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Preliminary List of Deep Water Crustacea in Green Lake, Wis., U. S. A.

By C. Dwight Marsh, Ripon-College, Ripon.

During the past season I made a large number of collections from the deep water of Green Lake, and while I wish to postpone a detailed statement of the results until after further collections and study, I think a preliminary list of the Crustacea would be of interest to those making similar investigations.

The collections were made between the months of August and November, inclusive, and in water between 17 and 49 meters in depth.

The list is as follows:

Diaptomus sicilis Forbes.
Diaptomus minutus Lillj.
Epischura lacustris Forbes.
Limnocalanus macrurus Sars.
Cyclops fluviatilis Herrick.
Cyclops Thomasi Forbes.
Cyclops sp.
Cypris sp.
Daphnella brachyura Lievin.
Daphnia kahlbergensis Schoedler.
Bosmina sp. nov.
Leptodora hyalina Lillj.
Pontoporeia Hoyi Smith.
Mysis relicta Loven.

The new *Bosmina* will be described by Dr. O. E. Imhof.

Diaptomus minutus Lillj. has not, to my knowledge, been found, hitherto, except in Newfoundland.

Pontoporeia Hoyi Smith, has, I think, been reported only from Lake Superior and Lake Michigan, and the only American locality for *Mysis relicta*, Loven, has been these same lakes. In fact, a comparison of this list with those published by Smith and Forbes of the fauna of the Great Lakes shows that the fauna of the deep water of Green Lake is almost identical with that of Lake Michigan.

Ripon, Wis., U. S. A., May 18, 1891.

ON THE DEEP WATER CRUSTACEA OF GREEN LAKE.

By C. DWIGHT MARSH.

Read before the Wisconsin Academy of Sciences, Arts and Letters, December 30th, 1891.

[Reprinted from volume VIII of the Transactions of the Academy.]

ON THE DEEP WATER CRUSTACEA OF GREEN LAKE.

BY C. DWIGHT MARSH.

During the past two seasons I have become interested in the deep water fauna of Green Lake, and have made a large number of collections. While the results may not be particularly striking, I think they are of sufficient interest to warrant the presentation of a short paper on the subject. Because of its depth, Green Lake resembles, in the conditions controlling animal life, the larger bodies of water, and might be expected to have a fauna somewhat different from that of the shallower lakes. My collections seem to justify this expectation.

It is only within a few years that it has been deemed worth while to make any investigation of the fauna of deep water. Even after the existence of a very rich pelagic fauna in the oceans was recognized, bodies of fresh water were almost entirely neglected. Now, it is well known that our lakes have a pelagic fauna rich in individuals, if not in species, and a less abundant abyssal fauna. Most of the European lakes have been explored with more or less thoroughness. Especially noticeable is the extended work of Prof. Forel upon Lake Geneva and the smaller Swiss Lakes.

In this country comparatively little has been done. Since the initiatory work of Dr. Hoy in Lake Michigan, some twenty years ago, so far as I know, only two persons have published anything on this subject — Prof. S. I. Smith, and Prof. S. A. Forbes.

The bottom of Green Lake, in the deeper parts, is a fine blue clay, in which are great numbers of ostracod shells and some few shells of molluscs. I submitted the molluscs to Mr. C. T. Simpson of the United States National Museum, who tells me that there was nothing of especial interest among them. They were all littoral forms, and, in most cases, probably washed in from shallower water.

There were also several species of hydrachna, worms, and infusoria, which I have not worked out. The crustacean fauna is extremely abundant, although the number of species is small.

The following species were noted:

Diaptomus sicilis Forbes.
" *minutus* Lillj.
Epischura lacustris Forbes.
Limnocalanus macrurus Sars.
Cyclops fluviatilis Herrick
" *serrulatus* Fischer.
Canthocamptus sp.
Cypris sp.
Daphnella brachyura Baird.
Ceriodaphnia reticulata Jurine.
Daphnia kalbergensis Schoedler.
Bosmina sp.
Alona glacialis Birge.
Leptodora hyalina Lillj.
Pontoporeia Hoyi Smith.
Mysis relicta Loven.

There were, besides, several forms of *cyclops*, which seem to differ from any described American species. As I am now engaged in a study of this genus, I will leave their description for a later publication. None of the species of cyclops which I have found is peculiar to the deep water, as I have found the same forms in the littoral zone of the lake, and in smaller bodies of water in the vicinity.

The pelagic fauna consists mainly of the following species: *Diaptomus minutus* Lillj; *Diaptomus sicilis* Forbes; *Epischura lacustris* Forbes; *Limnocalanus macrurus* Sars; *Daphnia kalbergensis* Schoedler; *Leptodora hyalina* Lillj. All of these, with the exception of *limnocalanus macrurus*, come to the surface at night. The species of *cyclops* are represented very sparingly, and *canthocamptus*, *daphnella*, *ceriodaphnia*, and *alona* are quite rare. Evening collections showed vast numbers of *diaptomus minutus* and *epischura lacustris*, and in some cases of *leptodora hyalina.* I found *bosmina* very abundant in November, but rather rare in the summer months. The *abyssal crustacea* are *cypris*, *pontoporeia Hoyi* Smith, *mysis relicta* Loven, and perhaps some of the forms of *cyclops.* Especial interest, perhaps, attaches to three species of the preceding list.

Diaptomus minutus Lillj. is found in great numbers, being much more abundant than *diaptomus sicilis* Forbes. My specimens correspond very closely to the description by Lilljeborg, as given in "Revision des Calanides d'Eau Douce," by Guerne and Richard, differing only in the following particulars. The joints of the right fifth foot of the male are shorter and stouter, and the terminal claw is longer and somewhat more slender; the lateral spine on the last joint is blunt. The inner ramus of the left foot is more nearly elliptical. The animal averages somewhat smaller than the type. These differences are so minute that I consider them only varietal, although they are constant in the specimens I have examined.

Diaptomus minutus has been found, hitherto, only in Greenland and Newfoundland, although it seems probable that it is widely distributed over the northern part of North America.

Pontoporeia Hoyi Smith, has been found, hitherto, only in Lake Superior and Lake Michigan. A species almost identical with it, *pontoporeia affinis* Kroyer, occurs in the abyssal fauna of the Scandinavian lakes.

Mysis relicta Loven, was first found in the Scandinavian lakes. It is so closely allied to *mysis oculata* Kroyer, a marine form found off the coast of Labrador and Greenland, as to be considered only a variety of that species. It was found in Lake Michigan by Dr. Hoy, receiving the name of *mysis diluvianus* from Prof. Stimpson. Later, Prof. S. I. Smith collected specimens in Lake Superior. I have not had an opportunity to compare my specimens with those from the Great Lakes, or with the original description of the Scandinavian form, but I have little doubt that they are identical with them.

When we compare the deep water crustacea of Green Lake with those of Lake Michigan and Lake Superior, as shown in the lists published by Prof. Smith and Prof. Forbes, we find a striking similarity. That this should be true of the pelagic fauna is not strange, for it is easy to explain the migration of such forms from one body of water to another through the agency of water fowl.

The presence of *pontoporeia Hoyi*, and *mysis relicta* however, is not so easily explained. They are abyssal forms, found only in deep water, and never coming to the surface. Their presence in the Scandinavian lakes is explained by supposing that the bodies of water, in which they are found, were formerly connected with the sea, and that, when the access of salt water was cut off, the change to fresh water was so gradual that the animals accustomed themselves to their new conditions of existence. They belong to the "fauna relegata" or "relickten-fauna" of the Germans. This explanation does not seem to apply to Green Lake. The lake is of glacial origin, a dam of drift at the western end preventing its waters from flowing into lake Puckaway. The outlet of the lake is a small stream flowing through the village of Dartford, and emptying into the Fox River. So far as I know, there is no geological evidence whatever of any connection of Green Lake with either the Mississippi Basin or the Great Lakes, by which these deep water animals could have migrated to their present location.

The problem is one for which I can at present offer no solution.

NOTES ON DEPTH AND TEMPERATURE OF GREEN LAKE.

By C. DWIGHT MARSH.

Read before the Wisconsin Academy of Sciences, Arts and Letters, December 30th, 1891.

[Reprinted from volume VIII of the Transactions of the Academy.]

NOTES ON DEPTH AND TEMPERATURE OF GREEN LAKE.

By C. DWIGHT MARSH.

Green Lake is situated in Green Lake county, and is something over seven miles in length, and rather less than two miles in its greatest breadth. It extends in a northeast and southwest direction, and is considered by geologists, to be of glacial origin, its shores at the western extremity being formed of drift hills.

The lake is of especial interest because of its depth, it being, I think, the deepest lake within the limits of the state.

While at various times soundings have been made by which the deepest parts of the lake were located with a fair amount of accuracy, the only attempt at systematic soundings was made some years ago by Prof. C. A. Kenaston, when he was connected with Ripon college. Through the kindness of Mr. Henry Wolcott, of Ripon, I was enabled to get the results of Prof. Kenaston's work. The soundings were made in winter through the ice and the distances between stations chained off.

Four lines of soundings were made: from Bowen's cottage to Oakwood Hotel, from Sandstone Bluff to Oakwood, from Sandstone Bluff to Sherwood Forest, and from Sandstone Bluff to Sugar Loaf. The following tables give the results:

From Bowen's Point to Oakwood.

Distance.		*Depth.*
64 rds.	1056 ft	63 feet.
192 "	3118	96 "
256 "	4174	84 "
272 "	4438	97 "
288 "	4702	90 "
304 "	4968	20 "
320 "	5232	61 "
336 "	5496	66 "
352 "	5760	53 "
384 "	6388	38 "
432 "	7180	49 "
464 "	7708	41 "
626 "	10581	Shore.

From Sandstone to Oakwood.

Distance.	*Depth.*
27 rds.	52 feet.
43 "	89 "
59 "	144 "
75 "	160 "
91 "	160 "
155 "	151 "
267 "	88 "
315 "	27 "
363 "	25 "
395 "	48 "
427 "	22 "
491 "	Shore.

From Sandstone to Sugar Loaf.

Distance.	*Depth.*
48 rds.	75 feet.
96 "	136 "
144 "	160 "
208 "	180 "
320 "	190 "
560 "	195 "
720 "	180 "
752 "	152 "
816 "	40 "
896 "	Shore.

From Sandstone to Sherwood Forest.

Distance.	*Depth.*
40 rds.	150 feet.
64 "	160 "
100 "	159 "
196 "	140 "
256 "	132 "
292 "	73 "
316 "	15 "
348 "	Shore.

From these tables and the profiles derived from them, it will be seen that the eastern part of the lake is comparatively shallow, and that there is a bar not far from the center where the depth is only twenty feet. The greatest depth — 195 feet — is reached between Sandstone Bluff and Sugar Loaf.

I have made no attempt at systematic soundings, but, in connection with dredging, have always taken the depth at the time of the haul, and my figures agree in all respects with those of Prof. Kenaston, except that they are uniformly somewhat less; this is easily explained by the fact that the level of the lake has been lower than usual for the past two or three years.

In the western part of the lake but few soundings have been made by any one. Capt. Pierce tells me that the greatest depth he has found is 172 feet. It is popularly supposed that the deepest place is between Sugar Loaf and the south shore, as that is the last place to freeze. I have found there, however, only 189 feet.

It will be noticed that the littoral zone, in most parts of the lake, is very narrow, considerable depths being reached quite near the shore.

When dredging in deep water, I also took surface and bottom temperatures. This work was done in Aug., Sept., and Oct. 1890, and July, 1891. As, so far as I know, very little work of this kind has been done in our lakes, I have thought the results worth recording, although my observations were too few to form a basis for any general inferences.

For bottom temperatures, I used a Miller-Casella deep sea thermometer, loaned by the United States Commissioner of Fish and Fisheries, and for surface temperatures a common chemical thermometer. As the thermometers were not tested, the results may not be absolutely accurate. The deep sea thermometer was attached about two meters from the sounding lead, giving the "bottom temperature."

The following tables give the temperatures arranged by depths:

AUGUST, 1890.

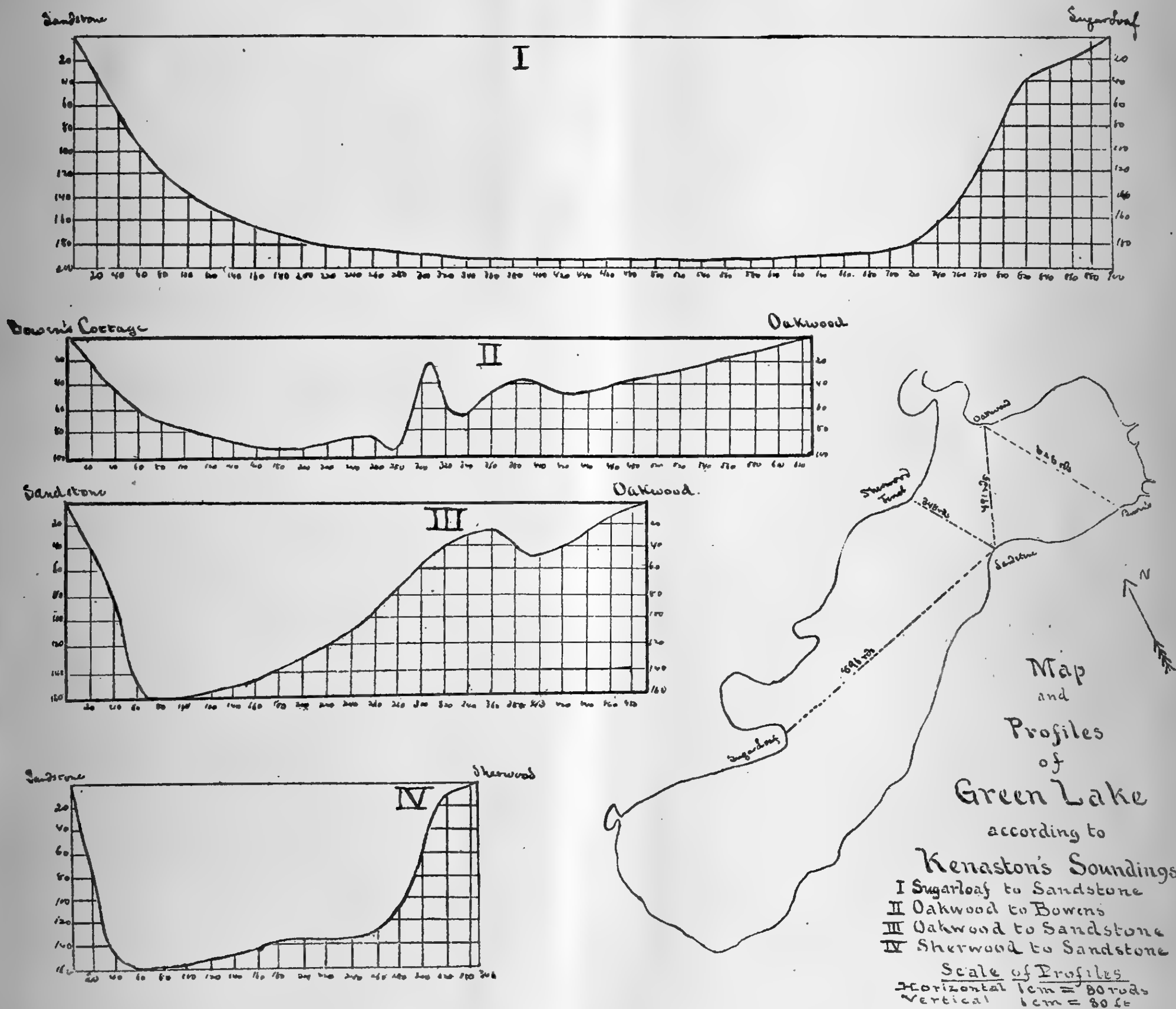
Depth.	Surface tem.	Bottom tem.
17 meters.	25° C.	10.25° C.
24.5	25.	7.7
31.	26.	7.45
33.	24.	7.2
36.	25.5	7.2
40.5	26.	7.
40.85	25.	7.
41.5	24.	7.
42.	24.5	7.
42.2	24.	7.
43.	24.	7.
45.25	....	6.6
46.75	24.	6.6
48.45	22.	6.6

July, 1891.

Depth.	Air tem.	Surface tem.	Bottom tem.
41.85 meters.	22°.77 C.	21.° C.	5.4° C.
43.5	23.33	23.	5.56
50.	22.22	22.	5.28
50.5	25.	22.	5.28
51.2	20.55	22.	5.28
56.	21.11	21.	5.28
57.75	24.72	21.	5.28
58.	26.3		5.28

We notice that in August, 1890, there was a uniform temperature of 6.6° C. below a depth of 45 meters, and that up to 25 meters there was an elevation of temperature of only one degree. In July, 1891, the bottom temperature was 5.28° C. While we cannot compare temperatures taken in August, 1890, with those taken in July, 1891, I think we may fairly infer that the maximum bottom temperature in Green Lake is reached in August, and that it remains nearly the same during September and October. The surface temperature is nearly the same in all the deeper parts of the lake. Swimmers, in crossing the lake, claim that they pass through "streaks" of different temperatures, but the thermometer determinations show a practical uniformity of surface temperature.

In comparing these temperatures with those obtained by Prof. and Mrs. Peckham in Pine Lake (Trans. Wis. Acad. V, 273), I notice that although the surface temperatures in Pine Lake, in both July and August, are higher than in Green Lake, the temperature of the deep water is nearly the same. For instance, in August, 1879, at a depth of 18.28 meters, the bottom temperature was 7.23° C., while the surface temperature at the same time was 24.44° C., and in July, at a depth of 24.38 meters, the bottom temperature was 5.56° C., and the surface temperature 26.12° C. Thus, at 24.38 meters, was reached very nearly the minimum temperature which I found in Green Lake at 50 meters and below.


Sandstone
Sugarloaf
I
Bowen's Cottage
Oakwood
II
Sandstone
Oakwood.
III
Sandstone
Sherwood
IV
N
Map
and
Profiles
of
Green Lake
according to
Kenaston's Soundings
I Sugarloaf to Sandstone
II Oakwood to Bowens
III Oakwood to Sandstone
IV Sherwood to Sandstone
Scale of Profiles
Horizontal 1 cm = 80 rods
Vertical 1 cm = 80 ft

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NOTES ON THE COPEPODA OF WISCONSIN.

BY C. DWIGHT MARSH, RIPON, WISCONSIN.

In the waters of Wisconsin and in the adjacent lakes are found the following twenty-one species of free-swimming copepods: *Diaptomus sanguineus*, Forbes; *D. leptopus*, Forbes; *D. pallidus*, Herrick; *D. sicilis*, Forbes; *D. ashlandi sp. nov*; *D. minutus*, Lillj.; *D. oregonensis*, Lillj.; *Epischura lacustris*, Forbes; *Limnocalanus macrurus*, Sars; *Cyclops americanus, sp. nov.*; *C. brevispinosus*, Herrick; *C. pulchellus*, Koch; *C. navus*, Herrick; *C. parcus*, Herrick; *C. leucarti*, Sars; *C. signatus*, Koch; *C. modestus*, Herrick; *C. fluviatilis*, Herrick; *C. serrulatus*, Fischer; *C. phaleratus*, Koch; *C fimbriatus*. Fischer.

Although two of these, *D. ashlandi* and *C. americanus*, are new species, it is not probable that they are peculiar to the Wisconsin fauna. The copepods of America have thus far received very little attention, the only important publications on the subject being by three men, Professor Cragin, Professor Herrick and Professor Forbes. If more were known of our copepods it is probable that it would be found that there are few local differences in the faunæ of our northern States. The copepods are readily transported from one body of water to another and, without change of structure, seem to endure great changes in their environment. In fact, half of our species of cyclops are not only widely distributed in America, but are identical with those of Europe. Those that may be considered distinctly American are closely allied to well-known European forms.

C. leucarti is found in nearly all parts of the world where collections have been made and, so far as can be inferred from the published descriptions, varies but little, even in the minute details of its structure.

C. americanus closely resembles *C. viridis*, and is probably the species which has by other American authors been identified with *viridis*. Although there seems to be good reason for separating it from the European species, the similarity of the two forms is so great that it is only by a close examination that the structural differences become apparent.

It is very possible that *C. brevispinosus* should be considered a pelagic variety of *C. americanus*, thus reducing by one the number of species peculiar to America. There is some reason, too, for supposing that *C. navus* is not specifically distinct from *C. pulchellus*.

C. pulchellus is the common pelagic form of the Great Lakes. Although found in smaller lakes, it is more commonly replaced by *C. brevispinosus*, which is a species of wide distribution.

C. navus is found only in stagnant pools.

The most common of all our species is *C. serrulatus*. Rarely is a collection without this form, which seems to adapt itself easily to very different surroundings. It has, however, wide

limits of variation, and it is, perhaps, due to this fact that it is so universally distributed. The littoral and pelagic forms are so different that they have been considered specifically distinct.

C. modestus is a rare form. Thus far it has been found in only a single locality in Wisconsin.

None of the American species of *Diaptomus* is identical with those of Europe, although in some cases the relationship is very close.

D. sicilis is the common pelagic form of the Great Lakes, but occurs also in smaller bodies of water. *D. ashlandi* has been found only in the Great Lakes.

The most common species in the smaller lakes is *D. oregonensis*. This was described by Lilljeborg from specimens collected in Oregon, and probably is common through our northern States. *D. minutus* is common in Newfoundland, Greenland and Iceland. It occurs in some of the small lakes in northern Wisconsin and in Green Lake. It is likely that it occurs quite generally through the northern part of North America, and possibly central Wisconsin is near its southern limit.

Especial interest attaches to the fauna of Green Lake. This is about seven miles long, with a maximum depth of nearly two hundred feet. While the pelagic fauna of the Great Lakes is quite distinct from that of the smaller lakes, we find in Green Lake both sets of faunæ. *D. sicilis* and *Limnocalanus macrurus* I have not found outside the Great Lakes except in Green Lake. But besides these species the pelagic fauna of Green Lake includes *C. brevispinosus* and *C. fluviatilis*, which are the characteristic species of the smaller lakes.

A more detailed account of the Wisconsin copepoda will soon appear in the Transactions of the Wisconsin Academy.

ON THE CYCLOPIDÆ AND CALANIDÆ OF CENTRAL WISCONSIN.

BY C. DWIGHT MARSH, RIPON, WIS.

Read before the Wisconsin Academy of Sciences, Arts and Letters, June, 1892.

[Reprinted from Volume IX of the Transactions of the Academy.]

ON THE CYCLOPIDÆ AND CALANIDÆ OF CENTRAL WISCONSIN.

BY C. DWIGHT MARSH.

The material on which this paper is based has been largely collected from the immediate vicinity of Ripon. The fauna of Green Lake I have been enabled to study with considerable thoroughness; I have not only made a large number of collections, but they have been made at all seasons from early spring to December, and the work has extended over several years. From some ponds in the neighborhood of Ripon, I have made similar repeated collections. From Lake Puckaway, Lake Winnebago, and the smaller lakes in Fond du Lac and Green Lake counties, my collections were for the most part made in the months of July and August.

Through the kindness of Prof. E. A. Birge, I have also had material collected by him from lakes in the northern part of the state, and by Miss H. Merrill from the Great Lakes.

This is not presented as a final report, for I still feel very doubtful in regard to the relationships of some species. But to properly define these relationships seems likely to involve a long period of study, and possibly it cannot be done satisfactorily until more is known of the embryonic and larval stages. Inasmuch as so little has been published in regard to American copepoda, I may be justified in publishing this paper, although I am well aware of its imperfections.

While faunistic studies of fresh-water crustacea have been quite thoroughly prosecuted in Europe, and to some extent in Asia and Africa, only a few localities in the United States have been studied with any degree of thoroughness. The only considerable publications on copepoda have been made by Prof. Forbes, Prof. Cragin and Prof. Herrick. Prof. Forbes, who has made very important additions to our knowledge of

American entomostraca, made his collections in Illinois, southern Wisconsin, the Great Lakes, and Montana and Wyoming. Prof Cragin collected in eastern Massachusetts. Prof. Herrick has collected very widely through the Mississippi valley and the southern states. His reports on the Minnesota crustacea (**22, 25, 26**) covered a region with a fauna nearly identical with that of Wisconsin. His work of exploration must have been done very thoroughly, for my work in Wisconsin gives me little to add in the way of new species. Because of incomplete descriptions or a lack of figures, it is, in some cases, however, difficult to identify his species.

In Wisconsin the cladoceran fauna is better known than in any other part of the United States through the well-known work of Prof. Birge, but the copepoda have been almost entirely neglected.

While the number of copepods in a collection from any locality is frequently very large, the number of species is generally small. In pools which are swarming with individuals, frequently there are not more than two or three species. In pelagic collections there are seldom more than four to six species. Of diaptomus there is ordinarily only one species in a locality, although two or three species are sometimes found together in pelagic collections.

Some species ot copepods may be considered strictly pelagic, and some as strictly littoral, while others are found only in stagnant pools. But many species readily adapt themselves to all these conditions, and with little or no change of structure seem to thrive equally well wherever they may be.

The following may be considered a fairly accurate division of the species according to their habitat:

	Pelagic.	Littoral.	Stagnant Pools.
Diaptomus sanguineus	......	......	x
" *leptopus*	......	......	x
" *pallidus*	......	x	......
" *sicilis*	x	......	......
" *ashlandi*	x	......	......
" *minutus*	x	......	......
" *oregonensis*	x	......	......
Epischura lacustris	x	......	......
Limnocalanus macrurus	x	......	......
Cyclops americanus	......	x	x
" *brevispinosus*	x	x	......
" *navus*	......	......	x
" *pulchellus*	x	......	......
" *parcus*	......	......	x
" *leuckarti*	x	x	......
" *signatus*	x	x	x
" *modestus*	......	x	......
" *fluviatilis*	x	......	......
" *serrulatus*	x	x	x
" *phaleratus*	......	......	x
" *bicolor*	......	......	x
" *fimbriatus*	......	......	x

None of our species is peculiar to this immediate region, and it is probable that they are widely distributed over the northern part of the United States and the southern part of British America. Indeed, the copepod fauna of North America resembles very closely that of Europe and northern Asia. This fact has already been remarked by Prof. Birge in regard to the cladocera, and it seems no less true of the copepoda. Many of our species are identical with those of Europe, even in the minutest details, as in the case of *Cyclops leuckarti* Sars. In other cases the structural differences are slight, and it is very probable that we should consider them of only varietal value, were we acquainted with the limits of species variation. That the species should be identical, or nearly so, over such a wide extent of territory is not at all strange when we remember how easily the living animals and their eggs may be transported by water-fowl. Most of the forms, too, seem to readily adapt themselves to change of environment with little perceptible change of structure. Thus *Cyclops pulchellus* Koch, is a common pelagic form of the larger lakes, and seems well adapted to its environment, but I have found it in Rush Lake, a reed-covered, shallow body of water, in which we would hardly expect to find any distinctive pelagic fauna.

It is to be noticed that the American species of *Diaptomus* are distinct from those of Europe, and that they are, in some cases, quite limited in their distribution.

The pelagic species are generally colorless, and the body and appendages are more elongated than in the littoral forms. When a species occurs both in shallow and in deep water, the same difference is noted, the pelagic forms in some cases forming well marked varieties.

The species of shallow water and stagnant pools are frequently highly colored, but the color is generally of little value in distinguishing species. Quite generally all the copepoda and cladocera of a pool have the same prevailing color, while the same species under other conditions of environment may be entirely colorless. This was noticed by Herrick in 1883 (**25** p. 385.) Certain species, however, seem to have a coloration peculiarly their own,—like the purple tips of the antennæ in *Diaptomus leptopus*. The specimens of *Cyclops modestus* which I have found, have possessed a distinct purple tinge, very different from the colors of the species with which they were associated.

In the synonomy of species I have followed the European authors. It seems to me next to an impossibility to identify the species of Koch and Baird, for their descriptions are of no value whatever. All that is left for one to do is to accept them as defined by later authors.

It has not been my aim to add to the already sufficiently numerous descriptions of "new species," but rather to make more clear the descriptions already given, to indicate the proper synonymy, and to reduce the number of specific names rather than to increase them. In doing this, I know I have laid myself open to criticism, for it is, perhaps, presuming too much to revise another author's descriptions. My only excuse is my reluctance to add to the cumbersome nomenclature of the genera under discussion. For example, I have no doubt of the identity of a Wisconsin species with *Cyclops brevispinosus* Herrick, but Herrick's description is not sufficient for a satisfactory identification. Therefore, rather than to add a new species name, I have ventured to describe this species more completely.

Inasmuch as printed descriptions, even when accurate, are frequently misleading, and as a list of species is only valuable when one is certain of the accuracy of the identification, I have, in most cases, drawn figures of the essential anatomical characteristics of the species treated of, and trust that I shall have made clear at least what species I have described, and have rendered it possible, if I have made mistakes, for others to detect those mistakes.

	Green Lake.	Little Green Lake.	Lake Winnebago.	Twin Lakes.	Spring Lake.	Rush Lake.	Heart Lake.	Lake Puckaway.	Lake Minocqua.	Great Lakes.	Stagnant Pools.
Diaptomus sanguineus											x
" *leptopus*											x
" *pallidus*							x				
" *sicilis*	x									x	
" *ashlandi*										x	
" *minutus*	x									x	
" *oregonensis*		x	x	x					x	x	
Epischura lacustris	x							x		x	
Limnocalanus macrurus	x									x	
Cyclops americanus	x	x				x					x
" *brevispinosus*	x	x	x	x	x	x	x	x	x	x	
" *navus*											x
" *pulchellus*						x			x	x	
" *parcus*											x
" *leuckarti*	x	x	x	x	x	x	x	x	x	x	
" *signatus*	x	x			x	x	x	x	x		
" *modestus*						x					
" *fluviatilis*	x	x							x		
" *serrulatus*	x	x	x	x	x	x	x	x	x	x	x
" *phaleratus*	x	x			x	x					x
" *bicolor*											x
" *fimbriatus*											x

The foregoing table will give an idea of the distribution of the species in some of the bodies of water which I have examined. Green Lake is about seven miles long and has a maximum depth of a little less than two hundred feet. The other lakes—the Great Lakes excepted—are shallow. Lake Winnebago, although a large body of water, is said to be nowhere more than twenty-five or thirty feet in depth. Rush Lake is pretty largely covered with a growth of rushes and wild rice, and is being gradually filled up. Lake Puckaway is an expansion of Fox river, is to a considerable extent covered with wild rice and rushes, and is very shallow.

FAMILY CALANIDÆ.

Genus DIAPTOMUS Westwood.

KEY TO SPECIES OF DIAPTOMUS FROM CHARACTERISTICS OF MALE.

Antepenultimate joint of antenna without appendage,
- Fifth feet nearly equal in length, *oregonensis.*
- Left fifth foot shorter than right, *pallidus.*

Antepenultimate joint of antenna with hyaline lamella, *leptopus.*

Antepenultimate joint of antenna with appendage,
- Appendage short and blunt, *sanguineus.*
- Appendage as long or longer than penultimate joint,
  - Terminal hook of right fifth foot broad, lateral spine minute, *minutus.*
  - Terminal hook falciform,
    - Lateral spine nearer outer extremity of joint, *sicilis.*
    - Lateral spine stout, near base of joint, *ashlandi.*

Diaptomus sanguineus Forbes.

Plate III. Figs. 1–3.

1876. *D. sanguineus* Forbes (**17**) pp. 15, 16 and 23, figs. 24, and 28–30.

1882. *D. sanguineus* Forbes (**22**) p. 647, pl. VIII, figs. 1–7, and 13.

1884. *D. sanguineus* Herrick (**26**) p. 138, pl. Q, fig. 12.

" " *minnetonka* Herrick (**26**) p. 138, pl. Q, figs. 8–10.

1889. " *sanguineus* DeGuerne and Richard (**32**) p. 20, pl. IV, fig. 24.

This species, which is found in pools in the spring months, is readily recognized by the characters of the male antennæ and fifth feet. My specimens differ in minute particulars from the figures given by Forbes; the lateral spine on the terminal joint of the outer ramus of the right fifth foot in the male is nearer the distal end of the joint, while Forbes's figure makes its position nearly median; the blunt spine on the inner angle of the second joint of this foot is a little longer than the spine at the outer angle, instead of shorter, as in his figure.

D. minnetonka Herrick is probably a variety of *D. sanguineus.*

Diaptomus leptopus Forbes.

Plate III. Figs. 4 and 5.

1882. *D. leptopus* Forbes (**22**) p. 646, pl. VIII, figs. 17–19.

1884. " *longicornis* var. *leptopus* Herrick (**26**) p. 140.

1889. " *leptopus* DeGuerne and Richard (**32**) pl. II, fig. 19, pl. III, fig. 9.

Forbes, in his description, states that the antepenultimate segment of the right male antenna bears a small hook. I have failed to find a hook in my specimens; the segment is armed only with a very inconspicuous hyaline lamella. DeGuerne and Richard have also noted the absence of the hook.

It is quite common in the summer and fall months. As I have found it, it has been of a brownish red color, much like *D. sanguineus*, with purple tipped antennæ and caudal setæ.

D. kentuckyensis Chambers, is probably identical with *leptopus*, although the imperfect figures make it impossible to decide with certainty.

DIAPTOMUS PALLIDUS Herrick.

Plate III. Figs. 6, 7 and 9.

1879. *D. pallidus*, Herrick (**18a**) p. 91, pl. II, a–d.
1884. " " " (**26**) p. 142, pl. Q, fig. 17.
1889. " " DeGuerne and Richard (**32**) p. 62, fig. 17.

A small, slender species. Cephalothorax elongated oval, widest at about the middle; the last segment is armed with two minute lateral spines.

The first abdominal segment of the female is as long as the remaining part of the abdomen, and is dilated laterally. The second abdominal segment is shorter than the third. The furcal joints are about twice as long as broad.

The antennæ reach beyond the furca. The right antenna of the male is swollen anterior to the geniculating joint; it bears no appendage on the antepenultimate joint.

The outer ramus of the fifth foot of the female is two-jointed; the third joint is represented by two blunt spines. The inner ramus is one-jointed, equaling in length the first joint of the outer ramus; it is armed with a short spine at tip, and two larger ones on inner margin of tip; the inner surface of the tip is covered with short hairs.

The fifth feet of the male are slender, with the basal joints nearly equal in length. The first joint of the outer ramus of the right foot is a little shorter than the basal joint. The second joint is nearly twice as long as the first; on its inner margin at about a third of its length is a short spine-like projection, the lateral spine is slender, situated near the outer end of the joint. The terminal hook is falciform, but not with a regular curvature, and is about once and a half the length of the second joint. The inner ramus is slender, one-jointed, as long as the first joint of the outer ramus.

The left foot extends to nearly one half the length of the second joint of the outer ramus of the right. The first joint of the outer ramus is about as long as the first joint of the outer ramus of the right foot. The second joint terminates in two projections,—a blunt finger-like process on the exterior side, with a pad armed with minute spines on its inner surface, and a slender falciform process from the inner margin, which curves over and nearly meets the process on the outer margin. There is also a small blunt projection on the inner margin of the joint. The inner ramus is slender, one-jointed, and equals in length the first joint of the outer ramus.

Length of the male, .875 mm.; of the female, 1.01 mm.

Locality, Heart Lake, near Marquette.

Herrick's descriptions of *D. pallidus* are not sufficient to identify the species, and his figures in the report of 1878 do not help the matter. In the final report on the Minnesota Crustacea, there is but one figure of *pallidus*—that of the left fifth foot of the male—and it is mainly from this figure that I have considered *D. pallidus* identical with my specimens. I have not found it quite as large as stated by Herrick, but in other respects it corresponds quite well with his descriptions, and it does not seem best to introduce a new name.

I have found *D. pallidus* in only one locality—Heart Lake, a small shallow lake south of Marquette.

Diaptomus sicilis Forbes.

Plate III. Figs. 8 and 10.

1882. *D. sicilis* Forbes (**22**) p. 645, pl. VIII, figs. 9 and 20.
1884. " " Herrick (**26**) p. 142, pl. Q, fig. 18.
1889. " " DeGuerne and Richard (**30**) p. 23, figs. 13 and 14, pl. II, fig 13.
1891. *D. sicilis* Forbes (**35**) p. 702, pl. 1, fig 6.

This species, which is abundant in the Great Lakes, I found as a common pelagic species in Green Lake in the summers of 1890 and 1891. In a large number of collections made in 1892, however, I did not find a single individual. This seems particularly strange, as the collections in 1892 were made at about the same seasons as in the preceding years.

The Green Lake specimens differ slightly from Forbes's type. They are somewhat smaller, the males averaging .9 mm., and the females 1.08 mm. The inner rami of the male fifth feet are not evidently two-jointed.

Diaptomus ashlandi sp. nov.

Plate III. Figs. 11–13.

A small pelagic species closely resembling *D. sicilis* Forbes. In form it is slender, hardly to be distinguished from *D. sicilis* and *D. minutus.*

The first joint of the abdomen in the female is longer than the remaining part of the abdomen, is dilated at the sides, and bears two minute lateral spines. The second and third joints are so closely united that the abdomen appears two-jointed. The furcal joints are about twice as long as broad.

The antennæ reach just beyond the furca. The right antenna of the male is much swollen anterior to the geniculating joint, and bears on the antepenultimate joint an appendage slightly exceeding in length the penultimate joint. This appendage may be blunt pointed or slightly enlarged at the extremity.

The fifth feet of the female are rather slender; the outer ramus is two-jointed. The third joint is represented by two short spines. The inner ramus is one-jointed, a little longer than the first joint of the outer ramus, armed at tip with two rather long spines.

The fifth feet of the male are slender. The basal joint of the right foot is about twice as long as that of the left. The first joint of the outer ramus is a little wider than long. The second joint is wider at the inner than at the outer end; the lateral spine is stout, curved, situated near the inner end. The terminal hook is slender and falciform. The inner ramus is slender, one-jointed, and about one-third longer than the first joint of the outer ramus.

The left foot extends a little beyond the first joint of the outer ramus of the right. The second joint of the outer ramus has three blunt spines upon its apex and is armed with minute bristles within. The inner ramus is slender, one-jointed, and reaches about half the length of the second joint of the outer ramus.

Length of male, .89 mm.; female, .97 mm.

Localities, Lake Superior and Lake Erie.

D. ashlandi is smaller than *D. sicilis*, from which it is distinguished by the form of the male fifth feet. The appendage of the antepenultimate joint of the right male antenna resembles the form in *sicilis* and *minutus*. The female is not so readily distinguished, although the fifth feet are more slender than in *sicilis*.

I have specimens from only two localities. In pelagic collections made by Prof. Birge at Ashland it occurred with *D. oregonensis* and *D. minutus*. In a collection made by Miss Merrill on Lake Erie nearly all the *Diaptomi* belonged to this species, *D. sicilis* being represented very sparingly.

Diaptomus minutus Lilljeborg.

Plate IV. Figs. 1–3.

1889. *Diaptomus minutus* DeGuerne and Richard (Lilljeborg) (**32**) p. 50, pl. I, figs. 5, 6 and 14, pl. III, fig. 25.

1891. *Diaptomus minutus* Marsh (**38**) p. 212.

I reported *D. minutus* in 1891 from Green Lake. I have since found it in collections from the Great Lakes, the St. Clair river, and one lake in northern Wisconsin. It was described by Lilljeborg from specimens obtained in Greenland and Newfoundland. It was later reported from Iceland (**39**).

It is probable, as stated by DeGuerne and Richard, that it is a common species through the northern part of North America. It is common in the pelagic collections from Green Lake, but I have found it nowhere else in central Wisconsin; it is possible that this is near the southern limit of the species. The stout terminal claw of the outer ramus of the right fifth foot in the male, and the short, leaf-like inner rami of the fifth foot of the female, make this species one easily recognized.

Diaptomus oregonensis Lilljeborg.

Plate IV. Figs. 4 and 5.

1889. *D. oregonensis* DeGuerne and Richard (Lillj.) (**32**) p. 53, pl. II, fig. 5, pl. III, fig. 8.

This is the most common species of *diaptomus*, being found quite generally in the shallower lakes. It is easily distinguished from the other species by the form of the male fifth foot.

The type specimens were obtained from Portland, Oregon, and according to the figures in DeGuerne and Richard's "Revision" are somewhat more slender in all their parts than are my specimens.

Genus EPISCHURA Forbes.

Epischura lacustris Forbes.

Plate IV. Fig. 6.

1882. *E. lacustris* Forbes (**22**) pp. 541 and 648, pl. VIII, figs. 15, 16, 21, 23, pl. IX, fig. 8.
1884. *E. lacustris* Herrick (**26**) p. 131, pl. Q, fig. 13.
1889. " " DeGuerne and Richard (**32**) p. 90, pl. IV, figs. 3, 9 and 10.
1891. *E. lacustris* Forbes (**35**) p. 704, pl. I, figs. 1–5, pl. II, fig. 7.

I have found *E. lacustris* in only two localities beside the Great Lakes—in Green Lake and Lake Puckaway. Probably, however, it is abundant in other localities, as Forbes reports it from many lakes in Illinois, Michigan, and southern Wis r sin.

The peculiar form of the male abdomen distinguishes nis in a striking manner from all other copepods.

GENUS LIMNOCALANUS Sars.

LIMNOCALANUS MACRURUS Sars.

Plate IV. Fig. 7.

1863. *L. macrurus* Sars (**11**) pp. 228–229.
1882. " " Forbes (**22**) p. 648.
1886. *Centropages grimaldi* DeGuerne (**29**) pp. 1–10.
1888. *L. macrurus* Nordqvist (**31**) pp. 31–37, pl. I, figs. 9–11; pl. II figs. 1–5; pl. III figs. 1–4.
1889. *L. macrurus* DeGuerne and Richard (**32**) p. 77, pl. IV, figs. 5, 11 and 12.
1891. *L. macrurus* var. *auctus* Forbes (**35**) p. 706.

L. macrurus is abundant in Green Lake. It is a species of especial interest because of its wide distribution. It is found quite generally throughout northern Europe. Forbes has found it in Lake Michigan, Lake Superior and Lake Geneva. I have found it also in collections from Lake Huron, Lake St. Clair, and the St. Clair river.

Family CYCLOPIDÆ.

Genus CYCLOPS Mueller.

KEY TO THE WISCONSIN SPECIES OF CYCLOPS.

Antennæ 17-jointed, fifth foot two-jointed,
  Second joint of fifth foot armed with seta and short spine,
    Terminal joint of outer branch of swimming feet armed externally with three spines,
      Furca of moderate length, — *americanus.*
      Furca elongated, — *brevispinosus.*
    Terminal joint of outer branch of swimming feet armed externally with two spines, — *parcus.*
  Second joint of fifth foot with two terminal setæ,
    Furca short, — *navus.*
    Furca elongated, — *pulchellus.*
  Second joint of fifth foot, with one terminal and one lateral seta, — *leuckarti.*
  Second joint of fifth foot, with three setæ, — *signatus.*
Antennæ 16-jointed, fifth foot 3-jointed, — *modestus.*
Antennæ 12-jointed, fifth foot 1-jointed,
  Furca variable in length, armed externally with a row of small spines, — *serrulatus.*
  Furca short, without armature of spines, — *fluviatilis.*
Antennæ 11-jointed, swimming feet three-jointed, — *phaleratus.*
  swimming feet two-jointed, — *bicolor.*
Antennæ 8-jointed, — *fimbriatus.*

Cyclops americanus sp. nov.

Plate IV. Figs. 8–10.

1882. *C. ingens* Herrick (**23**) p. 228, pl. V, figs. 1–8.
1883. " *viridis* Cragin (**24**) p. 3, pl. IV, figs. 8–16.
1884. " " Herrick (**26**) p. 145.

Cephalothorax oval, the first segment being about half its total length. Antennæ 17-jointed, about as long as first cephalothoracic segment. Abdomen rather slender, the last segment armed on its posterior border with small spines. All the abdominal segments in immature individuals are strongly pectinated posteriorly. Furca about three times as long as its average breadth, the lateral spine situated well towards the end. The first and fourth terminal setæ are short, slender and plumose, nearly equal in length. Of the internal setæ, the outer is a little more than three-fourths the length of the inner.

The armature of the terminal joints of the swimming feet is as follows:

FIRST FOOT.

Outer br.	ex.	3 spines.	Inner br.	ex.	1 seta.
	ap.	2 setæ.		ap.	1 spine, 1 seta.
	in.	2 setæ.		in.	3 setæ.

SECOND AND THIRD FEET.

Outer br.	ex.	3 spines.	Inner br.	ex.	1 seta.
	ap.	1 spine, 1 seta.		ap.	1 spine, 1 seta.
	in.	3 setæ.		in.	3 setæ.

FOURTH FOOT.

Outer br.	ex.	3 spines.	Inner br.	ex.	1 seta.
	ap.	1 spine, 1 seta.		ap.	2 spines.
	in.	3 setæ.		in.	2 setæ.

Fifth foot two-jointed, basal joint very broad, armed with one seta. Terminal joint armed with a seta and a blunt spine.

Length, 1.2 mm.

This takes the place in our fauna that is occupied by *C. viridis* Fischer, in Europe. In general form and appearance the two forms seem identical, and have been so considered by Herrick and Cragin. I have hesitated to propound a new species name, but it seems necessary. So far as Uljanin and Vosseler have figured *viridis* it corresponds to our species; but neither gives figures of the swimming feet. From the original description by Fischer our species differs markedly. According to his figure the antennæ reach to the third cephalothoracic segment, while in *americanus* they hardly exceed the first. He makes the furca about equal in length to the last abdominal segment; in *americanus* it equals or exceeds the last two segments. He gives a figure of "a foot," not designating which, but it corresponds to no one of the four in our species.

Sars says the terminal joint of the external ramus of the fourth foot has two external spines; *americanus* has three.

Brady's figure of the terminal joint of the outer branch of the fourth foot (**18**, pl. 20, fig. 7) corresponds to Sars' statement. He also figures the terminal joint of the inner branch (**18**, pl. 20, fig. 8,) which shows a very different armature from that in *americanus*.

Schmeil (**41**, p. 97, pl. VIII, figs. 12–14,) gives a more elab orate description of *viridis*. His formula for the spines of the swimming feet corresponds to the descriptions of the other European authors. Schmeil, however, does not consider the armature of the swimming feet as constant, and according to his view *americanus* should be a variety of *viridis*. In an examination of a large number of specimens from widely separated localities I have found no variation in the number and arrangement of the spines and setæ of *americanus*, and until such variation is shown, there seems to be no alternative but to institute a new species for the American form.

C. americanus is widely distributed. It occurs quite generally in stagnant pools, and is also found to some extent in lakes.

Cyclops brevispinosus Herrick.

Plate IV. Figs. 11 and 12.

1884. *C. brevispinosus* Herrick (**26**) p. 148, pl. S, figs. 7–11.

Cephalothorax oval, the first segment reaching about half its total length. Antennæ 17-jointed, shorter than first cephalothoracic segment. Abdomen slender, the last segment armed on its posterior border with a row of small spines. Furca slender, longer than the last two abdominal segments, lateral spine at two-thirds the distance from base to extremity. Of the terminal setæ, the outer is a short blunt spine, the inner slender and somewhat longer; the outer median seta rather more than two-thirds the length of the inner.

The armature of the terminal joints of the swimming feet is as follows:

FIRST FOOT.

Outer br.	ex.	3 spines.	Inner br.	ex.	1 seta.
	ap.	2 setæ.		ap.	1 spine, 1 seta.
	in.	2 setæ.		in.	3 setæ.

SECOND FOOT.

Outer br.	ex.	3 spines.	Inner br.	ex.	1 seta.
	ap.	1 spine, 1 seta.		ap.	1 spine, 1 seta.
	in.	3 setæ.		in.	3 setæ.

THIRD FOOT.

Outer br.	ex.	3 spines.	Inner br.	ex.	1 spine.
	ap.	1 spine, 1 seta.		ap.	2 spines.
	in.	3 setæ.		in.	3 setæ.

FOURTH FOOT.

Outer br.	ex.	3 spines.	Inner br.	ex.	1 spine.
	ap.	1 spine, 1 seta.		ap.	2 spines.
	in.	3 setæ.		in.	2 setæ.

The fifth foot is two-jointed. The basal joint is very broad and is armed with one seta. The terminal joint is armed with one seta and a short spine.

Length about 1 mm.

Herrick's description of *C. brevispinosus* is so imperfect that it is difficult to identify the species with certainty. The armature of the swimming feet is different from that in *C. parcus*, although one might infer from his statement that it is the same. The form and armature of the furca, however, is characteristic, and his figure of the furca makes me so certain of the identity of the form, that I have ventured to redescribe the species rather than to propose a new name. It is easily recognized by its short, 17-jointed antennæ, and the elongated furca, with the outer terminal seta reduced to a short blunt spine.

It is widely distributed in lakes and ponds, and is a pelagic species, though sometimes occurring in littoral collections.

I have had some doubt as to whether this should be considered a distinct species. In most of its structural features it closely resembles *americanus*, and I have suspected it to be a pelagic variety of that species. I have specimens of *americanus* with elongated furca like *brevispinosus*, and I have specimens of *brevispinosus* in which the outer terminal seta of the furca is slender and plumose as in *americanus*. For the differences in the armature of the swimming feet, however, I have as yet found no intermediate forms, and so must, for the present at least, consider the two distinct.

CYCLOPS NAVUS Herrick.

Plate IV. Figs. 13–15.

1882. *C. navus* Herrick (**23**) p. 229, pl. V, figs. 6–13, 15–17.
1884. " " " (**26**) p. 152.

Larger than *C. pulchellus*, the antennæ being about as long as first two segments of cephalothorax, as in that species. Armature of swimming feet as in *pulchellus*. Fifth foot armed as in *pulchellus*, but terminal joint more elongated, and its setæ more nearly equal in length, the inner being fully two-thirds the length of the outer. The furca is short, with the lateral seta on the posterior third; of the terminal setæ the first and fourth are short, the outer median about three-fifths as long as the inner.

It is generally reddish in color and occurs in pools. Herrick considers *navus* as probably a variety of *pulchellus*, and I am inclined to agree with him. The principal difference between the two species is in the form of the furca, and the difference is just that which we would expect from the difference of environment. It is just the difference which exists between the extreme forms of *serrulatus*. So far as I know, however, no one has reported forms intermediate between *C. pulchellus* and *C. navus*. In my collections, while I have seen many instances of considerable variation in *C. pulchellus*, particularly in the form and armature of the furca, I have found no forms which at all approach *C. navus*. Until such intermediate forms are discovered, *C. navus* must be considered distinct.

CYCLOPS PULCHELLUS Koch.

Plate IV. Figs. 18 and 19.

1838. *C. pulchellus* Koch (**3**) H. 21, pl. 2.
1857. " *bicuspidatus* Claus (**8**), p. 209, pl. XI, figs. 6 and 7.
1863. " " " (**9**), p. 101.
1863. " *pulchellus* Sars (**11**), p. 246.
1870. " *bicuspidatus* Heller (**12**), p. 71.
1872. " *bicuspidatus* Fric (**13**), p. 221, fig. 6.
1876. " *bicuspidatus* Hoek (**16**), p. 17, pl. I, figs. 7–11.
1880. " *pulchellus* Rehberg (**19**), p. 543.
1880. " *helgolandicus* Rehberg (**20**), p. 64, pl. IV, fig. 5.
1882. " *thomasi* Forbes (**22**), p. 649, pl. IX, figs. 10, 11 and 16.
1883. ,, *pectinatus* Herrick (**25**), p. 499, pl. VII, figs. 25–28.
1883. " *thomasi* Cragin (**24**), p. 3, pl. III, figs. 1–13.
1884. " *thomasi* Herrick (**26**), p. 151, pl. U, figs. 4, 5, 7 and 8.
1885. " *pulchellus* Daday (**27**), p. 220.
1886. " *pulchellus* Vosseler (**28**), p. 194, pl. V, figs. 19–28.
1891. " *thomasi* Forbes (**35**), p. 707, pl. II, fig. 8.
1891. " *bicuspidatus* Brady (**36**), p. 13, pl. 5, figs. 1–5.
1891. " *thomasi* Brady (**36**), p. 14, pl. VI, figs. 1–4.
1891. " *bicuspidatus* Schmeil (**37**), p. 27.
1891. " *bicuspidatus* Richard (**39**), p. 229, pl. VI, fig. 6.
1892. " *bicuspidatus* Schmeil (**41**), p. 75, pl. II, figs. 1–3.
1893. " *thomasi* Forbes (**42**), p. 249, pl. XXXIX, figs. 9–12; pl. XL, fig. 13.

Herrick considered *C. thomasi* a variety of *C. pulchellus* Koch. Brady also raises the question as to the specific distinction of the American form. I have gone over the literature of the subject with considerable care, and I can see no good reason for separating our American form from *C. pulchellus* Koch, or *bicuspidatus* Claus. All the European descriptions agree very closely with our form. We find in *C. thomasi* the same variations which Vosseler records in the European form,—for example, the variable position of the lateral spine of the furca. In general form, length of antennæ, form of furca and armature of swimming feet and fifth feet, it is difficult to find any clear distinction between the forms of the two continents. I cannot agree with Herrick and Brady in considering *C. bisetosus* Rehberg a synonym of *pulchellus*, for *pulchellus* has the swimming feet armed with two spines externally, while *bisetosus* has three, and my observations lead me to think that the armature of the swimming feet is quite constant.

The armature of the terminal joints of the swimming feet is as follows:

FIRST FOOT.

Outer br.	ex.	2 spines.	Inner br.	ex.	1 seta.
	ap.	2 setæ.		ap.	1 spine, 1 seta.
	in.	2 setæ.		in.	3 setæ.

SECOND AND THIRD FEET.

Outer br.	ex.	2 spines.	Inner br.	ex.	1 seta.
	ap.	1 spine, 1 seta.		ap.	1 spine, 1 seta.
	in.	3 setæ.		in.	3 setæ.

FOURTH FEET.

Outer br.	ex.	2 spines.	Inner br.	ex.	1 seta.
	ap.	1 spine, 1 seta.		ap.	2 spines.
	in.	3 setæ.		in.	2 setæ.

C. pulchellus occurs everywhere in the great lakes in pelagic collections, and in some of the smaller lakes of Wisconsin.

CYCLOPS PARCUS Herrick.

Plate IV, fig. 16; plate V, fig. 1.

1882. *C. parcus* Herrick (**23**), p. 229, pl. VI, figs. 12–15.
1884. " " " (**26**), p. 148, pl. R, fig. 22.

C. parcus, in the armature of the swimming feet is like *C. pulchellus* and *C. navus*, while its fifth feet are like those of *C. americanus* and *C. brevispinosus*, although the basal joint is somewhat narrower. My specimens agree with Herrick's description, except in the armature of the inner terminal segment of first feet, and his statement is evidently inaccurate, for no normal armature would be as he describes it.

C. parcus occurs in stagnant pools, and I have not found it common.

Cyclops leuckarti Sars.

Plate IV, fig. 17; plate V, figs. 2–6.

1863. *C. leuckarti* Sars (**11**), p. 239.
1874. " *simplex* Poggenpol (**14**), p. 70, pl. XV, fig. 1–3.
1875. " *tenuicornis* Uljanin (**15**), p. 30, pl. IX, figs. 12 and 13.
1876. " *leeuwenhoekii* Hoek (**16**), p. 19, pl. III, figs. 1–12.
1880. " *simplex* Rehberg (**19**), p. 542.
1886. " " Vosseler (**28**), p. 193, pl. IV, figs. 15–17.
1887. " " Herrick (**30**), p. 17, pl. VII, fig. 1, a–j.
1891. " *leuckarti* Schmeil (**37**), p. 25.
1891. " *edax* Forbes (**35**), p. 709, pl. III, fig. 15; pl. IV, figs. 16–19.
1881. (*C. scourfeldi* Brady)? (**36**), p. 10, pl. IV, figs. 1–8.
1891. " *leuckarti* Richard (**39**), p. 230, pl. VI, fig. 20.
1892. " *leuckarti* Schmeil (**41**), p. 57, pl. III, figs. 1–8.

This species was particularly abundant in the collections from Lake Puckaway.

I have compared my specimens very carefully with the descriptions of the European form as given by Sars, Hoek and Schmeil, and the correspondence is almost perfect. The only difference seems to be that the lower side of the second joint of the outer maxilliped is ordinarily crenulated rather than "*geperlte.*" Specimens from Heart Lake, however, have more minute crenulations to which the term "*geperlte*" would be more properly applied. But in other points there is perfect agreement, noticeably so in the toothed appendage of the last antennal joint.

Schmeil states that the membrane of the last antennal segment of the female has a single deep indentation. My specimens have several, agreeing in this respect with the figure of Hoek.

It occurs in both day and evening collections, and is generally reddish in color.

This is one of the most widely distributed of all the species of *Cyclops*, being found in various parts of Europe, in Asia, Africa, Madagascar, Ceylon, and the East Indies (**34**). Herrick mentions it as occurring in Alabama (**30**), and it is probable that it is widely distributed in America. It seems to me probable that the species identified by Herrick as *oithonoides* (**26,** p. 150, pl. S, figs. 2–6), is really *leuckarti.*

Brady's *scourfeldi* corresponds to this species in all details except the armature of the terminal joint of the outer branch of the fourth foot. The special character by which he distinguishes the species,—the marginal setæ of the second maxillipedes,—I find in my specimens. In his figure of the fourth foot, the terminal joint of the outer branch has one spine and *two setæ* on the apex, instead of the normal armature of one spine and one seta. Schmeil's figure of the fourth foot (**41,** pl. III, fig. 6) shows an armature like that of the American specimens, and one cannot help thinking that Brady's figure must have been drawn from an abnormal specimen.

C. edax Forbes appears to differ from *leuckarti* only in that it lacks the ridge on the terminal joint of the antennæ, and is probably simply a less highly developed variety of the same species.

There is considerable variation in the form of the spines of the swimming feet; in some specimens they are very slender and the joints are at the same time somewhat elongated, while in other cases they are robust. The robust form appears to be characteristic of the littoral specimens, and the slender form of the pelagic.

The armature of the terminal joints of the swimming feet is as follows:

FIRST FOOT.

Outer br.	ex. 2 spines.	Inner br.	ex. 1 seta.
	ap. 2 setæ.		ap. 1 spine, 1 seta.
	in. 2 setæ.		in. 3 setæ.

SECOND AND THIRD FEET.

Outer br.	ex.	2 spines.	Inner br.	ex.	1 seta.
	ap.	1 spine, 1 seta.		ap.	1 spine, 1 seta.
	in.	3 setæ.		in.	3 setæ.

FOURTH FOOT.

Outer br.	ex.	2 spines.	Inner br.	ex.	1 seta.
	ap.	1 spine, 1 seta.		ap.	2 spines.
	in.	3 setæ.		in.	2 setæ.

CYCLOPS SIGNATUS Koch.

Plate V, figs. 7–9.

1820. *Monoculus quadricornis albidus* Jurine (**2**), pp. 44 and 47, pl. II, figs. 10–11; pl. III, fig. 24.

1820. *Monoculus quadricornis fuscus* Jurine (**2**), p. 47, pl. II, fig. 2.

1841. *C. signatus* Koch (**3**), H 21, pl. VIII.

1841. " *annulicornis* Koch (**3**). H 21, pl. VI.

1850. " *quadricornis* var. *b* Baird (**4**), p. 202, pl. XXIV, fig. 4.

1850. " " var. *c* Baird (**4**), p. 203, pl. XXIV, fig. 5.

1857. " *coronatus* Claus (**7**), p. 29, pl. II, figs. 1–11.

1857. " *tenuicornis* Claus (**7**), p. 31, pl. III, figs. 1–11.

1863. " *coronatus* Claus (**9**), p. 97, pl. II, fig. 16; pl. X, fig. 1.

1863. " *tenuicornis* Claus (**9**), p. 99, pl. I, fig. 3; pl. II, fig. 17; pl. IV, fig. 5.

1863. " *signatus* Sars (**11**), p. 242.

1863. " *annulicornis* Sars (**11**), p. 243.

1863. " *tenuicornis* Sars (**11**), p. 242.

1863. " *coronatus* Lubbock (**10**), p. 199.

1863. " *tenuicornis* Lubbock (**10**), p. 202.

1872. " *coronatus* Fric (**13**), p. 218, fig. 11.

1872. " *tenuicornis* Fric (**13**), p. 219, fig. 12.

1874. " *clausii* Poggenpol (**14**), p. 70, pl. XV, figs. 4–14.

1875. " *signatus* Uljanin (**15**), p. 29, pl. IX, figs. 6–11; pl. XI, fig. 8.

1876. " " Hoek (**16**), p. 12, pl. I. figs. 1–4.

1876. " *coronatus* Hoek (**16**), p. 12.

1878. *C signatus* Brady (**18**), p. 100, pl. XVII, figs. 4–12.
1876. " *tenuicornis* Brady (**18**), p. 102, pl. XVIII, figs. 1–10.
1883. " " Cragin (**24**), p. 3, pl. II, figs. 1–14.
1883. " *signatus* var. *fasciacornis* Cragin (**24**), p. 2, pl. II, fig. 15.
1884. " *tenuicornis* Herrick (**26**), p. 153, pl. R, fig. 16.
1885. " " Daday (**27**), p. 211.
1885. " *signatus* Daday (**27**), p. 208.
1886. " " Vosseler (**28**), p. 189, pl. IV, figs. 1–5.
1886. " *tenuicornis* Vosseler (**28**), p. 189, pl. IV, figs. 6–10.
1891. " *gyrinus* Forbes (**35**), p. 707, pl. II, fig. 9; pl. III, fig. 14.
1891. " *albidus* Schmeil (**37**), p. 23.
1891. " *signatus* Brady (**36**), p. 6, pl. 2, fig. 5.
1891. " *fuscus* Richard (**39**), p. 223, pl. II, fig. 6.
1891. " *annulicornis* and *tenuicornis* Richard (**39**), pp. 224–226.
1892. " *fuscus* Schmeil (**41**), p. 123, pl. I, figs. 1–7*b*; pl. IV, fig. 2.
1892. " *albidus* Schmeil (**41**), p. 128, pl. I, figs. 8–14*b*; pl. IV, fig. 14.

Brady considers *signatus* as the ultimate form of which *tenuicornis* is the penultimate. The serrated ridge on the last antennal joint must be considered, then, as not distinctive of the species, but of the ultimate stage of the species. With this opinion I am inclined to agree, although I have not material to demonstrate their identity. Schmeil (**41**) discusses the relations of the two forms in detail, and gives his reasons for believing them specifically distinct. In this same paper, however, he describes certain "bastard" forms which combine the characters of *signatus* and *tenuicornis*, and it would seem that the existence of such "bastards" would be a strong argument in favor of the identity of the forms.

C. signatus is a widely distributed species, being found in northern and western Europe, and in Great Britain, as well as in North America. It occurs in standing pools, but is more common in the lakes, being found in both pelagic and littoral collections.

Cyclops modestus Herrick.

Plate V, figs. 10–13.

1883. *C. modestus* Herrick (**25**), p. 500.
1884. " " " (**26**), p. 154, pl. R, figs. 1–5.
1887. " " " (**30**), p. 14.

I have found *C. modestus* in only one locality,—Rush Lake. Herrick found it in Alabama and Minnesota. It appears to be a clearly marked species. The color in all my specimens was distinctly purplish, a color entirely different from that of the other entomostraca in the same collections. In all my specimens the antennæ were 16-jointed, and about as long as the first segment of the cephalothorax. The cephalothorax is oval and very broad as compared with the abdomen. The abdomen is slender. The furca is about as long as the last two abdominal segments, with the lateral spine situated about midway of its length. The external margin of the furca is hollowed out below the lateral spine. Of the terminal setæ, the first is small and spine like, the second about four-fifths the length of the third, and the fourth slightly shorter than the second.

The armature of the terminal joints of the swimming feet is as follows:

FIRST FOOT.

Outer br.	ex. 3 spines.	Inner br.	ex. 1 seta.
	ap. 1 spine, 1 seta.		ap. 2 spines, 1 minute seta.
	in. 3 setæ.		in. 2 setæ.

SECOND FOOT.

Outer br.	ex. 3 spines.	Inner br.	ex. 1 seta.
	ap. 1 spine, 1 seta.		ap. 2 spines.
	in. 4 setæ.		in. 1 spine, 2 setæ.

THIRD FOOT.

Outer br.	ex. 2 spines.	Inner br.	ex. 1 seta.
	ap. I spine, 1 seta.		ap. 2 spines.
	in. 4 setæ.		in. 1 spine-like seta, 2 setæ.

FOURTH FOOT.

Outer br. ex. 2 spines.		Inner br. ex. 1 seta.	
ap. 1 spine, 1 seta.		ap. 2 spines.	
in. 4 setæ.		in. 2 setæ.	

The fifth foot is three-jointed, the second joint armed with a seta, and the third joint with two terminal setæ.

Cyclops fluviatilis Herrick.

Plate V, figs. 14 and 15; plate VI, fig. 1.

1882. *C. fluviatilis* Herrick (**23**), p. 231, pl. VII, figs. 1–9.
1883. " *magnoctavus* Cragin (**24**), p. 5, pl. III, figs. 14–23.
1884. " *fluviatilis* Herrick (**26**), p. 159, pl. Q[5], figs. 1–9.
1887. " " " (**30**), p. 15.
1891. " *magnoctavus* Brady (**36**), p. 19, fig. 1-4.

I see no valid reason for separating *fluviatilis* and *magnoctavus*, although they are considered by Brady distinct species. *C. pentagonus* Vosseler is like *fluviatilis* in the form of the antennæ and abdomen, and in the armature of the feet. In the form of the cephalothorax it differs widely from *fluviatilis*, the first segment being short, broad and angular, while in *fluviatilis* the first segment is long and rounded, the whole cephalothorax being oval in outline. *C. fluviatilis* is not likely to be confounded with any other *Cyclops*, as we have only one other species with twelve-jointed antennæ,—*C. serrulatus*,—from which it is readily distinguished by its smaller size, and the different form of the abdomen and furca.

I have found *C. fluviatilis* only in pelagic collections. Cragin and Brady have found it in ditches. But Brady remarks: "It is curious that in both cases the animal was found in ditches immediately connected with large sheets of water."

Herrick says, "it is one of the most abundant forms in the larger lakes, and especially in streams."

CYCLOPS SERRULATUS Fischer.

Plate VI, figs. 2–5.

1838.	*C. agilis*	Koch (**3**), H 21, pl. III.
1851.	" *serrulatus*	Fischer (**5**), p. 423, pl. X, figs. 22, 26–31.
1853.	" "	Lilljeborg (**6**), p. 158, pl. XV, fig. 12.
1857.	" "	Claus (**7**), p. 36, figs. 1–3.
1863.	" "	Sars (**11**), p. 45.
1863.	" "	Claus (**9**), p. 101, pl. I, figs. 1 and 2; pl. IV, fig. 12; pl. XI, fig. 3.
1863.	" "	Lubbock (**10**), p. 197.
1870.	" "	Heller (**12**), p. 6.
1872.	" "	Fric (**13**), p. 222, fig. 18.
1875.	" "	Uljanin (**15**), p. 34, pl. VIII, figs. 1–8.
1878.	" "	Brady (**18**), p. 109, pl. XXII, figs. 1–14.
1880.	" *agilis*	Rehberg (**19**), p. 545.
1882.	" *serrulatus*	Herrick (**23**), p. 230.
1883.	" *pectinifer*	Cragin (**24**), p. 6, pl. IV, figs. 1–7.
1884.	" *serrulatus*	Herrick (**26**), p. 157, pl. O, figs. 17–19.
1885.	" *agilis*	Daday (**27**), p. 240.
1886.	" *agilis*	Vosseler (**28**), p. 190, pl. V, figs. 29–31.
1891.	" *serrulatus*	Schmeil (**37**), p. 29.
1891.	" "	Brady (**36**), p. 18, pl. VII, fig. 1.
1891.	" "	Richard (**39**), p. 234, pl. VI, fig. 19.
1892.	" "	Schmeil (**41**), p. 141, pl. V, figs. 6–12.

C. serrulatus is found everywhere. It is the most common of all the species of *Cyclops*. In the larger bodies of water it is more common in littoral collections, but it occurs not infrequently in pelagic collections.

This species has a wide limit of variation, the extreme forms differing so much that one is at first inclined to rank them as separate species. At one extreme is the form common in ditches, pools, and littoral collections, which seems to correspond nearly to *montanus* Brady. It averages .85 mm in length; the furca is not quite as long as the last two abdominal segments, and the external terminal seta is transformed into a stout spine three-fourths as long as the furca, projecting laterally from the body. At the other extreme is the pelagic form, *C. elegans* Herrick. It averages 1.25 mm in length. The furca is once and a third as long as the last two abdominal segments, and the external terminal seta is short and weak.

Sometimes the two forms occur together in pelagic collections, but only once have I found the *elegans* form as a littoral species. The European form is, in its characteristics, intermediate between these extreme forms.

Although the extreme varieties sometimes occur together, they are almost always entirely distinct. In only two localities have I found connecting forms. In Heart Lake I found an intermediate form associated with the smaller variety, and in Lake Puckaway I found the typical form in connection with both extremes.

Cyclops phaleratus Koch.

Plate VI, figs. 6 and 7.

1841. *C. phaleratus* Koch (**3**), H 21, pl. IX.
1851. " *canthocarpoides* Fischer (**5**), p. 246, pl. X, figs. 24, 32–38.
1853. " " Lilljeborg (**6**), p. 208.
1857. " " Claus (**7**), p. 37, pl, I, figs. 6–10.
1863. " " " (**9**), p. 102, pl. IV, figs. 1–4.
1863. " " Lubbock (**10**), p. 202.
1863. " *phaleratus* Sars (**11**), p. 46.
1872. " *canthocarpoides* Fric (**13**), p. 223, fig. 19.
1874. " *lascivus* Poggenpol (**14**), p. 72, pl. XV, figs. 22–24; pl. XVI, figs. 7 and 8.
1875. " *phaleratus* Uljanin (**15**), p. 38, pl. IX, figs. 1–5.
1878. " " Brady (**18**), p. 116, pl. XXIII, figs. 7–13.
1882. " *adolescens* Herrick (**23**), p. 231, pl. VI, figs. 16–20.
1883. " *perarmatus* Cragin (**24**), p. 7, pl. I, figs. 9–18.
1884. " *phaleratus* Herrick (**26**), p. 161, pl. R, figs. 6–10.
1885. " " Daday (**27**), p. 252.
1887. " " Herrick (**30**), p. 14, pl. VII, fig. 2, a–d.
1891. " " Schmeil (**37**), p. 36.

1891. *C. phaleratus*, Brady (**36**), p. 25, pl. IX, fig. 2.
1891. " " Richard (**39**), p. 238, pl. VI, fig. 12.
1892. " " Schmeil (**41**), p. 170, pl. VIII, figs. 1–2.

The European *C. phaleratus* has ten-jointed antennæ. Our specimens ordinarily have eleven joints, although sometimes, according to Herrick, occurring with ten. In other respects, my specimens agree with those figured by European authors even in minute details, and there seems no good reason for making a new species of our form.

It occurs quite widely distributed in the smaller lakes, and in stagnant pools.

Cyclops bicolor Sars.

1863. *C. bicolor* Sars (**11**), p. 253.
1880. " *diaphanus* Rehberg (**19**), p. 547.
1884. " " Herrick (**26**), p. 160, pl. R, fig. 12.
1885. " " Daday (**27**), p. 246.
1887. " " Herrick (**30**), p. 16, pl. VII, figs. 3a–e.
1891. " *bicolor* Schmeil (**37**), p. 34.
1891. " *diaphanus* Richard (**39**), p. 236, pl. VI, fig. 26.
1892. " *bicolor* Schmeil (**41**), p. 118, pl. VI, figs. 6–13.

The antennæ are 11-jointed, hardly as long as the first cephalothoracic segment. The abdomen is somewhat elongated, the last segment armed with spines posteriorly. The furca is nearly as long as the last two abdominal segments. The lateral spine is situated at about the posterior third. The first and fourth terminal setæ are short, the inner considerably longer than the outer. The median setæ are strongly plumose, and the longer is about as long as the abdomen.

The rami of the swimming feet are two-jointed. The armature of the terminal joints is as follows:

FIRST FOOT.

Outer br.	ex. 3 spines.	Inner br.	ex. 1 seta.
	ap. 2 setæ.		ap. 1 seta, 1 large spine.
	in. 3 setæ.		in. 3 setæ.

SECOND AND THIRD FEET.

Outer br.	ex. 3 spines.	Inner br.	ex. 1 seta.
	ap. 1 spine, 1 seta.		ap. 1 spine, 1 seta.
	in. 4 setæ.		in. 4 setæ.

FOURTH FEET.

Outer br.	ex. 2 spines.	Inner br.	ex. 1 seta.
	ap. 1 spine, 1 seta.		ap. 2 spines.
	in. 4 setæ.		in. 3 setæ.

The last cephalothoracic segment is expanded laterally, and bears upon each side a long seta. The fifth feet are attached to these expansions, are one-jointed, linear, and each bears at the tip a single seta.

Females average a little more than ½ mm. in length. The color in all the specimens I have seen has been purplish. My specimens agree very well with the descriptions of Sars and Schmeil, the only marked difference being in the length of the caudal setæ. More complete descriptions of the European form may show other differences, but so far as the descriptions go, they apply very well to our form.

C. bicolor occurs in stagnant pools, and is somewhat rare.

Cyclops fimbriatus Fischer.

Plate VI, figs. 8 and 9.

1785. *C. crassicornis* Mueller (**1**), p. 113, pl. XVIII, figs. 15–17.
1853. " *fimbriatus* Fischer (**5**), p. 94, pl. III, figs. 19–28 and 30.
1863. " *crassicornis* Sars (**11**), p. 47.
1870. " *gredleri* Heller (**12**), p. 8, pl. 1, figs. 3 and 4.
1872. " *pauper* Fric (**13**), p. 223, fig. 20.
1875. " *crassicornis* Uljanin (**15**), p. 39, pl. VIII, figs. 9–16; pl. XII, fig. 1.
1878. " " Brady (**18**), p. 118, pl. XXIII, figs. 1–6.
1880. " *poppei* Rehberg (**19**), p. 550, pl. VI, figs. 9–11.
1880. " *fimbriatus* Rehberg (**19**), p. 548, pl. VI, figs. 7 and 8.
1882. " *crassicornis* Herrick (**23**), p. 232, pl. IV, figs. 9–14.

1884.	*C fimbriatus*	Herrick (**26**), p. 162, pl. R, fig. 11.
1885.	" "	Daday (**27**), p. 262.
1885.	" *margoi*	Daday (**27**), p. 264, pl. III, figs. 20–25.
1886.	" *fimbriatus*	Vosseler (**28**), p. 192, pl. VI, figs. 4–8.
1891.	" "	Schmeil (**37**), p. 35.
1891.	" "	Brady (**36**), p. 25, pl. IX, fig. 1.
1891.	" "	Richard (**39**), p. 238, pl. VII, figs. 13 and 14.
1892.	" "	Schmeil (**41**), p. 161, pl. VII, figs. 8–13.

This, our only eight-jointed species, I have found in only two localities. It corresponds quite exactly wlth the descriptions of the European authors. Brady, however, in fig. 4, pl. XXIII of his monograph, represents the terminal joint of the inner ramus of the second foot as armed with a *spine* on the inner margin. In my specimens this joint has a *seta* on the inner margin. But making allowance for possible inaccuracies in the figure, I see no reason for doubting the identity of the forms.

Herrick states that the color is always reddish. I have found nearly colorless individuals, and I think that the color of this, as of other species, varies according to the environment.

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EXPLANATION OF PLATES.

PLATE III.

Fig. 1. *Diaptomus sanguineus*—terminal joints of male antenna x 163.
2. " " fifth feet of male x 163.
3. " " fifth foot of female x 163.
4. " *leptopus*—fifth foot of female x 163.
5. " " fifth feet of male x 163.
6. " *pallidus*—fifth feet of male x 300.
7. " " fifth foot of female x 300.
8. " *sicilis*—fifth feet of male x 163.
9. " *pallidus*—abdomen of female x 300.
10. " *sicilis*—fifth foot of female x 300.
11. " *ashlandi*—fifth feet of male x 163.
12. " " fifth foot of female x 163.
13. " " terminal joints of male antenna x 300.

PLATE IV.

Fig. 1. *Diaptomus minutus*—fifth feet of male x 163.
2. " " fifth foot of female x 300.
3. " " terminal joints of male antenna x 300.
4. " *oregonensis*—fifth feet of male x 163.
5. " " fifth foot of female x 300.
6. *Epischura lacustris*—abdomen of male x 92.
7. *Limnocalanus macrurus*—abdomen of male x 40.
8. *Cyclops americanus*—abdomen of female x 58.
9. " " fourth feet x 163.
10. " " fifth foot x 300.
11. " *brevispinosus*—furca x 163.
12. " " fourth foot x 163.
13. " *navus*—abdomen of female x 68.
14. " " fourth foot x 163.
15. " " fifth foot x 300.

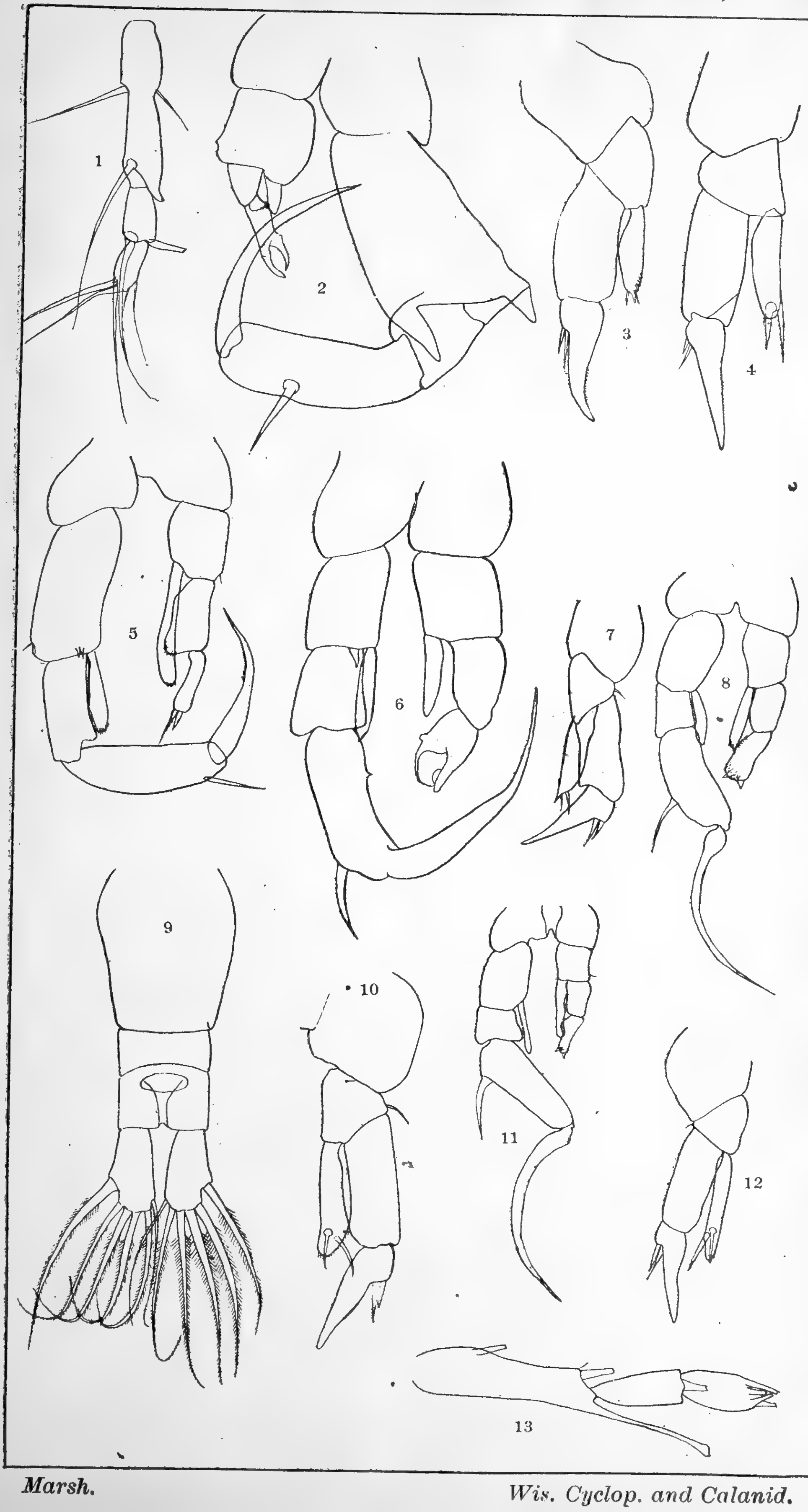
16. *Cyclops parcus*—fifth foot x 300.
17. " *leuckarti* from Heart Lake — second joint of outer maxilliped x 163.
18. " *pulchellus*—fifth foot x 300.
19. " " abdomen of female x 163.

PLATE V.

Fig. 1. *Cyclops parcus*—fourth foot x 163.
2. " *leuckarti*—fifth foot x 300.
3. " " last antennal joint of female x 300.
4. " " from Lake Gussie — outer maxilliped x 300.
5. " " abdomen of female x 58.
6. " " littoral variety—fourth foot x 163.
7. " *signatus*—fourth foot x 163.
8. " " fifth foot x 300.
9. " " last antennal joint of female x 300.
10. " *modestus*—fourth foot x 195.
11. " " furca x 163.
12. " " fifth foot x 360.
13. " " outer terminal joint of third foot x 300.
14. " *fluviatilis*—fifth foot x 360.
15. " " fourth foot x 300.

PLATE VI.

Fig. 1. *Cyclops fluviatilis*—abdomen of female x 300.
2. " *serrulatus*—abdomen of female, extreme pelagic form, x 75.
3. " " abdomen of female, intermediate form, x 100.
4. " " abdomen of female, littoral form, x 178.
5. " " fourth foot x 178.
6. " *phaleratus*—abdomen of female x 92.
7. " " second antenna x 300.
8. " *fimbriatus*—fourth foot x 300.
9. " " furca x 300.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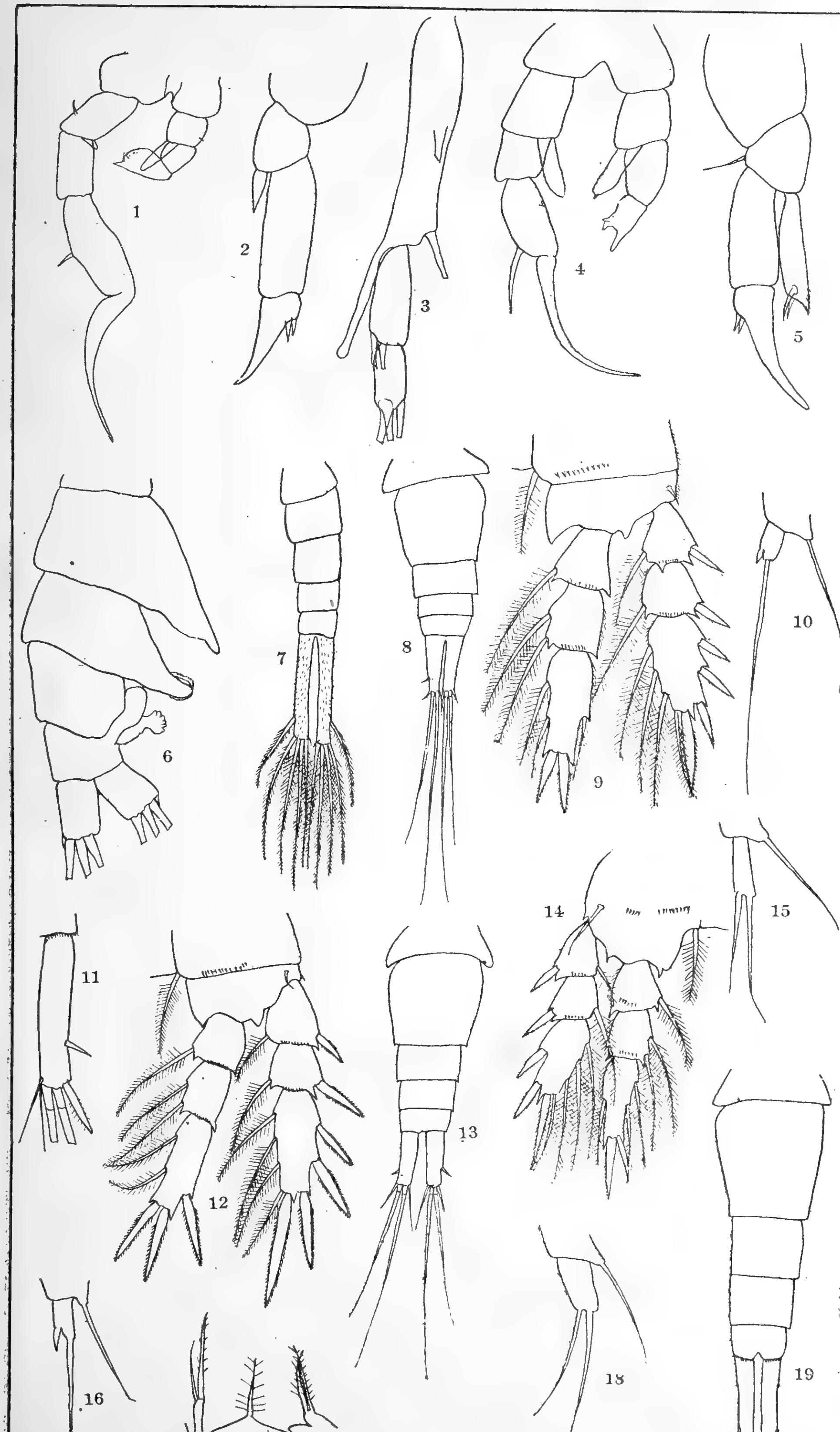
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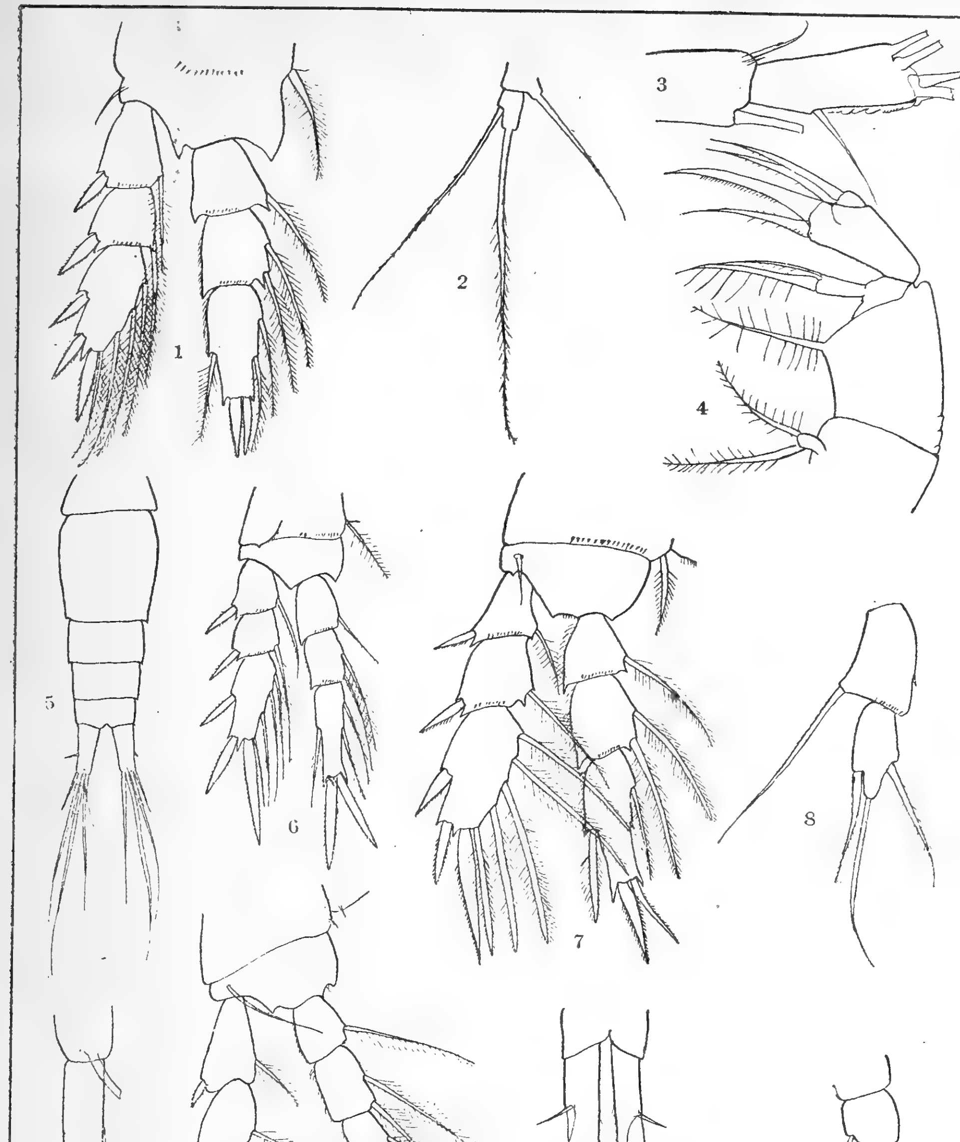
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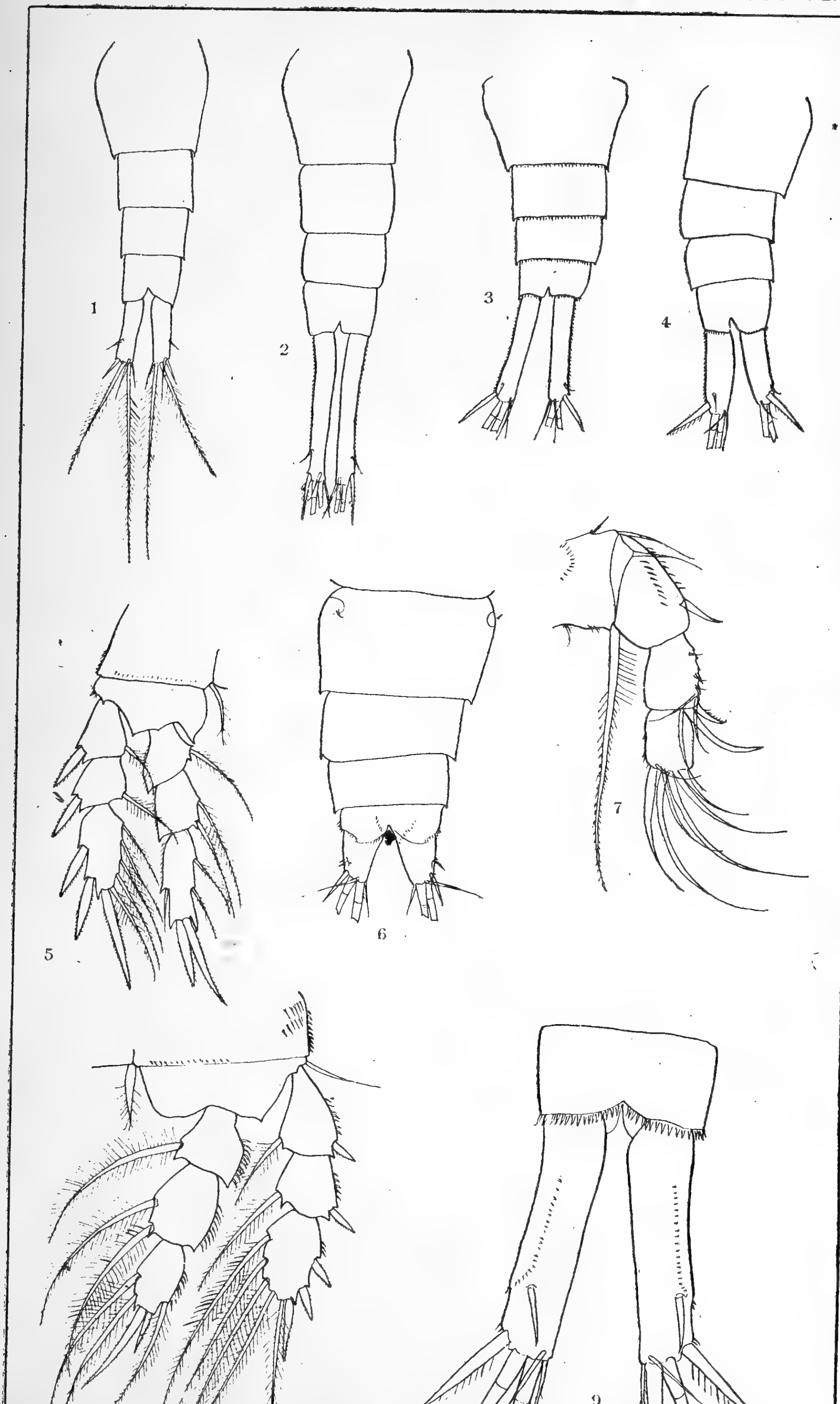
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ON TWO NEW SPECIES OF DIAPTOMUS.

C. DWIGHT MARSH,
Professor of Biology, Ripon College, Ripon, Wis.

FROM THE TRANSACTIONS OF THE WISCONSIN ACADEMY OF SCIENCES, ARTS, AND LETTERS, VOL. X.

[*Issued July 1894.*]

ON TWO NEW SPECIES OF DIAPTOMUS.

C. DWIGHT MARSH,

Professor of Biology, Ripon College.

DIAPTOMUS MISSISSIPPIENSIS. *Plate I, figs. 1–3.*

Of moderate size. The first two segments of the cephalotherax are nearly equal in length, and together form somewhat less than half the cephalothorax. The last segment of the cephalothorax is armed behind with two minute spines.

The first segment of the abdomen of the female is as long as the remainder of the abdomen and the furca; it is dilated laterally and in front, and bears two prominent lateral spines, the right spine being considerably larger than the left. The second segment is somewhat shorter than the third, and the third and the furca are of about equal length.

The antennæ reach beyond the furca. The right antenna of the male is swollen anterior to the geniculating joint, and the antepenultimate joint is without armature.

The outer ramus of the fifth foot of the female is two-jointed, the third joint being represented by two spines. The inner ramus is one-jointed, a little longer than the first joint of the outer ramus, and armed at the tip with minute setæ and two rather long spines.

In the right fifth foot of the male the basal joint is dilated on the inner margin. The first joint of the outer ramus is slightly broader than long. The second joint is elongated, quadrangular, with the lateral spine situated at the distal end. The terminal hook has the symmetry of the curve broken by two rather abrupt angles, and its inner margin is armed with fine serrulations. The inner ramus is one-jointed, and reaches about half the length of the second joint of the outer ramus.

The left fifth foot of the male reaches to about the middle of the second joint of the outer ramus of the right. The first joint of the outer ramus is as broad as long. The second joint is armed at tip with two finger-like processes, and both joints are armed within with minute hairs. The inner ramus is one-jointed, and nearly equal in length to the outer ramus.

Length of female, 1.2 mm.; male, 1.1 mm.

This species was found in some material kindly furnished to me by Professor E. A. Birge. The collections were made in January and February, 1893, in small lakes and ponds in Mississippi. It was the only *Diaptomus* in the collections, and was found in nearly all of them. It will be noticed that it bears a somewhat close resemblance to *D. graciloides* Sars.

DIAPTOMUS BIRGEI. *Plate I, figs. 4–6.*

Of moderate size. The first segment of the cephalothorax is nearly equal in length to the three following.

The first segment of the abdomen of the female is as long as the remainder of the abdomen and the furca. It is much dilated in front. The second segment is nearly twice as long as the third, and about equal in length to the furca. The second and third joints are very closely united.

The antennæ extend to the end of the furca. The right antenna of the male is much swollen anterior to the geniculating joint; the antepenultimate joint is produced on its distal end into a short, blunt process, which makes very nearly a right angle with the longitudinal axis of the joint.

The outer ramus of the fifth foot of the female is two-jointed, the third joint being represented by two spines. The inner ramus is one-jointed, hardly as long as the first joint of the outer ramus, and armed at the tip with minute setæ and two rather long spines.

The basal joint of the right fifth foot of the male is elongated, trapezoidal in form, its greatest breadth being at its distal extremity. The first joint of the outer ramus is broader than long, armed on its inner margin with a broad, thin expansion of the integument. The second joint is elongate, broader at base; the lateral spine is situated at about the middle of its length, is long and stout, and armed on its inner margin with fine serrulations. The terminal hook is slightly angular, and armed with fine serrulations on its inner margin. The inner ramus is one-jointed, equalling in length the first joint of the of the outer ramus.

The left fifth foot of the male reaches slightly beyond the first joint of the outer ramus of the right. The basal joint is quadrangular, considerably shorter than the right basal joint. The first joint of the outer ramus is about twice as long as broad. The second joint is slightly longer than the first joint; it is expanded at base, where it is armed with fine hairs, and terminates in a finger-like process bearing a falciform spine. The inner ramus extends to about one-half the length of the second joint.

Length of female, 1.5 mm.; male, 1.3 mm.

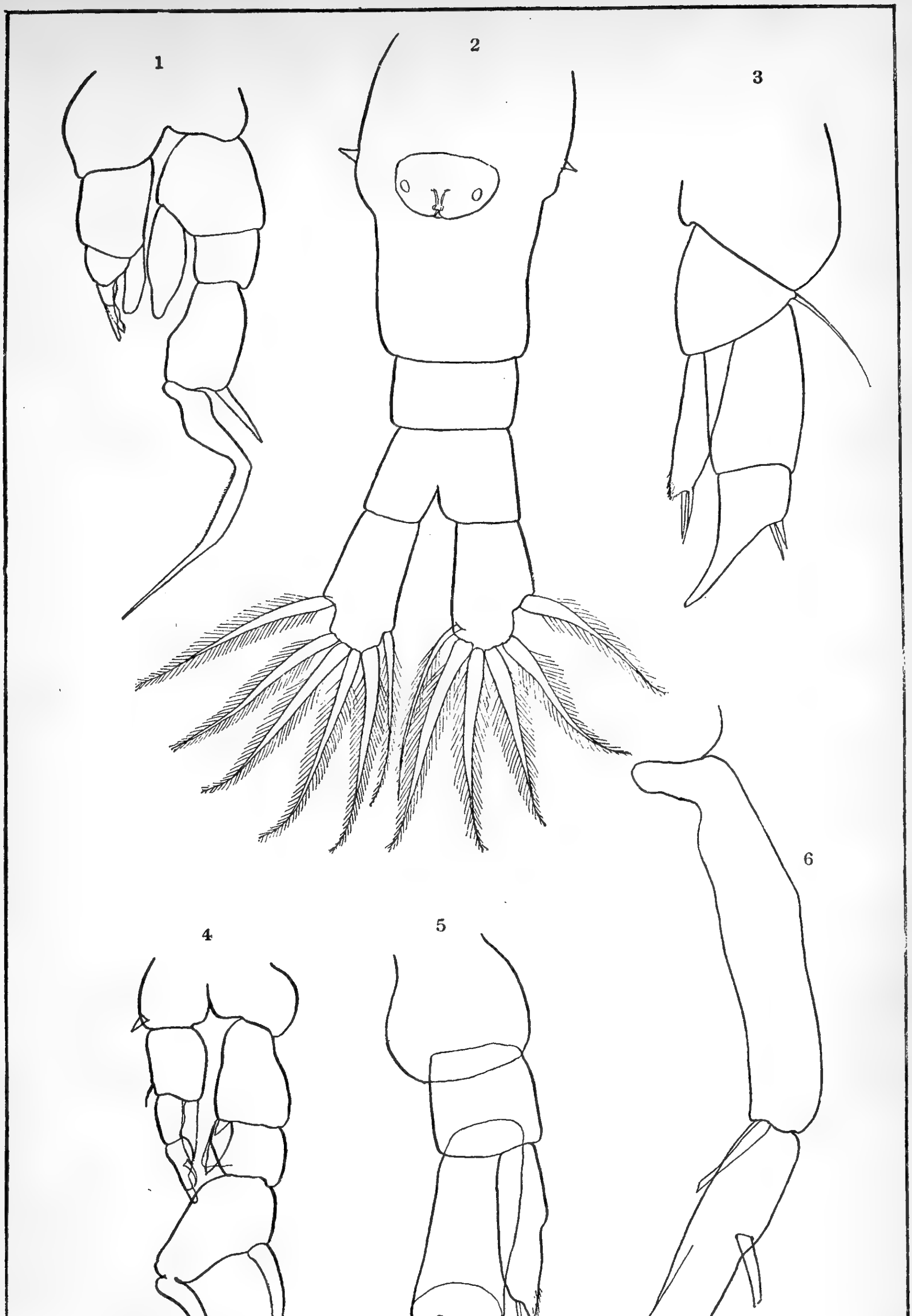
The material in which this species was found was collected by Professor E. A. Birge at New Lisbon, Wisconsin, and only a few individuals were found. I have expected to find it in the collections from other Wisconsin localities; but so far my search has been without success. It is a clearly marked species resembling the European *D. gracilis* Sars more closely than does any other described American species. The characters of the fifth feet, however, separate it from the European form.

I have taken the liberty of naming this species in honor of Professor Birge, to whose kind assistance and encouragement I have been greatly indebted.

Ripon, Wis.

Explanation of Plate I.

Fig. 1.	*Diaptomus*	*mississippiensis*—	fifth foot of male × 163.
" 2.	"	"	abdomen of female × 163.
" 3.	"	"	fifth foot of female × 300.
" 4.	"	*birgei*—	fifth foot of male × 163.
" 5.	"	"	fifth foot of female × 300.
6.	"	"	terminal joints of male antenna × 300.



MARSH ON DIAPTOMUS.

ZOOLOGY.

On the Vertical Distribution of Pelagic Crustacea in Green Lake, Wisconsin.—Green Lake is the deepest body of water in the State of Wisconsin, having a maximum depth of about 60 meters. Because of its great depth it has not only the litoral and pelagic faunæ of the shallower bodies of water, but also the true abyssal fauna which is characteristic of the deeper lakes. In fact, the crustacean fauna of Green Lake is almost identical with that of the great lakes.

In the deeper waters of Green Lake are found fifteen species of crustacea. Of these, twelve may be fairly considered as belonging peculiarly to the deep water fauna. Most of these can be captured in very large numbers at night by means of the skimming net. During the day, very few are found at the surface, some few never come to the surface, and are only obtained by dredging in the deep water.

Of course, an open dredge, dropped from the surface to the bottom and then hauled up, will collect from all depths. After a little experience, the collector has no difficulty in distinguishing between pelagic and abyssal species, and can even draw inferences, with a reasonable degree of accuracy, in regard to the general vertical distribution of species. So far as I know, however, very little exact work has been done to determine the vertical limits of the various species. By means of dredges which could be closed at any required depth, it has been found that in the deep sea there is a surface fauna and a deepwater fauna, but that the immediate intermediate region is barren of animal life. According to Agassiz, the surface fauna extends to the depth of 200 fathoms, and the bottom fauna is limited to about 60 fathoms.

Is there a similar condition in the waters of our lakes? With a view to answering this question, I made some preliminary collections in the summer of 1893.

I used, for the collections, a vertical dredge, so constructed that it could be closed at any desired depth. The collections upon which this paper is based were made in the latter part of August, at all hours between five o'clock in the morning and nine o'clock at night. Each series included collections for every five meters in depth. Of course, until a much larger number of collections is made, and at different seasons of the year, no final conclusions can be drawn. But the results thus far are interesting, and I think later collections are not likely to modify, to any great extent, the conclusions I have formed.

The results were a little disappointing to me at first, I must confess. I had made up my mind that I should find the three regions characteristic of the deep sea—the pelagic, intermediate and abyssal. It was rather discouraging, then, when I found material in my dredge from all depths. Not only that, but when I began to examine the collections under the microscope, I found certain species, which I had considered peculiar to the surface—like *Diaptomus minutus*—occurring all the way from the surface to the mud of the bottom. The barren intermediate zone, then, does not exist in Green Lake. It is true, however, that the numbers of individuals are less at intermediate depths than near the surface or near the bottom, and that some species are vastly more numerous in the upper zone, while others are almost entirely confined to the lower.

I counted the number of individuals in each haul, and after reducing the numbers to percentages, tabulated the results.

I will give briefly the conclusions I reached in regard to those species which are found most commonly.

The species which is found in the greatest numbers is *Diaptomus minutus*. In one haul this was associated with *D. sicilis* (a somewhat rare form in Green Lake), and in my computation I did not separate the two, as their habits are identical. On the average, 46 per cent of this species is within five meters of the surface, and 59.4 per cent within ten meters. Within ten meters of the bottom are only 7.37 per cent. It is evident that more than one-half of the individuals of these species are found within ten meters of the surface, and that from that point to the bottom, the numbers steadily decrease.

Daphnella is more exclusively pelagic—79 per cent being found within ten meters of the surface, and only 5.6 per cent at the bottom.

Epischura is still more distinctly pelagic—81 per cent being in the first ten meters, and 3.3 per cent in the last ten.

Leptodora, Bosmina and *Cyclops fluviatilis* are also found much more abundantly near the surface. *Leptodora* rarely goes below fifteen meters.

Daphnia kahlbergiensis seems somewhat erratic in its distribution. On the average, nearly 43 per cent are found within the first ten meters, but nearly 25 per cent are found in the last ten. Generally speaking, they appear more numerous near the surface and the bottom, but less so at intermediate depths. But they may occur at all depths, and sometimes quite numerously in the intermediate region.

Limnocalanus macrurus rarely, if ever, comes to the surface, and is found most abundantly within 20 meters of the bottom. Nordqvist states that he found *L. macrurus* in Finland, in June, most abundant at twelve meters below the surface, where the total depth was 25 to 26 meters.

Pontoporeia and *Mysis* live at the bottom, and belong to the true abyssal fauna.

In regard to the diurnal migrations of the pelagic species, I found it difficult to fix any exact limits. As has been before stated, they come to the surface at night. In the daytime, few of them go below ten meters. *Daphnia kahlbergiensis*, however, seems to be an exception, for, apparently, its migrations are limited only by the depth of the lake, and sometimes from 40 to 80 per cent are in the last ten meters.

As a result of these collections, I was led to doubt the value of "Plankton" determinations, at least so far as crustacea are concerned. All such determinations must start with the assumption that the life of the deeper waters is distributed uniformly. If this were true, successive hauls in the same depth of water would contain approximately the same number of individuals. This was far from the case in my collections. The position in the successive collections varied only as the boat drifted very slowly; yet the number of *Diaptomi* varied from 291 to 2,966; *Daphnella* from 0 to 122; *Daphnia kahlbergiensis* from 6 to 103, and *Epischura* from 7 to 105. It seems probable that they are present in swarms, and that the positions of the swarms are continually changing.

Zacharias, in his last report from the biological Station at Plön, has reached the same conclusions, not only in regard to the crustacea, but also the other pelagic organisms. "Plankton" determinations, in order to have much value, must be almost infinite in number.

Beginning with the fall of 1894, systematic work of a more detailed character will be carried on at Green Lake, as the Trustees of Ripon College have made an appropriation for the purpose.

—C. Dwight Marsh, Ripon College, Wisconsin.

Rotatoria of the Great Lakes.—The Michigan Fish Commission have issued, as Bulletin No. 3, a list of the Rotatoria found in Lake St. Clair and some of the inland lakes of Michigan, prepared by Mr. H. S. Jennings. Of the 122 rotifers named in the list, 6 are here described and figured for the first time. Strongly swimming forms, commonly found in the open water, are designated pelagic; those found among the vegetation of the shores and bottom, littoral. Of the former, 20 were observed in Lake St. Clair. In the case of the inland lakes, collections were made from the shore only. The most abundant pelagic species are *Polyarthra platyptera* Ehrbg., *Anuraea cochlearis* Gosse, and *Asplanchna priodonta* Gosse, which agree, in this respect, with the condition found in European lakes.

The Internal Anatomy and Relationship of Pauropus.—According to Peter Schmidt, whose preliminary paper appeared in the *Zoologischer Anzeiger*,[1] the internal anatomy of *Pauropus* allies it most closely with *Polyxenus* among the Diplopoda. The absence of trachea, of malpighian tubes and of a circulatory system, together with the presence of a rather complicated genital apparatus in the male, seem to show that it is very degenerate. That it belongs along with the Diplopoda—a fact that has been questioned—the presence of the ovary below the intestine, of the genital openings in the third body segment behind the second pair of legs, and of only two pairs of oval appendages, abundantly testify. The biramose antennæ may possibly be explained by a comparison with the sense papillæ at the end of the terminal joint of the Diplopod antenna, the more readily, too, since, according to Schmidt, the distal portions of the rami, the geisseln of Latzel appear to be finely ringed and not segmented.

Several peculiarities are interesting. The mid-gut is without a *muscularis* and its epithelial cells are filled with rhomboid crystals with double refractive powers. The supra- and sub-œsophageal and the first body ganglia are fused into one mass which is pierced by a very short fore-gut. The small processes on the first segment represent rudimentary legs and possibly function in respiration like the abdominal sacs of Thysanura, Symphyla and certain Diplopods. The sense organ of the antennæ, the *globulus* of Latzel, consists of an outer and inner capsule with the intervening space filled with a fluid. The whole is surrounded by ten or twelve bristles while the nerve passes into the inner capsule and expands into a nail-like head. (Fig: 1.)

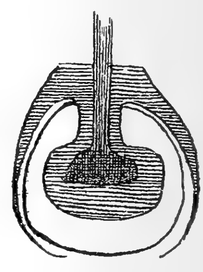


Fig. 1.

The female genital apparatus consists of an unpaired ovary lying, beneath the intestine, an unpaired receptaculum seminis and an oviduct opening to the exterior by an unpaired opening to the one side of the median line in the third segment. In the male there is an unpaired testis above the intestine, a complicated pair of ducts, a pair of seminal

[1] Zur Kenntniss des inneren Baues des Pauropus huxleyi Lubb. Zool. Anz., XVII, 189.

Bulletin of the Michigan Fish Commission

No. 5.

ON THE

CYCLOPIDÆ AND CALANIDÆ OF LAKE ST. CLAIR,

LAKE MICHIGAN, AND CERTAIN OF THE INLAND LAKES OF MICHIGAN.

BY C. DWIGHT MARSH,

PROFESSOR OF BIOLOGY IN RIPON COLLEGE.

RESULTS OF A BIOLOGICAL EXAMINATION OF LAKE ST. CLAIR UNDERTAKEN FOR THE STATE BOARD OF FISH COMMISSIONERS IN THE SUMMER OF 1893 UNDER THE SUPERVISION OF J. E. REIGHARD, AND OF SIMILAR WORK IN THE SUMMER OF 1894, IN THE VICINITY OF CHARLEVOIX UNDER THE SUPERVISION OF H. B. WARD.

LANSING

ROBERT SMITH & CO., STATE PRINTERS AND BINDERS,

1895.

Bulletin of the Michigan Fish Commission

No. 5.

ON THE

CYCLOPIDÆ AND CALANIDÆ OF LAKE ST. CLAIR,

LAKE MICHIGAN, AND CERTAIN OF THE INLAND LAKES OF MICHIGAN.

By C. Dwight Marsh,

Professor of Biology in Ripon College.

Results of a Biological Examination of Lake St. Clair Undertaken For the State Board of Fish Commissioners in the Summer of 1893 under the Supervision of J. E. Reighard, and of Similar Work in the Summer of 1894, in the Vicinity of Charlevoix under the Supervision of H. B. Ward.

LANSING:
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ON THE CYCLOPIDÆ AND CALANIDÆ OF LAKE ST. CLAIR, LAKE MICHIGAN, AND CERTAIN OF THE INLAND LAKES OF MICHIGAN.

From the standpoint of the pisciculturist, perhaps no class of animals outside the fishes themselves is so important and interesting as the entomostraca. It is a well known fact that these minute crustacea form the entire food material of the young of some of our most important food fishes, and in many cases form a large part of the food of the adults.

They are universally distributed. Every stream, lake, pond, and pool has its population of these minute creatures. Moreover they are present in some places in enormous numbers. In the deeper waters of our lakes the surface waters to a depth of about thirty feet fairly swarm with copepods. In limnetic collections there are always present some *Cladocera*, but the great bulk of the material in any lake will consist of two or three species of *Diaptomus* and as many of *Cyclops*.

Inasmuch as the occurrence and abundance of animals is largely dependent on their food supply, it will be seen that an accurate and thorough knowledge of entomostraca is of fundamental importance, if we would have an exact knowledge of the conditions controlling our fish.

The material on which this paper is based was obtained from the following sources.

1. Collections made by Professor Reighard in certain lakes in southern Michigan in the summers of 1891 and 1893.
2. Collections made by Professor Reighard in the northern part of Lake Michigan in the spring of 1893.
3. Collections made by Professor Reighard during the biological examination of Lake St. Clair in the summer of 1893. This involved a very large number of collections in the months of July and August, and its results probably give us a very accurate knowledge of the copepod fauna of Lake St. Clair in the summer season. In connection with this work a few collections were also made in the Detroit river and in Lake Erie.
4. Collections made in July and August 1894 in connection with the scientific work of the Michigan Fish Commission at Charlevoix. This involved a careful examination of Round Lake and Pine Lake, collections in Lake Michigan and the lakes on Beaver Island, and cursory examinations of the small lakes in the neighborhood of Charlevoix.

5. Collections made by Dr. R. H. Ward in September, 1894, in Emmet and Cheboygan Counties, along the "Inland Route."

Inasmuch as these collections were made for the most part, in the summer season, and more especial attention was paid to the larger bodies of water, the results of the examination cannot be considered as giving us a complete knowledge of the fauna of the State. A more careful examination of the smaller lakes and of the stagnant pools would doubtless add some species to the list. Yet the number of those species would be small, and for the larger bodies of water the list as given in this paper is probably very nearly complete.

This becomes evident when one remembers how nearly identical are the faunæ of the deeper waters of our lakes. To such an extent is this true that one can prophesy quite exactly what species will be found in a collection from any of the lakes of this latitude. The collections from the deeper water will almost invariably give the following species:—*Diaptomus oregonensis*, *Cyclops brevispinosus*, *C. Leuckarti and C. fluviatilis*. *C. albidus* and *C. serrulatus* may be present, but belong more properly to the littoral fauna. In the larger lakes, in addition to this list we may find *Epischura lacustris*. *Diaptomus sicilis*, *D. Ashlandi*, *D. minutus*, and *Limnocalanus macrurus* are not commonly found except in the Great Lakes and in the bodies of water in direct connection with them; in the Great Lakes, too, *C. pulchellus* takes the place which *C. brevispinosus* holds in the smaller lakes.

D. Reighardi is the only new species which I have found in the Michigan collections. As I have already remarked in a former paper ('93 p. 192) the species of *Diaptomus* are, in some cases, quite limited in their distribution, and apparently *Diaptomus* is much more susceptible to the influences of its environment than is *Cyclops*. Very little is known of the life histories of the species of *Diaptomus*, and it is possible that a more complete knowledge may lead to a reduction of the number of species. But, so far as I can see, all the forms described vary within comparatively narrow limits, and there is no evidence whatever to lead us to question the separation of the forms.

I have indicated, in the accompanying chart, the distribution of the species. It has not seemed necessary to indicate the character of the individual collections in Lake St. Clair and Lake Michigan as no particular significance is attached to such facts.

The sketch maps will show most of the localities where the collections were made.

It is interesting to note the greater richness of the copepod faunæ of our lakes as compared with those of the continent of Europe. Zacharias finds seven species of copepods belonging to the *Cyclopidæ* and *Calanidæ* in the Plöner See. In Lake Michigan there are nine, and that includes no littoral species; in the lakes on the Beaver Island there are eight, in Pine Lake nine, in Round Lake eleven, in Intermediate Lake eleven, and in Lake St. Clair sixteen. The large number in Lake St. Clair is probably explained by the fact that, being very shallow, it has the species of the smaller bodies of water and of the stagnant pools, and in addition, because of its connection with the Great Lakes, has also their limnetic species.

Table of occurrence of Cyclopidæ and Calanidæ.

	Diaptomus sicilis	" Ashlandi	" minutus	" Reighardi	" oregonensis	Epischura lacustris	Limnocalanus macrurus	Cyclops ater	" brevispinosus	" pulchellus	" parcus	" Leuckarti	" fuscus	" albidus	" fluviatilis	" serrulatus	" phaleratus	" bicolor
Lake near Baldwin.									+							+		
Bear Lake, Charlevoix County.			+		+	+			+			+			+	+		
Beaver Island, North Lake.				+					+					+		+		
Beaver Island, South Lake.					+	+			+			+		+	+	+		+
Black or Round Lake, Emmet County.									+			+		+		+		
Burt Lake, Cheboygan County.			+		+					+		+			+			
Carp Lake, Emmet County.						+			+			+		+	+	+		
Crooked Lake, Emmet County.			+	+	+	+			+			+			+	+		
Detroit River.	+	+	+				+		+	+						+		
Dodge Creek, Cheboygan County.														+		+		
Lake Erie.*					+	+			+	+		+			+			
Indian River, Cheboygan County.			+		+	+				+		+				+		
Intermediate Lake, Antrim County.				+	+			+	+			+	+	+	+	+	+	+
Long Lake, Genesee County.					+	+												
Long Lake, Ionia County.					+	+						+			+			
Lake Michigan.	+	+	+		+	+	+			+		+			+			
Mullet Lake, Cheboygan County.			+		+	+						+			+			
Pickerel Lake, Emmet County.					+				+			+		+		+		
Pigeon River, Cheboygan County.														+		+	+	
Pine Lake, Charlevoix County.	+	+	+		+	+				+		+			+			
Round Lake, Charlevoix County.		+	+		+	+		+	+	+		+		+	+	+		
Lake St. Clair.	+	+	+		+	+	+	+	+	+	+	+		+	+	+	+	+
Susan Lake.								+	+					+		+		
Twenty-sixth Lake.					+			+						+	+	+	+	
Twin Lakes, Charlevoix County.					+							+		+	+	+		

Pine Lake is peculiarly poor in its number of species. This is strikingly apparent when we compare it with Intermediate Lake. Pine Lake was very thoroughly examined, and it is likely that we are acquainted with all the species occurring there, and yet the number is only eight. All the collections from Intermediate Lake were made in one day by a party which went down from Charlevoix and remained only a few hours, and yet the number of different forms is eleven. Intermediate Lake seems to be an unusually rich collecting ground, for with the exception of Lake St. Clair and Round Lake, no other lake shows such a large number of species, and both Lake St. Clair and Round Lake have been very thoroughly explored. Moreover, in the case of Round Lake, several of the species may be considered as immigrants from Lake Michigan.

In general it may be said that the copepod fauna of Michigan does not differ materially from that of Wisconsin, which I have already described in a former report. (Marsh '93.) This is only what one would expect because of the very wide distribution of the species, as already noted. (Marsh '93, p. 191.)

Inasmuch as many of the species have been imperfectly described, it has seemed best to me in preparing this paper to devote some space to more detailed descriptions, and particularly to furnish some figures in addition to those already published, and in this way to supplement the work of preceding papers.

The literature of the *Copepoda* is so scattered that it is very difficult for any one except a specialist to make determinations of species that are at all satisfactory. Without doubt this fact has deterred many from attempting any study of the *Copepoda*. Much valuable work in regard to the distribution of species might be done by amateur investigators if there were any work giving brief directions by which the species might be determined with a fair degree of accuracy. This lack, with the advice of Professor Reighard, I have attempted to supply in the present paper. Preceding the notes on *Diaptomus* and *Cyclops*, I have given a brief synopsis of the species of those genera. These synopses, which, with some modifications, are like those in my paper on the copepods of Wisconsin, are intended simply to furnish a means of recognizing the species by some of their most obvious characters. While the first six plates may be considered as supplementing the work of my Wisconsin paper, I have thought best, in order to aid in the identification of species to add the seventh, which repeats some of the figures of the former paper. I think that by means of the synopses and plates, any one who has the patience to make the necessary dissections, will be able without much difficulty to identify our species of *Cyclops* and *Diaptomus*, at least as far as adult forms are concerned.

I have included in the synopses some species which have not yet been found in Michigan, but which have been reported from Wisconsin, and will, doubtless, after a more thorough exploration, be included in the Michigan fauna.

FAMILY CALANIDÆ.—Genus DIAPTOMUS Westwood.

KEY TO SPECIES OF DIAPTOMUS FROM CHARACTERISTICS OF THE MALE.

Antepenultimate joint of antenna without appendage,
  Fifth feet nearly equal in length, ... *oregonensis.*
  Left fifth foot shorter than right,
    Inner ramus of left fifth foot about equal in length to first joint of outer ramus, terminal hook of right foot not markedly angular, ... *pallidus.*
    Inner ramus of left fifth foot about twice as long as first joint of outer ramus, terminal hook of right foot with an abrupt angle at about midway of its length, *Reighardi.*
Antepenultimate joint of antenna with hyaline lamella, ... *leptopus.*
Antepenultimate joint of antenna with appendage,
  Appendage short and blunt,
    Left fifth foot hardly reaching end of basal joint of right, lateral spine of terminal joint of right foot weak, reaching about to end of joint, species large, occurring only in spring, ... *sanguineus.*
    Left fifth foot reaching to about one-third the length of the terminal joint of the right, lateral spine of terminal joint large, reaching to nearly one-half the length of the terminal hook, ... *Birgei.*
  Appendage as long or longer than the penultimate joint,
    Terminal hook of right fifth foot broad, lateral spine minute, ... *minutus.*
    Terminal hook falciform,
      Lateral spine nearer outer extremity of joint, ... *sicilis.*
      Lateral spine stout, nearer base of joint, ... *Ashlandi.*

Diaptomus sicilis Forbes.

Plate VII, figs. 1 and 11.

1882. *D. sicilis* Forbes, p. 645, pl. VIII, figs. 9 and 20.
1884. " " Herrick, p. 142, pl. Q, fig. 18.
1889. " " DeGuerne and Richard, p. 23, figs. 13 and 14, pl. II, fig. 13.
1891. " " Forbes, p. 702, pl. 1, fig. 6.
1893. " " Marsh, p. 197, pl. III, figs. 8 and 10.

D. sicilis is found everywhere in the Great Lakes, in Lake St. Clair and in the Detroit River. It is also found in Pine Lake, and very likely occurs in other bodies of water having direct connection with the Great Lakes.

I do not know of its occurrence in bodies of water away from the Great Lakes, except in Green Lake (Marsh '91 and '93), and Lake Geneva (Forbes, '90), and both of these are deep-water lakes.

Diaptomus Ashlandi Marsh.

Plate VII, fig. 2.

1893. *D. Ashlandi* Marsh, p. 198, pl. III, figs. 11–13.

When I described this species in my paper on the *Cyclopidæ* and *Calanidæ* of Wisconsin, I knew of only two localities for it, Lake Superior and Lake Erie. It occurred in the collections from Lake St. Clair and the Detroit River, but not abundantly. In the Lake Michigan collections it was a common species, but not nearly so numerous as *D. minutus*. I found it in none of the smaller lakes except Round Lake and Pine Lake.

DIAPTOMUS MINUTUS Lilljeborg.

Plate VII, fig 3.

1889. *D. minutus* DeGuerne and Richard, (Lilljeborg) p. 50, pl. I, figs. 5, 6 and 14, pl. III, fig. 25.

1891. *D. sicilis var. imperfectus* Forbes, p. 703.

1891. " " Marsh, p. 212.

1893. " " Marsh, p. 199, pl. IV, figs. 1 to 3.

D. minutus is, perhaps, the most common of all the *Diaptomi* in the collections from Lake St. Clair and the Great Lakes. With *D. sicilis* and *D. Ashlandi* it forms the great bulk of the crustacea in the limnetic collections. While I have found it in one or two of the Wisconsin lakes, it, like the two preceding species, has not so far been found in any of the Michigan waters which do not have direct connection with the Great Lakes. The three species may be fairly considered as characteristic of the fauna of the Great Lakes.

It is with considerable hesitation that I have considered Forbes's *imperfectus* identical with *minutus*. One can not be certain of the identity of the two forms from the description given by Forbes, and yet from the localities which he gives for his variety, it seems very probable that the two are the same. He speaks of it as common in Lake Superior and Lake Michigan, and in some adjacent lakes, and in Lake Geneva. Inasmuch as *D. minutus* is so common in the Great Lakes it is not at all probable that it has been overlooked by so accurate an observer as Professor Forbes, and as he reports *imperfectus* as an abundant form, I think the probabilities are that *imperfectus* is a synonym of *minutus*.

DIAPTOMUS OREGONENSIS Lilljeborg.

Plate VII, fig. 5.

1889. *D. oregonensis* DeGuerne and Richard, (Lillj.) pl. II, fig. 5, pl. III, fig. 8.

1893. " " Marsh, p. 200, pl. IV, figs. 4 and 5.

D. oregonensis is the common limnetic species of the smaller lakes. It occurs in the Great Lakes, but not abundantly, while in the smaller bodies of water it usually forms the larger part of the limnetic fauna.

DIAPTOMUS REIGHARDI, *sp. nov.*

Plate I, figs. 1-4.

The first segment of the cephalothorax is considerably shorter than the second. The first two segments form nearly half the length of the cephalothorax. The last segment is armed behind with two very minute spines.

The first segment of the abdomen of the female is elongated, nearly equal in length to the remainder of the abdomen and the furca. It is dilated laterally and in front and bears two rather small lateral spines. The second segment is about one-third shorter than the third. The third segment is slightly shorter than the furca.

The antennae reach the end of the furca. The right antenna of the male is swollen anterior to the geniculating joint; the antepenultimate joint has no appendage.

The outer ramus of the fifth foot of the female is two-jointed. The third joint is represented by the customary two spines. The inner ramus is one-jointed; it is somewhat longer than the first joint of the outer ramus, and is armed at tip with minute setæ and two spines.

In the right fifth foot of the male the basal joint is quadrangular, about one-half longer than broad. The length of the first joint of the outer ramus is about equal to its width. The second joint is elongate, concave on its inner margin; at about one-third of its length there is a minute spine on its inner margin; the rather long lateral spine is situated at about two thirds of its length. The terminal hook has a single abrupt angle at about one-half its length. The inner ramus is one-jointed and equals in length the first joint of the outer ramus.

The left fifth foot of the male reaches a little beyond the middle of the second joint of the outer ramus. The basal joint is about as broad as long, and is somewhat shorter than the basal joint of the right foot. The first joint of the outer ramus is about as broad as long, its distal end considerably narrower than the proximal. The second joint is about twice as long as the first, and the tip is expanded into two finger-like processes, of which the outer is much the larger and is armed on its inner surface with a pad bearing minute setæ. The inner ramus extends to rather less than one-half the length of the second joint of the outer ramus.

Length of female, 1.1395 mm.; male, 1.0248 mm.

This species, which is nearly related to *D. oregonensis*, is yet readily distinguished by the characters of the male fifth foot. I found it in the collections from only three localities,—the North Lake on Beaver Island, Intermediate Lake, and Crooked Lake.

I have named this species in honor of Professor Reighard who has, directly and indirectly, done so much to increase our knowledge of lacustrine faunæ.

GENUS EPISCHURA FORBES.

Plate II, figs. 1-6. Plate III, figs. 1-6.

EPISCHURA LACUSTRIS Forbes.

1844. *Scopiophora vagans* Pickering, p. 62.
1882. *E. lacustris* Forbes, pp. 541 and 648, pl. VIII, figs. 15, 16, 21, 23, pl. IX, fig. 8.
1884. *E. lacustris* Herrick, p. 131, pl. Q, fig. 13.
1889. " " DeGuerne and Richard, p. 90, pl. IV, figs. 3, 9 and 10.
1891. " " Forbes, p. 704, pl. I, figs. 1–5; pl. II, fig. 7.
1893. " " Marsh, p. 200, pl. IV, fig. 6.

I have very little doubt that, as stated by Herrick ('84, p. 131), the *Scopiophora vagans* of Pickering is the same as *E. lacustris.* The statement in regard to the armature of the abdominal furcæ can apply to no other genus, and as only one species of *Epischura* has been found in the Great Lakes, there would seem to be little doubt as to the identity of Pickering's species. If then we follow the laws of priority as strictly as do some authors, we should throw out Forbes's name. But I cannot think it wise when a name has been so long incorporated in our literature, and is founded on an accurate and easily recognized description, to throw it aside in favor of a name accompanied by a description which, it is true, probably applies to this animal, but is manifestly inaccurate in some particulars, and may be in all.

It is not necessary to give a detailed description of this species, as that has already been done by other authors, but, as very few figures of it have been published, it has seemed best to me to draw quite a number in order that they may serve for comparison of this genus with others, and of the various species of *Epischura* with each other.

A few points in the anatomy, which have not been noted by others should be mentioned.

Forbes has recently ('93, p. 255) called attention to the fact that the fourth abdominal segment of the male is without a process, and that the fifth bears two processes.

The antennæ are 25-jointed. In the female, clavate sensory setæ are present on all segments except the 4th, 6th, 8th, 10th, 20th, 21st, 22d and 24th. The 8th and 11th segments have each a short spine. The left antenna of the male is like those of the female except that the sensory setæ are much longer, particularly on the basal segments. The right antenna of the male is 22-jointed, with a hinge between the 18th and 19th segments. The 19th segment is formed by the union of the 19th, 20th and 21st of the typical antenna, and the 20th by the union of the 22d and 23d.

The outer rami of the swimming feet are three-jointed, and the inner one-jointed. In all the feet the inner ramus bears five setæ. In the first foot the first and second joints of the outer ramus have each one external and one internal seta. The terminal joint has six setæ. In the second, third, and fourth feet, the first and second joints of the outer ramus have spines externally instead of setæ as in the first foot. The terminal joint has two short spines externally, a long terminal spine with its outer margin deeply serrate, and four setæ on the internal margin.

E. lacustris was a common species in the collections from Lake St. Clair, Lake Michigan, and many of the smaller lakes.

Genus LIMNOCALANUS Sars.

Limnocalanus macrurus Sars.

Plate IV, figs. 1 and 2, Plate V, figs. 1-5.

1863. *L. macrurus* Sars., pp. 228-229.
1882. " " Forbes, p. 648.
1886. *Centropages Grimaldi* DeGuerne, pp. 1–10.
1888. *L. macrurus* Nordqvist, pp. 31–37, pl. I, figs. 9–11; pl. II, figs. 1–5; pl. III, figs. 1–4.
1889. *L. macrurus* DeGuerne and Richard, p. 77, pl. IV, figs. 5, 11, and 12.
1891. *L. macrurus* var. *auctus* Forbes, p. 706.
1893. " " Marsh, p. 201, pl. IV, fig. 7.

For the description of *L. macrurus* we must depend largely upon the elaborate description and figures of Nordqvist.

Forbes ('91, p. 706) thinks that our form is sufficiently different from the European to rank as a distinct variety. When preparing my former paper ('93) it did not seem to me that there was good reason for establishing a new variety. Recently I have made a more careful examination of the details of its structure, using material from Detroit River, Lake Michigan, and Green Lake. So far as the specimens I have examined are concerned, the points of difference mentioned by Forbes ('91, p. 707) do not exist. It seems to me that the twenty-fifth antennal segment is clearly separated from the twenty-fourth, and not consolidated as stated by him. In all my specimens I find the hook like spines on the eighth and twelfth segments.

Nordqvist and Forbes are in agreement in regard to the terminal teeth of the mandible, but Forbes finds one seta instead of the two figured by Nordqvist; in this respect my observations confirm those of Forbes. The accessory spines have been evident in my preparations. It would seem then, that unless *L. macrurus* is susceptible of local variations—a highly improbable supposition—that Forbes's variety can not stand, for the only point of difference on which it rests is the existence of one seta on the mandible instead of two.

The second joint of the second maxillipede differs slightly from Nordqvist's figure, and I have accordingly figured it. (Pl. V, fig. 5.) The difference appears to me, however, unimportant.

It is impossible to tell whether our species may not differ from the European in the armature of the antenna, as that was not worked out in detail by Nordqvist. In regard to the sensory setæ, he simply states that they are present on some of the segments, but does not state their number.

In the female, clavate sensory setæ are present on all joints except the 4th, 20th, 21st, 22d, and 24th. The setæ are distributed as follows: the first joint has three; there are two on the 2d, 3d, 5th, 7th, 9th, 10th, 11th 13th to 19th inclusive, and 22d to 24th inclusive; the 4th, 8th, 12th 20th, and 21st have one seta; the 6th has none; the 25th has four setæ, one of which is plumose; the 8th and 12th have, in addition to the ordinary and sensory setæ a hook-like spine.

The left antenna of the male is armed like the female antenna.

The right antenna of the male is 22-jointed, the 19-21 being united in one, and the 22d and 23d. The joint is between the 18th and 19th. The side of the 17th is produced into a blunt spine, and the 18th and 19th are armed on the inner margin with rows of minute spines. The number of the sensory setæ is the same as in the left antenna and in the antenna of the female, and not greater as stated by Nordqvist. In fact the differences in the armature of the right and left antennæ are only apparent, and are occasioned by the coalescence of the 19th–21st and the 22d and 23d joints.

It has seemed best to me to figure the swimming feet and describe them in some detail, in order to get a basis of comparison with similar forms.

In the first foot both the first and second basal joints are armed internally with a plumose seta. The first two joints of the exopodite have no external spines; the terminal joint has two external spines, two apical setæ—the outer spinulose on its outer margin—and three internal setæ. The terminal joint of the endopodite has one internal seta, two apical, and three internal.

The second, third and fourth feet have no seta on the second basal joint, and the first and second joints of the exopodite have each an external spine. In all the feet except the first there are groups of two or three minute spines at the bases of the spines of the exopodite.

The second and third feet are alike. The terminal joint of the exopodite has four internal setæ, and the terminal joint of the endopodite has two external setæ and four internal.

The fourth foot is like the second and third except that the terminal joint of the endopodite has three internal setæ. The fifth feet have no setæ on the basal joints. The second joint of the exopodite in the female is prolonged internally into a hook-like expansion. The exopodites of the male are two jointed, the terminal joints having a peculiar construction more easily understood from the figure than from any written description. The terminal joints of the endopodite in both male and female are armed with two external, two apical, and two internal setæ.

FAMILY CYCLOPIDÆ.—Genus CYCLOPS Müller.

KEY TO SPECIES OF CYCLOPS.

Antennæ 17-jointed,
- Fifth foot one-jointed, armed with one spine and two long setæ—a large species of dark color, ------------- *ater.*
- Fifth foot two-jointed,
  - Second joint of fifth foot armed with seta and short spine,
    - Terminal joint of outer branch of swimming feet armed externally with three spines,
      - Furca of moderate length—occurring in pools, ---- *Americanus.*
      - Furca elongated, outer furcal seta abbreviated to a short, thick spine—limnetic in habit, ---------*brevispinosus.*

Terminal joint of outer ramus of swimming feet armed externally with two spines, ... *parcus.*
Second joint of fifth foot with two terminal setæ,
Furca short—occurring in pools, ... *navus.*
Furca elongated—limnetic in habit, ... *pulchellus.*
Second joint of fifth foot with one terminal and one lateral seta, ... *Leuckarti.*
Second joint of fifth foot with three setæ,
With clavate seta on twelfth antennal segment, inner margin of furca not beset with hairs, egg-sacs lying away from abdomen, ... *albidus.*
Sensory hair on twelfth antennal segment, inner margin of furca beset with hairs, egg-sacs close to abdomen, ... *fuscus.*
Antennæ 16-jointed, fifth foot three-jointed, ... *modestus.*
Antennæ 12-jointed, fifth foot one-jointed,
Furca variable in length, armed externally with a row of fine spines, ... *serrulatus.*
Furca short, without armature of spines—a small limnetic species, ... *fluviatilis.*
Antennæ 11-jointed,
Swimming feet 3-jointed, ... *phaleratus.*
Swimming feet 2-jointed, ... *bicolor.*
Antennæ 8-jointed, ... *fimbriatus.*

CYCLOPS ATER Herrick.

Plate VI, figs. 1-4, 6, and 12.

1882. *C. ater* Herrick, p. 228, pl. III, figs. 9–12.
1884. " " " p. 145, pl. Q, figs. 9–12.
1887. " " " p. 14.

The cephalothorax is oval, nearly as broad as long, with the lateral angles produced caudally. The first segment equals two-thirds the total length of the cephalothorax.

The antennæ are 17-jointed, about as long as the cephalothorax, its segments having the typical armature of the *Cyclopidæ.* The last two segments have a smooth hyaline lamella, which in the last segment projects as a flat, blunt process beyond the end of the joint.

The abdomen is of moderate length, the last segment being armed posteriorly with a row of fine spines. The furca is rather more than twice as long as its width. The lateral spine is situated near the end. Of the terminal setæ, the outer is slightly shorter than the inner, the second is about twice as long as the outer, and the third about three times as long.

The swimming feet are armed as follows:

FIRST FOOT.

Outer br.	ex. 3 spines.	Inner br.	ex. 1 seta.
	ap. 2 setæ.		ap. 1 spine, 1 seta.
	in. 3 setæ.		in. 3 setæ.

SECOND AND THIRD FEET.

Outer br.	ex. 3 spines.	Inner br.	ex. 1 seta.
	ap. 1 spine, 1 seta.		ap. 1 spine, 1 seta.
	in. 4 setæ.		in. 3 setæ.

FOURTH FEET.

Outer br.	ex. 2 spines.	Inner br.	ex. 1 seta.
	ap. 1 spine, 1 seta.		ap. 2 spines.
	in. 4 setæ.		in. 2 setæ.

The fifth foot is one-jointed, and armed with a stout spine and two long setæ.

Average length 1. 77 mm.

A large, very robust form, of striking appearance because of its deep colors. The colors of the St. Clair specimens were as follows: antennæ, antennules, swimming feet and furcal setæ dark blue, almost black. The caudal margins of the cephalothorax have the same color. On each side of the abdomen, and extending to the ends of the furcæ is a strip of the same color but darker. Borders of the cephalothorax tinged with green. Oviducts white. The ovary is orange.

To the naked eye it resembles closely in form, size, and color an *Arrenurus* with which it is found associated. This may be a case of protective mimicry.

This species was originally described by Herrick in 1882, and is mentioned by him in his succeeding reports of 1884 and 1887, but has been noted by no other author. It was discovered by Professor Reighard in the St. Clair collections, and was worked out very thoroughly by him. It is from his notes that the above description is taken.

This seems to be a somewhat rare form in this region. I have found a few individuals in Rush Lake, Wisconsin, and in Michigan, besides in the St. Clair collections, have found it in Twenty-Sixth Lake, Intermediate Lake and Susan Lake. Where it occurs it is easily detected because of its large size and prominent colors. The specimens from Round Lake had more of the red color, so much so that this, on a superficial examination, seemed to be the most prominent color.

CYCLOPS BREVISPINOSUS Herrick.

Plate VII, fig. 12.

1884. *C. brevispinosus* Herrick, p. 148, pl. S, figs. 7–11.
1893. " " Marsh, p. 205, pl. IV, figs. 11 and 12.

C. brevispinosus occurred in the collections from Lake St. Clair, the Detroit river, Lake Erie, Susan Lake, Beaver Island, Intermediate Lake and Round Lake. I have found it in collections from Lake Superior and Lake Ontario, but, curiously, never in Lake Michigan collections.

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CYCLOPS ~~PULCHELLUS Koch.~~

Plate VII, fig. 14.

~~1838. *C. pulchellus* Koch, H. 21, pl. 2.~~
1857. " *bicuspidatus* Claus, p. 209, pl. XI, figs. 6 and 7.
1863. " " " p. 101.
1863. " *pulchelius* Sars, p. 246.
1870. " *bicuspidatus* Heller, p. 71.
1872. " " Fric, p. 221, fig. 6.
1876. " " Hoek, p. 17, pl. I, figs. 7–11.
1880. " *pulchellus* Rehberg, p. 543.
1880. " *helgolandicus* Rehberg ('80a), p. 64, pl. IV, fig. 5.
1882. " *Thomasi* Forbes, p. 649, pl. IX, figs. 10, 11, and 16.
1883. " *pectinatus* Herrick, p. 499, pl. VII, figs. 25, 28.
1883. " *Thomasi* Cragin, p. 13, pl. III, figs. 1–13.
1884. " " Herrick, p. 151, pl. U, figs. 4, 5, 7, and 8.
1885. " *pulchellus* Daday, p. 220.
1886. " " Vosseler, p. 194, pl. V, figs. 19–28.
1890. " " Lande, p. 50, pl. XXI, figs. 146–155.
1891. " *Thomasi* Forbes, p. 707, pl. II, fig. 8.
1891. " *bicuspidatus* Brady, p. 13, pl. V, figs 1–5.
1891. " *Thomasi* Brady, p. 14, pl. VI, figs. 1–4.
1891. " *bicuspidatus* Schmeil, p. 27.
1891. " " Richard, p. 229, pl. VI, fig. 6.
1892. " " Schmeil, p. 75, pl. II, figs. 1–3.
1893. " *Thomasi* Forbes, p. 249, pl. XXXIX, figs. 9–12, pl. XL, fig. 13.
1893. " *pulchellus* Marsh, p. 207, pl. IV, figs. 18–19.

C. pulchellus is the common *Cyclops* of the Great Lakes. It occurs sometimes in smaller bodies of water, but in the collections from Michigan I have not found it from any of the small lakes except Pine Lake and Round Lake.

According to Forbes ('82 b) *C. pulchellus* and the *Diaptomi* form the greater part of the food of the young white fish.

CYCLOPS PARCUS Herrick.

1882. *C. parcus* Herrick, p. 229, pl. VI, figs. 12–15.
1884. " " " p. 148, pl. R, fig. 22.
1893. " " Marsh, p. 208, pl. IV, fig. 16, pl. V, fig. 1.

I have found *C. parcus* only in the collections from Lake St. Clair.

CYCLOPS LEUCKARTI Sars.

Plate VII, fig. 15.

1863. *C. Leuckarti* Sars, p. 239.
1874. " *simplex* Poggenpol, p. 70, pl. XV, figs. 1–3.
1875. " *tenuicornis* Uljanin, p. 30, pl. IX, figs. 12 and 13.
1876. " *Leeuwenhoekii* Hoek, p. 19, pl. III, figs. 1–12.
1880. " *simplex* Rehberg, p. 542.
1884. " " Herrick, p. 150.

1884. *C. oithonoides* Herrick, p. 150, pl. S, figs. 2–6.
1885. " *Leuckarti* Daday, p. 218.
1885. " *simplex* Daday, p. 236.
1885. " *pectinatus* Daday, p. 223, pl. I, figs. 7–13.
1886. " *simplex* Vosseler, p. 193, pl. IV, figs. 15–17.
1887. " " Herrick, p. 17, pl. VII, fig. 1, a-j.
1890. " " Thallwitz, p. 79.
1890. " " Lande, p. 55, pl. XVI, figs. 42–45; pl. XVII, figs. 46–50.
1891. " *Leuckarti* Schmeil, p. 25.
1891. " *edax* Forbes, p. 709, pl. III, fig. 15; pl. IV, figs. 16–19.
1891. " *Scourfeldi* Brady (?) p. 10, pl. IV, figs. 1–8.
1891. " *Leuckarti* Richard, p. 230, pl. VI, fig. 20.
1892. " " Schmeil, p. 57, pl. III. figs. 1–8.
1893. " " Marsh, p. 209, pl. IV, fig. 17; pl. V, figs. 2–6.

I have no doubt that, as stated by Schmeil, *C. Leuckarti* Claus and *C. Leuckarti* Sars are identical, and that possibly by strict laws of priority Claus should be given as authority for the name. Yet, as the description by Claus is not only imperfect, but in many respects inaccurate and misleading, I have preferred to retain the designation of *C. Leuckarti* Sars. Other points in the synonomy are discussed in Schmeil '92 and Marsh '93.

As would be expected, this species was distributed almost universally in the waters examined.

Cyclops fuscus Jurine.

Plate VI, figs. 5, 7 and 11.

1820. *Monoculus quadricornis fuscus* Jurine, p. 47, pl. II, fig. 2.
1841. *C. signatus* Koch, H 21, pl. VIII.
1850. " *quadricornis var. c* Baird, p. 203, pl. XXIV, fig. 5.
1857. " *coronatus* Claus, p. 29, pl. I, fig. 5, and pl. II, figs. 1–11.
1863. " " " p. 97, pl. II, fig. 16; pl. X, fig. 1.
1863. " *signatus* Sars, p. 242.
1863. " *coronatus* Lubbock, p. 199.
1870. " " Heller, p. 71.
1872. " " Fric, p. 218, fig. 12.
1876. " " Hoek, p. 12.
1878. " *signatus* Brady, p. 100, pl. XVII, figs. 4–12.
1882. " *tenuicornis* Herrick, p. 227, pl. V, fig. 14; pl. VI, figs. 1–11, and 20.
1884. " *tenuicornis* Herrick, p. 153, pl. R, fig. 16; pl. Q[4], figs. 8–11, and 20.
1885. " *signatus* Daday, p. 208.
1886. " " Vosseler, p. 189, pl. IV, figs. 6–10.
1888. " *fuscus* Sostariç, p. 58.
1890. " *signatus* Thallwitz, p. 79.
1890. " " Lande, p. 33, pl. XV, figs. 1–12.
1891. " " Brady, p. 6, pl. 2, fig. 5.
1891. " *fuscus* Richard, p. 223, pl. VI, fig. 6.
1891. " " Schmeil, p. 22.
1892. " " " p. 123, pl. I, figs. 1–7b; pl. IV, fig. 2.
1893. " *signatus* Marsh, p. 211.

In my paper on the Wisconsin *Cyclopidæ* and *Calanidæ* ('93), agreeing with Herrick and Brady, I expressed my belief that the two forms here called *fuscus* and *albidus*, the *coronatus* and *tenuicornis* of Claus, belonged to the same species, *fuscus* being the more mature form. Since writing that paper I have examined a large number of specimens from widely separated localities, and I must acknowledge that I was wrong, and that, as stated by Schmeil ('92), the two forms must be considered distinct, for I have been utterly unable to find the connecting forms. The points of difference, as stated so elaborately by Schmeil, hold good for the American specimens. *C. fuscus* has a sensory hair on the twelfth antennal segment, the hyaline lamella of the 17th segment deeply notched, the third segment of the antennule short, the inner borders of the furca thickly beset with hairs, and the egg sacs lie close to the abdomen, while *C. albidus* has a clavate seta on the twelfth antennal segment, the membrane of the 17th segment serrate or smooth, the inner borders of the furca either without hairs or with only fine hairs, and the egg sacs lie separated from the abdomen. These characters, with the greater size of *C. fuscus*, serve to distinguish the species, while the less evident characters mentioned by Schmeil are easily demonstrated.

One characteristic not mentioned by Schmeil I have found constantly in my specimens. The larger of the two terminal spines of the endopodite of the fourth foot, instead of being serrated on its edges as is customary in all the spines of the swimming feet, is beset on its inner margin with long, rather irregular teeth, as shown in the plate. (Plate VI, fig. 7.) If this peculiarity exists in the European forms, it would seem probable that it would have been noted by some observer, but I have nowhere seen an account of it. It may serve then to indicate a slight variation from the European type.

I have found *C. fuscus* in the Michigan collections from only one locality, Intermediate Lake. I have found it in several Wisconsin localities, though nowhere abundantly, and it is probable that it occurs in other localities in Michigan.

Cyclops albidus Jurine.

Plate VI, figs. 8–10.

1820. *Monoculus quadricornis albidus* Jurine, pp. 44 and 47, pl. II, figs. 10 and 11; pl. III, fig. 24.
1841. *C. annulicornis* Koch, H 21, pl. VI.
1850. " *quadricornis* var. *b* Baird, p. 202, pl. XXIV, fig. 4.
1857. " *tenuicornis* Claus, p. 31, pl. III, figs. 1–11.
1857. " *pennatus* Claus, p. 35, pl. III, figs. 12–17.
1863. " *tenuicornis* Claus, p. 99, pl. I, fig. 3; pl. II, fig. 17; pl. IV, fig. 5.
1863. " *tenuicornis* Sars, p. 242.
1863. " *annulicornis* Sars, p. 243.
1863. " *tenuicornis* Lubbock, p. 202.
1870. " *tenuicornis* Heller, p. 71.
1872. " " Fric, p. 219, fig. 12.
1874. " *Clausii* Poggenpol, p. 70, pl. XV, figs. 4–14.
1875. " *signatus* Uljanin, p. 29, pl. IX, figs. 6–11; pl XI, fig. 8.
1876. " " Hoek, p. 12, pl. I, figs. 1–4.

1878. *C. tenuicornis* Brady, p. 102, pl. XVII, figs. 1–10.
1882. " " Herrick.
1883. " " Cragin, p. 3, pl. II, figs. 1–14.
1883. " *signatus* var. *fasciacornis* Cragin, p. 2, pl. II, fig. 15.
1884. " *tenuicornis* var. *a* Herrick, p. 153, pl. Q^4, figs. 1–7.
1885. " " Daday, p. 211.
1886. " " Vosseler, p. 189, pl. IV, figs. 6–10.
1888. " *albidus* Sostariç, pl. I, figs. 3, 4 and 12.
1890. " *tenuicornis* Thallwitz, p. 79.
1890. " " Lande, p. 36, pl. XVI, figs. 22–32.
1891. " *gyrinus* Forbes, p. 707, pl. II, fig. 9; pl. III, fig. 14.
1891. " *albidus* Schmeil, p. 23.
1891. " *annulicornis* and *tenuicornis* Richard, pp. 224–226.
1892. " *albidus* Schmeil, p. 128, pl. I, figs. 8–14b; pl. IV, fig. 2.
1893. " *signatus* Marsh, p. 211, pl. V, figs. 7–9.

Schmeil states that the antennæ of *C. albidus* are armed with crowns of spines as in the case of *C. fuscus*. This seems to be rarely true in our forms. Although I have examined with great care large numbers of mature females, it is only in very few specimens that I have found this peculiar armature. The membrane of the terminal antennal segment is ordinarily serrate. The common form corresponds to the *annulicornis* of Sars and Richard, which, according to Schmeil, Richard now allows to be a variety of *albidus*. The distinguishing characteristic of *annulicornis* is the rudimentary seta of the inner margin of the terminal segment of the endopodite of the fourth foot. This is represented in most of my specimens only by a minute spine. (Pl. VI, fig. 9.) In two individuals I have found in place of this minute spine a short seta. (Pl. VI, fig. 8.) In these two specimens the circlets of spines were present on the 8th, 9th, 10th, 12th, 13th, and 14th segments. It was this form evidently that Cragin called *C. tenuicornis* ('83 pl. II, figs. 1–14), as is shown very clearly by the figures of the fourth foot and antennule, although he did not figure the circlets of spines on the antennal segments. *C. signatus* var. *fasciacornis* Cragin, it is not possible to identify with certainty, although it seems probable that it is *albidus*. *C. gyrinus* Forbes does not have the antennal circlets of spines, but does have a short seta instead of a minute spine on the fourth foot, thus agreeing with Cragin's figures of *C. tenuicornis*. This would seem to be intermediate between the two forms I have seen. It is difficult in such a case to tell just where the limits of species should be drawn, for we are entirely ignorant of the life histories of the forms, and it is certain that the *Cyclopidæ* have wide limits of variation. It seems to me safer, for the present, at least, to consider such minute differences as varietal, and not to increase the number of species.

C. albidus is not very abundant, but occurred in many of the St. Clair collections, and in some of those from other points in Michigan. It is a universally distributed species, but does not occur in great numbers.

CYCLOPS FLUVIATILIS Herrick.

1882. *C. fluviatilis* Herrick, p. 231, pl. VII, figs. 1–9.
1883. " *magnoctavus* Cragin, p. 5, pl. II, figs 14–23.
1884. " *fluviatilis* Herrick, p. 159, pl. Q^5, figs. 1–9.
1887. " " Herrick, p. 15.

1891. *C. magnoctavus* Brady, p. 19, figs. 1–4.
1893. " *fluviatilis* Marsh, p. 214, pl. V, figs. 14 and 15; pl. VI, fig. 1.

C. fluviatilis occurs in most of the limnetic collections in all except the smallest bodies of water.

CYCLOPS SERRULATUS Fischer.

1851. *C. serrulatus* Fischer, p. 423, pl. X, figs. 22, 23, 26–31.
1853. " " Lilljeborg, p. 158, pl. XV, fig. 12.
1857. " " Claus, p. 36, figs. 1–3.
1863. " " Sars, p. 254.
1863. " " Claus, p. 101, pl. I, figs. 1 and 2; pl. IV, fig. 12; pl. XI, fig. 3.
1863. " " Lubbock, p. 197.
1870. " " Heller, p. 72.
1872. " " Fric, p. 222, fig. 18.
1875. " " Uljanin, p. 34, pl. VIII, figs. 1–8.
1878. " " Brady, p. 109, pl. XXII, figs. 1–6.
1878. " " var. *montanus* Brady, p. 110, pl, XXII, figs. 7–14.
1880. " *agilis* Rehberg, p. 545.
1882. " " Forbes, p. 649.
1882. " *serrulatus* Herrick, p. 230, pl. V, figs. 1–5; pl. VII, fig. 10.
1883. " *pectinifer* Cragin, p. 6, pl. IV, figs. 1–7.
1884. " *serrulatus* Herrick, p. 157, pl. O, figs. 17–19.
1884. " " var. *elegans* Herrick, p. 158.
1885. " *agilis* Daday, p. 240.
1886. " " Vosseler, p. 190, pl. V, figs. 29–31.
1890. " " Thallwitz, p. 79.
1890. " " Lande, p. 60, pl. XVII, fig. 69; pl. XVIII, figs. 70–80.
1891. " *serrulatus* Schmeil, p. 29.
1891. " " Richard, p. 234, pl. VI, figs. 6–12.
1891. " *agilis* Forbes, p. 710.
1892. " *serrulatus* Schmeil, p. 141, pl. V, figs. 6–12.
1893. " " Marsh, p. 215, pl. VI, figs. 2–5.

This well known species occurs everywhere in Michigan waters and with the same variations in structure which I have noted in the collections made in Wisconsin. (Marsh '93, pp. 215–216.)

CYCLOPS PHALERATUS Koch.

1838. *C. phaleratus* Koch, H 21, pl. IX.
1851. " *canthocarpoides* Fischer, p. 426, pl. X, figs. 24, 25, 32–38.
1853. " " Lilljeborg, p. 208.
1857. " " Claus, p. 37, pl. I, figs. 6–10.
1863. " " " p. 102, pl. IV, figs. 1–4.
1863. " " Lubbock, p. 202.
1863. " *phaleratus* Sars, p. 255.
1872. " *canthocarpoides* Fric, p. 223, fig. 19.
1874. " *lascivus* Poggenpol, p. 72, pl. XV. figs. 22–24; pl. XVI, figs. 7 and 8.
1875. " *phaleratus* Uljanin, p. 38, pl. IX, figs. 1–5.
1878. " " Brady, p. 116, pl. XXIII, figs. 7–13.
1882. " *adolescens* Herrick, p. 231, pl. VI, figs. 15–20.

1883. *C. perarmatus* Cragin, p. 7, pl. I, figs. 9–18.
1884. " *phaleratus* Herrick, p. 161, pl. R, figs. 6–10.
1885. " " Daday, p. 252.
1887. " " Herrick, p. 14, pl. VII, figs. 2, a–d.
1888. " " Sostariç, p. 74, pl. II, figs. 21–22.
1890. " " Lande, p. 75. pl. XX, figs. 126–136.
1891. " " Schmeil, p. 36.
1891. " " Brady, p. 25, pl. IX, fig. 2.
1891. " " Richard, p. 238, pl. VI, fig. 12.
1892. " " Schmeil, p. 170, pl. VIII, figs. 1–11.
1893. " " Marsh, p. 216, pl. VI. figs. 6 and 7.

I have found *C. phaleratus* in the collections from only three localities,—Lake St. Clair, Intermediate Lake, and Twenty-sixth Lake. Very little attention, however, was paid in the collections to the smaller lakes and stagnant pools, and it is probable that in such localities it occurs generally distributed through the State.

Cyclops bicolor Sars.

Plate I, figs. 5–7.

1863. *C. bicolor* Sars, p. 253.
1880. " *diaphanus* Rehberg, p. 547.
1884. " " Herrick, p. 160, pl. R, fig. 12.
1885. " " Daday, p. 246.
1885. " *brevisetosus* Daday, p. 255, pl. III, figs. 3, 5 and 10.
1887. " *diaphanus* Herrick, p. 16, pl. VII, figs. 3 a–e.
1888. " " Lande. p. 67, pl. 18, figs. 91–98.
1891. " *bicolor* Schmeil, p. 34.
1891. " *diaphanus* Richard, p. 236, pl. VI, fig. 26.
1892. " *bicolor* Schmeil, p. 118, pl. VI, figs. 6–13.
1893. " " Marsh, p. 217.

I have found *C. bicolor* in the collections from three of the Michigan lakes—Lake St. Clair, Intermediate Lake, and South Lake on Beaver Island. Doubtless more thorough collections from small lakes and stagnant pools would furnish other localities, though this species seems to be nowhere very abundant. I have found, in a collection from a lake in northern Wisconsin, an egg-bearing female with ten-jointed antennæ, the fourth and fifth joints of the eleven-jointed variety being united in one. Unless this specimen should be considered a monstrosity, we would infer that this species can reproduce in either the ten or eleven-jointed stage.

I have added to the synonomy as previously given *C. brevisetosus* Daday. I do not feel certain of the identity of the two forms, and yet it seems to me probable that they are the same. I can not read the Hungarian, but from the Latin synopsis and the figures I can not help thinking that *brevisetosus* is the same as *bicolor*. The points of difference are the following. The furca of *brevisetosus* is longer than in typical *bicolor*. The armature of the swimming feet does not correspond to Daday's description, but the one figure which he gives of a swimming foot closely resembles the structure of *bicolor*, and does not correspond to his own description. The antennæ of *brevisetosus* are ten-jointed, but they correspond exactly to the structure of my ten-jointed specimen of *bicolor*. In all other respects the descriptions agree.

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Although the list of papers consulted is very nearly the same as that of my paper on the Wisconsin *Cyclopidæ* and *Calanidæ*, I have though it best to insert it in this paper for convenience of reference. I have not had the opportunity of seeing the original paper of Poggenpol, nor the papers of Sostariç and Thallwitz, and the quotations from those authors are taken from Schmeil. In all other cases I have personally verified the references.

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EXPLANATION OF PLATES.

PLATE I.

Fig. 1. *Diaptomus Reighardi*—fifth feet of female x 340.
2. " " abdomen of male x 195.
3. " " fifth feet of male x 223.
4. " " abdomen of female x 190.
5. *Cyclops bicolor*—abdomen of female x 269.
6. " " antenna of female x 333.
7. " " 10-jointed antenna of female x 325.

PLATE II.

Fig. 1. *Epischura lacustris*—antenna of female x 113.
2. " " right antenna of male x 113.
3. " " antennule x 113a.
4. " " mandible and palpus x 217.
5. " " second maxillipede x 217.
6. " " first maxillipede x 217.

PLATE III.

Fig. 1. *Epischura lacustris*—first foot x 217.
2. " " second foot x 153.
3. " " fifth foot of female x 217.
4. " " fifth foot of male x 153.
5. " " abdomen of female x 113.
6. " " abdomen of male x 113.

PLATE IV.

Fig. 1. *L. macrurus*—right antenna of male x 275.
2. " " left antenna of male x 275.

PLATE V.

Fig. 1. *L. macrurus*—first foot x 275.
2. " " second foot x 275.
3. " " fifth foot of female x 275.
4. " " fifth foot of male x 275.
5. " " second and third joints of second maxillipede x 275.

PLATE VI.

Fig. 1. *Cyclops ater*—abdomen of male x 146.
2. " " receptaculum seminis x 113.
3. " " fourth foot x 113.
4. " " 11th, 12th, and 13th antennal segments of female x 113.
5. " *fuscus*—terminal joints of female antenna x 217.
6. " *ater*—terminal joints of female antenna x 217.
7. " *fuscus*—terminal joint of endopodite of fourth foot x 217.
8. " *albidus*—terminal joint of endopodite of fourth foot x 280.
9. " " terminal joint of endopodite of fourth foot x 280.
10. " " antennule x 217.
11. " *fuscus*—antennule, first three joints x 217.
12. " *ater*—outline of cephalothorax of female x 108.

PLATE VII.

Fig. 1. *Diaptomus sicilis*—fifth feet of male x 140.
2. " *Ashlandi*—fifth feet of male x 140.
3. " *minutus*—fifth feet of male x 140.
4. " " fifth foot of female x 250.
5. " *oregonensis*—fifth feet of male x 140.
6. " *pallidus*—fifth feet of male x 200.
7. " *leptopus*—fifth feet of male x 138.
8. " *sanguineus*—fifth feet of male x 138.
9. " *Birgei*—fifth feet of male x 136.
10. " *sanguineus*—terminal joints of male antenna x 136.
11. " *sicilis*—terminal joints of male antenna x 136.
12. *Cyclops brevispinosus*—fifth foot x 250.
13. " *modestus*—fifth foot x 250.
14. " *pulchellus*—fifth foot x 250.
15. " *Leuckarti*—fifth foot x 250.

PLATE VIII.

Sketch map of Lake St. Clair and vicinity, showing collecting stations.

PLATE IX.

Sketch map of Charlevoix and vicinity showing collecting stations.

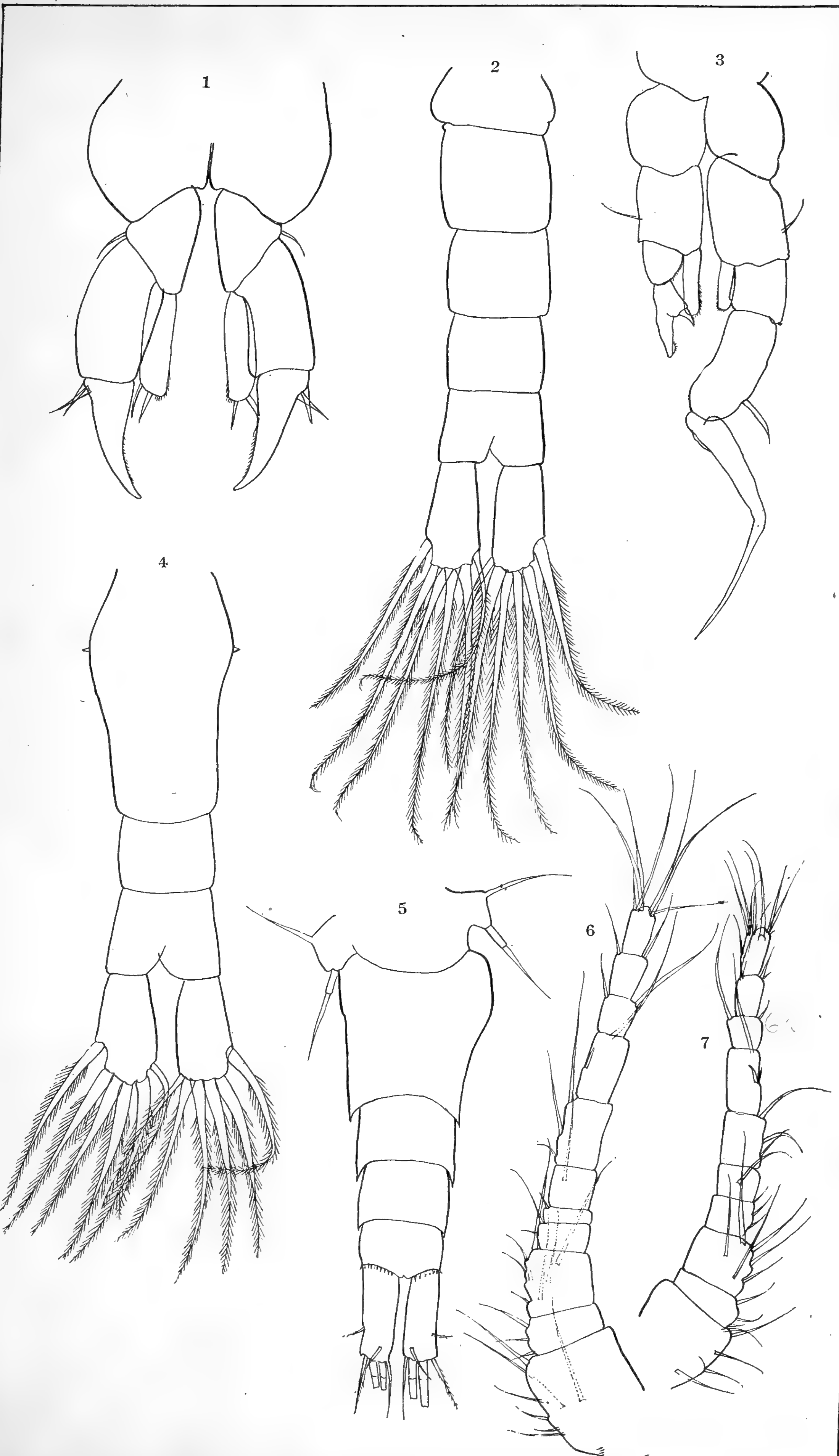


PLATE I.

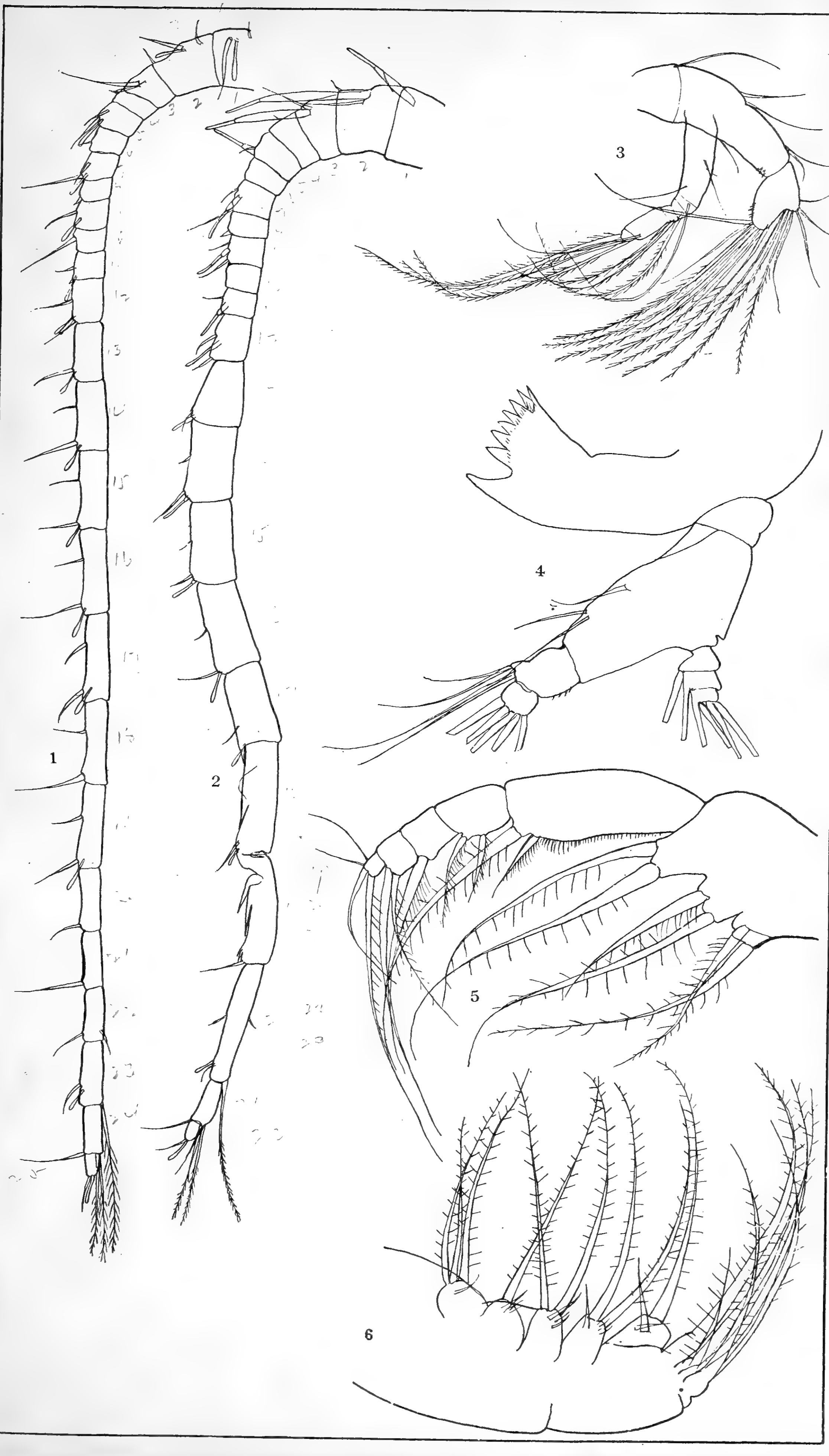


PLATE 11

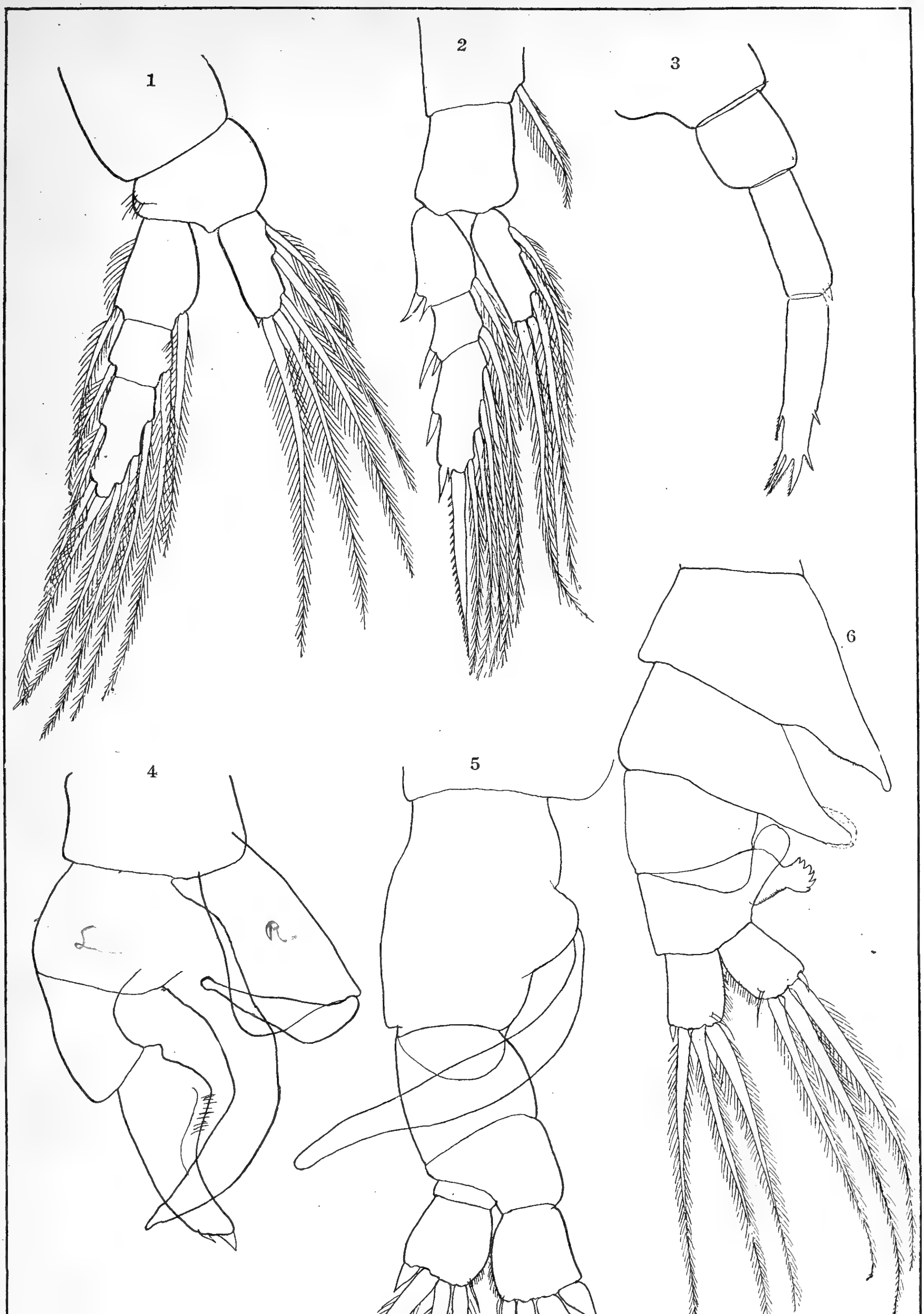
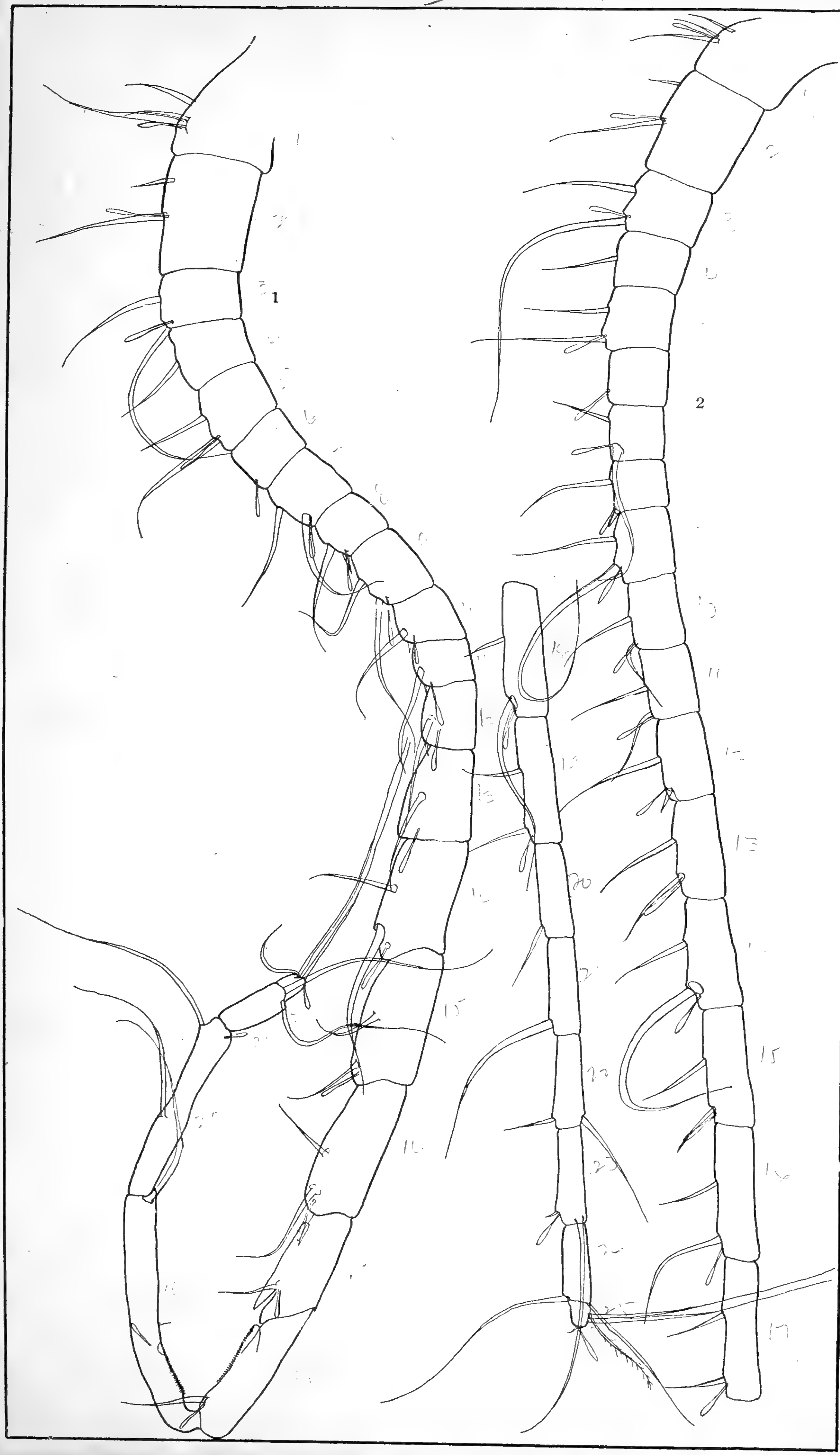


PLATE III

IV



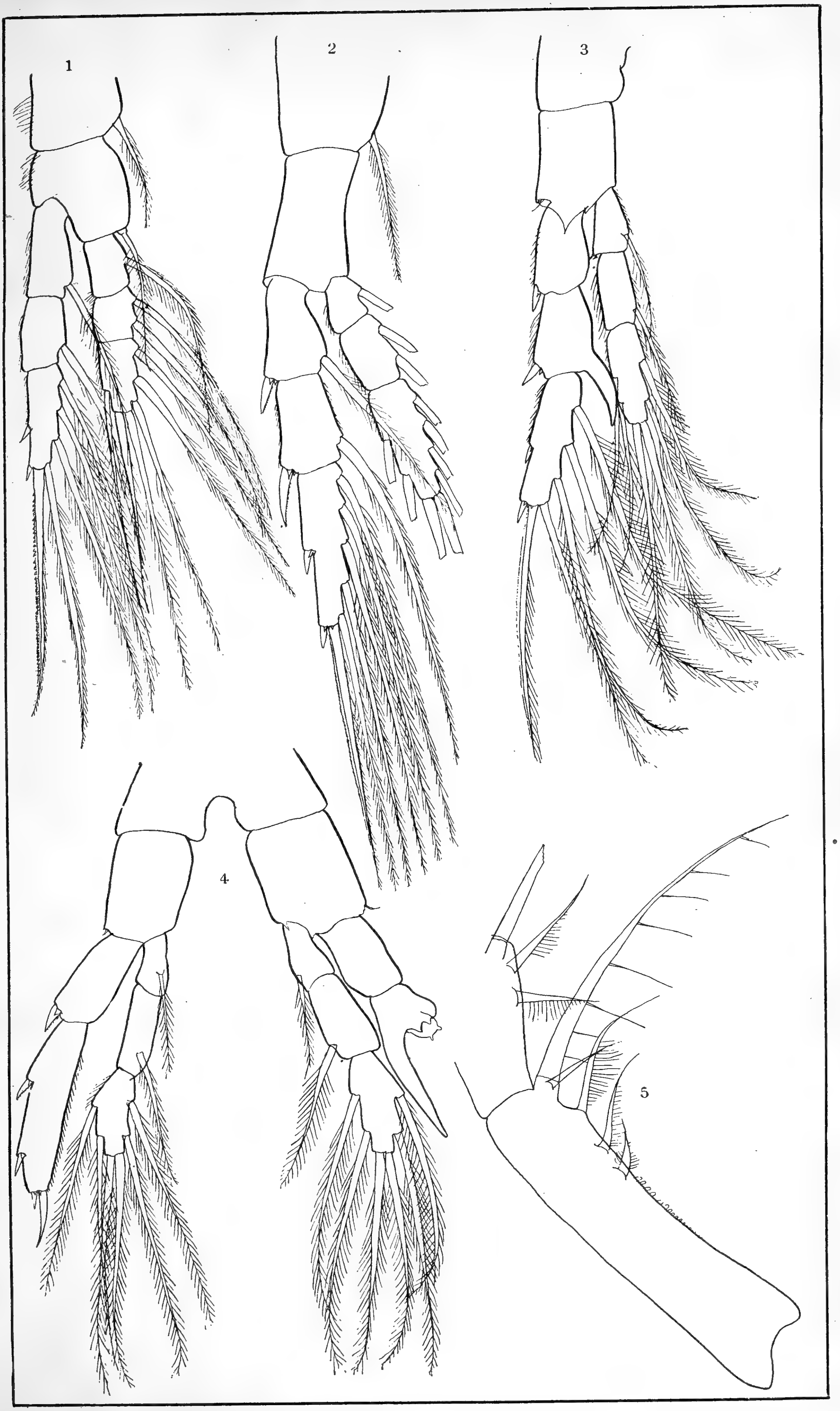


PLATE V.

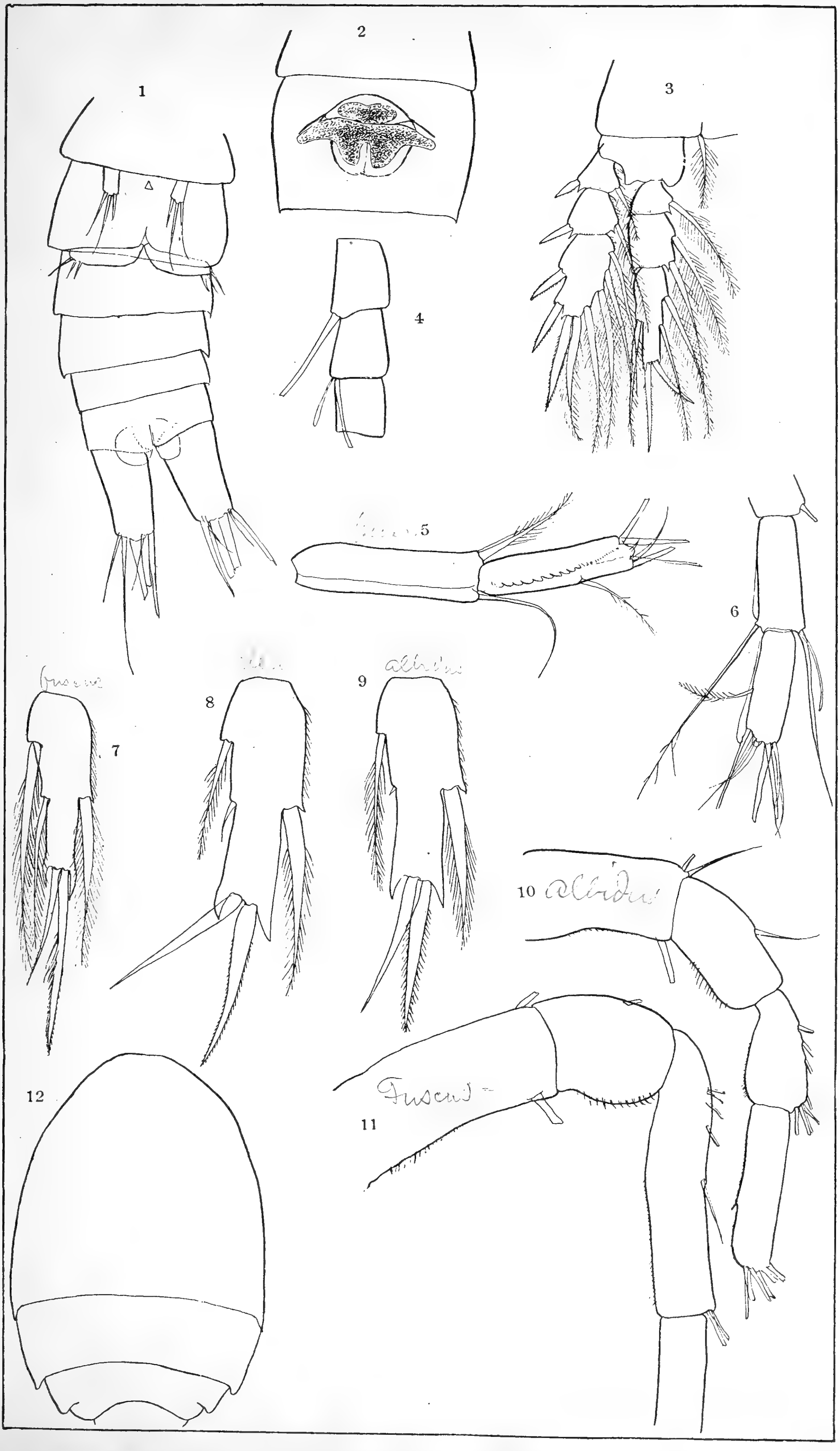
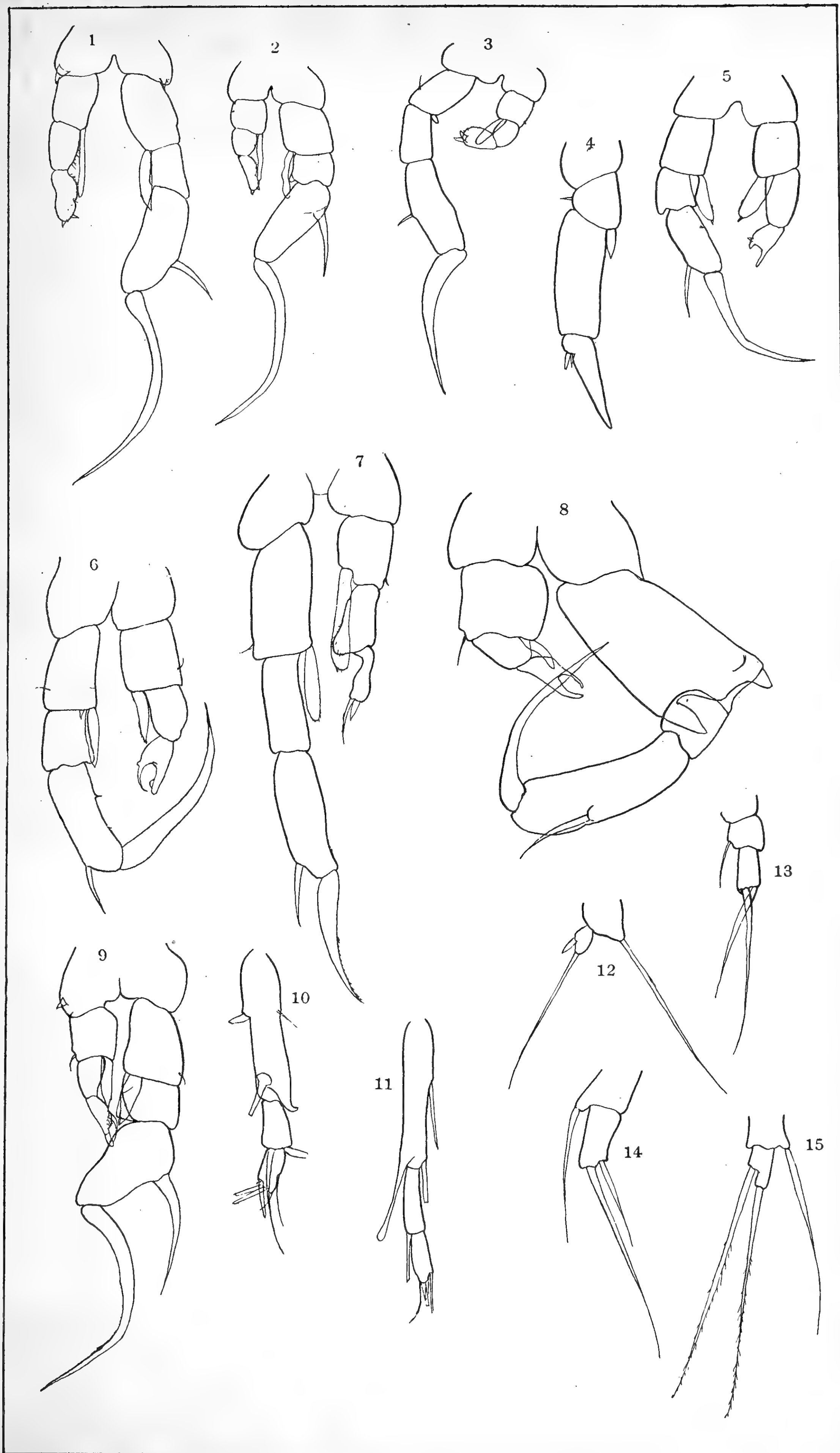


PLATE VI


1
2
3
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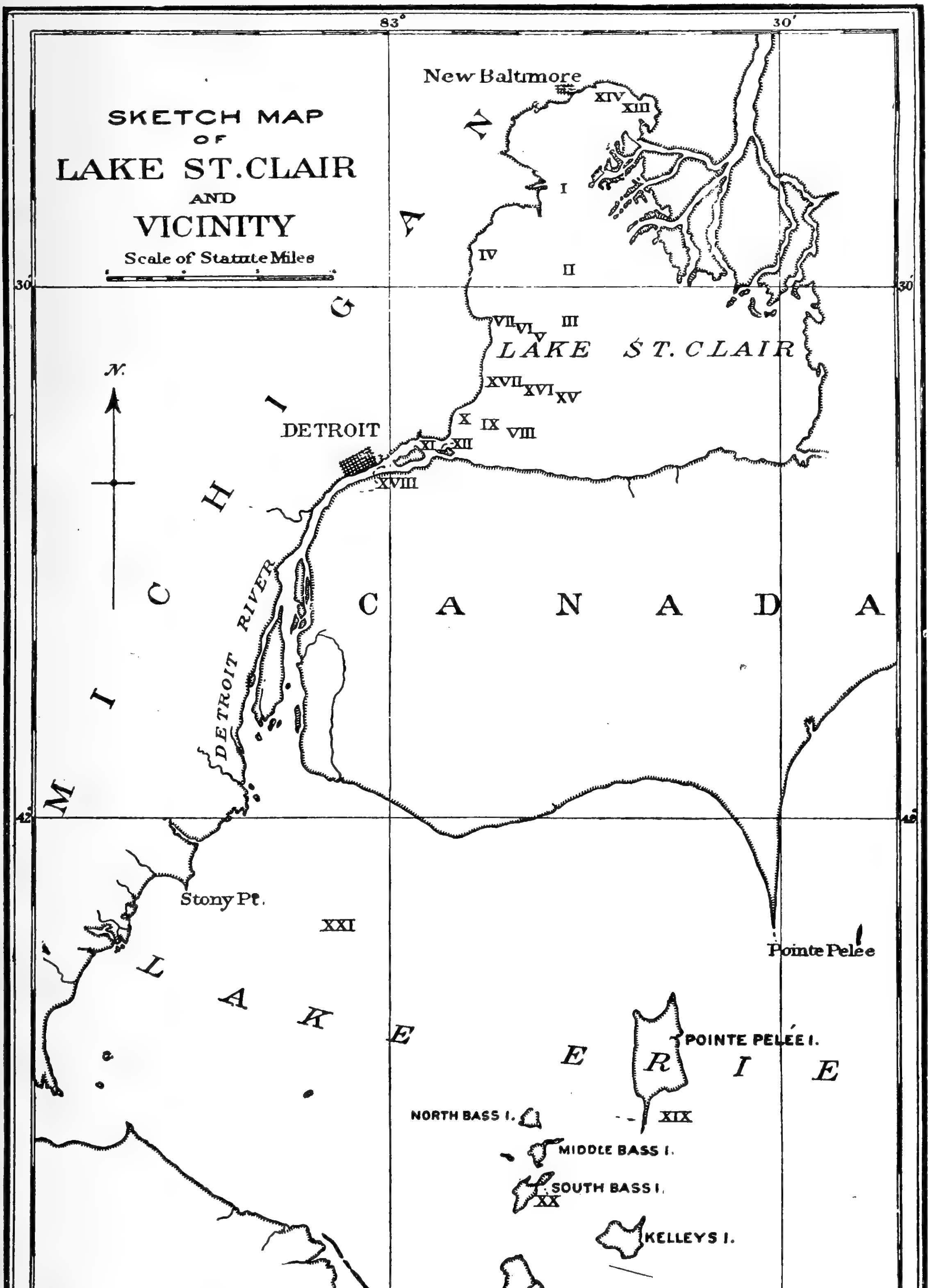
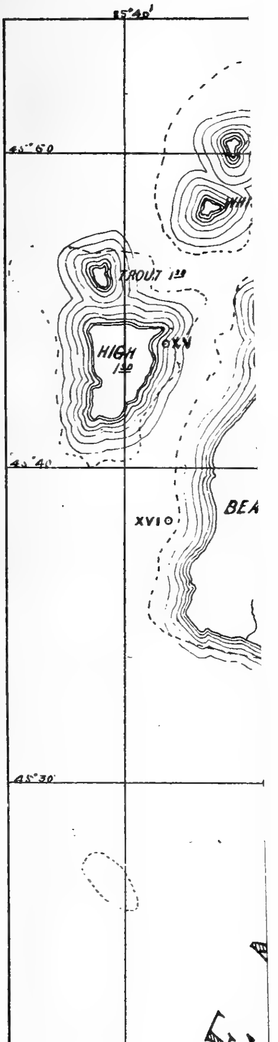


SKETCH MAP OF LAKE ST. CLAIR AND VICINITY
Scale of Statute Miles
83°
30′
30′
42°
N.
New Baltmore
XIV
XIII
I
II
III
IV
VII VI V
LAKE ST. CLAIR
XVII XVI XV
X IX VIII
XI XII
XVIII
DETROIT
DETROIT RIVER
MICHIGAN
CANADA
Stony Pt.
XXI
Pointe Pelee
LAKE ERIE
POINTE PELÉE I.
NORTH BASS I.
XIX
MIDDLE BASS I.
SOUTH BASS I.
XX
KELLEYS I.

PLATE VIII.


85°40'
TROUT Isd
HIGH Isd
XV
XVI
BEA
LAKE

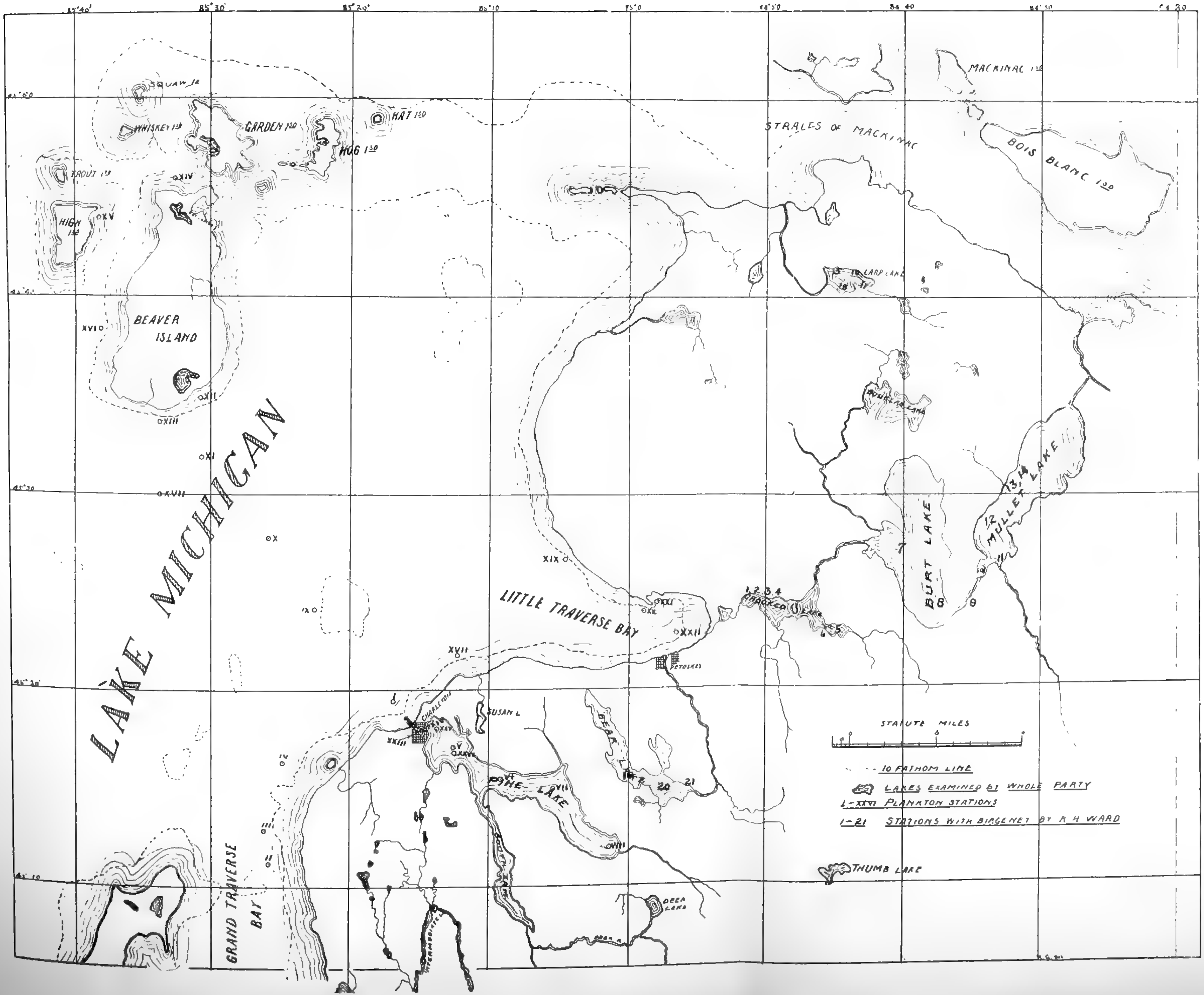

MACKINAC ISD
STRAITS OF MACKINAC
BOIS BLANC ISD
SQUAW ID
WHISKEY ID
GARDEN ISD
HOG ISD
HAT ISD
TROUT ID
HIGH ISD
BEAVER ISLAND
LAKE MICHIGAN
LITTLE TRAVERSE BAY
CROOKED LAKE
BURT LAKE
MULLET LAKE
PETOSKEY
CHARLEVOIX
SUSAN L
BEAR LAKE
PINE LAKE
GRAND TRAVERSE BAY
DEEP LAKE
THUMB LAKE
STATUTE MILES
10 FATHOM LINE
LAKES EXAMINED BY WHOLE PARTY
I–XXVI PLANKTON STATIONS
1–21 STATIONS WITH BIRGE NET BY R H WARD

PLATE IX.

9

ON THE LIMNETIC CRUSTACEA OF GREEN LAKE.

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ON THE LIMNETIC CRUSTACEA OF GREEN LAKE.

BY C. DWIGHT MARSH,

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WITH PLATES V TO XIV.

The investigations on which this paper is based were commenced in August, 1893. At that time I constructed a vertical net, which could be closed at any depth. With this net I made twelve series of five meter hauls in a little more than twenty-four hours. My object was to determine the facts in regard to the diurnal migration of limnetic crustacea,— a migration which I was certain, at that time, took place. The material obtained in these collections was carefully counted, the results tabulated, and reduced to percentages, and a report on the subject was made at the summer meeting of the Wisconsin Academy, in June, 1894, and a brief *résumé* was published in the *American Naturalist* in the same year.

So far as difference of diurnal distribution was concerned, the experiments gave only negative results, but certain facts in regard to the general vertical distribution of the different species came out very clearly. It seemed to me probable, however, that the distribution might not be the same on different days, and, in all probability, would differ greatly in the different seasons. At that time, very little had been published in regard to the occurrence of the entomostraca in different seasons. It seemed to me that if a systematic series of collections could be made throughout the year, the results would be very interesting. The matter was brought to the attention of the trustees of Ripon College, who recognized its importance, and made a special appropriation to pay the necessary expenses of the investigation.

The work was commenced in the latter part of September, 1894. During the fall the lake was visited twice each week, and at each visit from one to four series of collections were made. In the winter, while the lake was closed by ice, only three collections were made. From the latter part of April, 1895, until July, collections were made at intervals of about one week. In July and August no collections were made, but in September the work was resumed, and collections were made at intervals of about one month until July, 1896. From July, 1896, to December, weekly collections were made. Thus I had a series of collections running through a little over two years, with the exception that for the months of July and August, I had only the collections of 1896.

During the time in which this work has been going on, con siderable has been published on the periodicity and distribution of the limnetic crustacea, so that some of my results are simply corroborative of the work of others, especially in regard to the seasonal distribution of the crustacea. The peculiar character of Green Lake and its fauna and flora, however, makes simply corroborative work important, and some of the results, I think, are entirely new.

I wish to acknowledge the very efficient assistance of Mr. P. S. Collins, of Ripon, in the work of making the collections and observations. Sherwood Forest Hotel was the headquarters of the station work, and I am greatly indebted to the proprietor, Mr. Beckwith, and Mrs. Beckwith, for innumerable courtesies.

GREEN LAKE.

The general character of Green Lake has been indicated in my former paper. (Marsh, '91, b.) It is a long, narrow body of water, something over seven miles in length, and with a maximum width of less than two miles. At the eastern end where it is fed by a small stream, Silver Creek, the shore is low and swampy. At the western end another small stream enters, and here also the shore is low, but most of the shore line is made of bluffs of greater or less elevation. At Lucas's Point and Sugar Loaf are abrupt cliffs of Potsdam sandstone. There are a large number of springs on the south shore, and it is popularly supposed that most of the water is derived from this source.

The water of the lake is clear, of a beautiful green color, and reaches a maximum depth of two hundred and seventeen feet. The bottom in the deep water consists of a fine, blue clay, containing a large amount of organic matter, in which are found worms, none of which have been determined.

In the general character of its fauna, Green Lake resembles, in a striking manner, the Great Lakes. In its abysmal fauna, we find *Pontoporeia Hoyi* and *Mysis relicta,*— species which have not been found in America outside of the Great Lakes. In the intermediate depths is *Limnocalanus macrurus,*—a species seldom found except in the larger bodies of water, and in the upper layers are found the same species as in the Great Lakes with two exceptions,— *C. pulchellus* and *D. Ashlandi.* There is never any striking amount of vegetable matter in Green Lake except in the months of July and August, when ordinarily an *Anabaena,* which I think is either *flosaquae* or *circinalis* is found all over the lake, and forms little green ridges as it is washed up on the shore by the waves. But even this is not present in sufficient amount to form a scum, and never fouls the collecting net to any extent, as does the "scum" of shallower lakes.

Apstein divides lakes into two groups, which he styles *Chroococcaceae* lakes and *Dinobryon* lakes. According to the general characteristics which he gives to these two groups, Green Lake should be a *Dinobryon* lake, and yet I have never found *Dinobryon* in it.

It seems to me that our lakes in this part of North America can naturally be divided into the two classes of "deep" and "shallow" lakes, the faunae of the two classes being very distinct in their general character. The "shallow" lakes have, in the summer season, a large amount of the chlorophyll bearing algae; there is but little distinction between the littoral and limnetic species of *Cyclops*; *Limocalanus macrurus* is seldom present; and the abundant species of *Diaptomus* is *oregonensis. Epischura lacustris* may be present in shallow lakes, but is not always found.

In the deep water fauna of the "deep" lakes the common species of *Cyclops* are *brevispinosus*, *pulchellus* and *fluviatilis; Epischura lacustris* and *Limnocalanus macrurus* are commonly present, and *Diaptomus* is represented by *D. sicilis* and *D. minutus: D. Ashlandi*, is, so far as my observations go, confined to the Great Lakes and bodies of water in immediate connection with them.

The distinction thus made in regard to the distribution of *Diaptomus* is not without exception by any means, and I think that in more northern lakes *D. minutus* is found more abundantly in shallow lakes than it is in the region that has been more especially the subject of my studies. Inasmuch as *minutus* is found in great abundance in Greenland and Iceland, I presume that the real cause of its greater abundance in the deeper lakes of our latitude is not the depth of the water, but the low temperature which is coincident with depth.

In general, we may say that depth rather than extent of surface controls the character of the crustacean fauna. This is strikingly shown in a comparison of Green Lake with Lake Winnebago. Lake Winnebago is situated about twenty-five miles from Green Lake, and is about twenty-eight miles long by eight to ten miles broad. Through its whole extent it is very shallow, being for the most part from ten to thirty feet in depth. Its crustacean fauna consists of those species characteristic of shallow lakes, being very different from that of Green Lake. The same thing is noticed in comparing the fauna of Lake Mendota, as determined by Professor Birge, with that of Green Lake, Mendota falling distinctly into the class of shallow lakes. What depth may be considered as characterizing deep lakes, it is difficult to state with certainty, and I suppose it is doubtful if an exact limit can be fixed, but I think it is about forty meters. Lake Mendota, according to the soundings of Professor Birge, has a maximum depth of twenty-two meters. Lake Geneva is a little over forty meters in depth, and, judging from the collections of Professor Forbes, is somewhat intermediate in the character of its fauna between the shallow and deep lakes. Lake St. Clair is apparently an exception to this classification, as, although it is shallow, it has also the fauna of the deep lakes. This is easily explained, however, if we remember, as stated in my former report, (Marsh, '95, p. 4,) that Lake St. Clair has an immediate and constant connection with the deeper lakes, and there is, doubtless, continual migration into it of the forms characteristic of deep water.

DESCRIPTION OF THE DREDGE.—PLATES XIII, XIV.

The dredge which I have used was constructed after several experiments, and has, I think, answered admirably the requirements of my work. Inasmuch as I expected to use it entirely for vertical work, it did not seem necessary that it should be closed when descending, but that there should be some device for closing it at any desired point on its upward course. The upper frame of the dredge is a brass ring from which by three cords is suspended the bucket. The upper frame is thirty-one centimeters in diameter.

The bucket is like that described by Professor Birge. (Birge, '95, p. 428). Inasmuch as the wire gauze used in the bucket has meshes 1–100 of an inch in diameter, it does not retain the smallest organisms, but serves perfectly well as an apparatus for catching crustacea.

The dredge bag is of India linen, carefully selected so as to get cloth that is fairly uniform in texture, and is suspended between the upper frame and the bucket. The dredge bag is strengthened on its upper edge by heavy cloth, into which are let the eyelets, by which it is laced to the brass rings of the frame.

The cords between the frame and the bucket are continued below the bucket and fastened to a sounding lead weighing about six pounds. To the upper frame are attached three cords which unite in a brass ring, by which the dredge is suspended by the releasing apparatus. About half way of the length of the dredge there are attached to the suspending cords brass rings, through which a cord runs twice in such a way that when it is drawn tight it acts like a puckering string and closes the dredge. This cord is attached to the dredge rope, which, after being fastened to the releasing apparatus, hangs loosely ovcr the edge of the dredge.

The releasing apparatus consists of a brass frame (see Pl.

XIII.) fifteen centimeters long, by five centimeters broad. The frame is strengthened by three transverse braces. The frame and braces are made of strips cut from sheet brass, one millimeter thick and two centimeters wide.

Through the horizontal pieces of the apparatus are drilled two holes large enough so that the heavy brass wire D E will slide easily up and down. To the middle of this wire at E is attached an upright piece which passes through the lower part of the frame B, and strikes against the brace C. The wire is held in place by a rubber band passing around the plate B. The dredge is hung from this central pin at E, and cannot be detached except as the wire D E is lowered so as to throw the ring off the pin.

The releasing apparatus is fastened to the dredge rope by copper wire passed through small holes drilled in the upper and lower plates. The messenger is a brass cylinder five centimeters long and four centimeters in diameter.

The work of dredging is done from a row boat which is fitted with a sail. The mast is unshipped, and in the mast hole is inserted an upright about six feet long, to which is attached a cross piece extending over the side of the boat. From this cross piece the dredge is suspended by a pulley block, and upon the cross piece is a hook from which the messenger is suspended. The dredge is lowered vertically, and after being raised to the required point, is "set off" by the messenger. When the messenger strikes the releasing apparatus the top of the dredge falls over, and it remains suspended by the middle. At the same time the weight of the lead causes the cord around the middle of the dredge to tighten, so that there is a double safeguard against the entrance of any other organisms — the inverted top and the stricture of the suspending cord.

There is one source of inaccuracy in this dredge, and that is the loss of material, when it is released, between the top and the cord passing around the center. My hauls, however, were made through five meter distances, and I do not think that in this distance, the loss would have much effect on the results, and, of course, for comparative work it need not be considered at all.

For winter work, the apparatus is hung from a tripod placed over a hole in the ice. (Plate XIV.)

The tube at the bottom of the bucket was made of a size to fit in the top of an eight drachm homeopathic bottle, and in order to preserve material, I simply washed it with strong alcohol immediately from the bucket into the bottle.

A buoy was anchored in from forty to forty-five meters of water, and all collections were made from that point. In successive years the buoy was located in very nearly the same place, and when collections were made through the ice, it was intended that they should be taken at nearly the location of the buoy.

Collections were made in all kinds of weather, but more were made in comparatively pleasant weather, as naturally one would prefer to visit the lake under such conditions.

The record of observations was kept in a book arranged for the purpose. A sample page of this book appears on the next page.

The temperatures were taken by a Miller-Casella deep-sea maximum and minimum thermometer, which was loaned to me by the United States Fish Commission for the purpose. As those who have used this form of thermometer know, it is very slow in its action, it being necessary to allow at least twenty minutes for each observation. This made it impossible for me to get a record of temperatures at intermediate depths, although such a record is very important in determining the laws governing the vertical distribution.

The temperature curves of the two years, 1895 and 1896, are shown in plates V and VI, with the exception that no observations were made in July and August, 1895. It will be noticed that the maximum range of bottom temperature observed was from 35 to 45 degrees, thus indicating great uniformity of conditions of temperature at the bottom.

SERIAL COLLECTION. No. 13.96.

Made at Green Lake,.................... Aug. 3,...................... 1896, 6-6:40 p. m., with .... closing dredge .... at permanent station................ 4; .... depth 43.5 m. ;............ water, .'.... small waves; .....wind.......... s w.; .... sky .... clear;........ temperature, air ...83;... temperature, surface,.. 75; ... temperature, bottom... 43; ...

Observed *Diaptomi, D. minutus, C. fluviatilis* egg-bearing. Much fine sand in collection: is explained perhaps by the high wind earlier in the day.

Names.	0–5	5–10	10–15	15–20	20–25	25–30	30–35	35–40	40–45	45–50	50–55	55–60	Total
Diaptomus sicilis...	760	1,192	272	40	140	14	11	75	4	....	....	....	2,508
" Ashlandi	....	....	....	....	....	....	....	....	....	....	....	....	......
" minutus	....	....	....	....	....	....	....	....	....	....	....	....	......
" oregonensis	....	....	....	....	....	....	....	....	....	....	....	....	......
Epischura lacustris.	16	4	10	....	....	....	....	....	....	....	....	....	30
Limnocalanus macrurus	....	....	1	4	8	1	2	13	....	....	....	....	29
Cyclops brevispinosus....	....	....	....	....	....	....	....	....	....	....	....	....	.....
" pulchellus..	....	....	....	....	....	....	....	....	....	....	....	....	......
" Leuckarti....	....	....	....	....	....	....	....	....	....	....	....	....	......
" albidus......	....	....	....	....	....	....	....	....	....	....	....	....	......
" fluviatilis. ..	72	72	32	6	....	....	....	....	....	....	....	....	182
" serrulatus...	....	....	....	....	....	....	....	....	....	....	....	....	......
....	....	....	....	....	....	....	....	....	....	....	....	....	......
Cyclops larvæ.......	160	8	....	6	4	....	2	....	....	....	....	....	180
Leptodora hyalina.	4	....	....	....	1	....	....	....	....	....	....	....	5
Daphnia kahlbergiensis............	12	16	40	8	8	....	....	....	....	....	....	....	84
Bosmina	56	....	2	3	6	....	....	....	....	....	....	....	67
Daphnella	12	24	....	....	....	....	....	....	....	....	....	....	36
....	....	....	....	....	....	....	....	....	....	....	....	....	......
....	....	....	....	....	....	....	....	....	....	....	....	....	......
Mysis relicta........	....	....	....	....	....	....	....	....	....	....	....	....	......
Pontoporeia Hoyi..	....	....	....	....	....	....	....	....	....	....	....	....	......
....	....	....	....	....	....	....	....	....	....	....	....	....	......
Notholca	Nos	....	....	....	....	....	....	....	....	....	....	....	......
Ceratium	"	....	....	....	....	....	....	....	....	....	....	....	......
....	....	....	....	....	....	....	....	....	....	....	....	....	......
....	....	....	....	....	....	....	....	....	....	....	....	....	......
....	....	....	....	....	....	....	....	....	....	....	....	....	......

The surface temperature varied from the freezing point of water in winter to eighty degrees in August, 1896. In general the rise of surface temperature in the spring, and the fall in autumn, were both uniform and rapid, but there were some exceptions. Very noticeable is the jog in the curve in May, 1895. In this month there was a period of unusually warm weather, followed by severe frosts.

There was a curious rise in the bottom temperature in the fall of both 1894 and 1895. On November 11, 1894, I found the bottom temperature 45, while the highest point reached previous to that time was 42½.

On October 24, and November 3, 1894, I found the bottom temperature 44, while the highest point reached previous to that time was 43. On November 11, 1895, the bottom temperature was 45, while the highest previously recorded was 42½. My first impression on seeing these temperatures was that there must have been a mistake in the observation. I felt the more certain of this probability in one case, as the observation had been made by my assistant without my direct supervision. But a repetition of the work showed that there was no mistake.

A similar rise in bottom temperature in November has been noticed in Lake Cochituate (Whipple, '95, p. 205, and Fitzgerald, '95, p. 74), and these authors have also noticed a fall in bottom temperature in the spring. These apparent abnormalities in temperature have been explained by the above mentioned authors on the supposition that as the top and bottom temperatures approached each other, the water, being of nearly equal density from top to bottom, would be in a state of unstable equilibrium, and currents would be set in motion, which would effect the whole depth, especially under the influence of high winds. Whipple has shown ('95, p. 208), that under some circumstances an overturning and mingling of the whole mass of water in a lake may take place with almost incredible suddenness.

Although no attempt was made to keep a systematic record of other organisms than crustacea, some notes were kept of the appearance of other animals and of plants.

Of plants, the only one besides diatoms, which occurred in any abundance was the *Anabaena* already mentioned. In 1896 this appeared in the latter part of June, and continued well through August. In other years, I have found it present only during a very short time. I have notes also of a red alga that was found in considerable abundance about the middle of August. In one of the March collections there was also an undetermined green alga.

Rotifera were of course present in large numbers, but no attempt was made to keep any record of them. *Notholca longispina* was found throughout the year, sometimes in great abundance.

Ceratium occurred quite constantly in the collections from June to the latter part of October, and in 1896, until the middle of November.

From May through the year, *Diptera* are occasionally found in the collections. This is what one would expect, for the larvae are found in the bottom fauna.

METHOD OF COUNTING.

The method used in counting was somewhat different from that used by other authors, and a method that perhaps could not be used so successfully in collections containing a large amount of vegetable material. The alcohol in the bottles was largely replaced by glycerine in order to have the material in a medium that would not evaporate rapidly. I had prepared for me a glass plate sixteen centimeters in diameter, ruled with concentric circles a centimeter apart. The circles were divided by diameters into eight segments. The plate was mounted on a tripod such as is used in leveling gelatine plates in bacteriological work, and carefully leveled. The collection was then poured as nearly as possible upon the exact center of the plate. Ordinarily it would spread with great uniformity upon the plate. The fractional part of the whole counted depended upon the numbers of the species under consideration. Commonly I counted only one-eighth of the *Diaptomi*. Of the species present in smaller numbers, I would ordinarily count all on the plate. In any case all parts of the plate were examined in order to detect the presence of any unusual form. This work was done with the aid of a dissecting lens such as is furnished with a Reichert dissecting microscope. This lens answered every purpose so far as determining the species of the crustacea, except that I could not distinguish with certainty *D. minutus* from *D. sicilis.* As the object of the counting was mainly to determine distribution, the fact that I did not distinguish between these species was of little importance, as their habits are the same. In every case, however, a test of the collection was carefully examined under the compound microscope, and in this way a fairly accurate idea was obtained of the seasonal distribution of these species, and notes were made also in regard to the occurrence of other smaller organisms. No attempt, however, was made to keep any record of diatoms.

The accuracy of this method of counting was carefully tested, and the amount of error was found very small,—so small that I do not think the general results would be appreciably affected. As stated before, it is very doubtful if the method could be applied so successfully to plankton rich lakes.

These results were afterwards reduced to percentages in order to show the relative abundance in vertical distribution.

In the following table I have tabulated the conditions under which the various collections were made. The table is, in the main, self-explanatory. To indicate the condition of the surface I have used four terms, "smooth, ripples, waves, and rough."

In the tables given for the various species the "total" column indicates the actual number obtained in my dredge. These numbers might easily be reduced to give the actual number per square meter by multiplying by the coefficient of the dredge, but my object was simply to get comparative results, and, as indicated later in this paper, I myself have only limited confidence in the value of plankton determinations. In the columns following "total" are given the percentages found for every five meters of depth.

No.	Date.	Time.	Temp. Air.	Temp. Sur.	Temp. Bot.	Wind.	Water.	Sky.
1.94	Sept. 27....	6:30-7:30 p. m.	70	....	....	S. W.	Waves	Clear.
4.94	Oct. 6....	10:45-11:45 a. m.	57	60	43	S. W.	Ripples	Clear.
5.94	Oct. 6....	2:30-3:30 p. m.	59	59	43	S. W.	Waves	Clear.
6.94	Oct. 6....	4:50-5:45 p. m.	....	....	....	S.	Waves	Clear.
7.94	Oct. 6....	10-11 p. m.	53	....	....	S.	Waves	Clouds.
8.94	Oct. 9....	6-7 p. m.	....	....	....	S.	Waves	Clear.
10.94	Oct. 10....	6-7 a. m.	45	56	...	S. W.	Rough	Clouds.
11.94	Oct. 10....	9-10 a. m.	....	....	....	N. W.	Rough	Clouds.
12.94	Oct. 16....	6-7 p. m.	....	....	....	S. W.	Waves	Clear.
13.94	Oct. 16....	10:30-11:30 p. m.	54	53	43	S. W.	Waves	Clear.
14.94	Oct. 17....	6-7 a. m.	49	53	....	W.	Waves	Clear.
15.94	Oct. 17....	8:45-9:30 a. m.	51	....	....	W.	Waves	Clear.
16.94	Oct. 20....	11:15-12 a. m.	57	53	43	S. E.	Ripples	Clouds, fog.
17.94	Oct. 20....	2:15-3:15 p. m.	64	54	....	S. E.	Ripples	Clear.
18.94	Oct. 20....	4:40-5:20 p. m.	58	....	....	S. E.	Ripples	Clear.
20.94	Oct. 24....	10-11 p. m.	48	54	44	S.	Waves	Clouds.
21.94	Oct. 25....	6-6:50 a. m.	48	....	....	S.	Waves	Clouds.
22.94	Oct. 25....	8:45-9:30 a. m.	....	....	....	S. W.	Rough	Clouds.
24.94	Nov. 3....	2:45-3:30 p. m.	45	52	44	S.	Waves	Clouds.
25.94	Nov. 3....	4:30-5:20 p. m.	45	....	....	S. W.	Rough	Clouds.
26.94	Nov. 8....	5:30-6:15 p. m.	....	....	....	S.	Ripples	Clear.
27.94	Nov. 8....	10-11 p. m.	35	49	....	S.	Waves	Clouds.
29.94	Nov. 21....	....	38	39	43	W.	Ripples	Clear.
1.95	Feb. 14....	11:30-12:30 m.	29	33	38	N. W.	Ice	Clear.
2.95	Mar. 9....	11:30-12:30 m.	45½	36	37½	S. W.	Ice	Cloudy, and rain.
3.95	Mar. 27....	10:45-12 m.	51	36½	37	W.	Ice	Clear.
4.95	Apr. 27....	1:15-2:30 p. m.	58	42	40½	N. E.	Waves	Clear.
5.95	May 3....	4:30-5:15 p. m.	68½	47	40½	S. W.	Change	Cloudy.
6.95	May 3....	7:20-8 p. m.	53½	....	....	E.	Waves	Clear.
7.95	May 9....	4:30-5.30 p. m.	80½	55½	40½	S. W.	Rough	Clear.
8.95	May 18....	1:25-2:05 p. m.	81	51	41	N. E.	Waves	Clouds.
9.95	May 24....	4:30-5:30 p. m.	74	54	41½	S. W.	Rough	Clear.
10.95	June 1....	10:50-11:35 a. m.	81	63	41½	S. W.	Rough	Clear.
11.95	June 6....	....	70	65	42	S. E.	Waves	Clear.
12.95	June 15....	4:30-5:30 p. m.	78	68	42	E.	Waves	Clear.
13.95	June 22....	12:10-1:15 p. m.	90½	72	42¼	N. W.	Waves	Clear.
14.95	June 28....	3:30-4:30 p. m.	75	72	42	N W-N E	Waves	Clear.
15.95	Sept. 21....	2-3 p. m.	84½	71½	42½	S. W.	Rough	Clear.
16 95	Oct. 2....	4:45-5:45 p. m.	70	60	42½	S W-S E	Ripples	Clear.
17.95	Oct. 5....	4-5 p. m.	70	61	42½	S. W.	Smooth	Clear.
18.95	Oct. 24....	10-11 a. m.	40	50	42½	S. W.	Rough	Clear.
19.95	Nov. 11....	1:30-2:30 p. m.	48	46	45	S. W.	Waves	Clear.
20.95	Dec. 5....	12:15-1 m.	22	42	43	S. W.	Waves	Gray.
1.96	Jan. 28....	1-2 p. m.	32	34	35	S. W.	Ice	Cloudy.
2.96	Feb. 22....	12:30-1:30 p. m.	40	34½	35½	S. W.	Ice	Clear.
3.96	Mar. 21....	11:45-12:30 m.	45	36	36	S. W.	Ice	Overcast.
5.96	May 4....	3:25-4:10 p. m.	86	52	41	N. W.	Smooth	Clear.
6.96	May 18....	3:45-4:30 p. m.	74	55	42	N. W.	Waves	Clouds in west.
7.96	June 1....	3:15-4 p. m.	73	60	43	E.	Waves	Clear.
8.96	June 15....	3:40-4:20 p. m.	88	69	43½	E.	Waves	Clear.
9.96	June 29....	12:05-12:40 m.	101	74	43	N.	Smooth	Clear.
10.96	July 9....	11:45-12:30 a. m.	78	75	43	N. E.	Waves	Clouds.
11.96	July 20....	10:20-11:15 a. m.	78	74	43¾	S. W.	Rough	Clouds.
12.96	July 27....	3:30-4:15 p. m.	88½	75	43	S. W.	Waves	Clouds.
13.96	Aug. 3....	6-6:40 p. m.	83	75	43	S. W.	Waves	Clear.
14.96	Aug. 10....	3:35-4:10 p. m.	....	80	43½	S. W.	Waves	Clear.
15.96	Aug. 17....	12-12:45 m.	72	76½	44	N. W.	Waves	Clear.
16.96	Aug. 24....	3:25-4:05 p. m.	76	74	44	W.	Waves	Clear.
17.96	Aug. 31....	9:50-10:35 a. m.	68	70	44	N. W.	Waves	Clouds.
18.96	Sept. 7....	9:25-10:15 a. m.	78½	66	44	S. W.	Rough	Clear.
19.96	Sept. 15....	3.20-4:05 p. m.	62½	65	44½	N. E.	Waves	Clear.
20.96	Sept. 21....	2:45-3:30 p. m.	70	63	44	N. E.	Waves	Clouds.
21.96	Sept. 28....	2.55-3.40 p. m.	70	61	43½	E.	Ripples	Clear.
22.96	Oct. 6....	11-11:35 a. m.	59	58	44	N. W.	Waves	Clouds.
23.96	Oct. 15....	12:45-1:20 p. m.	67	56	43½	N.	Waves	Clouds.
24.96	Oct. 24....	11:30-12:15 m.	50	51½	43½	N. W.	Waves	Clear.
25.96	Nov. 14....	3.50-4:10 p. m.	49	45	43	S. W.	Waves	Clear.
26.96	Nov. 14....	7:20-8:45 p. m.	....	45	....	S. W.	Waves	Clear, moonlight.
27.96	Dec. 3....	11:15-12 a. m.	41	41½	39½	S.	Waves	Hazy.

DIAPTOMUS.

No. of Coll.	Total No.	*Per cent.*								
		0–5	5–10	10–15	15–20	20–25	25–30	30–35	35–40	40–
1.94..	3,912	58.64	11.63	12.48	7.16	1.23	5.11	1.43	1.02	1.23
4.94..	5,630	60.25	24.58	7.18	2.34	3.81	.85	.78	.78	.43
5.94..	4,171	72.50	14.67	3.93	4.22	.57	2.22	.86	.77	.26
6.94..	4,382	73.80	16.00	4.	3.40	.73	.32	1.40	.29	......
7.94..	2,023	46.27	20.56	11.86	12.46	2.37	1.98	1.19	.34	2.97
8.94..	4,585	68.57	20.54	4.62	2.62	.26	.59	1.22	.87	.70
10.94..	4,040	28.61	26.93	31.78	7.82	2.77	.74	.79	.37	.17
11.94..	3,991	54.92	14.88	17.24	3.66	1.05	7.02	.45	.50	.28
12.94..	6,439	36.77	19.32	17.52	6.21	13.36	5.60	.77	.25	.20
13.94..	4,611	57.73	13.54	16.39	5.12	5.29	1.34	.15	.24	.19
14.94..	4,347	45.73	19.05	23.92	7.72	1.84	1.14	.11	.25	.18
15.94..	3,466	46.39	27.81	14.19	9.81	.52	......	.38	.69	.20
16.94..	1,763	59.44	17.92	13.16	4.36	3.18	.28	.17	.11	.79
17.94..	1,542	71.92	17.38	4.60	3.76	.58	.39	.52	.26	.39
18.94..	1,386	80.81	4.97	10.39	1.44	.58	.36	1.01	.01	.43
19.94..	1,464	......	......	......	......	......	......	......	......	......
20.94..	2,197	59.17	18.02	15.66	1.86	2.82	1.91	.04	.36	.13
21.94..	1,917	35.89	27.33	25.45	4.23	2.87	2.39	1.15	.58	.11
22.94..	3,823	60.27	24.48	9.52	3.19	.71	1.59	.18	......	.05
24.94..	1,972	65.72	12.99	10.34	6.23	1.17	2.13	.56	.61	.25
25.94..	1,695	63.30	28.	2.53	1.35	2.80	.70	.18	.10	.10
26.94..	884	77.83	12.22	1.81	1.47	1.36	2.37	1.36	.90	.68
27.94..	6,447	28.29	21.98	25.56	13.57	9.06	.85	.39	.16	.12
29.94..	1,192	40.60	10.73	11.41	6.03	7.06	10.73	4.03	6.72	2.69
1.95..	1,374	27.80	7.57	22.13	7.57	2.04	5.53	7.57	13.68	6.11
2.95..	1,947	28.35	9.86	2.67	18.02	27.94	4.11	2.92	4.71	1.43
3.95..	2,742	68.27	4.67	4.52	2.77	4.82	3.50	5.11	3.87	2.47
4.95..	676	14.20	17.75	22.49	13.02	8.88	7.69	12.42	3.55	......
5.95..	686	35.27	9.91	14.58	6.99	5.25	11.67	9.04	5.25	2.04
6.95..	694	29.39	18.44	23.05	8.07	4.61	6.48	.14	5.76	4.03
7.95..	286	.69	15.39	14.69	5.59	15.39	24.48	16.08	3.50	4.19
8.95..	295	1.36	10.85	23.73	10.51	11.19	16.27	7.46	11.51	7.11
9.95..	576	44.44	22.22	4.16	10.41	6.08	4.51	2.60	2.79	2.79
10.95..	1,845	66.88	22.98	6.08	.16	1.30	.38	1.30	.65	.27
11.95..	1,250	......	......	......	......	......	......	......	......	......
12.95..	2,950	40.68	29.29	14.10	10.31	1.62	3.12	.47	.14	.27
13.95..	2,612	21.44	18.07	19.91	14.70	7.66	5.51	4.90	4.59	3.22
14.95..	3,039	54.72	22.51	5.79	7.63	4.21	1.71	.66	1.45	1.32
15.95..	2,605	37.77	24.57	12.59	6.45	9.52	1.84	2.46	4.15	.65
16.95..	1,748	34.32	35.69	18.31	4.12	1.83	1.38	1.14	2.75	.46
17.95..	1,813	10.59	43.35	33.54	4.85	4.86	1.27	.88	.67	......
18.95..	1,667	51.35	10.32	11.52	18.23	7.32	.72	.36	.18	......
19.95..	647	42.04	3.71	1.24	21.02	17.93	8.65	3.71	1.70	......
20.95..	520	33.85	17.69	5.38	9.23	6.92	10.77	12.31	3.85	......
1.96..	485	......	19.79	4.95	3.30	36.28	13.20	17.53	1.65	3.30
2.96..	1,324	25.98	11.48	10.88	12.08	23.56	7.25	1.81	3.33	3.63
3.96..	892	35.43	23.32	11.88	9.42	6.28	5.38	5.38	2.24	.67
5.96..	1,712	74.77	5.61	5.84	2.57	.82	2.10	4.91	1.87	1.52
6.96..	297	33.67	10.77	33.67	5.39	2.70	4.04	4.71	3.37	1.68
7.96..	2,712	36.87	50.44	9.44	1.62	.89	.30	.29	.11	.04
8.96..	3,044	27.59	47.83	13.14	3.68	3.71	.65	1.70	.78	.92

DIAPTOMUS — continued.

No. of Coll.	Total No.	Per cent.								
		0–5	5–10	10–15	15–20	20–25	25–30	30–35	35–40	40–
9.96..	2,392	56.52	25.09	10.70	5.02	.75	.50	.25	.12	1.05
10.96..	2,354	39.50	33.30	8.84	6.12	.25	.69	1.44	4.76	5.10
11.96..	2,793	36.17	24.63	28.07	2.72	.46	1.25	.68	4.80	1.22
12.96..	3,612	47.84	37.65	9.74	2.99	.30	.17	.75	.17	.39
13.96..	2,508	30.30	47.53	10.84	1.60	5.58	.56	.44	2.99	.16
14.96..	3,803	64.16	19.99	6.42	3.10	......	2.84	2.52	.26	.71
15.96..	1,563	98.91	.13	......	......	.06	.19	.13	.19	.39
16.96..	4,785	62.90	9.01	18.06	1.25	2.01	2.67	1.33	2.17	.60
17.96..	4,933	41.60	28.81	19.62	1.87	2.59	.57	.89	2.27	1.78
18.96..	5,646	70.86	.42	15.02	4.85	.49	.98	4.83	.78	1.77
19.96..	4,766	46.37	33.02	6.73	3.35	2.35	3.02	3.86	1.09	.21
20.96..	5,248	59.18	21.80	6.25	1.22	2.04	3.43	4.08	.69	.91
21.96..	3,772	54.72	26.73	14.21	1.06	.95	1.01	.64	.13	.50
22.96..	4,229	45.40	19.11	23.22	9.27	2.46	.11	.31	.07	.05
23.96..	4,736	78.21	7.43	8.96	4.39	.46	.25	.13	.13	.04
24.96..	1,527	54.49	16.76	23.58	4.19	.26	.20	.13	.26	.13
25.96..	746	18.23	7.51	6.43	15.55	16.09	23.59	7.50	3.76	1.34
26.96..	490	in 0–20	meter	s.						
27.96..	762	42.	7.35	9.98	6.30	4.20	5.77	6.29	15.75	2.36

A glance at Pl. VII will show that *Diaptomus* has a strongly marked minimum of occurrence in December and in January. There is an increase in February and March, but in both 1895 and 1896, the number in May was very small. *Diaptomus* appears to reach its maximum in the latter part of September and October. In the fall months, the collections consist mostly of mature forms. In the winter months most of them are immature. From the latter part of March to the latter part of May, nearly all are mature, and the females egg-bearing. In June there is a great preponderance of larvæ.

Apstein ('96, 179 and following) states that the maximum period of *D. graciloides* differs in different German lakes. The time of the maximum occurrence of Green Lake *Diaptomi* as recorded above, does not agree with any of his observations. Birge (Birge '95 p. 448) states that the maximum time of *Diaptomus* in Lake Mendota is in July. Inasmuch as *Diaptomus* is very little affected by differences of temperature, as will be shown later, I think these differences in maximum periods are probably caused by some differences in the development of food supply.

There are only two species of *Diaptomus* found in Green Lake, — *D. minutus* and *D. sicilis.* In the counting no distinction was made in regard to these species, but a slide was prepared from each collection and examined under the compound microscope and thus a rough idea obtained of the relative abundance of the two forms. During Sept. and Oct. *D. minutus* was much more abundant. In Sept. very few of *D. sicilis* were found. During October and November the relative number of *D. sicilis* increases, and in the winter months the collections were almost entirely of *D. sicilis.*

In 1894 I first found *D. sicilis* in the collection of Sept. 28. In 1895 it first appeared Oct. 5, and 1896 on Oct. 6. Although I did not find this species in the summer months while I was making my serial collections, I do not think that it was probably entirely absent from the lake; for in 1890 and 1891 I found it in summer collections, although I did not find it in 1892. (Marsh, '93 p. 198.) I find, on looking over my notes of 1890 and 1891 that it was not numerous in those years, and I presume that it occurs in the summer months, but only in very small numbers. A reexamination of my notes on the Michigan copepods shows that the same thing holds true there. In the collections made by Professor Reighard in April, in Lake Michigan, *D. sicilis* was always present, while in the summer collections in the Great Lakes and Lake Michigan, *D. minutus* was the more common form, as I have already noted in my paper on Michigan copepods, and *D. sicilis* occurs rather infrequently. In April and May *D. minutus* is entirely lacking in Green Lake, but appears again in June.

Inasmuch as it is claimed by some that some copepods show a seasonal dimorphism, one might raise the question whether we did not here have a case of that kind. I do not think that this is so, although I have not now material to fortify my belief.

The *Diaptomi* are found at all depths, but in the deeper strata only in small numbers. There were very few hauls in which I did not find some representatives of this genus in every five meter stratum, and yet from sixty to seventy-five per cent. were commonly in the upper ten meters.

In order to find out whether there was any difference in the vertical distribution in summer and in winter I took the averages in the upper three levels of collections 7.96 to 17.96 inclusive, and 24.94 to 3.95 inclusive. I took these years because in 1894–5 I made a large number of collections in cold weather, and in 1896 I made the largest number of collections in warm weather.

The following table indicates the results:

	0–5	5–10	10–15
Summer, 7.96–17.96	49.31	24.49	12.26
Winter, 24.94–3.95	50.02	13.50	10.12

It appears from these averages that the seasons make no difference in the vertical distribution of *Diaptomus*, but that it is uniform throughout the year.

Apstein comes to the same conclusion. ('96, p. 180.)

The day and night collections of October, 1894, compared as follows:

	0–5	5–10
Day	59.44	18.42
Night	53.70	18.40

Here is no evidence of diurnal migration.

I think, then, that I am safe in saying that the vertical distribution of *Diaptomus* varies but little from one end of the year to the other and is not appreciably affected by changes in the amount of light.

Birge finds the same thing to be true of *D. oregonensis*. (Birge, '95, 450.)

EPISCHURA LACUSTRIS.

No. of Coll.	Total. No.	*Per cent.*								
		0–5	5–10	10–15	15–20	20–25	25–30	30–35	35–40	40–
1.94..	155	77.42	20.65	1.23	......	......	......	......	......	......
4.94..	121	59.50	33.06	6.61	.83	......	......	......	......	......
5.94..	100	56.	24.	16.	4.	......	......	......	......	......
6.94..	180	87.	8.30	4.44	......	.55	......	......	......	......
7.94.	149	34.90	32.21	18.79	10.74	2.69	......	......	......	.67
8.94..	390	41.54	33.82	16.41	5.13	.51	.26	1.56	.51	.26
10.94..	220	50.90	21.82	23.63	2.72	.99	......	......	......	......
11.94..	191	54.45	15.71	25.13	2.09	......	2.09	......	.52	......
12.94..	104	19.23	7.69	9.61	38.46	11.54	11.54	.96	.96	......
13.94..	141	28.37	11.35	45.39	8.51	2.84	3.54	......	......	......
14.94..	126	38.09	19.05	22.22	9.52	9.52	.79	......	.79	......
15.94..	214	56.08	18.69	20.56	......	2.80	......	.93	.47	.47
16.94..	96	75.	14.79	8.33	1.04	......	......	1.04	......	......
17.94..	50	64.	28.	6.	......	......	......	......	2.	......
18.94..	183	81.43	3.27	8.74	......	......	......	......	.55	......
20.94..	95	23.16	25.26	47.37	......	1.05	3.16	......	......	......
21.94..	65	49.23	24.61	21.54	3.08	......	1.54	......	......	......
22.94..	32	62.50	21.88	9.38	3.12	3.12	......	......	......	......
24.94..	41	50.	......	25.	......	......	......	......	25.	......
25.94..	22	31.82	45.45	......	9.09	9.09	4.55	......	......	......
26.94..	118	74.57	14.41	4.24	5.93	......	......	.85	......	......
27.94..	330	53.33	5.45	31.52	8.49	.91	.30	......	......	......
29.94..	8	......	......	......	......	100.	......	......	......	......
1.95..	60	33.33	40.	26.67	......	......	......	......	......	......
2.95..	395	50.63	8.10	8.10	16.46	14.17	2.04	......	.50	......
3.95..	24	66.67	......	......	......	......	......	......	33.33	......
4.95..	......	......	......	......	......	......	......	......	......	......
5.95..	......	......	......	......	......	......	......	......	......	......
6.95..	......	......	......	......	......	......	......	......	......	......
7.95..	......	......	......	......	......	......	......	......	......	......
8.95..	......	......	......	......	......	......	......	......	......	......
9.95..	......	......	......	......	......	......	......	......	......	......
10.95..	93	98.72	......	1.28	......	......	......	......	......	......
11.95..	96	33.33	58.33	......	8.34	......	......	......	......	......
12.95..	41	19.51	78.05	2.44	......	......	......	......	......	......
13.95..	64	37.50	37.50	12.50	12.50	......	......	......	......	......
14.95..	196	24.49	69.39	4.08	2.04	......	......	......	......	......
15.95..	24	50.	12.50	25.	4.17	4.17	......	......	4.16	......
16.95..	65	73.84	18.46	4.62	......	1.54	......	......	1.54	......
17.95..	37	8.11	64.86	21.62	5.41	......	......	......	......	......
18.95..	100	48.	20.	8.	16.	8.	......	......	......	......
19 95..	4	50.	50.	......	......	......	......	......	......	......
20.95..	......	......	......	......	......	......	......	......	......	......
1.96..	223	7.79	......	32.29	3.59	......	......	22.87	39.46	......
2.96..	96	58.33	33.33	......	8.34	......	......	......	......	......
3.96..	......	......	......	......	......	......	......	......	......	......
5.96..	......	......	......	......	......	......	......	......	......	......
6.96..	......	......	......	......	......	......	......	......	......	......
7.96..	10	10.	80.	10.	......	......	......	......	......	......
8.96..	41	98.	2.	......	......	......	......	......	......	......
9.96..	32	50.	50.	......	......	......	......	......	......	......

EPISCHURA LACUSTRIS—continued.

No. of Coll.	Total. No.	Per cent.								
		0–5	5–10	10–15	15–20	20–25	25–30	30–35	35–40	40–
10.96..	140	61.43	34.29	1.43	.71	......	......	.71	......	1.43
11.96..	131	61.07	7.63	30.54	.76	......	......	......	......	......
12.96..	54	44.44	44.45	11.11	......	......	......	......	......	......
13.96..	30	53.33	13.33	33.34	......	......	......	......	......	......
14.96..	29	27.59	48.28	20.68	3.45	......	......	......	......	......
15.96..	203	99.01	.99	......	......	......	......	......	......	......
16.96..	397	84.63	11.34	4.03	......	......	......	......	......	......
17.96..	333	76.58	21.32	1.80	.30	......	......	......	......	......
18.96..	270	91.48	......	5.93	2.22	......	.37	......	......	......
19.26..	107	61.68	37.38	......	.94	......	......	......	......	......
20.96..	100	28.	72.		......	......	......	......	......	......
21.96..	120	46.66	40.	13.34	......	......	......	......	......	......
22.96..	46	34.79	34.78	26.09	2.17	2.17	......	......	......	......
23.96..	150	69.33	21.34	5.34	2.67	......	......	.66	.66	......
24.96..	46	69.56	15.22	15.22	......	......	......	......	......	......
25.96..	98	93.88	......	......	3.06	1.02	2.04	......	......	......
26.96..	9	in 0.20	met'rs	......	......	......	......	......	......	......
27.96..	4	100.	......	......	......	......	......	......	......	......

From the table it appears that *Epischura* occurs in the summer and fall months, with no very well defined time of maximum numbers. (See Pl. VIII.) The largest numbers obtained at single hauls were 390 in the evening of October 9, 1894, 395 from a haul made through the ice on March 9, 1895, and 397 on August 24, 1896. In the March haul a large proportion were larval forms. *Epischura* disappears entirely in the latter part of March and does not appear again until June.

The number of my winter collections was, unfortunately, very small, so that one must be very careful about drawing inferences from them. But I think we may consider it fairly certain that *Epischura* is hatched from the egg in the winter,—probably in February or the early part of March. This in itself is a matter of some interest, as, so far as I know, there is no previous record of the occurrence of any considerable number of larval forms of *Epischura*.

It is a curious fact that so soon after the appearance of the larval forms, *Epischura* entirely disappears for several months. I will not in this paper hazard a conjecture as to the explanation of this, as I hope in a later paper to treat more fully upon its life history after further researches.

So far as I know there have been no preceding observations on the seasonal distribution of *Epischura.* Its nearest European relative is *Heterocope*, and this is stated by Apstein to occur from the latter part of July into November, its maximum period being in the summer. He does not record any time of the appearance of the larval forms.

In its vertical distribution, *Epischura* is largely confined to the upper regions. While laboratory experiments would seem to indicate that it avoids bright light, the averages of my collections apparently show that it is more largely controlled by the conditions of temperature. In my collections of August, 1893, I found 81 per cent. in the upper ten meters. The average of the collections of 1894, extending from the latter part of September to the last of November was 53.11 per cent. in the upper five meters and 19.52 per cent. from five to ten meters, thus making 72.63 per cent in the upper ten meters. In order to compare the distribution at different seasons, I computed the average percentages in the collections from the surface to five meters, and from five meters to ten meters for June, July and August, 1896, and from November, 1894 to April, 1895, with the following results:

	0–5	5–10	0–10
Winter, 24.94–3.95	42.53	14.18	56.71
Summer, 7.96-17.96.............	60.55	28.51	89.06

This would seem to indicate that *Epischura* prefers the warmer water, although it is by no means absent from the cold water of the surface in the cold season. It occurred to me that if *Epischura* were, to a large extent, controlled in its vertical distribution by conditions of temperature, there might be a diurnal migration caused by the cooling of the surface water at night, for the surface responds quickly to changes in atmospheric temperature. To determine whether any such effect would be produced, I compared the night and day collections of October, 1894. From Oct. 6 to Oct. 24, I made five collections between six p. m. and six a. m. Four of these were made between ten and twelve o'clock. In these collections between six p. m. and six a. m., 29.44 per cent. were between the surface and five meters, and 22.06 per cent. between five and ten, making 51.50 per cent. in the upper ten meters.

In ten collections made during the same period between six a. m. and six p. m., 62.24 per cent. were between the surface and five meters, and 18.67 per cent. between five and ten meters, or 80.91 per cent in the upper ten meters. The average of all the collections made during this time was 51.31 per cent. from the surface to five meters, and 19.80 per cent. from five to ten meters, making 71.11 per cent. in the upper ten meters.

These results are contrary to my expectations, for I had supposed that *Epischura* came to the surface at night. On the contrary, it appears that in October nights it migrates to greater depths. It appears to me probable that temperature is the controlling cause of both its diurnal and seasonal migrations.

The fact that surface tows in summer evenings are sometimes rich in *Eprischau* is, I think, in harmony with the statements above. For while, as has been stated, *Epischura* prefers warm water, it also avoids bright light. In the daytime during the hot months, it is most abundant in the upper layers, but not at the immediate surface. In the darkness of the evening, however, it is no longer repelled from the surface by the light, and the change of temperature may not be sufficient to affect it.

In the 1893 collections, made in warm weather in the latter part of August, three of the hauls were made between six at night and six in the morning. In these three night hauls, there was an average of 82 per cent. in the 0-5 stratum, while the average in the day hauls in the same stratum was 33.32 per cent.

The fact that *Epischura* comes to the surface in such large numbers on warm summer nights may be accounted for by the fact that it is a large species and a strong swimmer, and moves toward the surface because of the greater amount of food material there.

LIMNOCALANUS MACRURUS.

No. of Coll.	Total No.	*Per cent.*								
		0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-
1.94..	72	......	......	......	44.44	27.77	5.55	13.88	1.39	6.95
4.94..	133	......	......	......	2.26	1.50	1.50	11.28	38.35	45.11
5.94..	87	1.15	2.30	......	1.15	1.15	3.45	9.20	31.03	50.57
6.94..	96	......	1.04	......	1.04	11.44	8.33	24.90	53.12	......
7.94..	113	.88	.88	......	6.19	38.94	20.35	13.27	7.08	12.39
8.94..	81	......	1.23	4.93	9.87	9.87	7.40	27.16	27.16	12.35
10.94..	59	......	1.69	1.69	1.69	23.73	28.81	13.56	18.66	10.17
11.94..	33	......	......	......	......	6.06	9.09	6.06	54.54	24.24
12.94..	79	......	1.27	5.06	10.13	20.25	15.19	12.66	22.78	12.66
13.94..	38	21.05	7.90	2.63	......	7.90	13.16	5.26	21.05	21.05
14.94..	43	......	......	......	2.32	13.95	16.28	9.30	25.58	32.56
15.94..	8	12.50	......	......	......	......	......	12.50	25.	50.
16.94..	16	......	......	......	6.25	12.50	......	6.25	6.25	68.75
17.94..	10	......	......	10.	......	......	10.	......	80.	......
18.94..	56	......	......	1.79	1.79	......	7.14	32.14	37.50	19.64
20.94..	30	3.33	3.33	40.	......	3.33	43.33	......	6.66	......
21.94..	19	......	......	......	......	......	26.32	15.79	31.58	26.32
22.94..	8	......	25.	......	......	......	12.50	12.50	......	50.
24.94..	20	......	......	......	......	......	10.	10.	20.	60.
25.94..	16	25.	......	......	......	12.50	25.	25.	6.	6.
26.94..	51	5.88	3.92	17.65	17.65	5.88	23.53	7.84	15.69	1.96
27.94..	113	23.01	4.42	14.16	16.81	8.85	6.20	19.47	2.66	4.42
29.94..	101	2.97	3.96	1.98	5.94	27.72	14.85	6.93	7.92	27.72
1.95..	25	16.	48.	8.	4.	......	......	8.	12.	4.
2.95..	64	37.50	1.56	3.13	1.56	4.69	1.56	6.24	21.88	21.88
3.95..	34	2.94	......	2.94	......	8.82	8.83	17.65	11.76	47.06
4.95..	140	8.57	22.87	25.71	7.14	14.28	10.	7.86	3.57	......
5.95..	90	11.11	3.33	4.44	4.44	5.56	22.22	27.78	15.56	5.56
6.95..	104	11.54	7.69	9.62	15.38	19.24	18.27	2.88	13.46	1.92
7.95..	85	......	......	3.53	2.35	17.65	35.30	30.59	8.23	2.35
8.95..	20	......	......	15.	10.	5.	10.	10.	25.	25.
9.95..	26	......	......	......	......	3.85	7.69	26.92	26.92	34.62
10.95..	6	98.72	......	1.28	......	......	......	......	......	......
11.95..	5	......	......	......	20.	......	20.	60.	......	......
12.95..	60	......	......	......	3.33	......	35.	40.	10.	11.67
13.95..	27	......	......	......	11.11	......	14.81	14.82	44.44	14.81
14.95..	7	......	......	......	......	......	14.28	......	71.43	14.29
15.95..	6	......	......	......	......	16.66	......	16.67	......	66.67
16.95..	15	......	......	......	6.66	6.66	26.67	......	46.67	13.34
17.95..	16	......	......	......	......	12.50	......	56.25	36.25	......
18.95..	1	......	......	100.	......	......	......	......	......	......
19.95..	22	13.64	13.64	4.55	13.64	......	13.63	27.27	13.63	......
20.95..	12	8.33	33.34	......	16.66	8.34	33.33	......	......	......
1.96..	8	......	......	......	......	......	12.50	25.	50.	12.50
2.96..	43	9.30	......	27.91	......	18.60	18.60	6.98	18.61	......
3.96..	76	15.79	10.52	3.95	......	......	15.79	21.05	31.58	1.32
5.96..	203	29.56	1.97	13.79	13.79	4.43	5.42	23.64	5.91	1.48
6.96..	52	1.92	23.08	11.54	19.23	15.38	......	19.23	1.92	7.70
7.96..	20	5.	......	......	15.	30.	40.	......	10.	......
8.96..	41	......	......	......	......	......	4.54	27.28	27.27	40.91
9.96..	4	......	......	......	......	......	......	25.	......	75.

LIMNOCALANUS MACRURUS — Continued.

No. of Coll.	Total No.	*Per cent.*								
		0–5	5–10	10–15	15–20	20–25	25–30	30–35	35–40	40–
10.96..	32	......	......	......	6.25	......	......	6.25	43.75	43.75
11.96..	17	......	......	23.53	5.88	5.88	......	5.88	17.65	41.18
12.96..	9	......	......	11.11	11.11	......	......	11.12	22.22	44.44
13.96..	29	......	......	3.45	13.79	27.58	3.45	6.90	44.83	......
14.96..	15	......	......	6.66	13.34	......	19.98	6.66	26.68	26.68
15.96..	......	......	......	......	......	......	......	......	......	......
16.96..	42	......	......	16.66	....	......	......	......	66.68	16.66
17.96..	21	......	......	......	28.57	9.52	14.29	23.81	9.52	14.29
18.96..	34	......	......	2.94	17.65	2.94	11.76	14.71	29.41	20.59
19.96..	35	......	......	......	28.57	22.86	5.71	11.43	25.71	5.72
20.96..	51	......	1.96	......	......	11.76	11.76	33.34	25.49	15.69
21.96..	37	......	......	......	8.11	......	5.41	2.70	16.21	67.57
22.96..	7	......	......	......	14.29	28.57	......	......	28.57	28.57
23.96..	34	......	......	5.88	2.94	11.76	11.76	14.71	17.65	35.30
24.96..	26	3.85	3.85	26.92	3.85	11.53	3.85	11.54	7.69	26.92
25.96..	56	1.78	5.36	3.57	25.	28.57	30.36	5.36	......	......
26.96..	200	from	0–2½	met'rs	106	from	0–20	met'rs		
27.96..	43	......	6.98	6.98	4.65	11.63	16.28	9.30	34.88	9.30

Limnocalanus macrurus (see Pl. IX) occurs in collections at all times of the year, but never in very large numbers. The largest single collection that I made was May 8, 1896. While the numbers were very variable, I think I can say that it was most abundant in the months of May and November, thus having two maximum periods,—the spring period showing greater numbers.

In February, March, and April most of the *Limnocalani* are immature.

In its vertical distribution *Limnocalanus* is very interesting. From May to November it is seldom found in the day time in the upper five meters, and only in small numbers in the upper ten. In the winter months it is found at all depths. Thus its vertical distribution would seem to be controlled, in part, at least, by temperature. It also seems to be somewhat sensitive to light, for the night collections in 1894 show a greater number near the surface. As these night collections were not extended through the year, it would perhaps be unsafe to say that *Limnocalanus* comes to the surface in the night, but it is certainly very significant that most of the evening collections show more or less of this species in the 0–5 and 5–10 hauls.

The collections of November 14, 1896, seem to show quite conclusively the effect of light on the vertical distribution of *Limnocalanus.* On this date, the temperature of the surface was 45, and that of the bottom 43, so that the temperature was practically uniform through the whole depth of the water. In the collection made at about four o'clock in the afternoon, *Limnocalanus* was absent in the upper two and one-half meters, there was one in the upper five meters, three in the layer from five to ten, two in ten to fifteen, and an increasing number in the deeper layers. In the evening, at about eight o'clock, there were two hundred in the upper two and one-half meters, and a rapidly decreasing number in the deeper layers. A surface tow taken in the evening consisted very largely of *Limnocalanus.*

I think we can state with positiveness from these observations that *Limnocalanus* is repelled by the higher temperature of the surface waters in summer, and is also repelled by light. There is a further question, however, which it is not so easy to answer, and that is the positive reason of the vertical migration. Why do they approach the surface when there is neither a high temperature or light to repel them. It occurred to me that possibly, while they are repelled by bright light, they may be attracted by a faint light, like that of the moon. A comparison of the collections of cloudy and moonlight nights, however, shows no essential difference.

It is possible that the more highly aerated surface waters may attract them; this is not probable, however, for the fact that during such a large portion of the year they are found in deeper water would seem to imply that they are adapted to the somewhat stagnant conditions of those waters. It seems to me most probable that the larger food supply of the surface waters is the main cause of the vertical migration.

The relation of *Limnocalanus* to the "sprungschicht" is interesting. Unfortunately I have been able to make temperature determinations for only the surface and bottom, so that I do not know the position of the "sprungschicht" in Green Lake at different periods of the year. By the kindness of Prof. E. A.

Birge a set of serial temperatures was taken with the thermophone September 3, 1896, which seemed to show that at that time the "sprungschicht" was located at about fourteen meters below the surface. Probably its location does not change materially during the summer months. In looking over the collection of *Limnocalanus*, I find that during the summer months it is found mostly below the fifteen meter level, its distribution becoming gradually more general in the fall, and continuing so until the late spring. This leads me to infer that the vertical distribution of the *Linnocalanus* varies nearly as the "sprungschicht" varies.

C. brevispinosus did not occur in large numbers in any of the serial collections. The largest number obtained at one time was 291, on June 6, 1895. In both 1895 and 1896 its occurrence was confined almost entirely to the month of June. It was found in both May and July, but only in small numbers. At other times I have found it in Green Lake in August, but it must be comparatively rare at that time, for in my serial collections in 1893 I did not find a single individual. I have found it in the Michigan lakes, too, in July and August.

In regard to its vertical distribution, it appears to be most abundant from five to twenty meters in depth. In the upper five meters only a few are found, and they do not go below 20 to 25 meters to any extent.

CYCLOPS BREVISPINOSUS.

C. brevispinosus not present in collections from 1.94 to 6.95.

No. of Coll.	Total No.	*Per cent.*								
		0–5	5–10	10–15	15–20	20–25	25–30	30–35	35–40	40–
7.95..	1	......	......	......	100.	......	......	......	......	......
8.95..	......	......	......	......	......	......	......	......	......	......
9.95..	......	......	......	......	......	......	......	......	......	......
10.95..	246	......	......	87.80	4.47	4.88	1.22	.81	.41	.41
11.95..	291	8.25	54.98	10.99	16.84	......	8.25	......	.69	......
12.95..	79	......	50.63	10.13	10.13	6.32	20.25	1.27	1.27	......
13.95..	166	......	......	19.28	62.65	14.46	3.61	......	......	......
14.95..	13	......	......	61.54	15.38	15.39	7.69	......	......	......
15.95..	......	......	......	......	......	......	......	......	......	......
16.95..	......	......	......	......	......	......	......	......	......	......
17.95..	......	......	......	......	......	......	......	......	......	......
18.95..	......	......	......	......	......	......	......	......	......	......
19.95..	......	......	......	......	......	......	......	......	......	......
20.95..	7	......	......	57.15	......	......	......	42.85	......	......
1.96..	6	16.66	50.	......	33.34	......	......	......	......	......
2.96..	......	......	......	......	......	......	......	......	......	......
3.96..	......	......	......	......	......	......	......	......	......	......
5.96..	......	......	......	......	......	......	......	......	......	......
6.96..	1	100.		......	......	......	......	......	......	......
7.96..	33	......	72.73	3.03	12.12	......	12.12	......	......	......
8.96..	52	15.38	46.15	30.77	3.85	3.85	......	......	......	......
9.96..	36	......	......	44.45	44.44	11.11	......	......	......	......
10.96..	7	14.28	......	14.29	57.14	......	......	14.29	......	......
11.96..	3	......	......	......	33.33	66.67	......	......	......	......
12.96..	......	......	......	......	......	......	......	......	......	......
13.96..	......	......	......	......	......	......	......	......	......	......
14.96..	......	......	......	......	......	......	......	......	......	......
15.96..	......	......	......	......	......	......	......	......	......	......
16.96..	1	......	......	100.	......	......	......	......	......	......
17.96..	......	......	......	......	......	......	......	......	......	......
18.96..	......	......	......	......	......	......	......	......	......	......
19.96..	......	......	......	......	......	......	......	......	......	......
20.96..	......	......	......	......	......	......	......	......	......	......
21.96..	2	......	100.	......	......	......	......	......	......	......
22.96..	......	......	......	......	......	......	......	......	......	......
23.96..	......	......	......	......	......	......	......	......	......	......
24.96..	......	......	......	......	......	......	......	......	......	......
25.96..	......	......	......	......	......	......	......	......	......	......
26.96..	......	......	......	......	......	......	......	......	......	......
27.96..	25	100.	......	......	......	......	......	......	......	......

CYCLOPS FLUVIATILIS.

No. of Coll.	Total No.	Per cent.								
		0–5	5–10	10–15	15–20	20–25	25–30	30–35	35–40	40–
1.94..	336	30.95	2.38	26.19	33.33	......	7.15	......	......	......
4.94..	530	24.15	23.39	21.89	23.77	6.04	.76	......	......	......
5.94..	740	16.22	41.62	14.46	23.78	1.76	.54	.27	1.35	......
6.94..	707	33.94	16.97	24.33	5.76	2.12	.42	.14	......	......
7.94..	968	23.97	3.72	10.74	47.52	9.50	1.26	.42	......	2.94
8.94..	823	14.58	18.97	33.53	26.24	4.13	1.10	.97	.12	.36
10.94..	791	25.79	15.67	11.63	31.86	8.09	3.16	3.54	.12	.12
11.94..	783	33.72	8.43	23.50	25.29	3.58	.38	1.02	.51	......
12.94..	881	21.34	16.34	13.62	9.53	17.71	19.52	1.36	.34	.23
13.94..	378	42.33	22.22	17.99	3.70	9.53	2.12	.79	......	1.32
14.94..	525	54.63	16.76	8.38	12.95	6.10	......	.95	......	......
15.94..	535	27.66	20.93	9.72	36.64	4.86	......	......	......	.19
16.94..	452	17.48	21.24	27.43	22.78	7.30	1.10	.44	1.33	.66
17.94..	378	22.22	16.93	21.43	34.66	3.17	.27	......	......	1.32
18.94..	262	36.87	16.87	24.42	18.32	3.05	......	.38	......	.38
20.94..	1,241	20.63	5.16	58.34	11.60	3.38	.64	......	.08	.16
21.94..	618	26.54	22.01	20.06	25.89	4.53	......	.81	.16	......
22.94..	625	38.40	14.08	9.60	30.40	6.55	.96	......	......	......
24.94..	865	55.49	14.80	9.94	11.79	6.59	.81	.23	.35	......
25.94..	1,043	45.60	24.35	12.20	8.40	7.70	1.10	.20	.30	.10
26.94..	1,912	42.67	33.47	13.39	4.55	3.76	.84	.89	.16	.32
27.94..	564	44.68	17.38	12.77	17.73	5.85	.53	.53	.53	......
29.94..	1,036	40.15	9.26	16.21	8.49	5.02	6.18	3.47	6.18	5.02
1.95..	134	......	......	17.91	47.76	23.88	4.48	2.98	2.24	.75
2.95..	322	24.84	7.45	2.48	14.91	22.36	9.94	12.42	5.59	......
3.95..	324	54.32	6.17	6.17	2.47	6.17	4.94	7.41	4.94	7.41
4.95..	114	14.03	6.14	5.26	10.53	21.93	28.07	10.53	3.51	......
5.9ç..	138	20.29	23.19	31.88	2.17	......	17.39	4.35	.73	......
6.95..	154	20.78	23.38	16.88	18.18	9.09	11.04	......	.65	......
7.95..	93	81.72	16.13	......	......	......	......	......	......	2.15
8.95..	116	91.38	6.89	......	.86	......	......	......	.86	......
9.95..	58	75.87	20.69	......	......	1.72	......	......	......	1.72
10.95..	415	86.75	9.64	1.93	......	......	1.44	......	......	.24
11.95..	357	71.71	8.96	.28	13.73	......	4.48	.28	.56	......
12.95..	68	29.41	11.77	47.05	11.77	......	......	......	......	......
13.95..	85	67.07	18.82	9.41	......	......	......	......	......	4.70
14.95..	400	73.75	14.	12.	......	......	.25	......	......	......
15.95..	397	8.06	2.02	65.49	14.11	10.07	.25	......	......	......
16.95..	340	56.47	25.88	9.41	5.89	1.76	.59	......	......	......
17.95..	385	6.23	14.55	47.79	22.86	8.31	.26	......	......	......
18.95..	610	45.25	11.80	18.36	14.43	3.93	3.93	1.64	.66	......
19.95..	403	23.82	11.91	......	36.24	19.85	3.97	3.47	.74	......
20.95..	280	14.29	14.29	8.57	14.29	8.57	5.71	14.28	20.	......
1.96..	91	......	......	26.38	13.19	52.75	2.19	1.09	......	4.40
2.96..	389	......	4.11	8.22	49.36	32.90	3.09	2.06	......	.26
3.96..	89	2.25	31.46	3.37	8.99	22.47	26.96	3.37	......	1.13
5.96..	23	69.57	17.39	13.04	......	......	......	......	......	......
6.96..	77	72.72	10.40	15.58	......	......	1.30	......	......	......
7.96..	124	77.42	12.90	6.45	......	3.23	......	......	......	......
8.96 .	136	100.	......	......	......	......	......	......	......	......
9.96..	328	82.92	4.88	12.20	......	......	......	......	......	......

CYCLOPS FLUVIATILIS—continued.

No. of Coll.	Total No.	Per cent.								
		0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-
10.96..	423	92.67	1.18	2.83	2.84	.24	......	......	.24	......
11.96..	607	96.21	2.63	......	......	.49	.17	.16	.34	......
12.96..	546	85.35	13.19	.73	......	.19	.18	.18	......	.18
13.96..	182	39.56	39.56	17.58	3.30	......	......	......	......	......
14.96..	153	31.37	31.37	33.99	3.27	......	......	......	......	......
15.96..	331	99.10	......	.60	......	.30	......	......	......	......
16.96..	230	55.65	5.22	24.35	3.48	......	8.69	1.30	......	1.31
17.96..	474	18.57	8.44	60.76	10.97	.84	.42	......	......	......
18.96..	368	32.61	.54	34.78	30.44	.54	.27	......	......	.82
19.96..	525	50.29	4.57	13.71	16.76	3.81	3.05	7.62	.19	......
20.96..	619	51.70	11.63	28.43	3.23	......	3.23	1.62	......	.16
21.96..	369	23.85	19.52	32.52	18.43	2.17	.27	1.64	.55	1.09
22.96..	489	29.45	11.45	8.18	32.72	16.36	.82	.61	.41	......
23.96..	396	51.01	12.12	14.14	22.48	.25	......	......	......	......
24.96..	253	28.46	17.39	22.13	25.30	2.77	.39	......	3.56	......
25.96..	342	25.73	12.86	4.68	8.19	7.02	4.68	18.72	7.60	10.52
26.96..	312	in	0–20	mete	rs.					
27.96..	400	10.	8.	8.	14.	42.	2.	6.	2.	......

C. fluviatilis (see Pl. X) occurs in the collections during the whole year, and generally in considerable numbers. The maximum seems to be reached in the months of October and November, although in 1896 quite large collections were made in July, and the smallest collections were made in the months of May and June.

C. fluviatilis is found in greater or smaller numbers at all depths, but is far the most abundant near the surface, the greater part of the collection being ordinarily within ten meters of the surface, and below twenty-five meters very few are found. In many cases more than fifty per cent. were in the upper five meters. In the winter collections, however, the numbers at the surface were smaller, and the bulk of the collection was frequently in the intermediate regions, between ten and thirty meters. There are apparent exceptions to this, however, as in 3.95, where 54 per cent. were in the upper five meters. But in this case the remaining fifty per cent. was distributed pretty evenly through the deeper regions.

In order to determine with some degree of exactness the difference in vertical distribution in cold weather as compared with that in warm weather I averaged the percentages in the upper five divisions from June until September, 1896, —7.96 to 17.96 inclusive,—and from November to April, 1895,—24.94 to 3.95 inclusive,— with the following results:

	0–5	5–10	10–15	15–20	20–25
7.96 to 17.96—warm weather..........	70.80	10.85	14.50	2.17	.48
24.94 to 3.95—cold weather...........	38.47	14.11	11.38	14.51	10.17

It is evident from these figures that there is a marked difference in the vertical distribution in warm and in cold weather. Nearly 71 per cent. in warm weather are in the upper five meters, while the upper fifteen include 96.15 per cent. In cold weather, on the other hand, only 38.47 per cent. are in the upper five meters, and below that they are somewhat evenly distributed.

To determine the difference between day and night I averaged the five hauls in October, 1894, which were taken between six p. m. and six a m., and compared them with ten hauls taken in the same month between six a. m. and six p. m. The following was the result:

	0–5	5–10	10–15	15–20
Night hauls..................................	24.57	13.28	26.84	19.72
Day hauls....................................	29.27	19.88	18.72	23.58

It will be seen that the percentages are very similar, and I infer that there is no appreciable diurnal migration. I conclude from this that they are not very sensitive to changes in the amount of light. I take it, too, that while they are affected by changes of temperature, they are not very sensitive to such changes, or a larger proportion would be found in the warmer deep water in the winter. *C. fluviatilis*, in this respect, differs very markedly from *Epischura lacustris*, which not only has a more pronounced seasonal migration, but moves vertically in accordance with diurnal changes of temperature in the surface water

LEPTODORA HYALINA.

No. of Coll.	Total No.	*Per cent.* 0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-
4.94..	3	33.33	33.33	33.34	......	......	......	......	......	......
5.94..	1	......	100.	......	......	......	......	......	......	......
6.94..	12	100.	......	......	......	......	......	......	......	......
7.94..	5	80.	20.	......	......	......	......	......	......	......
8.94..	4	100.	......	......	......	......	......	......	......	......
10.94..	5	......	80.	......	20.	......	......	......	......	......
11.94..	11	18.18	9.09	54.54	9.09	......	9.09	......	......	......
12.94..	5	20.	60.	......	......	......	20.	......	......	......
13.94..	1	......	100.	......	......	......	......	......	......	......
14.94..	1	......	......	100.	......	......	......	......	......	......
15.94..	2	......	100.	......	......	......	......	......	......	......
16.94..	......	......	......	......	......	......	......	......	......	......
17.94..	......	......	......	......	......	......	......	......	......	......
18.94..	......	......	......	......	......	......	......	......	......	......
20.94..	1	......	100.	......	......	......	......	......	......	......
21.94..	2	......	100.	......	......	......	......	......	......	......
22.94..	1	......	......	100.	......	......	......	......	......	......
					No *Leptodora* from 23.94 to 2.95.					
3.95..	3	100.	......	......	......	......	......	......	......	......
					No *Leptodora* from 4.95 to 12.95.					
13.95..	6	......	......	83.33	16.67	......	......	......	......	......
14.95..	12	100.	......	......	......	......	......	......	......	......
15.95..	2	......	......	50.	......	50.	......	......	......	......
16.95..	......	......	......	......	......	......	......	......	......	......
17.95..	......	......	......	......	......	......	......	......	......	......
18.95..	1	100.	......	......	......	......	......	......	......	......
19.95..	......	......	......	......	......	......	......	......	......	......
20.95..	......	......	......	......	......	......	......	......	......	......
1.96..	......	......	......	......	......	......	......	......	......	......
2.96..	......	......	......	......	......	......	......	......	......	......
3.96..	......	......	......	......	......	......	......	......	......	......
5.96..	......	......	......	......	......	......	......	......	......	......
6.96..	......	......	......	......	......	......	......	......	......	......
7.96..	......	......	......	......	......	......	......	......	......	......
8.96..	2	50.	50.	......	......	......	......	......	......	......
9.96..	16	37.50	18.75	12.50	31.35	......	......	......	......	......
10.96..	2	50.	50.	......	......	......	......	......	......	......
11.96..	24	100.	......	......	......	......	......	......	......	......
12.96..	8	75.	25.	......	......	......	......	......	......	......
13.96..	5	80.	......	......	......	20.	......	......	......	......
14.96..	6	33.33	66.67	......	......	......	......	......	......	......
15.96..	5	100.	......	......	......	......	......	......	......	......
16.96..	22	63.63	3.82	......	4.55	......	......	......	......	......
17.96..	15	53.34	13.33	26.67	......	......	......	......	6.66	......
18.96..	21	90.48	......	4.76	4.76	......	......	......	......	......
19.96..	1	......	......	......	100.	......	......	......	......	......
20.96..	4	25.	25.	50.	......	......	......	......	......	......
21.96..	8	37.50	37.50	......	12.50	12.50	......	......	......	......
22.96..	1	......	......	......	......	100.	......	......	......	......
23.96..	2	......	......	100.	......	......	......	......	......	......
24.96..	1	......	......	......	100.	......	......	......	......	......
25.96..	......	......	......	......	......	......	......	......	......	......
26.96..	......	......	......	......	......	......	......	......	......	......
27.96..	......	......	......	......	......	......	......	......	......	......

With the exception of three individuals in the collection of March 27, 1895, I found no *Leptodora* from the latter part of October to the middle of June. It was present pretty generally in the summer collections, but never in very large numbers. The largest number that I obtained in any collection was twenty-four.

In its vertical distribution, *Leptodora* is commonly within ten meters of the surface. I have found individuals at a depth of between twenty-five and thirty meters, but it is not a common occurrence.

Leptodora was never present in sufficient numbers in my collections so that I could draw any inferences in regard to the effect changes of temperature would have on its vertical distribution.

It will be noticed that my observations in regard to the seasonal distribution of *Leptodora* correspond very closely with what Zacharias says of *Leptodora* in Ploener See, for he states that it disappears in the course of the month of October, and appears again towards the end of May. (Zacharias, '94, p. 100. Also, Apstein '96, p. 175. Friç and Vávra, '94, pp. 55, 108.)

Apstein ('96, p. 80) states that *Leptodora* is found most abundantly in the deep water. This is certainly not according to my observations, as they would indicate that it should rather be considered a surface form, although it is by no means confined to the immediate surface. As Apstein does not state what he means by deep water in this case, the seeming contradiction in our observations may be more apparent than real.

DAPHNIA KAHLBERGIENSIS.

No. of Coll.	Total No.	Per cent.								
		0–5	5–10	10–15	15-20	20–25	25–30	30–35	35–40	40–
1.94..	292	60.27	24.66	13.70	......	1.03	......	.34	......	......
4.94..	372	6.45	23.66	22.58	11.83	12.90	6.45	5.91	8.60	1.61
5.94..	377	25.47	21.22	20.16	16.97	3.18	6.37	4.24	2.12	.27
6.94..	419	39.14	21.95	.10.50	15.28	9.55	3.34	.24	......	......
7.94..	419	43.91	30.55	16.23	1.91	3.82	......	.24	......	3.34
8.94..	345	46.38	32.47	14.49	2.90	.58	......	2.31	.58	.29
10.94..	353	31.76	37.39	14.73	6.79	3.40	1.98	1.70	1.70	.59
11.94..	414	46.37	13.53	27.06	7.24	1.93	1.93	.25	1.50	.25
12.94..	571	39.23	23.12	16.81	6.30	2.80	10.51	.70	.52	......
13.94..	641	77.38	16.85	2.49	1.23	.62	.31	.16	......	.96
14.94..	495	29.09	22.63	21.82	18.59	7.27	.20	.20	.20	......
15.94..	303	40.59	36.96	13.20	5.21	1.32	......	.33	1.66	.33
16.94..	140	62.85	21.43	10.	3.57	.71	1.42	......	......	......
17.94..	97	24.74	47.42	4.12	21.65	......	......	......	1.01	1.01
18.94..	248	77.41	8.07	9.84	1.61	1.61	......	1.61	......	......
20.94..	232	65.52	12.07	17.24	5.17	......	......	......	......	......
21.94..	236	28.81	35.59	22.03	10.13	.42	......	2.54	.42	......
22.94..	320	48.75	37.50	6.25	5.62	.94	.62	.31	......	......
24.94..	105	51.43	22.86	11.43	7.62	5.71	......	.95	......	......
25.94..	106	56.60	18.90	2.80	.90	20.	.90	......	......	......
26.94..	90	80.01	7.78	4.44	3.33	1.11	......	2.22	1.11	......
27.94..	242	52.07	6.65	23.14	12.81	4.54	.41	.41	......	......
29.94..	58	62.07	5.17	12.07	3.45	......	1.72	1.73	13.79	......
1.95..	3	66.	......	......	......	......	......	......	34.	......
2.95..	2	......	......	......	......	......	......	......	......	100.
3.95..	56	100.	......	......	......	......	......	......	......	......
4.95..	......	......	......	......	......	......	......	......	......	......
5.95..	1	100.	......	......	......	......	......	......	......	......
6.95..	2	......	......	50.	......	50.	......	......	......	......
7.95..	......	......	......	......	......	......	......	......	......	......
8.95..	25	......	32.	64.	4.	......	......	......	......	......
9.95..	9	......	89.	......	......	......	......	11.	......	......
10.95..	49	81.63	16.33	......	2.04	......	......	......	......	......
11.95..	33	3.03	48.49	......	48.48	......	......	......	......	......
12.95..	91	8.79	70.33	3.30	17.58	......	......	......	......	......
13.95..	137	......	29.20	52.57	8.76	2.92	5.84	.73	......	......
14.95..	89	......	35.95	35.96	8.99	3.37	13.48	......	2.25	......
15.95..	182	......	4.39	35.16	6.59	26.37	13.19	13.19	1.10	......
16.95..	28	28.57	57.14	7.15	7.14	......	......	......	......	......
17.95..	57	5.26	70.18	7.02	7.02	10.52	......	......	......	......
18.95..	170	42.35	9.41	9.41	32.94	4.71	1.18	......	......	......
19.95..	131	48.85	12.21	3.05	24.43	......	6.12	4.58	.76	......
20.95..	7	57.14	......	......	......	14.28	......	......	28.58	......

DAPHNIA KAHLBERGIENSIS.

D. kahlbergiensis did not occur in the collections from 1.96 to 7.96.

No. of Coll.	Total No.	0–5	5–10	10–15	15–20	20–25	25–30	30–35	35–40	40–
8.96..	40	7.50	60.	20.	10.	2.50	......	......	......	......
9.96..	225	42.67	17.78	21.34	17.77	.44	......	......	......	......
10.96..	129	37.21	18.60	15.50	24.81	.78	......	1.55	......	1.55
11.96..	71	11.27	56.34	16.90	7.04	1.41	4.22	......	2.82	......
12.96..	325	39.38	29.54	24.62	6.15	......	......	......	.30	......
13.96..	84	14.29	19.05	47.62	9.52	9.52	......	......	......	......
14.96..	32	......	62.50	37.50	......	......	......	......	......	......
15.96..	5	20.	......	......	......	......	......	20.	20.	40.
16.96..	108	......	3.70	81.48	11.12	.93	2.77	......	......	......
17.96..	68	......	5.88	35.30	35.29	22.06	......	......	1.47	......
18.96..	73	21.92	......	32.88	35.62	6.85	1.37	1.36	......	......
19.96..	86	37.21	27.91	......	9.30	10.46	13.96	1.16	......	......
20.96..	92	60.87	8.70	6.52	4.35	13.04	3.26	2.17	1.09	......
21.96..	94	34.04	42.55	8.51	8.51	1.07	4.26	1.06	......	......
22.96..	78	10.26	30.77	35.89	12.82	3.85	2.57	2.56	1.28	......
23.96..	223	46.19	17.94	17.94	10.76	5.38	.89	.45	......	.45
24.96..	72	13.88	22.23	33.34	27.78	......	2.77	......	......	......
25.96..	61	59.02	26.23	6.56	6.55	1.64	......	......	......	......
26.96..	102	in	0–20	met'rs						
27.96..	16	18.75	25.	12.50	6.25	12.50	25.	......	......	......

During the fall of 1894 (see Pl. XI) the collections of *Daphnia kahlbergiensis* were quite uniform in amount, reaching a maximum in the latter part of October. During the winter the number was very small, and they did not become numerous again until June. There is a fall maximum again in 1895 in the latter part of October, but, curiously, the total numbers collected during the fall of 1895 are much smaller than in 1894. During the winter and spring of 1896 *Daphnia* was entirely absent from the collections. They appear again about the middle of May, and the largest collections of the year were made from June 29 to July 27. In August and September the collections were rather small, but the number became larger the latter part of October as in the preceding years.

Apstein ('96, p. 170) states that the species of *Daphnia* reach their maximum in August, but that *D. cederstroemi* is somewhat later, so that it would appear that my results in regard to the seasonal distribution of *Daphnia* do not agree very closely with his. It is probable that the various species of *Daphnia* may differ considerable in their periods of maximum occurrence.

Daphnia may be found at all depths, but is most numerous in the upper ten meters. In some cases, however, more than fifty per cent. of the catch is below the twenty meter line.

Very few *Daphnias* occur in winter, and I could not distinguish any effect of season on distribution.

The averages of the day and night hauls of '94 were as follows:

	0-5	5-10	10-15
Day, Oct. '94....................	38.39	24.43	15.40
Night, Oct. '94....................	54.48	23.01	13.46

These averages would seem to indicate a movement towards the surface at night. I am not sure that this inference is warranted, however, for the averages are of numbers with wide limits of variation, and I accept the conclusion with considerable doubt.

BOSMINA.

No. of Coll.	Total No.	Per cent.								
		0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-
1.94..	9	89.	11.	......	......	......	......	......	......	......
4.94..	57	56.14	14.04	21.05	7.02	1.75	......	......	......	......
5.94..	112	71.43	17.86	7.14	3.57	......	......	......	......	......
6.94..	98	65.31	16.33	4.08	12.24	......	1.02	1.02	......	......
7.94..	26	11.54	61.54	7.69	3.85	......	......	......	......	15.38
8.94..	95	42.12	29.47	22.15	4.21	......	1.05	......	......	......
10.94..	57	42.10	28.08	3.51	21.06	......	5.27	......	......	......
11.94..	106	75.47	7.55	.94	......	15.09	......	......	......	......
12.94..	280	31.43	10.	34.29	5.71	10.	8.57	......	......	......
13.94..	64	37.50	6.25	18.75	9.37	25.	......	......	......	3.13
14.94..	40	20.	50.	20.	10.	......	......	......	......	......
15.94..	85	47.06	28.24	9.41	14.12	......	......	1.17	......	......
16.94..	51	78.43	3.92	5.88	3.92	......	5.88	......	......	1.96
17.94..	7	77.92	6.49	6.49	5.19	1.29	......	......	......	2.59
18.94..	212	75.47	11.32	13.11	......	......	......	......	......	......
20.94..	64	56.25	6.25	28.12	6.25	3.13	......	......	......	......
21.94..	37	13.51	43.24	43.24	......	......	......	......	......	......
22.94..	72	38.88	50.	5.55	2.78	1.39	1.39	......	......	......
24.94..	151	70.20	13.25	10.59	3.31	2.65	......	......	......	......
25.94..	115	70.	15.	6.10	5.20	1.70	1.70	1.	......	......
26.94..	257	80.93	12.45	1.55	1.95	1.56	.39	......	.39	.78

BOSMINA.

No. of Coll.	Total. No.	Per cent.								
		0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45
27.94..	191	56.54	8.38	8.38	14.66	11.52	......	.52	......	......
29.94..	772	56.48	14.51	9.33	3.11	4.14	4.14	3.63	4.14	.52
1.95..	26	46.15	15.38	15.38	3.85	3.85	7.70	......	3.85	3.84
2.95..	30	26.67	......	13.33	26.67	3.33	3.33	20.	3.33	3.34
3.95..	49	81.63	8.16	......	2.04	8.17	......	......	......	......
4.95..	......	......	......	......	......	......	......	......	......	......
5.95..	5	40.	20.	40.	......	......	......	......	......	......
6.95..	1	100.	......	......	......	......	......	......	......	......
7.95..	3	100.	......	......	......	......	......	......	......	......
8.95..	4	50.	50.	......	......	......	......	......	......	......
9.95..	10	80.	......	10.	......	10.	......	......	......	......
10.95..	48	83.34	2.08	12.50	......	......	......	2.08	......	......
11.95..	40	60.	40.	......	......	......	......	......	......	......
12.95..	91	52.75	8.79	35.16	......	......	1.10	2.20	......	......
13.95..	61	52.46	13.11	4.92	......	3.28	26.23	......	......	......
14.95..	64	25.	37.50	3.12	......	10.94	9.38	......	1.56	12.50
15.95..	75	42.67	10.66	21.33	10.67	10.67	4.	......	......	......
16.95..	42	57.14	4.76	19.05	19.05	......	......	......	......	......
17.95..	205	85.85	7.81	1.95	......	3.90	.49	......	......	......
18.95..	288	58.33	8.34	5.56	11.12	16.65	......	......	......	......
19.95..	279	51.61	11.47	1.44	10.75	17.20	5.73	1.08	.72	......
20.95..	232	24.13	6.90	20.69	6.90	6.90	1.73	25.86	6.89	......
1.96..	75	16.	32.	8.	2.66	16.	13.34	8.	4.	......
2.96..	66	6.06	36.36	7.58	18.18	25.75	3.03	1.52	1.52	......
3.96..	12	......	8.33	8.34	33.33	33.33	8.33	8.34	......	......
5.96..	......	......	......	......	......	......	......	......	......	......
6.96..	2	100.	......	......	......	......	......	......	......	......
7.96..	8	100.	......	......	......	......	......	......	......	......
8.96..	165	82.42	14.55	1.21	......	......	......	1.82	......	......
9.96..	94	51.06	8.51	17.02	17.02	4.26	2.13	......	......	......
10.96..	71	67.60	2.82	1.40	22.53	4.25	......	......	1.40	......
11.96..	99	72.72	20.20	4.04	1.01	......	2.02	......	......	......
12.96..	79	81.01	5.06	5.06	6.33	1.27	......	1.27	......	......
13.96..	67	83.58	......	2.98	4.48	8.96	......	......	......	......
14.96..	2	50.	......	......	50.	......	......	......	......	......
15.96..	57	98.25	1.75	......	......	......	......	......	......	......
16.96..	86	83.72	1.16	......	4.65	8.14	1.16	1.17	......	......
17.96..	134	89.55	1.49	1.49	2.99	4.48	......	......	......	......
18.96..	82	87.80	......	9.75	......	1.22	......	......	......	1.23
19.96..	92	47.83	52.17	......	......	......	......	......	......	......
20.96..	479	67.64	16.70	10.02	2.09	2.50	.21	.84	......	......
21.96..	322	84.47	3.11	4.97	.31	6.21	......	.62	......	.31
22.96..	247	68.02	25.91	.41	.40	4.86	.40	......	......	......
23.96..	435	95.63	2.53	1.84	......	......	......	......	......	......
24.96..	109	88.07	7.34	1.84	1.83	......	....	......	......	.92
25.96..	280	59.02	26.23	6.56	6.55	1.64	......	......	......	......
26.96..	438	in 0-	20 met	ers.						
27.96..	420	30.48	9.53	11.43	13.33	9.52	19.04	2.86	2.86	.95

Bosmina (see Pl. XII) was present at all times of the year. In only one collection during something over two years,—that of May 4th, 1896,—did I fail to find some individuals of this genus. Its time of maximum occurrence is in November. The numbers found in successive collections vary within very wide limits. For instance, Oct. 20, 1894, in a collection made between 2:15 and 3:15 p. m., I found only seven individuals, while in a collection made about two hours later, I found 212; and yet the conditions were apparently precisely the same.

In regard to its vertical distribution, its home is in the upper layers, although it is found occasionally at all depths.

In order to determine whether there was any difference in the vertical distribution at different seasons, I averaged the summer collections of 1896, from June to September,—7.96 to 17.96 inclusive,—and the winter collections of 1894-5 from November to April,—24.94 to 3.95 inclusive, with results as follows:

	0-5	5-10	10-15	15-20
Winter, 24.94 to 3.95................	61.07	10.89	8.08	7.60
Summer, 7.96 to 17.96................	78.18	5.05	3.02	9.91

While this would indicate a somewhat larger percentage in the 0-5 layer in summer, the difference is not very marked, and we may say that the vertical distribution is very little affected by the changes of season.

The averages of the night collections of 1894 compare with those of the day collections as follows:

	0-5	5-10	10-15	15-20
Night................................	35.77	22.70	22.20	5.88
Day................................	60.93	18.38	9.16	7.71

These figures would indicate that there is a distinctly larger number in the 0-5 layer in the day time than in the night, and I infer that is attracted, to some extent, at least, by the light.

DAPHNELLA.

No. of Coll.	Total No.	Per cent.								
		0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-
1.94..	29	55.17	20.69	3.45	......	3.45	13.79	3.45	......	......
4.94..	31	51.61	9.68	38.71	......	......	......	......	......	......
5.94..	27	88.88	7.41	......	3.71	......	......	......	......	......
6.94..	62	77.42	1.61	1.61	19.36	......	......	......	......	......
7.94..	24	66.66	16.67	8.33	......	......	......	......	......	8.34
8.94..	46	52.18	26.09	13.04	4.35	......	2.17	......	2.17	......
10.94..	25	80.	12.	4.	4.	......	......	......	......	......
11.94..	35	45.71	34.29	2.86	11.43	......	5.71	......	......	......
12.94..	47	59.57	4.26	4.26	17.02	12.77	2.13	......	......	......
13.94..	46	86.96	2.17	2.17	8.70	......	......	......	......	......
14.94..	11	9.09	36.36	18.18	27.27	......	......	9.09	......	......
15.94..	19	15.79	63.15	......	21.05	......	......	......	......	......
16.94..	......	......	......	......	......	......	......	......	......	......
17.94..	7	14.29	14.29	......	71.43	......	......	......	......	......
18.94..	1	......	......	100.	......	......	......	......	......	......
19.94..	2	......	......	......	......	......	......	......	......	......
20.94..	15	80.	......	13.33	......	......	......	......	6.66	......
21.94..	17	35.29	47.06	11.76	5.88	......	......	......	......	......
22.94..	16	25.	37.50	12.50	25.	......	......	......	......	......
24.94..	1	......	......	......	......	100.	......	......	......	......
25.94..	1	......	100.	......	......	......	......	......	......	......
26.94..	......	......	......	......	......	......	......	......	......	......
27.94..	......	......	......	......	......	......	......	......	......	......
28.94..	1	......	100.	......	......	......	......	......	......	......
29.94..	......	......	......	......	......	......	......	......	......	......
1.95..	......	......	......	......	......	......	......	......	......	......
2.95..	......	......	......	......	......	......	......	......	......	......
3.95..	16	100.	......	......	......	......	......	......	......	......
4.95..	......	......	......	......	......	......	......	......	......	......
5.95..	......	......	......	......	......	......	......	......	......	......
6.95..	......	......	......	......	......	......	......	......	......	......
7.95..	......	......	......	......	......	......	......	......	......	......
8.85..	......	......	......	......	......	......	......	......	......	......
9.95..	......	......	......	......	......	......	......	......	......	......
10.95..	1	100.	......	......	......	......	......	......	......	......
11.95..	......	......	......	......	......	......	......	......	......	......
12.95..	......	......	......	......	......	......	......	......	......	......
13.95..	......	......	......	......	......	......	......	......	......	......
14.95..	1	100.	......	......	......	......	......	......	......	......
15.95..	5	60.	......	40.	......	......	......	......	......	......
16.95..	26	66.54	30.77	7.69	......	......	......	......	......	......
17.95..	3	33.33	......	33.34	33.33	......	......	......	......	......
18.95..	8	12.50	12.50	37.50	12.50	25.	......	......	......	......
19.95..	......	......	......	......	......	......	......	......	......	......
20.95..	No	*Daph*	*nella*	from	1.96	to 8.96				
9.96..	8	88.88	......	......	11.12	......	......	......	......	......
10.96..	40	100.	......	......	......	......	......	......	......	......
11.96..	33	48.48	48.48	3.04	......	......	......	......	......	......
12.96..	18	88.88	11.12	......	......	......	......	......	......	......
13.96..	36	33.33	66.67	......	......	......	......	......	......	......
14.96..	50	4.	96.	......	......	......	......	......	......	......

DAPHNELLA—continued.

No. of Coll.	Total No.	Per cent.								
		0–5	5–10	10–15	15 20	20–25	25–30	30–35	35–40	40–
15.96..	201	99.50	......	......	......	......	.50	......	......	......
16.96..	141	56.74	31.21	8.51	......	......	2.12	1.42	......	......
17.96..	143	2.80	5.59	89.51	1.40	......	.70	......	......	......
18.96..	65	73.85	24.61	......	......	1.54	......	......	......	......
19.96..	211	15.16	51.87	26.54	.95	......	.48	......	......	......
20.96..	88	54.55	36.36	9.09	......	......	......	......	......	......
21.96..	22	18.18	45.45	36.37	......	......	......	......	......	......
22.96..	12	66.67	8.33	25.	......	......	......	......	......	......
23.96..	12	8.34	16.67	8.34	66.65	......	......	......	......	......
24.96..	2	......	......	50.	50.	......	......	......	......	......
25.96..	......	......	......	......	......	......	......	......	......	......
26.96..	......	......	......	......	......	......	......	......	......	......
27.96..	......	......	......	......	......	......	......	......	......	......

Daphnella is at its maximum in point of numbers from about the middle of August to the middle of September. From the last of October to the last of June, very few are found. Only in one collection made during the winter months did I find any *Daphnella*,—that of March 27, 1895. Friç and Vávra ('94, p. 103) state that *Daphnella* occurs from April to October. The observations of Apstein ('96, p. 166) very nearly agree with mine.

In regard to its vertical distribution, *Daphnella* may be found at any depth. By far the larger number, however, occur in the upper layers, ordinarily from seventy to eighty per cent. being found within ten or fifteen meters of the surface.

In order to get at the facts in regard to its vertical distribution, and possible migrations, I computed the average percentages in the upper four or five levels for the day and night collections of October, 1894, for the August collections,— all taken in the daytime,— of 1896, for the September and October collections of 1894, and for the collections of 1893, about twenty in number, made within two or three days in the latter part of August, with the following results:

	0-5	5-10	10-15	15-20
August, 1893	48.30	30.60	......	......
August, 1896	39.27	39.89	19.60	......
September-October, 1894	52.01	16.28	15.46	......
October, 1894, day	38.28	17.89	16.54	15.82
October, 1894, night	69.07	9.84	8.23	6.01

I do not think that the number of collections is large enough to draw inferences final in character in regard to the vertical distribution of *Daphnella*, especially since the total number in any collection is small. It would appear, however, that the upper five meters are more densely populated in September and October than in August and that the number is also greater in the upper five meters in the night time than in the day time. I do not feel like speaking in any dogmatic way in regard to the interpretation of these facts, but I venture to suggest that *Daphnella* is, in its vertical distribution, controlled rather by light and darkness than by changes of temperature. If it were very sensitive to changes of temperature the fact that it is found in greater numbers near the surface at night than in the day time, and also in greater numbers in September and October than in August would indicate a liking for cool water: but if this liking were very pronounced, it would seem that it would migrate deeper in August. If we suppose light to be the controlling factor, we would explain the greater number near the surface in September and October by the greater number of cloudy days in those months. Very likely the solution of this problem is not so simple as my speculations would indicate, and a satisfactory result can only be reached by a carefully conducted investigation in the laboratory of the behavior of the animal under different conditions of light and temperature. It may be noticed that Apstein ('96, p. 79) states that the time when the larger numbers are found at the surface, coincides with the time of total maximum numbers, a conclusion quite the opposite of what my observations would indicate. It does not appear, however, that his conclusions were based on any large number of exact observations.

GENERAL CONCLUSIONS IN REGARD TO VERTICAL DISTRIBUTION.

I had supposed that there was a general movement of the whole body of crustacea in such vertical migrations as existed. It is evident that this is not the case, for the different kinds have their individual peculiarities of distribution.

In the case of *Diaptomus* there is little or no vertical migration from any cause.

Epischura avoids bright light, and has a preference for warm water, and shows both seasonal and diurnal migrations.

Limnocalanus is repelled by bright light and by a high temperature, hence its diurnal migration is more pronounced in cold weather.

Cyclops brevispinosus occurs most abundantly between five and twenty meters in depth. I have no evidence in regard to its diurnal migrations.

Cyclops fluviatilis has no diurnal migration, but in its seasonal distribution shows a preference for the warmer water.

Leptodora is a surface form. I have no conclusive evidence in regard to its diurnal migrations.

Daphnia kahlbergienses apparently moves towards the surface at night.

There is no appreciable difference in the seasonal distribution of *Bosmina.* There is a distinct diurnal migration due to its attraction to light.

Daphnella has a diurnal migration due to the fact that it is repelled by light.

I cannot make out from my collections that the winds have any effect on the vertical distribution of entomostraca. The distribution when the surface is roughened by waves seems to be practically the same as when it is smooth. Neither is there any marked difference between dark and moonlight nights.

It must be remembered, however, that all my collections were at five meter intervals, and that there may be migrations within these limits of which I have no indication. I know for instance from surface tows that the immediate surface is almost entirely devoid of entomostraca in the day time, but is populated in enormous numbers in the night. There is evidently a very marked diurnal migration of most of the forms at the immediate surface, but it would take a series of collections at very short intervals to determine the limits of this genera. movement. These conclusions in regard to the surface phenomena are in harmony with the observations of Francé ('94, p. 35) and Birge ('95, p. 477).

THE HORIZONTAL DISTRIBUTION OF THE LIMNETIC CRUSTACEA.

The results of quantitative plankton determinations are entirely dependent on the assumption that the horizontal distribution of the plankton material is uniform. The laborious methods formulated by Hensen and his co-workers are founded on the assumption that over wide stretches of the ocean there is a practical uniformity in the distribution of the plankton. They believe that their investigations prove this assumption to be a fact. Their theory, however, has not gained universal assent. Haeckel (Haeckel, '90), among others, opposes it strongly. The same question has arisen in regard to lakes, and here it has a great practical importance, for if we can assume the horizontal uniformity of the plankton, then collections made in different lakes under similar conditions would furnish us accurate means of comparing the lakes in regard to the richness of the fauna and flora.

If this could be done, it would have a practical value in relation to the cultivation of fish, as we would expect that the lake rich in plankton would be especially adapted to nourish large numbers of fish. The question of horizontal uniformity of distribution in lakes has been actively discussed by many authors, and thus far with no uniformity of conclusions. Apstein ('92, p. 491) expressed his conviction from the measurements of plankton hauls and the counting of three comparative collections, that the distribution of the plankton in fresh water was practically uniform.

Friç and Vávra ('94, p. 118) come to a similar conclusion from their researches on the Unter Poçernitzer Teich.

Francé ('94, p. 34 ff.) from his investigations on Balaton See comes to directly opposite conclusions, and says that the plankton is very unequally distributed, and that the organisms occur in swarms.

Imhof (Imhof, '92) states that many of the organisms of the plankton occur in swarms.

Zacharias ('94, p. 129 ff.) enters into the subject in considerable detail, and gives his reasons for believing that the plankton is not uniformly distributed, one of his arguments being the very different character of the plankton at two distant points in Lake Plön, as determined by him.

Apstein again ('96, p. 51 ff.) takes up the question, and argues it at length, maintaining his original position.

Reighard ('94, p. 38) concludes that the plankton in Lake St. Clair and Lake Erie is distributed with great uniformity, and finds no positive evidence of swarms.

Ward in his report on Lake Michigan ('96, p. 62), concludes from his study of the plankton of that lake that there is no evidence whatever for the existence of swarms.

In my preliminary report on vertical distribution in Green Lake (Marsh, '94, p. 809) I stated that apparently the crustacea were not uniformly distributed. The figures of my collections of the past two years have served to confirm the opinion I expressed in 1894. It seems to me clear, that, so far as the crustacea are concerned, the horizontal distribution is far from uniform, and inasmuch as the crustacea ordinarily form the larger part of any plankton collection, it would follow that the distribution of the plankton is not uniform.

It must be remembered that all my collections were made from a buoy kept in one spot during the whole season, and in successive seasons, an attempt was made to drop the anchor as nearly as possible in the same spot. All collections, then, were made from the same depth of water in any season, and in very nearly the same depth in all the seasons. Now, if the distribution of the crustacea were uniform, collections made for the whole depth of water on the same day, or on successive days, should show nearly the same numbers of each species. Of course, if a species were rare, the fact that two or three individuals were found in one collection, and none in the next would not invalidate the assumption of uniformity. Nor even in cases where the numbers of a species were very large, would the fact that a considerably larger number were found in one collection than in another be any conclusive argument against the practical uniformity of distribution. Nor, on the other hand should it be assumed, because two or three successive hauls show the same, or nearly the same numbers, that the distribution is therefore uniform, because this could be easily explained by supposing that the swarm was of considerable extent or remained stationary for a considerable period.

My collections made in 1893, which were reported in the former paper, were made almost continuously in the course of two days. Now if the plankton is uniformly distributed, those collections should show a practical uniformity of numbers, and the more numerous a species was, the less should be the proportional variation. Yet the collections of *Diaptomus*, the most abundant genus, varied from 291 to 2,966. In many of the collections made in the fall of 1894 on the same day, or successive days, there was a marked uniformity in the numbers of *Diaptomus*, as for example, nos. 4.94, 5.94 and 6.94 show a range of numbers only from 4,171 to 5,630. If one were to base his conclusions on a small number of observations, he might well say that here was clear evidence of uniformity. Yet a few hours later in the same place I found only 2,023; with a difference as great as this, we certainly cannot speak of the *Diaptomi* as being uniformly distributed. In hauls 21.94 and 22.94, made in the forenoon of October 25, there was in one case 1,917 and in the other 3,823 — twice as many. Still more marked was the difference in two collections, one made at about six p. m., and the other between ten and eleven p. m., November 8. In the six o'clock collection there were 884, while in the evening collection there were 6,447. Such an enormous difference as this is certainly not consistent with any theory of uniformity of distribution. In these same two collections of November 8, *Cyclops fluviatilis* showed a similar wide variation,— the numbers in the six o'clock collection being 1,912, and in the evening collection being 564. October 24 I found between ten and eleven o'clock in the evening 1,241 *C. fluviatilis*, and yet the next morning between six and seven o'clock, I found only 618.

Limnocalanus is not a very good genus to consider in connection with this discussion, because it does not often occur in any large numbers. It is significant, however, that in successive hauls there were sometimes differences of from two to five hundred per cent. On November 14, 1896, I found in a collection made in the afternoon 56. In a collection made at about eight o'clock the same evening, I found 200 in the upper two and one half meters. In this case, curiously, the total number obtained in the other hauls from the surface to twenty meters was only 106.

An examination of the numbers of the other species as collected at similar times shows the same variations. None of them, however, seem to me to furnish such conclusive evidence as we get from *Diaptomus* and *C. fluviatilis,* because of the smaller number involved.

Thus my results are in harmony with those obtained by Zacharias and Francé. Inasmuch as one certainly would not question the accuracy of the work of the observers who have come to different conclusions, the question arises whether there is any way of explaining such differences I think a critical examination of their work and the inferences derived from it will show that such an explanation is possible.

In the first place I would state my entire agreement with the school of Hensen, that *only by an enumeration of individuals can we get at exact results in plankton work.* Volumetric determinations have a value in a general way, and may be used even in comparing different bodies of water, but only with a large allowance for the possibilities of error. Many of the difficulties in this method of work have been well pointed out by Ward himself. (Ward, '95a, p. 256 ff.). Most important is the difference in the time of subsidence due to the differences in the character of the plankton at different times and places. Some kinds of material will remain suspended for an almost indefinite period. Consequently, the volumetric method would rarely be sufficiently accurate to indicate even very considerable differences in horizontal distribution. There are, also, questions in regard to the accuracy of any gravimetric method that has yet been devised, although the amount of error by this method must be much less than by the volumetric method.

As a second principle I would say that *only a long continued series of observations on the same body of water will furnish sufficient evidence of the uniformity or lack of uniformity in distribution.* Two or three, or even several parallel, or successive collections do not furnish sufficient evidence.

Now, in criticising other observers, Friç and Vávra apparently determined the amount of plankton entirely by the method of weighing. Reighard and Ward made their comparisons entirely by the volumetric method, but in the results of both, there were certain discrepancies which could be most easily explained on the assumption that some of the organisms occurred in swarms. (Reighard, '94, p. 37, Ward, '96, p. 63.)

Apstein bases his opinion largely on volumetric determinations. He also furnishes an enumeration of individuals in three parallel hauls in the Dobersdorfer See, and two sets of two each in the Great Plöner See. These counts show a remarkable uniformity in the smaller organisms, but there is a considerable variation in the numbers of the crustacea, the difference being in many cases over 200 per cent. The only criticism one can make of Apstein's work is that the enumerations do not include a sufficient number of collections. While apparent uniformity in a few collections would be presumptive proof of a general uniformity, a single well authenticated case of unequal distribution would overthrow any conclusions founded on such collections.

Both Apstein and Ward raise the question as to the definition of the term "swarm." Now, it seems to me, the determination of the fact that limnetic organisms are or are not uniformly distributed is of first importance, and it makes very little difference just what meaning shall be attached to the word "swarm," until this question is decided. Without doubt the term has been used without any very exact meaning, as simply indicating a greater or less local aggregation of organisms, with very little thought of the cause of that aggregation, or of the exact or even approximate density of population that should be designated by the term.

Of course, as the result of my investigations I can speak only of the crustacea, and not of the plankton as a whole, except as the plankton, in many cases, is very largely composed of crustacea.

It seems to me that my collections clearly show that so far as the crustacea are concerned, while parallel or successive collections may show great similarity in numbers, they may, in other cases vary within such wide limits as to make plankton determinations unreliable, unless they are made from the average of a very large number of collections. Inasmuch as it is practically impossible to take a sufficiently large number of collections, it follows that plankton collections largely made of crustacea, cannot be taken as giving the exact measure of the productiveness of different bodies of water that some authors would have us think. We may say, indeed, with reasonable certainty, that one lake is much richer than another, but it seems to me very doubtful if we can express their relative productiveness by any definite numerical ratio.

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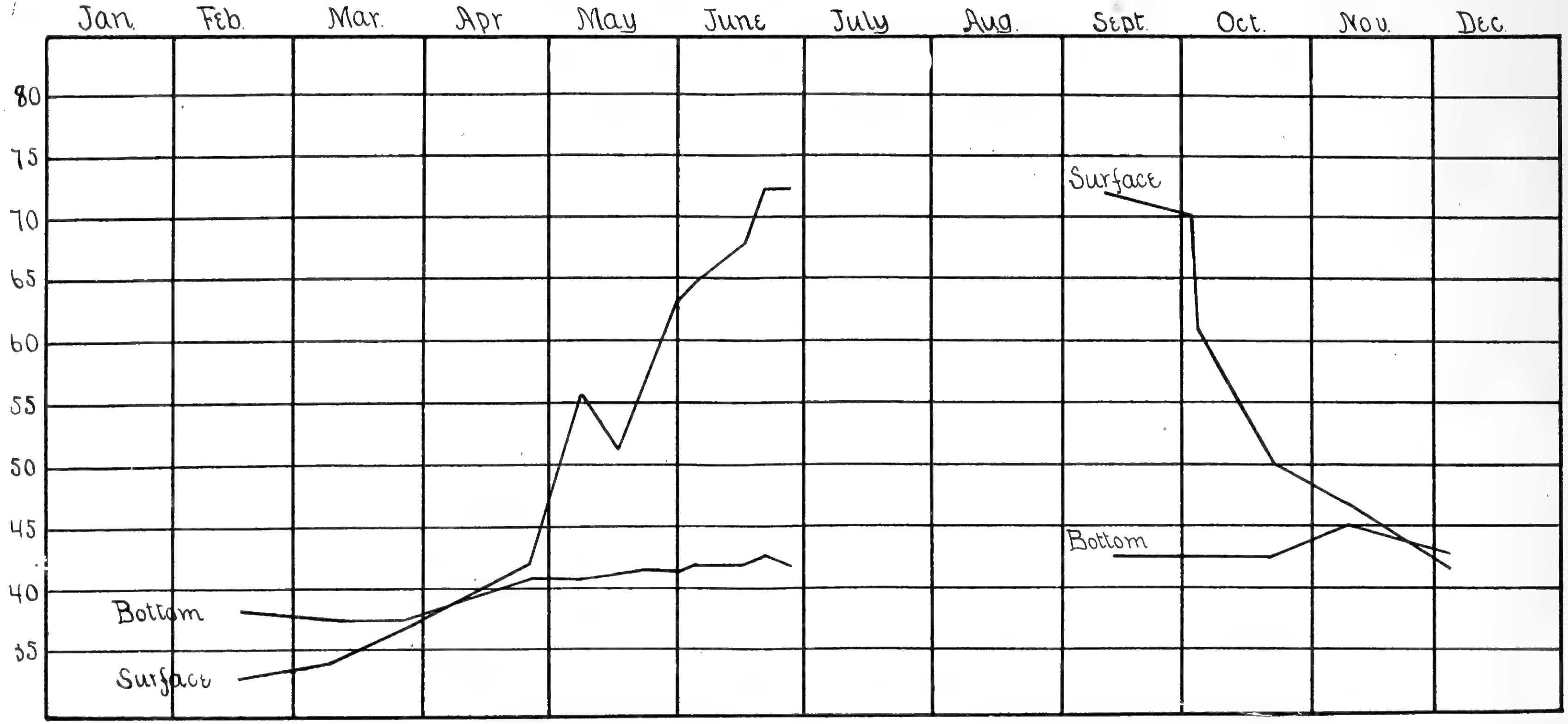

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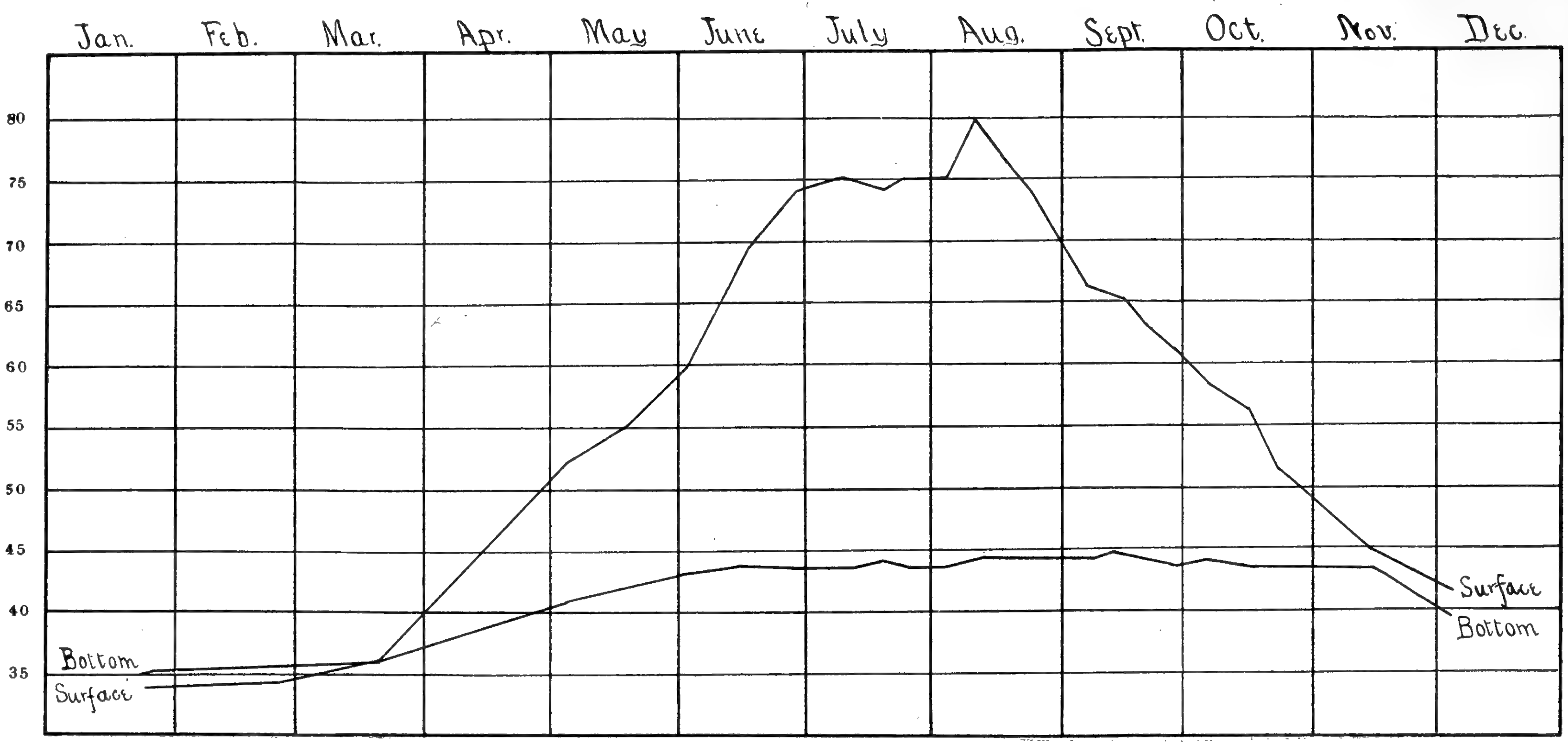

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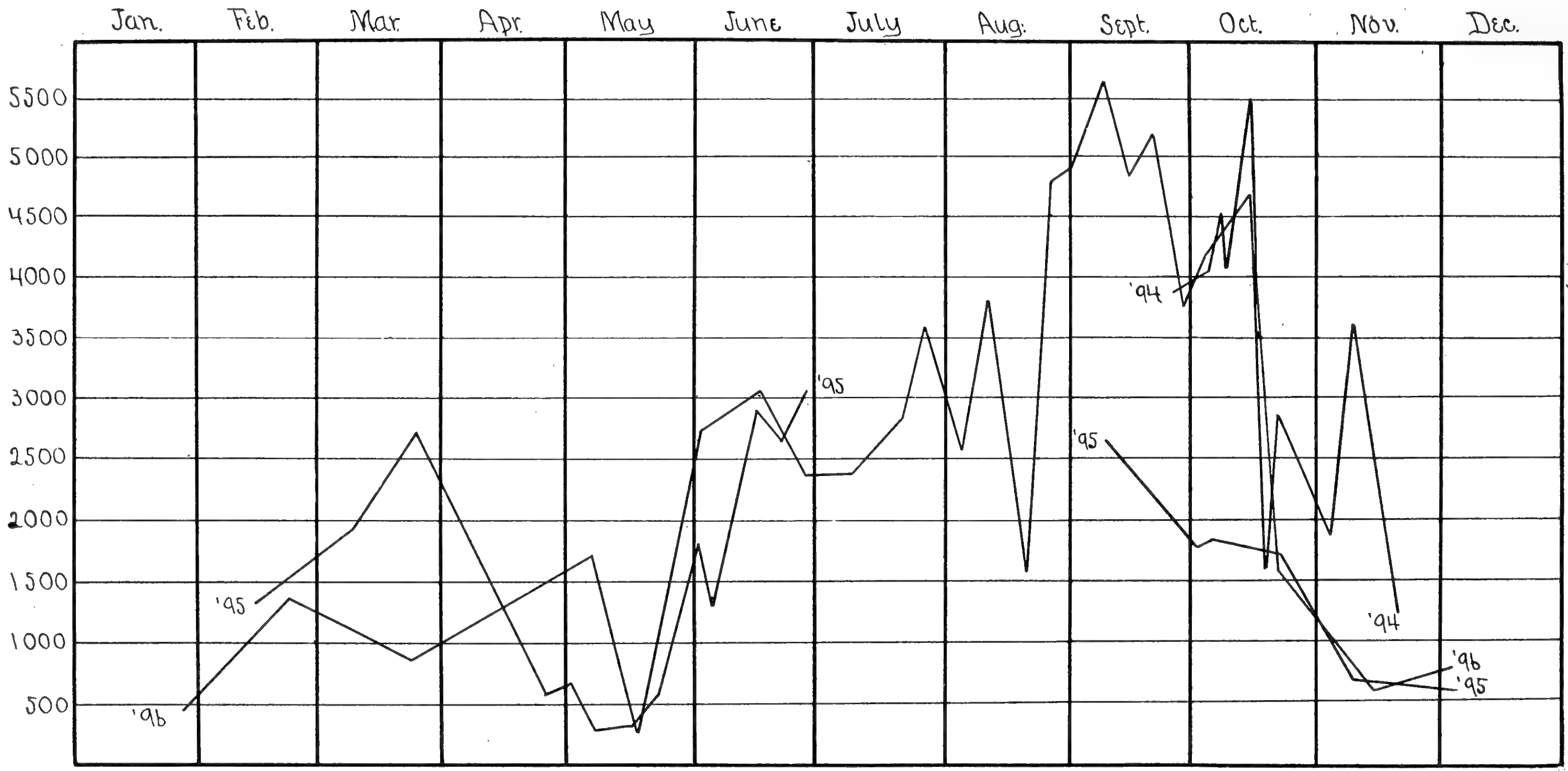
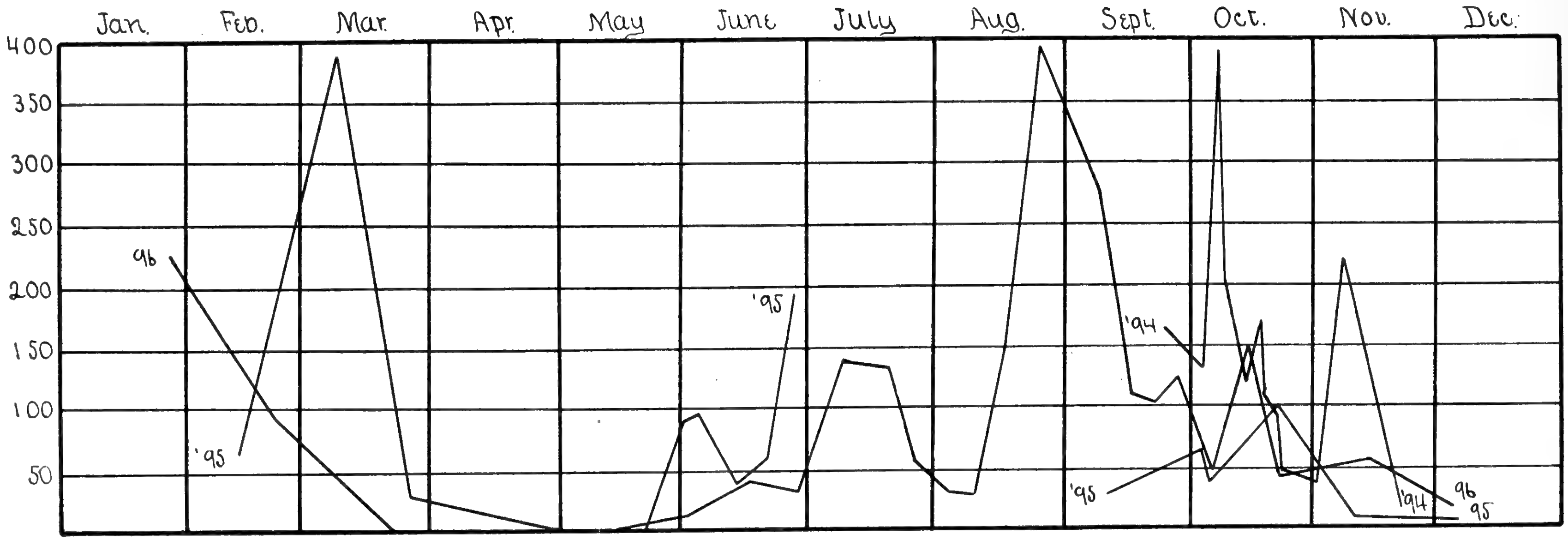
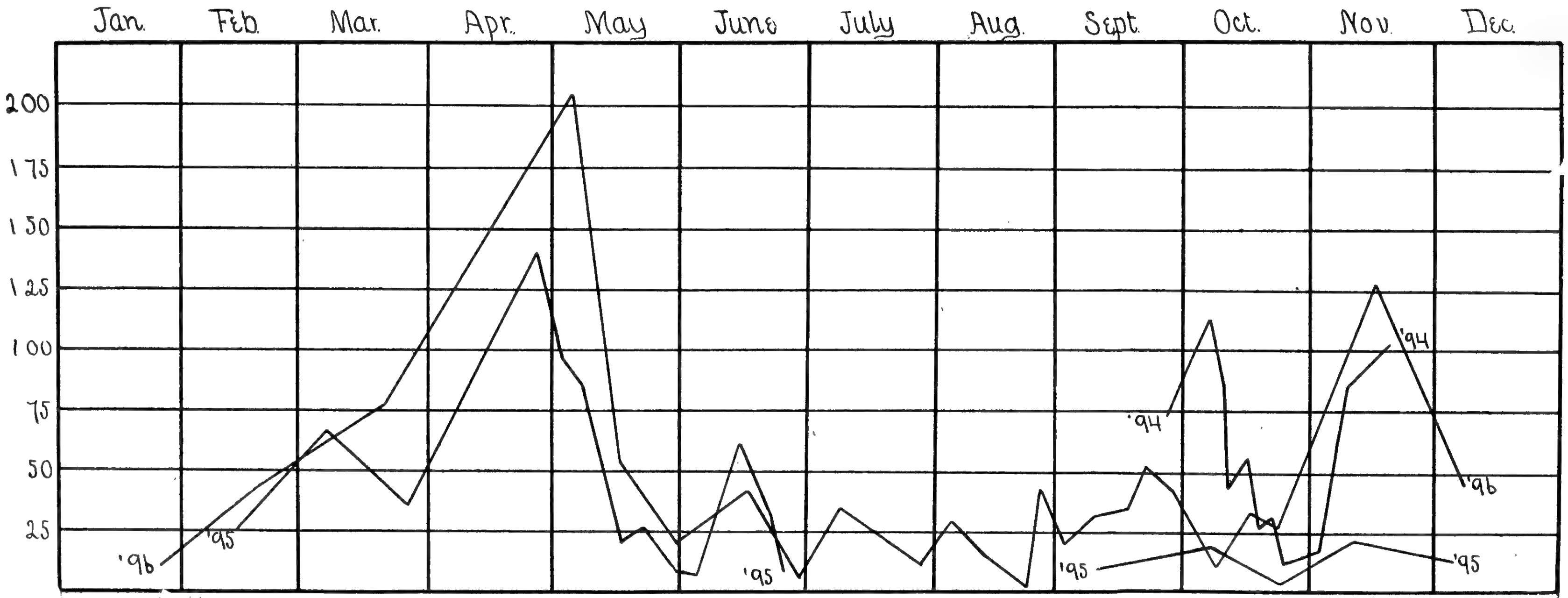


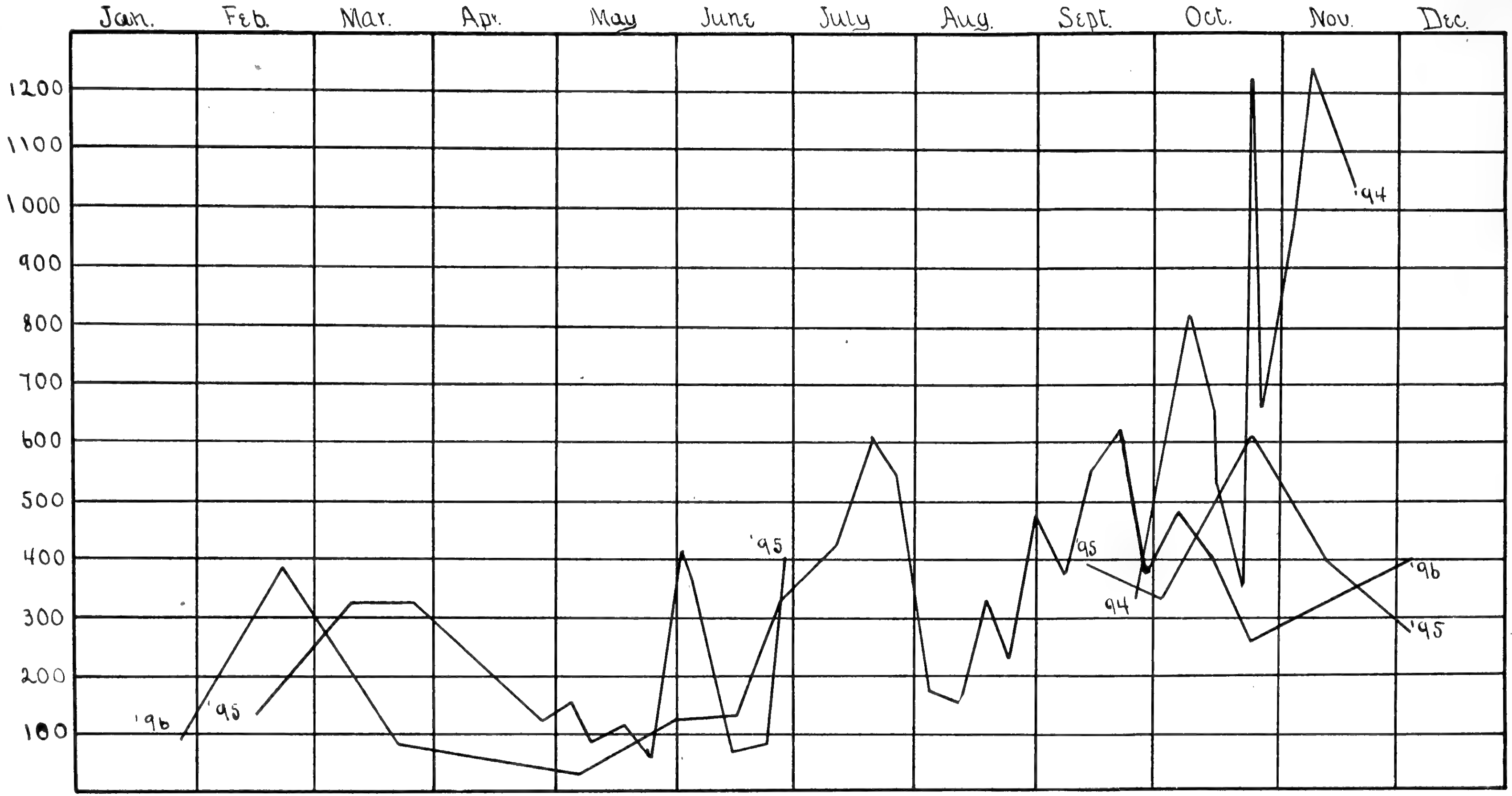
ANNUAL DISTRIBUTION OF DIAPTOMUS.



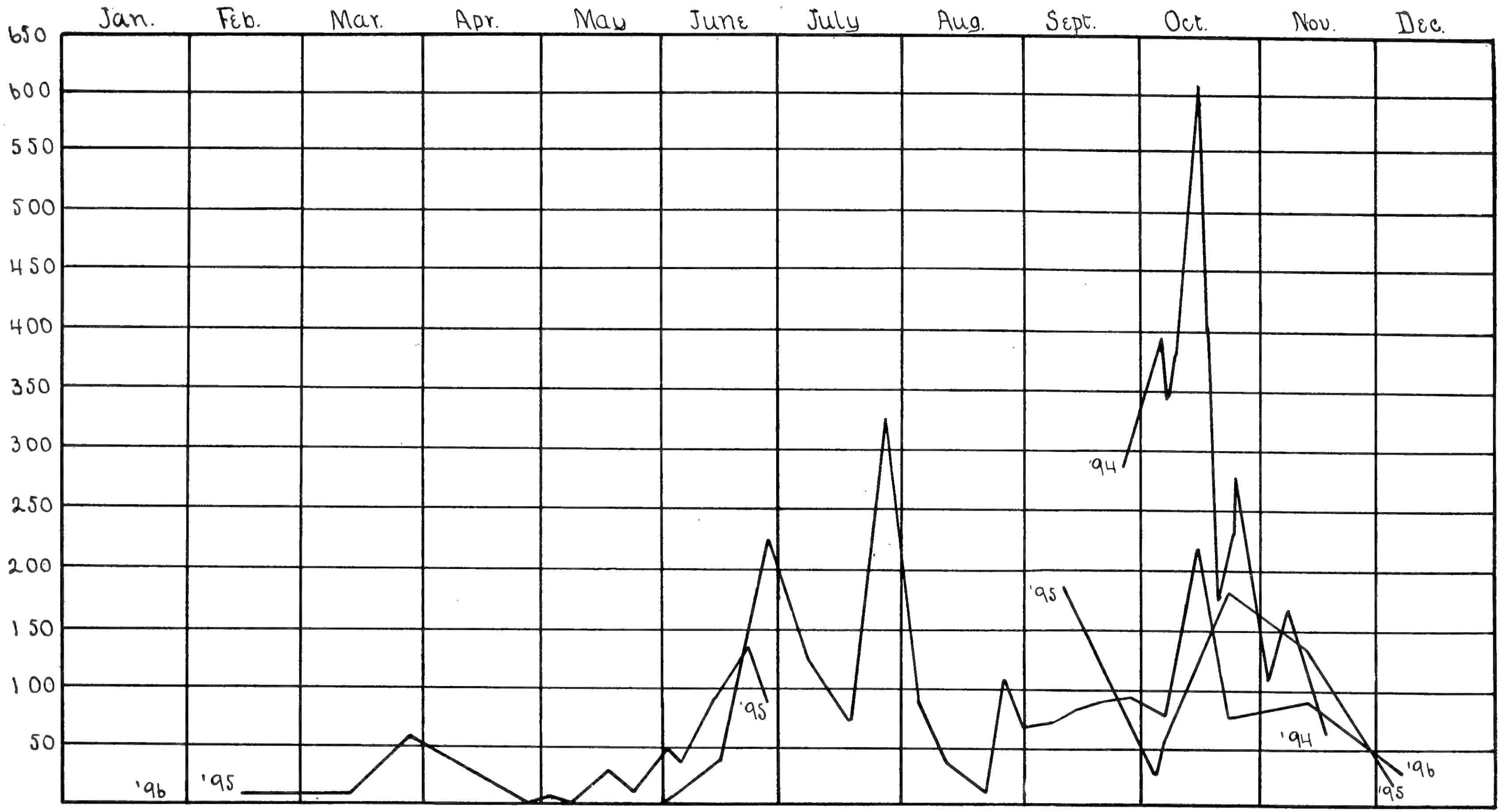
ANNUAL DISTRIBUTION OF EPISCHURA LACUSTRIS.



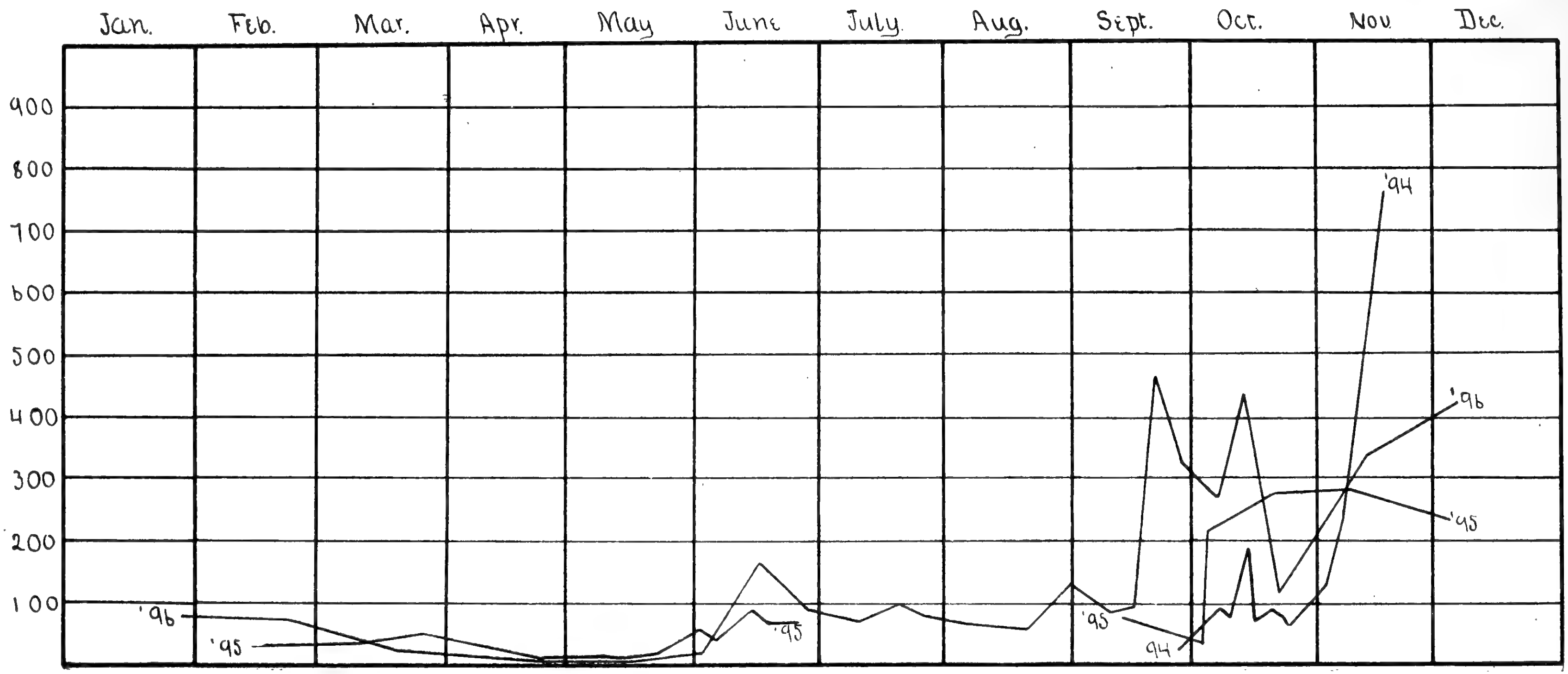
Annual Distribution of Limnocalanus Macrurus.



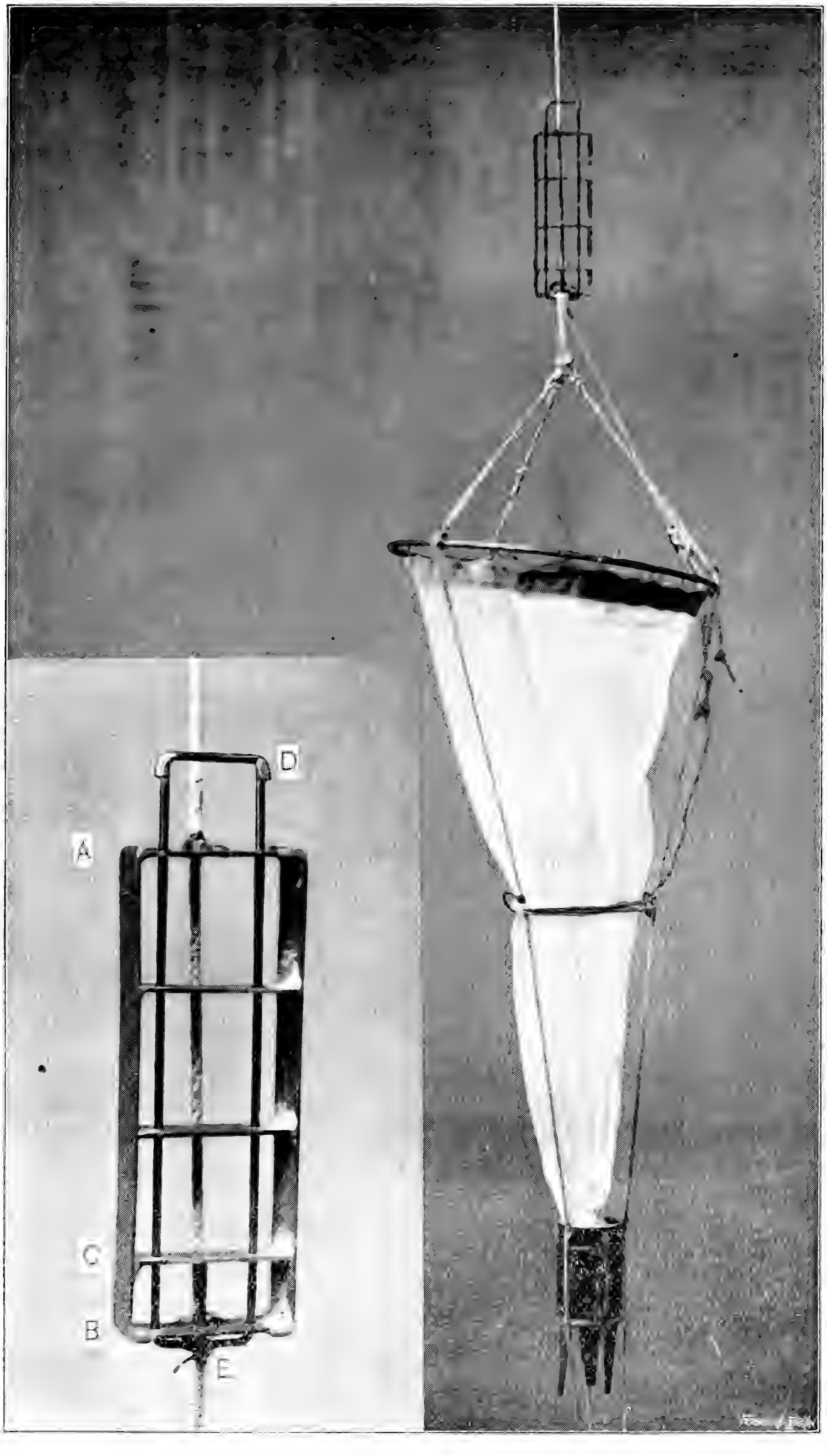
Annual Distribution of Cyclops Fluviatilis.



ANNUAL DISTRIBUTION OF DAPHNIA KAHLBERGIENSIS.



Annual Distribution of Bosmina.



CLOSING DREDGE AND RELEASING APPARATUS.

DREDGE AS MOUNTED FOR USE ON ICE.

Marsh, C. D. On the limnetic crustacea of Green Lake. (Trans. of the Wisconsin Acad. of sciences, Vol. XI, 1897, p. 179—224, Tab. V—XIV.)

Die vom Verfasser behandelten Resultate stützen sich auf eine mehrere Jahre umfassende Reihe von Untersuchungen (seit August 1893). In einer Beschreibung des Untersuchungsgebietes wird der Green Lake zu den Dinobryon-Seen gerechnet, „and yet I have never found Dinobryon in it". Verfasser schlägt für die nordamerikanischen Seen eine Eintheilung in tiefe (wenn über 40 *m* tief) und seichte Seen vor, und bemerkt, dass die Faunen dieser zwei Classen in ihrem allgemeinen Charakter sehr distinct seien. Für die seichten Seen sei wenigstens in den Sommermonaten das Vorkommen chlorophyllführender Algen charakteristisch.

Die folgenden Seiten bringen eine ausführliche Darstellung des vom Verfasser construirten Schliessnetzes, der Fang- und Zählmethode. Unter den untersuchten Thieren nimmt der schon durch seine Häufigkeit und seine von den übrigen Copepoden leicht unterscheidbare Körperform ausgezeichnete *Diaptomus* die erste Stelle ein. Während die in Europa untersuchten Seen meist immer nur eine Species zu beherbergen scheinen, fand Verfasser im Green Lake den *D. minutus* und *sicilis,* deren abwechselnde Häufigkeit („Während des September und October war *D. minutus* viel mehr häufig. Im September wurden von *D. sicilis* nur sehr wenige gefunden. Im October und November wuchs die relative Menge von *D. sicilis,* und in den Wintermonaten bestanden die Sammlungen fast ausschliesslich aus *D. sicilis.*") zur muthmasslichen Annahme eines Saisondimorphismus führte.

Die Diaptomiden wurden in allen Tiefen gefunden, doch in den tieferen Schichten nur in geringerer Anzahl. Verfasser findet weder in den verschiedenen Jahreszeiten,[1]) noch in den Tag- und Nachtfängen einen bedeutenden Unterschied (in Bezug auf die Quantität), so dass weder tägliche noch jährliche Wanderungen angenommen werden können.

Bei der Besprechung der übrigen Copepoden und der untersuchten pelagischen Cladoceren können wir uns kürzer fassen.

Epischura meidet helles Licht, zieht warmes Wasser vor und zeigt sowohl jahreszeitliche als auch tägliche Wanderungen.

Auch *Limnocalanus* meidet helles Licht und hohe Temperatur, weshalb seine täglichen verticalen Wanderungen im kalten Wasser ausgesprochener sind.

Cyclops brevispinosus ist sehr zahlreich zwischen 5 und 20 *m*. Tag- und Nachtfänge gaben für ihn keine augenfälligen Unterschiede.

Cyclops fluviatilis scheint keine täglichen verticalen Wanderungen zu unternehmen, doch konnte in Bezug auf sein Vorkommen in den verschiedenen Jahreszeiten eine Bevorzugung des wärmeren Wassers beobachtet werden.

Leptodora ist ein ausgesprochenes Oberflächenthier, doch konnte kein entscheidender Beweis, der für eine tägliche Wanderung sprechen würde, erbracht werden.

Bei *Daphnia Kahlbergiensis* wurde ein deutliches Aufsteigen gegen die oberflächlichen Wasserschichten zur Nachtzeit beobachtet.

Bosmina (Verfasser führt in dieser Arbeit leider nicht die Species an) zeigt in ihrem Vorkommen quantitativ keine merklichen Verschiedenheiten in den verschiedenen Jahreszeiten. Ihre nachweisbaren täglichen Migrationen dagegen werden durch *Phototaxis* erklärt.

Durch Meiden hellen Lichtes dagegen finden wiederum die täglichen Wanderungen der Daphnien ihre Erklärung.

Auf Grund dieser Thatsachen sieht sich Verfasser genöthigt, entgegen seiner ursprünglichen, vorgefassten Meinung von einer gleichmässigen Bewegung der Crustaceen in ihrer Gesammtheit, bei den einzelnen Genus, bezw. Species ein verschiedenes Verhalten anzunehmen, das für die einzelnen Formen wie für die einzelnen Localitäten von Fall zu Fall genau ermittelt sein will.

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[1]) Da, wie wir gesehen, zwei Species im See vorkommen, die, wie Verfasser selbst sagt, sich nicht gleich verhalten, sind diese Angaben nur ganz allgemein für das Genus verwerthbar und lassen Specialuntersuchungen an den einzelnen Arten um so wünschenswerther erscheinen.

Winde scheinen auf die Vertheilung der Entomostracen keinen merklichen Einfluss zu haben. Die oben hervorgehobenen Ergebnisse der Untersuchungen stehen in Uebereinstimmung mit den Beobachtungen Francé's und Birge's.

Ein Schlusscapitel endlich ist der horizontalen Vertheilung der limnetischen Crustaceen gewidmet. Nach einer übersichtlichen Zusammenstellung des gegenwärtigen Standes der Frage (Ansichten von Frič und Vávra, Imhof, Zacharias, Apstein, Reighard, Ward) kommt Verfasser auf Grund seiner Untersuchungen zu dem Resultate, dass die Crustaceen des Green Lake keine gleichmässige horizontale Verbreitung erkennen lassen.

Zum Schlusse seiner sehr interessanten Ausführungen gibt Verfasser der Hensen'schen Zählmethode vor der einfachen volumetrischen Messung den Vorzug und fordert zu möglichst genauen und durch lange Zeit fortgesetzten Untersuchungen auf, die allein im Stande sind, uns ein klares Bild von der Vertheilung der Organismen zu geben. Ad. Steuer.

W. A. Herdman, J. C. Thompson and **A. Scott.** On the plankton collected continuously during two traverses of the North Atlantic in the summer of 1897; with descriptions of new species of *Copepoda;* and an appendix on dredging in Puget Sound. (Trans. L'pool Biol. Soc., Vol. XII, Read Nov. 12the 1897. Pl V—VIII.)

Herdman benützte auf seiner Reise zum Sammeln des Plankton kein Netz, sondern verwendete die schon vor Jahren von Krämer[1]) im rothen Meere mit Erfolg in Anwendung gebrachte Pumpmethode, die ja überdies auch vor Kurzem von dem verstorbenen Frenzel für Süsswasser-Untersuchungen empfohlen wurde. Besonderes Interesse muss die nun auch von Herdman wieder hervorgehobene innige Beziehung der Strömungsverhältnisse zu der Vertheilung der Planktonorganismen erregen; Verfasser sagt p. 41 ungefähr: „Der Einfluss des Wechsels der Temperatur auf die Organismen war sehr bemerkbar, besonders im kalten Labradorstrom. . . . Hätten wir kein Thermometer gehabt und auch sonst unsere Position nicht bestimmen können, ich glaube, es wäre durch die mikroskopischen Planktonuntersuchungen allein möglich gewesen, Gewissheit zu erlangen, ob wir uns im Labradorstrom befunden hätten oder nicht."

Einem ausführlichen Verzeichnisse der einzelnen Fänge folgt eine Liste der von Thompson und Scott bestimmten Copepoden, unter denen sich auch drei neue Species finden, nämlich *Eurythemora herdmani, Corynura discaudata* und *Acartia forcipata.* Nicht unerwähnt darf bleiben, dass von dem bekannten, überall vorkommenden *Calanus finmarchicus* die grössten Exemplare im Labradorstrom gefunden wurden und dass diese Form im südlicheren Theile des North Atlantic von *C. propinquus* und *tonsus* vertreten zu werden scheint.

Endlich kommt Herdman auch auf das Capitel „Copepoden als Nahrungsmittel" zu sprechen. Er findet die Thiere, über deren Zubereitung schon vor Zeiten der Prinz von Monaco berichtet, äusserst schmackhaft und empfiehlt den Fang derselben bei Unglücksfällen auf See (Hungersnoth bei Schiffbruch).

Zum Schlusse bringt Herdman ein Verzeichniss der im Puget Sound (Pacific coast) gesammelten Thiere, unter denen *Pseudolichomolgus columbiae* (n. gen., n. spec.) für die Wissenschaft neu ist. Ad. Steuer.

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[1]) Ausserdem von J. Murray, wie Verfasser p. 82 anführt.