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ARTICLE II.—A CONTRIBUTION TO A KNOWLEDGE OF NORTH AMERICAN FRESH-WATER CYCLOPIDÆ.

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ERRATA.

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

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

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

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

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

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

ARTICLE II.—*A Contribution to a Knowledge of North American Fresh-water Cyclopidæ.** BY ERNEST B. FORBES.

INTRODUCTION.

During the past twenty years the fresh-water *Copepoda* of North America have received considerable attention from a small number of pioneer investigators, but as yet no one has made a careful comparative study of authentic representatives of the species described by them. It is my purpose in this paper to make a first contribution to a revision of the nomenclature of this genus, such as is usually found necessary when, for the first time, the work of unaffiliated investigators is brought into careful comparison. I have embodied in this paper, not a complete revision of the American species of *Cyclops*, but only such results of my study on that group as have now been brought to a satisfactory conclusion.

The excellent work of Claus and Schmeil in Germany has greatly modified our ideas of the comparative value of certain specific characters; and the revision of the European species of this genus in Schmeil's monograph† has made it possible for me to begin a revision of the American species along the same general lines.

The *receptaculum seminis*, which has recently come to be considered as the most important structure for purposes of specific distinction, has received almost no attention from American investigators; but after studying this organ in series of specimens of closely related forms from a great variety of widely separated situations, I have been forced to include under the same species name forms which have heretofore been considered valid species, and to discard as local or at the most varietal differences, distinctions which have

*This paper was prepared in the course of undergraduate study at the University of Illinois, and was accepted by the Faculty of the University June 7, 1897, as a thesis for the degree of Bachelor of Science in Zoölogy.

†Deutschlands freilebende Süsswasser-Copepoden, 1. Teil: Cyclopidae.

been used for the separation of species by our most eminent workers.

I have made a vigorous effort to obtain authentic examples of all the species considered; and while I have been in general successful, I have been forced in the case of Herrick's species to depend wholly upon the collections to which I have had access myself, and the identifications of other men who have collected in Herrick's localities.

The collections which I have had an opportunity to study in the preparation of this paper are those of the Illinois State Laboratory of Natural History, extending over a period of more than twenty years; several made under the auspices of the U. S. Fish Commission in Wisconsin and in the far West; collections made in Florida by Mr. Adolph Hempel and in Manitoba by Prof. L. S. Ross, of Drake University, Iowa, and kindly loaned me by these gentlemen; and all of the collections made at the Illinois Biological Station at Havana, Illinois. This material is from the following states: Massachusetts, Florida, Ohio, Indiana, Michigan, Wisconsin, Illinois, Kentucky, Iowa, Missouri, Minnesota, Idaho, Wyoming, Washington, and Oregon, and from Manitoba, in the Dominion of Canada.

The localities represented by these collections are widely distributed and of great variety. They extend from the New England states in the northeast to Florida in the southeast, to Manitoba on the north and to Washington and Oregon in the northwest, and from the sea-level in Massachusetts and Florida to some of the highest lakes in the Rocky and Sierra Nevada Mountains. In these collections are *Cyclops* from small temporary ponds of a few weeks' duration, from the greatest lakes and rivers in the world, and from a great number and variety of situations intermediate in character. They have been made in every season of the year; and although the southwestern part of the United States is not represented, they probably contain nearly all of the American species of the genus.

The results published in this paper do not, however, represent an exhaustive study of the distribution of the species

treated, and a more careful inspection of the collections examined would doubtless make evident many interesting facts with regard to the details of distribution.

I have had, for comparison with our American forms, named European specimens from S. A. Poppe, Prof. G. O. Sars, and Dr. Otto Schmeil. Those from Poppe were received in 1883 by Dr. S. A. Forbes and represent the following species: *Cyclops agilis*, *helgolandicus*, *pulchellus*, *signatus*, and *strenuus*. During the present year Dr. Schmeil has sent specimens of *Cyclops fuscus*, *varicans*, *leuckarti*, *albidus*, *strenuus*, *serrulatus*, *viridis*, and *phaleratus*, while Prof. Sars has sent to Dr. Forbes examples of the species of the following list: *Cyclops viridis*, *nanus*, *robustus*, *hyalinus*, *oithonoides*, *albidus*, *fuscus*, *vernalis*, *macrurus*, *gigas*, *leuckarti*, *insignis*, *bisetosus*, *fimbriatus*, *bicuspidatus*, *affinis*, *crassicaudis*, *phaleratus*, *bicolor*, *scutifer*, *serrulatus*, *varicans*, *dybowskii*, *lacustris*, and *strenuus*. These authoritatively named European specimens have given me the opportunity for comparative studies of American and European Cyclopidæ—the first, so far as I am aware, which have been made in America.

The mere study of American specimens of species first described from European material has not given me, in many cases, the data necessary for a critical judgment of the synonymy of such forms, and I have consequently accepted, as a rule, the determinations of Claus and Schmeil, whose long experience and critical and exhaustive work give to their conclusions the highest authority.

The genera and subgenera of Claus ('93a, '93c, '93d) seem to me very convenient subdivisions of this varied genus, and the species of this paper have, so far as possible, been arranged under Claus's groups. I find it necessary, however, to create two new subgenera, *Orthocyclops* and *Homocyclops*, for the two American species *C. modestus* and *C. ater*. The descriptions are incomplete, however, because of the lack of knowledge concerning the males of these two species.

Certain characters used by some of our American investigators for specific distinction have proven unreliable, and a

brief discussion of their comparative values may be of service to beginners in the study of this genus.

The number of antennal segments may be depended upon as fairly constant. It never varies in adult specimens by more than a single segment, and then only in the case of a very few species. The length of the antennæ, while constant in some species, is remarkably variable in others, notably in *C. serrulatus*. The proportionate length of antennal segments does not always remain the same in species in which the antenna is variable as to length. Sensory structures and the hyaline plates of the distal antennal segments are reliable characters.

In certain species, *C. phaleratus* for instance, the proportions of the stylets are quite constant, but in *C. viridis*, *serrulatus*, and *bicuspidatus*, the range of variation is very great; consequently such measurements are not of the highest specific value. The apical bristles of the stylets are not very variable as to comparative lengths, but the minute details of their structure are not constant. This fact is illustrated by the variation in the shape of the outer apical spine of *C. viridis* var. *brevispinosus* (Pl. XI., Fig. 1).

The armature of the swimming feet is of considerable value in certain cases, and is constant as a rule. Sometimes, however, the presence or absence of a spine or seta is not accompanied by other perceptible differences. The general character of the armature with regard to strength, etc., may usually be relied upon; but I have often seen in a single specimen all of the gradations between spines and setæ, and it would be impossible from this character to say which of the two names should be applied.

Of the easily observable structures, the fifth foot is the most valuable for specific distinction. Slight variations sometimes occur in the shape of the segments and in the comparative lengths of spines and setæ, but, as a rule, characters drawn from this appendage are quite constant.

Of all the specific characters, the most valuable are those derivable from the *receptaculum seminis*. Unfortunately, it is often very difficult to see this organ distinctly, especially if

the specimens have been killed in alcohol; but this difficulty is readily avoided by the use of formalin as a preservative. A 1% solution is amply strong, and the osmosis of fluids is not rapid enough to rupture the receptaculum, as is the case when strong alcohol is used. Some slight differences in the appearance of the receptaculum are due to stage of sexual activity of the animal. In the case of *C. viridis* var. *insectus* such a difference is noticeable. In Fig. 3, Pl. XI., the solid line represents the outline of the empty receptaculum; the dotted line, the shape when fully distended.

Through the generosity of Prof. G. O. Sars and Dr. Otto Schmeil, I have received much valuable material from Europe, by means of which I have been able to compare American and European forms. I wish also to acknowledge the assistance received from my co-laborers, Messrs. R. W. Sharpe and F. W. Schacht, and also to thank Prof. L. S. Ross, of Drake University, and Mr. Adolph Hempel, now of the Museu Paulista, Brazil, for the courtesies shown me in the loan and collection of material. A very great part of the credit for such portions of this paper as may be of value is due to my instructor, Dr. S. A. Forbes, whose kind supervision and encouragement have constantly guided and aided me in this work.

Genus **Cyclops** O. F. Müller.

Subgenus **Cyclops** s. str. Claus.

Cyclops leuckarti Claus. (Pl. VIII., Fig. 1–3.)

Cyclops leuckarti, Claus, '57, p. 35, Pl. I., Fig. 4; Pl. II., Fig. 13, 14.
Cyclops leuckarti, Schmeil, '92, pp. 57–64, Pl. III., Fig. 1–8.
Cyclops leuckarti, Herrick and Turner, '95, pp. 96–98, Pl. XVI.; XVIII., Fig. 1, A–J; XXIV., Fig. 2–6.

This species is of medium size, but is rather more slender than usual (Pl. VIII., Fig. 1). The cephalothorax is broadest at the first segment and tapers conspicuously toward the posterior end. The length as compared to the breadth is about as eleven to six.

The abdomen is long and slender, but the stylets are short, being one third or one fourth as broad as long. They are

not markedly divergent, and there is no conspicuously broad space between their points of attachment. The outer apical seta is delicate and as long as the stylet. Of the remaining three, all of which are well developed, the middle one is the longest and the innermost the shortest.

The first antennæ are long and slender, terminating at the middle or end of the third cephalothoracic segment. The last two segments are both long, but the sixteenth (penultimate) is the longer of the two. These two segments bear broad hyaline plates (Pl. VIII., Fig. 2). The margin of the one borne by the sixteenth segment is entire, but the one on the following segment besides being finely serrate its whole length is deeply notched near its distal end. This notch is very characteristic of the species. On the twelfth segment is the usual sense-club.

The posterior border of the second segment of the outer maxillipeds usually bears a series of rounded transverse ridges, which extend in a series from the proximal end of the segment nearly to the other end. The presence of this structure seems characteristic of the European form, but may rarely be entirely absent in American specimens.

The setæ and spines of the swimming feet are conspicuously long and strong. The margin of the connecting lamella of the fourth pair of feet bears a pair of sharp teeth. The feet are armed as follows:—First pair: outer ramus, two spines, four setæ; inner ramus, one seta, one spine, four setæ. Second and third pairs: outer ramus, three spines, three setæ; inner ramus, one seta, one spine, four setæ. Fourth pair: outer ramus, three spines, four setæ; inner ramus, one seta, two spines, two setæ.

The rudimentary foot (Pl. VIII., Fig. 3) is two-segmented. The basal segment is short and roughly quadrate, with a long plumose seta borne on its outer angle. The distal segment is long and slender. On the middle of the inner side is borne a long pectinate spine, and at the tip a seta of about equal length.

The *receptaculum seminis* is large and elliptical, and the anterior part, from which proceed the canals, is laterally expanded.

The egg-sacs are carried at a broad angle from the abdomen.

In length the female varies, in American specimens, from .95 to 1.5 mm.

The color is always inconspicuous and may be light blue or gray.

This is in general a very rare species in America. I have never, until recently, found it in collections in any great numbers, but in twos or threes at long intervals. I lately found it, however, in immense numbers in a collection made in August, 1896, from Fox River, Illinois. It is found in just such situations as is *C. edax*, but usually in very much smaller numbers. I have seen this species in collections from Lake Harriet, Minnesota; Delavan Lake, Wisconsin; and from Quiver, Flag, and Dogfish lakes, and the Sangamon and Fox rivers—all in Illinois. It is widely distributed in the lakes and rivers of America, but has not been reported from temporary pools.

Cyclops edax Forbes. (Pl. IX., Fig. 1–3.)

Cyclops edax. Forbes, '90a, p. 709, Pl. III., Fig. 15; IV., Fig. 16–19.
Cyclops annulatus. Wierzejski, '92, pp. 237, 238, Pl. VI., Fig. 14–18.
Cyclops leuckarti. Marsh, '93, pp. 209–211, Pl. IV., Fig. 17; V., Fig. 2–6.

SYNONYMY AND COMPARISON.

This form has been confounded with *C. leuckarti* Claus, from which, however, it is very easily separated by a careful comparison of specimens.

The original description of this species was incomplete in that no mention was made of the sense-club on the twelfth antennal segment, or of the hyaline plates of the sixteenth and seventeenth segments. As in *C. leuckarti* (Pl. VIII., Fig. 2), the plate of the sixteenth segment has an entire edge, though the plate itself is much narrower. The plate of the seventeenth segment (Pl. IX., Fig. 2) differs markedly from the corresponding structure in *C. leuckarti*. In *C. edax* the edge of the plate is cut by a series of deep oblique notches, forming teeth which point strongly backward. These notches

are deepest near the distal end and thence diminish in both directions. The segment itself is deeply excavated within and the plate merely completes its usual outline, while in *C. leuckarti* the segment is but slightly excavated and the broad plate projects far beyond the outline of the segment.

In *C. edax* the last two segments are equal, while in *C. leuckarti* the sixteenth segment is a fourth longer than the last.

The two pointed teeth of the connecting lamella of the fourth feet, which are characteristic of *C. leuckarti*, may sometimes be present in *C. edax*, though they are in this species not so sharp as in the other and are placed farther apart.

The transverse ridges of the outer maxillipeds, which Schmeil describes as characteristic of *C. leuckarti*, are usually absent in *C. edax* and when present are quite inconspicuous. They begin, as in *C. leuckarti*, at the proximal end of the segment, but soon fade away.

The abdominal stylets in *C. edax* are more divergent than in *C. leuckarti*, and are inserted farther apart.

The fifth feet (Pl. IX., Fig. 3) are markedly different. In *C. edax* the two setæ of the distal segment are parallel and the surfaces to which they are attached are at right angles to the long axis of the segment. In *C. leuckarti* the surface of attachment of the lower seta is at an angle of about forty-five degrees to the long axis of the segment. Furthermore, the whole distal segment is broader in *C. edax*.

There are differences in general proportions and appearances which make it very easy for one well acquainted with these species to distinguish them at a glance, but these differences can only be demonstrated by a long series of measurements. The structure of the *receptaculum seminis* is identical in the two species, so far as I can tell; but though the species are undeniably closely related, I think that on account of the above-mentioned differences they should be kept distinct.

Cyclops edax may possibly be the same as *C. leeuwenhoekii* Hoek, which Schmeil has made synonymous with *C. leuckarti*.

If the figures as published by Hoek are correct, *C. edax* differs from *C. leeuwenhoekii* in the following particulars: In *edax* the labrum has eleven teeth; in *leeuwenhoekii* it has but ten. In *edax* the seventeenth antennal segment is longer than the sixteenth; in *leeuwenhoekii* the sixteenth is longer than the seventeenth. In *edax* the first foot, outer ramus, bears on the distal segment two spines and four setæ; in *leeuwenhoekii* the corresponding segment bears three spines and two setæ. In *edax* the inner margin of the distal segment of the fifth foot is not incurved as in *leeuwenhoekii*. In *edax* there are never less than five prominent teeth in the lamella of the seventeenth antennal segment; in *leeuwenhoekii* but three are figured. The transverse ridges on the maxilliped of *leeuwenhoekii* are more prominent, smaller, and more numerous than in *edax*.

DISTRIBUTION.

This form is very abundant and widely distributed in America. I have found it, among many other places, in collections from the Mississippi and Illinois rivers; from various lakes and ponds of Illinois; from Sister Lake and Lake Butler in Florida; from Spirit Lake and Lake Okoboji in Iowa; and also from lakes Michigan, Superior, Winnebago, and Michigamme, and Yellowstone, Delavan, and Cedar lakes. It was described in 1892 by Wierzejski from the Argentine Republic under the name of *C. annulatus*.

SPECIFIC DESCRIPTION.

The cephalothorax is oval, compact, and broadest before the middle. The first segment is as long as the remainder. The last thoracic segment is scarcely broader than the first abdominal.

The first abdominal segment is very long, equaling the following three. The last segment is the shortest and is bordered by the usual row of spinules. The preceding segments are bordered posteriorly by coarse serrations, more pronounced and regular on the ventral than on the dorsal side. The stylets are one third as wide as long, and in a long series of measurements of individuals from the most widely separated

localities this proportion only varied by one thirtieth. The inner margins of the stylets are ciliate. The lateral spine is a trifle behind the middle; the outer seta about as long as the ramus; the inner five sixths the length of the third from within; the latter two thirds as long as the second.

The antennæ terminate between the end of the second and the end of the third segments. There is a sense-club and seta on the twelfth segment. The sixteenth segment is never longer than the seventeenth. The sixteenth and seventeenth segments bear hyaline plates (Pl. IX., Fig. 2), that of the sixteenth segment being very narrow, with its edge entire, and that of the seventeenth broader, with its edge deeply notched. The notches are most pronounced near the distal end and fade away in each direction. The intervening teeth point strongly toward the base of the antenna. The segment is excavate on the inner side, and the hyaline lamella completes the normal outline of the segment by filling up the depression.

The swimming feet are armed as follows:—First pair: outer ramus, two spines, four setæ; inner ramus, one seta, one spine, four setæ. Second and third pairs: outer ramus, three spines, three setæ; inner ramus, one seta, one spine, four setæ. Fourth pair: outer ramus, three spines, four setæ; inner ramus, one seta, two spines, two setæ.

The feet of the fifth pair (Pl. IX., Fig. 3) are two-segmented. The distal segment bears two parallel setæ, the outer one of which is set at about the middle of the segment. This seta is most strongly spinulose on the outer side, while the distal one is plumose on both sides.

The *receptaculum seminis* is large and elliptical, the long axis corresponding to the long axis of the segment. The lateral canals are connected with the expanded upper portion. The receptaculum is almost exactly as in *C. leuckarti*.

The egg-sacs are elliptical and stand out from the abdomen.

The usual length of the female is 1.2–1.4 mm.

Cyclops viridis Jurine. (Pl. X., Fig. 1–3.)

Monoculus quadricornis var. *viridis*, Jurine, '20, p. 46, Pl. III., Fig. 1.
Cyclops viridis, Schmeil, '92, pp. 97–101, Pl. VIII., Fig. 12–14.

SYNONYMICAL DISCUSSION.

Though the subdivision of the *viridis* group here proposed is not entirely satisfactory and may not be final, still after long study of more extensive collections than have heretofore been brought into comparison in America, I have arrived at some conclusions with regard to the subdivision of the group which may be of service to any one following me in the study of the American *Cyclopidæ*.

C. viridis occurs in America, so far as I now know, only in the larger forms of that species. *C. ingens* (Herrick, '82a) seems to me the only described form corresponding very nearly to the European *viridis*, and I therefore regard it as the American representative of that species. It is considered by Marsh as equivalent to *C. americanus* (= *C. insectus*), and Herrick himself says that it is distinguished from this form only by its greater size. From Fig. 3, Pl. XXV., in Herrick and Turner '95, I judge that *C. ingens* is synonymous with *C. viridis*, thus representing in America the maximum development of the species, as does *C. gigas* in Europe.

Dr. Forbes has for years recognized such a form as *C. ingens*, and it is to be found in the temporary ponds of central Illinois. The species was in 1870 given the manuscript and label name of *C. levis*, but the description was never published. This *C. ingens* or *levis* differs from specimens of *viridis* received from Sars and Schmeil only in its greater size, and from specimens of *C. gigas* received from Sars only in some of the more minute details in the outline of the two segments of the fifth foot. The two forms *gigas* and *ingens* are undoubtedly typical *C. viridis*. It is of interest to note that in both of these large forms the small spine of the fifth foot is not separate from the segment, but is a process of the segment itself. Schmeil states that in *C. viridis* it may or may not be separated from the segment by a suture. *C. ingens* is the only form in America having the stylets ciliate

internally. In the smaller forms most closely related to *viridis*, in which the small spine of the fifth foot is always separate from the segment, the inner border of the stylet is never ciliate, though in rare cases the whole inner aspect of the stylet seems to be set with the shortest of hairs, only visible on account of their points of attachment.

The first species closely related to *viridis* described in America was *C. insectus*, described in 1882 by Dr. Forbes. Later in the same year C. L. Herrick described a very closely related form under the name of *C. parcus*. This species has been most profusely figured by Herrick, but his drawings of the fifth foot are so very different as to make it impossible to say where it belongs in this most perplexing group. I have failed in my attempts to obtain authentic examples of *C. parcus*, but have found a few specimens answering to Herrick's description in a temporary pond in Urbana, Illinois. I cannot, however, vouch for their identity. In the same collection I found other specimens differing from those above mentioned only in the presence of the additional spine of the first and fourth feet—the feature separating this form from *C. insectus*.

So variable is *C. insectus*, found, as it is, in an endless variety of situations and localities, that the lack of a single spine on the distal segment of the outer ramus of the first and fourth feet is not sufficient ground for the distinction of even a variety, for I find, as does Dr. Schmeil, that the armature of the swimming feet is not in all species absolutely constant.

In Herrick and Turner '95 (Pl. XXXIV., Fig. 5), is a drawing of the fifth foot of *C. parcus*. This drawing was evidently made with somewhat greater care than were those on Plates XX. and XXI., and represents approximately the same appendage in *C. insectus*.

Cyclops americanus, described by C. D. Marsh in 1892, proves on examination of authentic examples to be synonymous with *C. insectus*. Undoubtedly *C. americanus* of Herrick and Turner is identical with Marsh's form and is consequently also a synonym of *insectus*.

Cragin in 1883 figured a form as *C. viridis* and stated that it was found at Cambridge, Mass. This form is *C. insectus*. *Cyclops uniangulatus*, described as new in the same article, is also *C. insectus*, the only apparent difference being a very slight one in the armature of the swimming feet.

Cyclops brevispinosus, described in 1884 by Herrick, differs from *C. insectus* principally in the shape of the outermost terminal spine of the stylet. In the type of *brevispinosus* this spine is very broad, heavy, and knife-like in character. I have seen considerable variations in the shape of this spine and have observed all of the gradations between it and the usual slender spine of *C. insectus*. I think, however, that *C. brevispinosus* should be considered as a good variety. The following description of *C. viridis* is a translation of the description by Schmeil ('92).

SPECIFIC DESCRIPTION.

"The two axes of the cephalothorax compare about as two to one; the ratio of the length of the cephalothorax and the abdomen is almost the same. The cephalothorax tapers about equally in both directions; each segment projects laterally far beyond the following. Seen from the side, the posterior angles of all the plates of the cephalothoracic segments are rounded, those of the first and fifth segments being at first straight, then convexly produced at their ends; and the second, third, and fourth segments, in which such prominences are lacking, are slightly lengthened posteriorly.

"The first abdominal segment is but little broadened in its anterior part. The posterior borders of all the segments are coarsely serrate, with the exception of the last, which bears a fringe of spinules.

"The stylets are often two, three, or even four times as long as the last abdominal segment. The inner border is always ciliate. The lateral spine is set beyond the middle of the outer edge. The outermost of the apical bristles (all of which are narrowly plumose) is not, as is the case with most species, changed into a spine, and is exceeded in length by the innermost. Both middle bristles are well developed, but their

proportional lengths are not entirely constant. Usually the smaller of the two is as long as the abdomen, and the larger exceeds it in length. They are often of exactly the same size, and often the difference is considerable.

"The first antennæ are seventeen-segmented, usually reaching back only to the posterior border of the first cephalothoracic segment. The last three segments are but little longer than those immediately preceding. The twelfth segment bears a projecting sense-club.

"The remaining pairs of appendages, with the exception of the rudimentary feet, present no notable characters and hence are systematically valueless. Spinous armature of swimming feet, 2. 3. 3. 3.

"The rudimentary foot (Pl. X., Fig. 2) is two-segmented. The extraordinarily broad basal segment bears on the lower outer angle a long plumose hair. On the lower border, immediately at the inner angle of this segment, is attached the relatively small distal segment, which bears at its distal end a plumose hair and at the inner margin a very minute spine.*

"The *receptaculum seminis* (Pl. X., Fig. 3), the two small lower divisions of which terminate in the lateral canals, are usually covered by the larger, more or less heart-shaped upper division. Exact knowledge of the structure of this organ is usually first possible after the application of delicate pressure.

"The large elliptical egg-masses stand off from the abdomen at a very sharp angle.

"The color is usually a dirty green, seldom a light brown. In a pool in Diemitz I met with quite fire-red examples.

"The size is very variable. With individuals 1.5–2 mm. one finds others 2.5, 3, 4, or even 5 mm. in length.

"The clearest and simplest recognition characters are the rudimentary feet and the structure of the *receptaculum seminis*."

*In a foot-note Schmeil states that Claus, Hoek, Richard, and Landé, consider this spine as a process of the segment, that Ulianin figures it as separated from the segment by a suture, and that he, Schmeil, had observed it both ways.

Var. **brevispinosus** Herrick.

(Pl. XI., Fig. 1 and 2.)

Cyclops brevispinosus, Herrick. '84, p. 148, Pl. S, Fig. 7–11.
Cyclops brevispinosus, Marsh, '93, pp. 205–206, Pl. IV., Fig. 11, 12.
Cyclops brevispinosus, Herrick and Turner, '95, p. 95, Pl. XXIII., Fig. 1–4; XXIV., Fig. 7–12.

This species of Herrick's, which I reduce to a variety, is distinguished from typical *C. viridis*, as follows: 1. By the form of the outer terminal spine of the stylet, which is short, broad, and knife-like. This form of spine is connected in series (Pl. XI., Fig. 1) with the slender spine of the variety *insectus*. 2. By the fifth foot (Pl. XI., Fig. 2). In this appendage the small spine is never a part of the segment as it may be in the European *viridis* and always is in the American form. This spine is also longer than in *viridis* and is lanceolate in shape. 3. By the armature of the swimming feet. The spines of these appendages are extravagantly long and heavy. While at first sight these differences might seem sufficient for the complete separation of the two forms, the distinguishing characters are in most species of *Cyclops* so variable that it seems to me best to consider *brevispinosus* as merely a variety.

The *receptaculum seminis* is as in *insectus*.

I find this variety in collections from Lakes Michigan, Manitoba, Okoboji, (Iowa); and from Lake Winnebago, Green Lake, and Lake Geneva in Wisconsin; from Swan Lake in Montana, and Lake Pend d'Oreille in Idaho; from the Detroit, Calumet, and Illinois Rivers; and from Sand, Fox, Quiver, Dogfish, Phelps, and Thompson's lakes—all in Illinois. It is never especially abundant but seems to be quite generally distributed.

Var. **insectus** Forbes.

(Pl. XI., Fig. 3–6.)

Cyclops insectus, Forbes, '82a, p. 649, Pl. IX., Fig. 6.
Cyclops parcus, Herrick, '82a, p. 229, Pl. VI., Fig. 12–15.
Cyclops insectus, Herrick, '84, pp. 151, 152, Pl. U, Fig. 9.
Cyclops viridis, Cragin, '83, p. 68, Pl. IV., Fig. 8–16.
Cyclops uniangulatus, Cragin, '83, p. 71, Pl. IV., Fig. 17.
Cyclops insectus, Schmeil, '92, p. 95.

Cyclops parcus, Marsh, '93, pp. 208, 209, Pl. IV., Fig. 16; V., Fig. 1.
Cyclops americanus, Herrick and Turner, '95, pp. 91, 92, Pl. XIV., Fig. 1–9.
Cyclops parcus, Herrick and Turner, '95, pp. 93, 94, Pl. XX., Fig. 12–15; XXI., Fig. 22; XXIII., Fig. 8; XXX., Fig. 1–8.

This variety represents in America the smaller members of the *viridis* relationship. It is distinguished from *viridis* in Europe by the lack of cilia on the inner side of the stylets, by some slight differences in the shape of the *receptaculum seminis* (Pl. XI., Fig. 3), and by the different shape of the fifth foot. The *receptaculum seminis* differs in that the upper part is larger in proportion to the segment in *insectus* and is somewhat different in outline. In the fifth foot (Pl. XI., Fig. 4 and 5), the outer distal angle of the basal segment is much less produced and the spine of the distal segment, which is always separated from the segment by a suture, varies in length from a minute barbule to a long heavy spine, longer than the segment itself. The armature of the swimming feet (Pl. XI., Fig. 6) is not constant and is not in *C. viridis* useful even as a varietal distinction.

This brief diagnosis includes under the varietal name *insectus*, forms which differ superficially to a marked degree, but after continuous work for more than a year with very large collections from all parts of the United States I have been forced to throw them all together for the simple reason that there is no one set or combination of characters sufficiently invariable to subdivide the group.

The antennæ of this variety usually terminate at or before the end of the first cephalothoracic segment, but in examples from Alturus Lake, they reach the middle of the second segment.

The stylets of this variety vary considerably in proportions. The following series of measurements of nine specimens shows the extent to which this character varies. On the left is a list of the localities from which the specimens were obtained and on the right are figures representing the proportion between the length and breadth of the stylet.

Pond, Normal, Ill.,	63:9
Creek, Wyoming,	52:11
Lake Winnebago,	52:8
Lake Superior,	44:9
Illinois River,	40:9
Mississippi River,	37:8
Pond, Urbana, Ill.,	34:7
Pond, Yellowstone Park,	33:9
Slough, Manitoba,	33:9

There is a very peculiar semicircular indentation of the outer side of the basal segment of the inner ramus of the fourth foot often present in this variety, but it may be entirely absent or only present in a slight degree of development. Whatever the function of this peculiar indentation, it does not seem to be essential to the animal.

The fifth foot varies but little in the basal segment but the distal segment is peculiarly variable. In one extreme, which reaches its highest development in the Illinois River, this segment is very short, its length compared to its breadth being as 3.5 to 3, and its sides strongly outcurved. The small spine is situated some distance from the end of the segment and is very small indeed. Examples of the other extreme are common in the ponds of central Illinois. In these the last segment is much longer, its length being to its breadth as 9 to 5. In this form the spine is parallel to and often longer than the segment.

The shape of this distal segment seems to vary independently of the other specific characters, and all gradations between the two forms may be found in a single pond. These variations are not demonstrably connected with the environment.

The *receptaculum seminis* (Pl. XI., Fig. 3) is, when fully distended, of the shape represented by the dotted line, but otherwise may have the shape outlined by the solid line. As will be seen by comparing this figure with that of the *receptaculum seminis* of *C. viridis* (Pl. X., Fig. 2), the anterior portion of the receptaculum is comparatively larger in *insectus* and its outline as a whole is somewhat different.

I find that the coloring of this species is so variable that no

dependence can be placed upon it for purposes of distinction. This variety may be wholly red or blue or greenish or it may even be colorless.

It is found everywhere in the United States and Canada where *Cyclops* have been collected, and no situation seems to be free from them. In Illinois by far the greater portion of the *Cyclops* of the small ponds and temporary pools and puddles belong to this species.

Cyclops bicuspidatus Claus. (Pl. XII., Fig. 1–4.)

Cyclops bicuspidatus, Claus, '57, p. 209.
Cyclops pulchellus, Sars, '63, pp. 246, 247, Pl. XI., Fig. 6 and 7.
Cyclops navus, Herrick, '82a, p. 229, Pl. V., Fig. 6–13, 15–17.
Cyclops thomasi, Forbes, '82a, p. 649.
Cyclops bicuspidatus, Schmeil, '92, pp. 75–87, Pl. II., Fig. 1–3.
Cyclops minutus, Forbes, '93, p. 247.
Cyclops serratus, Forbes, '93, pp. 247, 248.
Cyclops forbesi, Herrick and Turner, '95, p. 104.

SYNONYMICAL DISCUSSION.

This immensely variable and widely distributed species is represented in the United States by a number of forms which have been described by our most reliable zoölogists as species new to science. As more complete series of collections from the United States have been studied, it has become evident that these forms are so closely connected in series, that distinctions which a few years ago were considered as specific must be cast aside and the whole group united under the name of the European form.

With regard to *Cyclops thomasi* Forbes, I must agree with Dr. Schmeil that there is no need of considering this form as even a variety. A close study of the type specimens of *Cyclops thomasi* reveals a number of small differences between it and *Cyclops bicuspidatus* as described by Dr. Schmeil, but they agree almost exactly with other descriptions, by European investigators, of forms included in Dr. Schmeil's synonymy of *C. bicuspidatus* Claus. Only a single specimen of the form as described by Dr. Schmeil has been found by me in collections from this country. This single individual came from a

pond at Wood's Holl, Mass. The most conspicuous difference between this form and *C. thomasi* is a slight one in the shape of the fifth foot.

In the Illinois River are specimens which bridge over completely the gap between *C. bicuspidatus* and Herrick's *C. navus*, and I see no reason for considering *navus* as a good variety.

Cyclops minnilus Forbes is distinguished from *C. thomasi* by different proportions alone. It is one of the western representatives of this species and has been collected in the lakes and rivers of Wyoming.

Cyclops serratus Forbes is found in the same situations as *C. minnilus*, from which it is distinguished by a slight difference in the armature of the feet and by the fact that the vertical comb of spines of the furcal stylets is but poorly developed. The name *serratus* being already in use, Herrick renamed the species *forbesi*. This is the most elongate of the American representatives of the species.

SPECIFIC DESCRIPTION.

This is a long and slender species (Pl. XII., Fig. 1) with seventeen-segmented antennæ, oval cephalothorax, slender abdomen, very long and slender caudal stylets, and but two developed setæ to each stylet. The longer of these setæ is about twice as long as the shorter. The cephalothorax is widest at about the middle. In specimens from the eastern United States the posterior angles of the cephalothorax are not usually prominent except in the case of the last segment, where they are laterally produced. In the far western specimens the posterior angles of all the segments are prominent. The peculiar appearance of the cuticle caused by circular pits or depressions which Dr. Schmeil mentions, is rarely present in the American form. I have found it in greatly varying degrees of definiteness in specimens from Lake Superior and from Wyoming.

The first segment of the abdomen of the female (Pl. XII., Fig. 1) is emarginate behind the prominent lateral angle. This segment is about as long as all the others together. The

posterior margins of all but the last segment are irregularly and often very obscurely serrate. The last segment is bordered posteriorly by the usual row of spinules. The stylets are often slightly outcurved. In relative length to breadth they vary from four to one to nine to one, but the usual proportion is as seven to one. The inner of the two longer setæ is as long as the entire abdomen, and the outer of the two but half that length. The extreme outermost of the terminal setæ is two thirds as long as the inner. On the outer side of each stylet, a little behind the middle, is placed a spine surrounded at its base by a ring of spinules, and at one fourth of the distance from the proximal end is a vertical comb of small spines (Pl. XII., Fig. 2). This character seems to be invariably present.

The antennæ of the female are moderately robust and terminate in the American forms between the posterior end of the first segment and the middle of the third segment. A sense-club is borne on the distal end of the twelfth segment. No hyaline plate is present on the terminal segments. The last three segments gradually increase in length toward the distal end of the antennæ, the antepenult being two fifths the length of the last. The two segments preceding the former, taken together, are shorter than the last segment, and about equal to the penultimate.

The armature of the thoracic legs is as follows :—First pair : outer ramus, two spines, four setæ; inner ramus, one seta, one spine, four setæ. Second pair : outer ramus, three spines, four setæ; inner ramus, one seta, one spine, four setæ. Third pair, exactly like second. Fourth pair : outer ramus, three spines, four setæ; inner ramus, one seta, two spines, two setæ.

The fifth pair (Pl. XII., Fig. 3) are two-segmented, the basal segment about as long as broad, with a plumose seta at the outer angle, the terminal segment roughly cylindrical, at least twice as long as broad, with two terminal setæ, the outer of which is as long as the seta of the preceding segment and the inner a little more than half that length. This inner seta is sometimes spine-like.

The *receptaculum seminis* (Pl. XII., Fig. 4) is regular in outline, the anterior border being a low arch extending completely across the segment. The posterior portion is much deeper and about half as wide. The broad spermal canals arise from the anterior angles. The porus is exactly between the two anterior angles.

The egg-sacs are usually small and round in the specimens from large lakes; otherwise they are elliptical and very large.

The usual length of the female is 1–1.4 mm.

This species is very widely distributed in America. It has been found in Massachusetts and Wyoming and in all the intervening territory. It is the common pelagic species of the Great Lakes, but also occurs in large numbers in our ponds and rivers. Inhabiting, as it does, such a great amount of territory and such a variety of situations, it is not strange that it proves to be a very variable form. The Massachusetts form is exactly as described by Dr. Schmeil. In Wyoming this species is very much more slender in all its details, though not differing markedly in any other way from the type. Between these two extremes in location are a great number of intermediates in form. The fifth foot is rather variable, but I note no variation in the shape of the *receptaculum seminis*. The vertical combs of spines on the stylets are always present, but are not always conspicuous in the Western specimens. Although the most attenuate specimens examined were usually from large lakes and the most robust from ponds, I find that no other generalizations are possible with regard to the character of the specimens in connection with the nature of the situation—probably on account of the frequent transfers of individuals from one of these situations to another.

Subgenus **Macrocyclops** Claus.

Cyclops albidus Jurine. (Pl. XIII.)

Monoculus quadricornis var. *albidus*, Jurine, '20, p. 44, Pl. II.; Fig. 10, 11.

Cyclops gyrinus, Forbes, '90a, pp. 707–709, Pl. II., Fig. 9; III., Fig. 14.

Cyclops signatus var. *tenuicornis*, Herrick and Turner, '95, pp. 106, 107, Pl. XV., Fig. 5–7; XX., Fig. 1–7; XXXIII., Fig. 1, 2.

Cyclops albidus, Schmeil, '92, pp. 128–132, Pl. I., Fig. 8–14b; Pl. IV., Fig. 15.

SYNONYMY.

Since the description of *C. gyrinus* by Dr. Forbes in 1890, more careful descriptions of *C. albidus* in Europe and further studies in America have established the identity of the two forms. The original description of *C. gyrinus* was incomplete in that the presence of the sense-club and hyaline plates was not observed.

SPECIFIC DESCRIPTION.

This is a stout, heavy species, with a strongly arched cephalothorax, which, as a whole, is usually quite elliptical, with the lateral angles of the segments almost invisible; but in specimens from Manitoba I find the cephalothorax shaped much as in *C. viridis*. The first segment in these is subspherical, narrowing posteriorly, and the posterior end of the second segment is much broader than the anterior end. All of the lateral angles are prominent. The breadth of the first segment compared with its length is as ten or eleven to twelve.

The dorsum of the fifth segment in this species is ornamented by three or four transverse rows of spinules, the posterior one of which borders the segment.

The abdomen is thick and heavy. The first segment in the female is but slightly enlarged and tapers very little. The remaining segments are cylindrical. The stylets are short and slightly divergent. The proportion of the length to the breadth of the stylet varies but slightly. The usual ratio is two and one half to one. The apical bristles are all well developed, the third from without being the longest, and the innermost three times as long as the outermost.

The first antennæ of the female are seventeen-segmented, and reach to the first abdominal segment. The distal three segments bear hyaline plates, entire, except for minute serrations on the distal half of the plate of the seventeenth segment. The twelfth segment bears an unusually large sense-club.

The swimming feet are armed as follows:—First pair: outer ramus, four spines, four setæ; inner ramus, one seta,

one spine, four setæ. Second and third pairs: outer ramus, four spines, five setæ; inner ramus, one seta, one spine, four setæ. Fourth pair: outer ramus, three spines, five setæ; inner ramus, one seta, two spines (inner naked and movable), two setæ (distal one minute).

The fifth foot is two-segmented. The basal segment is two thirds as wide as long, its outer margin straight, its inner, convex and minutely hairy. The distal end is truncate, with a very long seta at the outer distal angle. The second segment is about as long as the preceding is wide, lobed in the middle and trisetose, the outer seta shorter than the inner, and the latter about half as long as the median.

The anterior portion of the *receptaculum seminis* is kidney-shaped and the posterior is two-lobed. The lateral canals are attached to the lower portion.

The usual length of the female in America is from 1.26–1.4 mm., but it seems to be much greater (2.5 mm.) in the European representatives of the species.

The color, which is blue or green, is distributed in dark bands with nearly colorless intervals on the thorax, the last abdominal segment and stylets, and on the second, third, ninth, and tenth antennal segments.

This species is very generally distributed, having been found in all the localities in America from which collections have been examined. It is not common in temporary ponds, but I have several times noted its occurrence in wells.

Subgenus **Homocyclops** n. subgen.

Cephalothorax very robust. Antennæ seventeen-segmented. Rami of swimming feet three-segmented. Fifth feet one-segmented, bearing one spine and two setæ.

Cyclops ater Herrick. (Pl. XIV., and Pl. XV., Fig. 1–3.)

Cyclops ater, Herrick, '82a, p. 228, Pl. III., Fig. 9–12.
Cyclops ater, Marsh, '95, pp. 13, 14, Pl. VI., Fig. 1–4, 6, 12.
Cyclops ater, Herrick and Turner, '95, pp. 89, 90, Pl. VII., Fig. 11, 12; XII., Fig. 9–12; XXI., Fig. 13–15, 17, 18.

The cephalothorax is peculiarly short and broad. Its first

segment is very large and is twice as long as the remaining segments together. The posterior edges of all the segments are smooth.

The abdomen is relatively small, but is broad in proportion to its length. It tapers but little and the first segment is scarcely at all enlarged. The segments, except the last, are finely and irregularly notched posteriorly. The caudal stylets are short, the length to the breadth being about as three to one. They are not ciliate within. In the small number of specimens which I have had an opportunity to examine there is no outer lateral spine, but at the usual place for this spine, a little behind the middle, is a shallow scar where a spine might at some time have been attached. I do not think, however, that this is probable. The terminal setæ are all well developed, but the median pair is much longer than the lateral ones. The innermost seta is slightly longer than the outermost. Of the four, the second from the inside is the longest.

The first antennæ of the female are seventeen-segmented and reach to the middle or end of the second cephalothoracic segment. The twelfth segment bears the usual seta and sense-club, though the latter organ is unusually small. The fourteenth segment bears an especially long, strong seta. The last two segments (Pl. XV., Fig. 1) bear a narrow hyaline lamella which projects some distance beyond the end of the seventeenth segment. The edge of this plate is entire. Of the last three segments, the middle one (sixteenth) is the longest.

The setæ of the swimming feet are short and stout. The armature is as follows:—First pair: outer ramus, three spines, five setæ; inner ramus, one seta, one spine, four setæ. Second and third pairs: outer ramus, four spines, five setæ; inner ramus, one seta, one spine, four setæ. Fourth pair: outer ramus, three spines, five setæ; inner ramus, one seta, two spines, two setæ.

The fifth feet (Pl. XV., Fig. 2) are one-segmented and bear one strong spine and two setæ each. The spine is about one third the length of the setæ. The inner seta, that is the one next the spine, is borne on a conical projection from the

body of the segment. Neither the setæ nor the spine seem to be provided with hairs or spinules.

The *receptaculum seminis* (Pl. XV., Fig. 3) is of an unusual and very characteristic shape. The anterior part is small, and its outline is marked by two anterior and two lateral rounded prominences. The posterior part consists of a median lobe, partially divided posteriorly, and two curved lateral lobes from which lead the lateral canals. The porus is in the median part connecting the upper and lower divisions.

The egg-sacs are of the usual size and shape.

In length the female varies from 1.77 to 2.88 mm.

The color is unusually variable. It is commonly dark blue or green but may be gray or red. The deep color and large size make this a conspicuous species.

Herrick says that it is widely but sparingly distributed over the Mississippi Valley. Marsh reports it from Rush, Round, St. Clair, Intermediate, Twenty-sixth, and Susan lakes in Wisconsin. I have noted its occurence in collections from Thompson's, Quiver, Flag, Phelps, and Dogfish lakes near Havana, Illinois.

Subgenus **Orthocyclops** n. subgen.

Antennæ sixteen-segmented. Rami of swimming feet, three-segmented. Fifth feet three-segmented, distal segment bearing two apical setæ.

Cyclops modestus Herrick. (Pl. XV., Fig. 4, and Pl. XVI., Fig. 1–3.)

Cyclops modestus, Herrick, '83a, p. 500.
Cyclops modestus, Herrick and Turner, '95, pp. 108, 109, Pl. XXI., Fig. 1–5.
Cyclops modestus, Marsh, '93, pp. 213, 214, Pl. V., Fig. 10–13.
Cyclops capilliferus, Forbes, '93, pp. 248, 249, Pl. XL., Fig. 14–17; XLI., Fig. 18.

SYNONYMY AND DISTRIBUTION.

By a study of the type specimens of *Cyclops capilliferus* I find that they agree almost completely with Herrick's description of *C. modestus*. The descriptions differ with respect to

the position of certain spines of the feet, but this is really a difference in description rather than in characters. I find also that specimens collected in Wyoming agree exactly with the Illinois representatives of the species.

I have noted its occurrence in collections from Quiver, Dogfish, and Thompson's lakes, and from the Illinois River, near Havana, Ill.; from the Sangamon River, in Champaign county, Illinois; and from Grebe Lake in Yellowstone Park. Marsh reports it from Rush Lake, Wisconsin, and Herrick finds it in Cullman county, Alabama, and in Minnesota lakes. I have never found it in temporary ponds nor in any of the Great Lakes. From the situations in which it occurs I judge that this species seeks shallow, weedy water rather than pelagic situations. It is not an especially rare species, but I have never found more than a very few individuals in a single collection.

SPECIFIC DESCRIPTION.

The cephalothoracic segments are closely articulated and the sides regularly convex. The first segment is longer than usual and the fourth is semicircularly excavate behind. The posterior edges of the first three segments are irregularly notched and the fourth is smooth. The length of the cephalothorax is to its breadth as two to one.

The abdomen is long, slender, and cylindrical, and is peculiar in lacking the usual fringe of spines on the posterior edge of the last segment. The posterior edges of the other segments are likewise smooth. The anterior end of the first segment is but little enlarged. The segments diminish regularly in length from first to last. The caudal stylets are about twice the length of the last segment and four times as long as broad. The lateral seta is placed a trifle beyond the middle of the ramus. Behind the lateral spine the stylet is peculiarly excavate. The outer terminal bristle, which is set farther forward than in most species, is a short, sparsely plumose seta, but the other three setæ are well developed. Of these three the middle one is considerably the longest and the inner one slightly shorter than the outer.

The antennæ are regularly sixteen-segmented, though Herrick mentions having notes on a similar form in which the antennæ are seventeen-segmented. They reach to the middle of the second cephalothoracic segment. On the third, tenth, and thirteenth segments are remarkably long, heavy setæ. The antenna (Pl. XVI., Fig. 1) is given a characteristic appearance by the conspicuous seta on the third segment and a sharp change in direction between the third and fourth segments. The last segment is much shorter than the one preceding.

The setæ of the three-segmented legs are long and slender. The distal segments of the third and fourth pairs of legs turn inward in a way peculiar to this species. The legs are armed as follows:—First pair: outer ramus, four spines, four setæ; inner ramus, six setæ. Second pair: outer ramus, four spines, five setæ; inner ramus, six setæ. Third pair: outer ramus, three spines, five setæ; inner ramus, six setæ. Fourth pair: outer ramus, three spines, five setæ; inner ramus, one seta, two spines, two setæ.

The fifth foot (Pl. XVI., Fig. 2) has three freely movable segments, though the basal one is small. The second segment bears one seta without, and the third segment bears two setæ—both at the tip. The outer seta is apt to be bent inward across the inner one. These feet are usually large and placed very close together.

The *receptaculum seminis* (Pl. XVI., Fig. 3) is very much as in *Cyclops bicuspidatus* Claus. It is nearly elliptical in outline, and only a small part of the anterior end extends farther forward than the suture in which the porus is situated. The lateral canals lead from the anterior part.

The egg-sacs are long and narrow and lie close to the abdomen.

In length this species does not vary to any marked degree from an average of 1.2 mm.

The coloring is most beautiful, varying from violet to purple. It is evenly distributed, and is quite persistent in specimens preserved in formalin.

Subgenus **Eucyclops** Claus.

Cyclops serrulatus Fischer. (Pl. XVII., and Pl. XVIII., Fig. 1–3.)

Cyclops serrulatus and *C. serrulatus* var. *montanus*, Brady, '78, Vol. I., pp. 109–111, Pl. XXII., Fig. 1–14.

Cyclops serrulatus and *C. serrulatus* var. *elegans*, Herrick, '84, Pl. Q. Fig. 17–19; Pl. Q³. Fig. 10.

Cyclops serrulatus. Schmeil, '92, pp. 141–146, Pl. V., Fig. 6–14.

SYNONYMY, VARIATION, AND DISTRIBUTION.

This is one of the most common and widely distributed of American *Cyclops*. It occurs almost everywhere between Maine and California and from Florida to Manitoba.

Herrick's variety *elegans* is based on such variable characters that no one acquainted with the species throughout its range could for an instant consider this form as worthy of a varietal name, especially since the measurements and descriptions of the type and the variety are contradictory as published in his "Synopsis of the Entomostraca of Minnesota." Herrick says that the variety is distinguished from the type by its greater size and by the elongation of the antennæ and caudal stylets; but gives 1.5 mm. as the length of the type, and 1.34 as that of the *larger* variety. In Europe the largest specimen on record measured 2.2 mm. in length, much more than Herrick's large variety. As to the length of the antennæ, I find that this varies immensely and quite independently of other variations in proportion. Below is a series of measurements of seven egg-bearing females of this species, from widely separated situations and exhibiting its variability. Further study of a much larger number of specimens has convinced me that there are no varietal distinctions possible among the American representatives of this species, unless for convenience we arbitrarily separate off the extreme forms. With the exception of the specimen from Thompson's Lake, each individual is fairly representative of the species as found in its own locality.

Locality	Length to breadth of caudal stylet	Antenna terminates	Length	Breadth.
Portage La Prairie, Manitoba	.078:.018=4.3:1	Before end of first segment.	.7	.252
Urbana, Ill.	.027:.015=1.8:1	End of first segment.	.54	.198
Spoon River, Ill.	.072:.0225=3.2:1	End of first segment.	.792	.324
Thompson's Lake, Ill.	.075:.018=4.2:1	End of third segment.	.72	.216
Pelican Creek, Wyo.	.087:.03=2.9:1	Middle of second segment.	.882	.324
Wood's Holl, Mass.	.111:.027=4.1:1	Middle of third segment.	.882	.36
Lake Geneva, Wis.	.24:.027=8.9:1	End of third segment.	1.426	.45

It is also my opinion that Brady's variety *montanus* should be considered as merely a variation of the typical form.

SPECIES DESCRIPTION.

The cephalothorax (Pl. XVII.) is quite regular in shape, being almost exactly elliptical in outline. Its segments are closely joined and its lateral outlines smooth. The fourth segment is deeply excavated behind and is usually bordered by fine sharp teeth or by long hairs.

The abdomen (Pl. XVII., and Pl. XVIII., Fig. 1) is broad in front, but narrows so rapidly posteriorly that the greater part of the first segment is as narrow as the slender segments following. Behind the enlargement of the first segment the abdomen tapers very little. The last segment is bordered posteriorly by the usual row of spinules, and the preceding segments by fine sharp serrations. The stylets are commonly about straight, but are occasionally strongly outcurved and divergent. Their length to breadth varies from 1 :1.8 to 1 : 9 but 1 : 4 is the commonest proportion. A row of spinules, spines, or curved hooks marks the outer border of each stylet and extends from its base to the point of insertion of the outer apical spine, near the posterior end. These projections in-

crease rapidly in length at the posterior end and fade away in front. The male does not have this character, and adult females are very rarely found without it. Of the four apical bristles the middle two are well developed. The inner one of this pair is much longer than the outer. The innermost of the four is a very slender seta. The outermost varies in character from a long seta bordered externally by barbules and internally by long slender cilia, to a long strong spine serrate on both sides. It may be anywhere from one half to four fifths as long as the stylet.

The first antennæ are twelve-segmented. Dr. Schmeil notes the presence of a minute sensory bristle on the ninth segment in the place occupied by the sense-club on the twelfth segment of seventeen-segmented antennæ. It is very inconspicuous indeed. The last three segments are usually very long and are armed on the inner side by hyaline plates.

The usual armature of the swimming feet is as follows:— First pair: outer ramus, three spines, five setæ; inner ramus, one seta, one spine, four setæ. Second and third pairs: outer ramus, four spines, five setæ; inner ramus, two spines, four setæ. Fourth pair: outer ramus, three spines, five setæ; inner ramus, one seta, two spines, two setæ.

The fifth foot (Pl. XVIII., Fig. 2) is one-segmented and plate-like. On the inner side is a very strong serrate spine. At the tip, borne on a cone-shaped projection, is a very long slender seta, parallel to the spine. On the outer side is a delicate little seta projecting outward at a considerable angle.

The *receptaculum seminis* (Pl. XVIII., Fig. 3) is almost completely divided into an anterior and a posterior part, by a median constriction. The porus is situated in the middle of this narrow connecting part. The lower half extends down into the narrow part of the first abdominal segment. The spermal canals are attached to the receptaculum at the outer angles of the lower part.

The egg-sacs are usually long, with many eggs, but sometimes contain only a few, arranged in a spherical mass.

Ordinarily the egg-sac tapers to a sharp point at the lower end, and stands out from the abdomen at a wide angle.

The size is remarkably variable. In Europe, the length varies from .883 to 2.2 mm. In America I have measured specimens varying in length from .54 to 1.47 mm. A common length is .9 mm.

Cyclops prasinus Fischer. (Pl. XIX., Fig. 1 and 2, and Pl. XX., Fig. 1 and 2.)

Cyclops prasinus, Fischer, '60, pp. 652–654, Pl. XX., Fig. 19–26a.
Cyclops fluviatilis, Herrick, '82 a, p. 231, Pl. VII., Fig. 1–9.
Cyclops magnoctavus, Cragin, '83, pp. 70, 71, Pl. III., Fig. 14–23.
Cyclops prasinus, Schmeil, '92, pp. 150–156, Pl. V., Fig. 1–5.
Cyclops fluviatilis, Herrick and Turner, '95, pp. 114, 115, Pl. XXVI., Fig. 1–8; XXX., Fig. 1.

SYNONYMY AND DISTRIBUTION.

On account of the great difficulty in determining the structure of the *receptaculum seminis* of *C. prasinus*, this organ has escaped study in the American representatives of this species, and although Marsh had noted a general resemblance of Herrick's *C. fluviatilis* to Vosseler's *C. pentagonus* (*C. prasinus* Fischer), he did not consider these as identical. By a careful study of a large number of specimens of *C. fluviatilis* from Illinois, Florida, and Wisconsin, I find a complete agreement in the characters of the *receptaculum seminis* of *C. prasinus* and *C. fluviatilis* and in all other specific characters as well.

I have noted the occurrence of *C. prasinus* in collections from Sister Lake, Florida; Long Lake, Adams county, Ill.; ponds and temporary pools at Urbana, Ill.; Illinois River at Havana, Ill.; Phelps, Flag, and Thompson's lakes in Fulton county, Ill.; Dogfish and Quiver lakes in Mason county, Ill.; and from Lake Geneva, Wisconsin. Herrick reports it from Lake Minnetonka, Minn., and from an estuary of the Mississippi. Marsh finds the species in Lakes Erie, Michigan, and St. Clair, and in fifteen smaller lakes of Michigan and Wisconsin. Cragin found it in ditches at Cambridge, Mass.

It is thus, in all probability, quite generally distributed over the eastern and central United States, but I have not found it in collections from the far West. It occurs in all situations from great lakes and rivers to temporary roadside puddles of but a few weeks' duration.

SPECIFIC DESCRIPTION.

This minute species has a slender cephalothorax which is very nearly elliptical in outline. The first segment is regularly convex anteriorly and is unusually long. The posterior borders of the segments are entire. The lateral edges of the last segment are fringed by a row of the finest hairs.

The abdomen is long and slender and tapers but little. The enlargement of the anterior segment is slight. The posterior borders of all the abdominal segments are very finely serrate. The stylets are short and divergent but are not themselves outcurved. The lateral spine is inserted just beyond the middle of the stylet. The inner and outer apical bristles are very short and delicate, the inner one, the longer of the two. Only the middle pair of setæ are well developed, and the outer of these is three fourths the length of the inner.

The first pair of antennæ (Pl. XIX., Fig. 2) of the female are twelve-segmented and often reach quite to the first abdominal segment. The seventh, eighth, and ninth segments are very long. The last three segments are curved and the last four are freely movable. Schmeil states that the ninth segment bears a sense-club. I do not find it present in the American representatives of the species, although there is a minute sensory bristle on the end of the tenth segment. The last three segments bear a hyaline plate whose edge is entire.

The spines and setæ of the three-segmented swimming feet are very long and slender. The armature is as follows:— First pair: outer ramus, three spines, five setæ; inner ramus, six setæ. Second pair: outer ramus, four spines, five setæ; inner ramus, six setæ. Third pair armed like second. Fourth pair: outer ramus, three spines, five setæ; inner ramus, one seta, one spine, three setæ.

The fifth foot (Pl. XX., Fig. 1) is one-segmented and bears

three bristles. The inner one is a ciliate spine while the other two are plumose setæ. The middle one of the three is borne at the tip of a cone-shaped process. The inner edge of the foot is bordered by a row of minute hairs.

The *receptaculum seminis* (Pl. XX., Fig. 2) is most peculiar and characteristic. It consists of two parts, anterior and posterior, separated by the suture marking the original division of the first abdominal segment. The upper part consists of two S-shaped canals, one on each side of the median line, extending across the abdomen. The inner ends which point downward, fuse in a thicker portion connecting the anterior division with the posterior. The part of the receptaculum behind the suture consists of two lateral sacs, which connect with each other and with the upper part of the receptaculum at the same point. In the middle of this common part is the porus. The outer ends of the tubular portion are slightly enlarged; otherwise the diameter is uniform. The structure of this organ has never before been observed in the American representatives of *Cyclops prasinus*.

The egg-sacs contain few ova and are closely adherent to the abdomen.

The length of the female varies from .48 to .7 mm.

The color is unusually variable. The prevailing color of European specimens seems to be green. I have seen both blue and pink individuals. Herrick says that the color varies from deep indigo to greenish brown.

Subgenus **Paracyclops** Claus.

Cyclops phaleratus Koch. (Pl. XX., Fig. 3.)

Cyclops phaleratus, Koch, '35–'41, Heft 21, pp. 8, 9. Pl. IX.
Cyclops perarmatus, Cragin, '83, pp. 72, 73, Pl. I., Fig. 9–18.
Cyclops phaleratus, Schmeil, '92, pp. 170–178, Pl. VIII., Fig. 1–11.
Cyclops phaleratus, Herrick and Turner, '95, pp. 120, 121, Pl. XVII., Fig. 1–7; XVIII., Fig. 2–2d; XIX., Fig. 1; XXI., Fig. 6–10.
Cyclops phaleratus, Marsh, '95, pp. 19, 20.

DISTRIBUTION.

In America this species is rare, though evidently widely distributed. I have noted its occurrence in collections from the Illinois River at Havana, Ill.; a pond at Urbana, Ill.;

Delavan Lake, Wisconsin; Quiver Lake, Ill.; Green Lake, Wisconsin; Cedar Lake, Ill.; and a slough at Portage La Prairie, Manitoba. Marsh reports it from Lake St. Clair; and from Twenty-sixth Lake, Pigeon River, and Intermediate Lake, Michigan. Cragin describes this species as *Cyclops perarmatus* from Glacialis Pond, Cambridge, Mass. It is a littoral rather than a pelagic form and where occurring in large bodies of water it is found only in the marginal vegetation.

SPECIFIC DESCRIPTION.

The cephalothorax is broad and elliptical. The first segment is longer than the remainder. The chitinous covering of the fifth segment, which in all other species of this genus is composed like the four preceding cephalothoracic segments of a dorsal and ventral plate, is in *C. phaleratus* like the chitinous covering of the abdominal segments in that it consists of but one piece. The ventral portion of the posterior border of this segment is set with a row of fine teeth, evanescent in the middle. About the rudimentary feet are several rows of fine spinules.

The abdomen is large and cylindrical, and very little smaller than the last cephalothoracic segment. The first segment tapers very little. The posterior borders of the first, second, and third abdominal segments of the female are finely serrate. The last segment is very short and the spines on its posterior border are especially long and strong. The profusely spinose stylets are short and broad and taper very rapidly. On the ventral side of each ramus is a row of long spinules, extending from the middle line of the anterior border to the point of insertion of the lateral spine. From this point on, the rami taper much more rapidly. The inner border of the stylets is ciliate* and the whole inner aspect may be spinose. The outermost apical bristle, which is placed high up on the side of the stylet, is short, and plumose on both sides. The inner bristle is very slender and is about as long as the outer. It is plumose on the outside only.* The two median bristles

*Incorrect in figure.

alone are well developed. The inner one of this pair is from two to three times as long as the outer. Except for the outer side of the outer one of the pair, the anterior third of each is naked. The remainder is usually sparsely plumose.

The antennæ of the female may be either ten- or eleven-segmented and reach only a little beyond the middle of the first cephalothoracic segment. In the ten-segmented antenna the seventh segment bears a delicate sensory hair at its distal end. This hair is borne on the eighth segment of the eleven-segmented antenna.

The second antennæ are short and proportionately broad. On the outer side of the second segment is a double row of spinules. On the upper border of this segment is a spine and a fringe of spinules. This spine and the shortest one at the end of the third segment are very peculiar. Both are strongly curved near the tip, and the inner side of this curve is fringed by a comb-like row of teeth.

The three-segmented swimming-feet are strongly armed and their outer borders bear rows of long spinules. The armature of the distal segments is as follows:—First pair: outer ramus, three spines, five setæ; inner ramus, one spine, four setæ. Second pair: outer ramus, four spines, four setæ; inner ramus, one spine, four setæ. Third pair: outer ramus, four spines, five setæ; inner ramus, one spine, four setæ. Fourth pair: outer ramus, three spines, five setæ; inner ramus, one seta, two spines, two setæ.

The rudimentary feet are lateral rather than ventral and consist of mere flange-like processes. They are connected by a row of strong serrations extending across the ventral side of the segment. Each foot is armed by three subequal spines, one naked and the other two plumose.

The *receptaculum seminis* consists of two sections, which extend as two narrow bands across the segment. The porus is situated on the median line where the two divisions unite.

The egg-sacs contain many eggs and are closely appressed to the abdomen. Schmeil calls attention to the fact that the oviducts, which in all other species are contained wholly within the cephalothorax, in *C. phaleratus* extend as blind

sacs as far back in the abdomen as the anterior border of the third segment.

The female varies in length from .9 mm. to 1.26 mm., and the male is usually about .2 mm. shorter. The largest specimens measured came from Portage La Prairie, Manitoba.

This is a beautifully colored species. The ground color is reddish brown. The second cephalothoracic segment, the last abdominal segment with the stylets, the swimming feet, and the last segment of the first antennæ are sky-blue. A yellow spot surrounds the eye.

The egg-sacs are dark blue or black.

The best character for the ready recognition of this species is its strong superficial resemblance to the genus *Canthocamptus*.

GENERAL DISTRIBUTION OF CYCLOPS IN NORTH AMERICA.

Of the eighteen species and three varieties of Cyclops which have been reported as occurring in North America, but three species and two varieties, namely, *ater*, *modestus*, and *edax*, and varieties *insectus* and *brevispinosus* of *viridis* are characteristic of America, while the remaining fifteen species and one variety are common to both Europe and America.

Probably *bicuspidatus*, *serrulatus*, *viridis*, *albidus*, and *edax* might be found in any state in the Union, so general is their distribution.

In the Great Lakes by far the most abundant species are *bicuspidatus* and *edax*. Often either one or the other of these two species will constitute nearly the whole of the crustacean plankton.

Collections from the high lakes and ponds of the Northwest usually contain Cyclops, often in considerable numbers, but they are never present in such great quantities as is the genus Diaptomus and the Cladocera. The commonest of these mountain forms are as follows: *bicuspidatus*, *viridis* var. *insectus*, *serrulatus*, and *albidus*, though *viridis* var. *brevispinosus*, *bicolor*, *dybowskii*, *modestus*, and *edax* have been found in such situations. In collections from Crater Lake, Oregon, I found a very few specimens of *albidus* and *ser-*

rulatus. This lake is in the Cascade Mountains and is the highest lake of its size in the world.

As very few observations have been made on the Cyclopidæ of rivers, I examined a continuous series of collections made in the Illinois River at the Illinois Biological Station, extending from May to September, 1896. In the first of these collections *bicuspidatus* was the predominating form, but it soon disappeared entirely, its place being taken by *viridis* var. *insectus*. From this time throughout the summer *insectus* was by far the most abundant form. *Edax*, *viridis* var. *brevispinosus*, *leuckarti*, *prasinus*, *serrulatus*, and *varicans* were common in the collections, while *fimbriatus* var. *poppei*, *viridis*, *modestus*, *bicolor*, *albidus*, and *phaleratus* were of rare occurrence.

LIST OF NORTH AMERICAN SPECIES.

Below is a list of the fresh-water Cyclopidæ reported from America. I have myself seen all of the species of this list except those herein credited to Herrick.

Genus *CYCLOPS*.

I. Subgenus *Cyclops* s. str. Claus.

1. *Cyclops leuckarti* Claus.

This is a rare species throughout the north central States.

2. *Cyclops insignis* Claus, *fide* Herrick.

Herrick has found at Long Island a form which he identifies as this species.

3. *Cyclops edax* Forbes.

This is a very common species in the Great Lakes and in the waters of the north central States, Florida, and Wyoming. It occurs in Argentina, South America.

4. *Cyclops oithonoides* Sars, *fide* Herrick.

I regard the occurrence of this species in America as very doubtful.

5. *Cyclops dybowskii* Landé.

A rare species found only in the small mountain lakes of Wyoming and in a temporary pond at Urbana, Illinois.

6. *Cyclops viridis* Jurine.

Either the typical form or its varieties occur everywhere in the fresh waters of the United States. It is the commonest form of the temporary ponds.

a. var. *brevispinosus* Herrick.

b. var. *insectus* Forbes.

7. *Cyclops bicuspidatus* Claus.

This species is of the widest range and greatest abundance. It is the commonest Cyclops in the Great Lakes.

8. *Cyclops vernalis* Fischer.

Occurs in small numbers in Lake Geneva, Wisconsin.

II. Subgenus *Macrocyclops* Claus.

9. *Cyclops fuscus* Jurine.

Occurs sparingly in the ponds and lakes of Wisconsin, Michigan, Illinois, and Massachusetts.

10. *Cyclops albidus* Jurine.

Rather a common species throughout the whole range of the genus.

III. Subgenus *Homocyclops* n. subgen.

11. *Cyclops ater* Herrick.

Very rare throughout the Mississippi Valley. Also in Lake St. Clair (Kofoid).

IV. Subgenus *Orthocyclops* n. subgen.

12. *Cyclops modestus* Herrick.

An uncommon species in the lakes and streams of Wyoming, Alabama, and the north central States.

V. Subgenus *Microcyclops* Claus.

13. *Cyclops bicolor* Sars.

Rare in Wyoming, Illinois, Wisconsin, Michigan, and Minnesota.

14. *Cyclops varicans* Sars.

A fairly common species throughout the range of *Cyclops* in North America.

VI. Subgenus *Eucyclops* Claus.

15. *Cyclops serrulatus* Fischer.

Very common everywhere.

16. *Cyclops prasinus* Fischer.

Abundant in all sorts of waters in the Mississippi Valley, Massachusetts, and Florida.

VII. Subgenus *Paracyclops* Claus.

17. *Cyclops phaleratus* Koch.

A rare species in Manitoba, Massachusetts, Alabama, and the north central States.

18. *Cyclops fimbriatus* var. *poppei* Rehberg.

A rare species in Manitoba, Alabama, and the north central States.

19. *Cyclops affinis* Sars, *fide* Herrick.

If this form occurs in America it is very rare, and limited in its distribution.

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EXPLANATION OF PLATES.

Plate VIII.

Fig. 1. *Cyclops leuckarti* Claus.
Fig. 2. Last two segments of antenna of same.
Fig. 3. Fifth foot of same.

Plate IX.

Fig. 1. *Cyclops edax* Forbes.
Fig. 2. Last two segments of antenna of same.
Fig. 3. Fifth foot of same.

Plate X.

Fig. 1. *Cyclops viridis* Jurine.
Fig. 2. Fifth foot of same.
Fig. 3. Receptaculum seminis of same.

Plate XI.

Fig. 1. Variations in outer terminal spine of stylet of *Cyclops viridis* var. *brevispinosus* Herrick.
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Fig. 1. *Cyclops bicuspidatus* Claus.
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Plate XIV.

Cyclops ater Herrick.

Plate XV.

Fig. 1. Last two segments of antenna of *Cyclops ater* Herrick.
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Plate XVI.

Fig. 1. Antenna of *Cyclops modestus* Herrick.
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Fig. 3. Receptaculum seminis of same.

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Cyclops serrulatus Fischer.

Plate XVIII.

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Fig. 1. *Cyclops prasinus* Fischer.
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Plate XX.

Fig. 1. Fifth foot of *Cyclops prasinus* Fischer.
Fig. 2. Receptaculum seminis of same.
Fig. 3. *Cyclops phaleratus* Koch.

ERRATA.

Page 31, line 8, for *solid* read *dotted;* line 10, for *dotted* read *solid.*

Page 34, line 6, for *equal* read *subequal.*

Page 44, line 8, for *species* read *variety.*

Page 63, line 16, before America insert North.

Page 66, under Birge, E. A., for '94 read '95.

Page 73, under Koch, C. L., for XXV. read XXXV.

Page 77, line 2, before Zoology insert 7e Sèr.; line 3, for XVI. read XII.

Page 78, line 13, for Heft II. read Heft 11.

Page 79, for *Villipoix*, R. M. de, read *Villepoix*, R. M. de.

Page 80, under Zacharias, O., for '85 read '86; and in entry for '87, for Taf. I. read Taf. XV.

Page 81, line 5, for '95 read '94.

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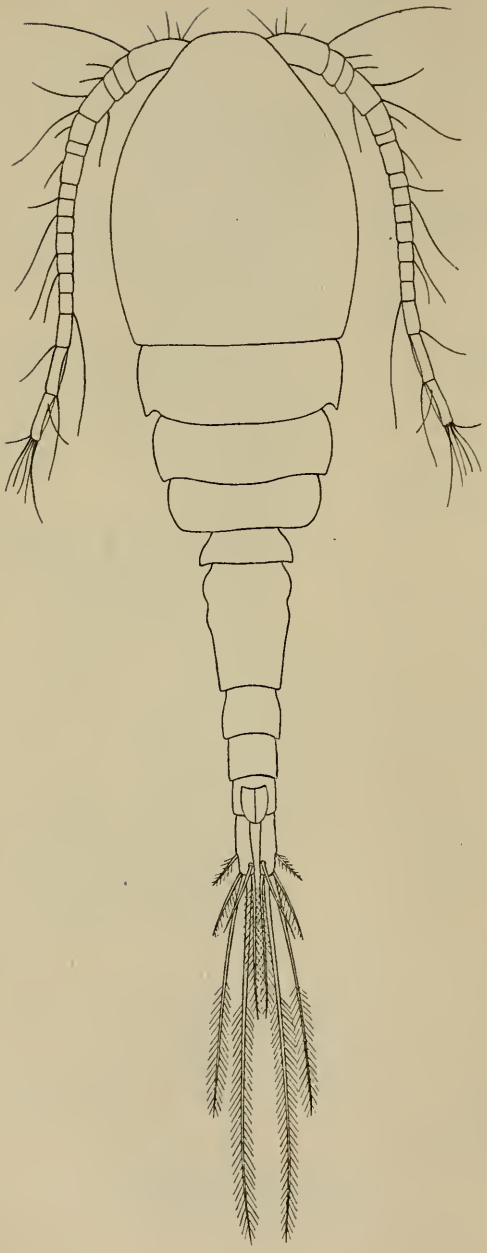
(Synonyms in Italics.)



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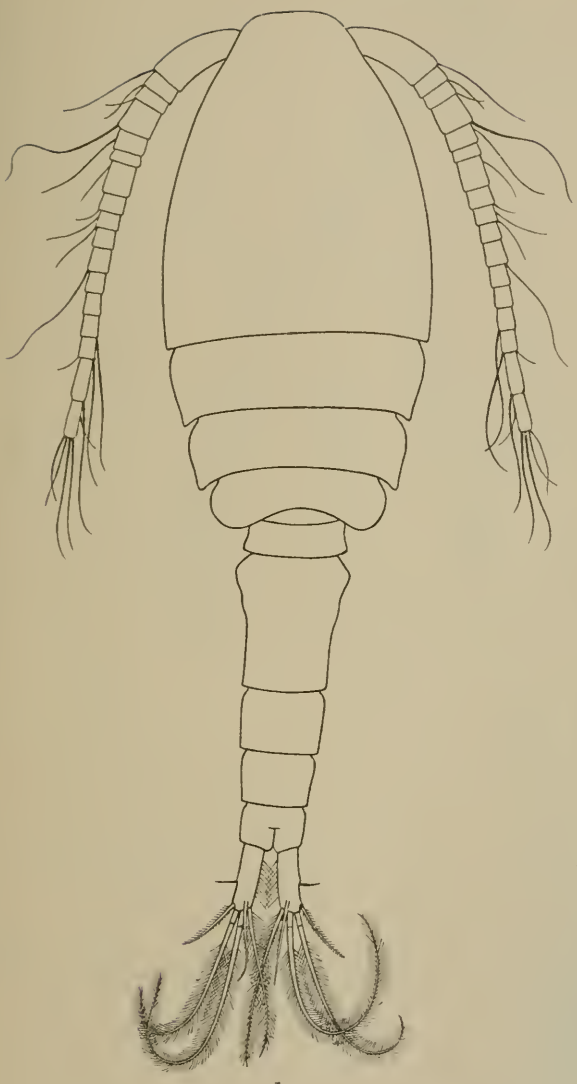

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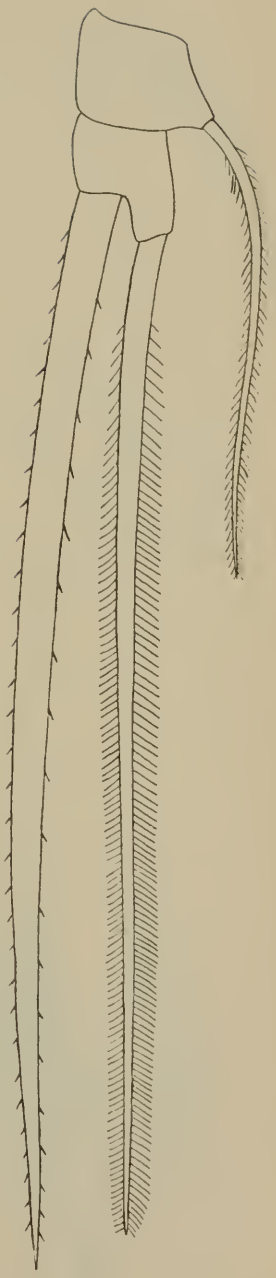

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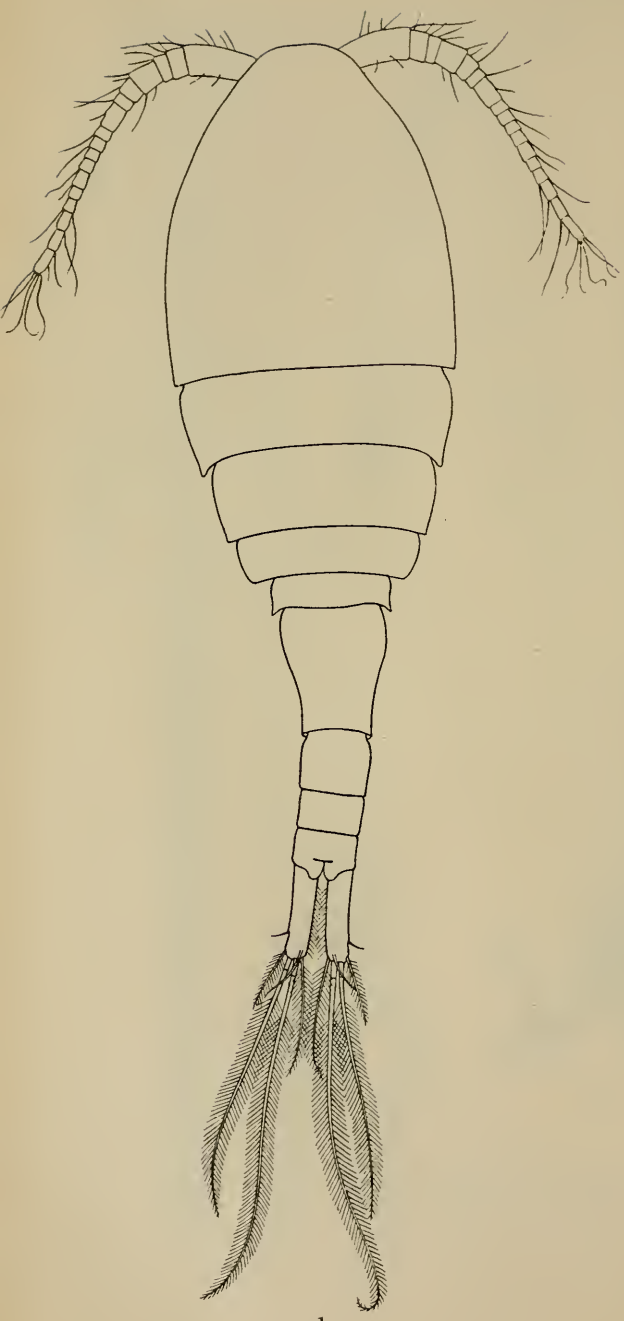

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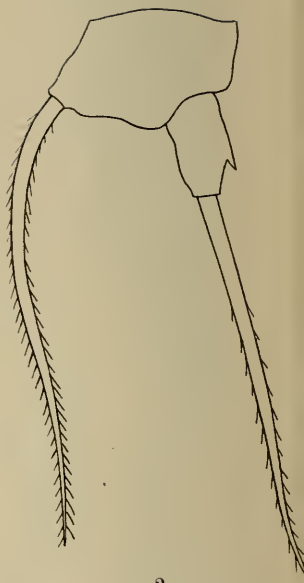

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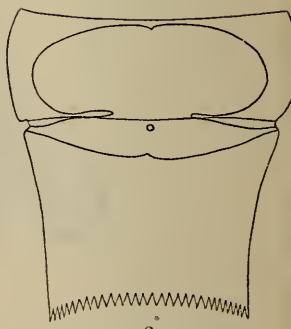

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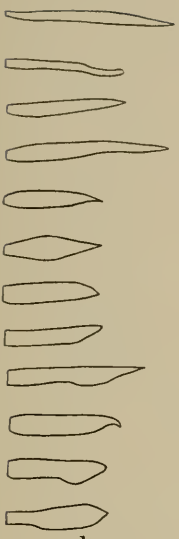

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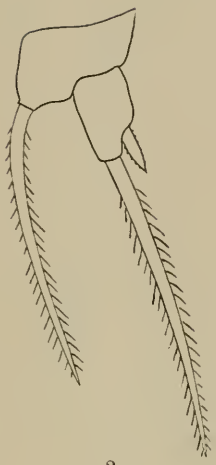

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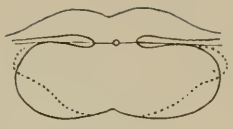

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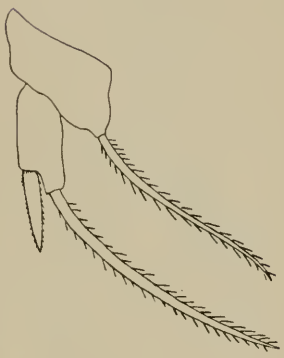

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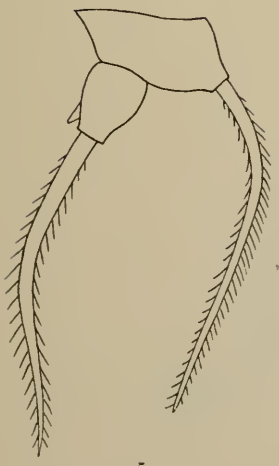

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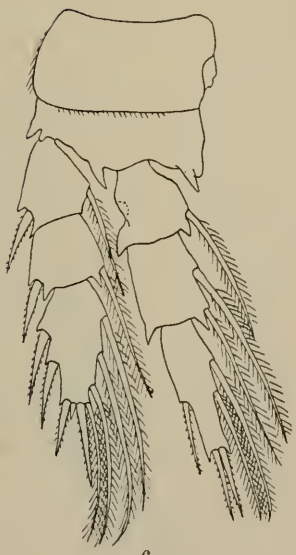

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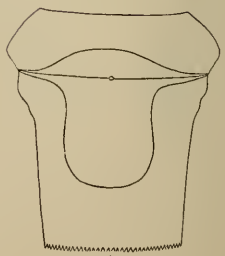

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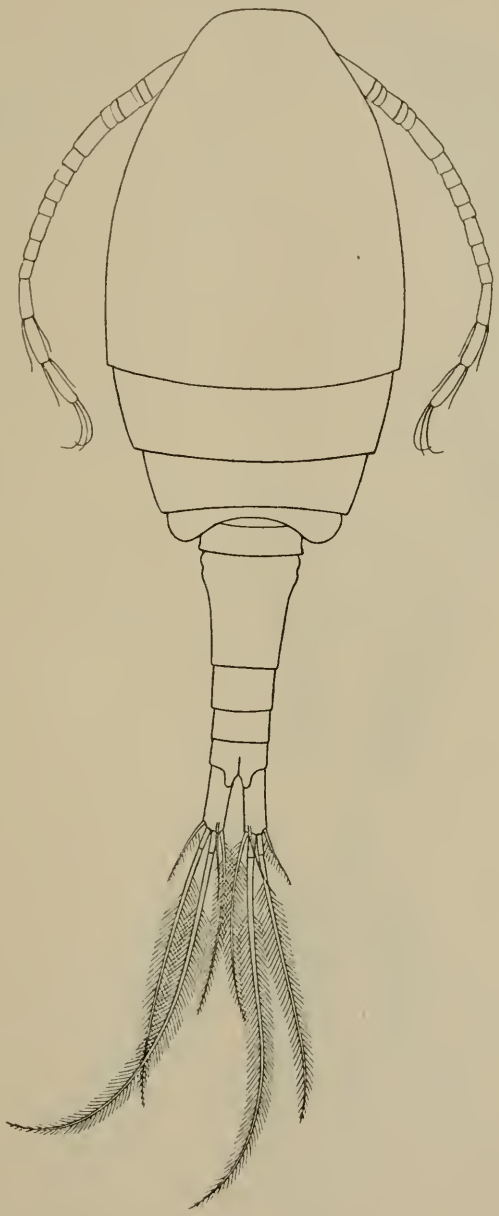

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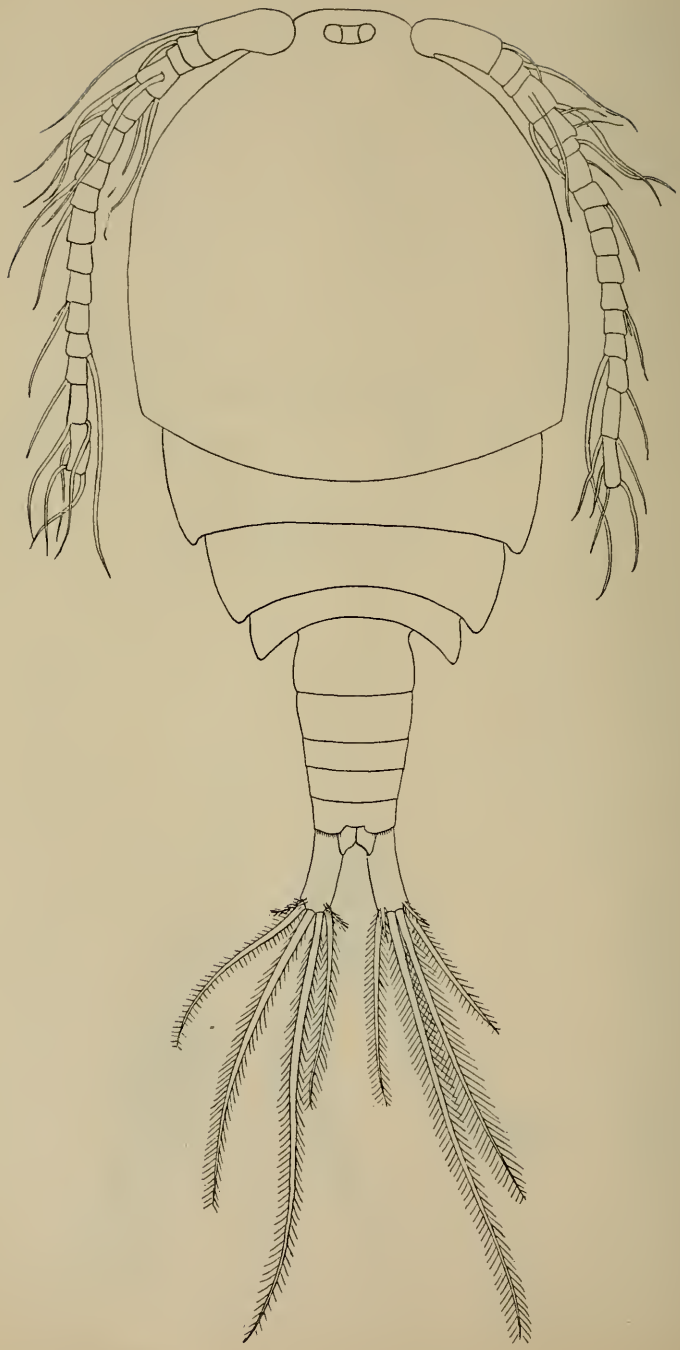

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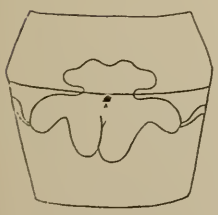

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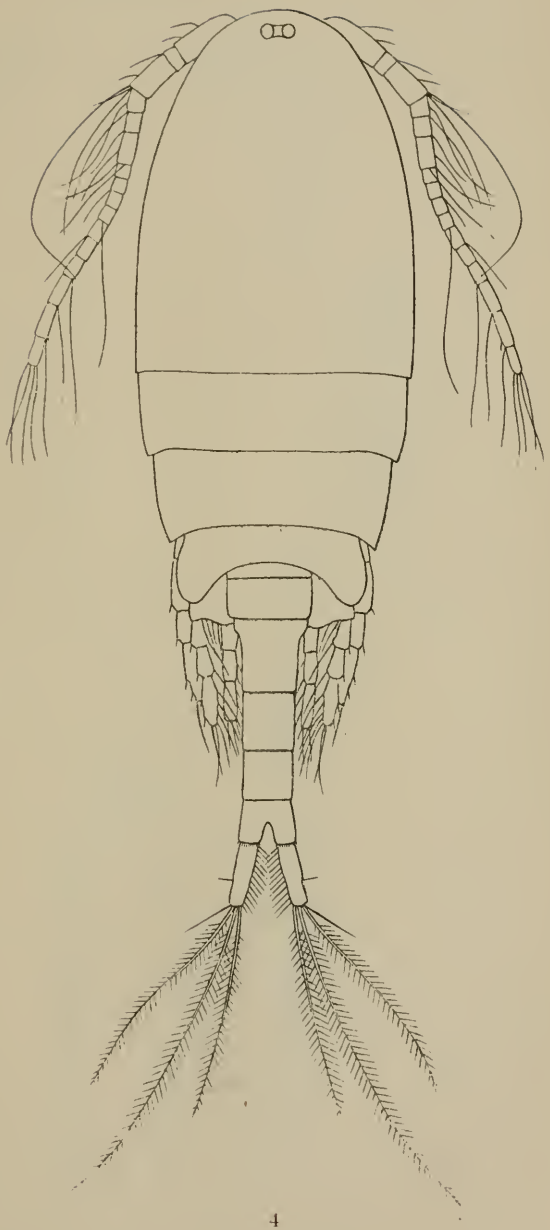

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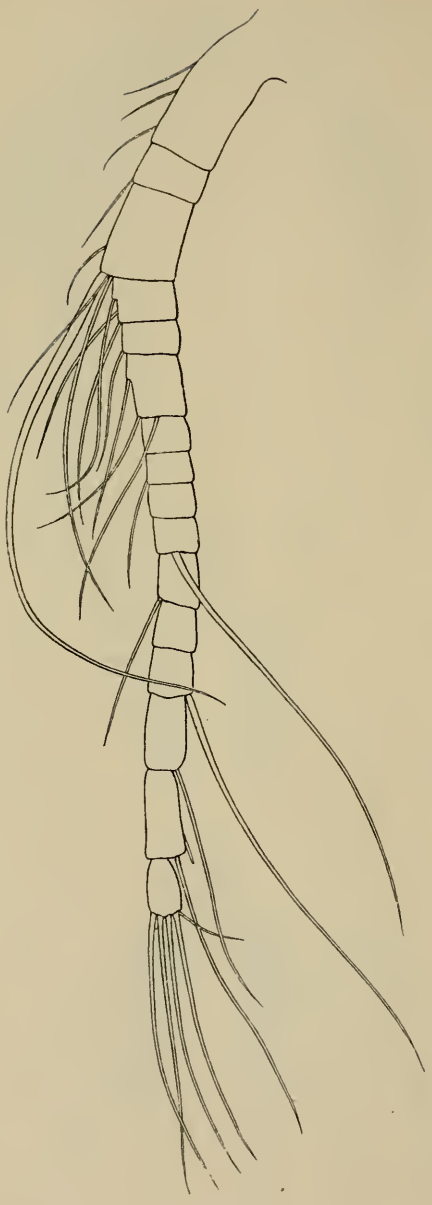

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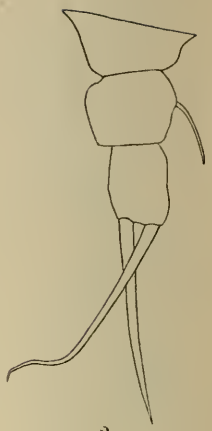

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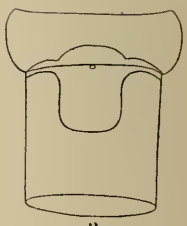

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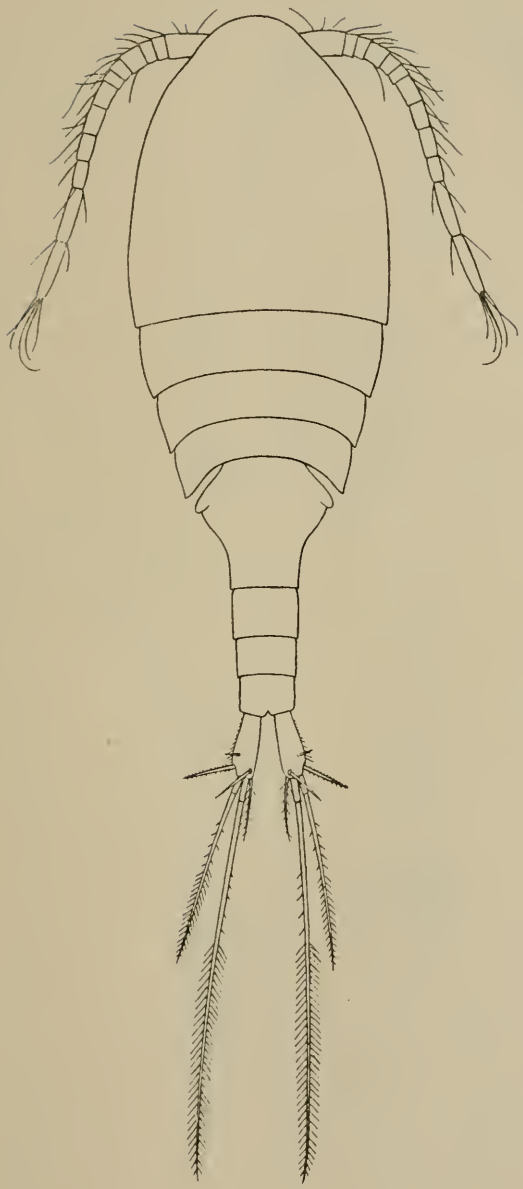

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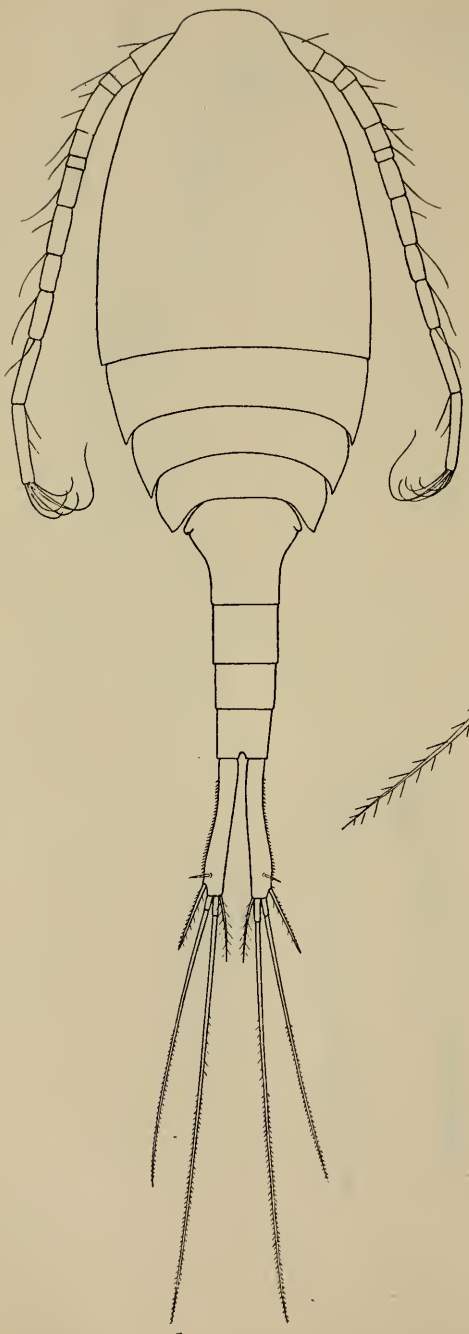

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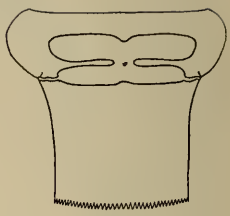

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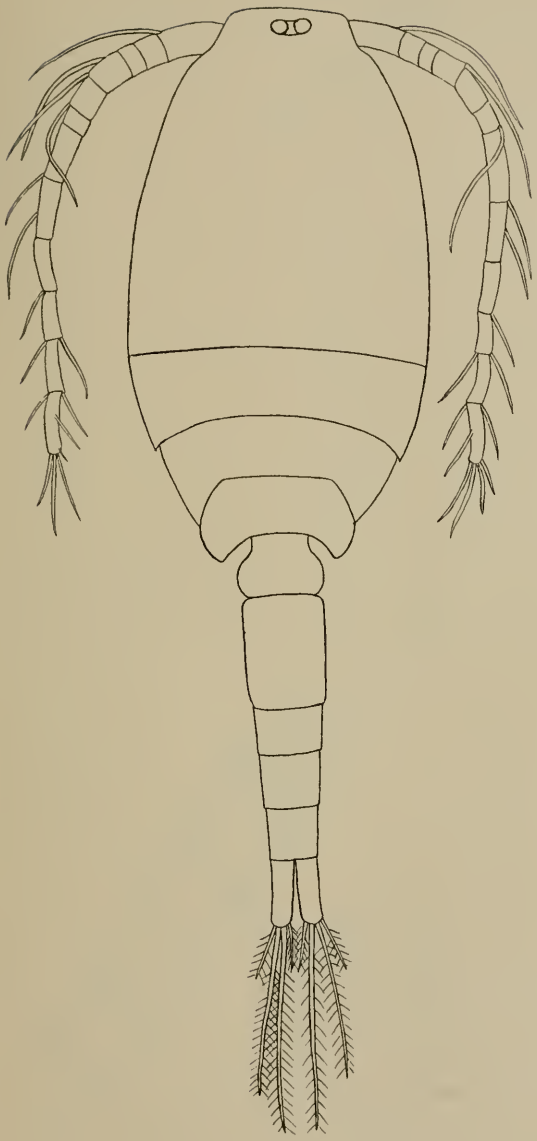

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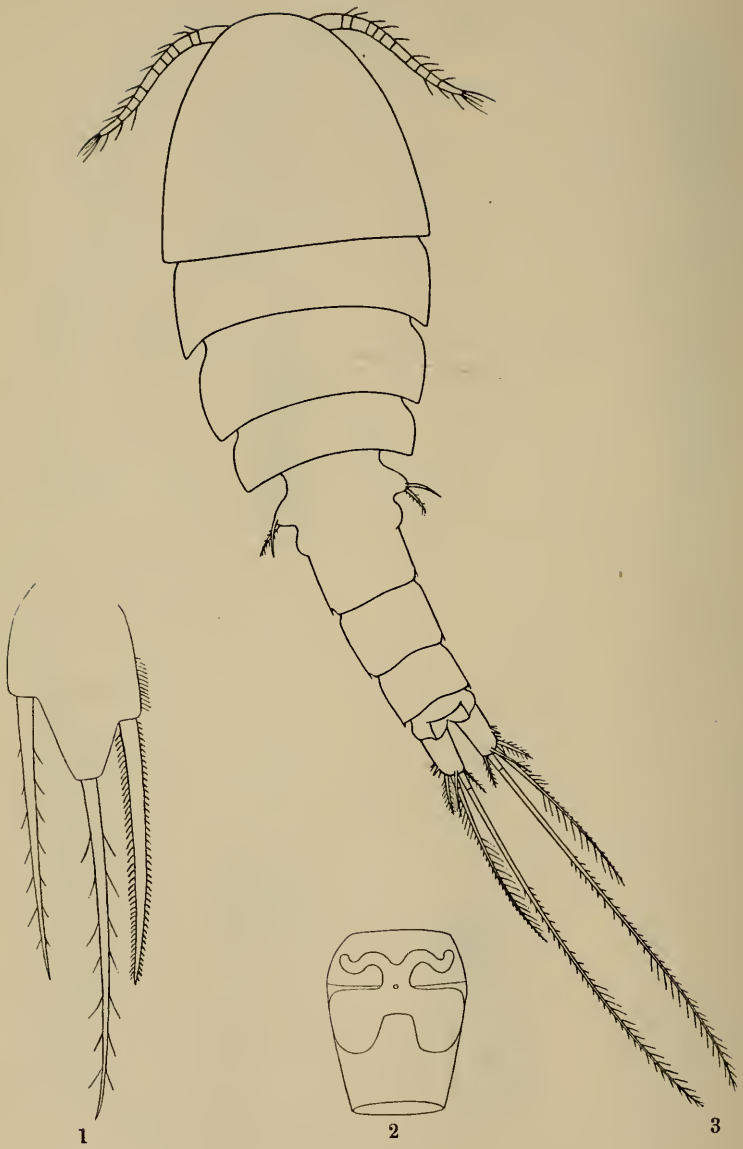

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