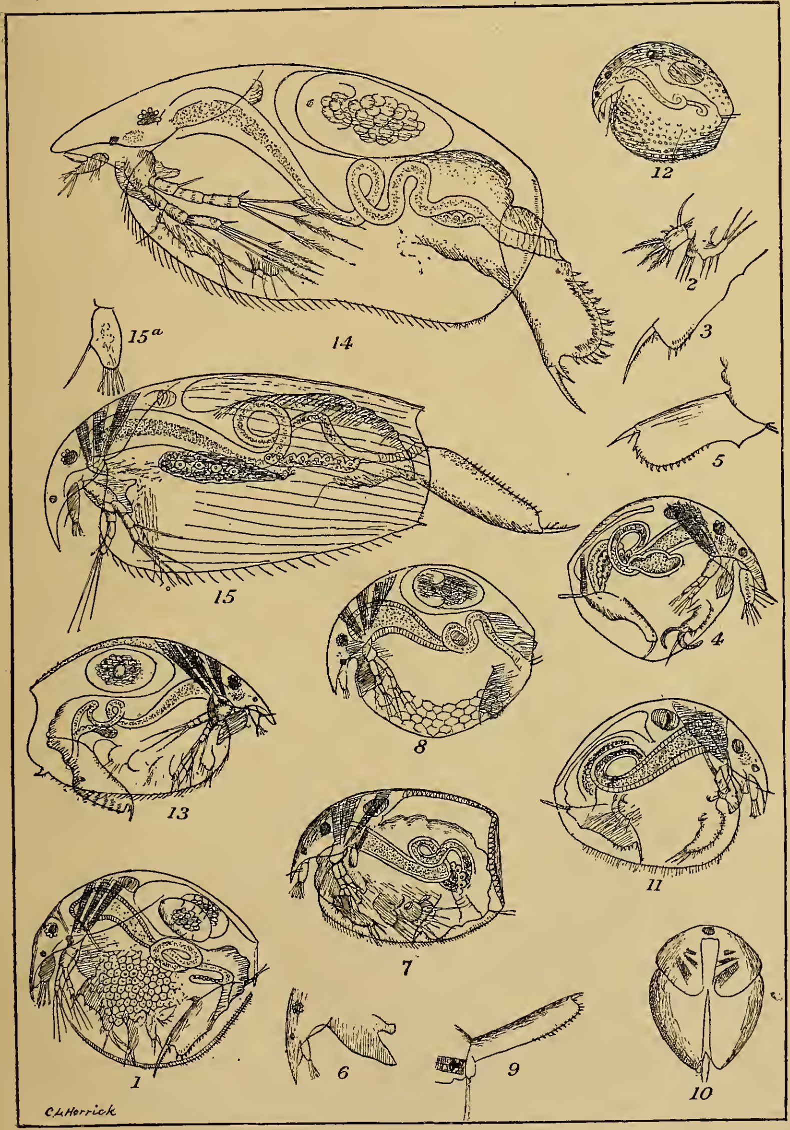

PLATE G.

Fig. 1. *Alonopsis latissima*, male.
Fig. 2. *Alona glacialis* ? female.
Fig. 3. do., male.
Fig. 4. *Alona tuberculata.*
Fig. 5. do., post-abdomen.
Fig. 6. do., labrum.
Fig. 7. do , antenna, setose branch.
Fig. 8. *Alona glacialis*, antenna.
Fig. 9. *Alonopsis latissima*, feet.
Figs.10, 11. *Alonella excisa*, details of shell sculpture.
Fig. 12. *Pleuroxus denticulatus*, female; 10a. outline of ephippium.
Fig. 13. do., common variety.
Fig. 14. *Alona tuberculata*, var.

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PLATE G.

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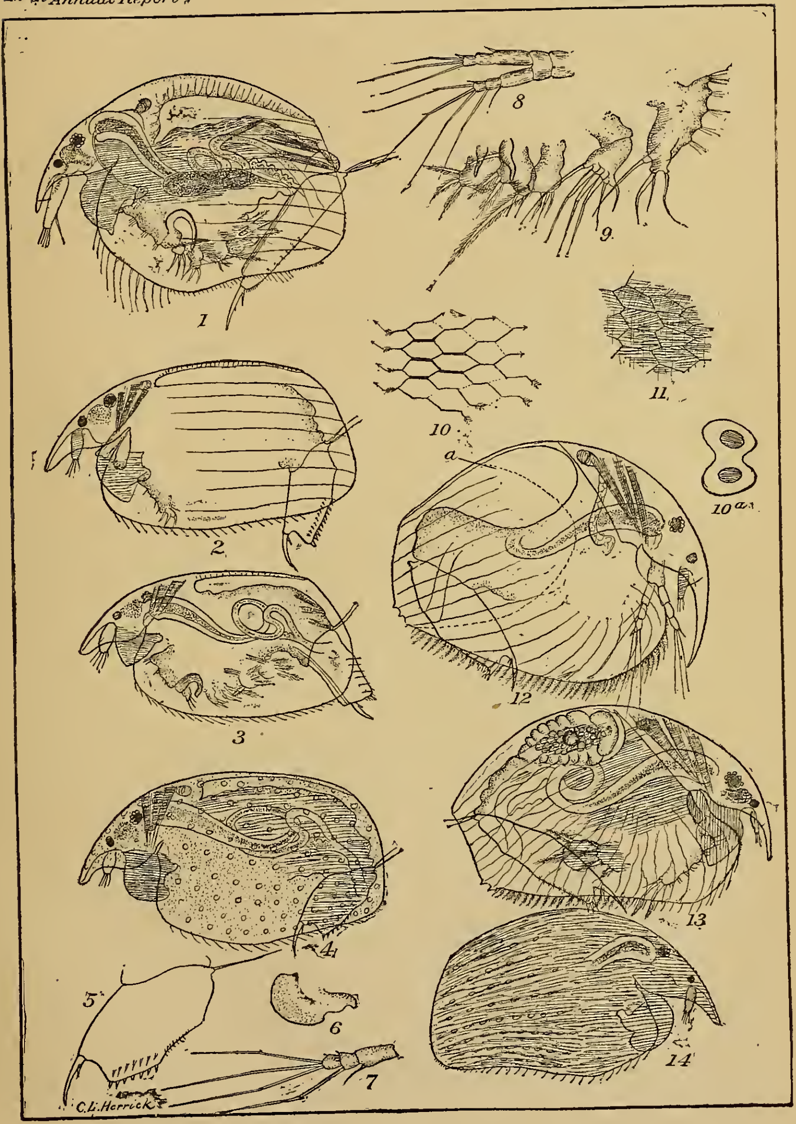

PLATE H.

Fig. 1. *Pleuroxus hamatus*, post-abdomen and antenna.
Fig. 2. *Pleuroxus affinis.*
Fig. 3. *Alona modesta* (= *lineata?*)
Fig. 4. *Leydigia quadrangularis.*
Fig. 5. *Eurycercus lamellatus*, male; 5a. posterior margin.
Fig. 6. do, antenna of female.
Fig. 7. *Alonella pygmæa.*
Fig. 8. *Temora affinis*, Poppe. female.
Fig. 9. do., abdomen of female.
Fig. 10. do., male.
Fig. 11. do., abdomen of male.
Fig. 12. do., fifth feet of male.
Fig. 13. do., " " of female.
Fig. 14. do., jaw.
Fig. 15. do., antennule.
Fig. 16. Nauplius larva of this or a related species.

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12th Annual Report — *PLATE H.* — *Geol. & Nat. Hist. Sur. Minn.*

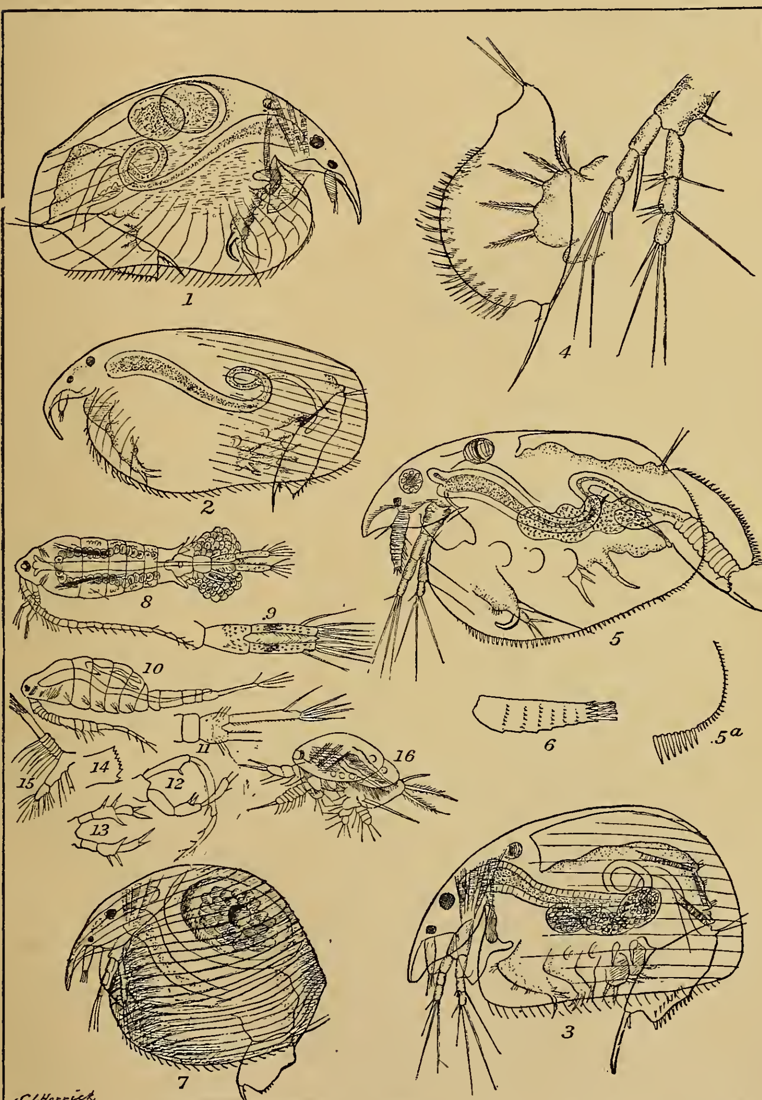

PLATE I.

Fig. 1. *Camptocercus rectirostris*, post-abdomen of female.
Fig. 2. do. post-abdomen of male.
Fig. 3. do. male.
Fig. 4. *Camptocercus biserratus*, head.
Fig. 5. *Camptocercus latirostris*, head of male.
Fig. 6. do., head of female.
Fig. 7. *Camptocercus lillgeborgii*, head.
Fig. 8. do., post-abdomen of female.
Fig. 9. *Acroperus leucocephalus*, post-abdomen of male.
Fig. 10. *Acroperus angustatus*, " "
Fig. 11. *Alona tenuicaudis*, post-abdomen.
Fig. 12. *Alona dentata*, post-abdomen.
Fig. 13. do. female.
Fig. 14. *Alona elegans*.
Fig. 15. *Alona intermedia*.
Fig. 16. *Pleuroxus hastatus*.
Fig. 17. *Leptorhynchus falcatus*.
Fig. 18. *Phrixura rectirostris*.
Fig. 19. *Eurycercus lamellatus*, first foot of female.
Fig. 20. *Alona sanguinea?* shell markings.
Fig. 21. *Monospilus dispar*; 21a. do., head seen from in front.

Figures 19-21 original, others from Kurz, P. E. Mueller and Schoedler.

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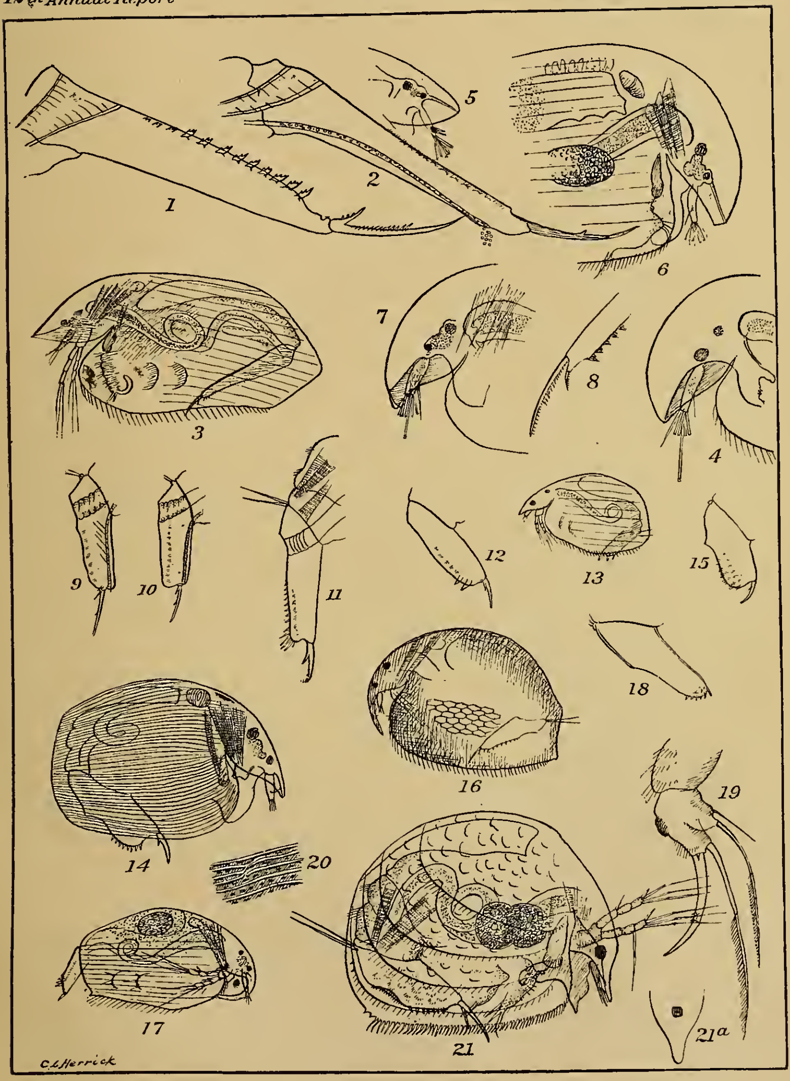

PLATE J.

Fig. 1. *Ceriodaphnia scitula*, (small var.) ephippial female.
Fig. 2. *Bosmina longirostris.*
Fig. 3. *Bosmina lilljeborgii.* After P. E. Mueller.
Fig. 4. *Bosmina*, hook on the first foot of male.
Fig. 5. *Scapholeberis mucronata.*
Fig. 6. *Scapholeberis cornuta*, head.
Fig. 7. *Scapholeberis angulata*, head; 7a. angle of shell.
Fig. 8. *Pleuroxus denticulatus*, male.
Fig. 9. *Simocephalus americanus*, head of female.
Fig. 10. *Bosmina*, post-abdomen of male (after Weismann).

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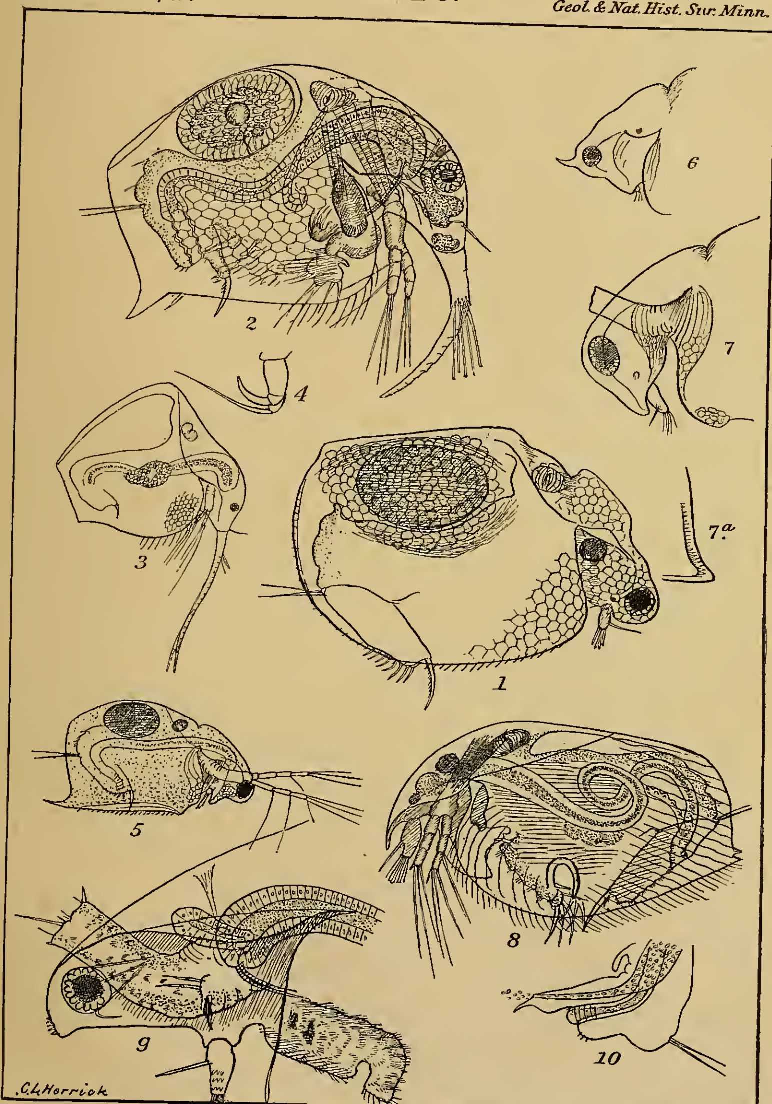

PLATE J[1].

Fig. 1. *Bosmina striata.*
Fig. 2. *Bosmina longirostris.* (See plate J, fig. 2.)
Figs. 3-5. *Bosmina cornuta.*
Figs. 6, 7. *Pleuroxus procurvatus.*
Fig. 8. *Graptoleberis inermis.*
Fig. 10. *Acroperus* sp.
Figs. 11, 12. *Graptoleberis inermis.*

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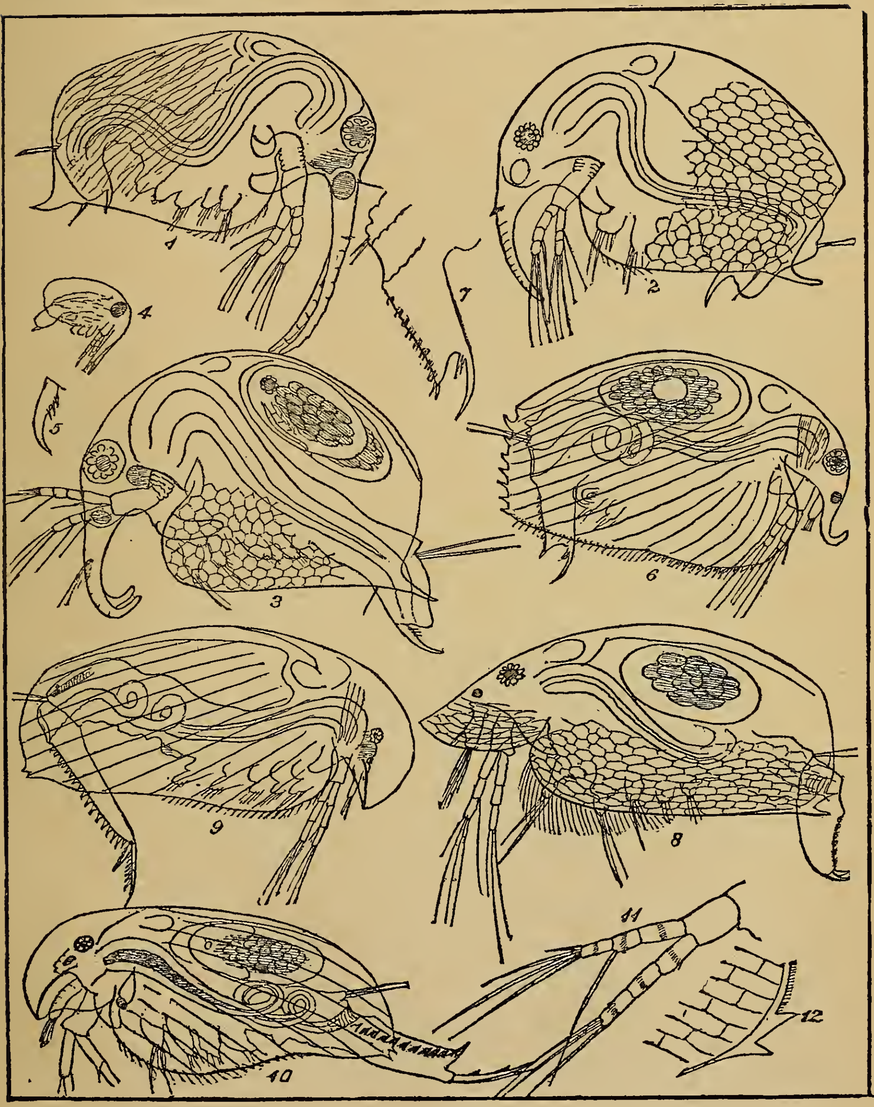

PLATE K.

Fig. 1. *Daphnia minnehaha*, male.
Fig. 2. " " part of feet of first and second pair.
Fig. 3. *Canthocamptus hibernicus*, antenna of female.
Fig. 4. " " fifth foot of female.
Fig. 5. " *palustris*, antenna of male.
Fig. 6. " *trispinosus*, fifth foot of female.
Fig. 7. " *minutus*, young.
Fig. 8. " " nauplius form.
Fig. 9. *Pseudo-sida bidentata*, adult female, antennule, labrum, angle of shell and post-abdomen.
Fig. 10. *Daphnia rosea*, young female.
Fig. 11. " " post-imago.
Fig. 12. " " beak.

MINNESOTA CRUSTACEA.

PLATE K.

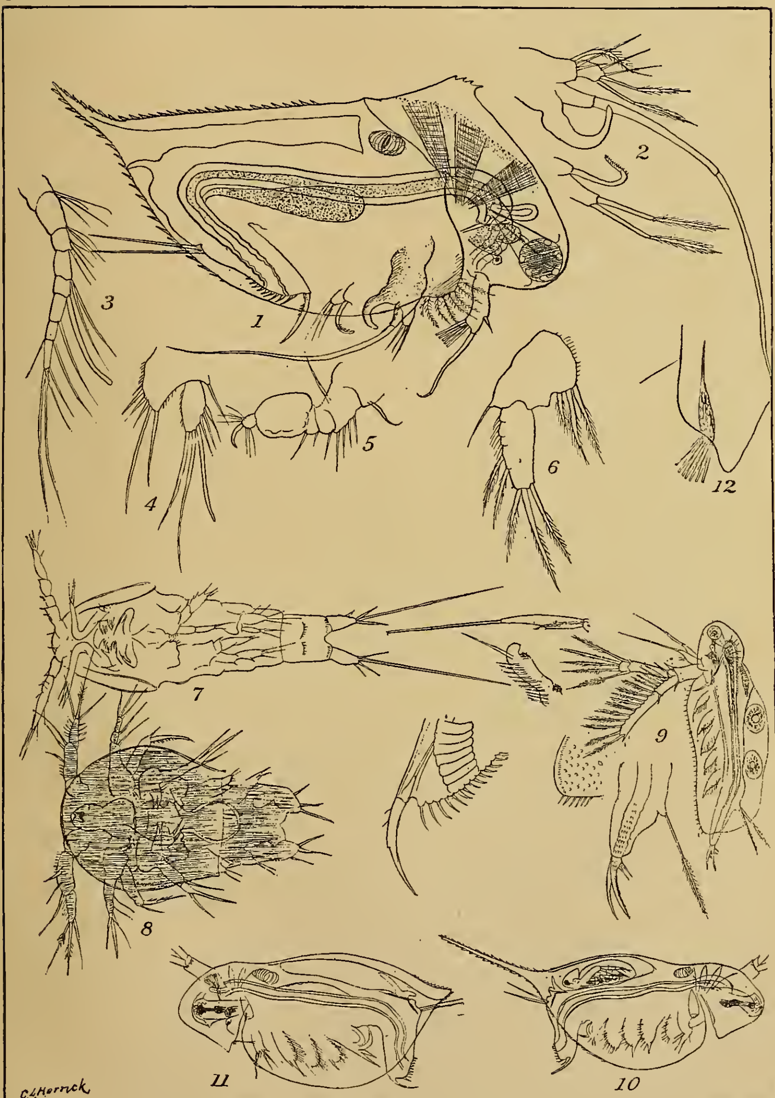

PLATE L.

Fig. 1.	*Daphnia minnehaha*, young female.	
Fig. 2.	" "	head of female; 2a. post-abdomen.
Fig. 3.	" *hyalina*, young female.	
Fig. 4.	" "	young.
Fig. 5.	" "	post-imago.
Fig. 7.	" *dubia*, young.	
Fig. 8.	" "	older female.

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12th Annual Report — PLATE L. — Geol. & Nat. Hist. Sur. Minn.

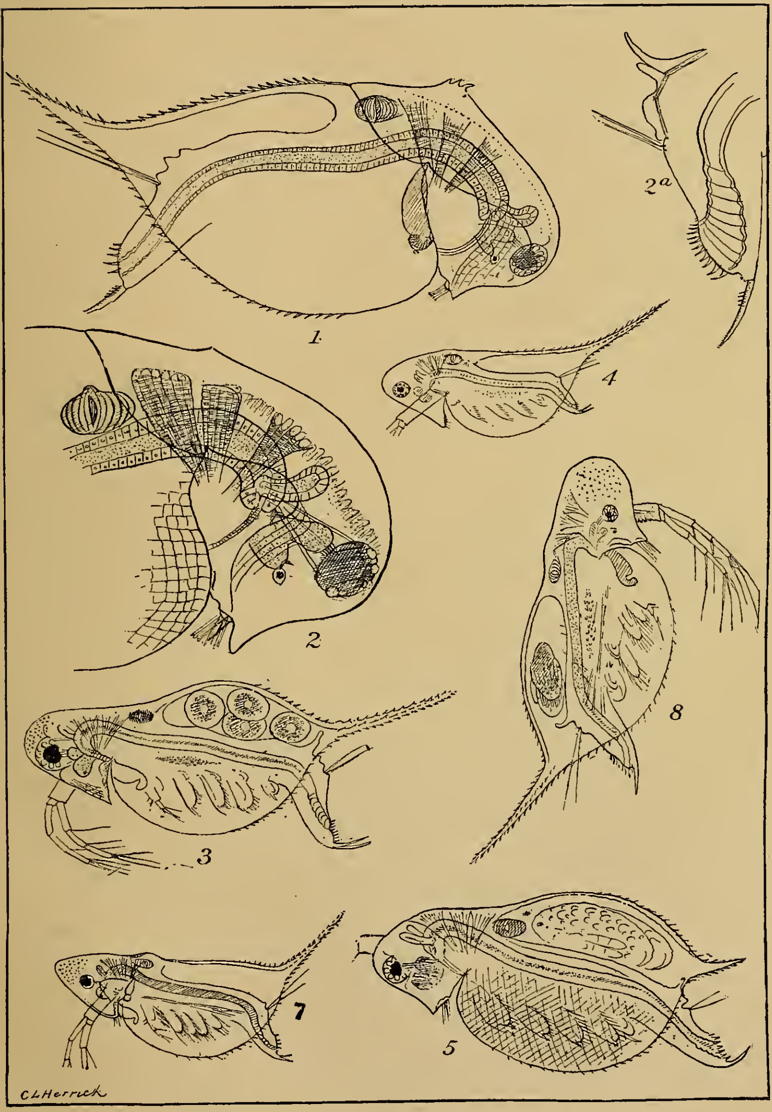

PLATE M.

Fig. 1. *Daphnia schæfferi*, post-abdomen of female.

Fig. 2. " " " " male.

Fig. 3. " " male antennule.

Fig. 4. " " brain and nerves.

inf. œ. g. infra-œsophagal ganglion with nerves to antennæ; œ. œsophagus; n. f. frontal nerve; g. opt. optic ganglion; m. opt. muscles which move the eye; p. f. pigment fleck; n. opt. optic nerve.

Fig. 5. *Daphnia schæfferi*, posterior part of embryo.

Fig. 6. *Eurycercus lamellatus*, heart, showing the anterior bifid portion between the lobes of which is the arterial opening and valve. The vaned arrows represent deeper currents while the unvaned indicate superficial ones. The dotted line represents the position of the pulsating membrane separating the venous from the arterial currents and seen in section at (a).

Fig. 7. *Daphnia similis*, anterior part of the nervous system seen from below. a. optic nerve; b. optic ganglion; c. frontal nerve; d. nerve to antennules; e. commissure connecting upper and lower œsophagal ganglion; f. nerves to antennæ and mandibles.

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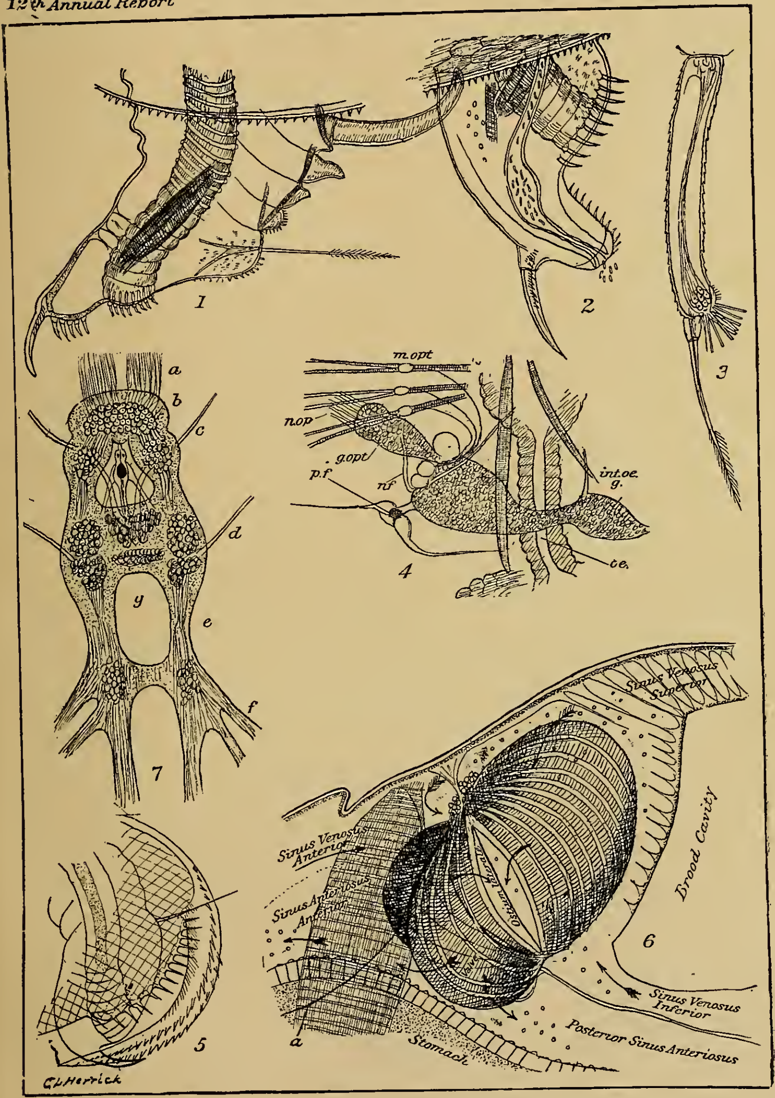

PLATE N.

Fig. 1-4. *Daphnia pulex*, *var. nasutus*.
Fig. 5. outline of head and (a) beak of D. similis.
Fig. 6. *Leptodora hyalina*, seen from above.
Fig. 7. " " larva.
Fig. 8. *Latona setifera*, female.
Fig. 9. *Limnosida frontosa*, female.
Fig. 10. " " antennule of male.
Fig. 11. *Holopedium gibberum*, female.
Fig. 12. *Sida elongata*, head outline.
Fig. 13. *Sida crystallina*, head outline of young female.
Fig. 14. " " antennule of male.
Fig. 15. " " " of female.
Fig. 16. *Daphnia galeata*, outline of head.
Fig. 17. " "*vitrea*" " " "

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PLATE N.

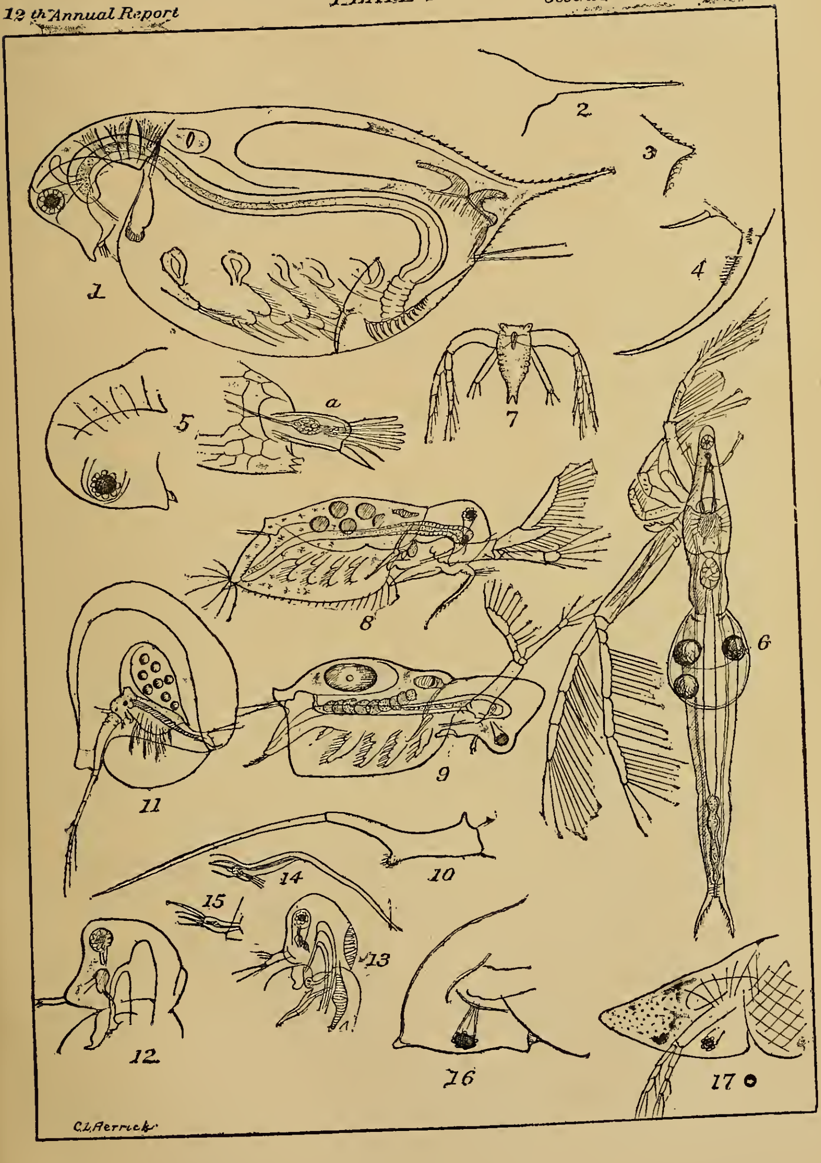

PLATE O.

Fig. 1. *Canthocamptus illinoisensis*, antenna of female.
Fig. 2. " " fifth foot of female.
Fig. 3. " " antennule.
Fig. 4. " " first foot.
Fig. 5. " " caudal stylet.
Fig. 6. *Canthocamptus northumbricus*, *var. americanus*, fifth foot of female.
Fig. 7. " " antenna of female.
Fig. 8. " " maxilliped.
Fig. 9. " " caudal stylet.
Fig. 10. " " antenna of male.
Fig. 11. " " first foot.
Fig. 12. " " fourth foot.
Fig. 13. " " fifth foot of male.
Fig. 14. " " frontal area.
Fig. 15. *Canthocamptus tenuicaudis*, stylets.
Fig. 16. " " fifth foot of female.
Fig. 17. *Cyclops serrulatus*, fifth foot.
Fig. 18. " " fourth foot.
Fig. 19. " " outer ramus of first foot.
Fig. 20. *Canthocamptus northumbricus*, inner ramus of third male foot.
Fig. 21. " " beak.
Fig. 22. " " maxilla.

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PLATE O.

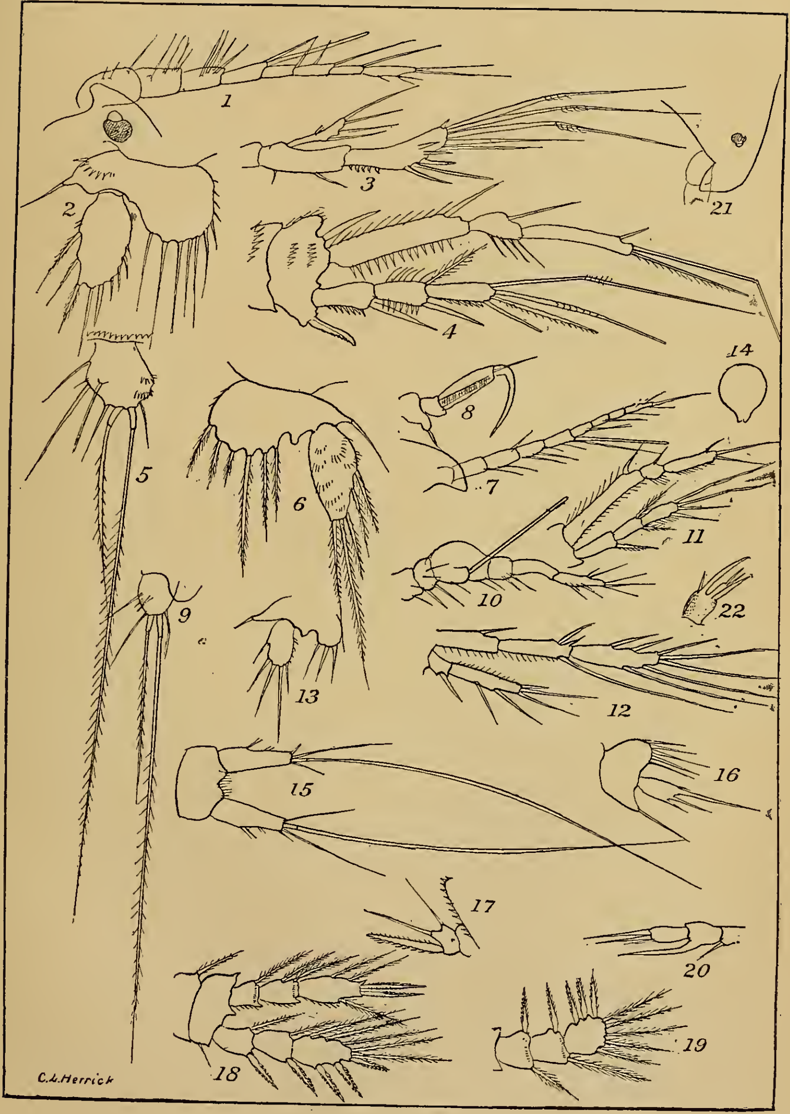

PLATE P.

Fig. 1. Heart of *Simocephalus vetulus*. a, tendons attached to lateral walls of heart. b, venous opening of heart. c, muscular bands supporting the abdomen, connected by transverse bands. d, cells of nutritive matter hiding the arterial opening. e, thin membrane seen in section which separates the venous from the arterial blood currents, is in focus near the side, but its situation in the center is shown by the dotted line. Above this or outside it is the attachment of the powerful antennary and mandibular muscles. f, posterior arterial sinus. g, brood-sac. h, alimentary canal with thick glandular cell walls. i, shell gland or excretory organ. j, powerful muscles supporting and moving the abdomen.

Fig. 2. An early stage of the embryo of *Daphnia schœfferi*. a, anus. n, nutritive globules or fat drops characteristic of the summer embryo. m^1, m^2, outer and inner envelope of the embryo. This is a nauplius stage, but not the first or proper nauplius. The portion darkly shaded is nutritive yolk.

Fig. 3. A well advanced winter embryo of *D. schœfferi*. a, shell growing over the eyes. b. c, inner shell. d. outer shell. e, lateral part of the head. f, antennules. g, labrum. h, mandibles. i, maxilla. j, second maxilla ? k′, l′, m′, n′, branchial appendages of the 2d–5th pairs of feet. represented by k, l, m, n. o, first foot. p. antenna, q, anus and intestine partly completed. s, shell growing out from the maxillary region.

Fig. 4. Older embryo bursting outer shell.

Fig. 5. Egg after extrusion into the brood cavity.

Fig. 6. Head of young embryo. a, lenses in formation. b, eyes appearing as dark flecks. c, shell growing over the head. d, labrum. e, antennule.

Fig. 7. Longitudinal section through an ephippium.

Fig. 8. Vertical section through an ephippial *Daphnia schœfferi*.

Fig. 9. Somewhat oblique section through the ephippium (a, b, c), heart (h), mandibles (m), and labrum (l).

Fig. 10. A vertical section through the ephippium and its egg.

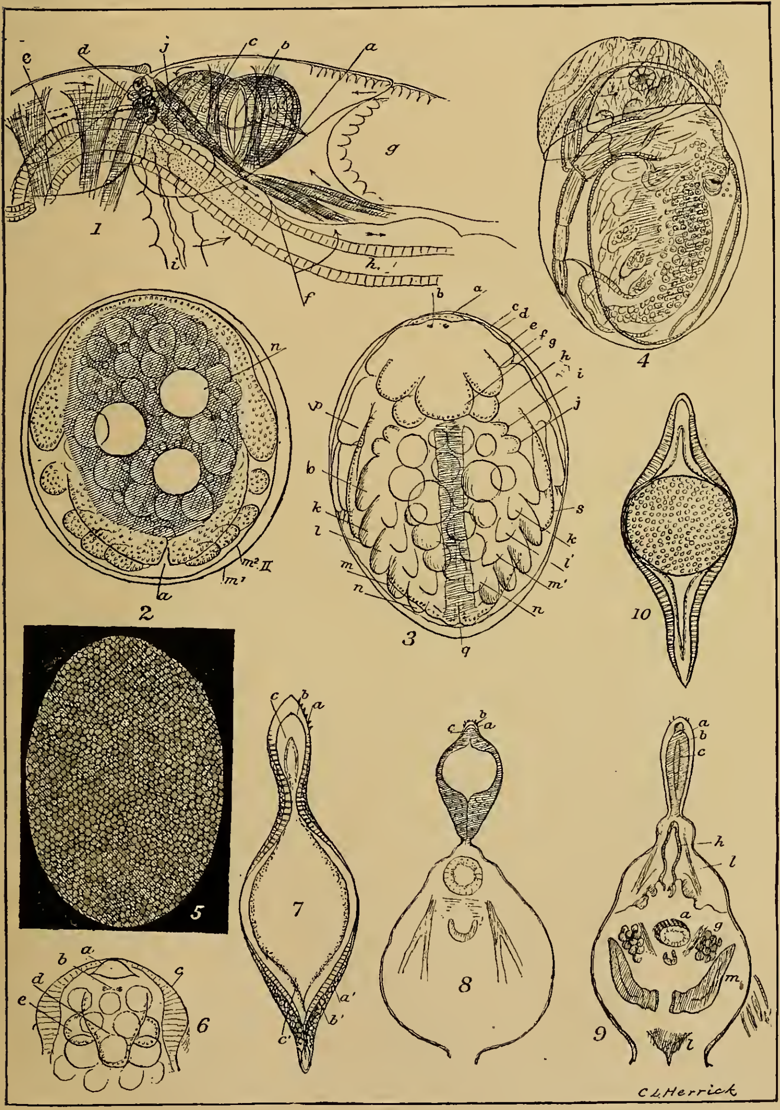
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PLATE Q.

Fig. 1.	*Alonella pulchella*, female.	
Fig. 2.	" "	reticulations.
Fig. 3.	" "	post-abdomen.
Fig. 4.	*Alona modesta*, male.	
Fig. 5.	*Diaptomus similis*, female. 5a. jaw.	
Fig. 6.	" "	fifth foot of male.
Fig. 7.	" "	" " " female.
Fig. 8.	" *minnetonka*, fifth foot of male.	
Fig. 9.	" "	" " " female.
Fig. 10.	" "	abdomen of female.
Fig. 11.	" *stagnalis*, margin of last thoracic segment.	
Fig. 12.	" *sanguineus*, " " " " "	
Fig. 13.	" *stagnalis*, fifth foot of the male.	
Fig. 14.	*Epischura fluviatilis*, abdomen of male.	
Fig. 15.	" *lacustris*, fifth feet of male.	
Fig. 16.	" *fluviatilis*, " " " "	
Fig. 17.	*Diaptomus pallidus* " " " " inner ramus.	
Fig. 18.	" *sicilis* " " " " " "	

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PLATE Q.

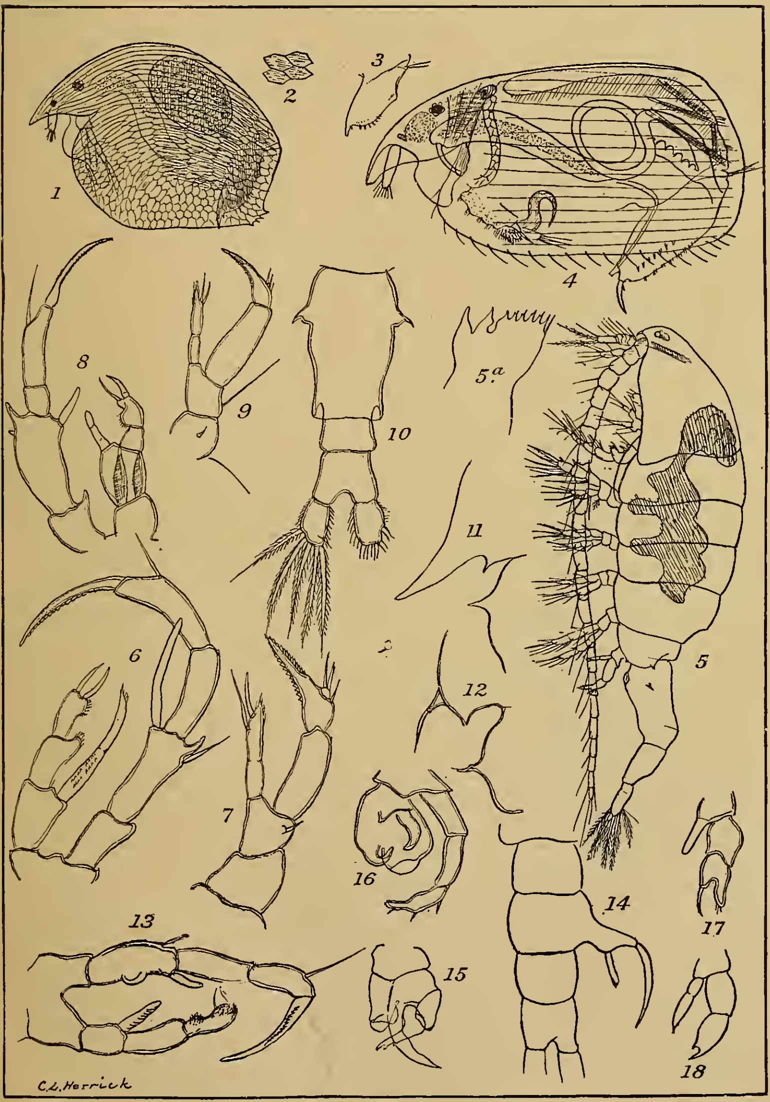

PLATE Q[1].

Fig. 1. *Diaptomus* sp. Young male; external parts as yet but partly developed showing alimentary and reproductive systems as well as a portion of the muscular system. The looped tube is the vas deferens. The small irregularly coiled tube anteriorly is the shell-gland or kidney.

Fig. 2. female with ovary, oviducts and heart.

Figs. 3-4. Nauplius larva of same.

Figs. 5-6. fifth pair of feet of male and female.

Fig. 7. mouth appendages, anteriorly the base of antennæ followed by antennule, labrum, mandible with palp, maxilla and maxilliped.

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From the 10th Annual Report. PLATE Q1. *Geol. & Nat. Hist. Sur. Minn.*

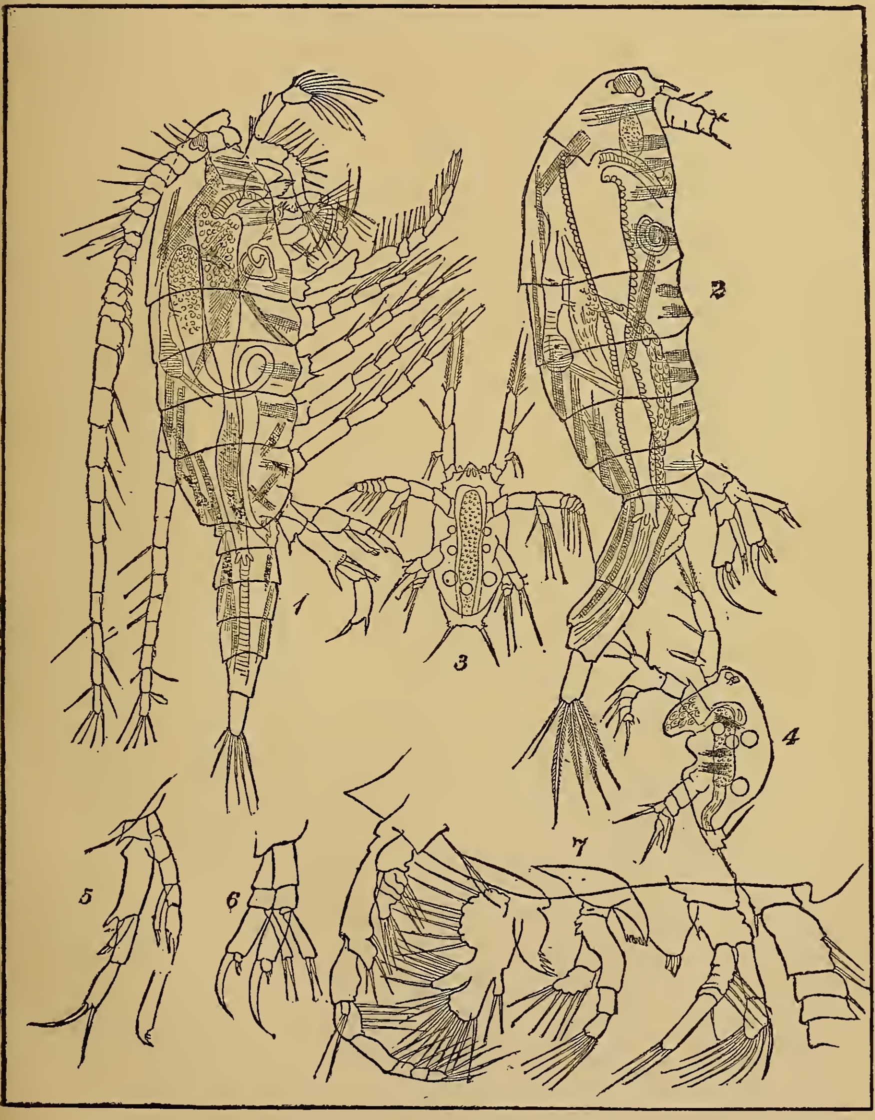

PLATE Q2.

Fig. 1. *Osphranticum labronectum* (*Potamoichetor*), male.
Fig. 2. antennule.
Fig. 3. maxilliped.
Fig. 4. fifth feet of male.
Fig. 5. palp of mandible.
Fig. 6. end of abdomen.
Fig. 7. feet of first pair.
Fig. 8. eye.
Fig. 13. maxilla.
Fig. 14. mandible.
Fig. 9. *Cyclops ater*, female.
Fig. 10. abdomen.
Fig. 11. maxilliped.
Fig. 12. antenna.

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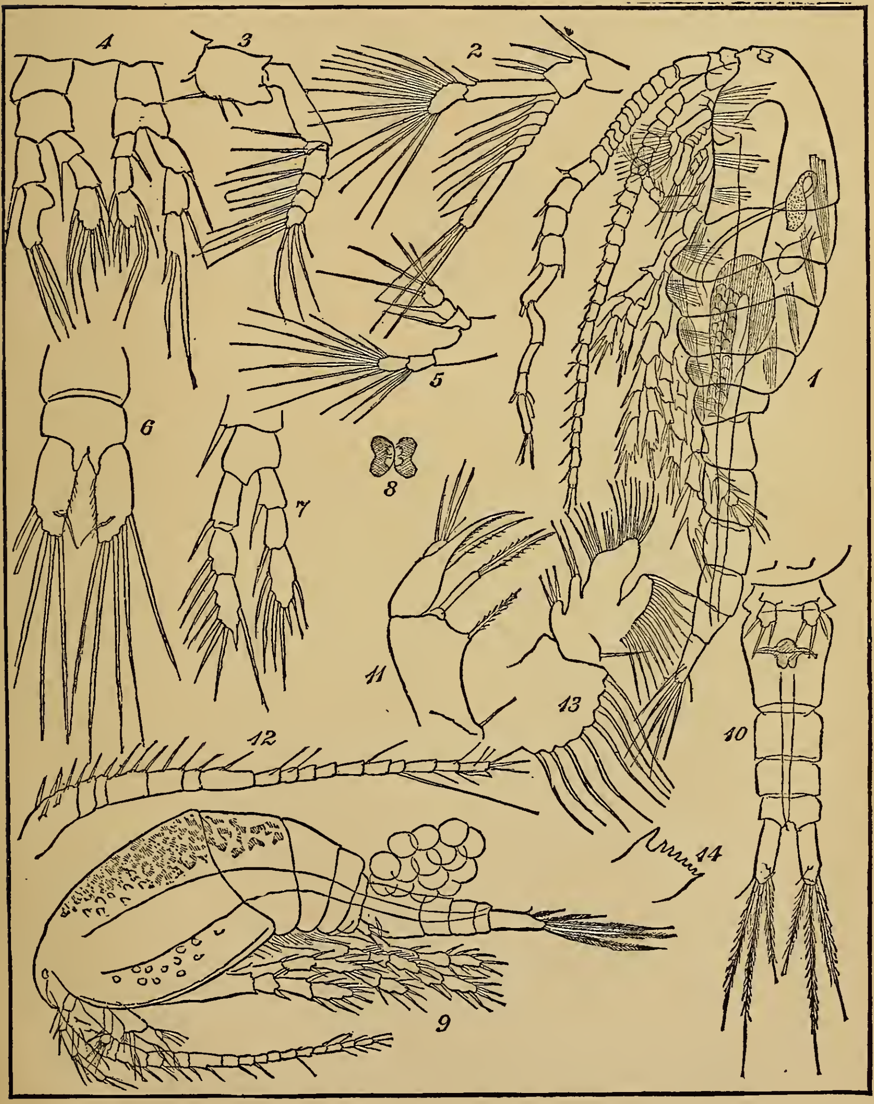

PLATE Q^3.

Fig. 1. *Cyclops ingens*, first segment of abdomen of female.
Fig. 2. antenna.
Fig. 3. fifth foot.
Fig. 4. antenna of young male.
Fig. 5. stylets of mature female.
Fig. 6. stylets of young male.
Fig. 7. maxilliped.
Fig. 8. mandible.
Fig. 9. *Cyclops fimbriatus*, female.
Fig. 10. antenna.
Fig. 11. terminal portion of abdomen.
Fig. 12. female fifth foot.
Fig. 13. second antenna.
Fig. 14. Nauplius form.

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From the 10th Annual Report. PLATE Q3. *Geol. & Nat. Hist. Sur. Minn.*

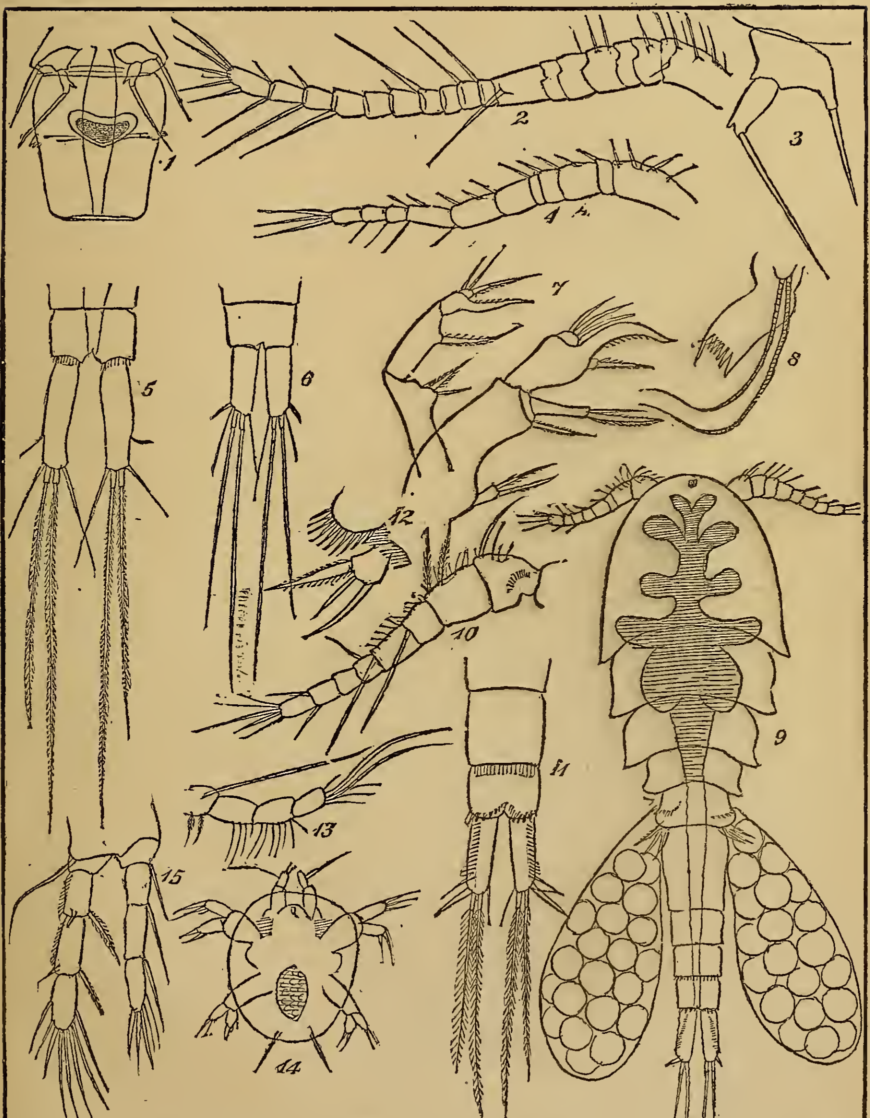

PLATE Q[4].

Fig. 1. *Cyclops tenuicornis*, female.
Fig. 2. mandible.
Fig. 3. maxillæ.
Fig. 4. stylet.
Fig. 5. fifth foot.
Fig. 6. maxillipedes.
Fig. 7. antennæ.
Fig. 8. *Cyclops "signatus,"* abdomen.
Fig. 9. antenna.
Fig. 10. fifth foot.
Fig. 11. male antenna.
Fig. 12. *Cyclops parcus,* abdomen.
Fig. 13. antenna.
Fig. 14. fifth foot.
Fig. 15. *Cyclops "adolescens,"* opening of spermatheca and cement gland.
Fig. 16. *Cyclops "adolescens,"* abdomen.
Fig. 17. foot.
Fig. 18. antenna of female.
Fig. 19. eye.
Fig. 20. antenna of male.
Fig. 21. *Cyclops "signatus,"* end of antenna.

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From the 10th Annual Report. PLATE Q4. *Geol. & Nat. Hist. Sur. Minn.*

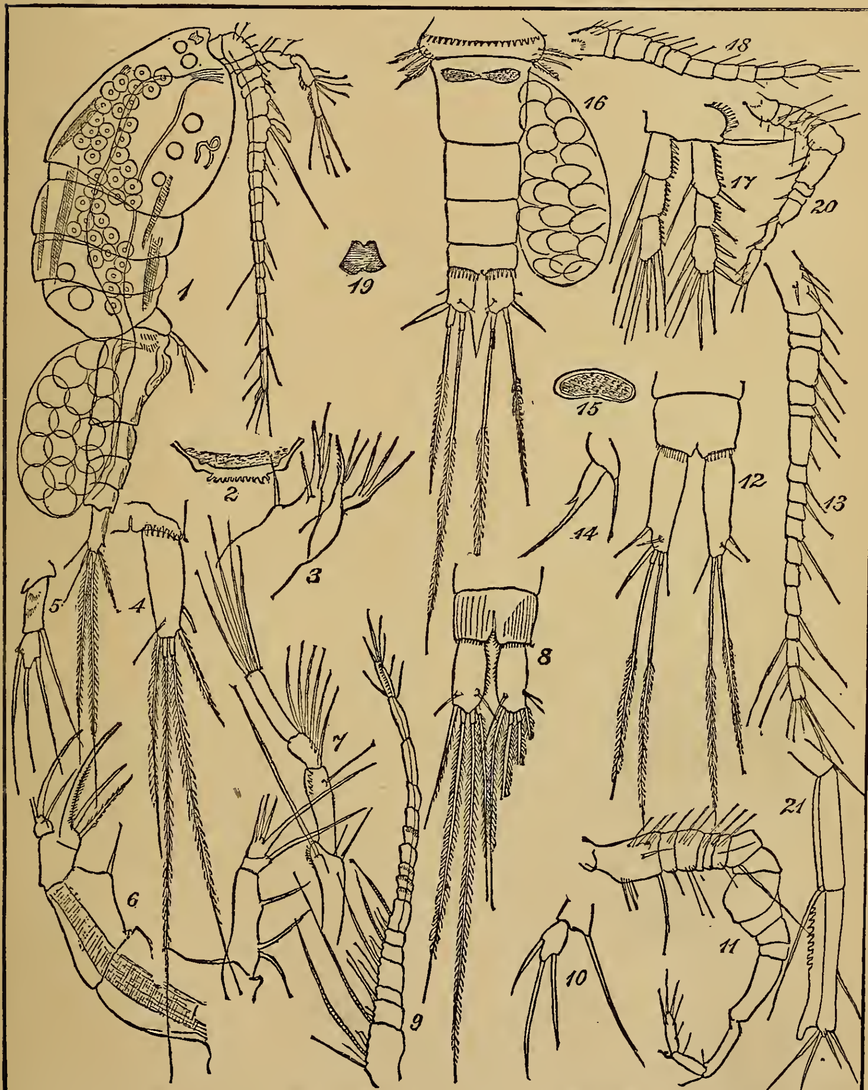

PLATE Q 5.

Fig. 1. *Cyclops fluviatilis,* female.
Fig. 2. antenna.
Fig. 3. antenna of young.
Fig. 4. abdomen of young.
Fig. 5. foot of young.
Fig. 6. foot of adult.
Fig. 7. fifth foot.
Fig. 8. eye.
Fig. 10. *C. serrulatus*, young.
Fig. 11. *Daphnella brachyura*, female.
Fig. 12. *Daphnella brachyura*, male.
Fig. 13. edge of valves.
Fig. 14. abdomen of male.
Fig. 15. abdomen of female.
Fig. 16. antenna of male.

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From the 10th Annual Report. PLATE Q5. *Geol. & Nat. Hist. Sur. Minn.*

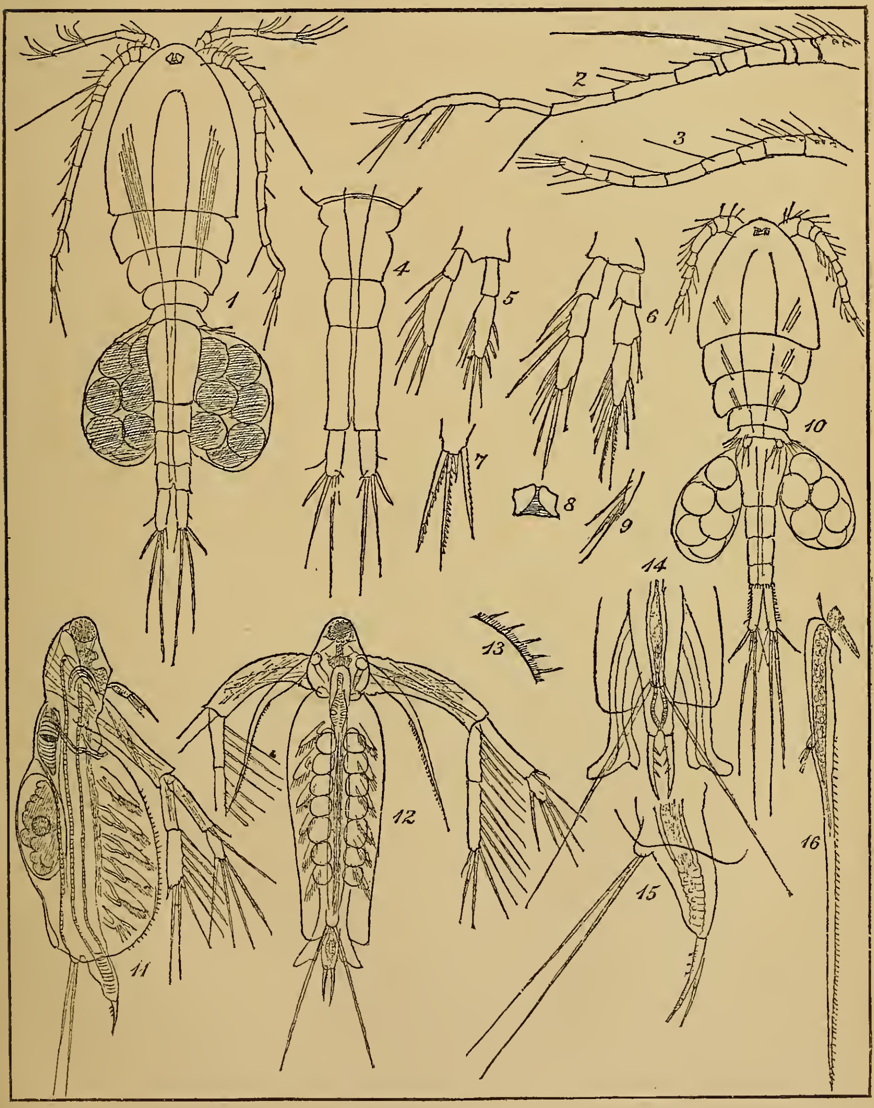

PLATE R.

Fig. 1. *Cyclops modestus.*
Fig. 2. " " end of abdomen.
Fig. 3. " " outer ramus of first foot.
Fig. 4. " " " " " second foot.
Fig. 5. " " fifth foot.
Fig. 6. " *phaleratus*, fourth foot.
Fig. 7. " " outer ramus of first foot.
Fig. 8. " " fifth foot.
Fig. 9. " " caudal stylets.
Fig. 10. " " antenna of young otherwise perfect.
Fig. 11. " *fimbriatus*, end of abdomen.
Fig. 12. " *diaphanus*, abdomen.
Fig. 13. " *ater*, inner ramus of first foot.
Fig. 14. " " outer " " " "
Fig. 15. " " " " " fourth foot.
Fig. 16. " "*signatus*," fourth foot.
Fig. 17. " *ater*, inner ramus of fourth foot.
Fig. 18. " " stylet.
Fig. 19. " *sp.?* first foot.
Figs. 20, 21. " " terminal segments of fourth foot.
Fig. 22. " " fifth foot.
Fig. 23. *Chydorus globosus,* first foot of male.

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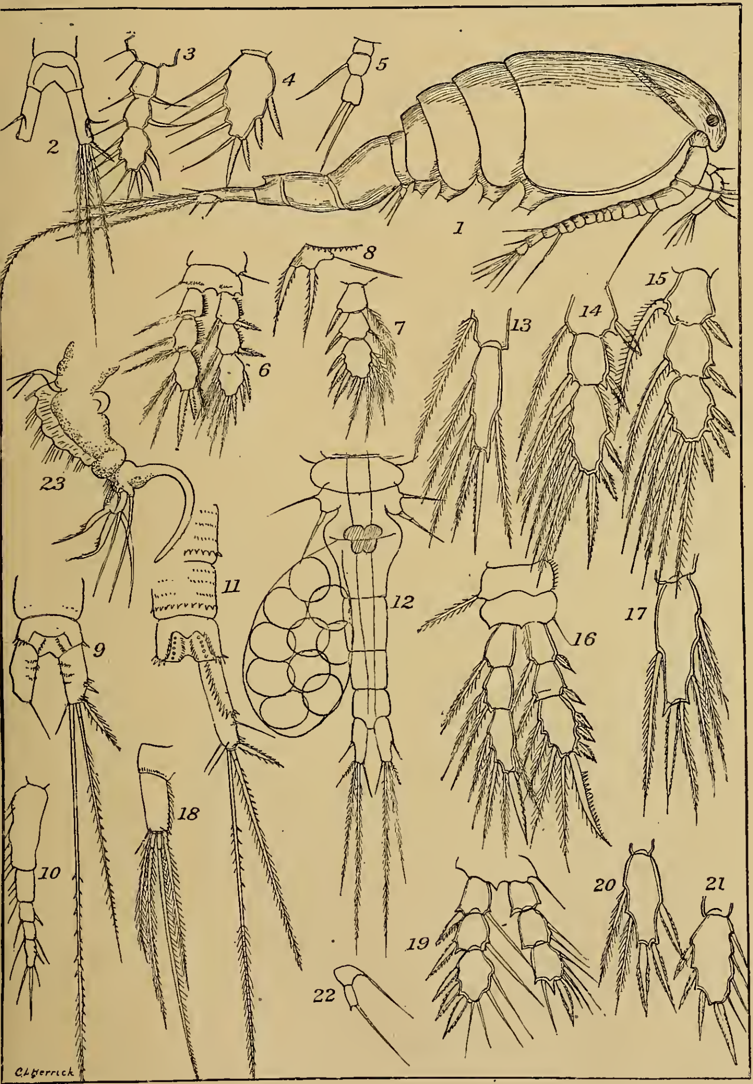

PLATE S.

Fig. 1.	*Ergasilus depressus*, male.		
Fig. 2.	*Cyclops oithonoides* (Amer. C. tenuissimus, var.), stylets.		
Fig. 3.	" "	fifth foot.	
Fig. 4.	" "	antennules.	
Fig. 5.	" "	fourth feet.	
Fig. 6.	" "	antenna of male.	
Fig. 7.	" "	*brevispinosus*, stylet.	
Fig. 8.	" "	"	inner maxilliped.
Fig. 9	" "	"	swimming foot.
Fig. 10.	" "	"	fifth foot,
Fig. 11.	" "	"	antennule.
Fig. 12.	" "	"	opening of spermatheca.
Fig. 13.	*Cyclops sp.?*, nauplius.		

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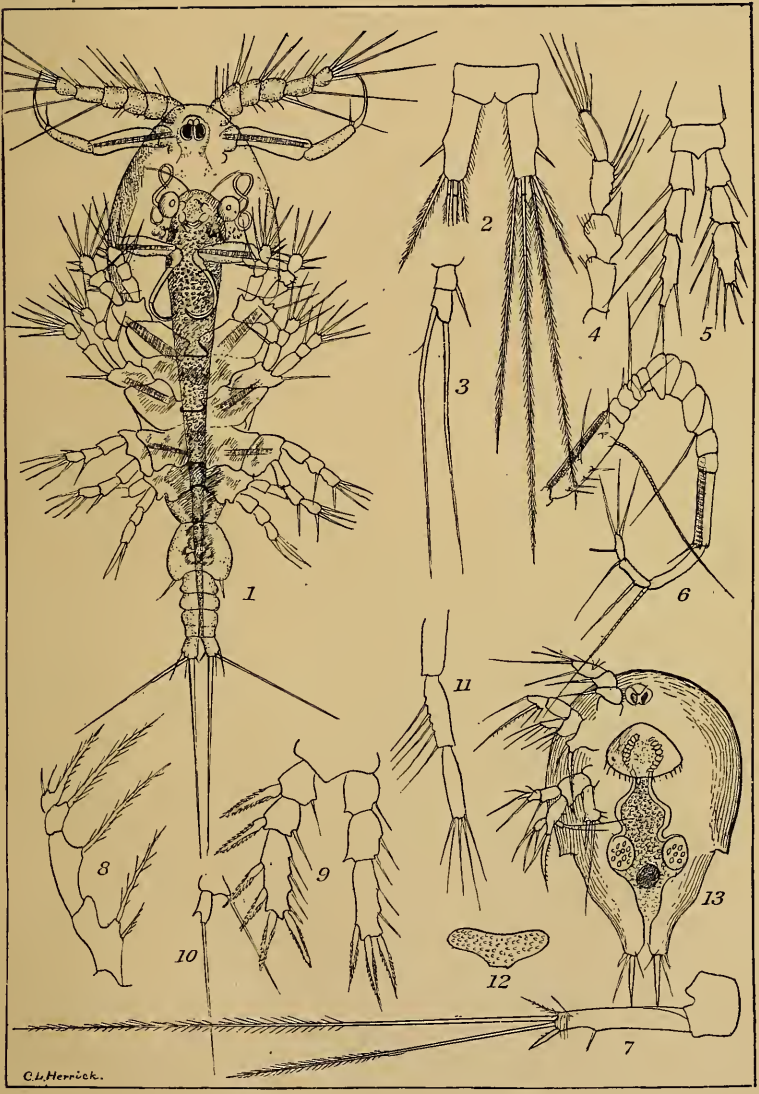

PLATE T.

Fig. 1. *Canthocamptus minnesotensis*, first foot.
Fig. 2. " " stylets.
Fig. 3. " " antenna of female.
Fig. 4. " " fifth foot of female.
Fig. 5. " " " " " male.
Fig. 6. " " antenna of male.
Fig. 7. *Daphnia galeata*, young.
Fig. 8. " " male.
Fig. 9. *Camptocercus leucocephalus*, male.
Fig. 10. *Alonella excisa*, male.
Fig. 11. *Cyclops insignis*, first foot, outer ramus.
Fig. 12. " " fifth foot.
Fig. 13. " " fourth foot.
Fig. 14. " " stylet.
Fig. 15. Worm parasitic in arterial sinus of *Daphnia schœfferi*.

NOTE. On pages 43 and 44, for "Plate T." read Plate J.

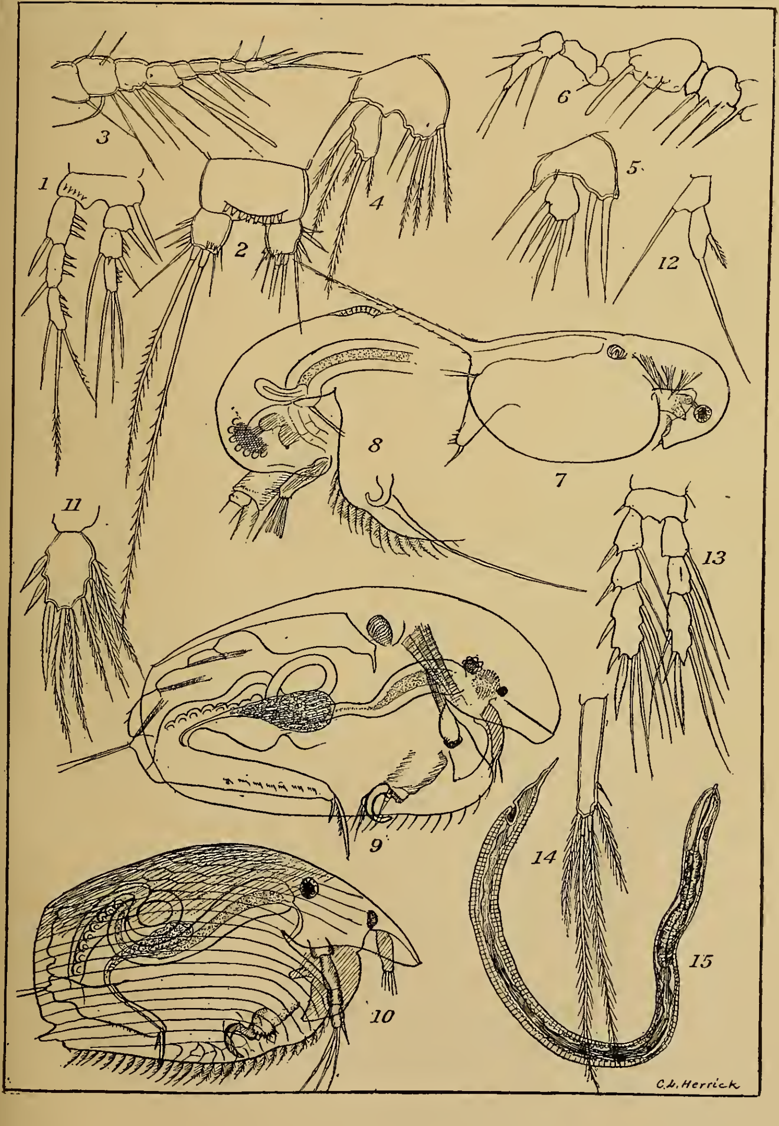
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PLATE U.

Fig. 1. *Daphnia kalbergensis*, of moderate size.
Fig. 2. " " antennule of male.
Fig. 3. " " head of var.
Fig. 4. *Cyclops thomasi*, fourth foot.
Fig. 5. " " outer ramus of first foot.
Fig. 6. *Daphnia galeata,* typical form.
Fig. 7. *Cyclops thomasi*, fifth foot.
Fig. 8. " " stylet.
Fig. 9. *Cyclops (insectus?)*, fourth foot.
Fig. 10. *Bythotrephes longimanus*, female.
Fig. 11. A curious large protozoan; a. infundibulum frame work b. pulsating vacuole; c. nucleus; d. food and digested matter; e. protective rods; 11a. spicules of the infundibulum.

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PLATE U

PLATE U[1].

Figs. 1-14. *Limnetes gouldii*, Baird.
Fig. 15. *Daphnia magniceps,* female.
Fig. 16. *Daphnia minnehaha*, female.

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From the 10th Annual Report. PLATE U 1. *Geol. & Nat. Hist. Sur. Minn.*

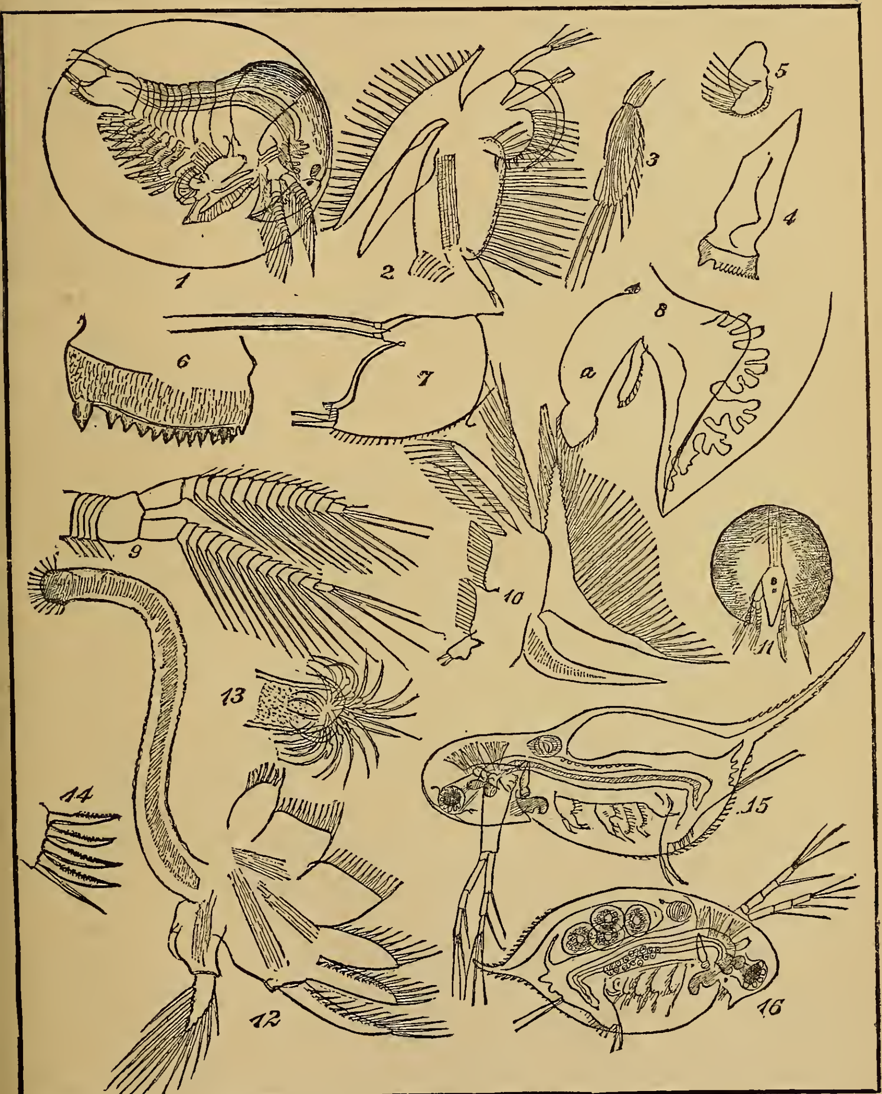

PLATE V.

Fig. 1. *Corethra appendiculata*, head of larva.

Fig. 2. " " portion of heart with its muscles. a. chitinous projection of the body wall to which are attached two muscular threads; b. peripheral muscle; c. proximal muscle attached to the wall of the heart; d. muscles scattered over the surface of the heart, serving as contractors; e. venous opening.

Fig. 3. do., extremity of body.

Fig. 4. do., abdomen of the pupa.

Figs. 5, 6, 7. Rotifera found with entomostraca in Minnesota.

Fig. 8. Flask-shaped rotifer, hermaphrodite, with eggs and sperm. a. jaws and head; b. shell gland; c. glandular portion of the stomach; d. testes; e. œsophagus; f. one of several embryos.

Fig. 9. jaws of the above.

Fig. 10. similar animal, female, deadly enemy to Chydorus.

Fig. 11. jaws of same.

Figs. 12, 13. ? pedicularis, ecto-parasite of *Diaptomus*.

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