LIST OF CRUSTACEA CLADOCERA FROM MADISON, WISCONSIN.

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In 1878 the writer published Notes on Cladocera in the fourth volume of the Transactions of this Academy,* in which were noted twenty-five species of Cladocera found at Madison. Returning to the subject with better means of collecting and a much larger command of the literature of the group, I have been able to enlarge greatly the number of species and to identify them more accurately. As the task of reviewing the greatly scattered literature, especially of the *Lynceidæ*, seems likely to occupy some time, it seems advisable to print a list of the species already found, with notes on rare or new forms.

A glance at the subjoined list of sixty-four species and varieties regarded by many European writers as species, will show how close our fauna is to that of Europe. Out of the whole number, only nine are peculiar to this country and of these five are varieties of species found elsewhere, or are very close to foreign species. Three species are determined as new, *Latonopsis occidentalis* from the *Sididæ*, *Moina sp. nov.* from the *Daphnidæ*, *Alona lepida* from the *Lynceidæ*.

With the exception of five species and varieties (*Daphnia pulex*, *D. retrocurva*, *Alona tenuicaudis*, and the species of *Moina*), all of the species in the list have been found in Lake Wingra. This is a small lake about one and three-fourths miles long and half as wide, with broad margins of marsh all around it. In the marsh the water is from a few inches to two feet deep between the areas of wild rice and reeds, and the bottom is partly composed of vegetable débris and partly covered by a dense growth of *Chara*. The lake itself hardly exceeds fifteen feet in depth, and almost the entire bottom is overgrown with water plants of various kinds. Among these weeds and in the marshes Cladocera abound. The abundance of food and variety of locality offered probably account for the great number of species. In Lake Mendota, a much larger body of water, six miles by four, and having a depth of sixty to eighty feet, I have found only thirty-eight species of Clado-

* Vol. IV, 1876-7 (printed 1878), pp. 77-110. Pl. I, II.

cera. Doubtless more careful and prolonged collecting would disclose new species in both bodies of water, but the larger lake is certainly poorer in number of forms, especially the littoral species. The pelagic forms are, of course, more abundant in the larger lake, and one variety has been found in Lake Mendota which Lake Wingra does not possess.

This single locality has yielded a number of species, comparing not unfavorably with the fauna described from England, Denmark or Russia. No European country shows more than 100 species; so that more than one-half of the probable fauna of Wisconsin has been found here. That so large a fraction of the entire fauna should belong to one locality will not appear strange when the similarity of the fauna to that of Europe is considered. If the species of Cladocera have so wide a range as appears from Sar's observations on Australian Cladocera, and from my work here, it is not probable that many species are strictly local. We should expect to find any given species over a large extent of country in suitable localities. This expectation has been realized in many cases. As conspicuous instances I may note the occurrence of *Drepanothrix dentata*, Eurén, in Wisconsin, the finding of *Dunhevedia setiger*, Birge, in Hungary by Daday, and the occurrence of *Ilyocryptus longiremis*, Sars, in Wisconsin and in Australia. No doubt some species are strictly local, confined to a small area, or the product of life-conditions existing there and not elsewhere. But the chance that this is true in any given case is small, and all well marked species should be looked for in every suitable locality. We should expect also that a locality especially favorable to the development of the Cladocera would contain a very large fraction of the fauna of the region.

The subjoined list also shows the value of long and careful collecting in one locality, and the impossibility of justly estimating the Cladocera of a lake from a single visit. The different forms behave much like the plants of a locality. Some species are present throughout the season. Some can be found only for a few days. Some come in the spring and disappear early, while others belong to the latter part of the open season. Of the nearly sixty species found in Lake Wingra I have never found more than thirty as the result of a single day's work. It is clear that a list of Cladocera compiled from a flying visit to a locality and containing from six to twenty species, has no claim to represent the fauna of that locality. Only careful collecting at intervals throughout an entire season can give even an approximate idea of the number of species present.

I may add that a single specimen was found in Lake Wingra, belonging to the genus *Anchistropus*, Sars, and apparently not to the species *emarginatus*, Sars. It was accidentally destroyed before it could be carefully studied.

LIST OF CLADOCERA FOUND AT MADISON, WISCONSIN.

1. *Holopedium gibberum*, Zad.
2. *Sida crystallina*, O. F. M.
3. *Daphnella brachyura*, Liév.
4. *Daphnella brandtiana*, Fisch.
5. *Latona setifera*, O. F. M.
6. *Latonopsis occidentalis*, spec. nov.
7. *Moina brachiata*, Jur.
8. *Moina*, spec. nov.
9. *Simocephalus vetulus*, O. F. M.
10. *Simocephalus serrulatus*, Koch.
11. *Ceriodaphnia megops*, Sars.
12. *Ceriodaphnia reticulata*, Jur.
13. *Ceriodaphnia pulchella*, Sars.
14. *Ceriodaphnia consors*, Birge.
15. *Scapholeberis aurita*, Fisch.
16. *Scapholeberis obtusa*, Schdl.
17. *Scapholeberis mucronata*, O. F. M.
18. *Daphnia pulex*, De Geer.
19. *Daphnia Schoedleri*, Sars.
20. *Daphnia minnehaha*, Herrick.
21. *Daphnia hyalina*, Leydig.
22. *Daphnia kahlbergensis*, Schoedler.
23. *Daphnia kahlbergensis*, var *cederstroemii*, Schdl.
24. *Daphnia kahlbergensis*, var. *retrocurva*, Forbes.
25. *Lathonura rectirostris*, O. F. M.
26. *Macrothrix rosea*, Jur.
27. *Macrothrix laticornis*, Jur.
28. *Drepanothrix dentata*, Eurén.
29. *Ophryoxus gracilis*, Sars.
30. *Ilyocryptus sordidus*, Liéven.
31. *Ilyocryptus longiremis*, Sars.
32. *Bosmina longirostris*, O. F. M.
33. *Bosmina longicornis*, Schoedler.
34. *Bosmina cornuta*, Jur.
35. *Bosmina bohemica*, Hellich. (?)
36. *Eurycercus lamellatus*, O. F. M.
37. *Leydigia quadrangularis*, Leydig.
38. *Alona quadrangularis*, O. F. M.
39. *Alona affinis*, Leydig.
40. *Alona lineata*, Fischer.
41. *Alona guttata*, Sars.
42. *Alona costata*, Sars.
43. *Alona tenuicaudis*, Sars.
44. *Alona lepida*, spec. nov.
45. *Graptoleberis testudinaria*, Fischer.
46. *Dunhevedia* (*Crepidocercus*) *setiger*, Birge.
47. *Pleuroxus trigonellus*, O. F. M.
48. *Pleuroxus denticulatus*, Birge.
49. *Pleuroxus gracilis*, Hudendorff, var. *unidens*, Birge.
50. *Pleuroxus exiguus*, Lillj.
51. *Pleuroxus excisus*, Fischer.
52. *Pleuroxus procurvatus*, Birge.
53. *Chydorus sphaericus*, O. F. M.
54. *Chydorus sphaericus*, var. *caelatus*, Schdl.
55. *Chydorus sphaericus*, var. *punctatus*, Hellich.
56. *Chydorus globosus*, Baird.
57. *Alonopsis latissima*, Kurz.
58. *Alonopsis media*, Birge.
59. *Acroperus leucocephalus*, Koch.
60. *Camptocercus macrurus*, O. F. M.
61. *Camptocercus rectirostris*, Schdl.
62. *Camptocercus biserratus*, Schdl.
63. *Polyphemus pediculus*, De Geer
64. *Leptodora hyalina*, Lillj.

NOTES ON THE PRECEDING LIST.

Species 1. HOLOPEDIUM GIBBERUM, Zad.

I have found this species only once in Madison. It is quite abundant in collections from northern Minnesota, and Forbes* notes its occurence at Grand Traverse Bay, Lake Michigan.

Species 2. SIDA CRYSTALLINA, O. F. Müller.

No specimens were found belonging to the form *S. elongata*, DeGeer.

Species 3 and 4. DAPHNELLA BRACHYURA, Liév. and D. BRANDTIANA Fisch.

Of those closely allied forms I have only to say that both are found with us, and show exactly the same differences as described and figured by Sars in his *Norges Ferskvandskrebsdyr. D. brachyura* is usually found in open water, and *D. brandtiana* in marshes. I cannot state this as a law, however, as both forms are found together sometimes, in either kind of locality.

Species 5. LATONA SETIFERA, O. F. Müller. Plate XIII. Fig. 6.

Our specimens of Latona have one peculiarity not mentioned by any European writer. There is a thick coat of short hairs on the head, body and antennæ. These hairs are .02 mm. or less in length, are close set and give the outline a velvety appearance when seen by transmitted light. P. E. Müller† says: "Hvad der er aldeles eiendommeligt for Latona og neppe jagttaget hos nogen anden Cladoceer, eret fint Lod af ganske korte Haar, der isaer findes over Matrix; det er vanskeligt at see og opdages kun ved staerkt Sidelys." This exact account shows that his specimens were not villous as ours are. The hairs are conspicuous in any light and are very easily seen. No other European writer mentions a similar structure. A more extended study of specimens from different localities will show whether this is a local peculiarity or is characteristic of a distinct variety. On old females which have not moulted recently the hairs are worn off.

The male antenna differs somewhat from the account given by Sars.‡

The *appendix ciliata* is much larger than Sars figures it, and is situated at the same level as the sense-hairs instead of distal to them. The size, number and arrangement of the setæ on the edge of the carapace differ from the details given by Sars, but not in any very important respect.

Latona seems to be rare in Europe, but the apparent rarity is, as Sars says, probably due to its mode of life and the method of collecting. In late summer and early fall, one can be certain of obtaining a good num-

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* Forbes, S. A. On some Entomostraca of Lake Michigan and adjacent Waters. Am. Naturalist, vol. xvi., p. 641. Aug., 1882.

† Müller, P. E. Danmarks Cladocera, pp. 97–98.

‡ Norges Ferskvandskrebsdyr, p. 55, Pl. III, figs. 17a, 17b.

ber at various localities near Madison. It lives in clear water among weeds, and a dredge which can be dragged *through* the weeds and not merely *above* them is needed in order to secure it. With the cone-dredge it is not difficult to obtain 20 to 100 specimens. The same may be said of such bottom forms as *Ophryoxus* and *Drepanothrix*.

Sars speaks feelingly of the difficulties which beset one who attempts to view this powerful and obstinate cladoceran from the side. If a life-box is used and a trace of ½ per cent. of solution of osmic acid in water is added to the water containing the animal, there will be little trouble in turning it on its side. After the poison begins to act, it is best to attempt turning the animal by rotating the cover of the life-box. If left to die undisturbed the antennæ are usually expanded while an irritation applied to it while alive causes it to fold the antennæ along its sides, when it can readily be turned into any position.

Species 6. LATONOPSIS OCCIDENTALIS, sp. nov. Plate XIII. Figs. 1–5.

In 1888 G. O. Sars* established the genus and species *Latonopsis australis* for a new form of the *Sididæ* raised by him from mud obtained from Australia. I have found here a second and closely allied species of this new and remarkable genus, and have succeeded in finding males which did not develope in Sars' aquaria.

Latonopsis, Sars, is closely alled to *Latona*, Sars, and may be characterized as follows:

LATONOPSIS, Sars.

Impression between head and thorax slight or wanting. Labrum devoid of plate-like expansion. Antennule with a long, plumose, straight or curved flagellum, articulated to the basal part. Antenna with simple rami, the superior ramus bi-articulate, the inferior tri-articulate, as in *Daphnella*. Heart concave dorsally, truncate anteriorly, the aorta arising on the ventral side. Shell-gland with three long branches. Male (of *L occidentalis*, Birge, at least) with simple copulatory organ, and hook on first leg. Antennule long, slightly curved, armed with fine teeth resembling in general the antennale of *Sida*, but having a median projection near the base. Color of both species yellowish-transparent.

SPECIES.

a. Fornices absent. Antennule shorter than anterior margin of head. *L. australis*, Sars.

b. Fornices present. Antennule longer than anterior margin of head. *L. occidentalis*, sp. nov.

* Sars, G. O. Additional notes on Australian Cladocera raised from Dried Mud. Christiania 1888, pp. 6–15. Pl. I. Christiania Videnskabs Selskabs Forhandlinger 1888. No. 7.

DESCRIPTION OF FEMALE.

Length up to 1.8 mm. but usually smaller.

Measurements of average specimens.	♀ mm.	♂ mm.	♂ mm.
Length	1.30	.82	.61
Height	.80	.40	.27
Antennule	.42	.35	.28
Abdominal setæ	.50	.41	.31
Longest spine on carapace	1.05	—	.50

The head is in some cases marked off from the body by a slight depression, not seen in young specimens, and often absent in older individuals. The anterior outline of the head as seen from the side forms a straight or slightly convex line from the attachment of the antennules to the eye, where it passes by an abrupt curve into the dorsal margin. This margin is frequently continuous to the hinder end of the valves, and is nearly straight in young specimens but strongly convex in old females. Ventrally the anterior margin of the head terminates in a small projection to which the antennules are attached. The ventral margin is continued into the labrum, and is entirely devoid of the leaf-like expansion characteristic of *Latona*, Sars' *organum affixionis*. Above the insertion of the antennæ the valves are continued into small bilobed fornices, resembling those of *Latona* but much smaller, and not continued to the insertion of the antennules as are those of *Latona*. The head as seen from above is somewhat pyramidal in form.

The carapace does not differ greatly from that of the *Sididæ* in general. It leaves the oral structures uncovered in front; it is straight or convex dorsally according to the age of the animal; the ventral margin is evenly rounded and passes into the nearly straight posterior margin by a curve which forms no marked projection. The upper posteal angle is well marked. The edge of the carapace is fringed with long plumose setæ, each set on a small elevation. At the lower posteal angle are placed three setæ, much longer than the others. They are often longer than the carapace, and diverge from each other as they leave the shell, one passing nearly straight backward and the others more outward. These setæ are longer in our species than in *L. australis* as figured by Sars. The valves are not marked except by the braces (Stützbalken).

Along the inside of the hinder edge of the shell, from the insertion of the long setæ to the junction of the valves, runs a row of fine spines like those of *Latona*.

APPENDAGES.

The antennule consists of the basal part, the sense-hairs and the flagellum. The first is short, oblong, freely movable. The sense-hairs num-

ber about eight and are placed on the posterior side of the distal end of the base. The flagellum is attached to the base with a distinct suture. Sars calls it "distinctly articulated" in *L. australis*. Whether he means that there is a movable joint he does not make clear. In *L. occidentalis* there is simply a distinct suture. The flagellum is long, curved backward, tapers to a fine point, and is fringed with long straggling sense-hairs. These are far less numerous than in *Latona*. Most of them are on the anterior side of the antennale but at the tip they are attached to all sides. In this arrangement of the hairs the structure differs from the antennule of *L. australis* as figured by Sars. The sense-hairs are also longer than he shows them and the whole antennule is about twice as long, relatively, as that of *L. australis*.

The antenna closely resembles that of *L. australis*. The basal joint is exceedingly stout, so that the branches look too small for it. The dorsal sames is bi-, the ventral tri-articulate. The setæ are $\frac{4\,(5)-7}{0-1-4}$ and the spines $\frac{1-1}{0-1-0.}$ The basal joint bears the usual dorsal sense organ at the base, and at the distal end are a spine anteriorly and a plumose sense-hair behind. The proximal joint of the dorsal ramus bears four well developed setæ, and sometimes a fifth, proximal, seta which is much smaller than the others. Its presence or absence seems to depend on no law, as it is either present or absent in specimens of all ages and both sexes and may be present on one side and absent on the other side of the same individual. All setæ are two jointed and densely plumose.

The proportionate length of individual setæ differs in my specimens from *L. australis* as figured by Sars. The terminal setæ of the dorsal ramus are little longer than the others in *L. occidentalis*. The seta of the second joint of the ventral ramus is as long as the largest on the distal joint and each is quite twice as long as any other seta on the branch.

The post-abdomen closely resembles that of *L. australis*. It is short, fleshy, obtusely conical, and armed with nine very small super-anal denticles. The abdominal setæ are two-jointed, plumose, each set on a fleshy projection. They are a little longer than those of *L. australis*. The terminal claws are strongly curved, and have two secondary teeth, of which the distal is the longer.

The mouth parts and legs seem to resemble closely those of the other *Sididæ*. No careful study of the legs, has, however, been made. They number six pairs, as in other *Sididæ*.

INTERNAL ORGANS.

In the structure of the internal organs *L. occidentalis* agrees closely with *L. australis*, and I can add little to Sars' account. The general arrangement of the organs of the head may been seen in the figures.

The heart as seen from the side, shows a tube convex below and concave above. It is truncated anteriorly, and the aorta issues from its ventral side. From above the heart closely resembles that of *Latona*, having the form of a broad sac, rounded behind, and widest through the venous ostia.

The shell-gland has a form in this genus, which is unique among the Cladocera. It consists of three branches, of which the shortest is dorsal and extends toward the heart, the next in length is ventral, while the longest extends posteriorly and may reach through two-thirds of the length of the valve. This last loop is found only in *Latonopsis*. The whole gland consists of a tube doubled on itself, whose course can easily be traced. Beginning near the mandible in a bladder-like expansion the tube passes into the valve and extends ventrally; it returns on itself to the middle point, then passes backward in a long loop, returns again to extend up toward the heart and come back to the middle. Then comes a second posterior loop, lying parallel to and within the first, and on its return the tube passes to its outlet near the mandible. Thus there are two passages in the dorsal and ventral loops and four in the posterior, not three as stated by Sars (op. cit. p. 9.). Sars' figure (Pl. I, Fig 1.) shows the organ quite correctly.

DESCRIPTION OF MALE.

The male resembles in general the young female.

The antennules are long and stout, being often nearly half as long as the animal. They taper toward the apex, are curved, but not geniculate. They are provided with a long row of very fine teeth extending from a point near the sense-hairs to the apex. They thus resemble in general the antennule of the male *Sida* and *Daphnella* and differ widely from the male *Latona*. Near the base of the antennule on the inner side is a stout projection, rounded at the apex and covered with very fine hairs. This projection is probably equivalent to the "appendix ciliata" of the male *Latona*.* In *Latona*, Sars shows the appendix ciliata some way distal from the olfactory hairs, while in *Latonopsis*, it is some way proximad to these. My specimens of *Latona*, however, show the appendix close the to sense-hairs; so that the difference of position does not interfere with homology. The cilia on the appendix of *Latonopsis* are very fine and easily overlooked; they are far less conspicuous than in *Latona*.

The copulatory organs resemble those of *Latona*. They are a pair of long, curved, flexible appendages, perforated by the vasa deferentia. They arise at the base of the post-abdomen and are long enough to reach beyond the terminal claws.

The first leg shows a very distinct and strong hook. In this structure *Latonopsis* differs from the other *Sididæ* and especially from *Latona*.

*Sars, G. O. Norges Ferskvandskrebsdyr. Cladocera Ctenopoda, p. 55. Pl. III, Fig. 17.

Sida, *Limnosida* and *Daphnella* have short, fleshy knobs rather than hooks, and *Latona* is devoid of any special structure. *Holopedium* has a hook similar to that of *Latonopsis* but much longer, as is natural in that genus.

The new hatched male has the copulatory organ in the form of a pair of small buds, which do not reach the adult form until after four or five moultings. The antennule of the young male differs widely from the adult form. It is short, lacks the appendix ciliata, and shows a distinct suture between base and flagellum. The latter is covered with long straggling hairs. The whole structure closely resembles the female antennule. It is clear that the extension of the male antennule beyond the sense-hairs in the homologue of the flagellum of the female.

RELATIONS OF THE GENUS.

Sars was entirely justified in separating *Latonopsis* from *Latona*. While the structure of the two genera is quite similar in the female, the male differs widely from that of *Latona*. The antenna is more like that of *Daphnella* than that of any other genus, especially in the rami, while the great development of the base is like that of *Latona*. The antennule is peculiar and shows an intermediate stage between that of *Latona* and *Daphnella*, though nearer the former. In the male, however, the antennule is more like that of *Sida* than that of *Latona*. In the form of the body, the outline of the head, in the fornices, the position of the eye, eye-muscles and optic ganglion; in the heart; in the shape of the carapace, and the development of the setæ of the carapace, it approaches *Latona*. It lacks entirely the peculiar development of the antenna seen in *Latona* and the plate on the lower side of the head; while *Latona* lacks the development of the shell-gland, which *Latonopsis* shows. In most of the points of resemblance and difference between the two genera, *Latonopsis* is nearer the ordinary form of the *Sididæ*, and it may be considered as connecting *Latona* with the other *Sididæ*, but with many cross-relations to other genera.

RELATIONS OF THE TWO SPECIES.

L. occidentalis is very close to *L. australis*. Indeed, I am not sure but that they are really the same species. There are many points of minor difference, but the most tangible is the antennule, which is about twice as long in the American form. It must not be forgotten, however, that Sars' specimens were hatched from mud, and it may be possible that specimens collected in their native waters will agree more closely with the American species. If the difference is constant, *L. australis* is nearer the ordinary type of the *Sididæ* in the structure of the antennule.

BIOLOGICAL REMARKS.

Latonopsis occidentalis was found in Lake Wingra, a small lake about one and three-fourths miles long with a broad margin of marsh. It lives chiefly in the marshy region although I have found it in deeper water—one to three meters. It is most abundant in openings among the reeds of the marsh, where there is a foot or so of water filled with algæ and vegetable débris. In one such spot it was especially abundant during the summer of 1891. A single haul of the dredge would give from six to thirty individuals. I have dredged it with *Latona* in the open water, while I have never found *Latona* in the marsh. Sars' specimens came from a clayey mud. I have never found this species in muddy water.

In the aquarium it behaves quite like *Latona*. It often remains suspended and motionless in the water, and can often be turned over with the dropping tube without disturbing it. When, however, it decides to move it starts very suddenly. Its movements are less vigorous than those of *Latona*, as would be inferred from the different structure of the antennæ.

I have never seen more than eight young in the brood cavity. There are two sexual eggs, for whose reception a special cavity is enclosed, although there is no true ephippium.

The males appear in the latter part of July and the first part of August, and in September no specimens of either sex could be found, while *Latona* was more plentiful at this time than earlier in the season. Constant observation at any small lake will convince the student that the appearance of the males does not depend on temperature or any other simple cause. Each species has its own time for sexual reproduction, which is related to external influences in the same complex way as is the flowering of plants.

Species 8. MOINA, spec. nov.

A species of *Moina*, apparently new, has been found, but it is not as yet thoroughly worked up and will probably form the subject of a special paper. It seems related to *M. brachiata*, Jur. and was at first identified with this species. Further study, however, showed that there was only one egg in the ephippium and that the structure in other particulars differ from *M. brachiata*. The male especially shows peculiarities not found in other species.

Species 21. DAPHNIA HYALINA, Leydig. Plate XIII. Fig. 9.

Into this species have been united *D. galeata*, Sars, *D. pellucida*, P. E. Müller and *D. gracilis*, Hellich. Two well marked varieties are found at Madison. One with pointed crest is found in Lake Wingra, and the other whose crest is rounded is found in the larger lakes. Although the

lakes are only a mile apart, I have not found the pointed variety in Mendota or the rounded in Wingra. The outlines of the head are very variable, the variations quite closely resembling those represented in *D. berolinensis*, *apicata*, and *cucullata*, although of course this species has the macula nigra.

The males appear in the latter part of September. The flagellum of the antennule is convex, stout and short, usually little longer than the sense-hairs. The anterior sense-bristle in our specimens lies little nearer the end of the basal portion of the antennule than the head. In this our specimens differ from Eylmann's * description, who says of it, that it is "von der Endborste nicht weit entfernt."

This species is the most abundant in the open waters of the Madison lakes. I have also obtained it from Minnesota and Michigan, showing some variation from our form in each case.

Species 24. D. KAHLBERGENSIS var. RETROCURVA, Forbes. Plate XIII. Figs. 7, 8.

This form was first described by Forbes * as a distinct species. It is the most extreme Daphnid form yet observed. I cannot agree in the statement of Forbes that the large helmeted forms predominate in the smaller lakes (l. c. p. 643.) At Madison the forms of *D. hyalina* and of *D. retrocurva* in Lake Mendota are much more helmeted than those in Lake Wingra. The former lake is about six miles by four, the latter 1¾ by ¾ mile. *D. hyalina* in the smaller lake is more like *D. apicata*, while in Mendota the crest is more developed than is shown by any European descriptions. *D. kahlbergensis* from Wingra shows the forms typical of that species and of *cederstroemii* while the full development of the crest only comes in the larger lake. The males of this species appear late in the fall, in the latter part of October and in November. The head is of the *kahlbergensis* type, sometimes curved up but never showing the extreme development of the female. The antennule has a flagellum a good deal longer than the sense-hairs, curved at the tip and distinctly articulated to the basal part.

Our specimens do not show the extreme development of the head before birth noted by Forbes (l. c., p. 642). The head in the young is not as much crested as in the adult *D. hyalina*. This species is always found in company with *D. hyalina* and is far less numerous. On calm summer nights the water of Lake Mendota swarms with these two species, together with a *Cyclops*, a *Diaptomus*, and *Leptodora hyalina*. They are not abundant close to shore and seem to spend the day in swarms at the

* Eylmann, E. Beitrag zur Systematik der Europäischen Daphniden, Freiburg i. B. 1886, p. 33.

* Forbes, S. A. Entomostraca of Lake Michigan and adjacent waters. American Naturalist. Vol. xvi., p. 642, August, 1882.

bottom where the vegetation consists mainly of diatoms, outside of the growth of weeds. The number of the Cladocera is simply incalculable. I do not think that any shallow water is more filled with crustacean life than are the open waters of our lakes. Dredging does not give a fair idea of the number of open water individuals. Only surface collecting at night will disclose them.

Species 26. MACROTHRIX ROSEA, Jurine. Plate XIII. Figs. 13, 14.

I have succeeded in finding several specimens of the male of this species and have materially increased the accuracy of my knowledge of its structure. I found a single male in 1877 which was described in the Transactions of the Wisconsin Academy, Vol. IV. p. 90. Since that time the male has been seen by Daday,* who gives a figure which, however, is so small and shows so little detail that it does not add much to our knowledge.

The male antennules are long and curved, provided with a long anterior sense-hair at the base. They are curved toward the median plane of the body at the tip and bear the olfactory hairs on a small elevation on the anterior side. On the posterior side of the apex is a cluster of 5–6 long diverging sense-hairs. Daday shows these in his figure, but does not mention them in the text. In the possession of this extra sense organ, the male *M. rosea* differs from all other male Cladocera known, including the closely allied *Macrothrix laticornis*. These sense-hairs were not seen by me in my earlier specimen.

The post abdomen is prolonged into a flexible projection, on whose summit the vas deferens opens, just before the very small terminal claws. The whole structure thus resembles that of the male *Bosmina*.

Species 27. MACROTHRIX LATICORNIS, Jurine.

This form, which is usually given as the commonest of European species seems very rare here. I have met with not more than a dozen specimens in a season's collecting, while *M. rosea* is very abundant in marshes. It is at times the predominant cladoceran, while *M. laticornis* has never appeared except in single specimens.

Species 28. DREPANOTHRIX DENTATA, Eurén. Plate XIII. Figs. 15–17.

1861. *Acantholeberis dentata*, Eurén, Om märkliga Crustaceer af ordningen Cladocera, funna i Dalarne. Öfvers, af K. Vet.-akad. Förh. 1861, p. 118. Description of female. Tafl. III, fig. 2. Female.

1862. *Drepanothrix sentigera*, Sars, G. O. Om de i Omegnen af Christiania jagttagne Crustacea cladocera. Forh. Vid.-Selskab. i Christiania, 1862, p. 156. Description of male and female.

1862. *Drepanothrix hamata*, Sars., Do. p. 300. Mention only.

*Daday, E. Crustacea Cladocera Faunae Hungaricæ, p. 106, Pl. II, fig. 43.

1867. *Drepanothrix hamata*, Norman and Brady. Monograph of the British Entomostraca belonging to the families Bosminidae, Macrothricidae and Lynceidae. Nat. Hist. Trans. Northumberland and Durham, 1867, p. 12, description of female. pl. XXII, figs. 5 female, 6, antennule, 7 post-abdomen.

1867. *Drepanothrix dentata*, P. E. Mueller. Danmarks Cladocera, p. 138. Description of female. Pl. II, fig. 13, antennule.

1884. *Drepanothrix dentata*, Herrick, C. L. Geol. and Nat. Hist. Survey, Minnesota. 12th Report, 1884, p. 73. Description from P. E. Mueller. Plate C, fig. 14, antennule, from P. E. Mueller. In the description of the genus the word "not" should be erased in the first sentence, "The head *not* separated from the valves by a depression."

1888. *Drepanothrix dentata*, Richard, J. Recherches sur la Faune des Eaux du Plateau Central. Clermont, 1888. Mention only.

The references given above show that this rare species occurs in Denmark, Scandinavia, Great Britain and France. I have found it here in both sexes and in considerable numbers. Sars' description is accurate, as is that of Norman and Brady. The vas deferens opens in front of the terminal claws without any prolongation of the base into a penis.

D. dentata is found in Lake Wingra at a depth of from 5–10 feet. It is most abundant in a particular zone of depth in that lake where the weeds of the marshy margin cease and those of the deeper water have not come in abundantly. Here is a stretch of bottom a few yards in width composed chiefly of broken up snail shells and vegetable debris and with a few Charae as the chief living plants. In this zone I have found this cladoceran quite common. It is not confined to it, however, but is met with both inside and outside of this limit. In the marsh proper, however, I have never found it. It is a bottom-haunting form and is therefore difficult to obtain in large numbers.

Under some conditions it is markedly repelled by light. If a portion of the bottom with this and other Cladocera is placed with water in a watch glass and the whole exposed to strong light as from a lamp, *Drepanothrix* will at once hurry to the side remote from the source of light. While *Chydorus*, *Pleuroxus*, *Daphnia* and most other forms present will congregate on the side toward the light, *Drepanothrix* hastens away from it in an awkward scramble. The sabre-like setae from which its name is derived are its chief organ of locomotion. These it uses much as a boy uses a pair of sticks to propel his sled over the ice. It can swim fairly well in the open water, but is hampered by the weight and stiffness of these setæ.

Species 29. OPHRYOXUS GRACILIS, Sars. Plate XIII. Figs. 10–12.

1862. *Ophryoxus gracilis* Sars, G. O. Oversigt af de i Omegnen af Christiania jagttagne Crustacea cladocera, p. 158. Description of male and female.

(?) 1875. *Ophryoxus paradoxurus*, Hudendorff, A. Beitrag zur Kenntniss der Süsswasser-Cladoceren Russlands, p. 43. Description of female. Tab. II., fig. 1, a. b. This species, founded on a single specimen, very possibly belongs here.

1882. *Lyncodaphnia macrothroides*, Herrick, C. L. American Naturalist, Vol. XVI, p. 1006. Description of female. Plate XVI. figs. 1, female, 2, antennae, 3, post-abdomen, 4, antennule.

1884. *Lyncodaphnia macrothroides*, Herrick, C. L. Geol. and Nat. Hist. Survey of Minnesota, 12th Annual Report, 1884, p. 74. Description of female. Pl. B, fig. 12, yg.; 13, labrum; 14, antennule; 15, last foot. Pl. B, 1, figs. 1, female; 2, post-abdomen; 3, antennule.

Ophryoxus is quite abundant in Lake Wingra, occurring through the the entire summer in openings in the marsh. It is nowhere rare, and never very plentiful. It seems to have the habit of a *Daphnia*, swimming feebly about in the open waters, rather than clinging to weeds. I give figures of the head, first leg, and the post-abdomen of the male, which have never been illustrated.

The statement that the young have a long spine, (Sars), or that the young differ in form from the adult (Herrick), need qualification. The form never differs greatly from that of the adult, and there is never any difficulty in recognizing it as the young of *Ophryoxus*. Indeed, the presence of the spine is the only important difference between the young and old. This spine is not long according to the standard of the genus *Daphnia* as it rarely measures more than ¼ of the length of the animal. It is possessed by the male as well as by the young female. In the adult female it is reduced to a sharp prominence, like that seen in many species of *Ceriodaphnia*.

Species 31. ILYOCRYPTUS LONGIREMIS, Sars. Plate XIII, fig. 18.

1888. *I. longiremis*, Sars. Additional notes on Australian Cladocera, Christ. Vid.-Selskabs Forhand. 1888, No. 7, p. 33–41. Description of male and female. Pl. iv. figs. 1, female; 2, female from below; 3, spines from edge of shell; 4, female post-abdomen; 5, male.

I am unable to distinguish our specimens from those raised by Sars out of mud from Australia. The antennary setæ, from whose length the name is derived, are evèn longer in our species than in Sars' figures, nearly equalling the total length of the animal. There are 5–7 super-anal teeth, largest in the middle, an outer row of about eight long post-anal spines and an inner row of 11–12 post-anal denticles besides several

very small teeth near the terminal claw. There are 3–4 denticles on each side of the anus. This armature of the post-abdomen distinguishes the species at once from *Ilyocryptus sordidus* and *I. acutifrons*, while the antennary setæ distinguish it from *I. agilis*. The fact that moulting is imperfect also serves to distinguish it from the latter species.

This is the common form of *Ilyocryptus* here, and is very abundant in shallow water and marshy localities throughout the summer and until after the formation of ice in the winter. The failure of food consequent on long continued cold seems the only thing which checks their multiplication. Whether *I. spinifer*, Herrick (op. cit., p. 77), is identical with this species can not be decided as none of the specific characters are mentioned or figured.

Species 37. LEYDIGIA QUADRANGULARIS, Leyd.

The shell-markings in my specimens are far more distinct than those described by European authors. Otherwise the species agrees entirely with the descriptions.

Species 40. ALONA LINEATA, Fischer.

If, following Matile's* advice, the specific name *lineata* is abandoned, my form would be *A. pulchra*, Hellich.

Species 44. ALONA LEPIDA, sp. nov. Plate XIII. Fig. 19.

Length, .8 mm.	Length of male, .6 mm.
Height, .45-50 mm.	Height of male, .3 mm.
Length post-abdomen, .40 mm.	

General shape conforms to the normal Alona type. Head depressed, rostrum sub-acute, nearly reaching the level of the ventral margin of the shell. Valves quadrangular, dorsal margin arched, superior posteal angle obtuse, well-marked. Posterior margin oblique, bearing a row of minute spinules. Inferior posteal angle rounded, very slightly emarginate. Ventral margin beset with a row of plumose setæ, of ordinary length, which ends abruptly at the posteal angle. Valves marked by close-set, conspicuous, longitudinal striæ, alternately stronger and weaker, occasionally anastomosing, running parallel to the dorsal and ventral margins and converging into a reticulated area at the anterior inferior portion of the valves. Between the striæ lie the braces.

Antennule extends nearly to end of rostrum: is spindle-shaped, largest near base, provided with an anterior sense-bristle and 6–8 subequal sense-hairs. Antennary setæ $\frac{800}{811}$. The terminal setæ are of unequal length. All are plumose and without spines. The eighth setæ is of moderate size, bi-articulate and plumose. Spines of antennae, $\frac{101}{100}$. On the middle joint of the inner branch is a circlet of small spines. Ventral margin of labrum often notched just anterior to the posterior angle,

* Matile, P. Die Cladoceren der Umgegend von Moskau, 1890, p. 46.

which is sharp. Eye moderate in size, showing four or fewer lenses. Macula nigra about as large as eye, angular, and somewhat nearer to eye than to apex of rostrum.

Post-abdomen enlarged posteriorly, lower angle rounded, bearing 15–17 serrate post-anal denticles and about the same number of squamae. Terminal claws smooth. Basal spine rather large. Abdominal setæ of ordinary length.

MALE.

Antennule cylindrical, with anterior sense-bristle and flagellum. Post-abdomen devoid of denticles and with a row of squamae. Vas deferens opens in front of terminal claw. Basal spine large.

Color yellowish to bright yellow, fairly transparent. Lake Mendota, in deeper water, 15–20 feet.

This species is evidently related to *A. elegans*, Kurz* from which it differs in its greater size, in the reticulation of part of the shell, and in the size, shape and armature of the post-abdomen. The post-abdomen of *A. lepida* resembles in general that of *A. quadrangularis*, O. F. M. The species lives at the bottom in rather deep water—15–20 or more feet—and is much more abundant in Lake Mendota than elsewhere in the vicinity of Madison.

Species 45. GRAPTOLEBERIS TESTUDINARIA, Fischer.

My species *G. inermis*,† is a variety of this species. The spine on the terminal claw is sometimes, though rarely, present, and the other characters adduced for *G. inermis* fall within the range of variation of European forms.

Species 46. DUNHEVEDIA (CREPIDOCERCUS) SETIGER, Birge. Plate XIII. Fig. 20.

In 1888, G. O. Sars‡ raised from dried mud and redescribed *Dunhevedia crassa* of King. From his description and figures it is plain that my genus *Crepidocercus* is identical with King's *Dunhevedia*, which was established in 1853. The genus was named by King from Dunheved, the place where the animal was found. My species differs from *D. crassa*, King, in the reticulation of the shell and, apparently, from *D. podagra*, King, in general form. I have not been able to see King's original paper. *D. setiger* has been found in Hungary by Daday.§

In the latter part of August I found the males of this species. *D. setiger* has always been one of the rarest species of Cladocera here. It was rarely collected at all, and if present in a dredging was found in only

*Kurz, W. Dodekas neuer Cladoceren. Sitzb. der K. Akad. der Wissensch. Wien; 1874. Separate reprint, p. 43. Description of female, Tab. II, fig. 1, female.

† Transactions Wis. Acad. Sci., vol. iv, p. 102, pl. I, fig. 17.

‡ Additional notes on Aust. Cladocera, 1888, p. 41, Pl. 5, figs. 1–4.

§ Daday, E. Crustacea Cladocera Faunæ Hungaricae, p. 93, Pl. I, fig. 47-48.

one or two specimens. At the time named I found in Lake Wingra, in water filled with *Millefolium*, immense numbers of the species in both sexes. Thousands were collected in a single haul of the cone-dredge. After about a week they disappeared and repeated efforts to find them in the same locality failed. Doubtless the winter eggs had been laid and both sexes were dead. It will be interesting to observe at what date the species will appear in 1892.

The male measures about .36 mm in length and .24 mm in height. It has the same general form as the female. The first foot has a stout hook. The post-abdomen resembles that of the female, and is provided with numerous scattered hairs. The vas deferens opens above the terminal claws. The terminal claws are smooth in both sexes, differing from *D. crassa* in which they are denticulate.

Species 47. PLEUROXUS TRIGONELLUS, O. F. Mueller.

This species is by no means abundant here, and is usually found in deep water, down to 12–15 feet.

Species 48. PLEUROXUS DENTICULATUS, Birge. Plate XIII. Fig. 21.

This is the ordinary *Pleuroxus* here. It corresponds to *P. aduncus*, Jur. in Europe. I give a figure of the male post-abdomen.

Herrick remarks on the similarity of this species to *P. procurvatus*, and suggests that the two names may really belong to varieties of the same species. I have looked carefully for connecting forms but have been unable to find then.

Species 49. PLEUROXUS GRACILIS, Hudendorff, var. UNIDENS, Birge.

I was not acquainted with Hudendorff's paper when I wrote my description of this species in 1877. Matile* notes the resemblance of the two forms and correctly points out that the chief difference lies in the overhanging projection of the upper posteal angle in *P. unidens*. As I find this difference constant and as there are other less important differences, I retain my name as characterizing a variety. Both Hudendorff and Matile note the species as rare. I did the same in my former paper, having then found only about 15 specimens. By the use of the cone-dredge I have found it quite abundant in Lake Wingra in late summer and autumn. There is no difficulty in getting 25 to 100 specimens from one haul of the dredge.

Species 60–62. CAMPTOCERCUS.

Three species of *Camptocercus* are found in Wisconsin. *C. macrurus*, O. F. M. has been formed in only a few specimens.

I am doubtful whether Schoedler's two species *C. biserratus* and *C. rectirostris* are really distinct. I find forms agreeing with both descriptions

* Die Cladoceren der Umg. von Moskau, 1890, p. 37.

in general, and include both names. In no case have I found the head directed so horizontally forward as in Schoedler's figures of *C. rectirostris*.* Nor are the posteal teeth so large. Our form more nearly resembles that figured by Matile.† In the other form, the head is more depressed, the macula nigra larger than the eye, and the ventral margin of the valves is concave. I have found no specimens connecting the two forms and have therefore identified them as above.

In both species I have found individuals in which the beak was truncate, resembling that part in *C. Lilljeborgii*, Schdl., as figured by Hellich,‡ or *C. latirostris*, Kurz.§ The shell markings differ from those figured by any author. If a cast shell is examined without cover glass and not covered by water, a reticulated area is seen in the anterior part of the valves just below the middle. From this radiate most of the striæ. These are in front parallel to the anterior edge of the shell and the direction gradually changes until they are parallel to the ventral edge. Sixteen or more striæ run out on the ventral edge of the shell. The longitudinal striæ anastomose occasionally and those on the dorsal part of the valves do not bend downward into the reticulated area. I have never found specimens reticulated all over with quadrangular meshes as Hellich (l. c., pp. 76–77) figures them.

Species 63. POLYPHEMUS PEDICULUS, De Geer.

This species I have found very rarely. Only two or three specimens have been discovered at long intervals. Zacharias‖ notes that this animal is distinctly northern in its range. My observations confirm his conclusion. I find it quite abundant in a small collection from northern Minnesota. Herrick also describes it as plentiful in Minnesota. As I have often searched vainly for it here, I believe that this locality must be close to the southern limit of its range. The same is probably true of *Holopedium gibberum*, Zad.

Species 64. LEPTODORA HYALINA, Lillj.

I quote this species by its old name, without passing on the correctness of the change to *L. Kindtii*, Focke. Focke's paper is inaccessible to me. *Leptodora* is very abundant in all our lakes. It grows to a large size and specimens 18–21 mm. in length are not rare.

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* Schoedler. J. E. Neue Beiträge zur Naturgeschichte der Cladoceren, 1853. Pl. III, fig 50.

† Matile, P. Die Cladoceren der Umgegend von Moskau. 1890. Pl. IV, fig.26.

‡ Hellich, B. Die Cladoceren Boehmens, 1877, p. 77, fig. 37.

§ Kurz, W. Dodekas neuer Cladoceren, 1874, Pl. II, fig. 9.

‖ Zacharias, O. Die Fauna des grossen und kleinen Teiches in Riesengebirge, Zeit. Wiss. Zool. Vol. XLI., p. 492.

THE CONE-DREDGE.

The dredge which I have used for collecting seems worthy of special description. It consists of four parts: the body, the cone, the net, and the screw-top. The body is a cylinder of stout tin, strengthened by a wire at each end, four inches long, and four inches in diameter. On top of this is placed a cone of brass netting, five inches high. This is attached below to a circle of tin so that it fits into the top of the body like the cover of a tin pail. The bail of the body is of stout brass wire; the ends passed through the side of the body and enlarged, and the loop of wire shaped so as to fit within the cone and project through a hole in its top with an eye into which the dredge-line can be fastened. To the end of the line is attached a snap-hook larger than the hole in the top of the cone, so that the cone can not come off the body when in use. There are two cones provided for my dredge, one of one-tenth inch mesh, and the other of one-twentieth inch.

The $\frac{1}{20}$ inch mesh is coarse enough unless it is desired to secure very large forms. For ordinary shallow water collecting it is the best size. The cone can easily be removed for work at night in the open water.

The net is of fine cheese cloth, eighteen to twenty-two inches long, conical, large enough at the base to slip over the dredge body, to which it is tied. It is faced with stout muslin for a distance of two or three inches at each end. At the smaller end it is small enough to fit the screw-top, a tin cylinder one inch in diameter and one and one-quarter inches in length, with a wire in one end and on the other a zinc screw-top, such as are used on kerosene cans.

The seam along one side of the net is so made as to leave a sort of a loop in the cloth, through which a string can be run. One end of this string is tied about the dredge body; to the other end can be attached a weight, when desired, without having the pull of the weight come on the net.

This dredge is very useful for collecting small animals in shallow or weedy water. It can easily be thrown from the shore to a distance of 50 feet or more, thus permitting much more extensive collecting from shore than does the ordinary hand net. It can be drawn through weeds and over muddy bottoms, straining large amounts of water without becoming filled with mud or clogged with weed. If it is desired to collect from water close to the bottom without obtaining mud, a weight fastened to the end of the cord spoken of, so as to drag behind the dredge will cause the dredge to lift at each pull and so exclude most of the mud, except in very deep water. If a band of cloth is fastened about the base of the cone, leaving only the upper part free it will admit the water just above the bottom without scraping up mud. An old rake or other irregular piece of iron fastened to the dredge-line in front of the dredge will stir up the bottom and thus samples of bottom ani-

mals can be gathered from a long distance, before the dredge fills. The cone not only excludes weeds but also keeps out insects, larvæ, large Gammari, etc., which so abound in localities favorable for Cladocera, and whose size and activity made it difficult to distinguish the smaller crustacea in the collector's jar. The fact that this dredge can be pulled through weeds and strain a large quantity of water without obtaining a large amount of vegetable debris makes it very valuable in obtaining the rarer Cladocera.

The dredge is emptied by unscrewing the screw-cap and washing out the contents of the bag into a tumbler or small jar of water. In collecting near home this is brought to the laboratory for study. When it is desired to preserve collections for future study, the water is allowed to stand and settle for a short time and then the clear water containing the animals and free from mud is poured through a funnel into a small bag of cheese-cloth which is tied and put into alcohol or other preserving fluid.

With this dredge it is not at all difficult to collect 20–30 species of Cladocera from one locality and in a few hauls. In a collection thus gathered from the shore on a flying trip to some small lakelets at Manistee, Mich., I found twenty-six species of littoral Cladocera. Zacharias* in a summer's campaign in North German lakes found only twenty-three species from the shore waters.

PLATE XIII.

Fig. 1. *Latonopsis occidentalis*, Birge. Head of male, enlarged 60 diameters.
Fig. 2. " " Head of young female, enlarged 50 diameters.
Fig. 3. " " Post-abdomen of male, enlarged 75 diameters. The spines of the carapace are omitted.
Fig. 4. " " Antennule of new-hatched male, enlarged 200 diameters.
Fig. 5. " " First leg of male, enlarged 175 diameters.
Fig. 6. *Latona setifera*, O. F. M. Male antennule to show position of *appendix ciliata* (a). Enlarged 200 diameters.
Fig. 7. *Daphnia retrocurva*, Forbes. Male antennule, enlarged 200 diameters.
Fig. 8. " " Female, enlarged 30 diameters.
Fig. 9. " *hyalina*, Leyd. Male antennule, enlarged 200 diameters.
Fig. 10. *Ophryoxus gracilis*, Sars. Head of male, enlarged 65 diameters.
Fig. 11. " " Post-abdomen of male, enlarged 160 diameters.
Fig. 12. " " Part of first leg of male, enlarged 200 diameters.
Fig. 13. *Macrothrix rosea*, Jur. Antennule of male, enlarged 240 diameters.
Fig. 14. " " Post-abdomen of male, enlarged 240 diameters.
Fig. 15. *Drepanothrix dentata*, Eur. Post-abdomen of male, enlarged 175 diameters.
Fig. 16. " " Female, enlarged 65 diameters.
Fig. 17. " " First leg of male, enlarged 300 diameters.
Fig. 18. *Ilyocryptus longiremis*, Sars. Male, enlarged 100 diameters. The spines of the carapace are omitted where they would cross the post-abdomen.
Fig. 19. *Alona lepida*, Birge. Cast shell to show markings, enlarged 60 diameters.
Fig. 20. *Dunhevedia setiger*, Birge. Male, enlarged 115 diameters.
Fig. 21. *Pleuroxus denticulatus*, Birge. Post-abdomen of male, enlarged 165 diameters.

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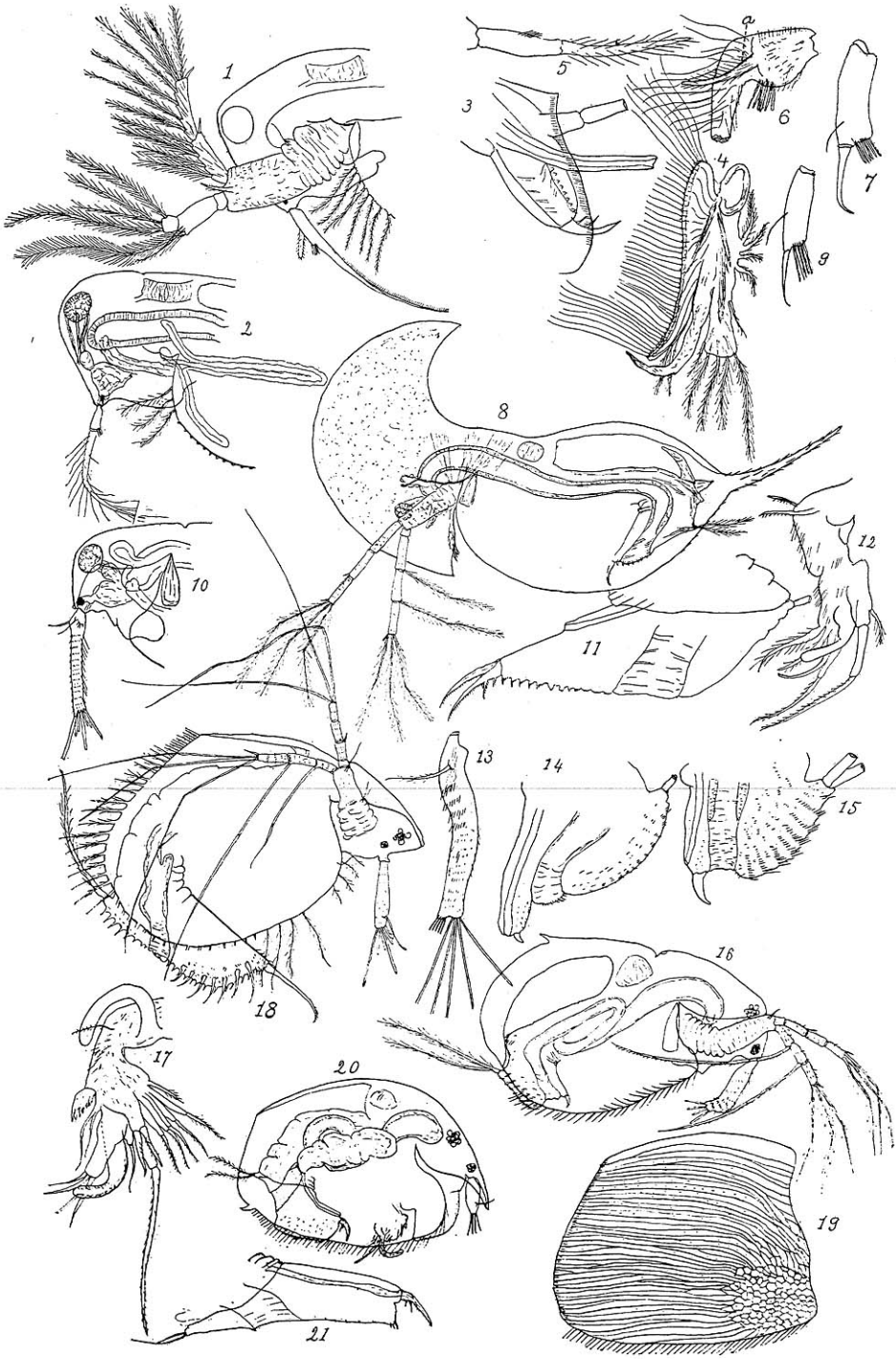
* Zacharias, O. Zur Kenntniss der pelagischen und littoralen Fauna Norddeutschen Seen. Zeit. Wiss. Zool. Vol XLV, 1887., p. 265.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