ON THE FRESH-WATER COPEPODA OF THE CENTRAL AND WESTERN UNITED STATES OF AMERICA.

By

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ON THE FRESH-WATER COPEPODA
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Introductory.

Our copepod fauna has as yet received little, except local, attention. Hoping to extend our knowledge of the order, especially in Illinois, I here present the results of my short study of these forms, with a few general introductory remarks.

Claus, Brady, Sars, Lilljeborg, De Guerne and Richard, and Vosseler, of Europe, with Forbes, Cragin, Say, and Herrick, of America, comprise the list of our most active recent workers on this part of our fauna. Some work has been done on the heterogenetic relationships of what are now called distinct species*, and when we consider the metamorphoses through which copepods pass before reaching maturity, the possibility of such relationships is evident. These metamorphoses and the close inter-gradation of related species cause great confusion. Marked variations are also known to be

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*Herrick, in Amer. Nat. Vol. VII., pp. 208, 381.

brought about by differences in the character of the habitat and through biological relationships. From the above causes most of the copepod synonymy has arisen.

So far as I can determine from my reading and observation, no mature Cyclops exists having swimming rami with only two segments. The individuals having such rami are usually found in that stage just preceding the adult, and may commonly be distinguished at a glance by the fluctuating character of their antennal segmentation, and the coagulated appearance of alcoholic specimens. Certain variations in the segmentation of the antennāe seem to be due to age and adaptation. Vosseler (13)* notes the finding of *Cyclops pulchellus* Koch at one time with scarcely any apparent antennal segmentation, at another, with antennāe of sixteen, seventeen, or even eighteen, segments. *Cyclops perarmatus* Cragin seems to have been described as a distinct species upon some such variation, as it primarily differs from *C. phaleratus* Koch in having 11-segmented antennāe. In a single collection, adult specimens of this form were found by me having both 10- and 11- segmented antennāe, which, it seems to me, ought to render untenable any specific distinctions on this basis alone.

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*This and similar parenthetical numbers in the text and in the list of synonyms indicate the published work referred to, its name being found against a corresponding number in the bibliographical index appended to this paper.

The occurrence of a "sense club" on the 12th antennal segment of some Cyclops having 17-segmented antennæ may be of considerable importance; but if this is a <u>sense</u> organ and only found in a comparatively few privileged species, the question arises, "Why are closely-related species deprived of it?" A circlet of short hairs on the basal segment of the antennæ also seems to be a distinguishing mark in some species of Cyclops, as, again, a ridge, either serrate, hooked, or plain, on one or more of the distal segments. (See Pl. III., Fig. 15,and Pl. V., Fig. 27.)

Biological.

The genus Cyclops is found in nearly all parts of the world, the temporary pool as well as the permanent body of water afford- it a suitable breeding place. Standing or slowly running water seems to suit these crustaceans best. In ponds especially, they thrive to perfection, where they often grow to three or four times their ordinary size in other waters. In an examination of material by me from ponds near Normal, Illinois, <u>Cyclops insectus</u> Forbes was found varying in length from 1 mm. to 3.5 mm.

Deeper and larger bodies of water commonly afford smaller, more slender, and semi-transparent copepods, this variation being

probably due to the greater territory necessarily covered by them in seeking a food supply and their need of protection from their enemies. Cyclops thomasi Forbes and Diaptomus sicilis Forbes are both preeminently deep-water forms, and are cases in point. Epischura was found in permanent bodies of water, while Osphranticum and Canthocamptus seem to inhabit the shallower, or less stable, pools and ponds.

The food of the Copepoda is mainly composed of plant and animals remains, protozoans, and parts of the leaves of water plants picked up from the bottom or from rocks.

Copepods are nearly always found in association with the Ostracoda, Cladocera, and Hydrachnidāe, and are an important element in the food supply of most of our fresh-water fishes. Living, as they do, in the shallower and weedier tracts, they are at once available for the fry of such fishes as make these places their breeding grounds, as do most of our fresh-water species.

The organic relationships of the Copepoda, both near and remote, are indeed very complex, and afford the student of biology a very fruitful subject for practical investigation.* Their func-

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*For a brief discussion of this question see an article by Professor Forbes entitled " The Lake as a Microcosm," p. 87 Bull. Scientific Ass'n Peoria, Ill., or p. 11 Separate.

tion in the aquatic balance of organic life is an important one, as has been demonstrated by Professor Forbes in investigations on the food of some of our most important food fishes.*

The essentials to a thorough study of this important order, either systematic or biological, are a variety of collections covering a wide range of territory; and the time, opportunity, and surroundings favorable to extended work.

Systematic.

Though little attention has been bestowed upon the distribution, relative abundance, and economic importance of the Copepoda, yet in the systematic line,as well as in economic and philosophic questions pertaining to this order,Professor Forbes has opened up a wide field of investigation, with valuable results, while Cragin and Herrick have added to our knowledge of the Copepoda of the Mississippi Valley, Massachusetts, and Alabama.

In 1886, Professor L. M. Underwood published a "List of the Described Species of Fresh-Water Crustacea from America, North of Mexico." At that time the Copepoda had been studied only in the eastern United States (Massachusetts), the Mississippi Valley, and

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*"The First Food of the Common Whitefish." Bull. Ill. State Lab. Nat. Hist., Vol. I., No. 6, p. 95.

a few scattered localities. The following list is a reproduction of the table of the distribution of copepod species in the United States and the Great Lakes as known in 1886 and given by Mr. Underwood, to which I have added in a parallel column the number of species now known to occur in the same localities, so far as I have been able to ascertain.

Locality.	1886.	1893.
Alabama	7	7
California	1	6
Colorado	1	1
Connecticut	1	1
Illinois	6	21
Indiana	1	2
Kentucky	4	4
Louisiana	3	3
Maine	1	1
Massachusetts	11	11
Michigan	4	4
Minnesota	24	27
Montana	0	2
New York	4	4
Ohio	1	1
Wyoming	0	6
Washington	1	1
Wisconsin	1	8
Lake Superior	2	10
Lake Michigan	4	6
Lake Erie	1	1
Lake Ontario	1	1
Lake Huron	0	0

In 1886, eight families, fourteen genera, and sixty species

were listed, including the parasitic forms. Deducting the latter there remain three families, seven genera, and forty species of the free-living forms, as follows:

I. FAMILY CALANIDAE.

(1) Genus *Diaptomus* Westw.

1. *D. armatus* Herrick.
2. *D. kentuckyensis* Chambers.
3. *D. leptopus* Forbes.
4. *D. longicornis* Herrick.
5. *D. minnetonka* Herrick.
6. *D. pallidus* Herrick.
7. *D. sanguineus* Forbes.
8. *D. sicilis* Forbes.
9. *D. stagnalis* Forbes

(2) Genus *Epischura* Forbes.

1. *E. lacustris* Forbes.
2. *E. fluviatilis* Herrick.

(3) Genus *Limnocalanus* Sars.

1. *L. macrurus* Sars.

(4) Genus *Osphranticum* Forbes.

1. *O. labronectum* Forbes.

II. FAMILY CYCLOPIDAE.

(5) Genus *Cyclops* Müll.

1. *C. agilis* Koch.
2. *C. ater* Herrick.
3. *C. brevispinosus* Herrick.
4. *C. diaphanus* Fischer.
5. *C. elongatus* Claus.

6. C. fimbriatus Fischer.
7. C. fluviatilis Herrick.
8. C. insectus Forbes.
9. C. modestus Herrick.
10. C. navicularis Say.
11. C. navus Herrick.
12. C. oithonoides Sars.
13. C. parcus Herrick.
14. C. pectinatus Herrick.
15. C. phaleratus Koch.
16. C. pulchellus Koch.
17. C. serrulatus Fischer.
18. C. tenuicornis Claus.
19. C. thomasi Forbes.
20. C. uniangulatus Cragin.
21. C. viridis Fischer.
22. C. ingens Herrick.

III. FAMILY HARPACTIDAE.

(6) Genus Canthocamptus Westw.

1. C. cavernarum Packard.
2. C. illinoisensis Forbes.
3. C. minutus Baird.
4. C. minnesotensis Herrick.
5. C. northumbricus Brady var. americanus Herr.

(7) Genus Tachidius Lillj.

1. T. fonticola Chambers.

Many of the above species have never been found or identified since first described, while others are known to be but synonyms.

All of the above genera are represented in Illinois with the exception of Tachidius, which has as yet been recorded only from Kentucky.* Of the twenty-one species of Cyclops recorded, six have

*Jour. Cin. Soc. Nat. Hist., IV., p.47 (1881).

been found and identified by me,* the remainder not occurring in Illinois waters, as far as yet known. The greater number of the above species are reported and described by Herrick (10,12) as common to Minnesota, but most of them lack identification by others than the original describer. Judging, however, from the different forms to be found even in our wells, a great number of varieties are to be expected which grade into one another so closely as to be a puzzle to the systematist.

Little has been done in the way of a classification of species. Rehburg sought to classify his species of Cyclops under three groups, while Vosseler (13) thinks that a separation into two groups at least is justifiable. The first of his groups includes all Cyclops having three setae or spines on the apical segment of the feet of the fifth pair, while the second group includes all having two setae or spines on this segment. This classification, with some necessary revision, has been essentially adopted by me, and appears in the key at the conclusion of this paper (p.52).

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*See Table of Geographic Distribution, p. 48.

FAMILY CYCLOPIDAE.

Cyclops sp.(1). (Pl. I.,Figs. 1—6.)

A small species, but 1.15 mm. long, with 17-jointed antennae, which, extended, barely reach to the second cephalothoracic segment.

The first cephalothoracic segment as broad as long (.35 mm.), equaling the following four segments, which rapidly taper as a series to unite with the abdomen. First abdominal segment much dilated or tumid anteriorly, tapering posteriorly, and equaling the three following segments, these being subequal and serrate posteriorly, the last segment shortest, and the serrations having the character of spinules. Caudal rami slender, five times as long as wide, and more than equal to the preceding two and a half abdominal segments. Each ramus with a stout, broad, knife-like spine at at the outer distal angle about one third as long as the ramus; a small slender seta at the inner angle slightly longer (one sixth the length of the third from within), which for half its length is stout and bare, with nearly parallel sides, the remainder tapering gradually and finely plumose; second seta from within of the same character, except that it is as long as the abdomen and furca, and sparsely setose along the inner margin of the basal half.

Antennae, short, rather stout, and well supplied with long setae. As with many other species with 17-jointed antennae, this one has a lanceolate, spine-like "sense club," or modified bristle, besides the ordinary bristle at the outer apical angle of the twelfth antennal segment. All the joints of the antennae are short and thick, the last three joints equaling the preceding seven. Antennules stout and reaching half the length of the antennae. Labrum with ten teeth.

The armatures of the apical segments of the outer and inner rami of the thoracic legs are as follows:

First Pair.

Outer ramus.	Inner ramus.
Ex.,three spines (one apparently at tip).	Ex.,one seta.
Ap.,two setae (Fig.6).	Ap.,one seta, one spine (stout).
In.,two setae.	In.,three setae.

Second Pair.

Outer ramus.	Inner ramus.
Ex.,three spines.	Ex.,one seta.
Ap.,one spine, one seta.	Ap.,one seta, one spine (stout).
In.,three setae.	In.,three setae.

Third Pair.

Outer ramus.	Inner ramus.
Ex.,three spines (one apparently at tip).	Ex.,one spine (broad, stout).
Ap.,one spine (long, stout), one seta.	Ap.,two spines (broad,equal).
In.,three setae.	In.,three setae.

Fourth Pair.

Outer ramus.	Inner ramus.
Ex.,three spines (one apparently at tip).	Ex.,one spine.
Ap.,one spine (long), one seta.	Ap.,two spines (equal).
In.,three setae (short).	In.,two setae (slender,short).

The apical segments of both rami of the second, third, and fourth pairs are as long as the remaining two segments; the spines are unusually stout, wide, and coarsely serrated, while the setae are, on the contrary, slender and short.

Feet of the fifth pair jointed; apical joint about a third as wide as the basal and nearly as long; basal joint bearing a short slender seta at its outer distal angle, and the apical with a short lanceolate spine at its inner distal angle and a short slender seta (as long as the preceding one) at its outer. (Fig.4.)

This species is quite readily distinguishable by the peculiar

form of the caudal setae, the broad coarse spines of the thoracic legs, and the short antennae.

Described from several specimens collected in July, 1891, along the shores of Lake Minnetonka, Minnesota, among rushes and lily pads. (Mr. H. S. Brode collector.)

Cyclops sp.(2). brevis [illegible] (Pl. II., Figs. 7—12.)

This species is rather slender in all its details, with 17-segmented antennae which reach scarcely to the third cephalothoracic segment.

Length, exclusive of caudal setae, 1.3 mm.

First cephalothoracic segment very long, one fourth longer than the remaining segments of the cephalothorax; the following three subequal, tapering to unite with the narrow abdomen. First abdominal segment equaling the following three, with the anterior half tumid in the female; the last segment about two thirds the length of the preceding, narrow, and armed with a row of spinules posteriorly.

The caudal rami are narrow, parallel, in width one seventh of their length, and equaling the preceding two and one fourth segments. The inner terminal bristle slender, five sixths the length of the ramus, and one and two thirds the length of the outer bris-

tle, which is somewhat stouter, and one fifth the length of the third from within, which is two thirds the length of the second from within. All are slender and weakly pinnate.

Antennae rather elongate, the third and sixth joints equal, the last two equal, each twice as long as the fifteenth, while all three fully equal the preceding seven segments. There are no special marks of distinction on the antennae other than a "sense club" on the 12th segment. Antennules rather slender, with long bristles at the end. Labrum with twelve rather prominent teeth.

Apical segments of thoracic legs armed as follows:

First Pair.

Outer ramus.	Inner ramus.
Ex.,two spines (one spine at tip).	Ex.,one seta.
Ap.,two setae (slender).	Ap.,one seta, one spine (prominent).
Ex., two setae.	In., three setae.

Second Pair.

Outer ramus.	Inner ramus.
Ex.,two spines.	Ex.,one seta.
Ap.,one spine (long as segment), one seta.	Ap., one seta (inner angle), one spine (slender).
In., three setae.	In.,three setae.

Third Pair.

Same as second pair.

Fourth Pair.

Outer ramus.	Inner ramus.
Ex.,two spines.	Ex.,one seta.
Ap.,one spine, one seta.	Ap.,two spines (nearly equal).
In.,three setae.	In.,two setae.

Legs of the fifth pair jointed; basal joint, in width three times the length, with the outer apical angle slightly produced, and bearing a slender naked seta slightly over twice the length of the apical joint, which in width to length is as one to three, and bears two nearly equal plain setae, little longer than the preceding.

Closely related to species (4), but differing in the proportions of the abdominal segment, of the caudal setae, and in the proportionate lengths of the antennae, and in the absence of the transverse row of spines of the caudal rami, which is so characteristic of *thomasi*.

Described from several specimens received from Mr. Chas. C. Adams, which were collected from ponds near Bloomington, Ill.

Cyclops sp.(3). (Pl. III.,Fig. 13.)

A stout, robust species, with long narrow furcal rami and 17-jointed antennae which reach but to the second cephalothoracic segment. Total length, 2 mm. Cephalothorax, 1.05 mm. long and .7 mm. wide; abdomen, .4 mm. long, and furca .2 mm.—together more than equaling the longest bristles. Labrum with nine prominent teeth.

Antennae not distinguished by amy unusual proportions, but much resembling those of C. viridis Fischer, with the exception that the last three segments of viridis are equal to the five and a half preceding segments, while in my species (3) they equal the seven and a half preceding segments. The last antennal segment but one third as wide as long, and but a rudiment of the usual sense club on the twelfth segment. The basal joint is as long as the three and a half following, while the third is only about one third the length of the fourth, which is equal to the second and third together. Antennules slender, reaching to the tenth antennal segment.

Armatures of apical segments of thoracic legs as follows:

The apical segments of the outer ramus of the legs of the first pair nearly as broad as long, with two setae at tip, two spines without, and two setae within; the inner ramus with one spine and one seta at tip, one seta without, and three within.

The apical segments of the legs of the remaining pairs only about half as wide as long, while in C. viridis they average three fifths as wide as long.

Legs of the second pair with one stout spine and one seta at the tip of the apical segment of the outer ramus, three stout spines without, and three setae within; inner ramus like that of the preceding pair.

Outer ramus of the legs of the third pair like that of the second; inner ramus with two spines at tip of the distal segment, one spine without, and three setae within.

Outer ramus of legs of the fourth pair like outer rami of the two preceding pairs, while the inner ramus has two spines at the tip of the apical segment, one spine without, and two setae within. (Pl. III.,Fig. 18.)

The second segment of the inner ramus of all the thoracic legs has two setae on the inner side, and all are unarmed on the outside. The emargination between the segments of the legs is very marked, the indentation amounting to about half the entire width of the segments.

Legs of the fifth pair jointed, the basal segment half as long as wide, the outer part lobed, and bearing at its tip a long seta. The apical segment is about as long as the preceding, in width to

length as two to four, and bearing on its outer side, near the tip, a short lanceolate spine, and at the tip a seta about as long as the first.

Abdomen slender; furcal rami long and slender, equaling the last three segments of the abdomen, parallel, and but one sixth as wide as long. (In _C_. _viridis_ they are one fourth as wide as long.) Inner terminal bristle slender, and one half the length of the ramus; outer terminal bristle coarse, spine-like, and about one sixth shorter than the inner one. The longest furcal bristle equals the abdomen with furca, and together they equal half the total length of the Cyclops, or, 1 mm. The posterior margin of the last abdominal segment with a row of spinules.

With the exception of species (1), this is the only Cyclops known to me having a spine as the outer armature of the inner ramus of the third and fourth pairs of legs.

Described from several specimens taken by Professor Forbes and party of assistants, under the auspices of the United States Commission of Fish and Fisheries, in Lake Winnebago, Wisconsin, June, 1892, where it is everywhere common in association with _C_. _edax_ Forbes.

Cyclops sp.(4). (Pl. IV.,Figs. 20—24.)

Length, 1.3 mm. Antennae 17-jointed, just reaching to the end of the first cephalothoracic segment.

The first cephalothoracic segment equals the following four segments, while the first abdominal, equals the following three segments in length, is moderately broadened anteriorly, and .18 mm. long. Abdomen (with furca), .5 mm. long and .1 mm. wide.

Each abdominal segment bordered posteriorly with a row of serrations, that of the last segment having the character of fine spinules; last segment two thirds as long as the preceding one. Caudal rami .1 mm long, and in width to length as three to eleven, equaling the last two abdominal segments, and bearing on their upper upper outer third two or three minute point-like spines, somewhat of the character of those on the caudal rami of C. thomasi. Ramal bristles short, slender, finely plumose, the inner bristle about as long as the ramus, two sevenths the length of the second from within, which is one and one third the length of the third from within, and proportionate to the outer as seven to one, the outer being about half the length of the ramus.

Antennal segments short, the last three equaling the preceding seven; sense club and seta at the posterior outer part of the twelfth segment; otherwise no special markings. Segments sixteen

and seventeen equal, fifteen,half as long as sixteen.

Apical segments of the thoracic legs armed as follows:

First Pair.

Outer ramus.	Inner ramus.
Ex.,two spines.	Ex.,one seta.
Ap., two setae.	Ap.,one seta, one spine.
In.,two setae	In.,three setae.

Second Pair.

Outer ramus.	Inner ramus
Ex.,two spines.	Ex.,one seta.
Ap.,one spine, one seta, (equal).	Ap.,one seta, one spine, (equal).
In.,three setae.	In.,three setae.

Third Pair.

Same as second pair.

Fourth Pair.

Outer ramus.	Inner ramus.
Ex.,two spines.	Ex.,one seta.
Ap.,one spine, one seta.	Ap.,one seta (spine-like),one spine, (equal).
In.,three setae.	In.,two setae.

The fourth legs thus differ from those of thomasi in having the apical spine and seta of the inner ramus equal, and in the proportionate widths of the apical segments of this pair, which in

thomasi is not more than a fifth as wide as long.

Feet of the fifth pair jointed; basal segment somewhat quadrate, half as long as wide, the outer distal angle being produced, and bearing a slender seta about four times as long as the segment; apical segment long, narrow, sides somewhat sinuate, length to breadth as four to one, the outer apical angle slightly produced and bearing a slender seta as long as the preceding, the inner angle bearing a setose seta, somewhat stouter but no longer.

Described from specimens taken from a temporary pond south of Urbana, Ill., Apr. 15, 1892.

[illegible]

Cyclops sp.(5). (Pl. V.,Figs. 25—30.)

A small, well-marked species, with seventeen- jointed antennae reaching just to the third cephalothoracic segment, the last segment with a ridge having a semi-lunar hook-like notch (Fig. 27), long, narrow abdomen, and slender caudal setae as well as setal armatures of the thoracic legs.

Length, exclusive of the caudal setae, 1.1 mm. Cephalothorax, .65 mm. long, .35 mm. wide; abdomen and furca, .45 mm.

Basal segment of the antennae equal to the following three segments; with no special markings and no circlet of hairs. Twelfth segment without a prominent seta or sense club. Segment fifteen

two thirds the length of sixteen, which is a fourth longer than the seventeenth, all three equaling the preceding seven.

Antennules nearly half the length of the antennae. Labrum with twelve teeth.

The armatures of the thoracic legs are remarkable for the width and prominence of the apical spines and the slenderness of the setae.

First Pair.

Outer ramus.	Inner ramus.
Ex.,two spines (slender).	Ex.,one seta.
Ap.,two setae.	Ap.,one seta, one spine (broad, coarse).
In.,two setae.	In.,three setae.

Second Pair.

Outer ramus.	Inner ramus.
Ex.,two spines (broad, one apparently at tip).	Ex.,one seta.
Ap.,one spine (long,broad), one seta (slender).	Ap.,one seta, one spine (long, coarse).
	In.,three setae.

Third Pair.

Same as second pair.

Fourth Pair.

Outer ramus.	Inner ramus.
Ex.,two spines (coarse).	Ex.,one seta.
Ap.,one spine (long,coarse), one seta (slender).	Ap.,two spines (inner half length of outer).
In.,three setae.	In., two setae (slender).

Feet of the fifth pair small and jointed, the basal segment five eights as long as wide, bearing a slender seta,four times as long as the segment, at the slightly produced outer angle; apical segment as long as the basal is wide, narrow,produced, and bearing a long slender seta, over four times as long as the apical segment, and a somewhat coarser setose seta, about the same length, at the middle inner side of the same segment. (Fig. 28.)

I know of no other species having the peculiar crescent-shaped hook on the last antennal segment, or with the fifth feet of such characteristic shape. The spines of the second, third, and fourth pairs of legs are also unusually coarse.

Described from several females taken by Mr. H. S. Brode from a pond,full of water lilies, rushes, and Anacharis, near Lake Harriet, Minnesota, July 13, 1891.

Cyclops edax Forbes. (Pl. VI.,Figs. 31--36; Pl. III.,Fig. 15).

1887. Cyclops edax Forbes, (15)[*], p. 709, pl.III.,fig. 15; pl.IV.,figs. 16—19.

A medium-sized species, with caudal setae well developed, 17-jointed antennae, reaching nearly to the fourth cephalothoracic segment, the last segment being characterized by a coarse serrate, or notched, ridge (Pl.III.,Fig.15). Setae on the outer distal

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[*] See foot-note, p. 2.

angles of segments one, four, and eleven long and stout, a long sense club besides seta on the twelfth segment, and a short blunt spine on the sixth segment; otherwise no special markings.

Basal segment of antennae long, equaling the following four segments, sixth slightly longer than the third, and the seventeenth slightly longer than the fifteenth and just equal to the sixteenth, all three equaling the preceding five and two thirds segments.

Total length, exclusive of caudal setae, 1.4 mm. Cephalothorax .83 mm.; abdomen .57 mm.

First cephalothoracic segment .35 mm. long and.4 mm. wide, equaling the three following segments, which are almost subequal, the middle one perhaps the longer.

First abdominal segment equals the following three segments; seven tenths as wide as long; the last segment the shortest, bordered posteriorly by a row of rather coarse spinules. Caudal rami somewhat divergent, rather short (equaling the preceding one and a half segments), the width about one third the length. All the caudal bristles well developed but short, the third from without, or longest, scarcely longer than the furca with the last three abdominal segments; the second from without eight ninths as long; the inner scarcely longer than the first abdominal segment; while the outer is to the inner as one to two.

Thoracic legs armed as follows:

First Pair.

Outer ramus.	Inner ramus
Ex.,two spines (one apparently at tip).	Ex.,one seta.
Ap.,two setae.	Ap.,one seta, one spine, (equal).
In.,two setae.	In.,three setae.

Second Pair.

Outer ramus.	Inner ramus.
Ex.,two spines (one apparently at tip).	Ex.,one seta.
Ap.,one spine, one seta, (both long).	Ap.,one seta, one spine (long as segment).
In.,three setae.	In.,three setae.

Third Pair.

Armed like the second.

Fourth Pair.

Outer ramus.	Inner ramus.
Ex.,two spines (one apparently at tip).	Ex.,one seta.
Ap.,one spine (long,narrow), one seta.	Ap.,two spines (inner two thirds length of outer.
In.,three setae.	In.,two setae.

Feet of the fifth pair jointed, the basal segment rather broader than long, bearing at the produced outer apical angle a short slender seta about six times as long as the segment; apical segment

as long as the basal but scarcely as broad, the outer apical angle being produced, and bearing a long, slender, plain seta three times as long as the preceding one, while the inner apical angle bears a plumose seta, longest of all. (Fig. 34.)

This species has seemingly a wide range of distribution in the United States.

Cyclops insectus Forbes. (Pl. VII., Figs. 37—42.)

1882. Cyclops insectus, Forbes, (9), p. 649.
1884. " " Herrick, (12), pp. 151—152, pl. U., fig. 9.
1886. " " Underwood, (14), p. 330.

A variable species, measuring (exclusive of caudal setae) from 1.1 mm. to 4 mm., the cephalothorax being to the abdomen as eleven to six.

First segment of the cephalothorax about equal to the three following segments. Last abdominal segment bordered posteriorly by a row of small spinules. Caudal rami four times as long as wide, fully equaling the last two segments of the abdomen. Outer caudal seta shortest, half the length of the ramus; the inner, a third longer than the outer; the third from within four times the length of the inner, and three fourths the length of the longest.

Antennae seventeen-jointed, reaching to the middle of the second cephalothoracic segment. No circlet of hairs; sense club and

seta on the twelfth segment. No unusual proportions of antennal segments.

Thoracic legs armed as follows:

First Pair.

Outer ramus.	Inner ramus.
Ex.,two spines.	Ex.,one seta.
Ap.,one spine, two setae.	Ap.,one seta, one spine (coarse).
In.,two setae.	In.,three setae.

Second Pair.

Outer ramus.	Inner ramus.
Ex.,three spines.	Ex.,one seta.
Ap.,one spine, one seta.	Ap.,one seta, one spine.
In.,three setae.	In.,three setae.

Third Pair.

Armed like the second.

Fourth Pair.

Outer ramus.	Inner ramus.
Ex.,three spines.	Ex.,one seta.
Ap.,one spine, one seta.	Ap.,two spines (inner smaller).
In.,three setae.	In.,two setae.

Fourth pair of feet also characterized by a peculiar narrowing of the basal segment of the inner ramus. (Pl. VII.,Fig. 41.)

Feet of the fifth pair segmented, the apical segment spmewhat longer than the basal and half as wide, with one short spine half the length of the segment and one seta, six to seven times the length of the spine, at the tip. Outer distal angle of the basal segment produced, bearing a seta about the same length as the first.

The fifth feet resemble those of *C. thomasi* Forbes and *C. viridis* Fischer, except that the small spine is shorter than in *thomasi* and longer than in *viridis*. The two median caudal setae are also more nearly equal than in *thomasi*, resembling those of *viridis*; but the rami are much longer and more attenuated in *insectus*.

This is the most variable species yet found by me, ranging in length from 1 to 4 mm.

Abundant in ponds throughout central Illinois.

Cyclops gyrinus Forbes. (Pl.VIII.,Fig. 43; Pl. III.,Fig.19.)

1887. *Cyclops gyrinus*, Forbes,(15), p. 707, pl. II.,fig. 9; pl.III.,fig. 14.
1891. " " Forbes,(18), index.

A robust species, with 17-jointed antennae, the last three joints being characterized by a knife-like ridge, that of the last joint faintly serrate (Fig.43). Basal segment of antennae with a weak circlet of hairs; twelfth segment with sense club.

Each side of the fifth thoracic segment furnished with

three transverse rows of minute spinules, much less prominent than in *C. tenuicornis* Claus.

This species is closely related to *C. signatus* Koch, from which, however, it differs in the character of the antennal ridge, the absence of the fine teeth of the eighth, ninth, tenth, twelfth, thirteenth, and fourteenth segments of the antennae, and in the presence of a sense club. It differs from *C. tenuicornis* in not being so coarse in any of its details, in the character of the antennal ridge, in the different proportions of the last antennal joints, and in the lesser width of the second and third cephalothoracic segments.

Cyclops viridis Fischer. (Pl. IX.,Fig. 54.)

1820. *Monoculus quadricornis viridis*, Jurine,(1),p. 46, pl.III.,fig.1.
1851. *Cyclops viridis*, Fischer,(2),p. 412, pl.IX.,figs. 1—11.
1857. " *brevicornis*, Claus,(3),pl.III.,figs.12—17.
1878. " *gigas*, Brady,(8), p. 105,pl.XX.
1882. " *ingens*, Herrick(10), p. 228, pl.IV.,figs. 1—8.
1883. " *viridis*, Cragin,(11), p.3, pl.IV.,figs.8—16.
1884. " " Herrick,(12), p. 145.
1886. " " Vosseler,(13), p. 190, pl. IV., figs. 11—14.
1886. " " Underwood,(14), p. 332,
1891. " " Brady,(17), p.17, pl. V.,figs.6—10.

A widely distributed species, with stout, short, 17-jointed

antennae, reaching barely to the end of the first cephalothoracic segment. Total length 1.8 mm. Longest seta.8 mm.; furca .1 mm. Cephalothorax just twice as long as the abdomen. Specimens found at Quincy varied somewhat, reaching nearly twice the above measurements, which represent average specimens.

Abdomen narrow, one fifth the width of the cephalothorax at its widest part; the last segment with serrulations.

Basal segment of antennae longest, the sixth slightly longer than the third, thirteenth and fourteenth of the same length as the eighth, twelfth a little longer, the last three somewhat longer still and not much attenuated, equaling the preceding five and a half segments. Setae all rather short or blunt, sense club showing plainly its setose origin by modification. Antennules much developed.

Thoracic legs armed as follows:

First Pair.

Outer ramus.	Inner ramus.
Ex.,three spines.	Ex.,one seta.
Ap.,two setae.	Ap.,one seta, one spine (large).
In.,two setae.	In.,three setae.

Second Pair.

Outer ramus.	Inner ramus.
Ex.,three spines.	Ex.,one seta.
Ap.,one spine, one seta.	Ap.,one seta, one spine.
In.,three setae.	In., three setae.

Third Pair.

Armed like the second.

Fourth Pair.

Outer ramus.	Inner ramus.
Ex.,three spines.	Ex.,one seta.
Ap., one spine, one seta.	Ap.,two spines (outer the shorter).
In.,three setae.	In., two setae.

Feet of the fifth pair bi-articulate. Basal segment broad, in length about half its width, with a long seta at its outer produced angle; apical segment small, about as wide as long, with one long seta (six times as long as the segment and somewhat longer than the preceding seta) and a minute spine at the inner apical angle about half as long as the segment.

This species is well characterizes by its short, thick antennae, the last three segments of which never equal more than the preceding five and a half segments. Owing to the prominent characters of insectus and my species (3), viridis is not easily confounded

with them.

Cyclops signatus Koch. (Pl. III., Fig. 16.)

1820. *Monoculus quadricornis albidus*, Jurine, (1), p. 44, pl.II., figs. 10,11.
1857. *Cyclops coronatus*, Claus, (4), p. 29, pl.II., figs. 1—11.
1863. " " , Claus, (5), p. 97, pl.II., fig. 16; pl. X., fig. 1.
1874. " *clausii*, Poggenpol, (6), p. 70, pl. XV., figs. 4—14.
1878. " *signatus*, Brady, (8), p. 100, pl. XVII., figs. 4—12.
1883. " " var. *fasciacornis*, Cragin, (11), p. 3, pl.II., figs. 1—14.
1886. " " Vosseler, (13), p. 189, pl. IV., figs. 1—5.
1891. " " Brady, (17), p. 6, pl. II., fig. 5.

This species is closely related to *gyrinus* and *tenuicornis*, occupying a median position with regard to them, *tenuicornis* being the grosser in all its details. The most prominent characteristics of *signatus* are the rows of the teeth on the distal borders of segments eight, nine, ten, twelve, thirteen, and fourteen of the first antennae. (Pl. III., Fig. 16.)

Circlet of hairs on basal antennal joint small, faintly perceptible; serrated ridge on last segment coarser than in *gyrinus*, and serrate on the proximal half of the segment, instead of the distal as in *gyrinus*. No sense club on twelfth segment. Like *tenuicornis*, this species has the three transverse rows of minute spinules on either side of the fifth thoracic segment. Antennules

with third segment twice as long as the second, which is three fourths as wide as long.

This is one of the most widely distributed species of the genus in Europe. Found by me only in collections made from Cedar Lake, in northern Illinois, under the direction of Professor S. A. Forbes, of the Illinois State Laboratory of Natural History.

Cyclops tenuicornis Claus. (Pl. III.,Figs. 17, 18.)

1820. Monoculus quadricornis fuscus, Jurine,(1), p. 47, pl. III.,figs. 2—4.

1857. Cyclops tenuicornis, Claus,(3), p.31, pl. III., figs. 1—11.
1863. " " Claus,(5), p. 99, pl. I.,fig.3; pl.II.,fig.17;pl. IV., fig. 5.

1875. " clausii, Poggenpol,(6), p.70, pl. XV.,figs. 4—11.

1878. " tenuicornis, Brady,(8), p.102, pl. XVIII., figs. 1—10.

1883. " " Cragin,(11), p.3, pl.,II.,figs. 1—14.
1884. " " Herrick,(12),p.102,pl.R.,fig. 17.
1886. " " Vosseler,(13), p. 189, pl. IV., figs. 6—10.
1886. " " Underwood,(14), p. 331.
1891. " signatus,Brady,(17), p. 6, pl. II.,fig. 5.

First cephalothoracic segment narrow anteriorly, and nearly twice as wide posteriorly; in length equal to the three following

segments and abdomen, exclusive of caudal rami. Gross in all its details, but resembling *gyrinus* and *signatus* in armatures of thoracic legs and the three transverse rows of fine spinules on the fifth body segment (Fig. 17).

Circlet of hairs on basal joint of antennae prominent. The last three antennal segments much elongated, with a ridge, not serrate nor as prominent as in either *gyrinus* or *signatus*. A prominent sense seta on the twelfth segment. The second and third segments of the antennules are almost equal in length, or nearly half as wide as long.

Abundant in England,and Europe generally ; found by Cragin at Cambridge, Massachusetts; and by me in a collection received from Mr, Chas. C. Adams, of Bloomington, Illinois.

Cyclops *thomasi* Forbes. (Pl. XIX.,Figs. 55,56.)

1882.	*Cyclops*	*thomasi*,	Forbes,(9), p. 649, pl. IX., figs. 10, 11—16.
1882.	"	"	Cragin,(11), p. 68, pl. III., figs. 1—13.
1884	"	"	Herrick,(12), p. 151, pl.U., figs. 4, 5, 7, 8.
1886.	"	"	Underwood,(14), p. 332.
1887.	"	"	Forbes,(16), p. 707, pl. II.,fig. 8.
1891.	"	"	Brady,(17), p. 15, pl. VI.,figs.1—4.
1891.	"	"	Forbes,(18), p. 249, pls. XXXIX.,XL.

A widely distributed species, for full description of which see Forbes,(18), p. 249.

Cyclops phaleratus Koch. (Pl. IX.,Figs. 61—64.)

1851.	*Cyclops*	*canthocarpoides*	Fischer,(2), p. 426, pl. X., figs. 24, 25, 32—38.
1857.	"	"	Claus,(3), p. 37, pl. I., figs. 6—10.
1863.	"	"	Claus,(5), p. 102, pl. IV., figs. 1—4.
1878.	"	"	Brady,(8), p.105, pl. XX.
1882.	"	*adolescens*,	Herrick,(10), p. 231, pl. VI., figs. 16—20.
1883.	"	*perarmatus*,	Cragin,(11), p. 7, pl. I. figs. 9—18.
1884.	"	*phaleratus*,	Herrick,(12), p. 161, pl. R., figs. 6—10.
1886.	"	"	Underwood,(14), p. 331.
1891.	"	"	Brady,(17), p. 25.

A medium-sized species, with the first cephalothoracic segment broad, and equaling the four and a half segments following. Length, exclusive of caudal setae, 1.3 mm.

Antennae 11-segmented, reaching to the middle of the first cephalothoracic segment, the basal joint equaling the next two segments, the third as long as the fourth and fifth, the fifth half the length of the sixth, the eighth, ninth, and tenth somewhat oval in outline, the eleventh narrow, bearing one very prominent seta (about three times the length of the segment) and four or five smaller ones. Labrum eight- toothed.

Apical segment of the legs of the first pair somewhat longer than broad, bearing apically two setae, the outer small, slender,

spine-like, three spines without and three setae within. Besides the usual armature, there is a fringe of spinules along the outer edge of each ramus. Apical segment of the inner ramus with one stout spine and two large setae at tip, a row of small spinules, and one seta without and two setae within. A somewhat remarkable lobe-like process at the inner base of the inner ramus, the inner edge setose, the outer somewhat thickened, crest-like.

The second and third pairs of feet agree with the first, except that the apical segment of the inner ramus has one extra seta within, and that the apical spine of the outer ramus is large.

Apical segment of the outer ramus of the fourth pair bears one spine and two setae at tip, two spines and a few small spinules without, and two setae within. Apical segment of the inner ramus tipped with one remarkably long spine, and another about half as long; one seta and a row of small spinules without, and two setae within.

Feet of the fifth pair mere simple flange-like processes bearing three subequal spines, the outer of which is roughly plumose, its inner, plain (Fig. 61). A ridge of tooth-like processes extends from side to side, uniting the feet.

Abdomen fully half as wide as long, tapering gradually, the last segment about a third the length of the preceding, with a row

of large spinules posteriorly. Rami of the same proportions, as long as the last two abdominal segments, armed with small spinules besides the usual caudal setae. The inner terminal caudal seta very short and slender; the outer spine-like, about the same length as the ramus; the second from within fully twice the length of the abdomen, plain at the base, and more sparsely spino-plumose on its inner than outer edge; the third from within one third the length of the second, spinose on the outer, cilio-spinose on the inner, edge.

This species was found only in shallow water among rushes and lily pads in the southwest cove of Cedar Lake, in northern Illinois.

Cyclops serrulatus Fischer. (Pl. IX.,Figs. 57, 58; Pl. III.,Fig.14

1851.	*Cyclops*	*serrulatus*,	Fischer,(2), p. 423, pl. X., figs. 22, 23, 26—31.
1857.	"	"	Claus,(3), p. 36, figs. 1—3.
1863.	"	"	Claus,(4), p. 101, pl. I., figs. 1, 2; pl.IV.,fig.12;pl.XI.fig3.
1878.	"	"	Brady,(8), p. 109, pl. XXII., figs. 1—14.
1883.	"	*pectinifer*,	Cragin,(11), p. 6, pl. IV.,figs. 1—7.
1884.	"	*serrulatus*,	Herrick,(12), p. 157, pl. O., figs. 17—19.
1886.	"	*agilis*,	Vosseler,(13), p. 190, pl. V.,figs. 29—31.
1886.	"	*serrulatus*,	Underwood,(14), p. 331.
1891.	"	"	Brady,(17), p. 18, pl. VII., fig. 1.

Body slender, antennae 12-jointed, reaching to the middle of the third cephalothoracic segment; the last three joints very long and narrow.

The form described by Cragin as C. pectinifer found, but such a variable proportion of caudal setae obtain, that I consider it less a specific character than a mere variation of serrulatus. Awaiting, therefore, further developments, I have classed C. pectinifer Cragin under serrulatus.

Feet of the fifth pair consist of but a single joint, lobed or produced at the tip, and bearing one large spine and two setae.

Everywhere common in Europe and the United States.

Cyclops capilliferus Forbes. (Pl. X.,Figs. 65—69.)

1891. Cyclops capilliferus, Forbes,(18), p. 248, pl. XL., figs. 14—17.

A 16-jointed species, examined by me simply for comparison, and as yet only known to occur in Grebe Lake,Yellowstone National Park.

FAMILY CALANIDAE.

Diaptomus sicilis Forbes. (Pl. VIII., Fig. 45.)

1882. Diaptomus sicilis, Forbes,(9), p.541—645.
1884. " pallidus var. sicilis, Herrick,(12),p.137.
1886. " sicilis, Underwood,(14), p. 329.

1887. *Diaptomus sicilis*, Forbes,(16), p. 702, pl. I.,Fig.6.
1891. " " Forbes,(18), index.

Found abundant in every locality indicated in the table of distribution*; it is notably a fresh-water species.

A closely similar form was commonly found with it, which is probably the variety *imperfectus*.

Diaptomus oregonensis Lillj. (Pl. VIII., Fig. 47.)

1889. *Diaptomus oregonensis*, de Guerne & Richard,(16), pp. 53,54,pl.II.,fig.3;pl.III. fig. 8.

Collected only in Cedar Lake, in northern Illinois, where numbers were found with a few specimens of *D. sicilis*.

Diaptomus sanguineus Forbes. (Pl. IX., Figs. 59, 60.)

1876. *Diaptomus sanguineus*, Forbes,(7), p. 15, figs. 24, 28--30.
1882. " " Forbes,(9), p.647, pl.VIII., figs. 1—7, 13.
1884. " " Herrick,(12), p.138, pl.Q., fig. 12.
1889. " " de Guerne & Richard,(16),pp. 20,21, pl.IV.,fig. 24.

A medium-sized species, common to ponds throughout central Illinois; quite abundant in pond collections made at Normal and Urbana, Illinois.

*See p.48.

Diaptomus stagnalis Forbes. (Pl. XI., Fig. 73.)

1882. *Diaptomus stagnalis*, Forbes, (9), p. 645, pl. VIII., figs. 8, 10—12, 14.
1882. " *giganteus*, Herrick, (10), p. 222.
1884. " *stagnalis*, Herrick, (12), p. 139, pl. Q., figs. 11—13.
1886. " " Underwood, (14), p. 329.
1889 " " de Guerne & Richard, (16), p. 23, pl. IV., figs. 14—16.

With the exception of *D. shoshone* this is the largest Diaptomus known to me.

Abundant in collections made in April from pond south of Urbana, Illinois.

Diaptomus shoshone Forbes. (Pl. VIII., Figs. 52, 53.)

1891. *Diaptomus shoshone*, Forbes, (18), p. 251, pl. XLII., figs. 23—25.

Distinguished by its large size, and as yet found only in Lake Shoshone and adjacent lakes and pools of Yellowstone National Park.

Diaptomus lintoni Forbes. (Pl. VIII., Figs. 50, 51.)

1891. *Diaptomus lintoni*, Forbes, (18), p. 252, pl. XLII., figs. 26—28.

Closely related to *D. stagnalis*, but smaller and with larger antennae.

Like the previous species, *lintoni* has as yet been found

only in lakes and pools of Yellowstone Park.

Osphranticum labronectum Forbes. (Pl. VIII., Fig. 44.)

1882. *Osphranticum labronectum*, Forbes, (9), p. 645, pl. VIII., figs. 24—28, 29; pl. IX., figs. 1,2,4,5,7,9.
1884. " " Herrick, (12), pp. 134, 135, pl. Q., figs. 1—8.
1886. " " Underwood, (14), p. 329.
1889. " " de Guerne & Richard, (16), p. 97, pl. IV., figs. 1,2.

Found by me in collections made by Professor Forbes from ponds near Clifton, Ill., and in collections made by Mr. H. S. Brode from a ditch along the Havana branch of the Illinois Central Railroad near White Heath, Illinois, May 13, 1893.

Epischura lacustris Forbes. (Pl. VIII., Figs. 48,49.)

1882. *Epischura lacustris*, Forbes, (9), pp. 541, 648, pl. VIII., figs. 15, 16, 21, 23, 25, 27; pl. IX., fig. 8.
1884. " " Herrick, (12), p. 131, pl. Q., fig. 15.
1886. " " Underwood, (14), p. 329.
1889. " " de Guerne & Richard, (16), p. 90, pl. VII., figs. 3,9,10.

This species seems to have quite a wide distribution in the larger lakes of Illinois and Wisconsin, as may be seen by reference to my table of distribution on another page.

FAMILY HARPACTIDAE.

Canthocamptus illinoisensis Forbes. (Pl. VIII., Fig. 46; Pl. XI., Figs. 70--72.)

1876.	Canthocamptus illinoisensis,	Forbes,(7),p. 14, figs. 25,26,27,31.
1884.	" "	Herrick,(12), p. 170, pl. Q., figs. 1—5.
1886.	" "	Underwood,(14), p.332.

A small robust species, averaging 1.2 mm. in length.

Antennae of female 8-segmented, as long as the fused first and second cephalothoracic segments; process on the fourth segment bearing a sense club about as long as the following two segments, and three setae somewhat longer; the fifth segment the shortest, obliquely united to the preceding; the last segment somewhat longer than either the sixth or seventh, with a constriction near the end causing an appearance of segmentation; sixth segment bearing two setae near the middle of the segment.

Antennules with five long setae at tip, three of which are prehensile on account of cross articulations; the outer, longest, bristle with two short spinules on the bristle itself, near its middle. Flagellum on the middle of the basal joint, narrow, with two bristles at tip and two on its inner side.

Last three thoracic segments equaling the first two fused,the

posterior one the shortest. Segmentation line between the first and second abdominal segments indistinct, the two segments not quite as long as the following two, which are equal, and each nearly twice as long as the posterior segment. Each abdominal segment with two rows of coarse spinules slightly anterior to the sutures, the next to the last segment much produced over the last.

Caudal rami triangular to oval in shape, as wide as long, and two thirds the length of the preceding segment. Of the two terminal setae the inner is fully as long as the abdomen, sparsely spino-plumose; the outer, slender, half the length of the preceding, bare on the inner side, sparsely spino-plumose on the outer. Besides these there is a tuft of three short spines and one seta, three or four times as long, at the inner terminal angle; and two setae as long as the preceding seta, and two or three short spines, on the outer margin.

Legs of the first pair with both rami three-jointed, the inner ramus much elongated, its basal joint almost as long as the outer ramus, the second joint about half the length of the apical, which is scarcely half the length of the basal and very narrow; the apical segment tipped in both sexes with three setae, the outer having the character of a spine, the middle the longer, the inner as short as the segment, both the latter prehensile. Segments

of the outer ramus not much longer than broad, the apical segment with two spines and two prehensile setae at tip.

Besides the above armatures, all the leg segments bear small spinules, the number varying.

Legs of the second and third pairs differ in the same individual and in the sexes. Inner ramus of second pair of legs of female three-jointed, nearly the same length as the outer, while in males the inner ramus is only half the length of the outer , but has the same number of segments. Legs of the third pair, in males, with the inner ramus short, the basal and second segments almost aborted, the second segment with two prominent setae within, the apical sub-oval in outline, and about as long as the corresponding segment of the outer ramus.

Legs of the fourth pair not differing much in the sexes, the inner ramus two-jointed, half the length of the outer, the basal joint about a third the length of the apical, which is as long as the middle joint of the outer ramus, and has three setae within and one seta and one spine at the tip.

Rudimentary legs of the male smaller than those of the female, of two joints,the inner being but a plate-like process, in length to width as one to three, bearing three spines at tip, of which the inner is two and a half times the length of the segment, the others

shorter, the outer about as long as the segment. Outer joint short, almost oval, three spines at tip, the inner about as long as the ramus, while the middle one is stout and twice as long, one spine and three or more spinules without.

Basal joint of the rudimentary legs in the female broad, the outer basal part produced, bearing the second joint, in width to length as three to five, having apically six large plumose setae, of which the inner, or longer, just equals the joint in length. Second joint smaller, two thirds as long as the preceding, half as wide, oval, with two plumose setae at tip, one short bristle within and two without, and numbers of smaller spinules on each margin.

Common in ponds of central Illinois, and also found in a collection made from a small creek running into Lake Winnebago, Wisconsin, south of Oshkosh, by Professor Forbes and party of assistants under the auspices of the United States Fish Commission, June, 1892.

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TABLE OF GEOGRAPHIC DISTRIBUTION.*

NAMES OF SPECIES.	Cyclops edax.	" serrulatus.	" gyrinus,	" signatus.	" tenuicornis.	" phaleratus.	" insectus.	" species (1).	" species (2).	" species (3).	" species (4).	" species (5).	" thomasi.	" viridis.	" capilliferus.	*Diaptomus sicilis	" oregonensis.	" sanguineus.	" stagnalis.	" lintoni.	" shoshone.	Canthocamptus illinoisensis.	Epischura lacustris.	Osphranticum labronectum.
ILLINOIS.																								
Cedar Lake.	*	X		X		X	/									/	/							
Quincy.	*	/												X										
Chicago Br'kwater.								/					*			*							X	
Meredosia.	*	X																						
Fox Lake.		X			/			/								X								
Peoria Lake.	*													X										
Pekin.	X				/			/						X										
Bloomington.					X						X													
Normal.							*											*				*		
Beaver Dam Lake.	*																	/						
Champaign.		/	/				X		X									X	X			X		
Clifton.							*															X		X
Slough Pond.	X	/			/																			/
White Heath.	X	/											X					/				X		X
Lake Zurich.								/																
Sand Lake.	*	*			/			/								X								
Fourth Lake.	X															X								
WISCONSIN.																								
Lake Winnebago.	*	/								*												/	X	
" Geneva.													*			*							X	
" Delavan.	X												X										X	
" Michigan.													*											
" Mendota.	X															X							X	
MINNESOTA.																								
L. Minnetonka.	X	/						/								X								
Bass Lake.	/	/	/																					
Calhoun Lake.																	*							
Harriet Lake.		/	/					X				X												
INDIANA																								
Pine Lake.													/											
WYOMING.																								
Grebe Lake.															X									
Yellowstone Lake.		/	/										X			X					X			
Heart Lake.			X																					
Twin Lake.																				*				
Mary Lake.																				*				
Flathead River.			X																					
Goose Lake.		X																						

*I have not examined collections from all these localities for the remaining species.

*Of the signs used in this table the *= abundant, X= common, and /= few.

ARTIFICIAL KEY
TO THE FAMILIES OF THE FREE-LIVING COPEPODA.*

Order COPEPODA.

Body without bivalve carapace, first antennae commonly largest. Eye single and simple, or rarely paired and compound, in parasitic forms sometimes wanting. Thorax and abdomen commonly well distinguished. Crust not hardened, usually delicate and transparent. Four or five pairs thoracic legs (rarely wanting), these 2-branched, flattened for swimming, but without branchial appendages.

a. Females with one egg sac.

b. Males with but one antenna (the right, seldom the left), with hinge joint. Body elongate, abdomen much narrower than thorax; first antennae long, normally 24- or 25-jointed, second antennae large, commonly two-branched, accessory branch large, mandibular palpus usually two-branched, maxillipeds large and long, with marginal bristles. Five pairs of developed legs,

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*The key to the families is copied from that used in the zoological laboratory of the University of Illinois.

all 2-branched, with 3-jointed outer branches except the fifth pair, which are often not branched, and greatly modified in both male and female, but especially in the former, where they are commonly unlike on the two sides and form sexual grasping organs.

(CALANIDAE.)

c. Furca with but three large terminal bristles to each branch. Abdomen of the male unsymmetrical, provided with lateral prehensile apparatus; fifth pair of legs of the female not branched, 3-jointed, not terminating with a long spine. Epischura.

cc. Furca with four large terminal bristles to each branch.

d. The inner branch of the first pair of legs 2-jointed, the corresponding branch of the three other pairs 3-jointed. Fifth pair of legs of male and female 2-branched, internal branch rudimentary. Diaptomus.

dd. Both internal and external branches of all the first four pairs of legs 3-jointed. Fifth pair of legs of both sexes 2-branched, those of the female only differing from the other legs

by presence of a strong internal hook at the second joint of the outer branch, those of the male with the inner branch 3-jointed and provided with plumose hairs, as in the other legs.

e. Fifth pair of legs of the female with the inner hairs of the last joint of the outer branch transformed into short thick spines. Fifth pair of legs of the male with two joints to the outer branch of the left leg and three to the outer branch of the right. Osphranticum.

ee. Fifth pair of legs of the female with the internal hairs of the last joint of the outer branch long and plumose. Fifth pair of legs of the male with two joints to both outer branches. Limnocalanus.

bb. Both antennae of males with hinge-joint. Body cylindrical, abdomen but little narrower than thorax and not sharply distinguished fromit; antennae short, 4--10 jointed, scarcely longer than first somite, first four pairs of legs two-branched, fifth pair foliaceous; simi-

lar in the sexes, first pair usually unlike the others, and prehensile (Harpactidae), second antennae with developed accessory branch, body linear; first pair of legs prehensile and different from the others, both branches 3-jointed; mandibular palpus simple, 2-jointed, last maxilliped slender. Canthocamptus.

aa. Females with two egg sacs. Males with first antennae both prehensile, second antennae never prehensile, simple, 4-jointed, palpus of mandible and of maxilla rudimentary; fifth pair of legs rudimentary, alike in the sexes (Cyclopidae). Mandibular palpus in form of small tubercle, bearing two long bristles, thorax oval or ovate, much broader than abdomen, composed in male of ten segments, in female of nine. Cyclops.

ARTIFICIAL ANALYSIS OF THE SPECIES OF CYCLOPS MENTIONED IN THE PRESENT PAPER.

a. Legs of the fifth pair with three spines or setae on the apical segment; 1--2 segmented.

b. Legs of the fifth pair 2-segmented.

c. Furcal bristles all developed (longer than the furca). Antennae 17-jointed, reaching nearly to the fourth cephalothoracic segment. A circlet of hairs on

the basal antennal segment.

d. No sense club on the 12th antennal joint.

(e) Antennal segments 8,9,10,12,13,14 each provided with a crown of coarse serrations. The third segment of the antennules long.

signatus (p. 32).

dd. A sense club on the 12th antennal joint.

f. Distal antennal segment with a narrow plain ridge. Third joint of the antennules equal to the second joint. Circlet of hairs coarse. *Tenuicornis* (p.33).

ff. Distal antennal segment with a broad finely serrate ridge. Circlet of hairs sparse.

Gyrinus (p. 28).

bb. Legs of the fifth pair not segmented. (Represented only by a narrow plate-like process and three bristles in

Phaleratus. p. 35).

g. Only the two middle furcal bristles developed. The inner and outer shorter than the furca.

h. Antennae 12-segmented and as long as the cephalothorax; the last four segments attenuated.

i. Furcal rami slender, the outer margins with a row of spinules. m. ♀. - [illegible] m 3

j. The second furcal bristle from without more than half as long as the third.

Serrulatus (p. 37).

aa. Legs of the fifth pair segmented, the apical segment always with two shorter or longer bristles.

k. Both end-bristles of the same length; at least one approximately half the length of the other.

l. Furcal bristles all developed; at least the inner longer than the furca.

m. Antennae 17-segmented, shorter than the cephalothorax, with ridge on the last segment. No circlet of hairs on the basal segment.

n. Ridge with a semilunar notch or hook. No sense club on 12th segment.

le. [illegible]

Cyclops sp.(5)(p.21).

nn. Ridge with several hook-like notches. A sense club on 12th segment.

Edax (p. 23).

mm. Antennae 16-jointed. No ridge; no circlet of hairs.

Capilliferus (p.38).

ll. Only the two middle furcal bristles developed; the inner and outer shorter than the furca.

o. Antennae 17-jointed, shorter than the cephalothorax. No ridge; no circlet of hairs.

p. Antennae not longer than the first cephalothoracic segment. Cyclops sp.(4)(p.19).

pp. Antennae reaching to the third cephalothoracic segment. Cyclops sp.(2)(p.13).

ppp. Antennae reaching nearly to the (fourth) cephalothoracic segment. Rami with small patch of point-like teeth on their upper third. Thomasi (p.34).

kk. One end-bristle reduced to a short rudiment.

q. Furcal bristles all developed; at least the inner the same length as the furca or longer.

r. Antennae 17-segmented, shorter than the cephalothorax. A sense club on the 12th segment.

s. The last three antennal segments equaling the preceding five and a half.

Viridis (p.29).

ss. The last three antennal segments equaling

the seven and a half preceding ones.

Cyclops sp.(3)(p.16).

qq. Only the two middle furcal bristles developed; the inner and outer shorter than the furca.

t. Antennae 17-jointed. A sense club on the 12th segment. No circlet of hairs; no ridge.

u. Antennae as long as the first cephalothoracic segment. Insectus (p.26).

uu. Antennae shorter than the first cephalothoic segment. (The outer furcal bristle knife-like, resembling a spine.)

Cyclops sp.(1)(p.10).

EXPLANATION OF PLATES.

Plate I.

Figs. 1--6. *Cyclops (1)*. (1) Adult female. (2) Antenna of female. (3) Labrum. (4) Fifth leg. (5) First leg. (6) Fourth leg.

Plate II.

Figs. 7--12. *Cyclops (2)*. (7) Adult female. (9) Labrum. (10) Fifth leg. (11) First leg. (12) Fourth leg.

Plate III.

Fig. 13. *Cyclops (3)*, fourth legs.

Fig. 14. *Cyclops serrulatus*, fifth leg.

Fig. 15. *Cyclops edax*, terminal segments of antenna of female.

Fig. 16. *Cyclops signatus*, antenna of female.

Figs. 17--18. *Cyclops tenuicornis*. (17) Fifth leg. (18) Antenna of female.

Fig. 19. *Cyclops gyrinus*, first legs.

Plate IV.

Figs. 20--24. Cyclops (4). (20) Adult female. (21) Fifth leg. (22) Antenna of female. (23) First leg. (24) Fourth leg.

Plate V.

Figs. 25--30. Cyclops (5). (25) Adult female. (26) Antenna of female. (27) Terminal segments of antenna. (28) Fifth leg. (29) First leg. (30) Fourth leg.

Plate VI.

Figs. 31--36. Cyclops edax. (31) Adult female. (32) Labrum. (33) Antenna of female. (34) Fifth leg. (35) Fourth leg. (36) First leg.

Plate VII.

Figs. 37--42. Cyclops insectus. (37) Adult female. (38) Antenna of female. (39) Labrum. (40) Fifth leg. (41) Fourth leg. (42) First leg.

Plate VIII.

Fig. 43. Cyclops gyrinus, antenna of female.

Fig. 44. Osphranticum labronectum, fifth legs of female.

Fig. 45. Diaptomus sicilis, fifth pair of legs of male.

Fig. 46. Canthocamptus illinoisensis, fifth leg of female.

Fig. 47. Diaptomus oregonensis, fifth pair of legs of male.

Figs. 48, 49. Epischura lacustris. (48) Fifth leg of female. (49) Abdomen of male.

Figs. 50, 51. Diaptomus lintoni. (50) Fifth leg of female. (51) Fifth pair of legs of male.

Figs. 52, 53. Diaptomus shoshone. (52) Fifth leg of female. (53) Fifth pair of legs of male.

Plate IX.

Fig. 54. Cyclops viridis, fifth leg.

Figs. 55, 56. Cyclops thomasi. (55) Rami. (56) Fifth leg.

Figs. 57, 58. Cyclops serrulatus. (57) Rami of typical specimen. (58) Rami of variety pectinifer (?).

Figs. 59. 60. Diaptomus sanguineus. (59) Fifth leg of female. (60) Fifth pair of legs of male.

Figs. 61--64. Cyclops phaleratus. (61) Fifth leg. (62) Antenna of female. (63) First leg. (64) Fourth leg.

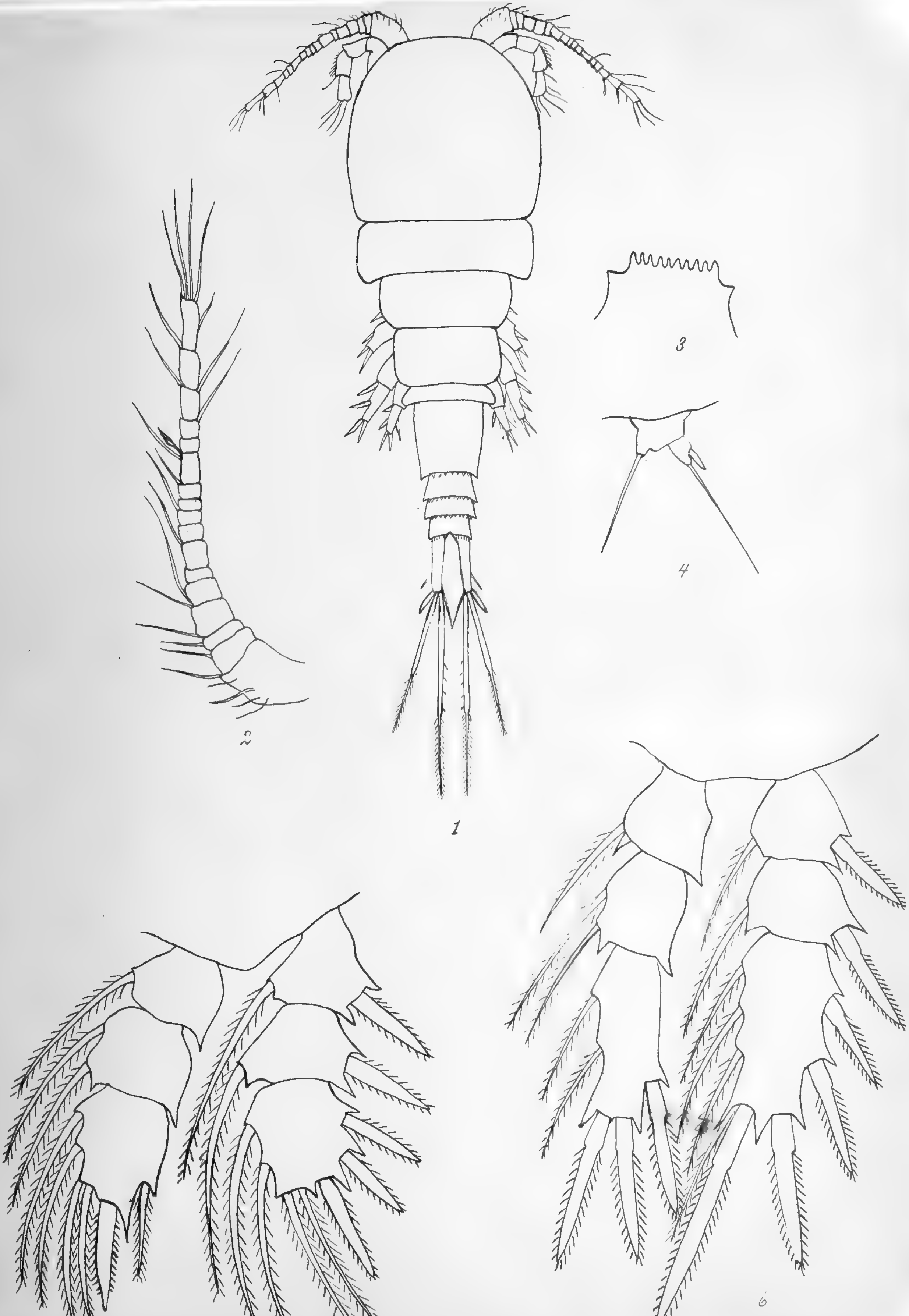
Plate X.

Figs. 65--69. Cyclops capilliferus. (65) Adult female. (66) Antenna of female. (67) Fifth leg. (68) First leg. (69) Fourth leg.

Plate XI.

Figs. 70--72. Canthocamptus illinoisensis. (70) First leg of male. (71) Antenna of female. (72) Fifth leg of male.

Plate I.



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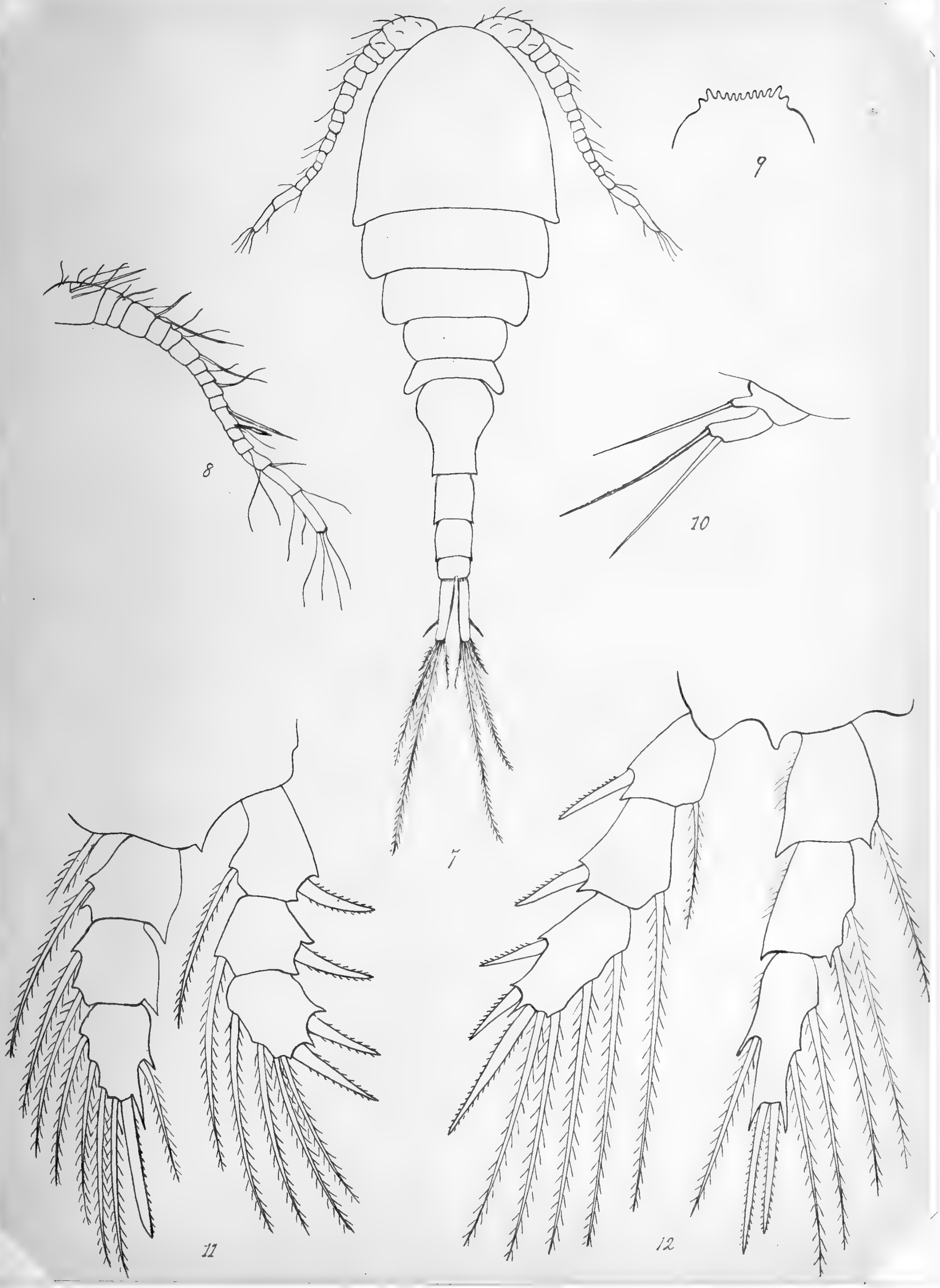
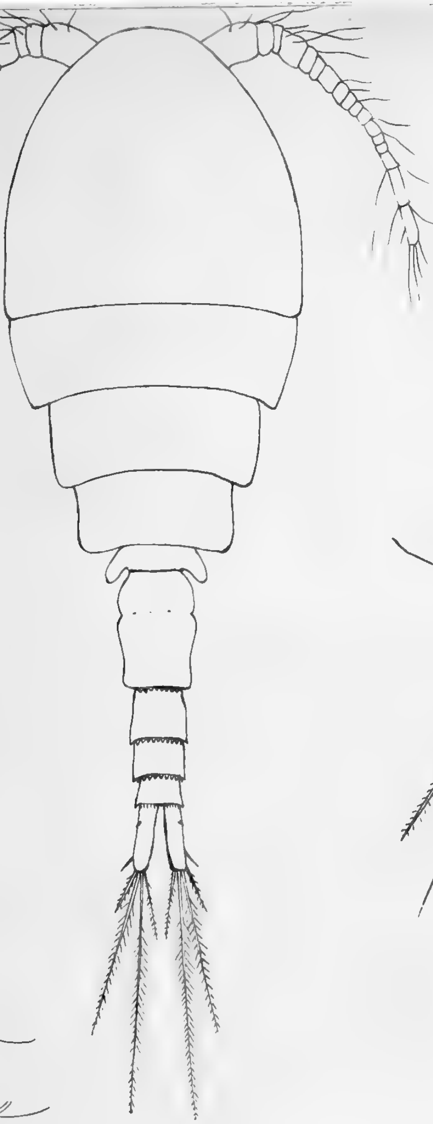


Plate III.

Plate IV.



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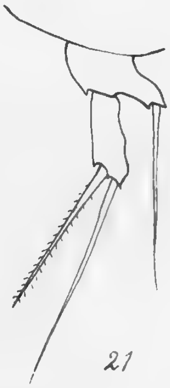

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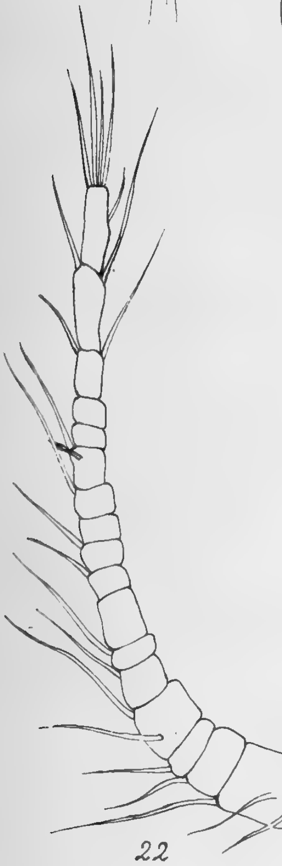

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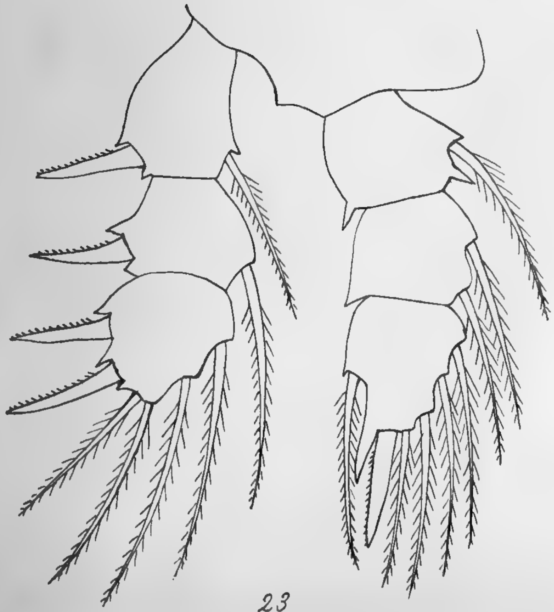

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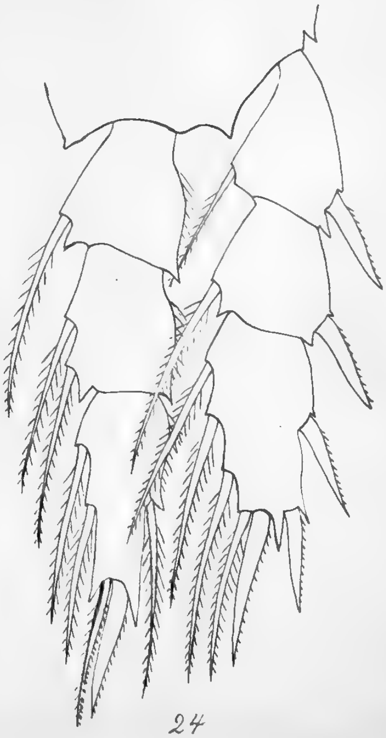

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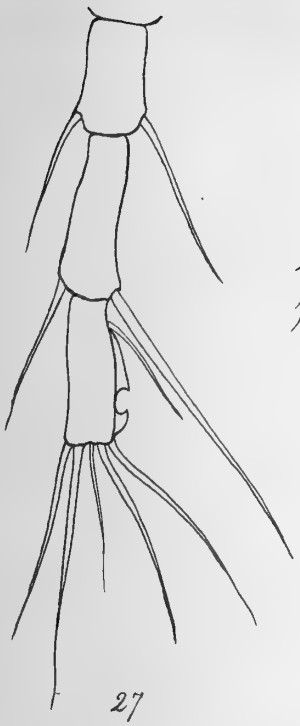
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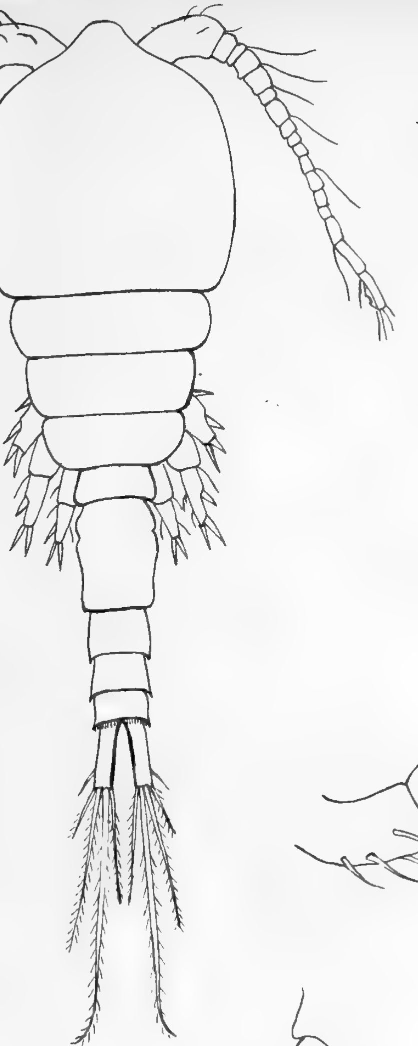
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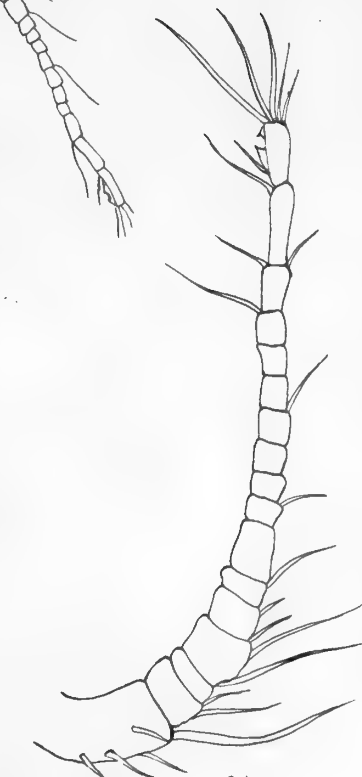
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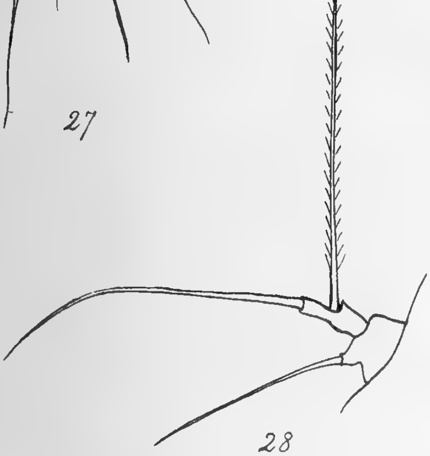
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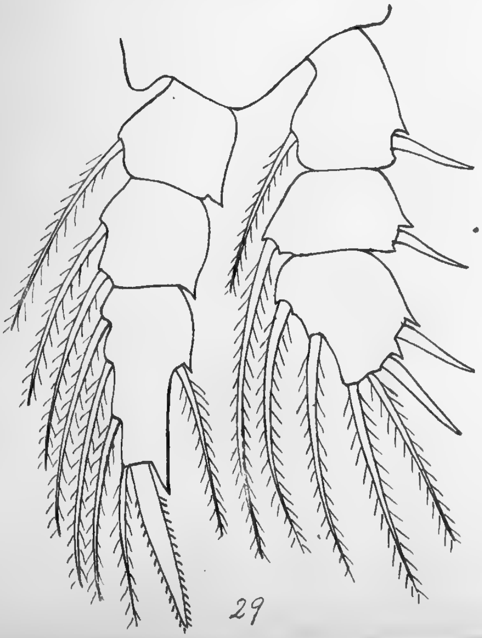
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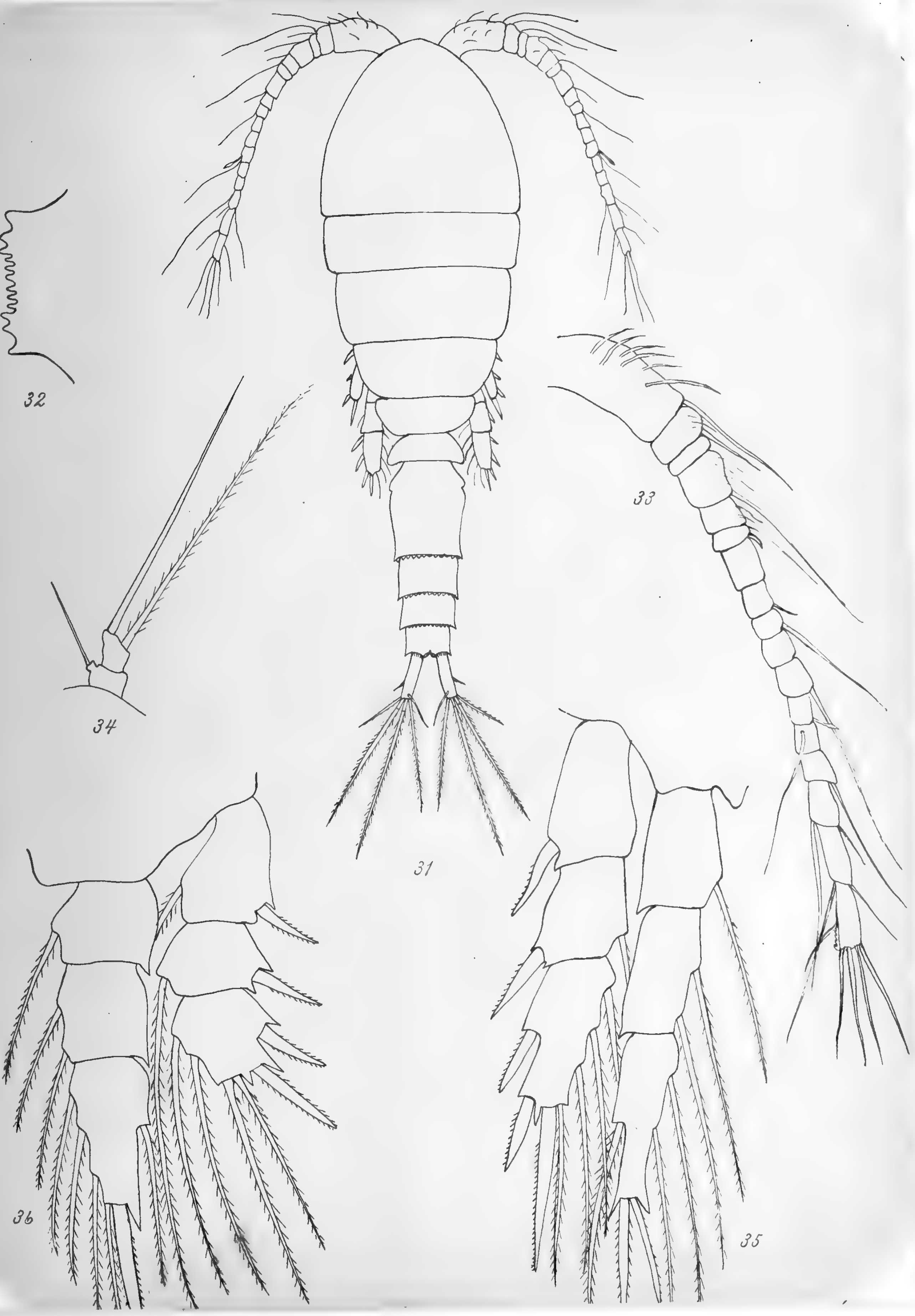

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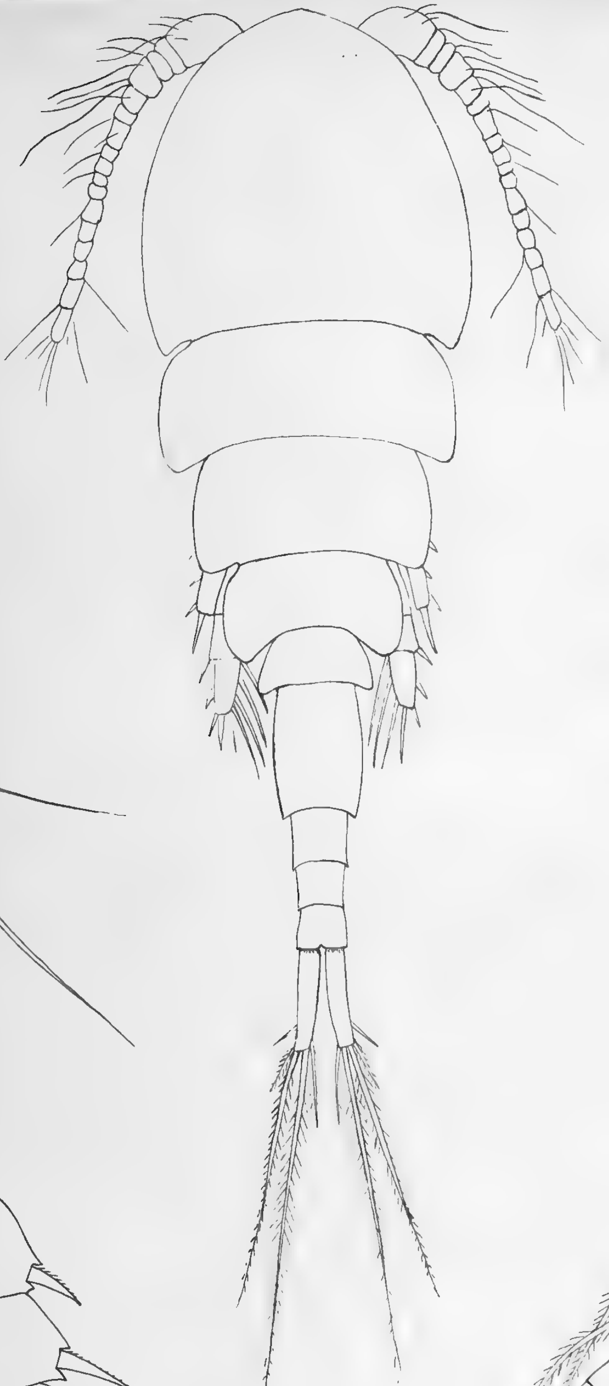

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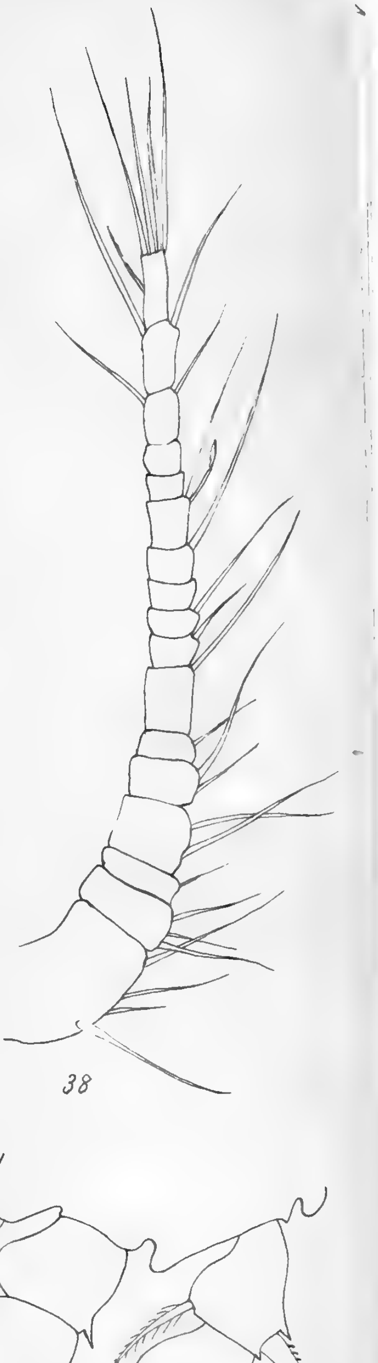

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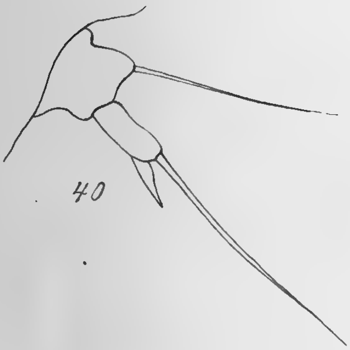

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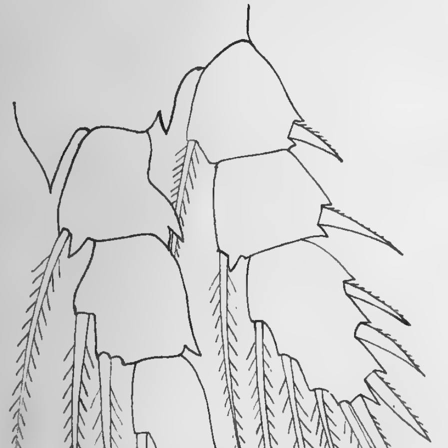

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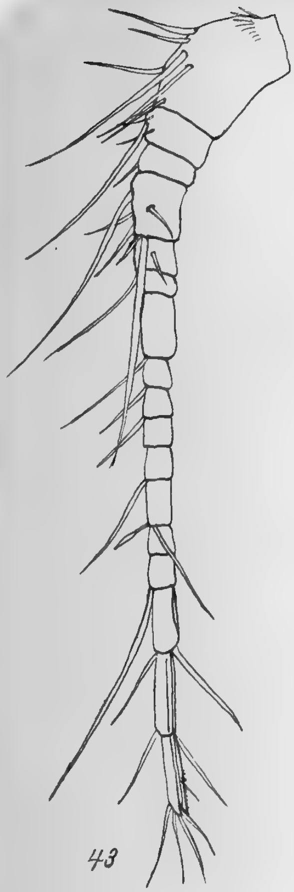
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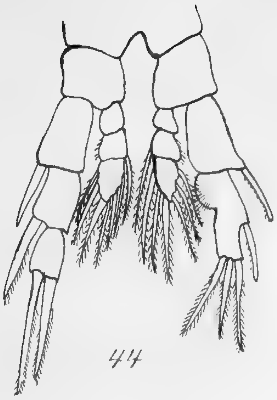
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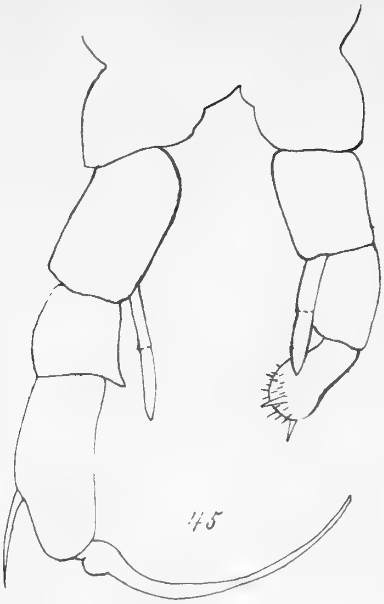
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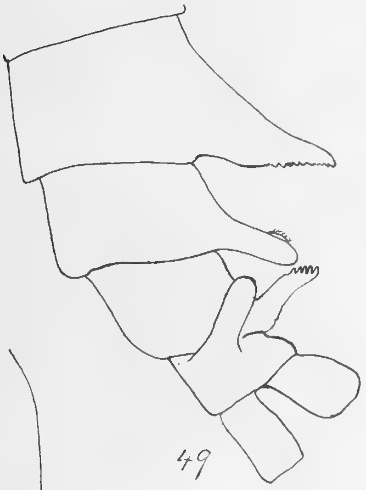
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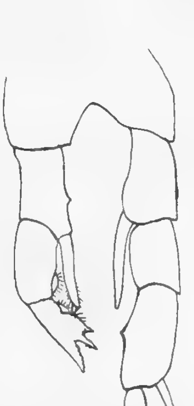
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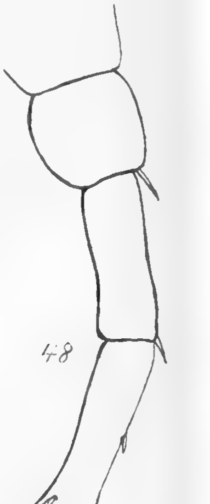
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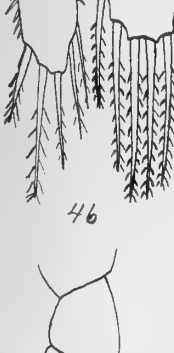
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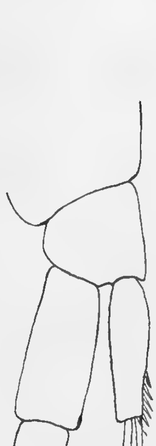
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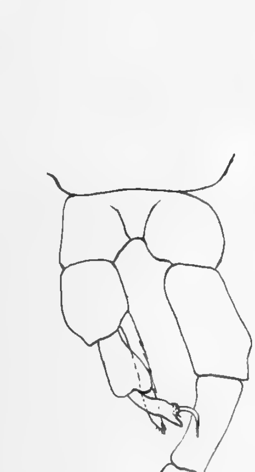
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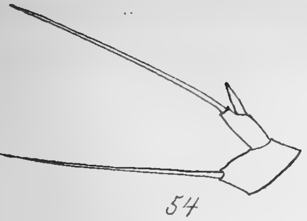
Plate IX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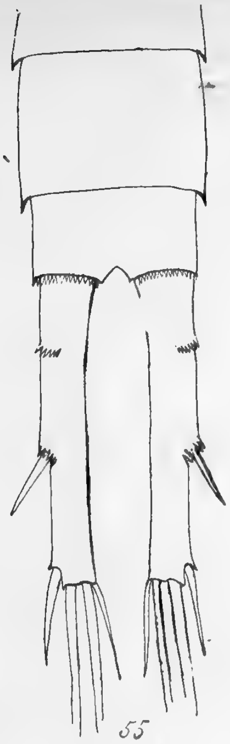
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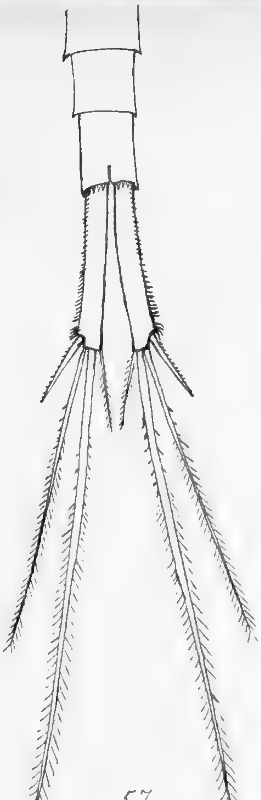
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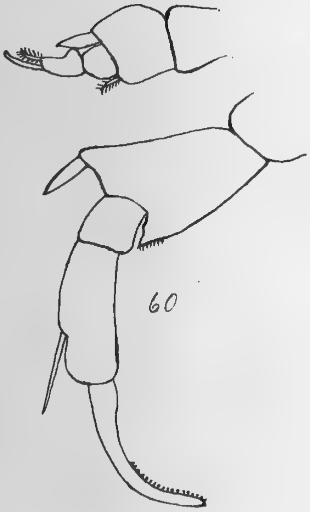
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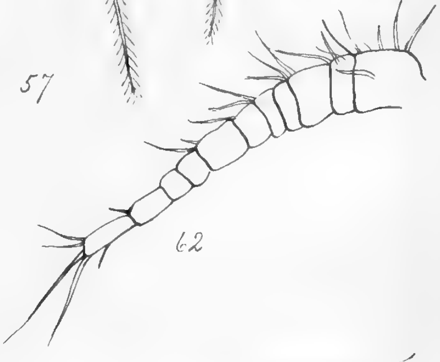
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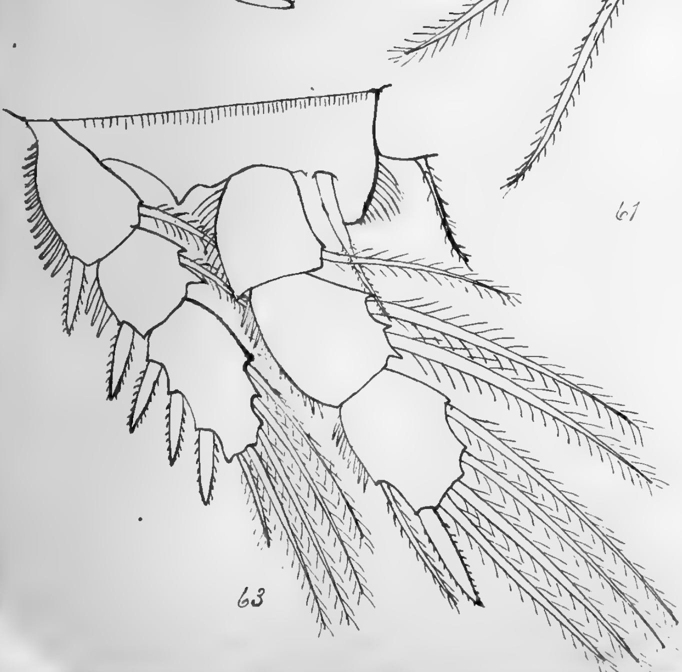
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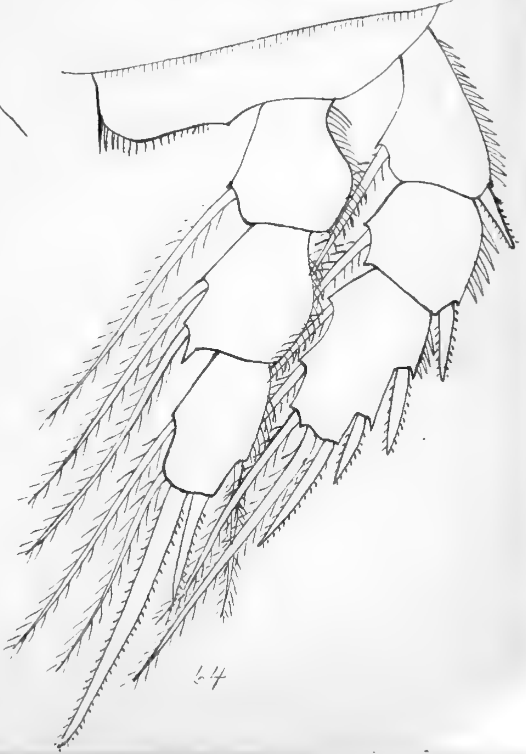
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Plate X

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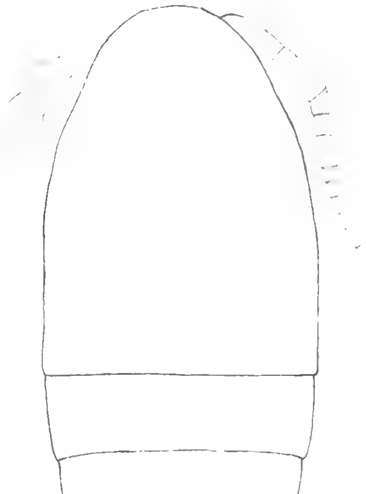

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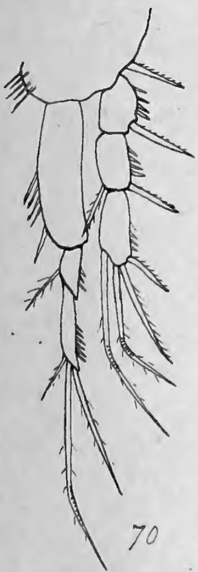
Plate XI



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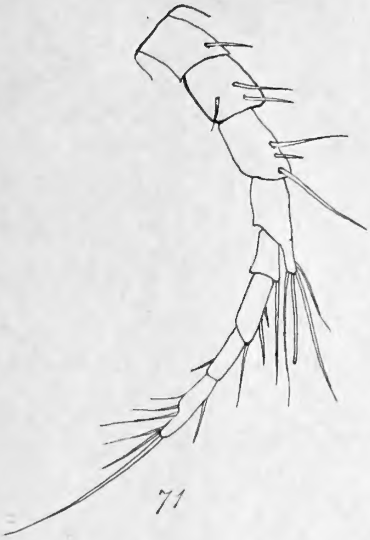

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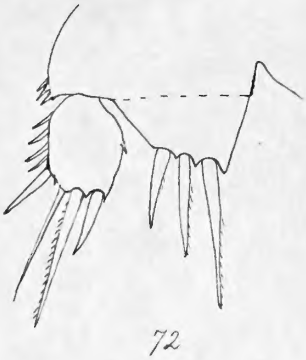

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