8.—ON SOME LAKE SUPERIOR ENTOMOSTRACA.

By S. A. Forbes.

(With 4 plates.)

It seems hardly creditable to American zoology, or to the present tendency of zoological research among us, that the minute animal life of the greatest body of fresh water on the globe should be less fully known than that of scores of insignificant European lakes, or even of many a wayside pool. While our students eagerly engage, often at arm's length and under almost prohibitory disadvantages, in merely imitative work on the problems most prominent in the laboratories of the Old World, we leave untouched, at our very doors, virgin fields of research which must deeply stir the envy of the active group of zoologists who have lately enriched science with a mass of new and highly significant knowledge of the lake fauna of Europe.

It is especially with the hope of calling more general attention to the animal life of our own larger lakes that I present here a preliminary description of the product of a few hauls of the surface net made in August, 1889, from piers and breakwaters, during a hurried trip along the south shore of Lake Superior. The only points from which it was possible for me to make even these imperfect collections were the little town of l'Anse (at the head of Keweenaw Bay), Marquette, and White Fish Point. I improved also a brief opportunity to use the net from a skiff in Lake Michigamme, in Marquette County, a few miles south of the great lake, with which its waters are connected only by way of the Menominee River and Lake Michigan.

The only published information on the Entomostraca of Lake Superior is that given by Prof. S. I. Smith, of Yale, fifteen years ago, in the Report of the U. S. Fish Commissioner for 1874,* and there but four species of the free-swimming forms of these minute Crustacea are positively identified. Concerning the entomostracan fauna of the Great Lakes in general, we have brief papers by Professor Birge† and myself‡ on species

*Sketch of the Invertebrate Fauna of Lake Superior, p. 690.

†"Notes on Cladocera." Trans. Wis. Acad. Sci., 1876–'77, p. 77. "Notes on Crustacea in Chicago Water Supply, with Remarks on the Formation of the Carapace." Chicago Med. Jour. & Examiner, xvi, pp. 584–590 (Dec., 1881).

‡"On Some Entomostraca of Lake Michigan and Adjacent Waters." Amer. Nat., xvi, pp. 537, 640.

from Lake Michigan, mention of a single doubtful form in De Kay's Zoology of New York,* and a brief article on "Fish Parasites" by Dr. Kellicott.†

In preparing the present notes I have had particularly in mind, besides mere discrimination and description, the biological relations of the species, as dependent on their situations and relative abundance; the origin of the Great Lake fauna, whether immediately and especially marine or common with that of the Northern lakes at large; and the phenomena of the evolution of species in some of the more intricately related groups.

This subject has also its important economic relation. A thorough examination of the minute life of the Great Lakes, with special reference to the distribution, numbers and habits of the species of Entomostraca occurring there, would greatly assist in the solution of some of the difficult problems of practical fish culture. Since it is now demonstrated that our most important fishes are almost wholly dependent, at a critical period of their lives, on a sufficient supply of these small crustaceans, these furnishing to fishes the first food they eat, and continuing for some time to be substantially their only food resource, a knowledge of these little creatures is scarcely less important to the scientific fish culturist than a knowledge of fishes themselves.

Order COPEPODA.

Family CALANIDÆ.

Diaptomus sicilis Forbes (Plate I, fig. 6).

D. sicilis, Forbes. Am. Nat., xvi (1882), pp. 541 (July), 645 (Aug.).

D. pallidus, var. *sicilis*, Herrick. Final report on the Crustacea of Minnesota included in the orders Cladocera and Copepoda (in 12th Ann. Rep. Geol. and Nat. Hist. Surv. Minn. (1883), p. 137).

D. sicilis Underwood. Bull. Ill. State Lab. Nat. Hist., II, 1886, p. 329.

This beautiful species, a model of elegance and symmetry, is perhaps the most abundant entomostracan in my Lake Superior collections—relatively much more common than in the southern waters of Lake Michigan. It is closely similar to *D. gracilis* Sars (a common species of clear lakes in Europe, from northern Italy‡ to Finland and Scandinavia), but the constancy of the characters which distinguish it warrants its separation. Although it is a decidedly-variable form, its observed variations do not appear to include or sensibly approximate the characters of *gracilis*. The two have evidently had a common origin, not very remote; but their present geographical separation, shown by the constancy of their differences, makes it altogether probable that this origin dates from a time when communication between the fresh waters of the

* Part VI, "Crustacea," p. 62.

† "On Certain Crustacea Parasitic on Fishes from the Great Lakes. Proc. Amer. Soc. of Microscopists," I, pp. 53–57.

‡ Imhof.

northern regions of Europe and of America was more immediate than now—a time, that is, when the lands of the northern hemisphere were more closely connected or less widely sterilized by ice.

The typical form of *sicilis* is larger than *gracilis*, females ranging from 1.3 to 1.6^{mm} in length, without the caudal setæ, while *gracilis* does not commonly surpass 1^{mm}. The fifth and sixth segments of the cephalothorax are very imperfectly divided (no suture being apparent on the back), and the last segment is more deeply emarginate behind than seems to be the case with *gracilis*. There is a single very minute spine at the tip of the lateral lobe of this segment, and sometimes a still more minute one some distance below and within this, on the inner inferior part of the lobe.

In ovigerous females the abdomen has three segments, besides the furca, of which the first is as long as the second and third—the second being the shortest, but still nearly equaling the third. The furca is, in the female, a little longer than the third segment, in the male much longer than the second, the second, third, and fourth abdominal segments in the latter sex being almost exactly equal, and the first a little shorter.

The basal joint of the legs of the fifth pair (Pl. 1, fig. 6,) bears, in both male and female, a large cylindrical process, ending with a stout spine or spine-like tip. In the female, the third joint of the outer ramus is scarcely distinguishable as such, being merely a stout spine or hair articulated at the base and without accessory hairs or spines. The large process of the second joint is slightly curved outward. The inner ramus has two long, strong diverging spines, half as long as the ramus, near its tip, this extending beyond their insertion as a smooth, obtuse triangle. Left leg of male without spine on second basal joint or terminal seta on outer ramus. Inner rami of both legs smooth at tip, one- or two jointed. Outer ramus of left leg distinctly two-jointed, the segments equal, the tip a rounded cushion covered with delicate short hairs. A similar hairy pad at middle of inner surface of this segment.

In specimens taken August 9 at Marquette, spots of vivid red about the mouth and at the posterior fourth of the cephalothorax were commonly connected by an indigo-blue or pale red stripe, which included the alimentary canal and often adjacent structures. The ovaries were also often blue, sometimes very bright. Occasionally one was seen with much more red irregularly distributed in the center of the body, and it is probable that earlier in the season red was the prevailing color. The egg masses of the female were blue, varying to red; the eye dark red; the abdomen colorless; and the thoracic legs of a bluish tint.

D. sicilis, var. **imperfectus**, new var.

Occurring commonly with the form above described is another (often certainly adult, as shown by the developed spermatophore in the male and the external egg masses in the female) much smaller in average size, and with the terminal hook of the fifth pair of legs of the male thicker,

stouter, and less regularly curved. I have not been able to find positive and unvarying distinctions between this form and the preceding, and am disposed to regard it as the barely matured adult, reproducing while yet capable of further structural progress. Its average total length, without setæ, is 1^{mm}, the thorax measuring $.7^{mm}$ and the abdomen $.3^{mm}$. The antennæ are relatively longer than in the typical form, extending five or six joints beyond the cephalothorax instead of two or three, as in the other. The inner ramus of the left leg is also relatively longer, reaching to the tip of the outer ramus, while in the typical form it reaches only to the base of the preceding joint.

Both the above are extremely abundant in all the collections made from northern Michigan, and are likewise among the commonest Entomostraca of southern Lake Michigan and adjacent waters. The more highly developed variety is relatively commoner in the Great Lakes, and the imperfect form is the ordinary Diaptomus of the smaller lakes and permanent ponds adjacent. The latter, if either, is to be identified with the insufficiently described *Diaptomus pallidus* of Herrick.*

Epischura lacustris Forbes. (Pl. I, figs. 1–5; Pl. II, fig. 7.)
Amer. Nat., XVI (1882), p. 648.

This remarkable species,† the most peculiar of our fresh-water Copepoda, distinguished from all others known by the modification of several abdominal segments in the male as a sexual grasping organ, was common in both Lake Superior and the smaller lake—most abundant in a collection made at night in the harbor at Marquette.

Among the many hundreds of specimens which I have examined from the Great Lakes and from several of the smaller lakes of Illinois, Michigan, and Wisconsin, I have rarely seen an immature form, still more rarely a female without a spermatophore attached, and never one with an egg sac. The spermatophore (occasionally there are two) is fixed to the female abdomen by a large oval mass of cement, which may be so softened by a solution of potash as to permit the removal of this finger-shaped structure, otherwise easily mistaken for a process of the abdomen itself. The absence of an external egg mass is one of several features of this genus relating it to Heterocope of the lakes of Europe, which genus is indeed its nearest ally.

Specimens taken from Lake Michigamme, August 9, were tinged with red or violet, most deeply in the ventral region, as if a much more brilliant color had largely faded.

The cephalothorax of the male (Pl. I, fig. 1) has but three completely distinct segments, the last being united to that preceding, and that bear-

* 7th Ann. Rep. Geol. and Nat. Hist. Surv. of Minn. (1878), p. 91.

† Two additional species of this genus, *E. nevadensis* Lillj. and *E. nordenskiældi* Lillj., the former from lakes in the Sierras and the latter from Newfoundland, have lately been published in *Revision des Calanides d'Eau Douce*, par Jules de Guerne et Jules Richard, pp. 92–96 (Paris, 1889).

ing the third pair of legs alone being free. Beneath, however, all the leg-bearing segments except the last are marked off by sternal sutures.

The head is distinguished by a transverse constriction, but without suture, and the antennal region is similarly marked off from the remainder of the head. The eye is distinctly double in structure, with but little pigment.

Owing to modification and distortion of the male abdomen (Pl. I, fig. 1; Pl. II, fig. 7) its segmentation is difficult to make out, but the muscular structure shows that there are but four free segments. Of these the second and third are laterally produced to form a large chela, and the fourth bears the toothed and broadly paddle-shaped processes previously described,* the former of these springing from the ventral portion of the segment and the latter from the dorsal. The base of the right ramus of the furca is concave without to adapt it to these structures, the whole abdomen being evidently strongly flexed to the right when this complicated apparatus is in use. There are but three developed plumose setæ at the tip of each ramus, and besides these a short, stout tooth at the outer distal angle, and a delicate simple hair at the inner.

The antennæ are twenty-five jointed, and reach about to the third segment of the abdomen. The median joints of the female antennæ and of the left of the male are thickened at the articulations, giving them a slender hour-glass form.

The right antenna of the male is apparently twenty-one jointed, the thirteenth to the eighteenth segments are dilated, and the nineteenth segment is hinged upon the preceding. Both antennæ are richly supplied with sensory structures, which have the form of two- or three-jointed hairs, with very delicate terminal segments, no olfactory clubs occurring. The basal segments of these hairs on the first and third joints are especially large and long, and contain distinct cells and finely granular matter. The terminal joint of each antenna is lobed at tip, with six long hairs; and there are four such hairs on the penultimate joint.

The antennules are short, the ramus apparently but three-jointed, the short median joints common in this appendage being only obscurely indicated. The second joint is as long as both the other two, the first is very short, the third about three-fourths the second. The ramus bears four terminal and four lateral long curved plumose hairs.

Before the mouth opening is a vaulted labrum, opposed to a similar elevation behind, the mandibles fitting into the transverse cleft between these lips.

The mandibular palpus (Pl. I, fig. 4) is three-jointed, the first and last joints very short, each about a fourth of the length of the middle one. The greatest width of the latter is contained about twice in its length. The tip of the palpus bears six long plumose hairs, with a cluster of four shorter ones near it. The ramus is short, twice as long as the third joint, obscurely four-jointed, and bears three long plumose terminal hairs and three longer lateral ones.

* Amer. Nat., *loc. cit.*

First maxilliped stout and short, about four times as long as wide. Three distinct joints or segments, with a number of small indefinite articles compacted at the tip, this last bearing four long, stout, curved, parallel bi-pennate setæ, and two smaller ones not in the same series. Proximal joint the longest, the second shortest, about half as long as the third, the latter two thirds the first. The second joint bears two plumose setæ and the third joint three, the two basal of these upon a separate lobe. The latter joint bears also a fourth short stout seta inserted near the lower one.

The second maxilliped has three lobes on the anterior margin of the basal joint, each bearing two long, stout, coarsely plumose bristles, with their barbs extending forwards. The second joint bears one very long and one short plumose bristle at the anterior inferior angle. The remaining joints, together about as long as the second joint, bear five long and two shorter plumose bristles.

The first four pairs of legs (Pl. I, fig. 5) are similar, the outer ramus three-jointed, and the inner one-jointed. The last joint of the outer ramus of the first pair is about as long as the two preceding, and the tip of the inner ramus reaches about to the middle of the second joint of the outer. The outer ramus of the fourth pair of legs (Pl. I, fig. 5) has two teeth at the outer tip of each of the two basal joints. The terminal joint of this ramus is armed as follows: A short, simple spine at middle of outer margin, and another at the distal outer angle; a single large and long terminal seta, strongly and sharply toothed externally and plumose within; and four long plumose setæ attached to the inner margin. The inner ramus bears two terminal and three internal plumose setæ. The left leg of the fifth pair in the male (Pl. I, fig. 3), viewed from behind, has the basal joint very large, broader than long, with the inner inferior angle produced downwards as a long, stout, curved process or arm, as long as the two remaining joints. The second joint is trapezoidal, shortest within. The third joint is about half as wide at base as the first, is straight without, with a sharp small tooth at its distal third, and bifid at tip. On the inner margin this joint is at first dilated a little and then deeply excavated to the narrow tip, to receive the lower end of the left leg, the lower two thirds of this margin forming the segment of a circle.

The marked distinction of this genus points to a separation from the stock common to it and Heterocope earlier than that of our other characteristic species of Calanidæ, and a much earlier appearance in its present habitat than that, for example, of the following species, which, like Epischura, is without egg sac.

Limnocalanus macrurus Sars, var. **auctus**, new var.

Amer. Nat., XVI (1882) p. 648.

This large calanid, very abundant at times in the southern end of Lake Michigan, and occurring also in Geneva Lake, Wis., I found twice in Lake Superior, at Marquette. Our specimens differ constantly

from the European, so far as I have seen, in a few slight particulars—especially interesting because of their minute and trivial character; but in every detail of any importance the New and Old World individuals are alike, so far as I can judge from the original description of Sars* and from the amply illustrated paper of Nordqvist.†

The minute terminal segment of the antennæ, the twenty-fifth of the European form, is in our examples consolidated with the preceding, so that there are but twenty-four segments, and numbers 8 and 12 are without the hook-like spines mentioned by Nordqvist. The armature of the mandible is somewhat reduced, consisting in the American form of seven short teeth, the two lower acute and widely separated, and the five remaining blunt and emarginate at tip. At the upper end of this series is a slender, acute tooth, and a small simple hair. There is no row of accessory spines on the mandible, as figured by Nordqvist.

The slight differences noted are in the direction of a higher specialization, and suggest, as do those of the Diaptomi, that our American variety has had a more rapid course of development than the European.

In the Old World, Limnocalanus has been found only in the larger lakes of Finland and Scandinavia, and in the gulfs of the Baltic (Finland and Bothnia). It seems to have been distributed in company with *Diaptomus sicilis*, and later than Epischura; and is probably now isolated from its European brotherhood—a geographical variety on the way to become a species.

Family HARPACTIDÆ.

Canthocamptus, sp.

Only a few specimens of this genus of minute Copepoda have been found in my Lake Superior collections, and in the one from Lake Michigamme—a number too small to permit a study of the species.

Family CYCLOPIDÆ.

Cyclops thomasi Forbes. (Pl. II, fig. 8.)

Cyclops thomasi Forbes, Amer. Nat. xvi (1882), p. 649; Cragin, Trans. Kan. Acad. Sci., viii (1882–'83), pp. 68–70.)

This well-marked species—the commonest of Lake Superior, where it is the usual companion of the Great Lake Diaptomi—was taken in nearly every haul, often in countless numbers. It is a species of clear water and the open lake, and was far less frequent at L'Anse Bay than at Marquette and White Fish Point. In Lake Michigamme it was not seen.

Cyclops gyrinus, n. sp. (Pl. II, fig. 9; Pl. III, fig. 14).

A stout, heavy species, with long first segment, strongly arched

*Oversigt af de indenlandske Ferskvandscopepoder. Forhand. i Vidensk.-Selsk, i Christiania, p. 226.

†Die Calaniden Finlands, p. 31.

cephalothorax, short furca, well-developed terminal setæ, and seventeen-jointed antennæ, reaching the abdomen, with acute ridge on the three distal joints, that on the last serrate. (Pl. III, fig. 14.)

Total length 1.8^{mm}, cephalothorax 1.1^{mm} long, .63^{mm} wide, and .43^{mm} high; abdomen and furca .7^{mm} long, equaling the longest bristle.

Basal segment of antennæ without circlet of minute hairs, the second segment short, the third shorter, the fourth equal to the second and third together, the fifth a little longer than the second, the sixth equal to the third, the seventh slightly longer than the fifth and sixth together; segments eight to eleven sub-equal, increasing a little in length, twelve to fourteen a little longer, fifteen to seventeen much longer. Antennules with line of delicate hairs inclosing a patch on posterior surface of each segment, elongate oval on all but the proximate, where it is circular.

Labrum with twelve conspicuous teeth, the second from each end decidedly larger than the others.

The swimming legs with all the rami three-jointed. The first pair (Pl. II, fig. 10) with the segments of the outer ramus about as broad as long, the terminal segment with one spine and two spine-like setæ at tip, two spines without and three setæ within; the other segments all with one spine and one seta. The inner ramus with one very stout spine at tip and one very slender seta not longer than the spine, one seta without and three within on the distal segment; the basal segment of this ramus with one seta and the second with two.

Second pair of legs with two very stout spines and a slender seta at tip of the last segment of the outer ramus; two stout spines without and four setæ within. The armature of the inner ramus like that of the preceding.

Outer ramus of the third pair of legs with two spines and one seta at tip (the inner spine the longer), three spines without and four setæ within; the inner ramus as before.

In the fourth pair of legs (Pl. II, fig. 11), the outer ramus has two spines and one bristle at tip (the bristle shorter than the longer spine), one spine without and four bristles within, the lower of the latter abortive. The inner ramus has the last joint slender, truncate, with two stout spines at tip, the outer one the larger, with one seta without and two within.

The fifth pair of legs (Pl. II, fig. 12), are jointed, the basal segment 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 (terminal) segment is about as long as the preceding is wide, lobed in the middle, and tri-setose, the outer seta shorter than the inner, and the latter about half as long as the median.

Abdomen short, the greatest breadth but twice in length, the furca short and broad, the rami half as wide as long, about as long as the two

last segments of the abdomen. The inner terminal bristle three times as long as the outer, three fifths as long as the outer median, and about two fifths the length of the longest. A transverse row of spinules at the base of the outer seta; the distal end of the last abdominal segment dentate; and the distal end of the segment preceding with a few teeth at the sides.

Last thoracic segment minutely dentate on posterior margin.

This species is allied to *coronatus*, from which it is distinguished (among other characters) by the absence of the dentations of the antennal segments, which gave the latter its name, by the absence of cilia on the inner surfaces of the rami of the furca, and by the much smaller size.

Described from several specimens (females)taken inshore at the head of Keweenaw Bay on the south shore of Lake Superior.

Cyclops edax, n. sp. (Pl. III, fig. 15; Pl. IV, figs. 16-19.)

A small species, usually more or less pigmented, moderately robust, with short furca, subequal caudal setæ, seventeen-jointed antennæ, and unusually prominent maxillipeds.

Length, without caudal setæ, 1.1^{mm}.

Cephalothorax oval, rather compact, broadest before the middle; first segment as long as the remainder; back moderately arched. Last thoracic segment scarcely broader than the first abdominal, slightly emarginate at the sides. First abdominal segment (Pl. III, fig. 15) very long, equaling the following three; last segment shortest, with a row of spinules at the posterior margin. Rami three eighths as wide as long, nearly twice the length of the last segment. The lateral spine 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 reach to the fourth thoracic segment and are without serrations, acute ridges, or other special armature, except a stout spine at the tip of the sixth segment. The basal joint is as long as the three following, and the last three joints are about as long as the six preceding, joints sixteen and seventeen being equal, and fifteen four fifths as long as sixteen. The fourth segment is as long as the fifth and sixth together, and the seventh a little longer. The tenth segment is wholly destitute of hairs and bristles. The antennules are slender, the first and second segments not distinctly articulated, the first twice as long as the second, the third and fourth equal to each other, and to the first. The two last segments minutely hairy on the posterior surface, except a little space near the tip of the last.

The first maxilliped is unusually long and slender, the basal segment being very nearly three times as long as wide, and the whole appendage as long as the last five antennal joints.

The last segment of the outer ramus of the legs of the first pair (Pl. IV, fig. 16) bears one spine and two setæ at tip, one spine without and

two setæ within. The inner ramus has at the tip of the last joint one stout spine and one slender seta, one seta without and three setæ within. The legs of the second and third pairs are armed alike, the terminal segment of the outer ramus in each bearing a slender seta and two spines at tip (the inner of these the longer, and the seta a little longer still), and one spine without and three setæ within. The inner ramus like the outer, except at the tip, where there is a single stout spine and a single seta. In the fourth pair of legs the last joint of the outer ramus bears two terminal spines and one seta, one spine on the outer margin and three setæ on the inner. The corresponding joint of the inner ramus is very narrow, has two spines at the tip, one seta without and two setæ within. The outer margin of this last segment is minutely hairy above the marginal seta. The rudimentary fifth foot is small, two-jointed, the first joint half as long as the second, twice as broad as long, with a slender simple bristle at the outer distal angle; the second joint with two setæ, the outer simple, longer than the preceding, the inner plumose and longest of all.

By its seventeen-jointed antennæ and two-jointed fifth foot with two terminal bristles, this species is related to *C. simplex* Pog., from which it is, however, readily distinguishable by the shorter last joints of the antennæ and the absence of the knife-like ridge. The proportions of the joints of the antennules, and the plumose terminal setæ of the fifth foot are additional distinctive characters.

This Cyclops was taken in moderate numbers from Lake Michigamme only.

Cyclops agilis Koch.

Amer. Nat., XVI (1882), p. 649.

This wide-spread Old World species, reported from England to Russia and Turkestan, and from Scandinavia to the Tyrol, and also known in this country from Massachusetts to Illinois and Minnesota, occurred in my Lake Superior collections from Marquette.

Cyclops pectinifer Cragin.

Trans. Kans. Acad. Sci. (1883) p. 71.

I have had no difficulty in distinguishing Professor Cragin's species described under this name* from the very closely related form last mentioned, although it is possible that larger collections of both might show them intergrading. This was the commonest Cyclops in the collections made at l'Anse.

Order CLADOCERA.

Family POLYPHEMIDÆ.

Polyphemus pediculus L.

In this curious crustacean, not uncommon in clear shallow lakes and ponds in Europe, we have an example of an immigrant, which has not

*A Contribution to the History of the Fresh-Water Copepoda. Trans. Kan., Acad. Sci., VIII, p. 66.

varied, that I can see, in any particular since its advent here, my specimens from l'Anse Bay, Marquette, and White Fish Point agreeing precisely with the specific descriptions and figures of P. E. Müller,* Lilljeborg,† and Schoedler.‡ Even the rudimentary legs of the fourth pair, although more swollen than in Müller's and Lilljeborg's figures, are similarly lobed, and bear the same armature; and the coxal tuberosities noted by Müller are also present.

My examples differ, on the other hand, from Leydig's plates and descriptions in the presence of four curved spines instead of three at the tip of each of the first three pairs of legs, and in the number of plumose bristles on the antennæ,—seven on each ramus in ours, while in Leydig's *oculus* there are eight on the outer ramus. These distinctions of *pediculus* and *oculus* have already been noticed by Schoedler, but subsequent writers have considered them insignificant, and bring all known forms of Polyphemus under one specific name.

In this country, this species has been reported previously from Massachusetts (Birge) and from Minnesota (Herrick).

Family LEPTODORIDÆ.

Leptodora hyalina Lillj.

A beautiful and interesting species, likewise common to the northern parts of both worlds, and equally abundant in both, occurred frequently in my Michigan collections, although much more abundantly in Lake Michigamme than in Lake Superior. Great numbers were taken in the former lake, *at the surface*, on a bright day, with high wind, at 3 p. m.

Family LYNCEIDÆ.

Eurycercus lamellatus O. F. M.

Identical with the European species. Taken in Marquette harbor and l'Anse Bay.

Acroperus leucocephalus Koch.

From l'Anse Bay.

Alona sp.

A very few specimens of this difficult genus were taken, usually in numbers too small for precise determination. *A. oblonga* P. E. M., and others allied to *modesta* Hk., and *quadrangulata* P. E. M., occurred at Marquette and at White Fish Point, and still another form was taken in Lake Michigamme.

Pleuroxus procurvus ? Birge.

Trans. Wis. Acad. Sci., IV (1877), p. 92.

To this species I assign doubtfully a few specimens taken at Mar-

* Danmark's Cladocera, p. 200.

† De Crustaceis ex ordinibus tribus Cladocera, Ostracoda et Copepoda, in Scania occurrentibus, p. 62.

‡ Neue Beiträge zur Naturgeschichte der Cladoceren (Crustacea Cladocera), p. 67.

quette and l'Anse differing from those described by Professor Birge only in slight detail. None of the striæ of the shell take a direction to meet the ventral margin at right angles, but all incline backwards; the plumose setæ of the ventral margin are not sparse, but are placed as thickly as they can stand; and the anterior margins of the shell are not dentate, but the setæ there are articulated by greatly thickened bases.

Chydorus sphæricus Baird.

Taken frequently in small numbers in both lakes.

Chydorus rugulosus n. sp.

Allied to *C. sphæricus*, but with the depth only three fourths the length, the pigment speck nearly or quite as large as the eye and half as far from the eye as from the tip of the rostrum, and the hexagonal shell-areas marked by a delicate reticulum of minute rugosities.

Shell highest at middle, scarcely truncate posteriorly, but the hind margin rounding broadly into the lower, the anterior dorsal surface flattened, meeting the flattened valves at an acute projecting angle, giving the shell a trigonal form like that of a beech nut. The dorsal outline not uniform, but flattened in front. Submarginal row of hairs along the ventral edge rather coarse and strong—about four to the length of a marginal hexagonal area. Surface of the shell everywhere distinctly reticulate, bearing besides the coarse hexagonal reticulations, a very fine but distinct net-work of minute rugosities, the meshes of which are longest in the direction of the margin of the shell.

The labial appendage long, reaching as far as the tip of the rostrum, and as broad at the base as high. The posterior inferior angle produced and extending slightly backwards, the whole quite different in form from that of *C. sphæricus*.

Post-abdomen short, broad, inferior margin broadly rounded, with nine or ten simple, stout teeth. Anal tubercle forming an acute angle; the caudal claw smooth, with a small basal tooth, the length of which is about equal to the diameter of the claw.

Length, .5^{mm}; depth, .38^{mm}; width, .33^{mm}.

Collected in considerable number from the surface in Marquette harbor at 5 a. m., August 11, 1889, and less abundantly August 9.

Chydorus globosus Baird.

Seemingly less abundant than the preceding. Noticed only at l'Anse.

Bosmina longirostris O. F. M.

A few specimens of this common species—the only one of its genus noticed—were taken repeatedly at Marquette, at White Fish Point, and at l'Anse.

Family DAPHNIIDÆ.

Scaphloberis mucronata O. F. M.

This abundant European entomostracan occurred in the very miscellaneous collections from l'Anse, but was not noticed elsewhere.

Daphnia retrocurva Forbes, var. **intexta.**

This form, although remarkably constant in the collections made in northern Michigan, both from Lake Michigan and the smaller lakes, differs from *retrocurva*,* previously described, only in the inferior development of the head and the smaller size and number of the pectinations of the caudal claw. It is probably to be regarded as a slightly depauperate form of *retrocurva*.

The head, averaging two fifths the length of the body without the spine, is helmeted, triangular, the apex antero-dorsal, recurved. Its dorsal outline otherwise nearly straight or slightly concave; lower margin sometimes slightly sinuate near the rostrum, the latter produced to or beyond the tips of the sensory hairs. Length of the borders of the head subequal, but the antero-ventral margin commonly the longest. Pigment speck wanting. Eyes small, about half as far from lower as from upper margin of the head, and either equidistant from rostrum and apex, or a little nearer the former. Viewed from above, the head is about half as thick at base as it is long.

Dorsal outline of the body more or less convex, spine in the adult nearly or quite equal to the depth of the valves. The latter about three fourths as deep as long, surface conspicuously reticulate, lower margin very slightly spinose, with sparse, short appressed teeth, which are continued on to the terminal spine. Dorsal abdominal processes quite distinct at base, brood cavity with one or two eggs. The caudal claws bear a row of conspicuous teeth on the basal half, about twelve in number, in two sets, those of the distal set the larger. (In *retrocurva* these teeth are about twenty in number, the smaller proximal set twelve to fourteen, and the distal more conspicuous set, about eight in number.) Beyond these a row of very fine hairs continued nearly to the tip of the claw. Posterior outline of the post-abdomen regular, bearing nine or ten curved spines.

Total length, without spine, about 1.6^{mm}.

This was the only Daphnia taken in the longshore collections in Lake Superior and in Lake Michigamme—the latter being, it will be remembered, a body of water not directly connected with Lake Superior, but emptying through the Menominee River into Lake Michigan.

This form adds to the characters of the section *Hyalodaphnia* the pectinate claw of the group to which *D. pulex* belongs. It is distinguished from *D. pellucida* at once by the armature of the claw and the lack of the pigment speck; from *cucullata* and its varieties by the same characters and by the fact that the dorsal abdominal processes are distinct at base. From *hyalina* and *galeata* it is separated by the lack of the pigment speck and the form of the head.

This Daphnia stood next in abundance in my Lake Superior collections to *Cyclops thomasi*, Diaptomus, and Epischura, occurring in large or moderate number in every haul.

* American Naturalist, XVI (1882), p. 642.

Daphnia lævis Birge.

A single specimen of this strictly American species occurred in my Lake Michigamme collections.

Daphnella brachyura Lievin.

Excessively abundant in Lake Michigamme, where it was the commonest crustacean, but not noticed in the Lake Superior material.

Sida crystallina O. F. M.

Very abundant in the rather dirty waters of l'Anse Bay, but not seen elsewhere.

Holopedium gibberum Zaddach.

A very remarkable form included among the pelagic species of the European lakes, and hitherto reported in America only from the deeper waters of Lake Michigan.* Taken in moderate number at l'Anse, in shallow water from the pier.

The following lists will show how the species above mentioned were associated under the circumstances represented by my collections:

Marquette breakwater, August 9, surface, shallow water, sandy bottom, bright weather, good wind. Fairly full collections.

Diaptomus sicilis, very abundant.
imperfectus, very abundant.
Epischura lacustris, a few.
Limnocalanus macrurus, rare.
Cyclops thomasi, common.
Polyphemus pediculus, very rare.
Chydorus sphæricus, few.
rugulosus, few.
Bosmina longirostris, few.
Daphnia intexta, not uncommon.

Off Light-House Point, near Marquette, August 9, 3 p. m., deeper water, sandy bottom, bright weather, high wind. Net hauled at a depth of about 40 feet. Collection scanty.

Diaptomus sicilis, common.
imperfectus, common.
Epischura lacustris, a few.
Limnocalanus macrurus, a few.
Cyclops thomasi, a few.
Leptodora hyalina, very few.
Bosmina longirostris, several.
Daphnia intexta, a few.

Marquette breakwater, August 11, at 5 a. m., clear, still. A scanty collection.

Diaptomus sicilis, common.
imperfectus, common
Canthocamptus, sp., a few.
Cyclops thomasi, common.
Chydorus rugulosus, several.
Bosmina longirostris, many.
Daphnia intexta, few.

Marquette harbor, August 11, 9 p. m., clear, calm, shallow water, surface. A large collection.

Diaptomus sicilis, very abundant.
imperfectus, very abundant.
Epischura lacustris, common.
Cyclops thomasi, common.
agilis, less abundant.
Eurycercus lamellatus, several.
Alona oblonga, few.
Pleuroxus procurvus, few.
Chydorus sphæricus, few.
Bosmina longirostris, several.
Daphnia intexta, many.

* "On some Entomostraca of Lake Michigan and Adjacent Waters." Amer. Nat., XVI, p. 641.

L'Anse Bay, August 14, 1 p. m., pier, shallow water, somewhat weedy and dirty. A swift stream entering about a quarter of a mile above. Still. Sun and shower. A good collection.

Diaptomus sicilis, common.
imperfectus, common.
Canthocamptus, sp., very few.
Cyclops thomasi, few.
gyrinus, a few.
pectinifer, several.
Polyphemus pediculus, many.
Leptodora hyalina, several.
Eurycercus lamellatus, few.
Acroperus leucocephalus, few.
Alona, sp., several.
Pleuroxus procurvus, a few.
Chydorus globosus, a few.
Bosmina longirostris, several.
Scapholeberis mucronatus, several.
Daphnia intexta, several.
Simocephalus vetulus, few.
Sida crystallina, abundant.
Holopedium gibberum, several.

White Fish Point, August 15, shallow water, sandy bottom, sun, high wind. Fair collection.

Diaptomus sicilis, common.
imperfectus, common.
Cyclops thomasi, abundant.
Polyphemus pediculus, several.
Leptodora hyalina, a few.
Alona oblonga, a few.
Alona, sp., a few.
Chydorus sphæricus, few.
Bosmina longirostris, few.
Daphnia intexta, several.

Lake Michigamme, August 8, 3 p. m., sun, high wind. At surface and about 15 feet below. Very large collection.

Diaptomus sicilis, common.
imperfectus, common.
Epischura lacustris, common.
Canthocamptus, sp., a few.
Cyclops æedax, a few.
Leptodora hyalina, many.
Alona, sp., a few.
Chydorus sphæricus, a few.
Daphnia intexta, several.
lævis, rare.
Daphnella brachyura, very abundant, below the surface.

The facts now known concerning the animal life of the Great Lakes furnish an insufficient basis for a final discussion of the origins of this fauna, but may nevertheless serve to indicate the general lines within which such a discussion must proceed. There are three such principal origins possible; some of the Great Lake species may have made their way directly from the sea, undergoing meanwhile more or less modification; others may be a part of a general north-temperate fauna, whose formerly continuous area of distribution has been broken up by changes of level and climate, with consequent organic differentiation; and others may have had an independent southern and southwestern origin, possibly reaching back, in some instances, to a South American starting-point.

Too little is as yet known concerning our southern Entomostraca, or even those of our Atlantic and Pacific coasts, to make it possible to point out with any assurance the elements of the Great Lake fauna which are to be referred to these origins, and we can only undertake to show which are related to the much better known fauna of the lakes of northern Europe.

Three of the four Calanidæ now reported from our Great Lakes are so closely related to those of European lakes as to leave not the slight-

est doubt that they have had a relatively recent origin in common with these Old World species. On the other hand, the points of difference between our species and their European representatives, though slight and scarcely entitled to specific rank unless on the ground of their constancy, indicate a separation long enough ago to permit at least incipient differentiation. These facts seem to point to an origin connected with the "glacial period"—whether immediately subsequent to that period, as suggested by Herrick,* or just previous to the time of actual glaciation, when the milder climate and the greater land elevation northward† permitted a freer passage than now of fresh-water forms across the north Atlantic, it would seem impossible to say until we know more of the present northward limit of distribution of the species concerned. If they now range far up into the arctic regions, it would seem possible that they may have lived everywhere in the icy waters of the time of diminishing glaciation; but if their habitat is strictly subarctic or temperate, their area can not have been continuous with that of the European species since pre-glacial times.

That Epischura must have had a different history is a fact already noticed, and considering the fact that its nearest known relative, Heterocope, is both fresh water and marine, it is not unlikely that it came to us from the sea.

The four or five Cyclopidæ of this paper, it will be noticed, are all American but one; but this large and difficult family has been far too little studied to permit generalization, the current descriptions of even the more abundant species not commonly being given in sufficient detail to permit careful comparison.

The list of Cladocera, on the other hand, is remarkable for the number of unaltered European species which it contains, all but four of the sixteen here reported being quite indistinguishable from those described from Europe, while the four excepted have very closely allied Old World kindred.

Finally I would remark upon the minuteness and physiological insignificance of the changes which so far seem to separate several of our Entomostracan species from their European representatives. If more extended collections and exhaustive study should show that the dif-

* List of the Fresh-Water and Marine Crustacea of Alabama, with Descriptions of the New Species and Synoptical Keys for identification, p. 49.

† "The progress of events seems to have been about as follows: In the warm period preceding the Glacial epoch, when the vegetation of the temperate zone flourished about the north pole, there was land connection between the continents, permitting the larger species of the Old World to migrate to North America. At the same time the conditions in North America were favorable to the tropical species of animals which had developed and flourished in South America. The refrigeration of the climate on the approach of the Glacial period, and the advance of the ice from the north, cut off retreat to the Old World species, and gradually hemmed them in over the southern portion of the continent, where all forms of life were compelled to re-adjust themselves to new conditions.—(C. Frederick Wright, in "The Ice Age in North America," p. 387.)

ferences now apparent are indeed constant; if the presence or absence in the adult of that rudiment of the larval eye known as the pigment speck, a slight increase or decrease in the size or number of teeth on the caudal claws, the presence or absence of a suture between two successive antennal joints, and other equally trivial differences, serve really to distinguish animal groups which have been separated from each other by the physical division of their area of distribution, we shall have additional illustrations of the rise of specific and other distinctions as an indirect consequence of simple isolation.

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[Note.—The references are to page figures in brackets.]

EXPLANATION OF PLATES.

PLATE I.

FIG. 1. *Epischura lacustris*. Male.
2. Same species, female. Fifth pair of legs.
3. Same species, male. Fifth pair of legs.
4. Same species. Mandible with palpus.
5. Same species. Fourth pair of legs.
6. *Diaptomus sicilis*. Female. Fifth pair of legs.

PLATE II.

FIG. 7. *Epischura lacustris*. Abdomen of male.
8. *Cyclops thomasi*. Female.
9. *Cyclops gyrinus*, n. sp. Female.
10. Same species. Leg of first pair.
11. Same species. Leg of fourth pair.
12. Same species. Leg of fifth pair.

PLATE III.

FIG. 13. *Leptodora hyalina* (after Lilljeborg).
14. *Cyclops gyrinus*, n. sp. Female. Terminal joints of antenna.
15. *Cyclops edax*, n. sp. Abdomen of female.

PLATE IV.

FIG. 16. *Cyclops edax*, n. sp. Leg of first pair.
17. Same species. Leg of third pair.
18. Same species. Leg of fourth pair.
19. Same species. Leg of fifth pair.

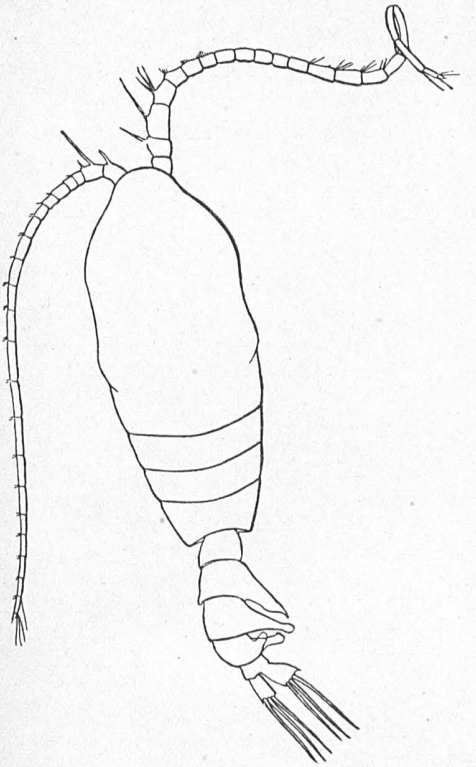
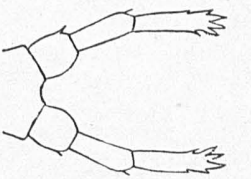


Fig. 1.



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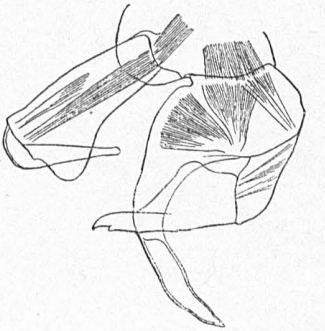

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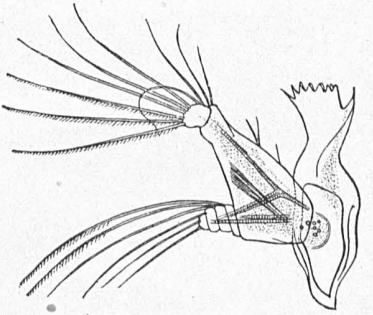

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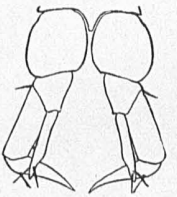

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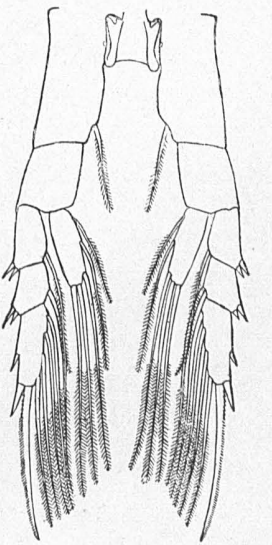

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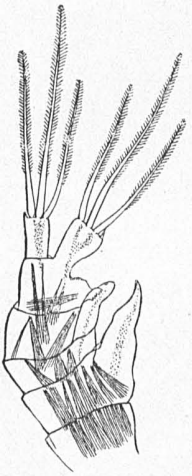

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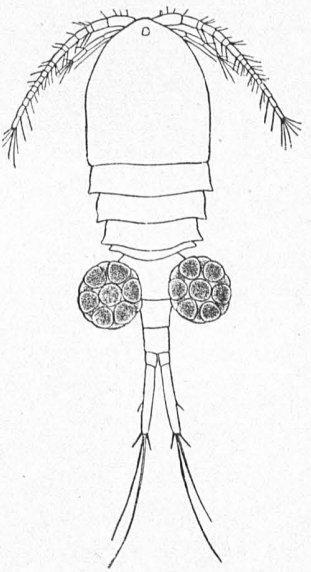

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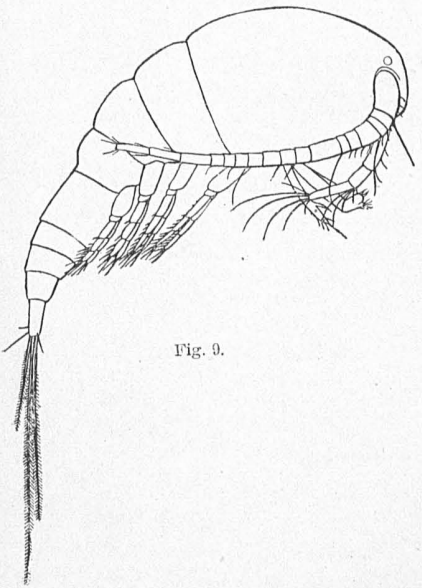

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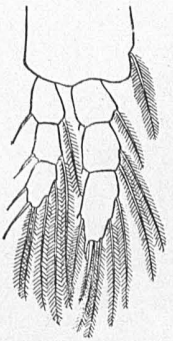

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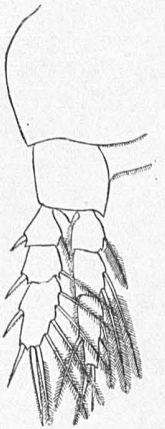

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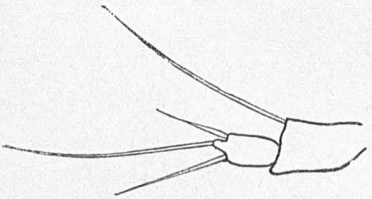


Fig. 12.

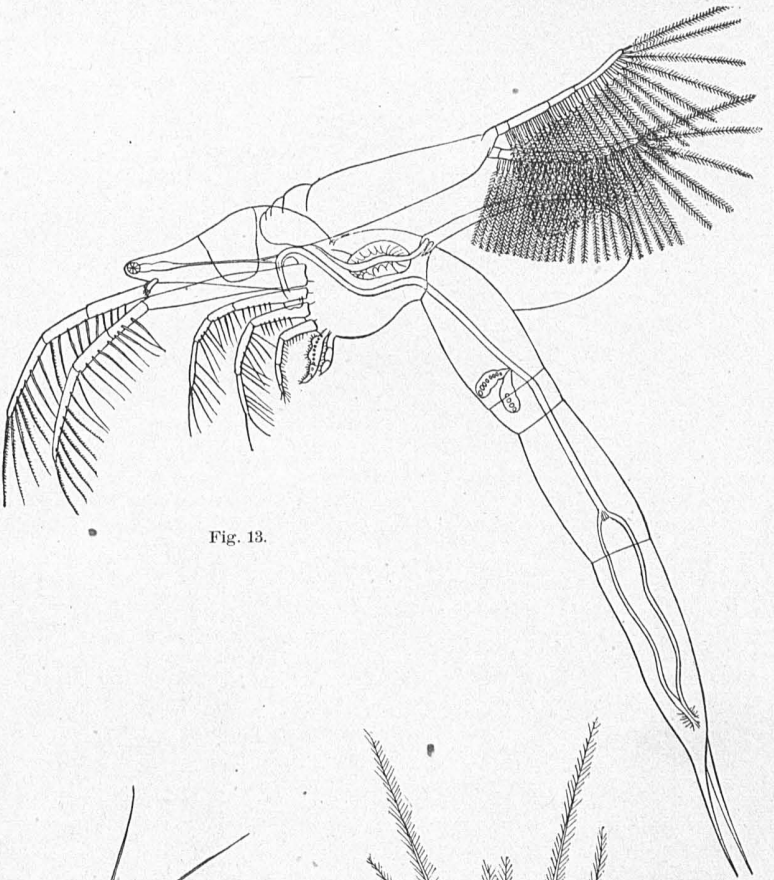


Fig. 13.

Fig. 14.

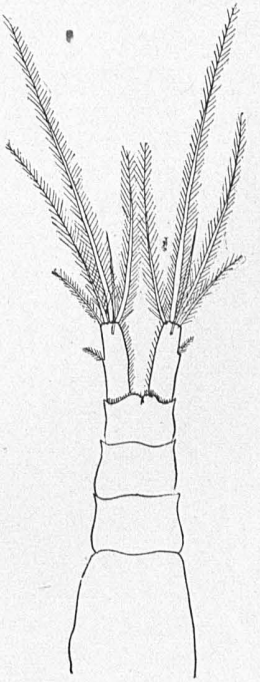
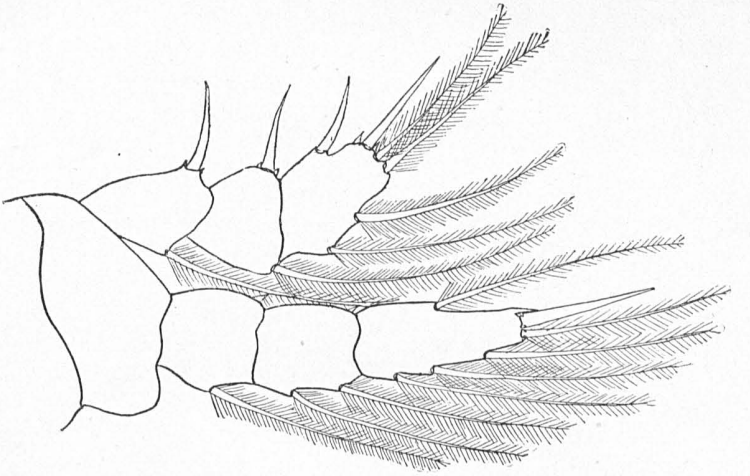


Fig. 15.



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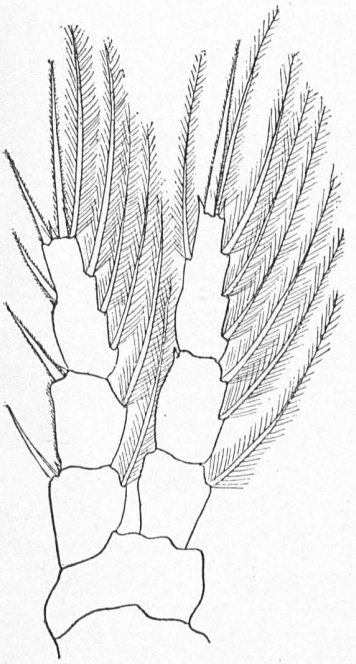

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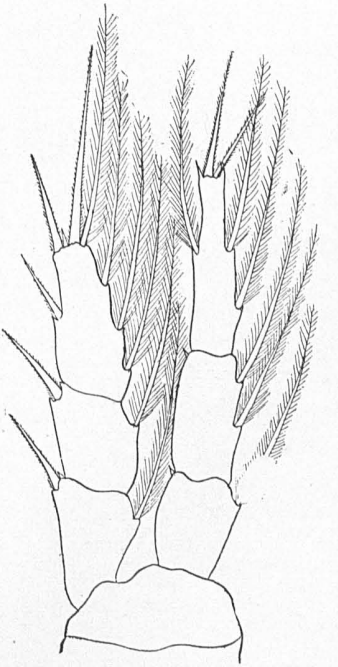

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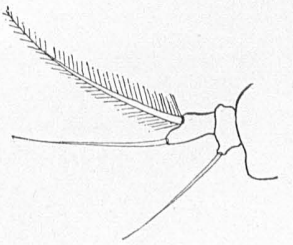

Fig. 19.