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ON SOME ENTOMOSTRACA OF LAKE MICHIGAN AND ADJACENT WATERS.

BY S. A. FORBES.

ONE cannot go far in the study of the system of organic life which prevails in a stream or lake, without being made aware of the important part played therein by the neglected but interesting group of the smaller crustaceans. They occupy a central position not only in the classification of aquatic animals, but also in the complicated network of physiological relations by which the living forms of a body of water are held together as an organized society. Feeding, themselves, upon the lowest and smallest of plants and animals, they furnish food in turn to a great variety of the higher animals, and even to some plants.[1]

The fisherman who toils at his nets, the sportsman in pursuit of health and recreation, rarely reflect, even if they know, that their amusements and their labors depend strictly upon these humble creatures, of whose very existence, indeed, many of them are unaware; and yet there is ample evidence that, with few and unimportant exceptions, all young fishes, of our fresh waters at least, live for a time almost wholly upon entomostraca.[2] If de-

[1] In ten "bladders" of *Utricularia vulgaris*, taken at random, I found ninety-three animals, either entire or in recognizable fragments, and representing at least twenty-eight species. Seventy-six of the animals found were Entomostraca, and belonged to twenty species. Nearly three-fourths of both individuals and species were Cladocera. Just one-third of all the animals found in these bladders belonged to the single species *Acroperus leucocephalus* Koch.

[2] On the Food of Young Fishes. By S. A. Forbes. Illinois State Laboratory of Natural History, Bulletin No. 3, November, 1880, pp. 66–79.

On the First Food of the Whitefish. By S. A. Forbes, Normal, Ill. The *American Field*, Vol. XVII, No. 11, p. 171, March 11, 1882.

prived of this resource for the nourishment of their young, fishes would be reduced to an insignificant remnant of their present numbers.

Immense quantities of them are also taken by adult fishes, especially in early spring, and some of the largest species make them a principal dependence. The shovel fish (Polyodon) of our great central rivers—a giant among inland fishes—engulfs untold myriads of them at a meal—thus performing in fresh water the functions of the whale in the great seas. In the lakes of Europe they are the main food resource of several deep water salmonoids, while in our own great lakes, clouds of the higher crustaceans (Mysis) live wholly at their expense; and these Mysidæ, again, contribute largely to the maintenance of the whitefish and blackfin, and other important species. Some insect larvæ likewise prey upon them; and amphipod crustaceans, while they seem to feed chiefly upon vegetable structures of one sort or another, certainly sometimes attack and devour entomostraca with a surprising ferocity. Mollusca, one would say, could afford to be indifferent to them, since they neither eat them nor are eaten by them, nor seem to come in contact with them anywhere, through any of their habits or necessities. But for this very reason these two classes afford an excellent illustration of the stringent system of reactions by which an assemblage of even the most diverse and seemingly independent organisms is held together. To say nothing of the fact that both groups feed to a considerable extent upon the same kinds of food, and thus probably limit each other's multiplication, in some degree, the further fact that vast quantities of both are destroyed by fishes, brings them into a mutually hostile relation. If there were no entomostraca for young fishes to eat, there would be very few fishes indeed to feed upon mollusca, and that class would flourish almost without restraint; while, on the other hand, if there were no mollusca for the support of adult fishes, entomostraca would be relieved from a considerable part of the drain upon their numbers, and would multiply accordingly.

It is through their intervention that fishes and certain carnivorous plants are brought into apparent competition. The number of entomostraca and minute insect larvæ destroyed by the bladder-wort in some situations where the plant fills acres of the water, must be prodigious, taking the season through; and it

is not impossible that the food supply of young fishes is sometimes thereby materially diminished.

In short, it would be difficult to mention a single group of aquatic or semi-aquatic animals or plants, whose interests are not affected, immediately or remotely, by these little animals.

But they have other claims upon our attention besides their importance in the general system of aquatic life. To the student of classification, they offer a fresh and inviting field of original work; the physiologist and the histologist may examine here the animal organs and tissues reduced almost to their lowest and simplest terms, and yet easily studied in detail, while they still form living parts of living organisms; and those attracted by natural beauty (as who is not?) will find few lovelier objects for the microscope, or more admirable illustrations of the play of life than these exquisite, crystalline specks, each comprising within its minute anatomy a system of organs and structures which for complexity and for perfection of detail, would scarcely discredit a butterfly or a fish.

I know of but one contribution to an exact knowledge of the Entomostraca of Lake Michigan—a brief paper by Professor E. A. Birge, containing a list of nine species of Cladocera found in the Chicago water supply,[1] with a description of *Latona setifera* O. F. M.; and I have seen nothing upon those of any other of the great lakes, except the notes on a few Cladocera published by Professor S. I. Smith in his paper on the invertebrate animals of Lake Superior.[2]

On the smaller crustacea of the region adjacent to the lakes, we have the valuable "Notes on Cladocera,"[3] by Professor Birge, and a paper by the writer on the Crustacea of Illinois.[4]

The lake material upon which the present paper is based, was obtained chiefly by the towing-net and dredge in Grand Traverse

[1] Notes on Crustacea in Chicago Water Supply, with remarks on the Formation of the Carapace. By E. A. Birge, Professor of Zoology, University of Wisconsin, Madison, Wis. The Chicago *Medical Journal and Examiner*, Vol. XIV, No. 6, Dec., 1881, pp. 584–590, Pl. I and II.

[2] Sketch of the Invertebrate Fauna of Lake Superior. By Sidney I. Smith, United States Commissioner of Fish and Fisheries. Part II. Report of the Commissioner for 1872 and 1873, pp. 690–707.

[3] Transactions of the Wisconsin Academy of Sciences, Arts and Letters, Vol. IV, 1876–77, Madison, Wis., 1879, pp. 77–110, and Pl. I and II.

[4] Bulletin of the Illinois Museum of Natural History, No. 1, December, 1876, pp. 3–25, and Pl. I.

bay, in the north-eastern part of Lake Michigan, and in the south end of the lake off Chicago and Racine. Several of the lacustrine species had been previously received from Mr. B. W. Thomas and Mr. Chas. S. Fellows, of Chicago, by whom they had been strained from the Chicago water supply.

A few additional species from the lakes and pools of Central and Northern Illinois, are described in the appendix to this paper, one of which occurs also in Southern Massachusetts, and probably throughout the country intervening.

One of the most interesting species was obtained in considerable numbers in Grand Traverse bay, associated with the ordinary forms of the lake, nearly all of which were abundant there in October, 1881. It is a copepod of the family Calanidæ, representing a new genus and species, for which the name *Epischura lacustris* is proposed (Pl. IX Fig. 8, and Pl. VIII Figs. 15, 16, 21–23 and 25–27).

The family is easily distinguished from Cyclopidæ and Harpactidæ, to which most of our other fresh-water species belong, by the elongate anterior antennæ of 23–25 articles, by the (usually) two-branched antennulæ and mandibular palpi, by the wide difference in size between the abdomen and thorax, and by the fact that in the male only one antenna is converted into a clasping organ. Epischura is colorless in autumn, although possibly red in spring, .063 in. long by .015 in. wide, and distinguished in both sexes by what seems at first a deformity of the abdomen. On closer inspection it is seen that in the male the last three segments of this region are laterally produced into a grasping organ of peculiar construction, and that the whole abdomen is thus distorted and rendered unsymmetrical. The lateral processes of the first and second segments evidently act against each other as a powerful pair of nippers, while the third, bearing upon the same side a stout toothed plate, must greatly increase the security of the grasp, when brought into play by the strong muscles of the abdomen. A fourth process extending forward from near the base of the right ramus of the furca, also contributes to the formation of this organ. A steel-trap attachment to the tail of an alligator would very well illustrate the vigorous embrace of this little crustacean. Besides this, the right antenna is thickened and hinged as a clasper, and the last pair of legs is also converted into a complicated apparatus of claws and forceps. In the adult

female the abdomen is usually bent outward to the left, to leave space for a finger-like process which arises at the hind end of the ovisac and curves upward beside the second segment. This is the spermatophore, the neck of which is firmly cemented to the under side of the abdomen. In this sex the legs of the fifth pair are extremely simple and rather small. They are not branched like the other legs, and are without the delicate and beautiful fringes of feathery hairs with which the swimming appendages are provided, but each consists of a single flat, three-jointed plate, with five spreading spines at and near its tip. The swimming legs of both male and female are peculiar in the fact that the inner branch of all the pairs is reduced to a single joint. The affinities of this genus are with Heterocope Sars, found in the lakes of Scandinavia, Switzerland and Upper Italy, and probably in other parts of Europe also; but the modification of the abdomen as a prehensile organ is a new idea among Copepoda. Mutilated specimens of the female of this species have been taken by Mr. Thomas from the water supply of Chicago; I also found the species common in Geneva lake, in Southern Wisconsin, in October, 1881.

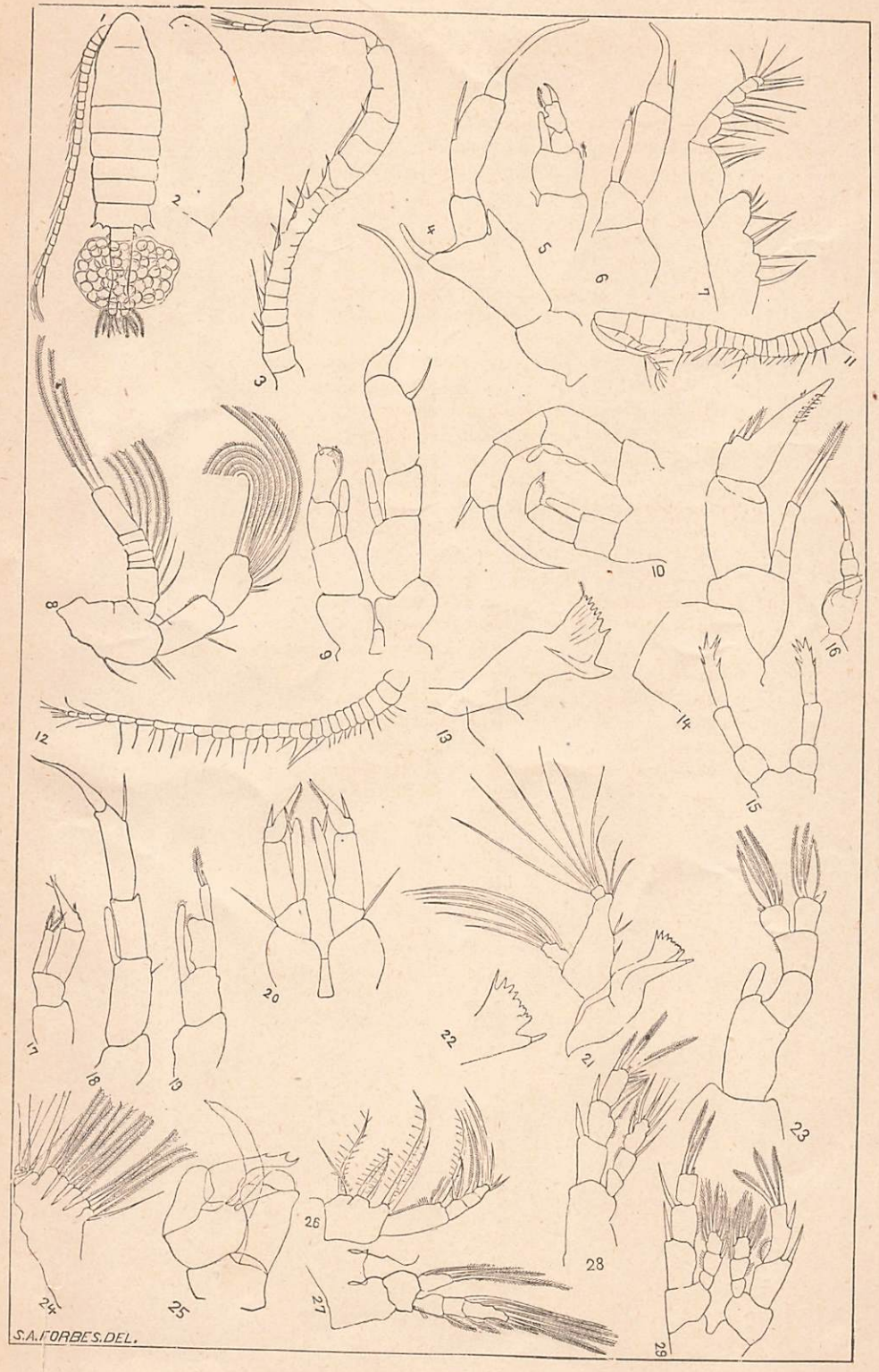
Another beautiful member of this family, occurring abundantly everywhere in the lake and at all seasons of the year, is closely related to the *Diaptomus gracilis* of Europe; but a careful study of it during successive seasons, and a comparison with the original description of Sars and with the descriptions and plates of *D. gracilis* published by Gruber in 1878, have satisfied me that our species is distinct, and I therefore propose for it the name of *Diaptomus sicilis* (Pl. VIII, Figs. 9 and 20). It is the most slender and elegant of our Calanidæ, usually colorless and transparent, but sometimes crimson in spring. The antennæ are long and weak, reaching beyond the tip of the abdomen, and are provided with hairs of unusual length, that on the ninth joint, for example, reaching beyond the fourteenth. It is in the fifth pair of the legs of both male and female that we find the best distinguishing characters in this family—and here the clearest distinctions from *Diaptomus gracilis* occur. In the male both pairs are two-branched. The last joint of the right leg forms a slender, sickle-shaped hook, which is regularly curved from base to apex, while the outer branch of the left leg of this pair is two-jointed, with a pubescent, rounded extremity, bearing two short diverging claws.

EXPLANATION OF PLATE VIII.

FIG. 1.—Diaptomus sanguineus, ♀, × 42.
" 2.—Dorsal outline of the same.
" 3.—Diaptomus sanguineus, ♂, geniculate antenna, × 50.
" 4.— " " ♂, right leg of fifth pair, × 67.
" 5.— " " ♂, left " " × 70.
" 6.— " " ♀, leg of fifth pair.
" 7.— " " second maxilliped, × 63.
" 8.— " stagnalis, antennula, × 48.
" 9.— " sicilis, ♂ fifth pair of legs, × 160.
" 10.— " stagnalis, ♂, fifth pair of legs, × 48.
" 11.— " " ♂, geniculate antenna, × 22.
" 12.— " " ♂, left antenna, × 22.
" 13.— " sanguineus, mandible, × 160.
" 14.— " stagnalis, ♀, leg of fifth pair, × 86.
" 15.—Epischura lacustris, ♀, fifth pair of legs, × 88.
" 16.— " " ♀, side view of abdomen, × 17.
" 17.—Diaptomus leptopus, ♀, leg of fifth pair, × 66.
" 18.— " " ♂, right leg of fifth pair, × 66.
" 19.— " " ♂, left " " × 66.
" 20.— " sicilis, ♀, fifth pair of legs, × 160.
" 21.—Epischura lacustris, mandible and palpus.
" 22.— " " blade of mandible.
" 23.— " " ♀, abdomen and furca from above, × 48.
" 24.—Osphranticum labronectum, first maxilliped, × 180.
" 25.—Epischura lacustris, ♂, fifth pair of legs, 70.
" 26.— " " second maxilliped, × 88.
" 27.— " " leg of first pair, × 70.
" 28.—Osphranticum labronectum, ♀, leg of fifth pair, × 70.
" 29.— " " ♂, fifth pair of legs, × 70.

(To be continued.)

PLATE VIII.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S.A.FORBES.DEL.

(*From the American Naturalist, August, 1882.*)

ON SOME ENTOMOSTRACA OF LAKE MICHIGAN AND ADJACENT WATERS.

BY S. A. FORBES. 1882

(Continued from July number.)

A THIRD Calanid deserves special mention as a species of Limnocalanus, a genus known hitherto only from Scandinavian lakes. It is readily distinguished, without dissection, from the other fresh-water Calanidæ, by the extraordinary length, size and prominence of the five or six terminal setæ of the first maxillipeds. The second maxillipeds are also very long. The legs are all bi-ramose, the inner ramus of the fifth pair resembling the same appendage of the other legs. This species, which may be *Limnocalanus macrurus* Sars, was first sent me by Mr. C. S. Fellows, of Chicago, about four years ago, a mutilated female having been obtained by him from the city water supply. The furca is as long as the entire abdomen. The rami are hairy, parallel, about seven times as long as wide, and provided with five subequal terminal setæ, and one some distance in front of the external angle. It has been collected thus far only in the south end of the lake. I have found it abundant in the city harbor, even in the polluted water near the mouth of the river, where it is associated especially with *Diaptomus sicilis* and the Cyclops next to be described.

The Calanidæ seem to have an unusual development in this country; and to facilitate their study and comparison, I have described further on all the species which I have hitherto clearly distinguished.

Smallest and most abundant of the Copepoda of the lake, is a minute Cyclops (*C. thomasi*, n. s., Pl. IX Figs. 10, 11 and 16), only four hundredths of an inch in length (without setæ) and about eleven thousandths of an inch in width, slender and colorless, with remarkably long caudal stylets; and especially noticeable for the great difference in the length of the caudal setæ. The inner and outer ones are inconspicuous, while the outer of the two median setæ is longer than the furca, and the inner of these two is as long as the whole abdomen. This Cyclops was first received from Mr. B. W. Thomas, and I have since found it excessively abundant in the lake. I have not encountered it, however, in any other waters.

Its nearest European ally is apparently *Cyclops bicuspidatus*

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Claus, but from this the description on another page will serve easily to distinguish it.

This is the only Cyclops which I have yet noticed in Lake Michigan, and is certainly far the most abundant species.

Of the many species of Cladocera occurring here, I have selected but three for especial comment. The first of these, *Leptodora hyalina* Lillj. (Pl. IX Fig. 3), which occurs also in Europe, is a most interesting creature. When in its native element it is almost perfectly transparent, and consequently invisible—a true microscopic ghost—a fact associated by Professor Weissmann with its predaceous habit and feeble locomotive power. To the little Cyclops host it must indeed be a dreadful and mysterious enemy. Concealed by its transparency, it need not lurk in obscure hiding places, like grosser robbers, but can wing its way unnoticed among its prey.

The common Daphnids of the lake are, however, almost equally transparent, and as these are not at all carnivorous, we must either suppose that they have developed independently the same peculiarity for a directly opposite purpose—that of self-protection—or else we must conclude that there is something in the conditions of life here which tends to render the bodies of all entomostraca transparent.

A single mutilated specimen of Leptodora was dredged by Professor S. I. Smith in Lake Superior; it has been found in both ends of Lake Michigan, and I have also collected it in the Illinois river and the small lakes adjacent, and in a muddy pond in Northern Illinois only half a mile across and twenty feet in depth.

A careful comparison of my specimens with the descriptions and figures of Lilljeborg and Weissmann, leaves no room for doubt that they belong to the European species.

This is likewise the case with the remarkable *Holopedium gibberum* Zaddach (Pl. IX Figs. 12–15) found as yet only in Grand Traverse bay, where it occurred not rarely with Epischura, Diaptomus, Cyclops and *Daphnia hyalina.* In this animal the bivalve shell has undergone a truly monstrous development, the brood cavity on the back being elevated to a height greater, when filled with young, than that of the remainder of the animal. On the other hand, the lateral valves of the shell are so shortened that they do not completely cover the branchial feet. For the protection of the creature and its young, and partly also, according to

P. E. Müller's supposition, to restore the balance of the body and enable it to float feet downwards, the shell secretes a layer or cloak of a gelatinous character and of an enormous thickness, relatively to the size of the animal. Through a slit in this mantle the antennæ and feet are thrust out; but otherwise the animal is completely buried in a lump of gelatine.

Bosmina (Pl. IX Fig. 17) was less abundant in my collections than the other forms mentioned, but occurred very commonly in the stomachs of *Mysis oculatus*, dredged from the deeper waters of the bay.

The commonest Cladocera in the lake are two forms of Daphnia, remarkable for their thinness and exquisite transparency. They are allied to *galeata* and *pellucida* of the old world, recently reduced by Adolph Lutz to varieties of *Daphnia hyalina* Leydig. Although our specimens do not agree strictly either with the descriptions or the figures of those varieties extant, their differences probably do not pass the limits of allowable variation in this excessively variable species. The head is keeled, convex in dorsal outline and either rounded *(pellucida)* or pointed *(galeata)* in front, the shell is compressed and reticulate, and terminates posteriorly in a long, straight, dentate spine.

An allied species, from the smaller Illinois lakes, where it is in autumn by far the most abundant entomostracan, resembles *Daphnia cederströmii* Schödler, but differs especially in the still more enormous development of the head. This is as high as the body and more than two-thirds as long, deeply concave on the upper border, the apex curving upwards far beyond the dorsal line of the body. The head is expanded inferiorly also to such a degree that the sensory hairs of the antennules fall much short of the tip of the rostrum. The shell is reticulate, and its spine long and straight, there is no *macula nigra*, and the caudal claws have a row of teeth at their base. For this curious form I propose the name of *Daphnia retrocurva*.

I have not found it in Lake Michigan, although in the smaller lakes it is mingled with both varieties of *Daphnia hyalina*. Even in the young, before they have left the brood cavity of the mother, the helmet is developed far beyond that of the adult of any of the latter species.

The female carries but one or two eggs, and the young sometimes attain a size more than half that of the body of the mother within the shell, before they leave her protection.

This is the farthest extreme of a development of the head, which, beginning with such forms as *pellucida*, runs through *galeata*, *apicata*, *berolinensis*, *vitrea*, *kahlenbergensis* and *cederströmii* to the present species, where it reaches truly enormous proportions. The meaning of such a character I am not able to imagine. The expansion of the head is a thin and flexible plate, affording lodgment to no organs, and seems an utterly useless encumbrance.

In Geneva lake, Wisconsin, the most abundant entomostracan in October, was an extremely variable Daphnia approaching *hyalina* on the one hand and *retrocurva* on the other, but still separable from both. It is evident that this group of helmeted Daphnias is still in process of active evolution, and it is possible that there are no actual breaks anywhere along the line from *hyalina* to *retrocurva*, although in the former the head may be scarcely larger than in *Daphia pulex*, while in the latter it is often more than half as large as the body.

Comparing the Daphnias of Lake Michigan with those of Geneva lake, Wis. (nine miles long and twenty-three fathoms in depth), those of Long lake, Ills. (one and a half miles long and six fathoms deep), and those of other still smaller lakes of that region, a curious progressive predominance of the large-helmeted forms is very evident in passing from larger to smaller lakes. If we extend the comparison further, and include the other entomostraca, and the swamps and smaller ponds as well, we shall be struck by the inferior development of the entomostraca of the larger bodies of water, in numbers, in size and robustness, and in reproductive power. Their smaller numbers and size are doubtless due to the relative scarcity of food. The system of aquatic animal life rests essentially upon the vegetable world, although perhaps less strictly than does the terrestrial system; and in a large and deep lake vegetation is much less abundant than in a narrower and shallower one, not only relatively to the amount of water but also to the area of the bottom. (In all the lakes which I have dredged, life of all sorts was much more scanty in the interior deeper portions than along the margins.) From this deficiency of plant life results a deficiency of food for entomostraca, whether of Algæ, of Protozoa or of higher forms, and hence, of course, a smaller number of the entomostraca themselves, with more slender bodies suitable for more rapid locomotion.

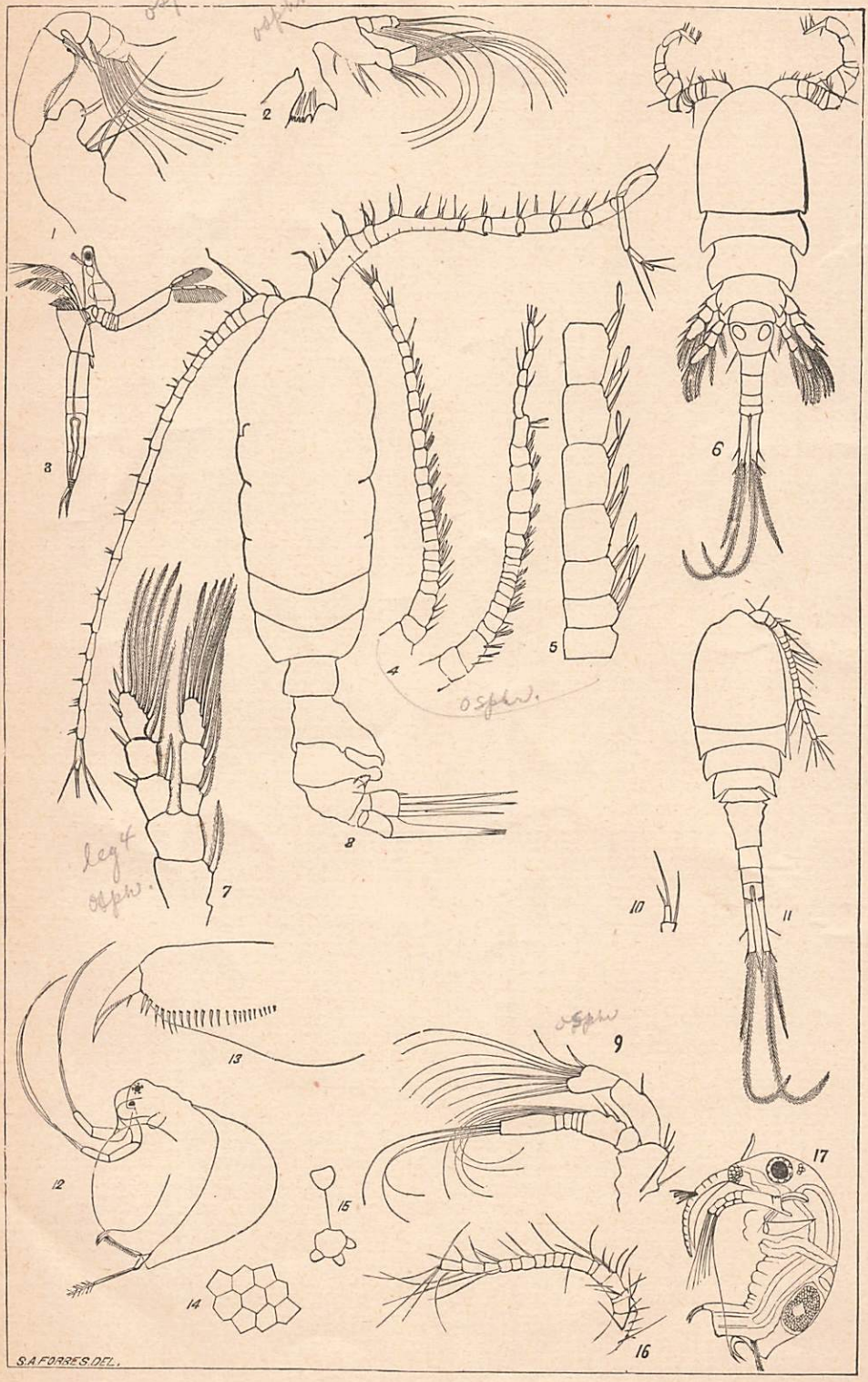
The difference of reproductive energy, as shown by the much smaller egg-masses borne by the lacustrine species, depends upon the vastly greater destruction to which the paludinal crustacea are subjected. Many of the latter occupy waters liable to be exhausted by drought, with a consequent enormous waste of entomostracan life. The opportunity for reproduction is here greatly limited—in some situations to early spring alone—and the chances for destruction of the summer eggs in the dry and often dusty soil are so numerous that only the most prolific species can maintain themselves under such conditions.

Further, the marshes and shallower lakes are the favorite breeding grounds of fishes, which migrate to them in spawning time, if possible, and it is from the entomostraca found here that most young fishes get their earliest food supplies—a danger from which the deep-water species are measurably free. Not only is a high reproductive power therefore rendered unnecessary among the latter by their freedom from many dangers to which the shallow-water species are exposed, but in view of the relatively small amount of food available for them, a high rate of multiplication would be a positive injury, and could result only in wholesale starvation.

EXPLANATION OF PLATE IX.

FIG. 1.—Osphranticum labronectum, second maxilliped, × 123.
" 2.— " " mandible and palpus, × 75.
" 3.—Leptodora hyalina, ♀ (After Weissman).
" 4.—Osphranticum labronectum, ♂, antennæ, × 38.
" 5.— " " ♂, part of left antenna, showing olfactory clubs, × 120.
" 6.—Cyclops insectus, ♂, × 38.
" 7.—Osphranticum labronectum, leg of fourth pair.
" 8.—Epischura lacustris, ♂, × 42. (Some of the basal segments of the antenna are concealed. The segmentation of the cephalothorax is incompletely shown. See text.)
" 9.—Osphranticum labronectum, antennula.
" 10.—Cyclops thomasi, leg of fifth pair.
" 11.— " " ♀, × 38.
" 12.—Holopedium gibberum, ♀.
" 13.— " " abdomen and furca.
" 14.— " " marking of shell.
" 15.— " " eye and macula nigra.
" 16.—Cyclops thomasi, antenna, × 65.
" 17.—Bosmina (after Gerstaecker).

PLATE IX.



NEW GENERA AND SPECIES OF COPEPODA.

Genus OSPHRANTICUM, gen. nov.

(Plate VIII Figs. 24, 28 and 29; Plate IX Figs. 1, 2, 4, 5, 7 and 9.)

This genus is similar to Diaptomus in general appearance, but differs especially in the structure of the fifth pair of legs of male and female.

The antennæ are 23-jointed, the right of the male geniculate between the 18th and 19th. Joints 13–18 are dilated on this antenna, and the 19th and 20th are united, reducing the number to 22.

The antennules and mouth-parts have the same general structure as in Diaptomus, but the former are unusually large. The legs of the first pair have both rami 3-jointed. In the male both legs of the fifth pair are bi-ramose and armed with plumose cilia (Pl. VIII Fig. 29). The inner ramus of each is 3-jointed and unmodified. In the outer ramus of the left leg the second and third joints are consolidated, and bear three plumose terminal setæ, a strong spine on the outer margin and a pubescent tubercle at the inner base. The outer ramus of the right leg is 3-jointed, bears two setæ at tip and is unarmed within.

In the female the legs of the fifth pair are nearly alike and only the third joint of the outer ramus is modified (compare Fig. 28 Pl. VIII, with Fig. 7 Pl. IX).

1. *Osphranticum labronectum*, sp. nov.

The cephalothorax is oval, symmetrical, and composed of six segments regularly decreasing in length from before backwards. The head is not distinct from the first thoracic segment, and the posterior angles of the cephalothorax are evenly rounded. The abdomen is cylindrical and unarmed; of five segments in the male, four in the female. The antennæ scarcely surpass the cephalothorax, and are very richly supplied with olfactory clubs. The second joint is nearly as long as the three following. The setæ of the antennules reach to the 20th joint of the antennæ. The egg-sac in the female is unusually large, obovate, widest posteriorly, flattened vertically, and extending to the tips of the setæ. The latter are five in number to each ramus, the fourth from the outside being much the longest.

This species is readily distinguished in life by the short and compact thorax (its depth being contained but two and a-half times in its length), and by its steady movement in the water, as it does not commonly swim with the jerking motion of Diaptomus. Those taken at Normal were pale brown in color, without markings. Found in a wayside pool at Normal, Ill., in February, 1877, and in swamps in Iroquois county, in the same month of 1882. The females of the latter lot were bearing eggs.

Genus DIAPTOMUS.

1. *Diaptomus sicilis*, sp. nov. (Pl. VIII Figs. 9 and 20.)

This is the American representative of *Diaptomus gracilis* of Europe. It differs from that species as described by Sars, as follows: The antepenultimate joint of the right male antenna is not armed with a hook, but with a long and slender spine-like process, nearly equaling the following joint. The last joint of the fifth pair of legs of the female is not distinct, nor indeed at all distinguishable, and its terminal spines reach less than half the distance to the tip of the claw of the penultimate joint. The inner ramus of this leg is much longer than the basal joint of the outer ramus, and is not 2-jointed in any specimen which I have examined. The terminal claw of the right foot of the male is regularly curved from base to apex.

The species is usually colorless, although I have seen occasionally individuals of

a uniform crimson. Equally conspicuous differences are apparent on comparison of the legs of the fifth pair of the male with the descriptions and figures of Gruber[1] (see Fig. 9).

The thoracic segments corresponding to the two last pairs of legs are not distinct, but the head is divided into an anterior and a posterior part by an evident constriction and an incomplete suture. The body is .065 in. long (without caudal setæ) by one-fourth that depth.

This species has a special economical value as constituting, with one species of Cyclops, hereafter to be described, almost the entire first food of the whitefish. I have not found it anywhere outside of Lake Michigan, but there it occurs in immense numbers; sometimes being the most abundant species appearing in the net. A similar but not identical form occurs in the small and shallow lakes of Northern Illinois and Indiana. The latter is possibly the *D. pallidus* of Herrick,[2] although neither his description nor figures are really specific.

2. *Diaptomus leptopus*, sp. nov. (Pl. VIII Figs. 17–19.)

This species resembles the foregoing in general appearance, but may be easily distinguished by the relative robustness of the antennæ and the shortness of their hairs and spines, by the width and shortness of the rami of the furca (the width being a little more than two-thirds the length), by the serrate setæ of the swimming legs and the different shape and proportions of the fifth pair.

An average male measures .07 in. in length by .015 in. in depth. The cephalothorax is a little the widest before the middle, with angles rounded and terminating in a single acute spine. The second segment of the female abdomen is very short. The antennæ reach to the tip of the furca, and the antepenultimate segment of the right antenna bears a small hook at the tip in the male.

The outer ramus of the first pair of legs has three long bristles at its tip, of which the outer is dentate externally and plumose within, while the short spine at its base is dentate on both margins. The outer edge of this ramus is fringed with long delicate pubescence. On all the swimming feet the terminal seta is dentate externally. The characters of the fifth pair of legs of male and female are sufficiently shown by Figs. 17, 18 and 19 of the first plate.

This species is of especial interest and value, since I have collected it from pools in Southern Massachusetts, near Wood's Holl, and also from similar situations at Normal, Illinois.

The characters of specimens from these widely separate localities agree very closely, thus affording a most useful indication of the constancy of such characters as I have used in separating our species of this genus.

3. *Diaptomus stagnalis*, sp. nov. (Pl. VIII Figs. 8, 10–12 and 14.)

This species is the largest of its genus which I have seen, measuring .11 in. without the caudal setæ. It is apparently nearest to *Diaptomus cæruleus* (= *castor*) of Europe, but differs constantly from that form in several particulars in which the various figures of *castor* and *westwoodii* given by Baird, Lilljeborg, Lubbock and Brady agree with each other.

The lateral angles of the cephalothorax are salient in the male and bifid in the female. The branches of the furca are nearly as broad as long, are hairy within and

[1] Ueber zwei süss-wasser-Calaniden.

[2] Microscopic Entomostraca. By C. G. Herrick. The Geological and Natural History Survey of Minnesota. The seventh annual report for the year 1878. Minneapolis, 1879.

about equal in length to the last abdominal segment. The antennæ are robust and long, attaining the middle of the abdomen, and the antepenultimate joint of the male bears at its tip a stout conical process about one-third the length of the joint.

On all the swimming feet the lateral spines of the outer ramus are bi-serrate, and the outer seta of the terminal three is strongly and sharply serrate without. This seta is about twice as broad as the others, and is but sparingly plumose within.

The inner ramus of the right leg of the fifth pair is rudimentary and unarmed, about half the length of the basal joint of the outer ramus.

The third joint of the outer ramus of the fifth pair of legs in the female is distinct and bears three setæ, while the inner margin of the tip of the preceding joint is coarsely toothed. The inner ramus is bi-articulate and terminates in two long feathered spines, which are longer than the whole ramus.

Several specimens were taken from pools in Central Illinois, in early Spring. All were red throughout.

4. *Diaptomus sanguineus* Forbes. (Pl. VIII Figs. 1–7 and 13.)

To the description of this species published in the first Bulletin of the Illinois Museum of Natural History, I will add but a few details. The posterior angles of the cephalothorax in the female are bifid, and its dorsal outline, regular in the male, is broken in the other sex by an elevation at the anterior margin of the penultimate segment, within which one of the levator muscles of the abdomen takes its rise. I know of no other Diaptomus possessing this character. None of the bristles of the anterior feet are serrate, although the lateral spines of the outer rami are so. The outer margins of these feet are not hairy.

Genus EPISCHURA, gen. nov.

(Pl. VIII, Figs. 15, 16, 21–23, 25–27, and Pl. IX, Fig. 8.)

In the general character of the legs, both natatory and clasping, this genus stands near Heterocope of Sars, but is remarkably distinguished from all the other Copepoda known to me by the development of the abdomen of the male as a prehensile organ. The abdomen has five segments, the second and third of which are produced on the right side as large and strong processes which act against each other like forceps, while a toothed plate on the fourth segment and a spatulate one on the fifth, assist to form a peculiar and powerful grasping apparatus. The cephalothorax has six segments, of which the last bears both the fourth and fifth pairs of legs. The head is very distinct from the following segment. The eye is single, small.

The female abdomen is four-jointed (the first joint very short), and is usually provided with a curved, cylindrical spermatophore, firmly cemented to the under side of the ovisac and extending upwards on the right, beside the third segment.

In the male the legs of the fifth pair are both one-branched, the left ramus three-jointed and the right two-jointed. In the former the second and third joints oppose an enormous, curved and flattened process of the first. In the right leg the second joint is conical and hinged upon the first.

The fifth legs of the female are likewise one-branched and simple. They are three-jointed, small and unarmed, except at the tip where they are palmately toothed.

In all the remaining legs of both sexes, the inner ramus has but one joint, and the outer three.

The antennæ are 25-jointed and the right of the male is geniculate.

1. *Epischura lacustris*, sp. nov.

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

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

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

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

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

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

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

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

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

Genus LIMNOCALANUS.

1. *Limnocalanus macrurus?* Sars.

Our specimens are distinguished from *Limnocalanus macrurus* as described by Sar-,[1] by the antennæ, which are 24-jointed instead of 25; by the mandibles which

[1] Oversigt af de indenlandske Ferskvands copepoder. Forhandlinger i Videnskabs-Selskabet i Christiana. Aar, 1862, pp. 212–262.

have but eight teeth instead of nine—only one setiform tooth where the other has two; and by the second pair of antennæ, which are rather slender, and armed with long but weak setæ. The penultimate abdominal segment has a terminal circlet of spinules.

Genus CYCLOPS.

1. *Cyclops thomasi*, n. s. (Pl. IX Figs. 10, 11 and 16.)

Elongate, slender, broadest in front and tapering backward, antennæ 17-jointed, reaching the middle of the third segment.

The first abdominal segment in the female is broad in front and slightly emarginate on each side before the anterior angles, and the last segment has a terminal circlet of small spines. The rami of the furca are more than half as long as the abdomen, and each bears two short rows of transverse spinules outside, one at the anterior the other at the posterior third. With the latter a spine occurs about as long as the outer terminal seta. The inner seta at the tip of the ramus is about half the length of the furca, the outer still shorter. The inner median seta is as long as the abdomen and furca, and the outer about half as long.

In the outer ramus of the first pair of legs the terminal joint has one spine and two setæ at the tip, one spine on the outer margin and two setæ within.

In the second, third and fourth pairs the last joint has one spine and one seta at tip, two spines externally and two setæ within. The inner rami of the second and third pairs terminate in one spine and one seta, that of the fourth pair in two spines, the inner of which is only half as long as the other.

The legs of the fifth pair are two-jointed, with the basal joint quadrate, broad, and bearing one long spine. The second joint is narrow and longer, parallel and truncate, with one terminal spine about equal to the preceding, and one about half that length.

From *C. bicuspidatus* Claus, this species may be distinguished by the armature of the outer ramus of the first pair of legs, and from *C. bisetosus* Rehberg., by the armature of the outer rami of the other legs.

It shares with *Diaptomus sicilis* the responsibility of affording to the young whitefish their earliest food.

2. *Cyclops insectus*, sp. nov. (Pl. IX Fig. 6.)

Closely allied to the preceding, but more robust in all its parts, and with the second cephalothoracic segment widest. The abdominal segments are all bordered with spinules posteriorly. The two median caudal setæ are much more nearly equal than in *thomasi*, the outer and the inner are very short, but longer than in that species. The inner in our specimens is longer than the outer—the reverse being the case in *bicuspidatus* as described by Claus.

The legs are armed nearly as in *thomasi*, but the last joint of the outer ramus of the first pair has two spines externally besides the one at the tip, and the terminal spines on the last segment of the inner ramus of the fourth pair of legs are about equal.

This is, perhaps, the commonest of the minute Cyclops of the small, temporary pools in Northern Illinois.

3. *Cyclops agilis* Koch. (= *serrulatus* Fischer.)

This species, distinguishable at a glance by its 12-jointed antennæ and a fringe of spinules along each ramus of the furca, occurs with the preceding, but less abundantly.